SECTION 01 10 00
STATEMENT OF WORK

1.0 PROJECT OBJECTIVES

1.1. SECTION ORGANIZATION

2.0 SCOPE

2.1. Training Support Center

2.2. SITE

2.3. GOVERNMENT-FURNISHED GOVERNMENT INSTALL EQUIPMENT (GFGI)

2.4. FURNITURE REQUIREMENTS

3.0 Training Support Center

3.1. GENERAL REQUIREMENTS

3.2. FUNCTIONAL AND AREA REQUIREMENTS

4.0 APPLICABLE CRITERIA

4.1. INDUSTRY CRITERIA

4.2. MILITARY CRITERIA

5.0 GENERAL TECHNICAL REQUIREMENTS

5.1. SITE PLANNING AND DESIGN

5.2. SITE ENGINEERING

5.3. ARCHITECTURE AND INTERIOR DESIGN

5.4. STRUCTURAL DESIGN

5.5. THERMAL PERFORMANCE

5.6. PLUMBING

5.7. ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

5.8. HEATING, VENTILATING AND AIR CONDITIONING

5.9. ENERGY CONSERVATION

5.10. FIRE PROTECTION

5.11. SUSTAINABLE DESIGN

5.12. CONSTRUCTION AND DEMOLITION (C&D) WASTE MANAGEMENT

5.13. SECURITY (ANTI-TERRORISM STANDARDS)

6.0 PROJECT SPECIFIC REQUIREMENTS

6.1. GENERAL

6.2. APPROVED DEVIATIONS

6.3. SITE PLANNING AND DESIGN

6.4. SITE ENGINEERING

6.5. ARCHITECTURE

6.6. STRUCTURAL DESIGN

6.7. THERMAL PERFORMANCE

6.8. PLUMBING

6.9. SITE ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

6.10. FACILITY ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

6.11. HEATING, VENTILATING AND AIR CONDITIONING

6.12. ENERGY CONSERVATION

6.13. FIRE PROTECTION

6.14. SUSTAINABLE DESIGN

6.15. ENVIRONMENTAL

6.16. PERMITS

6.17. DEMOLITION

6.18. ADDITIONAL FACILITIES

1.0 PROJECT OBJECTIVES

The project objective is to design and construct facilities for the military that are consistent with the design and construction practices used for civilian sector projects that perform similar functions to the military projects. For example, a Company Operations Facility has the similar function as an office/warehouse in the civilian sector; therefore the design and construction practices for a company operations facility should be consistent with the design and construction of an office/warehouse building.

Comparison of Military Facilities to Civilian Facilities

Military Facility	Civilian Facility
Training Support Center	Warehouse, Classroom

It is the Army's objective that these buildings will have a 25-year useful design life before a possible re-use/re-purpose or renovation requirement, to include normal sustainment, restoration, modernization activities and a 50-year building replacement life. Therefore, the design and construction should provide an appropriate level of quality to ensure the continued use of the facility over that time period with the application of reasonable preventive maintenance and repairs that would be industry-acceptable to a major civilian sector project OWNER. The site infrastructure will have at least a 50-year life expectancy with industry-accepted maintenance and repair cycles.

The project site should be developed for efficiency and to convey a sense of unity or connectivity with the adjacent buildings and with the Installation as a whole.

Requirements stated in this contract are minimums. Innovative, creative, and life cycle cost effective solutions, which meet or exceed these requirements are encouraged. Further, the OFFEROR is encouraged to seek solutions that will expedite construction (panelization, pre-engineered, etc.) and shorten the schedule. **The intent of the Government is to emphasize the placement of funds into functional/operational requirements. Materials and methods should reflect this by choosing the lowest Type of Construction allowed by code for this occupancy/project allowing the funding to be reflected in the quality of interior/exterior finishes and systems selected.**

1.1. SECTION ORGANIZATION

This Section is organized under 6 major “paragraphs”.

(1) Paragraph 1 is intended to define the project objectives and to provide a comparison between the military facility(ies) and comparable “civilian” type buildings.

(2) Paragraph 2 describes the scope of the project.

(3) Paragraph 3 provides the functional, operational and facility specific design criteria for the specific facility type(s) included in this contract or task order.

(4) Paragraph 4 lists applicable industry and government design criteria, generally applicable to all facility types, unless otherwise indicated in the Section. It is not intended to be all-inclusive. Other industry and government standards may also be used, where necessary to produce professional designs, unless they conflict with those listed.

(5) Paragraph 5 contains Army Standard Design Criteria, generally applicable to all facility types, unless otherwise indicated in the Section.

(6) Paragraph 6 contains installation and project specific criteria supplementing the other 5 paragraphs.

2.0 SCOPE

2.1. TRAINING SUPPORT CENTER

Provide a Training Support Center to support military mission to educate and train soldiers.

Number of building stories: 1

Size of Facility: 29,200 square feet

2.2. SITE:

Provide all site improvements necessary to support the new building facilities. Refer to Paragraph 6.

Approximate area available 4.18 acres

2.3. GOVERNMENT-FURNISHED GOVERNMENT-INSTALLED EQUIPMENT (GFGI)

Coordinate with Government on GFGI item requirements and provide suitable structural support, brackets for projectors/VCRs/TVs, all utility connections and space with required clearances for all GFGI items. Fire extinguishers are GF/GI personal property, while fire extinguisher brackets and cabinets are Contractor furnished and installed CF/CI. All Computers and related hardware, copiers, faxes, printers, video projectors, VCRs and TVs are GFGI.

The following are also GFGI items: Storage racks in the warehouse

2.4. FURNITURE REQUIREMENTS

Provide furniture design for all spaces listed in Chapter 3 and including any existing furniture and equipment to be re-used. Coordinate with the user to define requirements for furniture systems, movable furniture, storage systems, equipment, any existing items to be reused, etc. Early coordination of furniture design is required for a complete and usable facility.

The procurement and installation of furniture is NOT included in this contract. Furniture will be provided and installed under a separate furniture vendor/installer contract. The general contractor shall accommodate that effort with allowance for entry of the furniture vendor/installer onto this project site at the appropriate time to permit completion of the furniture installation for a complete and usable facility to coincide with the Beneficial Occupancy Date (BOD) of this project. The furniture vendor/installer contract will include all electrical pre-wiring and the whips for final connection to the building electrical systems however; the general contractor shall make the final connections to the building electrical systems under this contract. Furthermore, the general contractor shall provide all Information/Technology (IT) wiring (i.e. LAN, phone, etc.) up to and including the face plate of all freestanding and/or systems furniture desk tops as applicable, the services to install the cable and face plates in the furniture, the coordination with the furniture vendor/installer to accomplish the installation at the appropriate time, and all the final IT connections to the building systems under this contract.

The Government reserves the right to change the method for procurement of and installation of furniture to Contractor Furnished/Contractor Installed (CF/CI). CF/CI furniture will require competitive open market procurement by the Contractor using the Furniture, Fixtures and Equipment (FF&E) package.

2.5. NOT USED

3.0 TRAINING SUPPORT CENTER

3.1. FUNCTIONAL/OPERATIONAL REQUIREMENTS

The Training Support Center (TSC) is a building that is used to fabricate, maintain, store, and issue training devices including the Multiple Integrated Laser Engagement System (MILES). The average of 5,000 components associated with a standard Brigade MILES Set is used to size Training Support Real Property as defined in the Training Support Facility Design Guide per USACE Huntsville, November 2007.

The Training Support Center Facility (TSC) is composed of five main types of functional areas: Training Space, Classroom; Administrative Spaces (Customer Waiting Area, Administration Offices, Device Maintenance and Repair Area); Warehousing and Storage (Shipping/Receiving Loading Dock, Device Fabrication, Warehouse/Storage Area); Special Functional Use Areas (Latrines, Student/Staff Break Areas, Secure Operations Storage, Retail Device Storage); and Support Spaces (Janitor Closet, Mechanical/Electrical Space).

Refer to the attached floor plan for the functional layout. Generally, the size of this facility depends on the mission of the installations. The space requirement and layout for each project will be as specified in the Training Support Facility Design Guide per USACE Huntsville, November 2007.

3.1.1. SUPPLEMENTAL REQUIRESMENTS

3.1.2. HANDICAPPED ACCESS. The entire facility will be handicapped accessible.

3.1.2.1. Site Plan Design and Construction:

(a) Provide ADA compliance access from the parking lot to the building.

(b) Provide handicapped vehicle parking stalls, signage, and pavement markings IAW ADA requirements.

3.1.2.2. Facility Design and Construction:

(a) Designed per applicable code, shall be handicapped accessible. Electronic exterior door push buttons are not required.

(b) Provide ADA clearances and door accesses in the building lobby.

(c) Provide handicapped accessible drinking fountains.

(d) Provide handicapped accessible public toilet(s).

3.1.3. OPERATIONAL SITE ORIENTATION. The TSC is to be oriented per the Design/Build contractor.

3.1.4. CORE AREAS. Core areas may be arranged in one story configurations.

3.1.4.1. Training Space. General instruction rooms are space that includes primarily classroom space for multipurpose training instruction. These general purpose rooms are intended for use by organizations which serve a large population for classroom and device simulation instruction.

3.1.4.2. Administrative Spaces.

3.1.4.2.1. Customer Waiting Area. Customers factored based on 4 personnel for each Brigade Combat Team MILES Set authorized.

3.1.4.2.2. Administration Offices. Space for building operations, budget, scheduling, technical support, contracting officer representative, program and training administration.

3.1.4.2.3. Device Maintenance and Repair Area. Device set-up, storage, maintenance and repair. Provide work bench, storage, tools storage and repair parts storage areas.

3.1.4.3. Warehousing and Storage.

3.1.4.3.1. Shipping/Receiving Loading Dock. A loading dock is important for new stand-alone facilities. It should be remote from the customer entrance and collocated with supply/storage are.

3.1.4.3.2. Device Fabrication. Training aids are fabricated using woodworking tools, bench fabrication, tools used are saws, drills, sanders, routers. Plastics fabrication uses injection molding, roto molding, and other similar tools and setups. Installations with and Army wide fabrication mission require space for plastics manufacturing.

3.1.4.3.3. Warehouse/Storage Area. General Purpose Warehouse requirement based on physical measurement of standard Brigade Combat Team (BCT) Multiple Integrated Laser Engagement System (MILES) Set, average of 5,000 components, containerized and stored on racks four tiers high.

3.1.4.4. Special Functional Use Areas

3.1.4.4.1. Latrines. Male and female latrines with standard fixtures.

3.1.4.4.2. Student/Staff Break Areas. Refrigerator, Sink, microwave, vending, phones, television. Lounge type furniture with tables and with seating for personnel.

3.1.4.4.3. Secure Operations Storage. Secure storage area for sensitive devices and other sensitive communication and automation components.

3.1.4.4.4. Retail Device Storage. Retail space derived as a percentage (10%) of General Warehouse/Storage Category Code 44220 requirement. 10% factor derived from physical measurement of related and support components for standard BCT MILES Set and all other Training Aide devices. Hazardous Material Storage Areas used by the training support center include, but not limited to, propane, polyurethane, and oxygen. Storage area will be in compliance with existing government safety regulations.

3.1.4.5. Support Spaces

3.1.4.5.1. Janitor Closet.

3.1.4.5.2. Mechanical/Electrical Space. Dedicated interior spaces and exterior areas for plumbing, fire protection, and HVAC equipment. Allowances based on industry averages.

3.2 SITE PLANNING AND DESIGN

TSC should be located in close proximity to other training facilities; classroom and simulations. Components of land requirements are: primary facility; site egress and ingress; utility access; POV parking; Tactical vehicle parking; and force protection stand-off distances. Future expansion needs should factor a minimum 100% expansion of each functional component.

Organize the site to be compatible with the site planning and style of adjacent existing structures. Locate the building to reflect local climatic conditions. For example, provide protection from prevailing winds, snow load, glare, and orient operable windows to take advantage of summer breezes. Locate the building to take advantage of passive solar heating and day lighting.

3.2.1 Environmental. The sitting of the facility should result in the minimal disturbance to the existing topography, vegetation and drainage patterns and reduce negative impact on the environment.

3.2.2 Soils Testing. A qualified geo-technical engineer licensed in the state of the location for the TSC will be retained to take borings on the site and recommend an adequate foundation system. The soils analysis report should reveal any surface or subsurface problems effecting the design and construction of the TSC.

3.2.3 Groundwater and Runoff. The control of water flow around the site, site runoff and below grade ground water is critical to ensuring proper long term drainage around the building(s) and the parking areas. The presence of ground water within the frost depth of the foundation system typically warrants the use of a complete subsurface drainage system and/or the use of perimeter foundation drains. The minimum recommended requirements for most soil conditions involve the incorporation of foundation drains. Consideration should include minimizing roof runoff onto grade. Certain soil types may require the piping of roof and site runoff into a controlled storm drainage system.

3.2.4 Landscape Design Considerations. Consider use of sustainable landscape features where possible. Utilize plant material to improve the physical and psychological appearance of the TSC site and the surrounding community. Where possible preserve trees and planting to enhance the overall visual quality of the facility and the installation. Landscape plans will be prepared and approved by qualified personnel to ensure quality and promote design consistency with the architectural theme of the building.

3.2.5 Signage. All TSCs must have a sign placed at the front of the facility which clearly serves as a landmark for the facility. The sign should be placed at eye level. Provide standardized signage systems in compliance with Technical Manual (TM) 5-807-10 to facilitate movement and provide a sense of orientation.

IAW TM 5-807-10, interior signage shall be as follows:

Signage may be informational, directional, or regulatory. Informational signage provides the user with information and includes room or area labels, bulletin boards, menus, artwork descriptions, and emergency information. Directional signage directs circulation and provides orientation. It includes entry directories, directional arrows, and maps. The purpose of regulatory signage is control: providing prohibitions, warnings, emergency instructions, and use restrictions (para 8.13.11.3, Fig. 8.20).

Interior signage is covered in detail in TM 5-807-10 (paragraph 8.13.11.3.2). The TM includes graphics for the following: directional, identification signs, information, and pictograms.

3.2.6 Hardstand. Hardstand areas will be rigid pavement. Pavement for organizational vehicle areas should be designed for the heaviest vehicle at the installation.

3.2.7 Antiterrorism and Force Protection. The TSC must be designed in compliance wit DOD minimum Anti-Terrorism Standards for Buildings, United Facility Criteria 4-010-01.

3.2.8 Exterior Lighting. Exterior area lighting systems will be provided for facility aprons, open storage areas, and parking areas. Exterior area lighting systems should consist of color corrected high intensity discharge lighting units mounted on poles and located within the clear zone and on the primary facility. Illumination levels will be 50 lux for areas adjacent to the primary facility and 5 lux for parking areas. Lighting circuits will be controlled by a time switch. This is to facilitate 24 hour and night operations when necessary.

3.2.9 Perimeter Security Lighting. Protective lighting systems will be provided in response to project specific requirements to deter trespassers and make them visible to guards. Levels of exterior lighting for protected areas will conform to the requirements in the IES Lighting Handbook. Lighting circuits will be controlled by a photoelectric cell with manual override.

3.2.10 Storm Water Management. Site storm water management may require controls on the peak flow that can be discharged. Installations are required to have a storm water pollution prevention plan. Implement the applicable portions of this plan using best management practices. Segregate drainage from areas likely to be contaminated (e.g., fueling area). Provide treatment for contaminated water prior to its discharge. Maintenance should not be performed outside the primary facility.

3.2.11 Parking and Other Access Drives. Provide adequate parking based on the TDA and visitors. Integration of tactical vehicles for daily parking to access simulation systems evokes proximity needs for existing tactical vehicle maintenance facilities. Locate parking areas so they do not dominate the main entrance and public image of the facility. Comply with UFC 4-010-01 DOD Minimum Antiterrorist Standards for Buildings.

3.3 ARCHITECTURE

3.3.1 Architectural Theme. Utilize the architectural style, materials and colors indigenous to the region. Consider historical and cultural influences of the installation and region.

3.3.2 Architectural Planning. The architectural plan will accommodate the functional and spatial relationships required for a functionally efficient TSC. Building layouts will recognize the contrasting operational, administrative and shipping functional requirements and the facility will be designed for the appropriate accomplishment of each function.

3.3.3 Circulation Design Considerations. The interior functional arrangement will allow for ease of circulation and movement and will consider the safety, health and operational efficiency of the occupants. Exterior circulation at the facility will also meet antiterrorism and security requirements and will be designed to provide safe and efficient vehicular movement.

3.3.4 Accessibility. The Uniform Federal Accessibility Standards (UFAS) established by public law requires any DoD building, except those specifically occupied only by able-bodied personnel, be accessible to the disabled. Therefore the TSC interior design as well as the exterior site circulation considerations will meet the standards of the Architectural Barriers Act (ABA) and the UFAS standards.

3.3.5 Sustainable Design. Sustainable design must be considered and incorporated early in the design process and should be carried throughout the design package in accordance with the principles of Sustainable Design and Development (SSD) practices. Specifications should require energy efficient products. Incorporating energy efficiency requirements into the specification for building envelopes, mechanical and electrical equipment, and installed special purpose equipment can result in substantial long term reductions in energy consumption and operating costs.

3.3.6 General Considerations. Design for the exteriors of buildings shall conform to the Fort Sam Houston Installation Design Guide requirements for Visual Zone 5 and any State Historic Preservation Office (SHPO) guidelines.

3.3.7 Building Exterior. Select exterior materials to be attractive, economical, and durable and low maintenance. Pre-engineered metal building systems are preferred for their factory finished metal siding and roof panels. Masonry walls are preferred at the ground floor level.

3.3.7.1 The TSC shall present a cohesive architectural image. Comply with Command and Installation architectural standards. Also, consider the local geographical and cultural environment. Use durable and low-maintenance exterior finishes.

3.3.7.2 Ensure that the main entrance is clearly identifiable to discourage visitors from entering the facility Warehouse and Storage area. In cold climates, provide a canopy (or a recess) at required egress doors to ensure that doors can completely open without obstruction from snow and ice. Comply with NFPA 80 Standard.

3.3.8 Building Interior.

3.3.8.1 Construction and finishes (walls, floor, and ceiling) shall support the cohesive image and theme of the facility.

3.3.8.2 Durability is extremely important when specifying materials for interior construction and finishes. Heavy equipment is regularly handled throughout the facility. These conditions will lead to greater interior damage being incurred compared too many other facility types.

i. Casework: Provide counters, casework, and cabinets of high-quality and durable construction with Premium or Custom finishes per AWI Quality Standards, 8th Edition. Casework, cabinet doors, and

drawer faces shall be veneer panel core. At a minimum use plastic laminate doors, drawers, and casework faces. Where no water source is present, countertops shall be plastic laminate as a minimum. Where a water source is present, countertops shall be solid surface/solid composite plastics only.

ii. Interior Finishes: Finishes must take into account the intended uses, be highly durable, and meet the requirements listed in NFPA 101 Life Safety Code.

3.3.9 Floors. Provide highly durable and easily maintained flooring in the warehousing area, fabrication area, device maintenance/repair area, mechanical, electrical and storage areas. As a minimum please provide resilient flooring in other areas.

3.3.10 Natural Lighting. Preference will be given for designs providing clerestory lighting over the warehouse roll-up doors, and with vision panels in overhead doors. Provide operable windows for natural lighting and ventilation in administration and shop control, training room, break/training/conference room.

3.3.11 Warehouse Doors. Provide overhead doors in the exterior wall at each end of each structural bay. Provide 10 foot by 10 foot overhead doors for Consolidated Bench repair shop. Provide doors of coiling, sectional, or telescoping design. Provide electrically operated doors with provision for manual chain operation.

i. Locking. Provide overhead doors that are operable from the interior only. Provide doors will be with a positive locking mechanism that will allow the door to remain open at engine exhaust position approximately 1 ft above the floor. Coordinate door locking requirements with the using service.

ii. Serviceability. Doors shall be designed to meet heavy duty loads and high frequency of operation. Provide testing of deflection and operation of the doors prior to acceptance during construction. Doors shall be provided and installed by a commercial door company having not less than five years of experience in manufacturing, installing, and servicing the size and type of doors provided.

iii. Insulated Doors. Preference will be given to proposals that include insulated doors for thermal resistance and noise control.

3.3.12 Personnel Doors. Provide exterior personnel doors in the ends of central corridor maintenance areas and in the circulation bays as shown in the functional area adjacency diagram attached. Provide steel doors with vision panels, except at storage, janitorial, and latrine areas. Minimum size for personnel doors is 3 feet wide by 7 feet high.

3.3.13 Special Acoustical Requirements

Typical STC ratings range from 35 to 125 STC depending on the space and its intended use. During design, special consideration should be given by the design team to achieving the minimum required STC values by treating wall surfaces, wall openings, and the structure with sound attenuating materials.

3.3.14 Finishes

3.3.14.1 Paint

i. All paints used shall be listed on the "Approved product list" of the Master Painters Institute, (MPI). Application criteria shall be as recommended by Master Painters Institute (MPI) guide specifications for the substrate to be painted and the environmental conditions existing at the project site.

ii. Exterior surfaces, except factory pre-finished material or exterior surfaces receiving other finishes shall be painted a minimum of one prime coat and two finish coats. Paints having a lead content over 0.06 percent by weight of nonvolatile content are unacceptable. Paints containing zinc-chromate, strontium-chromate, mercury or mercury compounds, confirmed or suspected human carcinogens shall not be used on this project. Exterior paints and coating products shall be classified as containing low volatile organic compounds (VOCs) in accordance with MPI criteria. Application criteria shall be as recommended by MPI guide specifications. Provide an MPI Gloss Level 5 Finish (Semi-gloss), unless otherwise specified.

iii. Interior surfaces, except factory pre-finished material or interior surfaces receiving other finishes shall be painted a minimum of one prime coat and two finish coats. Paints having a lead content over 0.06 percent by weight of nonvolatile content are unacceptable. Paints containing zinc-chromate, strontium-chromate, mercury or mercury compounds, confirmed or suspected human carcinogens shall not be used on this project. Interior paints and coating products shall contain a maximum level of 150 g/l (grams per liter) of volatile organic compounds (VOCs) for non-flat coatings and 50 g/l of VOCs for flat coatings. Provide an MPI Gloss Level 5 Finish (Semi-gloss) in wet areas and a flat finish in all other areas.

3.3.14.2 Minimum Interior Finishes

i. Designers are not limited to finishes listed in the following table MINIMUM INTERIOR FINISHES and are encouraged to offer higher quality finishes.

ii. Wall, ceiling and floor finishes and movable partitions shall conform to the requirements of the IBC, NFPA and UFC 3-600-01. Where code requirements conflict, the most stringent code requirement shall apply.

iii. Carpet shall not be used as a floor finish on this project. Resilient and ceramic flooring are preferred. If selected, vinyl composition tile (VCT) shall be a minimum 1/8 inch thick, conforming to ASTM F 1066, Class 2, through-pattern tile, Composition 1, asbestos free, with color and pattern uniformly distributed throughout the thickness of the tile.

iv. Walls: All wall finish shall be painted gypsum board, except where stated otherwise. Use impact resistant gypsum board in corridors and the centralized laundry, if provided.

v. All ceiling finishes shall be painted gypsum board, except where stated otherwise.

3.4 STRUCTURAL REQUIREMENTS

Design and construct as a complete system in accordance with APPLICABLE CRITERIA.

3.5 MECHANICAL REQUIREMENTS

3.5.1 Fire Protection. Provide facilities with automatic sprinklers that provide 100 percent coverage of the facility. Take care to avoid freezing sprinkler pipes located in attic spaces. Portions of the sprinkler system subject to freezing may be pre-action sprinkler systems.

3.5.2 Plumbing. Provide facilities with a fully functional plumbing system that complies with the International Plumbing Code (IPC).

3.5.3 Drains: Provide floor trench drains parallel to the centerline of each vehicle. All vehicle bay drains should connect to an approved oil/water separator prior to discharge.

3.5.4 Compressed Air: Provide compressed air on self-retracting lines at each vehicle bay and Self-Contained Breathing Apparatus (SCBA) Maintenance Room.

3.5.5 Heating, Ventilating and Air-Conditioning (HVAC)

Provide facilities with a HVAC system that is automatically controlled by a Building Automation System (BAS). HVAC is not prohibited in the Warehouse and Storage areas.

3.6 ELECTRICAL REQUIREMENTS

Electrical power, lighting and telecommunications shall be provided to the facility as specified below, in accordance with APPLICABLE CRITERIA and where itemized, in the combined interdisciplinary areas cited in paragraphs above.

3.6.1 Emergency Power. Not applicable.

3.6.2 Mass Notification. The Mass Notification System(MNS) should be provided and be combined with the Fire Alarm System to prevent duplication of devices and maintenance and should interface with the installation MNS to provide emergency notifications of an area, regional or national nature.

3.6.3 Coordinate any closed-circuit television (CCTV)/camera systems with the appropriate Installation security office.

3.7 TELECOMMUNICATIONS REQUIREMENTS

Telecommunications provide access to post voice and data systems. Interior telecommunications provided voice and data services, wireless (as needed) and primary facility intercom system connectivity.

3.7.1 Service Coordinate service with local DOIM personnel.

3.7.2 System Provide a fully operational system from the demarcation point to each outlet.

3.8 CABLE TV (CATV) REQUIREMENTS

CATV is not required for this project. See Paragraph 6.4.6.6 in Section 01 10 00.

3.9 FIRE ALARM REQUIREMENTS

There shall be one complete addressable Fire Alarm System for each building. Combine system with MNS and consider incorporating PA system to reduce device and maintenance costs. This system shall consist of a control panel, a communications device, initiating devices, notification devices and associated wiring and pathways. Class A addressable systems shall be installed.

3.10 PHYSICAL SECURITY REQUIREMENTS

3.10.1 Electronic Security Equipment. Intrusion detection devices are required for the arms rooms and for other special space (SIPRNET) where intrusion detection is required to maintain secure conditions. Intrusion detection devices and other security equipment should be connected to the police station central security monitor station. In addition to these devices, a closed circuit television system will be installed to monitor the secured parking areas as well as exterior entrances to the building and other sensitive areas.

3.10.2 Arms, Ammunition, and Explosive (AA&E) Rooms. The following are physical security requirements for AA&E. Comply with AR 190-11.

3.10.3 The Secret Internet Protocol Router Network (SIPRNET) Room. SIPRNET is the Defense Department's communication backbone, used for passing tactical and operational information at the secret classification level. If the SIPRNET connection is stored within a secure room the following physical security measures are required. Comply with AR 380-5.

3.10.4 Electronic Security System (ESS) Central Monitoring Station (CMS). The electronic security system CMS shall be located within a secure room. Electronic Entry Control, IDS and CCTV are required.

3.10.5 Secure Parking. Not applicable.

3.10.6 Security Lighting. The lighting will be sufficient to allow guards (or individuals responsible for maintaining surveillance) to see illegal acts such as forced entry, or the unauthorized removal of arms during hours of reduced visibility. Lighting will provide a minimum of 0.2 foot–candles (2lux) illumination measured on the horizontal plane at ground level. Interior and exterior lighting will be provided for all arms storage buildings, buildings in which arms storage rooms are located, and arms storage rooms.

4.0 APPLICABLE CRITERIA

Unless a specific document version or date is indicated, use criteria from the most current references as of the date of issue of the contract or task order, including any applicable addenda, unless otherwise stated in the task order. In the event of conflict between References and/or Applicable Military Criteria, apply the most stringent requirement, unless otherwise specifically noted in the contract or task order.

4.1. INDUSTRY CRITERIA

Applicable design and construction criteria references are listed in Table 1 below. This list is not intended to include all criteria that may apply or to restrict design and construction to only those references listed. See also Paragraph 3 for additional facility-specific applicable criteria.

Table 1: Industry Criteria

Air Conditioning and Refrigeration Institute (ARI)	
ARI 310/380	Packaged Terminal Air-Conditioners and Heat Pumps
ARI 440	Room Fan-Coil and Unit Ventilator
ANSI/ARI 430-99	Central Station Air Handling Units
ARI 445	Room Air-Induction Units
ARI 880	Air Terminals
Air Movement and Control Association (AMCA)	
AMCA 210	Laboratory Methods of Testing Fans for Rating
American Architectural Manufacturers Association (AAMA)	
AAMA 605	Voluntary Specification Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels
AAMA 607.1	Voluntary Guide Specifications and Inspection Methods for Clear Anodic Finishes for Architectural Aluminum
AAMA 1503	Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections
American Association of State Highway and Transportation Officials (AASHTO)	
	Roadside Design Guide [guardrails, roadside safety devices]
	Standard Specifications for Transportation Materials and Methods of Sampling and Testing [Road Construction Materials]

	Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals
	Guide for Design of Pavement Structures, Volumes 1 and 2 [pavement design guide]
	A Policy of Geometric Design of Highways and Streets
American Bearing Manufacturers Association (AFBMA)	
AFBMA Std. 9	Load Ratings and Fatigue Life for Ball Bearings
AFBMA Std. 11	Load Ratings and Fatigue Life for Roller Bearings
American Boiler Manufacturers Association (ABMA)	
ABMA ISEI	Industry Standards and Engineering Information
American Concrete Institute	
ACI 302.2R	Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials
ACI 318	Building Code Requirements for Structural Concrete
ACI SP-66	ACI Detailing Manual
ACI 530	Building Code Requirements for Masonry Structures
ADA Standards for Accessible Design	
See US Access Board	ADA and ABA Accessibility Guidelines for Buildings and Facilities, Chapters 3-10.
American Institute of Steel Construction (AISC)	
	Manual of Steel Construction – 13th Edition (or latest version)
American Iron and Steel Institute	
AISI S100	North American Specification for the Design of Cold-Formed Steel Structural Members
American National Standards Institute 11 (ANSI)	

ANSI Z21.10.1	Gas Water Heaters Vol. 1, Storage water Heaters with Input Ratings of 75,000 Btu per Hour or less
ANSI Z124.3	American National Standard for Plastic Lavatories
ANSI Z124.6	Plastic Sinks
ANSI Z21.45	Flexible Connectors of Other Than All-Metal Construction for Gas Appliances
ANSI/IEEE C2-2007	National Electrical Safety Code
ANSI/AF&PA NDS-2001	National Design Specification for Wood Construction
American Society of Civil Engineers (ASCE)	
ASCE 7	Minimum Design Loads for Buildings and Other Structures
ASCE 37	Design and Construction of Sanitary and Storm Sewers, Manuals and Reports on Engineering Practice [sanitary sewer and storm drain design criteria]
ASCE/SEI 31-03	Seismic Evaluation of Existing Buildings [Existing Building Alteration/Renovation]
ASCE/SEI 41-06	Seismic Rehabilitation of Existing Buildings [Existing Building Alteration/Renovation]
American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)	
ASHRAE 90.1	ANSI/ASHRAE/IESNA 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE Guideline 0	The Commissioning Process
ASHRAE Guideline 1.1	The HVAC Commissioning Process
ASHRAE Handbooks	Fundamentals, HVAC Applications, Systems and Equipment, Refrigeration (Applicable, except as otherwise specified)
ASHRAE Standard 15	Safety Standard for Refrigeration Systems
ASHRAE Standard 62.1	Ventilation for Acceptable Indoor Air Quality
ASHRAE Standard 55	Thermal Environmental Conditions for Human Occupancy (Design portion is applicable, except where precluded by other project requirements.)

American Society of Mechanical Engineers International (ASME)	
ASME BPVC SEC VII	Boiler and Pressure Vessel Code: Section VII Recommended Guidelines for the Care of Power Boilers
ASME A17.1	Safety Code for Elevators and Escalators
ASME B 31 (Series)	Piping Codes
American Water Works Association (AWWA)	
	Standards [standards for water line materials and construction]
American Welding Society	
	Welding Handbook
	Welding Codes and Specifications (as applicable to application, see International Building Code for example)
Architectural Woodwork Institute (AWI)	
Version 1.2	AWI Quality Standards 7th Edition
Associated Air Balance Council (AABC)	
AABC MN-1	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems
	AABC Associated Air Balance Council Testing and Balance Procedures
ASTM International	
ASTM C1060-90(1997)	Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
ASTM E 779 (2003)	Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
ASTM E1827-96(2002)	Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
Builders Hardware Manufacturers Association (BHMA)	
ANSI/BHMA	American National Standards for Builders Hardware

Building Industry Consulting Service International	
	Telecommunications Distribution Methods Manual (TDMM)
	Customer-Owned Outside Plant Design Manual (CO-OSP)
Code of Federal Regulations (CFR)	
49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards
10 CFR 430	Energy Conservation Program for Consumer Products
Consumer Electronics Association	
CEA 709.1B	Control Network Protocol Specification
CEA 709.3	Free-Topology Twisted-Pair Channel Specification
CEA 852	Tunneling Component Network Protocols Over Internet Protocol Channels
Electronic Industries Association (EIA)	
ANSI/EIA/TIA 568	Structured Cabling Series
ANSI/EIA/TIA 569	Commercial Building Standard for Telecommunications Pathways and Spaces (includes ADDENDA)
ANSI/TIA/EIA-606	Administrative Standard for the Telecommunications Infrastructure of Commercial Buildings
J-STD EIA/TIA 607	Commercial Building Grounding and Bonding Requirements for Telecommunications
Federal Highway Administration (FHWA)	
	Manual on Uniform Traffic Control Devices for Streets and Highways [signage and pavement markings for streets and highways]
FHWA-NHI-01-021	Hydraulic Engineering Circular No. 22, Second Edition, URBAN DRAINAGE DESIGN MANUAL
Illuminating Engineering Society of North America (IESNA)	
IESNA RP-1	Office Lighting

IESNA RP-8	Roadway Lighting
IESNA Lighting Handbook	Reference and Application
Institute of Electrical and Electronics Engineers Inc. (IEEE)	
	Standard for Use of the International System of Units (SI): the Modern Metric System
Standard 1100	Recommended Practice for Powering and Grounding Sensitive Electronic Equipment
International Code Council (ICC)	
IBC	International Building Code Note: All references in the International Building Code to the International Electrical Code shall be considered to be references to NFPA 70. All references in the International Building Code to the International Fuel Gas Code shall be considered to be references to NFPA 54 and NFPA 58. All references in the International Building Code to the International Fire Code and Chapter 9 shall be considered to be references to Unified Facilities Criteria (UFC) 3-600-01.
IMC	International Mechanical Code – Note: For all references to “HEATING AND COOLING LOAD CALCULATIONS”, follow ASHRAE 90.1 Note: For all references to “VENTILATION”, follow ASHRAE 62.1
IRC	International Residential Code
IPC	International Plumbing Code
IEC	Energy Conservation Code (IEC) –Applicable only to the extent specifically referenced herein. Refer to Paragraph 5, ENERGY CONSERVATION requirements.
IGC	International Gas Code - not applicable. Follow NFPA 54, National Fuel Gas Code and NFPA 58, Liquified Petroleum Gas Code.
International Organization for Standardization (ISO)	
ISO 6781:1983	Qualitative detection of thermal irregularities in building envelopes –

	infrared method
LonMark International (LonMark)	
LonMark Interoperability Guidelines	(available at www.lonmark.org), including: Application Layer Guidelines, Layer 1-6 Guidelines, and External Interface File (XIF) Reference Guide
LonMark Resource Files	(available at www.lonmark.org), including Standard Network Variable Type (SNVT) definitions
Metal Building Manufacturers Association (MBMA)	
	Metal Building Systems Manual
Midwest Insulation Contractors Association (MICA)	
	National Commercial and Industrial Insulation Standards Manual
National Association of Corrosion Engineers International (NACE)	
NACE RP0169	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
NACE RP0185	Extruded, Polyolefin Resin Coating Systems with Adhesives for Underground or Submerged Pipe
NACE RP0285	Corrosion Control of Underground Storage Tank Systems by Cathodic Protection
NACE RP0286	Electrical Isolation of Cathodically Protected Pipelines
National Electrical Manufacturers Association (NEMA)	
National Environmental Balancing Bureau (NEBB)	
	Procedural Standards Procedural Standards for Testing Adjusting Balancing of Environmental Systems
National Fire Protection Association (NFPA)	
NFPA 10	Standard for Portable Fire Extinguishers
NFPA 13	Installation of Sprinkler Systems
NFPA 13R	Residential Occupancies up to and Including Four Stories in Height Sprinkler Systems

NFPA 14	Standard for the Installation of Standpipes and Hose Systems
NFPA 20	Installation of Centrifugal Fire Pumps
NFPA 24 NFPA 25	Standard for the Installation of Private Fire Service Mains and Their Appurtenances [underground fire protection system design] Inspection, Testing And Maintenance Of Water-Based Fire Protection Systems
NFPA 30	Flammable and Combustible Liquids Code
NFPA 30A	Motor Fuel Dispensing Facilities and Repair Garages
NFPA 31	Installation of Oil Burning Equipment
NFPA 54	National Fuel Gas Code
NFPA 58	Liquefied Petroleum Gas Code
NFPA 70	National Electrical Code
NFPA 72	National Fire Alarm Code
NFPA 76	Fire Protection of Telecommunications Facilities
NFPA 80	Standard for Fire Doors and Fire Windows
NFPA 90a	Installation of Air Conditioning and Ventilating Systems
NFPA 96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
NFPA 101	Life Safety Code
NFPA 780	Standard for the Installation of Lightning Protection Systems
National Roofing Contractor's Association (NRCA)	
	Roofing and Waterproofing Manual
National Sanitation Foundation, International	
NSF/ANSI Std. 2, 3, 4, 5, 6, 7, 8, 12, 13, 18, 20, 21, 25, 29, 35, 36, 37, 51, 52, 59,	Food Equipment Standards

169	
ANSI/UL Std. 73, 197, 471, 621, 763	Food Equipment Standards
CSA Std. C22.2 No. 109, 120, 195	Food Equipment Standards
Occupational Safety and Health Administration (OSHA)	
Title 29, Part 1926	OSHA Construction Industry Standards, Title 29, Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction
Plumbing and Drainage Institute (PDI)	
PDI G 101	Testing and Rating Procedure for Grease Interceptors with Appendix of Sizing and Installation Data
PDI WH201	Water Hammer Arrestors
Precast Concrete Institute	
PCI Design Handbook	Precast and Prestressed Concrete
Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)	
SMACNA HVAC Duct Construction Standards	HVAC Duct Construction Standards - Metal and Flexible
SMACNA Architectural Manual	Architectural Sheet Metal Manual
SMACNA HVAC TAB	HVAC Systems - Testing, Adjusting and Balancing
State/Local Regulations	
	State Department of Transportation Standard Specifications for Highway and Bridge Construction
	Sedimentation and Erosion Control Design Requirements
	Environmental Control Requirements
	Storm Water Management Requirements
Steel Door Institute (SDI)	

ANSI A250.8/SDI 100	Standard Steel Doors and Frames
Steel Deck Institute	
	SDI Diaphragm Design Manual
Steel Joist Institute	
	Catalog of Standard Specifications and Load Tables for Steel Joists and Joist Girders
Underwriters Laboratories (UL)	
UL 96A	Installation Requirements for Lightning Protection Systems
UL 300	Standard for Safety for Fire Testing of Fire Extinguishing Systems for Protection of Restaurant Cooking Areas
UNITED STATES ACCESS BOARD: U.S. ARCHITECTURAL AND TRANSPORTATION BARRIERS COMPLIANCE BOARD	
ADA and ABA Accessibility Guidelines for Buildings and Facilities	ABA Accessibility Standard for DoD Facilities Derived from the ADA and ABA Accessibility Guidelines: Specifically includes: ABA Chapters 1 and 2 and Chapters 3 through 10. Use this reference in lieu of IBC Chapter 11. Excluded are: (a) Facilities, or portions of facilities, on a military installation that are designed and constructed for use exclusively by able-bodied military personnel (See Paragraph 3 for any reference to this exclusion). (b) Reserve and National Guard facilities, or portions of such facilities, owned by or under the control of the Department of Defense, that are designed and constructed for use exclusively by able-bodied military personnel. (See paragraph 3 for any reference to this exclusion).
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES	
	FDA National Food Code
U.S. GREEN BUILDING COUNCIL (USGBC)	
LEED-NC	Green Building Rating System for New Construction & Major Renovations
	Application Guide for Multiple Buildings and On-Campus Building Projects

4.2. MILITARY CRITERIA

The project shall conform to the following criteria. Certain design impacts and features due to these criteria are noted for the benefit of the offeror. However, all requirements of the referenced criteria will be applicable, whether noted or not, unless otherwise specified herein.

4.2.1. Energy Policy Act of 2005 (Public Law 109-58) (applies only to the extent specifically implemented in the contract, which may or may not directly cite or reference EPACT)

4.2.2. Executive Order 12770: Metric Usage In Federal Government

(a) Metric design and construction is required except when it increases construction cost. Offeror to determine most cost efficient system of measurement to be used for the project.

4.2.3. TB MED 530: Occupational and Environmental Health Food Sanitation

4.2.4. Unified Facilities Criteria (UFC) 3-410-01FA: Heating, Ventilating, and Air Conditioning - applicable only to the extent specified in paragraph 5, herein.

4.2.5. Deleted.

4.2.6. UFC 3-600-01 Design: Fire Protection Engineering for Facilities. Use the latest edition of the IBC in coordination with this UFC. Use Chapters 3, 6, 7, 33 and UFC 3-600-01. If any conflict occurs between these Chapters and UFC 3-600-01, the requirements of UFC 3-600-01 take precedence. Use UFC 3-600-01 in lieu of IBC Chapters 4, 8,9,10.

4.2.7. UFC 4-010-01 DoD Minimum Antiterrorism Standards for Buildings

4.2.8. UFC 4-023-03 Design of Buildings to Resist Progressive Collapse (Use most recent version, regardless of references thereto in other publications)

(a) Note the option to use tie force method or alternate path design for Occupancy Category II.

4.2.9. UFC 4-021-01 Design and O&M: Mass Notification Systems

4.2.10. Technical Criteria for Installation Information Infrastructure Architecture (I3A)

(a) Email: DetrickISECI3Aguide@conus.army.mil

4.2.11. U.S. Army Information Systems Engineering Command (USAISEC) TG for the Integration of SECRET Internet Protocol (IP) Router Network (SIPRNET). See Paragraph 3 for applicability to specific facility type. May not apply to every facility. This is mandatory criteria for those facilities with SIPRNET.

5.0 GENERAL TECHNICAL REQUIREMENTS

This paragraph contains technical requirements with general applicability to Army facilities. See also Paragraph 3 for facility type-specific operational, functional and technical requirements. Residential or similar grade finishes and materials are not acceptable for inclusion in these buildings, unless otherwise specifically allowed.

5.1. SITE PLANNING AND DESIGN

5.1.1. STANDARDS AND CODES: The site planning and design shall conform to APPLICABLE CRITERIA and to paragraph 6, PROJECT SPECIFIC REQUIREMENTS.

5.1.2. SITE PLANNING OBJECTIVES: Group buildings in configurations that create a sense of community and promote pedestrian use. See paragraph 3 for additional site planning requirements relating to building functions.

5.1.2.1. Provide enclosures and or visual screening devices for Outdoor Utility such as dumpsters, emergency generators, transformers, heating, ventilation, and air conditioning units from streetscape and courtyard views to limit visual impact. Enclosures shall be compatible with the building they serve and accessible by vehicle. The location of dumpsters can have a significant visual impact and should be addressed as part of an overall building design and incorporated in site planning.

5.1.2.2. Where included in the project, dumpster pads shall be concrete (minimum of 8 inches thick on 4 inch base course, unless site conditions dictate more conservative requirements) and directly accessible by way of a paved service drive or parking lot with adequate overhead clearance for collection vehicles. Provide space at dumpster areas for recycling receptacles. Coordinate with Installation on recycling receptacle types, sizes and access requirements and provide space at dumpster areas to accommodate them.

5.1.2.3. Vehicular Circulation. Apply design vehicle templates provided by the American Association of State Highway and Transportation Officials (AASHTO) to the site design. The passenger car class includes passenger cars and light trucks, such as vans and pick-ups. The passenger car template is equivalent to the non-organizational – privately owned vehicle (POV). The truck class template includes single-unit trucks, recreation vehicles, buses, truck tractor-semi-trailer combinations, and trucks or truck tractors with semi-trailers in combination with full trailers. Provide vehicle clearances required to meet traffic safety for emergency vehicles, service vehicles, and moving vans. Provide required traffic control signage Site entrances and site drive aisles shall maximize spacing between drives, incorporate right-angle turns, and limit points of conflict between traffic. Design Services Drives to restrict access to unauthorized vehicles by removable bollards, gates, or other barriers to meet Anti-Terrorism/Force Protection (ATFP) requirements. Orient service drives to building entrances other than the primary pedestrian entry at the front of the building.

5.1.2.4. Provide Emergency Vehicle Access around the facility and shall be in accordance with AT/FP requirements. Maintain a 33-foot clear zone buffer for emergency vehicles, designed to prevent other vehicles from entering the AT/FP standoff to the building.

5.1.2.5. Clear and grub all trees and vegetation necessary for construction; but, save as many trees as possible. Protect trees to be saved during the construction process from equipment.

5.1.2.6. Stormwater Management. Employ design and construction strategies (Best Management Practices) that reduce stormwater runoff, reduce discharges of polluted water offsite and maintain or restore predevelopment hydrology with respect to temperature, rate, volume and duration of flow to the maximum extent practicable. See paragraph 6, PROJECT SPECIFIC requirements for additional information.

5.1.3. EXTERIOR SIGNAGE: Provide exterior signage in accordance with Appendix H, Exterior Signage. Provide exterior NO SMOKING signage that conveys building and grounds smoking policy.

5.1.4. EXISTING UTILITIES: Base utilities maps and capacities for this site are included as part of this RFP. See paragraph 6 for more detailed information.

5.2. SITE ENGINEERING

5.2.1. STANDARDS AND CODES: The site engineering shall conform to APPLICABLE CRITERIA.

5.2.2. SOILS:

5.2.2.1. A report has been prepared to characterize the subsurface conditions at the project site and is **appended to these specifications.** The report provides a general overview of the soil and geologic conditions with detailed descriptions at discrete boring locations. The Contractor's team shall include a licensed geotechnical engineer to interpret the report and develop earthwork and foundation recommendations and design parameters in which to base the contractor's design. If any additional subsurface investigation or laboratory analysis is required to better characterize the site or develop the final design, the Contractor shall perform it under the direction of a licensed geotechnical engineer. There will be no separate payment for the cost of additional tests. If differences between the Contractor's additional subsurface investigation and the government provided soils report or the reasonably expected conditions require material revisions in the design, an equitable adjustment may be made, in accordance with the provisions of the Differing Site Conditions clause. The basis for the adjustment would be the design and construction appropriate for the conditions described in the Government furnished report or the reasonably expected conditions, in comparison with any changes required by material differences in the actual conditions encountered, in accordance with the terms of contract clause Differing Site Conditions.

5.2.2.2. The contractor's licensed geotechnical engineer shall prepare a final geotechnical evaluation report, to be submitted along with the first foundation design submittal, as described in Section 01 33 16, *Design After Award*.

5.2.3. VEHICLE PAVEMENTS: (as applicable to the project)

5.2.3.1. Design procedures and materials shall conform to one of the following: 1) the USACE Pavement Transportation Computer Assisted Structural Engineering (PCASE) program, 2) American Association of State Highway and Transportation Officials (AASHTO) or, 3) the applicable state Department of Transportation standards in which the project is located. See paragraph 5.2.2.2 and Section 01 33 16 for required information for the Contractor's geotechnical evaluation report. The minimum flexible pavement section shall consist of 2 inches of asphalt and 6 inches of base or as required by the pavement design, whichever is greater, unless specifically identified by the Government to be a gravel road. Design roads and parking areas for a life expectance of 25 years with normal maintenance. Parking area for tactical vehicles (as applicable to the project) shall be Portland Cement Concrete (PCC) rigid pavement design. For concrete pavements, submit joint layout plan for review and concurrence. Design pavements for military tracked vehicles (as applicable to the project) IAW USACE PCASE. Traffic estimates for each roadway area will be as shown on the drawings or listed in Section 01 10 00 Paragraph 6.4.4. Pavement markings and traffic signage shall comply with the Installation requirements and with the Manual on Uniform Traffic Control Devices.

5.2.3.2. Parking Requirements.

(a) All handicap POV parking lots (where applicable in the facility specific requirements) shall meet the ADA and ABA Accessibility Guidelines for accessible parking spaces.

(b) Design POV parking spaces for the type of vehicles anticipated, but shall be a minimum of 9 ft by 18 ft for POVs, except for two wheel vehicles.

5.2.3.3. Sidewalks. Design the network of walks throughout the complex (where applicable) to facilitate pedestrian traffic among facilities, and minimize the need to use vehicles. Incorporate sidewalks to enhance the appearance of the site development, while creating a sense of entry at the primary patron entrances to the buildings. Minimum sidewalk requirements are in Paragraph 3, where applicable and/or paragraph 6 and/or site plans, where applicable..

5.2.4. CATHODIC PROTECTION: Provide cathodic protection systems for all underground metallic systems and metallic fittings/portions of non-metallic, underground systems, both inside and outside the building 5 foot line that are subject to corrosion. Coordinate final solutions with the installation to insure an approach that is consistent with installation cathodic protection programs.

5.2.5. UTILITIES: See paragraph 6.4.6 for specific information on ownership of utilities and utility requirements. Meter all utilities (gas, water, and electric, as applicable) to each facility. For Government owned utilities, install meters that are wireless data transmission capable as well as have a continuous manual reading option. All meters will be capable of at least hourly data logging and transmission and provide consumption data for gas, water, and

electricity. Gas and electric meters will also provide demand readings based on consumption over a maximum of any 15 minute period. Configure all meters to transmit at least daily even if no receiver for the data is currently available at the time of project acceptance. For privatized utilities, coordinate with the privatization utility(ies) for the proper meter base and meter installation.

5.2.6. PERMITS: The CONTRACTOR shall be responsible for obtaining all permits (local, state and federal) required for design and construction of all site features and utilities.

5.2.7. IRRIGATION. Landscape irrigation systems, if provided, shall comply with the following:

5.2.7.1. Irrigation Potable Water Use Reduction. Reduce irrigation potable water use by 100 percent using LEED credit WE1.1 baseline (no potable water used for irrigation), except where precluded by other project requirements.

5.2.8. EPA WaterSense Products and Contractors. Except where precluded by other project requirements, use EPA WaterSense labeled products and irrigation contractors that are certified through a WaterSense labeled program where available.

5.3. ARCHITECTURE AND INTERIOR DESIGN:

This element will be evaluated per APPLICABLE CRITERIA under the quality focus.

5.3.1. STANDARDS AND CODES: The architecture and interior design shall conform to APPLICABLE CRITERIA.

5.3.2. GENERAL: Overall architectural goal is to provide a functional, quality, visually appealing facility that is a source of pride for the installation and delivered within the available budget and schedule.

5.3.3. COMPUTATION OF AREAS: See APPENDIX Q for how to compute gross and net areas of the facility(ies).

5.3.4. BUILDING EXTERIOR: Design buildings to enhance or compliment the visual environment of the Installation. Where appropriate, reflect a human scale to the facility. Building entrance should be architecturally defined and easily seen. When practical, exterior materials, roof forms, and detailing shall be compatible with the surrounding development and adjacent buildings on the Installation and follow locally established architectural themes. Use durable materials that are easy to maintain. Exterior colors shall conform to the Installation requirements. See paragraph 6.

5.3.4.1. Building Numbers: Permanently attach exterior signage on two faces of each building indicating the assigned building number or address. Building number signage details and locations shall conform to Appendix H, Exterior Signage.

5.3.5. BUILDING INTERIOR

5.3.5.1. Space Configuration: Arrange spaces in an efficient and functional manner in accordance with area adjacency matrices.

5.3.5.2. Surfaces: Appearance retention is the top priority for building and furniture related finishes. Provide low maintenance, easily cleaned room finishes that are commercially standard for the facility occupancy specified, unless noted otherwise.

5.3.5.3. Color: The color, texture and pattern selections for the finishes of the building shall provide an aesthetically pleasing, comfortable, easily maintainable and functional environment for the occupants. Coordinate the building colors and finishes for a cohesive design. Select colors appropriate for the building type. Use color, texture and pattern to path or way find through the building. Trendy colors that will become dated shall be limited to non-permanent finishes such as carpet and paint. Select finisheswith regards to aesthetics, maintenance, durability, life safety and image. Limit the number of similar colors for each material. Use medium range colors for ceramic and porcelain tile groutto help hide soiling. Plastic laminate and solid surface materials shall have patterns that are mottled, flecked or speckled. Coordinate finish colors of fire extinguisher cabinets, receptacle bodies and plates, fire alarms / warning lights, emergency lighting, and other miscellaneous items with the building interior. Match color of equipment items on ceilings (speakers, smoke detectors, grills, etc.) the ceiling color.

5.3.5.4. Circulation: Circulation schemes must support easy way finding within the building.

5.3.5.5. Signage: Provide interior signage for overall way finding and life safety requirements. A comprehensive interior plan shall be from one manufacturer. Include the following sign types: (1) Lobby Directory, (2) Directional Signs; (3) Room Identification Signs; (4) Building Service Signs; (5) Regulatory Signs; (6) Official and Unofficial Signs (7) Visual Communication Boards (8) NO SMOKING signage that conveys building smoking policy. Use of emblems or logos may also be incorporated into the signage plan.

5.3.5.6. Window Treatment: Provide interior window treatments with adjustable control in all exterior window locations for control of day light coming in windows or privacy at night. Maintain uniformity of treatment color and material to the maximum extent possible within a building.

5.3.6. COMPREHENSIVE INTERIOR DESIGN

5.3.6.1. Comprehensive Interior Design includes the integration of a Structural Interior Design (SID) and a Furniture, Fixtures and Equipment (FF&E) design and package. SID requires the design, selection and coordination of interior finish materials that are integral to or attached to the building structure. Completion of a SID involves the selection and specification of applied finishes for the building's interior features including, but not limited to, walls, floors, ceilings, trims, doors, windows, window treatments, built-in furnishings and installed equipment, lighting, and signage. The SID package includes finish schedules, finish samples and any supporting interior elevations, details or plans necessary to communicate the building finish design and build out. The SID also provides basic space planning for the anticipated FF&E requirements in conjunction with the functional layout of the building and design issues such as life safety, privacy, acoustics, lighting, ventilation, and accessibility. See Section 01 33 16 for SID design procedures.

5.3.6.2. The FF&E design and package includes the design, selection, color coordination and of the required furnishing items necessary to meet the functional, operational, sustainability, and aesthetic needs of the facility coordinated with the interior finish materials in the SID. The FF&E package includes the specification, procurement documentation, placement plans, ordering and finish information on all freestanding furnishings and accessories, and a cost estimate. Coordinate the selection of furniture style, function and configuration with the defined requirements. Examples of FF&E items include, but are not limited to workstations, seating, files, tables, beds, wardrobes, draperies and accessories as well as marker boards, tack boards, and presentation screens. Criteria for furniture selection include function and ergonomics, maintenance, durability, sustainability, comfort and cost. See Section 01 33 16 for FFE design procedures.

5.4. STRUCTURAL DESIGN

5.4.1. STANDARDS AND CODES: The structural design shall conform to APPLICABLE CRITERIA.

5.4.2. GENERAL: The structural system must be compatible with the intended functions and components that allows for future flexibility and reconfigurations of the interior space. Do not locate columns, for instance, in rooms requiring visibility, circulation or open space, including, but not limited to entries, hallways, common areas, classrooms, etc. Select an economical structural system based upon facility size, projected load requirements and local availability of materials and labor. Base the structural design on accurate, site specific geotechnical information and anticipated loads for the building types and geographical location. Consider climate conditions, high humidity, industrial atmosphere, saltwater exposure, or other adverse conditions when selecting the type of cement and admixtures used in concrete, the concrete cover on reinforcing steel, the coatings on structural members, expansion joints, the level of corrosion protection, and the structural systems. Analyze, design and detail each building as a complete structural system. Design structural elements to preclude damage to finishes, partitions and other frangible, non-structural elements to prevent impaired operability of moveable components; and to prevent cladding leakage and roof ponding. Limit deflections of structural members to the allowable of the applicable material standard, e.g., ACI, AISC, Brick Industry Association, etc. When modular units or other pre-fabricated construction is used or combined with stick-built construction, fully coordinate and integrate the overall structural design between the two different or interfacing construction types. If the state that the project is located in requires separate, specific licensing for structural engineers (for instance, such as in Florida, California and others), then the structural engineer designer of record must be registered in that state.

5.4.3. LOADS: See paragraph 3 for facility specific (if applicable) and paragraph 6 for site and project specific structural loading criteria. Unless otherwise specified in paragraph 6, use Exposure Category C for wind. If not

specified, use Category C unless the Designer of Record can satisfactorily justify another Exposure Category in its design analysis based on the facility Master Plan. Submit such exceptions for approval as early as possible and prior to the Interim Design Submittal in Section “Design After Award”. Design the ancillary building items, e.g. doors, window jambs and connections, overhead architectural features, systems and equipment bracing, ducting, piping, etc. for gravity, seismic, lateral loads and for the requirements of UFC 4-010-01, DOD Minimum Antiterrorism Standards for Buildings. Ensure and document that the design of glazed items includes, but is not limited to, the following items under the design loads prescribed in UFC 4-010-01:

(a) Supporting members of glazed elements, e.g. window jamb, sill, header

(b) Connections of glazed element to supporting members, e.g. window to header

(c) Connections of supporting members to each other, e.g. header to jamb

(d) Connections of supporting members to structural system, e.g. jamb to foundation.

5.4.4. TERMITE TREATMENT: (Except Alaska) Provide termite prevention treatment in accordance with Installation and local building code requirements, using licensed chemicals and licensed applicator firm.

5.5. THERMAL PERFORMANCE

5.5.1. STANDARDS AND CODES: Building construction and thermal insulation for mechanical systems shall conform to APPLICABLE CRITERIA.

5.5.2. BUILDING ENVELOPE SEALING PERFORMANCE REQUIREMENT. Design and construct the building envelope for office buildings, office portions of mixed office and open space (e.g., company operations facilities), dining, barracks and instructional/training facilities with a continuous air barrier to control air leakage into, or out of, the conditioned space. Clearly identify all air barrier components of each envelope assembly on construction documents and detail the joints, interconnections and penetrations of the air barrier components. Clearly identify the boundary limits of the building air barriers, and of the zone or zones to be tested for building air tightness on the drawings. Pending the publication of the 2010 version of ASHRAE 90.1, the use of painted interior walls is not an acceptable air barrier method.

5.5.2.1. Trace a continuous plane of air-tightness throughout the building envelope and make flexible and seal all moving joints.

5.5.2.2. The air barrier material(s) must have an air permeance not to exceed 0.004 cfm / sf at 0.3” wg (0.02 L/s.m2 @ 75 Pa) when tested in accordance with ASTM E 2178

5.5.2.3. Join and seal the air barrier material of each assembly in a flexible manner to the air barrier material of adjacent assemblies, allowing for the relative movement of these assemblies and components.

5.5.2.4. Support the air barrier so as to withstand the maximum positive and negative air pressure to be placed on the building without displacement, or damage, and transfer the load to the structure.

5.5.2.5. Seal all penetrations of the air barrier. If any unavoidable penetrations of the air barrier by electrical boxes, plumbing fixture boxes, and other assemblies are not airtight, make them airtight by sealing the assembly and the interface between the assembly and the air barrier or by extending the air barrier over the assembly.

5.5.2.6. The air barrier must be durable to last the anticipated service life of the assembly.

5.5.2.7. Do not install lighting fixtures with ventilation holes through the air barrier

5.5.2.8. Provide a motorized damper in the closed position and connected to the fire alarm system to open on call and fail in the open position for any fixed open louvers such as at elevator shafts.

5.5.2.9. Damper and control to close all ventilation or make-up air intakes and exhausts, atrium smoke exhausts and intakes, etc when leakage can occur during inactive periods.

5.5.2.10. Compartmentalize garages under buildings by providing air-tight vestibules at building access points.

5.5.2.11. Compartmentalize spaces under negative pressure such as boiler rooms and provide make-up air for combustion.

5.5.2.12. Performance Criteria and Substantiation: Submit the qualifications and experience of the testing entity for approval. Demonstrate performance of the continuous air barrier for the opaque building envelope by the following tests:

(a) Test the completed building and demonstrate that the air leakage rate of the building envelope does not exceed 0.25cfm/ft2 at a pressure differential of 0.3" w.g.(75 Pa) in accordance with ASTM's E 779 (2003) or E-1827-96 (2002). Accomplish tests using either pressurization or depressurization or both. Divide the volume of air leakage in cfm @ 0.3" w.g. (L/s @ 75 Pa) by the area of the pressure boundary of the building, including roof or ceiling, walls and floor to produce the air leakage rate in cfm/ft2 @ 0.3" w.g. (L/s.m2 @ 75 Pa). Do not test the building until verifying that the continuous air barrier is in place and installed without failures in accordance with installation instructions so that repairs to the continuous air barrier, if needed to comply with the required air leakage rate, can be done in a timely manner.

(b) Test the completed building using Infrared Thermography testing. Use infrared cameras with a resolution of 0.1deg C or better. Perform testing on the building envelope in accordance with ISO 6781:1983 and ASTM C1060-90(1997). Determine air leakage pathways using ASTM E 1186-03 Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems, and perform corrective work as necessary to achieve the whole building air leakage rate specified in (a) above.

(c) Notify the Government at least three working days prior to the tests to provide the Government the opportunity to witness the tests. Provide the Government written test results confirming the results of all tests.

5.6. PLUMBING

5.6.1. STANDARDS AND CODES: The plumbing system shall conform to APPLICABLE CRITERIA.

5.6.2. PRECAUTIONS FOR EXPANSIVE SOILS: Where expansive soils are present, include design features for underslab piping systems and underground piping serving chillers, cooling towers, etc, to control forces resulting from soil heave. Some possible solutions include, but are not necessarily limited to, features such as flexible expansion joints, slip joints, horizontal offsets with ball joints, or multiple bell and spigot gasketed fittings. For structurally supported slabs, suspend piping from the structure with adequate space provided below the pipe for the anticipated soil movement.

5.6.3. HOT WATER SYSTEMS: For Hot Water heating and supply, provide a minimum temp of 140 Deg F in the storage tank and a maximum of 110 Deg F at the fixture, unless specific appliances or equipment specifically require higher temperature water supply.

5.6.4. SIZING HOT WATER SYSTEMS: Unless otherwise specified or directed in paragraph 3, design in accordance with ASHRAE Handbook Series (appropriate Chapters), ASHRAE Standard 90.1, and the energy conservation requirements of the contract. Size and place equipment so that it is easily accessible and removable for repair or replacement.

5.6.5. JANITOR CLOSETS: In janitor spaces/room/closets, provide at minimum, a service sink with heavy duty shelf and wall hung mop and broom rack(s).

5.6.6. FLOOR DRAINS: As a minimum, provide floor drains in mechanical rooms and areas, janitor spaces/rooms/closets and any other area that requires drainage from fixtures or equipment, drain downs, condensate, as necessary.

5.6.7. URINALS: Urinals shall be vitreous china, wall-mounted, wall outlet, non-water using, with integral drain line connection, and with sealed replaceable cartridge or integral liquid seal trap. Either type shall use a biodegradable liquid to provide the seal and maintain a sanitary and odor-free environment. Install, test and maintain in accordance with manufacturer's recommendations. Slope the sanitary sewer branch line for non-water use urinals a minimum of 1/4 inch per foot. Do not use copper tube or pipe for drain lines that connect to the urinal. Manufacturer shall provide an operating manual and on-site training to installation operations personnel for the proper care and maintenance of the urinal. For complexes, non-water using urinals are not required for barracks type spaces.

5.6.8. BUILDING WATER USE REDUCTION. Reduce building potable water use in each building 30 percent using IPC fixture performance requirements baseline.

5.6.9. Do not use engineered vent or Sovent® type drainage systems.

5.6.10. Where the seasonal design temperature of the cold water entering a building is below the seasonal design dew point of the indoor ambient air, and where condensate drip will cause damage or create a hazard, insulate plumbing piping with a vapor barrier type of insulation to prevent condensation. Do not locate water or drainage piping over electrical wiring or equipment unless adequate protection against water (including condensation) damage is provided. Insulation alone is not adequate protection against condensation. Follow ASHRAE Fundamentals Chapter 23, Insulation for Mechanical Systems, IMC paragraph 1107 and International Energy Conservation Code for pipe insulation requirements.

5.7. ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

5.7.1. STANDARDS AND CODES: The electrical systems for all facilities shall conform to APPLICABLE CRITERIA.

5.7.2. MATERIALS AND EQUIPMENT: Materials, equipment and devices shall, as a minimum, meet the requirements of Underwriters Laboratories (UL) where UL standards are established for those items. Wiring for branch circuits shall be copper. Motors larger than one-half horsepower shall be three phase. All electrical systems shall be pre-wired and fully operational unless otherwise indicated. Wall mounted electrical devices (power receptacles, communication outlets and CATV outlets) shall have matching colors, mounting heights and faceplates.

5.7.3. POWER SERVICE: Primary service from the base electrical distribution system to the pad-mounted transformer and secondary service from the transformer to the building service electrical equipment room shall be underground. See paragraph 6 for additional site electrical requirements.

5.7.3.1. Spare Capacity: Provide 10% space for future circuit breakers in all panelboards serving residential areas of buildings and 15% spaces in all other panelboards.

5.7.4. TELECOMMUNICATION SERVICE: Connect the project's facilities to the Installation telecommunications (voice and data) system through the outside plant (OSP) telecommunications underground infrastructure cabling system per the I3A Criteria. Connect to the OSP cabling system from each facility main cross connect located in the telecommunications room.

5.7.5. LIGHTING: Comply with the recommendations of the Illumination Engineering Society of North America (IESNA), the National Energy Policy Act and Energy Star requirements for lighting products..

5.7.5.1. Interior Lighting:

(a) Reflective Surfaces: Coordinate interior architectural space surfaces and colors with the lighting systems to provide the most energy-efficient workable combinations.

(b) High Efficiency Fluorescent Lighting: Utilize NEMA premium electronic ballasts and energy efficient fluorescent lamps with a Correlated Color Temperature (CCT) of 4100K. Linear fluorescent and compact fluorescent fixtures shall have a Color Rendering Index of (CRI) of 87 or higher. Fluorescent lamps shall be the low mercury type qualifying as non-hazardous waste upon disposal. Do not use surface mounted fixtures on acoustical tile ceilings. Provide an un-switched fixture with emergency ballast shall be provided at each entrance to the building.

(c) Solid State Lighting: Fixtures shall provide lighting with a minimum Correlated Color Temperature (CCT) of 4100K and shall have a Color Rendering Index of (CRI) of 75 or higher. Verify performance of the light producing solid state components by a test report in compliance with the requirements of IESNA LM 80. Verify performance of the solid state light fixtures by a test report in compliance with the requirements of IESNA LM 79. Provide lab results by a NVLAP certified laboratory. The light producing solid state components and drivers shall have a life expectancy of 50,000 operating hours while maintaining at least 70% of original illumination level. Provide a complete five year warranty for fixtures.

(d) Metal Halide Lighting (where applicable): Metal Halide lamp fixtures in the range of 150-500 Watts shall be pulse start type and have a minimum efficiency rating of 88%.

(e) Lighting Controls: ANSI/ASHRAE/IESNA 90.1 has specific lighting controls requirements. Provide a high level of lighting system control by individual occupants or by specific groups in multi-occupant spaces (classrooms, conference rooms) to promote the productivity, comfort and well being of the building occupants. In office spaces, the preferred lighting should be a 30 FC ambient lighting level with occupancy sensor controlled task lighting in the work spaces to provide a composite lighting level of 50 FC on the working surfaces. Consider incorporating daylighting techniques for the benefit of reducing lighting energy requirements while improving the quality of the indoor spaces. If daylight strategies are used, additional coordination is required with the architect and mechanical engineer. Additionally, incorporate electric lighting controls to take advantage of the potential energy savings.

(f) Exterior Lighting: See paragraph 6.9 for site specific information, if any, on exterior lighting systems. Minimize light pollution and light trespass by not over lighting and use cut-off type exterior luminaries.

5.7.6. TELECOMMUNICATION SYSTEM: Building telecommunications cabling systems (BCS) and OSP telecommunications cabling system shall conform to APPLICABLE CRITERIA, including but not limited to I3A Technical Criteria. An acceptable BCS encompasses, but is not limited to, copper and fiber optic (FO) entrance cable, termination equipment, copper and fiber backbone cable, copper and fiber horizontal distribution cable, workstation outlets, racks, cable management, patch panels, cable tray, cable ladder, conduits, grounding, and labeling.. Items included under OSP infrastructure encompass, but are not limited to, manhole and duct infrastructure, copper cable, fiber optic cable, cross connects, terminations, cable vaults, and copper and FO entrance cable.

5.7.6.1. Design, install, label and test all telecommunications systems in accordance with the I3A Criteria and ANSI/TIA/EIA 568, 569, and 606 standards. A Building Industry Consulting Services International (BICSI) Registered Communications Distribution Designer (RCDD) with at least 2 yrs related experience shall develop and stamp telecommunications design, and prepare the test plan. See paragraph 5.8.2.5 for design of environmental systems for Telecommunications Rooms.

5.7.6.2. The installers assigned to the installation of the telecommunications system or any of its components shall be regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. Key personnel; i.e., supervisors and lead installers assigned to the installation of this system or any of its components shall be BICSI Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel. In lieu of BICSI certification, supervisors and installers shall have a minimum of 5 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

5.7.6.3. Perform a comprehensive end to end test of all circuits to include all copper and fiber optic cables upon completion of the BCS and prior to acceptance of the facility. Provide adequate advanced notification to the COR to allow COR and Installation personnel attendance The BCS circuits include but are not limited to all copper and fiber optic(FO) entrance cables, termination equipment, copper and fiber backbone cable, copper and fiber horizontal distribution cable, and workstation outlets. Test in accordance with ANSI/EIA/TIA 568 standards. Use test instrumentation that meets or exceeds the standard. Submit the official test report to include test procedures, parameters tested, values, discrepancies and corrective actions in electronic format. Test and accomplish all necessary corrective actions to ensure that the government receives a fully operational, standards based, code compliant telecommunications system.

5.7.7. LIGHTNING PROTECTION SYSTEM: Provide a lightning protection system where recommended by the Lightning Risk Assessment of NFPA 780, Annex L.

5.8. HEATING, VENTILATING, AND AIR CONDITIONING

5.8.1. STANDARDS AND CODES: The HVAC system shall conform to APPLICABLE CRITERIA.

5.8.2. DESIGN CONDITIONS.

5.8.2.1. Outdoor and indoor design conditions shall be in accordance with UFC 3-410-01FA. Outdoor air and exhaust ventilation requirements for indoor air quality shall be in accordance with ASHRAE 62.1. All Buildings with

minimum LEED Silver requirement (or better) will earn LEED Credit EQ 7.1, Thermal Comfort-Design., except where precluded by other project requirements. Where the contract specifies indoor design temperature , airflow, humidity conditions, etc., use those parameters.

5.8.2.2. High Humidity Areas: Design HVAC systems in geographical areas meeting the definition for high humidity in UFC 3-410-01FA to comply with the special criteria therein for humid areas.

5.8.2.3. Cooling equipment may be oversized by up to 15 percent to account for recovery from night setforward. Heating equipment may be oversized by up to 30 percent to account for recovery from night setback. Design single zone systems and multi-zone systems to maintain an indoor design condition of 50% relative humidity for cooling only. For heating only where the indoor relative humidity is expected to fall below 20% for extended periods, add humidification to increase the indoor relative humidity to 30%. Provide ventilation air from a separate dedicated air handling unit (DOAU) for facilities using multiple single zone fan-coil type HVAC systems. Do not condition outside air through fan coil units. Avoid the use of direct expansion cooling coils in air handling units with constant running fans that handle outside air.

5.8.2.4. Locate all equipment so that service, adjustment and replacement of controls or internal components are readily accessible for easy maintenance.

5.8.2.5. Environmental Requirements for Telecommunications Rooms,(including SIPRNET ROOMS, where applicable for specific facility type). Comply with ANSI/EIA/TIA 569 and the I3A.

5.8.2.6. Fire dampers: dynamic type with a dynamic rating suitable for the maximum air velocity and pressure differential to which the damper is subjected. Test each fire damper with the air handling and distribution system running.

5.8.3. BUILDING AUTOMATION SYSTEM. Provide a Building Automation System consisting of a building control network , and integrate the building control network into the UMCS as specified.

The building control network shall be a single complete non-proprietary Direct Digital Control (DDC) system for control of the heating, ventilating and air conditioning (HVAC) systems as specified herein. The building control network shall be an Open implementation of LONWORKS® technology using ANSI/EIA 709.1B as the only communications protocol and use only LonMark Standard Network Variable Types (SNVTs), as defined in the LonMark® Resource Files, for communication between DDC Hardware devices to allow multi-vendor interoperability.

5.8.3.1. The building automation system shall be open in that it is designed and installed such that the Government or its agents are able to perform repair, replacement, upgrades, and expansions of the system without further dependence on the original Contractor. This includes, but is not limited to the following:

(a) Install hardware such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

(b) Necessary documentation (including rights to documentation and data), configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the Government such that the Government or its agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor.

5.8.3.2. All DDC Hardware shall:

(a) Be connected to a TP/FT-10 ANSI/EIA 709.3 control network.

(b) Communicate over the control network via ANSI/EIA 709.1B exclusively.

(c) Communicate with other DDC hardware using only SNVTs

(d) Conform to the LonMark® Interoperability Guidelines.

(e) Be locally powered; link power (over the control network) is not acceptable.

(f) Be fully configurable via standard or user-defined configuration parameter types (SCPT or UCPT), standard network variable type (SNVT) network configuration inputs (*nci*), or hardware settings on the controller itself to support the application. All settings and parameters used by the application shall be configurable via standard or

user-defined configuration parameter types (SCPT or UCPT), standard network variable type (SNVT) network configuration inputs (*nci*), or hardware settings on the controller itself

(g) Provide input and output SNVTs required to support monitoring and control (including but not limited to scheduling, alarming, trending and overrides) of the application. Required SNVTs include but are not limited to: SNVT outputs for all hardware I/O, SNVT outputs for all setpoints and SNVT inputs for override of setpoints.

(h) To the greatest extent practical, not rely on the control network to perform the application..

5.8.3.3. Controllers shall be Application Specific Controllers whenever an ASC suitable for the application exists. When an ASC suitable for the application does not exist use programmable controllers or multiple application specific controllers.

5.8.3.4. Application Specific Controllers shall be LonMark Certified whenever a LonMark Certified ASC suitable for the application exists. For example, VAV controllers must be LonMark certified.

5.8.3.5. Application Specific Controllers (ASCs) shall be configurable via an LNS plug-in whenever t an ASC with an LNS plug-in suitable for the application exists.

5.8.3.6. Each scheduled system shall accept a network variable of type SNVT_occupancy and shall use this network variable to determine the occupancy mode. If the system has not received a value to this network variable for more than 60 minutes it shall default to a configured occupancy schedule.

5.8.3.7. Gateways may be used provided that each gateway communicates with and performs protocol translation for control hardware controlling one and only one package unit.

5.8.3.8. Not Used

5.8.3.9. Perform all necessary actions needed to fully integrate the building control system. These actions include but are not limited to:

- Configure M&C Software functionality including: graphical pages for System Graphic Displays including overrides, alarm handling, scheduling, trends for critical values needing long-term or permanent monitoring via trends, and demand limiting.
- Install IP routers or ANSI/CEA-852 routers as needed to connect the building control network to the UMCS IP network. Routers shall be capable of configuration via DHCP and use of an ANSI/CEA-852 configuration server but shall not rely on these services for configuration. All communication between the UMCS and building networks shall be via the ANSI/CEA-709.1B protocol over the IP network in accordance with ANSI/CEA-852.

5.8.3.10. Provide the following to the Government for review prior to acceptance of the system:

- The latest version of all software and user manuals required to program, configure and operate the system.
- Points Schedule drawing that shows every DDC Hardware device. The Points Schedule shall contain the following information as a minimum:
    - Device address and NodeID.
    - Input and Output SNVTs including SNVT Name, Type and Description.
    - Hardware I/O, including Type (AI, AO, BI, BO) and Description.
    - Alarm information including alarm limits and SNVT information.
    - Supervisory control information including SNVTs for trending and overrides.
    - Configuration parameters (for devices without LNS plug-ins) Example Points Schedules are available at https://eko.usace.army.mil/fa/besc/
- Riser diagram of the network showing all network cabling and hardware. Label hardware with ANSI.CEA-709.1 addresses, IP addresses, and network names.
- Control System Schematic diagram and Sequence of Operation for each HVAC system.
- Operation and Maintenance Instructions including procedures for system start-up, operation and shut-down, a routine maintenance checklist, and a qualified service organization list.
- LONWORKS® Network Services (LNS®) database for the completed system.
- Quality Control (QC) checklist (below) completed by the Contractor's Chief Quality Control (QC) Representative

Table 5-1: QC Checklist

5.8.3.11. Perform a Performance Verification Test (PVT) under Government supervision prior to system acceptance. During the PVT demonstrate that the system performs as specified, including but not limited to demonstrating that the system is Open and correctly performs the Sequences of Operation.

5.8.3.12. Provide a 1 year unconditional warranty on the installed system and on all service call work. The warranty shall include labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition.

5.8.3.13. Provide training at the project site on the installed building system Upon completion of this training each student, using appropriate documentation, should be able to start the system, operate the system, recover the system after a failure, perform routine maintenance and describe the specific hardware, architecture and operation of the system.

•

5.8.4. TESTING, ADJUSTING AND BALANCING. Test and balance air and hydronic systems, using a firm certified for testing and balancing by the Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB), or the Testing Adjusting, and Balancing Bureau (TABB). The prime contractor shall hire the TAB firm directly, not through a subcontractor. Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB TABES, or SMACNA HVACTAB unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard shall be considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practicable to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations. All quality assurance provisions of the TAB Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the TAB Standard, the TAB Specialist shall develop TAB procedures. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are mandatory.

5.8.5. COMMISSIONING: Commission all HVAC systems and equipment, including controls, and all systems requiring commissioning for LEED Enhanced commissioning, in accordance with ASHRAE Guideline 1.1, ASHRAE Guideline 0 and LEED. Do not use the sampling techniques discussed in ASHRAE Guideline 1.1 and in ASHRAE Guideline 0. Commission 100% of the HVAC controls and equipment. Hire the Commissioning Authority (CA), certified as a CA by AABC, NEBB, or TABB, as described in Guideline 1.1. The CA will be an independent subcontractor and not an employee of the Contractor nor an employee or subcontractor of any other subcontractor on this project, including the design professionals (i.e., the DOR or their firm(s)). The CA will communicate and report directly to the Government in execution of commissioning activities. The Contracting Officer’s Representative will act as the Owner’s representative in performance of duties spelled out under OWNER in Annex F of ASHRAE Guideline 0. All buildings with Minimum LEED Silver (or better) requirement will earn LEED Credit EA3 Enhanced Commissioning.

5.9. ENERGY CONSERVATION

5.9.1. The building including the building envelope, HVAC systems, service water heating, power, and lighting systems shall meet the Mandatory Provisions and the Prescriptive Path requirements of ASHRAE 90.1. Substantiation requirements are defined in Section 01 33 16, Design After Award.

5.9.2. Design all building systems and elements to meet the minimum requirements of ANSI/ASHRAE/IESNA 90.1. Design the buildings, including the building envelope, HVAC systems, service water heating, power, and lighting systems to achieve an energy consumption that is at least 40% below the consumption of a baseline building meeting the minimum requirements of ANSI/ASHRAE/IESNA Standard 90.1. Energy calculation methodologies and substantiation requirements are defined in Section 01 33 16, Design After Award.

5.9.3. Purchase Energy Star products, except use FEMP designated products where FEMP is applicable to the type product. The term “Energy Star product” means a product that is rated for energy efficiency under an Energy Star program. The term “FEMP designated product” means a product that is designated under the Federal Energy Management Program of the Department of Energy as being among the highest 25 percent of equivalent products

for energy efficiency. When selecting integral sized electric motors, choose NEMA PREMIUM type motors that conform to NEMA MG 1, minimum Class F insulation system. Motors with efficiencies lower than the NEMA PREMIUM standard may only be used in unique applications that require a high constant torque speed ratio (e.g., inverter duty or vector duty type motors that conform to NEMA MG 1, Part 30 or Part 31).

5.9.4. Solar Hot Water Heating. Provide at least 30% of the domestic hot water requirements through solar heating methodologies, unless the results of a Life Cycle Cost Analysis (LCCA) developed utilizing the Building Life Cycle Cost Program (BLCC) which demonstrates that the solar hot water system is not life cycle cost effective in comparison with other hot water heating systems. The type of system will be established during the contract or task order competition and award phase, including submission of an LCCA for government evaluation to justify non-selection of solar hot water heating. The LCCA uses a study period of 25 years and the Appendix K utility cost information. The LCCA shall include life cycle cost comparisons to a baseline system to provide domestic hot water without solar components, analyzing at least two different methodologies for providing solar hot water to compare against the baseline system.

5.9.5. Process Water Conservation. When potable water is used to improve a building's energy efficiency, employ lifecycle cost effective water conservation measures, except where precluded by other project requirements.

5.9.6. Renewable Energy Features. The Government's goal is to implement on-site renewable energy generation for Government use when lifecycle cost effective. See Paragraph 6, PROJECT SPECIFIC REQUIREMENTS for renewable energy requirements for this project.

5.10. FIRE PROTECTION

5.10.1. STANDARDS AND CODES Provide the fire protection system conforming to APPLICABLE CRITERIA.

5.10.2. Inspect and test all fire suppression equipment and systems, fire pumps, fire alarm and detection systems and mass notification systems in accordance with the applicable NFPA standards. The fire protection engineer of record shall witness final tests. The fire protection engineer of record shall certify that the equipment and systems are fully operational and meet the contract requirements. Two weeks prior to each final test, the contractor shall notify, in writing, the installation fire department and the installation public work representative of the test and invite them to witness the test.

5.10.3. Fire Extinguisher Cabinets: Provide fire extinguisher cabinets and locations for hanging portable fire extinguishers in accordance with NFPA 10 Standard for Portable Fire Extinguishers. The Government will furnish and install portable fire extinguishers, which are personal property, not real property installed equipment.

5.10.4. Fire alarm and detection system: Required fire alarm and detection systems shall be the addressable type. Fire alarm initiating devices, such as smoke detectors, heat detectors and manual pull stations shall be addressable. When the system is in alarm condition, the system shall annunciate the type and location of each alarm initiating device. Sprinkler water flow alarms shall be zoned by building and by floor. Supervisory alarm initiating devices, such as valve supervisory switches, fire pump running alarm, low-air pressure on dry sprinkler system, etc. shall be zoned by type and by room location.

5.10.5. Roof Access: Paragraph 2-9 of UFC 3-600-01 Fire Protection for Facilities will be modified in the next update to that UFC. Pending revision, comply with roof access and stairway requirements in accordance with the International Building Code. Where roof access is required by the IBC or other criteria, comply with UFC 4-010-01, Anti-Terrorist Force Protection, Standard 14. "Roof Access".

5.10.6. Fire Protection Engineer Qualifications: In accordance with UFC 3-600-01, FIRE PROTECTION ENGINEERING FOR FACILITIES**,** the fire protection engineer of record shall be a registered professional engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveys (NCEES), or a registered P.E. in a related engineering discipline with a minimum of 5 years experience, dedicated to fire protection engineering that can be verified with documentation.

5.11. SUSTAINABLE DESIGN

5.11.1. STANDARDS AND CODES: Sustainable design shall conform to APPLICABLE CRITERIA. See paragraph 6, PROJECT-SPECIFIC REQUIREMENTS for which version of LEED applies to this project. The LEED-NC

Application Guide for Multiple Buildings and On-Campus Building Projects (AGMBC) applies to all projects. Averaging may be used for LEED compliance as permitted by the AGMBC but is restricted to only those buildings included in this project. Each building must individually comply with the requirements of paragraphs ENERGY CONSERVATION and BUILDING WATER USE REDUCTION.

5.11.2. LEED RATING, REGISTRATION, VALIDATION AND CERTIFICATION: See Paragraph PROJECT-SPECIFIC REQUIREMENTS for project minimum LEED rating/achievement level, for facilities that are exempt from the minimum LEED rating, for LEED registration and LEED certification requirements and for other project-specific information and requirements.

5.11.2.1. Innovation and Design Credits. LEED Innovation and Design (ID) credits are acceptable only if they are supported by formal written approval by GBCI (either published in USGBC Innovation and Design Credit Catalog or accompanied by a formal ruling from GBCI). LEED ID credits that require any Owner actions or commitments are acceptable only when Owner commitment is indicated in paragraph PROJECT-SPECIFIC REQUIREMENTS or Appendix LEED Project Credit Guidance

5.11.3. OPTIMIZE ENERGY PERFORMANCE. : Project must earn, as a minimum, the points associated with compliance with paragraph ENERGY CONSERVATION. LEED documentation differs from documentation requirements for paragraph ENERGY CONSERVATION and both must be provided. For LEED-NC v2.2 projects you may substitute ASHRAE 90.1 2007 Appendix G in its entirety for ASHRAE 90.1 2004 in accordance with USGBC Credit Interpretation Ruling dated 4/23/2008.

5.11.4. COMMISSIONING. See paragraph 5.8.5 COMMISSIONING for commissioning requirements. USACE templates for the required Basis of Design document and Commissioning Plan documents are available at http://en.sas.usace.army.mil (click on Engineering Criteria) and may be used at Contractor's option.

5.11.5. DAYLIGHTING. Except where precluded by other project requirements, do the following in at least 75 percent of all spaces occupied for critical visual tasks: achieve a 2 percent glazing factor (calculated in accordance with LEED credit EQ8.1) OR earn LEED Daylighting credit, provide appropriate glare control and provide either automatic dimming controls or occupant-accessible manual lighting controls.

5.11.6. LOW-EMITTING MATERIALS. Except where precluded by other project requirements, use materials with low pollutant emissions, including but not limited to composite wood products, adhesives, sealants, interior paints and finishes, carpet systems and furnishings,

5.11.7. CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT. Except where precluded by other project requirements, earn LEED credit EQ 3.1 Construction IAQ Management Plan, During Construction and credit EQ 3.2 Construction IAQ Management Plan, Before Occupancy.

5.11.8. RECYCLED CONTENT. In addition to complying with section RECYCLED/RECOVERED MATERIALS, earn LEED credit MR4.1, Recycled Content, 10 percent except where precluded by other project requirements.

5.11.9. BIOBASED AND ENVIRONMENTALLY PREFERABLE PRODUCTS. Except where precluded by other project requirements, use materials with biobased content, materials with rapidly renewable content, FSC certified wood products and products that have a lesser or reduced effect on human health and the environment over their lifecycle to the maximum extent practicable.

5.11.10. FEDERAL BIOBASED PRODUCTS PREFERRED PROCUREMENT PROGRAM (FB4P). The Farm Security and Rural Investment Act (FSRIA) of 2002 required the U.S. Department of Agriculture (USDA) to create procurement preferences for biobased products that are applicable to all federal procurement (to designate products for biobased content). For all designated products that are used in this project, meet USDA biobased content rules for them except use of a designated product with USDA biobased content is not required if the biobased product (a) is not available within a reasonable time, (b) fails to meet performance standard or (c) is available only at an unreasonable price. For biobased content product designations, see http://www.biopreferred.gov/ProposedAndFinalItemDesignations.aspx.

5.12. CONSTRUCTION AND DEMOLITION (C&D) WASTE MANAGEMENT: Achievement of 50% diversion, by weight, of all non-hazardous C&D waste debris is required. Reuse of excess soils, recycling of vegetation, alternative daily cover, and wood to energy are not considered diversion in this context, however the Contractor

must tracked and report it. A waste management plan and waste diversion reports are required, as detailed in Section 01 57 20.00 10, ENVIRONMENTAL PROTECTION.

5.13. SECURITY (ANTI-TERRORISM STANDARDS): Unless otherwise specified in Project Specific Requirements, only the minimum protective measures as specified by the current Department of Defense Minimum Antiterrorism Standards for Buildings, UFC 4-010-01, are required for this project. The element of those standards that has the most significant impact on project planning is providing protection against explosives effects. That protection can either be achieved using conventional construction (including specific window requirements) in conjunction with establishing relatively large standoff distances to parking, roadways, and installation perimeters or through building hardening, which will allow lesser standoff distances. Even with the latter, the minimum standoff distances cannot be encroached upon. These setbacks will establish the maximum buildable area. All standards in Appendix B of UFC 4-010-01 must be followed and as many of the recommendations in Appendix C that can reasonably be accommodated should be included. The facility requirements listed in these specifications assume that the minimum standoff distances can be met, permitting conventional construction. Lesser standoff distances (with specific minimums) are not desired, however can be provided, but will require structural hardening for the building. See Project Specific Requirements for project specific siting constraints. The following list highlights the major points but the detailed requirements as presented in Appendix B of UFC 4-010-01 must be followed.

(a) Standoff distance from roads, parking and installation perimeter; and/or structural blast mitigation

(b) Blast resistant windows and skylights, including glazing, frames, anchors, and supports

(c) Progressive collapse resistance for all facilities 3 stories or higher. Unless determined otherwise by the Installation and noted in paragraphs 3 or 6, the building shall be considered to have areas of uncontrolled public access when designing for progressive collapse.

(d) Mass notification system (shall also conform to UFC 4-021-01, Mass Notification Systems)

(e) For facilities with mailrooms (see paragraph 3 for applicability) – mailrooms have separate HVAC systems and are sealed from rest of building

6.0 PROJECT SPECIFIC REQUIREMENTS FORT SAM HOUSTON, TX

6.1. GENERAL

The requirements of this paragraph augment the requirements indicated in Paragraphs 3 through 5.

6.2. APPROVED DEVIATIONS

The following are approved deviations from the requirements stated in Paragraphs 3 through 5 that only apply to this project: NONE

6.3. SITE PLANNING AND DESIGN

6.3.1. General:

6.3.1.1. Site Development Plan (SDP). The SDP provided by the government is included within the Appendices. Bring any discrepancies which are found in the furnished plans to the attention of the Contracting Officer's Representative.

6.3.1.2. Building Setback and Force Protection: Lay the site out based on the facility threat security level to protect against exterior attack by providing standoff distance between an aggressor or bomb, barriers, and to facilitate visual monitoring of the site. See the force protection requirements in UFC 4-010-01.

6.3.1.3. Building Spacing: Fire clearance separations shall be in accordance with UFC 3-600-01 and the International Building Code. Verify that fire clearances and access for equipment is acceptable to the installation's Fire Chief. Separation for buildings shall conform to force protection requirements per UFC 4-010-01.

6.3.1.4. Confine pad preparation operations to the work area defined by the SDP.

6.3.1.5. . Walks: Locate walks paralleling buildings beyond the eave drip line and at least 5 feet from the foundation. Walks paralleling parking areas shall be at least 6 feet wide and shall abut the back of the curb.

6.3.1.6. Troop Formation Areas: Walkways for troops marching in formation shall be wide enough to accommodate personnel walking four abreast. The walkways shall be constructed of concrete

6.3.1.7. Parking Areas:

Parking for 73 vehicles has been shown on the proposed site layout. Parking spaces are determined per UFC requirements. Maximum occupancy is estimated at 116. The parking standard is 60% of maximum occupancy - 70 regular spaces plus 3 handicap parking spaces.

Access to the loading dock must be controlled by means of a remote controlled, electrically operated gate.

Access to the fire/service access road must be controlled by a manually operated double swing gate.

6.3.2. Site Structures and Amenities

6.3.2.1. Dumpsters: Coordinate location of the dumpsters with the Installation. Provide concrete loading aprons for the first 15 feet in front of the dumpster pads to accommodate loading and to avoid rutting of the pavement in front of the dumpsters. Provide the following number of dumpsters

An existing 20-inch sanitary sewer line may be impacted by the proposed TSC building. The sewer line will have to be replaced and rerouted if it passes under the TSC Building or other paved areas.

Dumpster area should be screened as an enclosure by using walls and landscaping. Screen walls should be between six and eight feet high and should be in harmony with the adjacent building. One (1) dumpster will be required and should be located within the fenced loading dock area. Landscape planting should be used to supplement wood fence and masonry wall dumpster enclosures.

An outdoor open storage canopy, fence enclosed, of approximately 1,800 to 2,000 SF is required for storage of compressed gases. Storage shed should be on a concrete slab. Concrete paving access is preferred for warehouse lift trucks.

6.3.3. Site Functional Requirements:

6.3.3.1. Stormwater Management (SWM) Systems.

(a) Comply with the requirements of general permit number

The stormwater management system must be designed to treat the quality and attenuate the quantity of stormwater in accordance with permit number TRX150000.

EISA Section 438 Compliance:

Since the entire, existing project area has an impervious asphalt surface, no mitigation is required since stormwater run-off will not increase as the result of this project.

Fort Sam Houston 'prefers' some level of water quality treatment on all projects. The facility has a high preference to provide water quality treatment to collect the 'first flush. Detention is a secondary priority. The extent and actual requirements are determined on a project-by-project basis.

(b) Storm Drainage System Plans are shown within the SDP. Tie into these systems as appropriate for his areas of design responsibility. Design and construction of the storm drainage system shall be in accordance with Federal Aviation Administration Advisory Circular FAA AC 150-5320-5C, Surface Drainage Design; Federal Highway Administration Publication No. FHWA-NHI-01-021, Hydraulic Engineering Circular No. 22, Second Edition, URBAN DRAINAGE DESIGN MANUAL; and U.S. Weather Bureau Technical Paper No. 40, dated May 1961, Rainfall Frequency Atlas of the United States for Durations from 30 minutes to 24 hours, and return periods from 1 to 100 years. Base the design of drainage structures on a 10-year storm frequency. Incorporate the principles of Low Impact Development (LID), as detailed in UFC 3-210-10 DESIGN: LOW IMPACT DEVELOPMENT MANUAL. Construct manholes, surface inlets, and curb inlets of reinforced concrete or pre-cast reinforced concrete. Design structures in pavement to handle H-20 loading. Structures in turfed areas can be constructed for lighter weight loading. Design the storm drainage system to be as economical as possible, while taking into account the topography, drainage area, and outfall locations, as well as coordination with existing drainage systems, and existing and future underground utilities. Profiles are required for underground storm drainage systems and sections are required for culverts.

(c) Underground Systems: Whenever possible, match pipe crowns in elevations. Profiles of pipes shall show all existing and new underground utilities and pertinent surface features. Design the minimum pipe gradient shall be designed to provide a minimum velocity (full flow) of 3.0 fps. Design the new outfall and receiving channel to withstand the shear stress acting on the channel from the runoff to prevent erosion. Size new underground storm drainage pipes by computation of backwater surface profiles. The minimum pipe size shall be 12 inches, unless the pipe is a part of the roof drain system, in which case the minimum size of laterals and collector pipes is 4 inches.

(d) Street Drainage: Accomplish street drainage by the use of curb and gutter and curb inlets. Curb gaps can be considered in areas where roadside ditches are used. The center one-third of the street shall not convey runoff during the passing of the design storm. Do not use inverted crown sections for the streets without prior approval.

Do not locate curb inlets in the radius of street intersections, at curb returns, or where pedestrian traffic is most likely to occur.

(e) POV Parking and Hardstands: Do not concentrate the flow of storm runoff on asphalt pavement. Convey storm runoff within POV parking areas to perimeter curbs by sheetflow. However, if it is necessary to concentrate flow within a parking area, provide concrete paving at the swale flowline. Concentrated flow will not be permitted to flow from POV parking or hardstand areas onto adjacent gravel areas or turfed slopes. Examine sheetflow from parking areas and hardstands onto adjacent gravel or turfed areas for possible erosive effects.

(f) Ditches and Swales: Use a minimum longitudinal ditch or swale gradient of 0.5% with an absolute minimum of 0.3% . Side slopes on ditches or swales shall be no steeper than 1 vertical on 2-1/2 horizontal. Pave steeper slopes. Use Turf Reinforcement Matting (TRM) in ditches that are subject to high velocity storm runoff. Use erosion control matting as necessary to control erosion on steeper slopes.

(g) Culverts: The recommended gradient of culverts shall be 0.5% with an absolute minimum of 0.3%. Provide concrete headwalls or end sections for all culverts. Design headwalls and end sections to reduce velocities to levels that are non-erosive for the soil types encountered.

6.3.3.2. Erosion and Sediment Control: Prepare and comply with Storm Water Pollution Prevention Plans (SWPPP) for the limits of the entire construction site. Include silt fences, mulch straw/hay bales around inlets, and sediment traps to control erosion during construction.

6.3.3.3. Vehicular Circulation.

(a) Geometric Features: Geometric design of all roads, streets, access drives, and parking areas shall conform to the requirements presented in AASHTO, a Policy of Geometric Design of Highways and Streets. Verify with the local installation that access for fire equipment is adequate. Radii, to back of curb, for intersections are standardized as follows:

Primary and Secondary Intersection - 30 feet
Tertiary intersections - 20 feet
Access drives at end parking space - 5 feet

(b) Parking: Provide perimeter concrete curbs and gutters for all parking areas and access drives in developed areas. In remote or little used areas, use concrete curbs and gutters only when required to control drainage. Where flexible pavements are used, removable prefabricated reinforced concrete wheel stops, as approved, may be used.

(c) Service Drives: Widths of drives to unloading ramps or docks for usual types of trucks or tractor trailers are:

Trucks, Single-Unit - 12 feet
Semi-trailers - 16 feet

Vehicle access for POV and organizational vehicles is required. Larger vehicles, such as 5-ton trucks and commercial delivery vehicles, require access to the loading dock.

Access to 3 sides of the building is required for fire trucks. Paving is not required but permeable paving bricks are acceptable. Access for a pick-up truck sized vehocle is required to the mechanical room.

Access to the loading dock must be controlled by means of a remote controlled, electrcally operated gate with a signaling buzzer located at the gate with audible buzzers located in the Administration and Warehouse areas. Remote gate release will be required at both the Administration and Warehouse (inside, near loading dock) areas.

Access to the fire/service access road must be controlled by a manually operated double swing gate.

6.4. SITE ENGINEERING

6.4.1. Existing Topographical Conditions: The government furnished survey Horizontal and Vertical control complies with EM 1110-1-8005, Table 2-1, Military Construction, Building or Structure Design.

A three dimensional digital topographic and utility survey for this site has been prepared by the Government and included as a part of this contract. Any discrepancies which are found in the Government furnished survey shall be brought to the immediate attention of the Government for clarification. An existing drainage swale runs west to east along the southern portion of the parcel. Site demolition will be required to remove and relocate the sanitary sewer line. Site contours are shown on drawing CG-100 in Appendix J.

6.4.2. Existing Geotechnical conditions: See Appendix A for a preliminary geotechnical report.

6.4.2.1. Existing Subsurface Conditions: A Government Preliminary Geotechnical Report has been prepared, and is appended to these specifications (Appendix A). The Government Geotechnical Report provides a general overview of the areal geologic conditions with detailed descriptions of the subsurface strata encountered during the Government geotechnical field investigation. Based on the results of the field investigation, laboratory testing program, and engineering analyses, the Government Geotechnical Report further provides parameters and minimum foundation design requirements. However, as stated in the Government Geotechnical Report, the Contractor is responsible for drilling additional borings at the site, and performing additional laboratory testing (specified in the Government Geotechnical Report). The Contractor's additional geotechnical field investigations shall be ONLY for the purpose of supplementing the data regarding subsurface conditions provided by the Government geotechnical field investigation, as presented in the Government Geotechnical Report

6.4.3. Fire Flow Tests See Appendix D for results of fire flow tests to use for basis of design for fire flow and domestic water supply requirements.

Fire flow test for this site has been done by the Government and is included as part of this contract. See Appendix D for hydrant data.

6.4.4. Pavement Engineering and Traffic Estimates:

6.4.4.1. Pavements: Geometric design of roads and streets shall follow the guidance provided in AASHTO - A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS and GUIDELINES FOR GEOMETRIC DESIGN OF VERY LOW-VOLUME LOCAL ROADS (ADT≤400). Design pavement structures in accordance with criteria contained in AASHTO - GUIDE FOR DESIGN OF PAVEMENT STRUCTURES. Vehicle types expected to occupy the pavements and their frequency of use are as follows:

Pavement design has been performed by the Government and is included as part of the Geotechnical Report in Appendix A.

Pavement for the external storage building for compressed gases should be concrete.

Paved access is required to mechanical rooms/yards. New curb and gutter shall be concrete paved.

6.4.4.2. Emergency Vehicle Access: Provide access drives to allow access for fire trucks and emergency vehicles in accordance with NFPA and UFC 3-600-1. Access to the emergency drive(s) shall be restricted by using removable bollards or metal pipe swing gates with a removable center bollard. Refer to the gate detail in the drawings.

6.4.4.3. Concrete Hardstands for Vehicle Parking and Storage Areas: Develop a joint pattern plan showing locations of each type of joint to be used. Spot elevations are required at the intersection of each joint to facilitate placement of forms during construction.

6.4.5. Traffic Signage and Pavement Markings

6.4.5.1. Permanent and construction roadway signs shall be as required by the FHWA MUTCD and FHWA Standard Highway Signs.

6.4.5.2. Pavement markings and striping shall be in accordance with state DOT standards and the Manual of Uniform Traffic Control Devices (MUTCD). Channelization and pavement markings shall be as required by the FHWA MUTCD and FHWA Standard Highway Signs.

6.4.6. Base Utility Information

(a) Do not place underground utility lines such as sanitary sewer, water, and gas under existing or proposed pavements. Place the utility between the back slope of a road ditch and building, or back of curb. Coordinate deviations to the aforementioned requirements with the COR. Do not locate above ground utility features in front of, or in such a manner as to detract from the facility, make landscaping more difficult, or restrict or negate close-in recreational areas. Do not locate high pressure gas lines closer than 100 feet from an occupied building without special protective provisions and COR approval.

(b) Coordinate and plan utility information with the Installation's DPW through the COR. The SDP provides existing utility routing and general orientation for points of connection. Specific connection locations not shown are noted hereinafter.

6.4.6.1. Connect all utilities from the building to the service connection points shown on the SDP or listed herein. Coordinate between the SDP and utility providers, as well as coordinating utility outages with the installation and service provider.

6.4.6.2. Water Distribution System: The water distribution system is shown on the SDP. Coordinate points of connection through the COR with the installation DPW. Design and construction of potable water service between the main line and the facility shall be the responsibility of the Contractor. Design and install the water system and meter in accordance with the requirements of the installation DPW through coordination of the COR. Install valves on the water service lines near the connection point and on each service line to the building. For water mains, provide 2 valves at tees and 3 valves at crosses. Velocities in water lines shall be less than 7 feet per second (fps) to prevent possible water hammer effects.

(a) Potable Water Disinfection – Verify water line disinfection per AWWA C651-05. Analyze the samples by an analytical lab that holds a current state license and certification. Repeating disinfection protocols per AWWA C651-05 is required until satisfactory results are obtained (two consecutive sets of acceptable samples taken 24 hours apart). Collect water samples in proper sterilized containers, and perform a bacterial examination in accordance with state approved methods. As a minimum, collect one water sample from each 1000 linear feet segment of disinfected water line. The water supply system disinfection is not approved for usage until each test result is negative for bacteriological examination. Provide the water sample analytical results to the DPW's Environmental Office for record keeping. The commercial laboratory shall be certified by the state's approving authority for examination of potable water.

6.4.6.3. Natural Gas Distribution: Natural Gas distribution lines are shown on the SDP. Coordinate points of connection to the facility with CPS Energy. CPS Energy will provide natural gas service to the face of the building and shall install the site gas distribution piping. CPS Energy shall install the gas meter and connect the meter to the building stub out. The contractor shall stub the gas feed out of the building. The Contractor is not responsible for costs incurred for services provided by CPS Energy Design and construct the natural gas service lines with ANSI B31.8, Gas Transmission Distribution and Piping Systems. Natural gas shall be provided to the building . Provide a meter/regulator assembly for the facility with a valved bypass.

6.4.6.4. Sanitary Sewer System: The sanitary sewer system is shown on the SDP. Coordinate points of connection through the COR with the DPW. Design and construct the sanitary sewer system in accordance with American Society of Civil Engineers (ASCE) and the Water Environment Federation (WEF), Gravity Sanitary Sewer Design and Construction, Second Edition (ASCE Manuals and Reports on Engineering Practice No. 60 / WEF Manual of Practice No. FD-5). Provide sanitary sewer service to the building. Install two-way cleanouts and all structures required by criteria, as well as, all piping between the designated point of connection and the building. Minimize the use of lift stations. If a lift station is required, provide a packaged unit assembled of coated materials that do not easily corrode. Provide an audible and visible alarm. Ensure location of lift station is accessible by service vehicles. Provide manholes at every change of direction and every 400 feet. Provide drop manholes if pipe elevations differ more than 18 inches. The minimum sewer main size shall be 8-inch. Provide 6-inch minimum sewer connections to buildings. Provide two-way cleanouts every 100 feet along a sewer branch connection from a

building, and provide two-way cleanouts at the building connection. Construct manhole inlets of reinforced concrete or pre-cast reinforced concrete. Design structures in pavement to handle H-20 loading. Structures in turfed areas can be constructed for lighter weight loading. Profiles are required for underground sanitary sewer systems.

6.4.6.5. Oil-Water Separators: Provide oil-water separators for the pretreatment of wastewater containing free-floating oils and grease prior to discharge into sanitary sewers. Additionally, determine the pretreatment limits required by the receiving wastewater utility and select or design a system to meet these discharge limits and to resist buoyant forces acting on the structure.

(a) Prepackaged Separators: The design shall consider the anticipated flow rate and the quantity of dirt and grit contained in the wastewater. High-volume wastewater containing large amounts of solids will usually require design of a cast-in-place separator.

(b) Cast-in-Place Separators: Cast-in-place reinforced concrete separators are required for the pretreatment of wastewater generated at outdoor facilities such as washracks. Provide a grit chamber either upstream of the separator, or integrally with the separator at the upstream end of the separator when large quantities of sediments are expected. In all cases, when the flow rate resulting from storm runoff significantly exceeds the normal operating flow rate, include a bypass in order to divert the storm water into the storm drainage system instead of allowing it to flow into the treatment system. Design cast-in-place oil/water separators to conform to Chapters 5 and 6 of the American Petroleum Institute's Manual on Disposal of Refinery Wastes. This manual provides minimum detention times. Provide slotted, rotation-type or belt type oil skimmer and waste oil storage tanks in accordance with user requirements.

6.4.6.6. Cable TV (CATV): Cable TV is privatized and provided by others. Privatized utility will provide design and service to the building(s) and is not in this contract.

6.4.7. Cut and Fill

6.4.7.1. Strive to achieve a balanced cut and fill for earthwork. Do not waste excess soil within the SDP work area without the written approval of the Contracting Officer’s Representative (COR).

6.4.7.2. Grading Requirements:

(a) Finished Floor Elevations: A building's finished floor elevation shall be a minimum of 12 inches above the highest point of the adjacent outside finished grade, unless there is an overriding technical reason to deviate. Slope the finished grade a minimum of 5% for the first 10 feet away from the building.

(b) Turfed Areas Adjacent to Buildings: Slope outside finished grade away from the building at a 5% grade for the first 10 feet. Extend the 5% grade to 20 to 30 feet in areas with expansive soils. When site conditions require the use of steep slopes near buildings, provide a berm that is a minimum of 6 feet wide at a 5% grade adjacent to the building. Indicate these requirements on the grading plan with critical spot elevations.

(c) Lawn Areas: Lawn areas beyond the 5% finished grade stated above shall have a 1% minimum slope and a desirable maximum slope of 25%. If it becomes necessary to use slopes steeper than 25%, provide slope protection, but in no case shall the slope exceed 33%. Base the type and amount of slope protection provided on the soil type, slope length, and aesthetic, environmental, and economic considerations.

(d) Roads, Streets, and Access Drives: Gradients for roads, streets and access drives shall be as outlined in AASHTO, A Policy of Geometric Design of Highways and Streets. Accomplish grade changes in excess of 1% by means of vertical curves. Determine the length of vertical curves in accordance with the aforementioned AASHTO criteria. Profiles are mandatory for vertical control of centerline gradients. Show roads, streets and highways using of half-plan/half-profile type drawings.

(e) Parking Areas: Pavement grades shall provide positive surface drainage with a 1 percent minimum slope in the direction of drainage. Provide a maximum slope within a 90-degree parking space of 5 percent from front to rear end and 1-½ percent from side to side. Provide a maximum slope within a 45-degree or 60-degree parking space of 5 percent from front to rear end and 1 percent from side to side. Slope grade perpendicular to direction of parking 5 percent maximum for bituminous or concrete surfaces and 3 percent for other surfaces.

(f) Finish Grade Contours and Spot Elevations: Provide finish grade contours at 1-foot intervals and spot elevations to construct all site development features. Spot elevations on the drawings should be sufficient so that interpolation between contours is not required for structures, grading or paved areas. Provide spot elevations

where grade changes a minimum of 1 percent and use at point of tangency for curbs on end islands and at corners of parking lots.

A balanced cut and fill should be attempted but due to the nature of material on-site and requirement for stormwater retention, excess material is expected. Unsuitable material excavated from the site must be disposed of off-site. Suitable fill required must be brought in.

6.4.8. Borrow Material

There is no borrow source on-site.

6.4.9. Haul Routes and Staging Areas

6.4.9.1. See Appendix J, DRAWINGS for the project location and the location of haul routes and Contractor's staging area. Construction limits shall be confined to the construction site boundaries as shown on the Site Development Plan (SDP) within the Appendices.

6.4.9.2. The Contractor will be allotted an area as shown on the SDP for the placement of a construction trailer complex and storage for the Contractor and respective Subcontractors. Permanent Trailers are not permitted within the building envelope work areas. Trailers within the work area may be required to be relocated at no additional cost to the Government to accommodate site activities. The Contractor shall be responsible for the site preparation, fencing, access drives, and maintenance of the compound at all times. Upon completion of the project and after removal of trailers, materials, and equipment from within the fenced area, remove the fence. . Restore areas used by the Contractor for the storage of equipment or material, or other use, to the original or better condition. Remove gravel used to traverse grassed areas and restore the area to its original condition, including top soil and seeding as necessary.

6.4.9.3. For proposal purposes, assume Contractor will be responsible for providing temporary utilities (water, sewer, and electricity, etc.) during construction at the project site. A water fill point will be provided as indicated on the SDP. It may be necessary, initially, for the Contractor to truck water to the project site until new utilities are constructed. Contractor is responsible for installation and maintenance of the haul road from the water fill point to the entrance of the construction site.. Coordinate routing of haul roads with the COR.

6.4.10. Clearing and Grubbing:

Clearing and grubbing will not be required. The existing site is mostly asphalt paving that will have to be removed.

6.4.11. Landscaping:

(a) Provide native or well adapted species of plants in the landscaping plan. Choose trees, shrubs, and ground covers from the preferred plant list included in Appendix I. Provide shade trees . Use flowering vegetation at focal points to provide visual interest. All landscaping within 33 feet of the facility shall adhere to force protection clear zone requirements as specified in UFC 4-010-01.

(b) The landscaping integrated design shall emphasize the goal to achieve energy efficiency and water conservation. Select t vegetation based on hardiness, availability, and drought tolerance, which aids in the conservation of water, as well as, maintenance resources. Locate the trees to optimize shading opportunities, which aids in energy efficiency of the buildings by cooling during the summer.

(c) Landscape Irrigation.

Landscaping requirements for this project will be installed under the Infrastructure contract according to the FSH Installation Design Guidelines (IDG). In particular, the use of native materials and the exclusion of aggressive non-natives should be considered in the design. Also, adaptation to the Southwest Texas climate and the availability of water resources needed to sustain landscaping plants should be considered in the selection of plant materials. The landscaping contract will also include hardscape elements to include sidewalks, troop trails, courtyards, shade structures, seating, and certain site amenities.

6.4.12. Turf: Turfing is required on all graded, unpaved and disturbed areas resulting from the Contractor's operations. Use sod in areas with steep slopes (≥ 3:1) or ditch linings to assist in establishing turf and to aid in

erosion protection. Use Turf Reinforcement Matting (TRM) in ditches that are subject to high velocity storm runoff. Use erosion control matting as necessary to control erosion on steeper slopes.

6.5. ARCHITECTURE

6.5.1. General: To the maximum extent possible within the contract cost limitation, the buildings shall conform to the look and feel of the architectural style and shall use the same colors as adjacent facilities as expressed herein . The Government will evaluate the extent to which the proposal is compatible with the architectural theme expressed in the RFP during the contract or task order competition. The first priority in order of importance is that the design provides comparable building mass, size, height, and configuration compared to the architectural theme expressed herein. The second priority is that design is providing compatible exterior skin appearance based upon façade, architectural character (period or style), exterior detailing, matching nearby and installation material/color pallets, as described herein.

6.5.2. **Design**

6.5.2.1. Appendix F is provided “For Information Only”, to establish the desired site and architectural themes for the area. Appendix F identifies the desired project look and feel based on **Fort Sam Houston’s** Installation Architectural Theme from existing and proposed adjacent building forms; i.e. building exterior skin, roof lines, delineation of entrances, proportions of fenestration in relation to elevations, shade and shadow effects, materials, textures, exterior color schemes, and organizational layout.

6.5.2.2. The design should address Fort Sam Houston’s identified preferences. Implement these preferences considering the following:

(a) Achievable within the Construction Contract Cost Limitation (CCL)

(b) Meets Milestones within Maximum Performance Duration.

(c) Achieves Full Scope indentified in this Solicitation

(d) Best Life-Cycle Cost Design

(e) Meets the Specified Sustainable Design and LEED requirements.

(f) Complies with Energy Conservation Requirements Specified in this RFP.

6.5.2.3. Priority #1. Visual Compatibility: Facility Massing (Size, Height, Spacing, Architectural Theme, etc.) Exterior Aesthetic Considerations: The buildings massing, exterior functional aesthetics, and character shall create a comprehensive and harmonious blend of design features that are sympathetic to the style and context of the Installation. The Installation’s intent for this area is:

To be in compliance with the Fort Sam Houston Installation Design Guide requirements for Visual Zone 5. Facility shall be compatible with the buildings shown in Appendix F.

6.5.2.4. Priority #2. Architectural Compatibility: Exterior Design Elements (Materials, Style, Construction Details, etc.) Roofs, Exterior Skin, and Windows & Door Fenestrations should promote a visually appealing compatibility with the desired character while not sacrificing the integrity and technical competency of building systems.

6.5.2.5. See Appendix F for exterior colors that apply to Architectural character at Fort Sam Houston. The manufacturers and materials referenced are intended to establish color only, and are not intended to limit manufacturers and material selections.

6.5.2.6. Additional architectural requirements:

(a) Install fall protection anchor points on all roofs with a slope greater than 2:12

(b) The wall and ceiling/roof will have a continuous insulative/vapor barrier connection with no air gaps.

(c) Screen mechanical equipment by parapets at flat or low slope roofs.

(d) Roof shapes may be gabled or hip roofs or a combination of these roof shapes with flat roofs concealed by a parapet wall.

6.5.3. Programmable Electronic Key Card Access Systems:

A card reader is required at the main entrance. Keyed access at other doors. Door hardware shall be 7 pin and "Best" compatible.

6.5.4. INTERIOR DESIGN

Provide a description of furnishings and equipment required for the project. Note the intended procurement appropriation (OMA – Operation and Maintenance Army, OPA – Other Procurement Army, etc) for the included furnishings and equipment and include a confirmation of the party responsible for obtaining/budgeting for the funding (Proponent, Facility User, etc.).

(a) Maximum allowed building area is 29,200 square feet, including out buildings.

(b) Facility will have 1 Brigade Combat Team (BCT).

(c) A Fabrication shop is required. Shop will be for woodworking, making crates, small training aides, and small bomb simulated devices. Shop will contain 4 large saws. 1 Fabricator will occupy this space.

(d) A loading dock is required.Administrative space is required for 7 people. Buzzers are required in the Administrative and warehouse areas to allow activation of the entry gate.

(e) 2 people will be in the Customer Service Area in the Warehouse.

(f) Warehouse will require motorized vertical bi-fold doors providing a clear opening of 10'wx12' high when in the open postition.

(g) Classroom is required for 30 people.

(h) EST Trainer is required in both classrooms and construction shall support the EST. One classroom shall include an operable partition to all the room to be divided into 2 rooms. Provisions should be made to prevent noise and vibrations from the EST Classrooms to adjacent spaces.

(i) Fire alarm panel with backup batteries can be located in the Mechanical Room.

(j) A dedicated Communications room is required. This room shall be 8'-0"x10'-0" minimum. No additional equipment or furniture will be allowed in this space.

(k) Contractor will be required to coordinate structure with the placement of existing racks that will be relocated from a different facility into the new TSC warehouse space.

(l) Card reader will be required at main entrance. Keyed access at other doors.

(m) Infrastructure (empty conduits with pull wires and junction boxes) for an Access Control System.

(n) A Knox Box is required at the front door to the building.

(o) Mechanical equipment cannot be placed on the roof. Roof access hatch is required in the mechanical room.

(p) A covered storage shed is required, as shown on the drawings. It shall have a standing seam metal roof with fenced sides.

(q) Project is required to meet the International Building Code 2009 version.

(r) Warehouse roof deck height and structural steel should be designed so that material may be stored up to 23 feet above finished floor without interfering with sprinklers heads, steel girders, light fixtures, and other fixed items in the warehouse section. This dimension allows for an 18-foot high rack deck with 5-foot high material storage on top. Slab design shall accommodate this size rack - typical vertical rack load capacity is 17,460 pounds on each vertical section (4 feet deep x 8 feet long x 18 feet high). Warehouse is not intended to be clearspan.

(s) Expansion joints in EIFS system shall be proportional to wall (office/classroom, warehouse) and shall be aesthetically proportional to the building in relation to wall heights, windows, and door locations.

(t) Fire extinguisher cabinets will be required, however actual fire extinguishers will be provided by Ft. Sam Houston.

(u) Concrete masonry construction is required to a minimum height of 14' in the warehouse. Split faced masonry is acceptable.

Interior building signage requirements:

An interior sign package must be developed utilizing UFC 3-120-01, Air Force sign Standard. Signage must form a well-organized, comprehensive interior environment that guides users and visitors through the building to their destinations.

6.6. STRUCTURAL DESIGN

6.6.1. General

Place floor mounted mechanical and electrical equipment on a 4” minimum concrete pad.

6.6.2. Project Specific Design Loads:

6.6.2.1. Ground Snow: 5 psf

6.6.2.2. Wind Speed: 90 mph

6.6.2.3. Seismic Design Data: The mapped maximum considered earthquake (MCE) spectral response accelerations for site class B are:

Ss (at short periods) = 11% g
S_1 (at 1-second period) = 3% g.

The acceleration values identified are for the general location of the facility. Verify and use site specific criteria based on the final site location of the facility. Adjust site class per IBC to match specific site information in geotechnical report.

6.6.2.4. For design of structural components subjected to dynamic loads, the U.S. Army Corps of Engineers Protective Design Center (PDC) developed SBEDS, Single-Degree-of-Freedom Blast Effects Design Spreadsheets (SBEDS). SBEDS is available at the software tab of the PDC website, https://pdc.usace.army.mil/.

6.6.3. Foundation

Use a vapor barrier system with a minimum 10-mil polyethylene membrane under all slabs-on-grade.

6.6.4. Site Features – Retaining Walls/Bridges/etc.

Design site features, e.g. retaining walls, culverts, bridges, in accordance with the appropriate American Association of State Highway and Transportation Officials (AASHTO) criteria including AASHTO LRFD Bridge Design Specifications, AASHTO Standard Specifications for Highway Bridges, and AASHTO Guide Specifications for Design of Pedestrian Bridges. Consider operation and maintenance requirements, e.g. painting, mowing, inspecting, routine maintenance. Design site features to drain properly in order to meet loading assumptions.

6.7. THERMAL PERFORMANCE

Consider moisture protection. Consider protection from damage to flooring and wall finishes when designing floor slabs and walls. This could be as simple as placing a vapor barrier under the floor slab, building wrap, or vapor barrier on the walls.

6.8. PLUMBING

6.8.1. The storm drainage system will consist of gutters and downspouts on each building. Direct all drainage to the existing storm sewer system.

6.8.2. Consider the use of tankless domestic water heaters.

6.8.3. General Plumbing Requirements:

6.8.3.1. Each building will have a domestic water service entrance with a floor drain for backflow preventer testing and discharge.

6.8.3.2. Wall Hydrants: Provide a minimum of 4 exterior wall hydrants, at least one per face of the building. These shall have a removable key and freeze protection. Mount wall hydrants 2 feet above finished grade and spaced around the building perimeter to allow watering of all grass areas with no greater than 100 feet of garden hose. Provide a minimum of one (1) hose-bib in each mechanical room, mechanical area, or utility area.

6.8.3.3. Install all backflow preventers in mechanical rooms for accessibility and comply with the requirements of Texas Commission on Environmental Quality, International Building Code, and International Plumbing Code. Backflow preventers shall pass certification testing for compliance with Title 30 Texas Administrative Code Rule 290.44(h). State licensed plumbers shall install and/or test backflow preventers, and cross connection devices. Initial testing and certification of new backflow devices needs to be performed, and submitted for approval prior to domestic water usage.

6.8.3.4. Water Meters: Locate the water meter inside the building. Meters shall have a pulse generator with each pulse representing an adjustable volume of water. The meter shall be capable of operating up to speeds of 500 pulses per minute with no false pulses. Pulse generators shall provide the maximum number of pulses up to five hundred (500) per minute that is obtainable from the manufacturer. Connect meters to the building control system. Provide meters with isolation valves upstream and downstream of the meter and with a building piping drain valve downstream of the meter. Connect meters to the Post wide Utility Control System (UCS).

6.8.3.5. Water Service Utility Provider (WSUP) Coordination: Provide separate service for the fire water and domestic water services. The domestic water service shall include a meter inside the building and fire water service line shall have a backflow preventer with a post indicator valve.

6.8.3.6. Exterior Water Piping Freeze Protection: Detail and install seasonally (not used in winter) utilized water supply piping for complete drain down and provide an interior or below grade isolation valve. Insulate, heat trace and protect exposed water piping that is utilized year round with pipe jacketing to ensure that the piping will not freeze.

6.8.3.7. Irrigation: Potable water irrigation is generally prohibited due to water reduction best management practices. Use gray (re-use) water (where available) for all outdoor irrigation unless building purpose is health related for treatment of patients where gray water would be considered a risk factor.

6.8.4. Natural Gas Meters for Buildings Only:

6.8.4.1. Install a shutoff valve, meter set assembly, and service regulator set assembly on the service line outside each building, eighteen (18) inches above the ground on the building gas service riser.

6.8.4.2. Install an insulating joint on the inlet side of the meter set assembly and service regulator and construct to prevent flow of electrical current. A 3/8 inch tapped fitting equipped with a plug shall be provided on both sides of the service regulator, downstream of the gas shutoff valve; for installation of pressure gages for adjusting the regulator.

6.8.4.3. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

6.8.4.4. Meters shall have a pulse generator with each pulse representing an adjustable volume of gas. The meter shall be capable of operating up to speeds of five hundred (500) pulses per minute with no false pulses. Pulse generators shall provide the maximum number of pulses up to five hundred (500) per minute that is obtainable from the manufacturer. Connect meters to the Post wide Utility Control System (UCS).

6.8.4.5. Include a seismic shutoff valve.on the gas service entrance to each building.

6.8.4.6. Normally utilize the standard gas pressure from utility provider's building regulator of 5.3 ounces. If higher pressures are needed, coordinate those requirements with the utility provider. Additionally, provide the utility provider with their required flow rate and expected gas usage diversity. Provide an allowance of $25,000.00 for the costs associated with the installation and design that will be required by CPS Energy for the new natural service extension to the site. The Contractor is responsible for all costs associated with the natural gas service to the site in accordance with the requirements of CPS Energy. Do not contact CPS Energy for pricing during the bidding process..

6.9. SITE ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

6.9.1. Power

Primary electrical power is privatized and owned by City Public Service (CPS). Both temporary and permanent power for buildings will be provided by CPS Energy. The solicitation drawings show a suggested route for distribution based on CPS Energy standards. A separate bid item is included in this request for proposal with CPS Energy's preliminary connection charge. CPS will perform electrical field surveys at the D/B Contractor's expense. There will be a charge for any upgrades to the primary distribution system (both overhead and underground). For complete design and connection details

6.9.2. Lighting:

Electrical Service - Following is a description of the proposed electrical utility requirements during RFP preparation.

The contractor shall verify this information during proposal development:

Power: The building will be fed from a pad mounted transformer that is to be provided by CPS Energy, but paid for with MILCON dollars. The service will be 480Y/277 volts, 3-phase, 4-wire for large mechanical loads and lighting. 208Y/120 volt, 3-phase, 4-wire dry type transformers will be provided in the facility to provide power to receptacle loads and computers. Primary voltage to be determined by CPS dpending upon their source requirements.

Exterior and Interior Electrical systems: Exterior electrical systems will consist of extension of existing primary power to the project site by CPS Energy, pad mounted transformer, secondary into building, site lighting, and fire alarm connection to PIV valve.

Interior electrical systems will consist of power, lighting, electrical distribution to mechanical equipment, fire alarm/mass notification, special systems, and communications.

Exterior Lighting: Provide photodiode sensor and astronomical time clock based controls for parking lot lighting. Light levels should be in accordance with UFC requirements and the use of cut-off fixtures to reduce light pollution is required. Review exterior lighting designs with Fort Sam Houston DPW personnel to assess and reduce or eliminate potential light pollution issues. Provide photovoltaic powered bollard type lighting for exterior walkways.

Interior Lighting, Warehouse: Provide photodiode sensor based dimming controls for warehouse area lighting. Select lighting system based upon economic performance and life cycle costs.

Lightning and Cathodic Protection: Lightning protection will be provided in accordance with NFPA 780 Standard for the Installation of Lightning Protection Systems. Cathodic protection will not be required unless the designer decides to use steel piping underground.

Intrusion Detection Systems: The 1391 states that the IDS will be provided by the contractor. The only location in the facility using IDS is the Vault area. The contractor will install the conduit and install the junction boxes for Government Furnished/Government Installed (GFGI) equipment and devices.

Public Address System/Mass Notification System: A combination fire alarm/mass notification system will be provided for the facility. The system will be installed in accordance with UFC 4-021-01Design and O&M: Mass Notification Systems. The mass notification system will also be capable of being used as a public address system.Fire/smoke detcctors in the duct work will have the capability of shutting down the HVAC systems in the event of an emergency.

Additional Electrical Requirements: For ACS equipment, the design-build contractor will only provide electrical power and an infrastructure system including conduit with pull strings, boxes, etc. for use by the ACS contractor.

When calculating electrical load for the building, provide for a battery charger station for a typical 4,000-pound capacity electrcial lift truck for warehouse use.

6.9.3. Telecommunications

Site telecommunications access is available in the maintenance hole located at along Garden Avenue, on the side of the road opposite to the site.

Additional information regarding the telecommunications installation is included in Appendix JJ.

A new maintenance hole will be required on the facility side of Garden Avenue. The existing maintenance hole should be connected to the new maintenance hole by 4 each 4" PVC conduits. From the new maintenance hole to the comm room of the new TSC facility, extend 2 each 4" PVC conduits with pull string.

Maintenance Holes:

Maintenance Holes shall be communications specific and conform to 13A standards

Maintenance hole size shall be 12'X6'X7' (interior dimensions)

Maintenance Holes shall be equipped with pre-cast plastic terminators

The main terminators shall be oriented in the bottom half of the maintenance hole and center aligned

Break-out terminators shall be located on end walls only and be spaced 4" from the closest interior side wall and 4" from the top interior ceiling

Main conduit entrances shall be non-splayed configuration

All Maintenance Holes shall have the collar and cover located in the center of the top half of the manhole

All Maintenance Holes shall be provided with a galvanized steel ladder of sufficient length for ingress/egress capabilities

If the specific job dictates that the maintenance hole neck must be extended with additional collars, then galvanized steel collar steps/rungs must be installed

All new Maintenance Holes installed shall be equipped with a locking cover. The approved locking cover for Ft. Sam Houston and Camp Bullis is the *LockDown-LockDry Security System,* or equivalent or better with prior DOIM approval. See the enclosed attachment.

All new Maintenance Holes shall have the assigned maintenance hole number stenciled in the collar/neck of the manhole

On all Maintenance Holes (new and existing) all auxiliary lateral conduit entrances shall be accomplished from the end walls only.

All vacant conduits and inner-ducts shall be plugged with expandable duct plugs, both at the building location and the serving maintenance hole location. Tapered plugs (Flower-pots) are not acceptable.

Fiber optic duct plugs shall be installed on all fiber optic cables placed and contained within inner-duct. Any void between the duct/inner-duct/cable shall be filled with an acceptable water blocking compound. Expandable foam compound is not allowed inside buildings.

The contractor will be responsible for sealing all conduits/ducts/inner-ducts utilized during the placement of facilities for the assigned project.

Maintenance hole bonding and grounding

All Maintenance Holes shall be equipped with a ground rod of iron or steel that is galvanized or copper clad at least 5/8 inch in diameter and 9 feet in length. The ground rod shall be installed through the floor of the maintenance hole between 2-3 inches from the vertical surface of the adjacent wall. Four inches of the rod, plus or minus Y, inch, shall extend above the maintenance hole floor.

The bonding ribbon shall be attached to all rack anchors and be pre-cast into the manhole. The bonding ribbon shall be installed around the interior of the maintenance hole to provide bonding capabilities for splice cases.

Bonding ribbon shall be flat tinned copper material, similar to the type that is pre-cast into the manhole.

Note: Additional guidance is available in section 3.8.1 Maintenance Holes of the current issue of the 13A Guidelines issued July 2008.

6.10. FACILITY ELECTRICAL AND TELECOMMUNICATIONS SYSTEMS

6.10.1. Power

6.10.1.1. Connect the pulse initiator on the electric meter to the building's Direct Digital Control System. Connect meters to the Post wide Utility Control System (UCS).

6.10.1.2. Provide an exterior entrance to the main electrical room containing service equipment.

6.10.1.3. Locate panelboards in designated electrical rooms or non public areas. Do not install panel-boards in hallways or general access areas.

6.10.2. Telecommunications

6.10.2.1. Coordinate with the Directorate of Information Management (DOIM) during the design process. The POC for DOIM is Ms. Erma Brown at (210) 221-4546 or email at Erma.M.Brown@us.army.mil.

6.10.2.2. In waiting areas and courtyards (if applicable) provide one 8-pin modular jack in a single gang outlet faceplate with mounting lugs labeled "voice". In the mechanical room provide two 8-pin modular jacks (in addition to UFC requirement) in an outlet box with one labeled "voice" and the other "DDC".

6.10.2.3. Provide LC-LC patch cord for fiber patch panel.

6.10.2.4. Install pull wires in conduits which have spare capacity.

6.10.2.5. Provide fiber patch panels with LC connectors.

6.10.2.6. Coordinate with EMCS/UMCS paragraphs in section 01 10 00 to provide two 8-pin modular jacks adjacent to the Building Point of Connection hardware for connection to Fort SAM's existing EMCS.

6.10.2.7. Provide sufficient space on one of the walls in the main telecommunications room for a customer provided locked cabinet. Clear area for cabinet will be minimum 48 inches wide and 24 inces deep.

6.10.3. Cable TV (CATV)

See Appendix LL, Special Project Procedures for Fort Sam for additional requirements.

6.10.3.1. Route all CATV conduits and cables in accordance with specifications provided by local CATV provider. Provide 10' of slack for cables at the designated CATV box location.

6.10.4. Elevators (if applicable) shall have a dedicated "hot" telecommunications line to the fire department for emergency situations. Provide a 1" conduit with pull wire from the elevator machine room to the nearest telecommunications room.

6.11. HEATING, VENTILATING, AND AIR CONDITIONING

6.11.1. General: Integrate the control system to the installation's existing UMCS. The existing UMCS is FSH Industrial Grade Direct Digital Control System (IGDDCS) using Rockwell RSView Front End Operating Software.

6.11.2. System Selection:

6.11.2.1. HVAC System for Communications Room: All Communication Rooms shall have air-conditioning provided for cooling 365 days per year, regardless of outdoor air temperature.

6.11.2.2. HVAC System for Mechanical Room and other Service, Storage and Utility spaces: Mechanical, fire protection, electrical, and storage spaces shall be automatically ventilated to limit space temperatures to 10 degrees F above design outdoor air temperature.

6.11.3. EMCS

6.11.3.1. EMCS/UMCS at Fort Sam Houston: Fort Sam Houston does have a central utility monitoring and control system. The basewide UMCS system uses front end software RS View, Version 3.2 by Rockwell, to the individual buildings via a VLAN provided by ITBC. All heating, ventilating, and air-conditioning (HVAC) controls shall use a programmable logic control (PLC) based FSH Industrial Grade DDC System (IGDDCS). The PLC system shall be compatible with the Fort Sam Houston UMCS. PLC's shall be networked. All LAN equipment shall fully comply with IEEE 802.3 (10 BASE 2 or 10 Base T) Ethernet networks. See Specification 23 09 10.00 44 PROGRAMMABLE LOGIC CONTROL FOR HVAC (FORT SAM HOUSTON) in the Appendix for further requirements.

6.11.3.2. Integration of new facilities into the existing UMCS database and monitoring and controls software (such as the post-wide demand limiting) will require generation of custom graphics matching the style and complexity of the existing graphics. Integration of new facilities shall also include programming of alarm handling and demand load limiting which will require Directorate of Public Works (DPW) input for critical alarm lists and priority of building for demand load limiting. This will have to be done at the existing UMCS "front-end". Integration will be limited to experienced companies and personnel.

6.11.4. Water Quality Analysis and Treatment: Water quality for the installation and surrounding area is 'hard'. Treatment will be required for use as make-up water in HVAC equipment. Water analysis data from water treatment contractor and as given below:

- Chlorides: 20 ppm
- Total Alkalinity: 264 ppm
- Total Hardness: 292 ppm (CaCO3)
- Calcium: 81 ppm
- Magnesium: 23 ppm
- Total Dissolved Solids: 321 ppm

Coordinate with water treatment contractor to confirm water data and current water treatment methods to obtain the required quantity and types of chemicals to be initially introduced into the closed loop heating and condensing water systems.

6.11.5. Mandatory Equipment Requirements: All mechanical equipment shall automatically restart after a power outage. Provide equipment such as low water boiler cut-offs and controls that can restart in a normal mode after power is restored. Protect all mechanical equipment and controls against power surges and low and high supply voltage situations. Power loss, surges or low or high voltage shall not in any way effect HVAC or plumbing equipment or controls, set points, controls bindings etc.

6.12. ENERGY CONSERVATION

6.12.1. Inclusion of Renewable Energy Features. The following renewable energy features have been determined lifecycle cost effective, are included in the project budget and shall be provided:

6.12.2. Minimize roof penetrations.

6.13. FIRE PROTECTION

6.13.1. The Fire Alarm Control Panel shall be fully compatible with the existing Monaco presently in use at Fort Sam Houston.

6.13.1.1. The RF transceiver shall be a Monaco BT-X2 or approved equal.

6.13.1.2. The Fire alarm receiving system is a Monaco D-21 system.

6.13.1.3. Provide a remote enunciator panel for the fire alarm system.

6.13.1.4. Key all fire alarm equipment. Keys shall be per Fort Sam Houston requirements.

6.13.1.5. All tamper devices shall be supervised with supervisory signals sent to the Fort Sam Houston monitoring station.

6.13.1.6. Mark aire lanes in accordance with Fort Sam Houston requirements.

6.13.1.7. All FA tampers (PIV, valves, etc.) shall have cover tampers.

6.13.1.8. Provide a list of special tools and spare parts for the fire alarm and fire sprinkler systems. List shall include cost and source of supply for each item. In addition, provide a copy of computer software and technical data for the fire alarm system. Computer software shall include any special hardware required to operate the system.

6.13.2. Fire Sprinkler System

6.13.2.1. The water flow data given in this RFP is historical water flow data taken near this project site. Refer to Appendix D for the water flow test data. Verify this water flow data with a Contractor performed flow test. If the test indicates that the available flow or pressure has deteriorated from the data given in this RFP, bring this to the attention of the Government. If the test indicates that the available water flow or pressure has not deteriorated, use the water flow test data given in this RFP as the basis of design for the fire extinguishing systems.

6.13.2.2. Perform the water flow test at hydrants near to this project site. Perform flow testin accordance with the procedures contained in NFPA 291 to determine the available water supply. Report the flow test using a form containing all the data and having the same format as on the Sample Report of a Hydrant Flow Test found in NFPA 291. A fire protection engineer or an engineer experienced in water flow testing shall perform or witness the required flow tests prior to the first sprinkler system design submittal. Submit the qualifications of the engineer performing or witnessing the test. The Government won't concur with the sprinkler system design before the Government concurs with the water flow tests.

6.13.2.3. Identify and locate the test hydrants on the sprinkler system submittal drawings.

6.13.2.4. Install a double detector check assembly on the fire water service line for the building. Systems utilizing antifreeze require reduced pressure principle backflow preventers. Backflow preventers shall pass certification testing for compliance with Title 30 Texas Administrative Code Rule 290.44(h).

6.13.2.5. Install fire risers in dedicated space or mechanical room with external access for fire department.

6.13.3. Fire Alarm System

The fire alarm system shall send a trouble signal to the Installation's central fire receiving station for the Post Indicator Valve. Central receiving station is a radio based Monaco system.

6.13.4. Mass Notification System (MNS)

Program the MNS with standard Fort Sam Houston prerecorded messages. Ft. Sam personnel will provide messages thru the Contracting Officer's Representative.

Fire Alarms: A combination Class A fully addressable fire alarm/mass notification system will be provided for the facility. The system will be installed in accordance with UFC 3-600-01 Fire Protection Engineering for Facilities, and applicable NFPA codes. Ft. Sam Houston uses a Monaco FM radio transmitter for alarm communications. The Fire alarm control panel (FACP) shall be located in the mechanical room. Backup batteries will be provided for the FACP. A backup generator shall not be used to serve the FACP.

Early Suppression Fast Response (ESFR) sprinkler heads, if used, require special consideration in location with respect to the warehouse racks and structural steel. If these types of heads are placed above the rack, adequate flue space and clearances must be maintained to allow proper operation.

6.14. SUSTAINABLE DESIGN

6.14.1. LEED Rating Tool Version. This project shall be executed using LEED-NC Version 2.2.

6.14.2. The minimum requirement for this project is to achieve LEED Silver level. Each non-exempt facility (building plus sitework) must achieve this level. In addition to any facilities indicated as exempt in paragraph 3, the following facilities are exempt from the minimum LEED achievement requirement: None.

6.14.3. Credit Validation: LEED registration, compiling of documentation at LEED OnLine and use of the LEED Letter Templates is required. Registration and payment of registration fees will be by the Government. Administration/team management of the online project will be by the Contractor. Validation of credits will be accomplished by the Government. LEED certification of the project by the Contractor is not required. The Government may choose to seek LEED certification of the project, in which case the Government will pay certification fees and coordinate with the GBCI and the Contractor will furnish audit data as requested at no additional cost.

6.14.4. Commissioning: See Appendix M for Owner’s Project Requirements document(s).

6.14.5. LEED Credits Coordination. The following information is provided relative to Sustainable Sites and other credits.

SS Credit 1 Site Selection:

Project site IS NOT considered prime farmland.

Delineation of 100-year flood elevation is shown on site drawings provided in this CONTRACT.

Delineation of threatened or endangered species habitat is shown on site drawings provided in this CONTRACT.

Delineation of water, wetlands and areas of special concern is shown on site drawings provided in this CONTRACT.

Project site WAS NOT previously used as public parkland.

SS Credit 2 Development Density & Community Connectivity.

Project site DOES NOT meets the criteria for this credit.

SS Credit 3 Brownfield Redevelopment.

Project site DOES NOT meets the criteria for this credit.

SS Credit 4.1 Public Transportation Access.

Project site DOES NOT meets the criteria for this credit.

EA Credit 6 Green Power.

35% of the project's electricity WILL NOT will be provided through an Installation renewable energy contract. Do not purchase Renewable Energy Credits (REC's) to earn this credit.

MR Credit 2 Construction Waste Management.

The Installation does not have an on-post recycling facility available for Contractor's use.

6.14.6. LEED Credit Preferences, Guidance and Resources. See Appendix L LEED Project Credit Guidance for supplemental information relating to individual credits.

6.14.7. Not Used

6.14.8. Additional Information

No additional requirements.

6.15. ENVIRONMENTAL

CPS Energy may offers rebate programs. Check their website for additional information at: http://www.cpsenergy.com.

6.16. PERMITS

FSH digging permit is required by DPW. Mr. Carlos Herrera will fill out the top part to include the control number and date and will schedule the FSH DPW utility locators.

The contractor is responsible for notifying and scheduling the private utility companies for locations. The contractor is also responsible to obtain concurrences and signatures from FSH DPW.

Any "hot work" permits shall be obtained from the FSH DPW Fire Dept.

The SWPPP permit will be handled by USACE, the A/E and the FSH Environmental Dept.

The "Special Project Procedure" will be handled by USACE, the A/E, and NEC.

6.17. DEMOLITION

Remove and dispose of all existing asphalt paving on site. The removed material is not be reused as aprt of the new construction unless as a recycled product.

6.18. ADDITIONAL FACILITIES

A Covered Storage shed is required, as shown on the drawings.

Dust Collection Systems: The TSC Fabrication Shop woodworking and plastics working equipment is primarily for small repairs and minor fabrication. It is recommended that the dust collection system be limited to either dust collectors at each machine which are normally less than 500 CFM or group multiple woodworking machines to use an enclosureless bag-type dust collector where two or more woodworking machines could be connected and having an aggregate of less than a1500 CFM. If the woodworking dust collection system exceeds 1500 CFM, it exceeds the threshold and requires full compliance with NFPA 664-2007 “Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities” NFPA 664 requires fire protection sprinklers inside the dust collection system ductwork and in the dust collector located outside of the building along with several other costly items such as non combustibles duct work that is electrically bonded and grounded along with individual woodworking machine interlocks to the dust collection system etc. By the user purchasing individual woodworking machine with dust collectors under 500 CFM or grouping machines and using an enclosureless bag-type dust collectors (EDC) below 1500 CFM, the air can be exhausted back to the building space eliminating the need for additional conditioned make-up air and special fire protection systems.

End of Section 01 10 00

SECTION 01 32 01.00 10
PROJECT SCHEDULE

1.0 GENERAL

1.1. REFERENCES

1.2. QUALIFICATION

2.0 PRODUCTS (NOT APPLICABLE)

3.0 EXECUTION

3.1. GENERAL REQUIREMENTS

3.2. BASIS FOR PAYMENT AND COST LOADING

3.3. PROJECT SCHEDULE DETAILED REQUIREMENTS

3.4. PROJECT SCHEDULE SUBMISSIONS

3.5. SUBMISSION REQUIREMENTS

3.6. PERIODIC SCHEDULE UPDATE MEETINGS

3.7. REQUESTS FOR TIME EXTENSIONS

3.8. DIRECTED CHANGES

3.9. WEEKLY PROGRESS MEETINGS

3.10. OWNERSHIP OF FLOAT

3.11. TRANSFER OF SCHEDULE DATA INTO RMS/QCS

1.0 GENERAL

1.1. REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

- U.S. ARMY CORPS OF ENGINEERS (USACE) ER 1-1-11 (1995) Progress, Schedules, and Network Analysis Systems http://www.usace.army.mil/publications/eng-regs/er1-1-11/entire.pdf

1.2. QUALIFICATIONS

Designate an authorized representative who shall be responsible for the preparation of the schedule and all required updating (statusing) and preparation of reports. The authorized representative shall be experienced in scheduling projects similar in nature to this project and shall be experienced in the use of the scheduling software that meets the requirements of this specification.

2.0 PRODUCTS (Not Applicable)

3.0 EXECUTION

3.1. GENERAL REQUIREMENTS

3.1.1. Submit a project schedule as specified herein for approval showing the sequence in which the Contractor proposes to perform the work and dates on which the Contractor contemplates starting and completing all schedule activities. The scheduling of the entire project, including the design and construction sequences is required. Contractor management personnel shall actively participate in its development. Designers, subcontractors and suppliers working on the project shall also contribute in developing an accurate project schedule. The schedule must be a forward planning as well as a project monitoring tool. The approved project schedule shall be used to measure the progress of the work and to aid in evaluating requests for excusable time extensions. The schedule shall be cost loaded and activity coded as specified herein. The schedule will provide the basis for all progress payments. If the Contractor fails to submit any schedule within the time prescribed, the Contracting Officer may withhold approval of progress payments until the Contractor submits the required schedule

3.1.2. Status the schedule on at least a monthly basis, as specified herein. If in the opinion of the Contracting Officer, the Contractor falls behind the approved schedule, the Contractor shall take steps necessary to improve its progress including those that may be required by the Contracting Officer, without additional cost to the Government. In this circumstance, the Contracting Officer may require the Contractor to increase the number of shifts, overtime operations, days of work, and/or the amount of construction plant, and to submit for approval any supplementary schedule or schedules as the Contracting Officer deems necessary to demonstrate how the approved rate of progress will be regained. See paragraph 3.7.4.

3.1.3. Failure of the Contractor to comply with the requirements of the Contracting Officer shall be grounds for a determination by the Contracting Officer that the Contractor is not prosecuting the work with sufficient diligence to ensure completion within the time specified in the contract. Upon making this determination, the Contracting Officer may terminate the Contractor's right to proceed with the work, or any separable part of it, in accordance with the default terms of the contract.

3.2. BASIS FOR PAYMENT AND COST LOADING

The schedule shall be the basis for determining contract earnings during each update period and therefore the amount of each progress payment. Lack of an approved schedule update or qualified scheduling personnel will result in an inability of the Contracting Officer to evaluate contract earned value for the purposes of payment. Failure of the Contractor to provide all information, as specified herein will result in the disapproval of the preliminary, initial and subsequent schedule updates. In the event schedule revisions are directed by the Contracting Officer and those revisions have not been included in subsequent revisions or updates, the Contracting Officer may hold retainage up to the maximum allowed by contract, each payment period, until such revisions to the project schedule have been made. Activity cost loading shall be reasonable as determined by the Contracting Officer. The aggregate value of all activities coded to a contract CLIN as specified herein shall equal the value of the CLIN on the Schedule.

3.3. PROJECT SCHEDULE DETAILED REQUIREMENTS

The computer software system utilized to produce and update the project schedule shall be capable of meeting all requirements of this specification. Failure of the Contractor to meet the requirements of this specification will result in the disapproval of the schedule. Scheduling software that meets the activity coding structure defined in the Standard Data Exchange Format (SDEF) in ER-1-1-11(1995) referenced herein are Primavera Project Planner (P3) by Primavera, and Open Plan by Deltek.

3.3.1. Use of the Critical Path Method

Use the Critical Path Method (CPM) of network calculation to generate the project schedule. Prepare the project schedule using the Precedence Diagram Method (PDM).

3.3.2. Level of Detail Required

Develop the project schedule to an appropriate level of detail. Failure to develop the project schedule to an appropriate level of detail, as determined by the Contracting Officer, will result in its disapproval. The Contracting Officer will consider, but is not limited to, the following characteristics and requirements to determine appropriate level of detail:

3.3.2.1. Activity Durations

Reasonable activity durations are those that allow the progress of ongoing activities to be accurately determined between update periods. Less than 2 percent of all non-procurement activities shall have Original Durations (OD) greater than 20 work days or 30 calendar days. Procurement activities are defined herein.

3.3.2.2. Design and Permit Activities

Include design and permit activities, including necessary conferences and follow-up actions and design package submission activities. Include the design schedule in the project schedule, showing the sequence of events involved in carrying out the project design tasks within the specific contract period. This shall be at a detailed level of scheduling sufficient to identify all major design tasks, including those that control the flow of work. Include review and correction periods associated with each item.

3.3.2.3. Procurement Activities

Include activities associated with the submittal, approval, procurement, fabrication and delivery of long lead materials, equipment, fabricated assemblies and supplies. Long lead procurement activities are those with an anticipated procurement sequence of over 90 calendar days. A typical procurement sequence includes the string of activities: submit, approve/review, procure, fabricate, and deliver.

3.3.2.4. Mandatory Tasks

Include and properly schedule the following tasks (See also the Sample Preliminary Submittal Register Input Form):

3.3.2.4.1. Submission, review and acceptance of design packages, including BIM

3.3.2.4.2. Submission of mechanical/electrical/information systems layout drawings

3.3.2.4.3. Submission and approval of O & M manuals

3.3.2.4.4. Submission and approval of as-built drawings

3.3.2.4.5. Submission and approval of 1354 data and installed equipment lists

3.3.2.4.6. Submission and approval of testing and air balance (TAB)

3.3.2.4.7. Submission of TAB specialist design review report

3.3.2.4.8. Submission and approval of fire protection specialist

3.3.2.4.9. Submission and approval of testing and balancing of HVAC plus commissioning plans and data. Develop the schedule logic associated with testing and commissioning of mechanical systems to a level of detail consistent with the contract commissioning requirements.

3.3.2.4.10. Air and water balancing

3.3.2.4.11. HVAC commissioning

3.3.2.4.12. Controls testing plan submission

3.3.2.4.13. Controls testing

3.3.2.4.14. Performance Verification testing

3.3.2.4.15. Other systems testing, if required

3.3.2.4.16. Contractor's pre-final inspection

3.3.2.4.17. Correction of punch list from Contractor's pre-final inspection

3.3.2.4.18. Government's pre-final inspection

3.3.2.4.19. Correction of punch list from Government's pre-final inspection

3.3.2.4.20. Final Inspection

3.3.2.5. Government Activities. Show Government and other agency activities that could impact progress. These activities include but are not limited to: approvals, design reviews, review conferences, release for construction of design package(s), environmental permit approvals by State regulators, inspections, utility tie-ins, Government Furnished Property/Equipment (GFP) and Notice to Proceed for phasing requirements, if any.

3.3.2.6. Activity Responsibility Coding (RESP)

Assign Responsibility Code for all activities to the Prime Contractor, Subcontractor or Government agency responsible for performing the activity. Activities coded with a Government Responsibility code include, but are not limited to: Government approvals, Government design reviews, environmental permit approvals by State regulators, Government Furnished Equipment (GFE) and Notice to Proceed (NTP) for phasing requirements. Code all activities not coded with a Government Responsibility Code to the Prime Contractor or Subcontractor responsible to perform the work. Activities shall not have more than one Responsibility Code. Examples of acceptable activity code values are: DOR (for the designer of record); ELEC (for the electrical subcontractor); MECH (for the mechanical subcontractor); and GOVT (for USACE). Unacceptable code values are abbreviations of the names of subcontractors.

3.3.2.7. Activity Work Area Coding (AREA)

Assign Work Area code to activities based upon the work area in which the activity occurs. Define work areas based on resource constraints or space constraints that would preclude a resource, such as a particular trade or craft work crew from working in more than one work area at a time due to restraints on resources or space. Examples of Work Area Coding include different areas within a floor of a building, different floors within a building, and different buildings within a complex of buildings. Activities shall not have more than one Work Area Code. Not all activities are required to be Work Area coded. A lack of Work Area coding will indicate the activity is not resource or space constrained.

3.3.2.8. Contract Changes/Requests for Equitable Adjustment (REA) Coding (MODF)

Assign Activity code to any activity or sequence of activities added to the schedule as a result of a Contract Modification, when approved by Contracting Officer, with a Contract Changes/REA Code. Key all Code values to

the Government's modification numbering system. Any activity or sequence of activities added to the schedule as a result of alleged constructive changes made by the Government may be added to a copy of the current schedule, subject to the approval of the Contracting Officer. Assign Activity codes for these activities with a Contract Changes/REA Code. Key the code values to the Contractor's numbering system. Approval to add these activities does not necessarily mean the Government accepts responsibility and therefore liability for such activities and any associated impacts to the schedule, but rather the Government recognizes such activities are appropriately added to the schedule for the purposes of maintaining a realistic and meaningful schedule. Such activities shall not be Responsibility Coded to the Government unless approved. An activity shall not have more than one Contract Changes/REA Code

3.3.2.9. Contract Line Item (CLIN) Coding (BIDI)

Code all activities to the CLIN on the Contract Line Item Schedule to which the activity belongs. An activity shall not contain more than one CLIN Item Code. CLIN Item code all activities, even when an activity is not cost loaded.

3.3.2.10. Phase of Work Coding (PHAS)

Assign Phase of Work Code to all activities, based upon the phase of work in which the activity occurs. Code activities to either a Design Phase or a Construction Phase. Code fast track design and construction phases proposed by the Contractor to allow filtering and organizing the schedule by fast track design and construction packages. If the contract specifies construction phasing with separately defined performance periods, identify a Construction Phase Code to allow filtering and organizing the schedule accordingly. Each activity shall have only one Phase of Work code.

3.3.2.11. Category of Work Coding (CATW)

Assign Category of Work code to all Activities based upon the category of work which the activity belongs. Category of Work Code must include, but is not limited to: Design, Design Submittal, design reviews, review conferences, Construction Submittal, Approvals (if any), Acceptance, Procurement, Fabrication, Delivery, Weather Sensitive Installation, Non-Weather Sensitive Installation, Start Up, Test, and Turnover. Assign a Category of Work code to each activity. Each activity shall have only one Category of Work Code.

3.3.2.12. Definable Features of Work Coding (FOW1, FOW2, FOW3)

Assign a Definable Feature of Work Code to appropriate activities based on the definable feature of work to which the activity belongs. Definable Feature of Work is defined in Specification Section 01 45 04.00 10, Contractor Quality Control. An activity shall not have more than one Definable Feature of Work Code. Not all activities are required to be Definable Feature of Work Coded.

3.3.3. Scheduled Project Completion and Activity Calendars

The schedule interval shall extend from NTP date to the required contract completion date. The contract completion activity (End Project) shall finish based on the required contract duration, as adjusted for any approved contract time extensions. The first scheduled work period shall be the day after NTP is acknowledged by the Contractor. Schedule activities on a calendar to which the activity logically belongs. Activities may be assigned to a 7 day calendar when the contract assigns calendar day durations for the activity such as a Government Acceptance activity. If the Contractor intends to perform physical work less than seven days per week, schedule the associated activities on a calendar with non-work periods identified including weekends and holidays. Assign the Category of Work Code - Weather Sensitive Installation to those activities that are weather sensitive. Original durations must account for anticipated normal adverse weather. The Government will interpret all work periods not identified as non-work periods on each calendar as meaning the Contractor intends to perform work during those periods.

3.3.3.1. Project Start Date

The schedule shall start no earlier than the date on which the NTP was acknowledged. Include as the first activity in the project schedule an activity called "Start Project" or "NTP". The "Start Project" activity shall have an "ES" constraint date equal to the date that the NTP was acknowledged, with a zero day duration.

3.3.3.2. Schedule Constraints and Open Ended Logic

Constrain completion of the last activity in the schedule by the contract completion date. Schedule calculations shall result in negative float when the calculated early finish date of the last activity is later than the contract completion date. Include as the last activity in the project schedule an activity called "End Project". The "End Project" activity shall have an "LF" constraint date equal to the contract completion date for the project, and with a zero day duration or by using the “project must finish by” date in the scheduling software. The schedule shall have no constrained dates other than those specified in the contract. The use of artificial float constraints such as “zero fee float” or “zero total float” are typically prohibited. There shall only be 2 open ended activities: Start Project (or NTP) with no predecessor logic and End Project with no successor logic.

3.3.3.3. Early Project Completion

In the event the Preliminary or Initial project schedule calculates an early completion date of the last activity prior to the contract completion date, the Contractor shall identify those activities that it intends to accelerate and/or those activities that are scheduled in parallel to support the Contractor's "early" completion. The last activity shall have a late finish constraint equal to the contract completion date and the schedule will calculate positive float. The Government will not approve an early completion schedule with zero float on the longest path. The Government is under no obligation to accelerate activities for which it is responsible to support a proposed early contract completion.

3.3.4. Interim Completion Dates

Constrain contractually specified interim completion dates to show negative float when the calculated early finish date of the last activity in that phase is later than the specified interim completion date.

3.3.4.1. Start Phase

Include as the first activity for a project phase an activity called "Start Phase X" where "X" refers to the phase of work. The “Start Phase X" activity shall have an "ES" constraint date equal to the date on which the NTP was acknowledged, and a zero day duration.

3.3.4.2. End Phase

Include as the last activity for a project phase an activity called "End Phase X" where "X" refers to the phase of work. The "End Phase X" activity shall have an "LF" constraint date equal to the specified completion date for that phase and a zero day duration.

3.3.4.3. Phase “X” Hammock

Include a hammock type activity for each project phase called "Phase X" where "X" refers to the phase of work. The "Phase X" hammock activity shall be logically tied to the earliest and latest activities in the phase.

3.3.5. Default Progress Data Disallowed

Do not automatically update Actual Start and Finish dates with default mechanisms that may be included in the scheduling software. Activity Actual Start (AS) and Actual Finish (AF) dates assigned during the updating process shall match those dates provided from Contractor Quality Control Reports. Failure of the Contractor to document the AS and AF dates on the Daily Quality Control report for every in-progress or completed activity, and failure to ensure that the data contained on the Daily Quality Control reports is the sole basis for schedule updating shall result in the disapproval of the Contractor's updated schedule and the inability of the Contracting Officer to evaluate Contractor progress for payment purposes. Updating of the percent complete and the remaining duration of any activity shall be independent functions. Disable program features which calculate one of these parameters from the other.

3.3.6. Out-of-Sequence Progress

Activities that have progressed before all preceding logic has been satisfied (Out-of-Sequence Progress) will be allowed only on a case-by-case basis subject to approval by the Contracting Officer. Propose logic corrections to eliminate all out of sequence progress or justify not changing the sequencing for approval prior to submitting an

updated project schedule. Correct out of sequence progress that continues for more than two update cycles by logic revision, as approved by the Contracting Officer.

3.3.7. Negative Lags and Start to Finish Relationships

Lag durations contained in the project schedule shall not have a negative value. Do not use Start to Finish relationships (SF).

3.3.8. Calculation Mode

Schedule calculations shall retain the logic between predecessors and successors even when the successor activity starts and the predecessor activity has not finished. Software features that in effect sever the tie between predecessor and successor activities when the successor has started and the predecessor logic is not satisfied ("progress override") will not be allowed.

3.3.9. Milestones

Include milestone activities for each significant project event including but not limited to: milestone activities for each fast track design package released for construction; design complete; foundation/substructure construction complete; superstructure construction complete; building dry-in or enclosure complete to allow the initiation of finish activities; permanent power complete; and building systems commissioning complete.

3.4. PROJECT SCHEDULE SUBMISSIONS

Provide the submissions as described below. The data CD, reports, and network diagrams required for each submission are contained in paragraph SUBMISSION REQUIREMENTS.

3.4.1. Preliminary Project Schedule Submission

Submit the Preliminary Project Schedule, defining the Contractor's planned operations for the first 90 calendar days for approval within 15 calendar days after the NTP is acknowledged. The approved Preliminary Project Schedule will be used for payment purposes not to exceed 90 calendar days after NTP. Completely cost load the Preliminary Project Schedule to balance the contract award CLINS shown on the Price Schedule. Detail it for the first 90 calendar days. It may be summary in nature for the remaining performance period. It must be early start and late finish constrained and logically tied as previously specified. The Preliminary Project Schedule forms the basis for the Initial Project Schedule specified herein and must include all of the required Plan and Program preparations, submissions and approvals identified in the contract (for example, Quality Control Plan, Safety Plan, and Environmental Protection Plan) as well as design activities, the planned submissions of all early design packages, permitting activities, design review conference activities and other non-construction activities intended to occur within the first 90 calendar days. Schedule any construction activities planned for the first 90 calendar days after NTP. Constrain planned construction activities by Government acceptance of the associated design package(s) and all other specified Program and Plan approvals. Activity code any activities that are summary in nature after the first 90 calendar days with Responsibility Code (RESP) and Feature of Work code (FOW1, FOW2, FOW3)

3.4.2. Initial Project Schedule Submission

Submit the Initial Project Schedule for approval within 42 calendar days after NTP. The schedule shall demonstrate a reasonable and realistic sequence of activities which represent all work through the entire contract performance period. The Initial Schedule shall be at a reasonable level of detail as determined by the Contracting Officer. Include detailed design and permitting activities, including but not limited to identification of individual design packages, design submission, reviews and conferences; permit submissions and any required Government actions; and long lead procurement activities required prior to design completion. The Initial Project Schedule shall include the entire construction sequence and all fast track construction activities, with as much detail as is known at the time but, as a minimum, shall include all construction start and completion milestone activities, and detailed construction activities through the dry-in milestone, including all activity coding and cost loading. Include the remaining construction, including cost loading, but it may be scheduled summary in nature. As the design proceeds and design packages are developed, fully detail the remaining construction activities concurrent with the monthly schedule updating process. Constrain construction activities by Government acceptance of associated

designs. When the design is complete, incorporate into the then approved schedule update all remaining detailed construction activities that are planned to occur after the dry-in milestone.

3.4.3. Design Package Schedule Submission:

With each design package submitted to the Government, submit a frag-net schedule extracted from the then current Preliminary, Initial or Updated schedule which covers the activities associated with that Design Package including construction, procurement and permitting activities.

3.4.4. Periodic Schedule Updates

Based on the result of the meeting specified in PERIODIC SCHEDULE UPDATE MEETINGS, submit periodic schedule updates. These submissions shall enable the Contracting Officer to assess Contractor's progress. If the Contractor fails or refuses to furnish the information and project schedule data, which in the judgment of the Contracting Officer or authorized representative is necessary for verifying the Contractor's progress, the Contractor shall be deemed not to have provided an estimate upon which progress payment may be made. Update the schedule to include detailed lower WBS activities procurement and construction activities as the design progresses, but not later than the submission of the final, un-reviewed design submission for each separate design package. The Contracting Officer may require submission of detailed schedule activities for any distinct construction that is started prior to submission of a final design submission, if such activity is authorized.

3.4.5. Standard Activity Coding Dictionary

Use the activity coding structure defined in the Standard Data Exchange Format (SDEF) in ER 1-1-11, Appendix A. This exact structure is mandatory, even if some fields are not used. A template SDEF compatible schedule backup file (sdef.prx) is available on the QCS website: www.rmssupport.com. The SDEF format is as follows:

Field	Activity Code	Length	Description
1	WRKP	3	Workers per Day
2	RESP	4	Responsible Party (e.g. GC, subcontractor, USACE)
3	AREA	4	Area of Work
4	MODF	6	Modification or REA number
5	BIDI	6	Bid Item (CLIN)
6	PHAS	2	Phase of Work
7	CATW	1	Category of Work
8	FOW1	10	Feature of Work (used up to 10 characters in length)
9	FOW2	10	Feature of Work (used up to 20 characters in length)
10	FOW3	10	Feature of Work (used up to 30 characters in length)

3.5. SUBMISSION REQUIREMENTS

Submit the following items for the Preliminary Schedule, Initial Schedule, and every Periodic Schedule Update throughout the life of the project:

3.5.1. Data CD's

Provide two sets of data CD's containing the project schedule in the backup format. Each CD shall also contain all previous update backup files. File medium shall be CD. Label each CD, indicating the type of schedule (Preliminary, Initial, Update), full contract number, Data Date and file names. Each schedule shall have a unique file name as determined by the Contractor.

3.5.2. Narrative Report

Provide a Narrative Report with the Preliminary, Initial, and each Periodic Update of the project schedule, as the basis of the progress payment request. The Narrative Report shall include: a description of activities along the 2 most critical paths where the total float is less than or equal to 20 work days, a description of current and anticipated problem areas or delaying factors and their impact, and an explanation of corrective actions taken or required to be taken. The narrative report is expected to communicate to the Government, the Contractor's thorough analysis of the schedule output and its plans to compensate for any problems, either current or potential, which are revealed through its analysis. Identify and explain why any activities that, based their calculated late dates, should have either started or finished during the update period but did not.

3.5.3. Approved Changes Verification

Include only those project schedule changes in the schedule submission that have been previously approved by the Contracting Officer. The Narrative Report shall specifically reference, on an activity by activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes.

3.5.4. Schedule Reports

The format, filtering, organizing and sorting for each schedule report shall be as directed by the Contracting Officer. Typically reports shall contain: Activity Numbers, Activity Description, Original Duration, Remaining Duration, Early Start Date, Early Finish Date, Late Start Date, Late Finish Date Total Float, Actual Start Date, Actual Finish Date, and Percent Complete. The following lists typical reports that will be requested. One or all of these reports may be requested for each schedule submission.

3.5.4.1. Activity Report

A list of all activities sorted according to activity number.

3.5.4.2. Logic Report

A list of detailed predecessor and successor activities for every activity in ascending order sorted by activity number.

3.5.4.3. Total Float Report

A list of all incomplete activities sorted in ascending order of total float. List activities which have the same amount of total float in ascending order of Early Start Dates. Do not show completed activities on this report.

3.5.4.4. Earnings Report by CLIN

A compilation of the Contractor's Total Earnings on the project from the NTP to the data date. This report shall reflect the earnings of specific activities based on the agreements made in the schedule update meeting defined herein. Provided that the Contractor has provided a complete schedule update, this report shall serve as the basis of determining progress payments. Group activities by CLIN Item number and sort by activity number. This report shall: sum all activities coded to a particular CLIN and provide a CLIN Item percent earned value; and complete and sum CLIN items to provide a total project percent complete. The printed report shall contain, for each activity: the Activity Number, Activity Description, Original Budgeted Amount, Quantity to Date, Percent Complete (based on cost), and Earnings to Date.

3.5.5. Network Diagram

The network diagram is required for the Preliminary, Initial and Periodic Updates. Depict and display the order and interdependence of activities and the sequence in which the work is to be accomplished. The Contracting Officer will use, but is not limited to, the following conditions to review compliance with this paragraph:

3.5.5.1. Continuous Flow

Show a continuous flow from left to right with no arrows from right to left. Show the activity number, description, duration, and estimated earned value on the diagram.

3.5.5.2. Project Milestone Dates

Show dates on the diagram for start of project, any contract required interim completion dates, and contract completion dates.

3.5.5.3. Critical Path

Clearly show the critical path.

3.5.5.4. Banding

Organize activities as directed to assist in the understanding of the activity sequence. Typically, this flow will group activities by category of work, work area and/or responsibility.

3.5.5.5. S-Curves

Earnings curves showing projected early and late earnings and earnings to date.

3.6. PERIODIC SCHEDULE UPDATE MEETINGS

Conduct periodic schedule update meetings for the purposes of reviewing the Contractor’s proposed out of sequence corrections, determining causes for delay, correcting logic, maintaining schedule accuracy and determining earned value. Meetings shall occur at least monthly within five days of the proposed schedule data date and after the Contractor has updated the schedule with Government concurrence respecting actual start dates, actual finish dates, remaining durations and percent complete for each activity it intend to status. Match the acutal start and finish dates with the dates exported, as described in paragraph 3.3.5. Provide a computer with the scheduling software loaded and a projector during the meeting which allows all meeting participants to view the proposed schedule update during the meeting. The meeting and resultant approvable schedule update shall be a condition precedent to a formal submission of the update as described in SUBMISSION REQUIREMENTS and to the submission of an invoice for payment. The meeting will be a working interactive exchange which will allow the Government and the Contractor the opportunity review the updated schedule on a real time and interactive basis. The Contractor’s authorized scheduling representative will organize, sort, filter and schedule the update as requested by the Government. The meeting will last no longer than 8 hours. A rough draft of the proposed activity logic corrections and narrative report shall be provided to the Government 48 hours in advance of the meeting. The Contractor's Project Manager and Authorized Scheduler shall attend the meeting with the Authorized Representative of the Contracting Officer.

3.6.1. Update Submission Following Progress Meeting

Submit a complete update of the project schedule containing all approved progress, revisions, and adjustments, pursuant to paragraph SUBMISSION REQUIREMENTS not later than 4 working days after the periodic schedule update meeting, reflecting only those changes made during the previous update meeting.

3.6.2. Staus of Activities

Update statusing information, including Actual Start Dates (AS), Actual Finish Dates (AF), Remaining Durations (RD) and Percent Complete shall be subject to the approval of the Government prior to the meeting. As a minimum, address the following items on an activity by activity basis during each progress meeting:

3.6.2.1. Actual Start and Finish Dates

Accurately status the AS and/or AF dates for each activity currently in-progress or completed since the last update The Government may allow an AF date to be assigned with the percent complete less than 100% to account for the value of work remaining but not restraining successor activities. Only assign AS dates when actual progress occurs on an activity.

3.6.2.2. Remaining Duration

Update the estimated RD for all incomplete activities independent of Percent Complete. Remaining durations may exceed the activity OD or may exceed the activity's prior update RD if the Government considers the current OD or RD to be understated based on current progress, insufficient work crews actually manning the job, unrealistic OD or deficiencies that must be corrected that restrain successor activities.

3.6.2.3. Percent Complete

Update the percent complete for each activity started, based on the realistic assessment of earned value. Activities which are complete but for remaining minor punch list work and which do not restrain the initiation of successor activities may be statused 100 percent complete. To allow for proper schedule management, cost load the correction of punch list from Government pre-final inspection activity(ies) not less than 1% of the total contract value, which activity(ies) may be declared 100 percent complete upon completion and correction of all punch list work identified during Government pre-final inspection(s).

3.6.2.4. Logic Changes

Specifically identify and discuss all logic changes pertaining to NTP on change orders, change orders to be incorporated into the schedule, contractor proposed changes in work sequence, corrections to schedule logic for out-of-sequence progress, and other changes that have been made pursuant to contract provisions. The Government will only approve logic revisions for the purpose of keeping the schedule valid in terms of its usefulness in calculating a realistic completion date, correcting erroneous logic ties, and accurately sequencing the work.

3.6.2.5. Other Changes

Other changes required due to delays in completion of any activity or group of activities include: 1) delays beyond the Contractor's control, such as strikes and unusual weather. 2) delays encountered due to submittals, Government Activities, deliveries or work stoppages which make re-planning the work necessary. 3) Changes required to correct a schedule that does not represent the actual or planned prosecution and progress of the work.

3.7. REQUESTS FOR TIME EXTENSIONS

In the event the Contractor believes it is entitled to an extension of the contract performance period, completion date, or any interim milestone date, furnish the following for a determination by the Contracting Officer: justification, project schedule data, and supporting evidence as the Contracting Officer may deem necessary. Submission of proof of excusable delay, based on revised activity logic, duration, and costs (updated to the specific date that the delay occurred) is a condition precedent to any approvals by the Government. In response to each Request For Proposal issued by the Government, the Contractor shall submit a schedule impact analysis demonstrating whether or not the change contemplated by the Government impacts the critical path.

3.7.1. Justification of Delay

The project schedule shall clearly display that the Contractor has used, in full, all the float time available for the work involved with its request. The Contracting Officer's determination as to the number of allowable days of contract extension shall be based upon the project schedule updates in effect for the time period in question, and other factual information.

Actual delays that are found to be caused by the Contractor's own actions, which result in a calculated schedule delay, will not be a cause for an extension to the performance period, completion date, or any interim milestone date.

3.7.2. Submission Requirements

Submit a justification for each request for a change in the contract completion date of less than 2 weeks based upon the most recent schedule update at the time of the NTP or constructive direction issued for the change. Such a request shall be in accordance with the requirements of other appropriate Contract Clauses and shall include, as a minimum:

3.7.2.1. A list of affected activities, with their associated project schedule activity number.

3.7.2.2. A brief explanation of the causes of the change

3.7.2.3. An analysis of the overall impact of the changes proposed.

3.7.2.4. A sub-network of the affected area

Identify activities impacted in each justification for change by a unique activity code contained in the required data file.

3.7.3. Additional Submission Requirements

The Contracting Officer may request an interim update with revised activities for any requested time extension of over 2 weeks. Provide this disk within 4 days of the Contracting Officer's request.

3.7.4. If Progress Falls Behind the Approved Project Schedule

3.7.4.1. Should progress fall behind the approved schedule (more than 20 work days of negative float) due to Contractor generated problems, promptly provide a supplemental recovery or completion schedule that illustrates its efforts to regain time to assure a completion by the required contract completion date.

3.7.4.2. The supplemental recovery or completion schedule will not replace the original, approved schedule as the official contract schedule. Continue to update the original, approved schedule on at least a monthly basis. In addition, the Contractor and the Contracting Officer will monitor the supplemental recovery or completion schedule on at least a bi-weekly basis to determine its effect on regaining the rate of progress to assure project completion by the contractually required completion date.

3.7.4.3. Do not artificially improve progress by simply revising the schedule logic, modifying or adding constraints, or shortening future work activity durations. Resource and manpower load the supplemental recovery schedule or completion schedule with crew size and productivity for each remaining activity, indicating overtime, weekend work, and/or double shifts needed to regain the schedule, in accordance with FAR 52.236.15, without additional cost to the Government. Indicate assumptions made and the basis for any logic, constraint, or duration changes used in the creation of the supplemental recovery or completion schedule in a narrative submitted for the Contracting Officer’s approval. Any additional resources or manpower must be evident at the work site. Do not modify the official contract schedule to include these assumptions.

3.7.4.4. Failure to perform work and maintain progress in accordance with the supplemental recovery or completion schedule may result in an interim and final unsatisfactory performance rating and/or may result in corrective action by the Contracting Officer in accordance with FAR 52.236-15.

3.8. DIRECTED CHANGES

If the NTP is issued for changes prior to settlement of price and/or time, submit proposed schedule revisions to the Contracting Officer within 2 weeks of the NTP being issued. The Contracting Officer will approve proposed revisions to the schedule prior to inclusion of those changes within the project schedule. If the Contractor fails to submit the proposed revisions, the Contracting Officer may furnish the Contractor with suggested revisions to the project schedule. The Contractor shall include these revisions in the project schedule until revisions are submitted and final changes and impacts have been negotiated. If the Contractor has any objections to the revisions furnished by the Contracting Officer, advise the Contracting Officer within 2 weeks of receipt of the revisions. Regardless of the objections, the Contractor shall continue to update the schedule with the Contracting Officer's revisions until a mutual agreement in the revisions is reached. If the Contractor fails to submit alternative revisions within 2 weeks of

receipt of the Contracting Officer's proposed revisions, the Contractor will be deemed to have concurred with the Contracting Officer's proposed revisions. The proposed revisions will then be the basis for an equitable adjustment for performance of the work.

3.9. WEEKLY PROGRESS MEETINGS

3.9.1. The Government and the Contractor shall meet weekly (or as otherwise mutually agreed to) between the meetings described in paragraph PERIODIC SCHEDULE UPDATE MEETINGS for the purpose of jointly reviewing the actual progress of the project as compared to the as planned progress and to review planned activities for the upcoming two weeks. The then current and approved schedule update shall be used for the purposes of this meeting and for the production and review of reports. The Contractor’s Project Manager and the Authorized Representative of the Contracting Officer shall attend. The weekly progress meeting will address the status of RFI’s, RFP’s and Submittals.

3.9.2. Provide a bar chart produced by the scheduling software, organized by Total Float and Sorted by Early Start Date, and a two week “look-ahead” schedule by filtering all schedule activities to show only current ongoing activities and activities schedule to start during the upcoming two weeks, organized by Work Area Code (AREA) and sorted by Early Start Date.

3.9.3. The Government and the Contractor shall jointly review the reports. If it appears that activities on the longest path(s) which are currently driving the calculated completion date (driving activities), are not progressing satisfactorily and therefore could jeopardize timely project completion, corrective action must be taken immediately. Corrective action includes but is not limited to: increasing the number of work crews; increasing the number of work shifts; increasing the number of hours worked per shift; and determining if Government responsibility coded activities require Government corrective action.

3.10. OWNERSHIP OF FLOAT

Float available in the schedule, at any time, shall not be considered for the exclusive use of either the Government or the Contractor.

3.11. TRANSFER OF SCHEDULE DATA INTO RMS/QCS

Download and upload the schedule data into the Resident Management System (RMS) prior to RMS databases being transferred to the Government and is considered to be additional supporting data in a form and detail required by the Contracting Officer pursuant to FAR 52.232-5 - Payments under Fixed-Price Construction Contracts. The receipt of a proper payment request pursuant to FAR 52.232-27 - Prompt Payment for Construction Contracts is contingent upon the Government receiving both acceptable and approvable hard copies and electronic export from QCS of the application for progress payment.

End of Section 01 32 01.00 10

SECTION 01 33 00
SUBMITTAL PROCEDURES

1.0 GENERAL

1.1. DEFINITIONS

1.2. NOT USED

1.3. SUBMITTAL CLASSIFICATION

1.4. APPROVED OR CONCURRED WITH SUBMITTALS

1.5. DISAPPROVED SUBMITTALS

1.6. WITHHOLDING OF PAYMENT

1.7. GENERAL

1.8. SUBMITTAL REGISTER

1.9. SCHEDULING

1.10. TRANSMITTAL FORM (ENG FORM 4025)

1.11. SUBMITTAL PROCEDURES

1.12. CONTROL OF SUBMITTALS

1.13. GOVERNMENT APPROVED SUBMITTALS

1.14. INFORMATION ONLY SUBMITTALS

1.15. STAMPS

1.0 GENERAL

1.1. DEFINITIONS

1.1.1. Submittal

Contract Clauses "FAR 52.236-5, Material and Workmanship," paragraph (b) and "FAR 52.236-21, Specifications and Drawings for Construction," paragraphs (d), (e), and (f) apply to all "submittals."

1.1.2. Submittal Descriptions (SD)

Submittals requirements are specified in the technical sections. Submittals are identified by SD numbers and titles as follows.

SD-01 Preconstruction Submittals

- Certificates of insurance.
- Surety bonds.
- List of proposed subcontractors.
- List of proposed products.
- Construction Progress Schedule.
- Submittal register.
- Schedule of prices.
- Accident Prevention Plan.
- Work plan.
- Quality control plan.
- Environmental protection plan.

SD-02 Shop Drawings

- Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.
- Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Contractor for integrating the product or system into the project.
- Drawings prepared by or for the Contractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

- Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials or equipment for some portion of the work.
- Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

- Physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.
- Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.
- Field samples and mock-ups constructed on the project site establish standards by which the ensuring work can be judged. Includes assemblies or portions of assemblies that are to be incorporated into the project and those which will be removed at conclusion of the work.

SD-05 Design Data

- Calculations, mix designs, analyses or other data pertaining to a part of work.
- Design submittals, design substantiation submittals and extensions of design submittals.

SD-06 Test Reports

- Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. (Testing must

have been within three years of date of contract award for the project.)

- Report which includes findings of a test required to be performed by the Contractor on an actual portion of the work or prototype prepared for the project before shipment to job site.
- Report which includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.
- Investigation reports.
- Daily checklists.
- Final acceptance test and operational test procedure.

SD-07 Certificates

- Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that product, system or material meets specification requirements. Must be dated after award of project contract and clearly name the project.
- Document required of Contractor, or of a supplier, installer or subcontractor through Contractor, the purpose of which is to further quality of orderly progression of a portion of the work by documenting procedures, acceptability of methods or personnel qualifications.
- Confined space entry permits.
- Text of posted operating instructions.

SD-08 Manufacturer's Instructions

- Preprinted material describing installation of a product, system or material, including special notices and Material Safety Data sheets concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

- Documentation of the testing and verification actions taken by manufacturer's representative to confirm compliance with manufacturer's standards or instructions.
- Factory test reports.

SD-10 Operation and Maintenance Data

- Data that is furnished by the manufacturer, or the system provider, to the equipment operating and maintenance personnel. This data is needed by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

SD-11 Closeout Submittals

- Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

1.1.3. Approving Authority

Office authorized to approve submittal.

1.1.4. Work

As used in this section, on- and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction.

1.2. NOT USED

1.3. SUBMITTAL CLASSIFICATION

Submittals are classified as follows:

1.3.1. Designer of Record Approved (DA)

1.3.1.1. Designer of Record (DOR) approval is required for all extensions of design, critical materials, equipment whose compatibility with the entire system must be checked, and other items as designated by the Contracting Officer. Within the terms of the Contract Clause entitled "Specifications and Drawings for Construction", they are considered to be "shop drawings". Provide the Government the number of copies designated hereinafter of all DOR approved submittals, after the DOR has taken appropriate action. The DOR shall ensure that submittals conform to the Solicitation, the Accepted Proposal and the completed design, however see below for those submittals proposing a deviation to the contract or a substitution of a material, system, or piece of equipment that was identified by manufacturer, brand name or model description in the accepted contract proposal.

1.3.1.2. The DOR shall ensure that the submittals comply with all applicable Buy American Act and Trade Agreement Act clauses in the contract. The DOR may confer with the Contracting Officer's Representative for advice and interpretation of those clauses, as necessary.

1.3.1.3. The Government may, but is not required to, review any or all DOR approved submittals for conformance to the solicitation, accepted proposal and the completed design. Except for submittals designated as deviating from the Solicitation, the Accepted Proposal or completed design, the Contractor may proceed with acquisition and installation upon DOR approval. Government Approved (GA)

1.3.2. Government Approved (GA)

Government approval is required for any item specifically designated as requiring Government approval in the Solicitation, for internal and external color finish selections and other items as designated by the Contracting Officer. Within the terms of the Contract Clause entitled "Specifications and Drawings for Construction," they are considered to be "shop drawings."

1.3.3. Government Conformance Review of Design (CR)

The Government will review all intermediate and final design submittals for conformance with the technical requirements of the solicitation. Section 01 33 16 **DESIGN AFTER AWARD** covers the design submittal and review process in detail. Review will be only for conformance with the applicable codes, standards and contract requirements. Design data includes the design documents described in Section 01 33 16 **DESIGN AFTER AWARD**. Generally, design submittals should be identified as SD-05 Design Data submittals.

1.3.4. Designer of Record Approved/Government Conformance Review (DA/CR)

1.3.4.1. Deviations to the Accepted Design. Designer of Record approval and the Government’s concurrence are required for any proposed deviation from the accepted design which still complies with the contract (the Solicitation and Accepted Proposal) before the Contractor is authorized to proceed with material acquisition or installation. Within the terms of the Contract Clause entitled "Specifications and Drawings for Construction", they are considered to be "shop drawings.” If necessary to facilitate the project schedule, the Contractor and the DOR may discuss a submittal proposing a deviation with the Contracting Officer's Representative prior to officially submitting it to the Government. However, the Government reserves the right to review the submittal before providing an opinion, if it deems it necessary. In any case, the Government will not formally agree to or provide a preliminary opinion on any deviation without the DOR's approval or recommended approval. The Government reserves the right to non-concur with any deviation from the design, which may impact furniture, furnishings, equipment selections or operations decisions that were made, based on the reviewed and concurred design.

1.3.4.2. Substitutions. Unless prohibited or provided for otherwise elsewhere in the Contract, where the accepted contract proposal named products, systems, materials or equipment by manufacturer, brand name and/or by model number or other specific identification, and the Contractor desires to substitute manufacturer or model after award, submit a requested substitution for Government concurrence. Include substantiation, identifying information and the DOR’s approval, as meeting the contract requirements and that it is equal in function, performance, quality and salient features to that in the accepted contract proposal.

1.3.5. Designer of Record Approved/Government Approved (DA/GA)

Any proposed deviation to the solicitation and/or the accepted proposal constitutes a change to the contract. In addition to the above stated requirements for proposed deviations to the accepted design, both Designer of Record and Government Approval and, where applicable, a contract modification are required before the Contractor is

authorized to proceed with material acquisition or installation for any proposed deviation to the contract. Within the terms of the Contract Clause entitled "Specifications and Drawings for Construction", they are considered to be "shop drawings". The Government reserves the right to accept or reject any such proposed deviation at its discretion.

1.3.6. Information Only

All submittals not requiring Designer of Record or Government approval will be for information only. Provide the Government “For Information Only” copies of all submittals not requiring Government approval or concurrence, after the Designer of Record has taken the appropriate action.

1.4. APPROVED OR CONCURRED WITH SUBMITTALS

Do not construe the Contracting Officer's approval of or concurrence with submittals as a complete check, but only that design, general method of construction, materials, detailing and other information appear to meet the Solicitation and Accepted Proposal. Approval or concurrence will not relieve the Contractor of the responsibility for any error which may exist, as the Contractor under the Contractor Quality Control (CQC) requirements of this contract is responsible for design, dimensions, all design extensions, such as the design of adequate connections and details, etc., and the satisfactory construction of all work. The Government won’t consider re-submittals for the purpose of substituting previously approved materials or equipment unless accompanied by an explanation of why a substitution is necessary.

1.5. DISAPPROVED SUBMITTALS

Make all corrections required by the Contracting Officer, obtain the Designer of Record's approval when applicable, and promptly furnish a corrected submittal in the form and number of copies specified for the initial submittal. Resubmit any "information only" submittal found to contain errors or unapproved deviations from the Solicitation or Accepted Proposal as one requiring "approval" action, requiring both Designer of Record and Government approval. If the Contractor considers any correction indicated on the submittals to constitute a change to the contract, provide prompt notice in accordance with the Contract Clause "Changes" to the Contracting Officer.

1.6. WITHHOLDING OF PAYMENT

No payment for materials incorporated in the work will be made if all required Designer of Record or required Government approvals have not been obtained. No payment will be made for any materials incorporated into the work for any conformance review submittals or information only submittals found to contain errors or deviations from the Solicitation or Accepted Proposal.

1.7. GENERAL

Make submittals as required by the specifications. The Contracting Officer may request submittals in addition to those specified when deemed necessary to adequately describe the work covered in the respective sections. Units of weights and measures used on all submittals shall be the same as those used in the contract drawings. Each submittal shall be complete and in sufficient detail to allow ready determination of compliance with contract requirements. Prior to submittal, the Contractor’s Quality Control (CQC) System Manager and the Designer of Record, if applicable, shall check, approve, sign, and stamp all items, indicating action taken. Clearly idenify proposed deviations from the contract requirements. Include items such as: Contractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals. Schedule and make submittals requiring Government approval prior to the acquisition of the material or equipment covered thereby. Pick up and dispose of samples remaining upon completion of the work in accordance with manufacturer's Material Safety Data Sheets (MSDS) and in compliance with existing laws and regulations.

1.8. SUBMITTAL REGISTER (GA)

Develop a complete list of submittals, including each separate design package submittal. Submit the initial submittal register within 15 days after Notice to Proceed, including, as a minimum, the design packages and other initial submittals required elsewhere in the contract. The Designer of Record shall identify required submittals in the

specifications, and use the list to prepare the Submittal Register, utilizing the government-provided software, QCS (see Section 01 45 01.10), to create the ENG Form 4288. Appendix Ris a preliminary submittal register input form for use with the Quality Management System and the Resident Office Management System (QCS and RMS). The Government will provide the Contractor the actual Excel Spreadsheet version of this sample input form after award to modify and to use for input into QCS. The Excel Spreadsheet is not totally inputable into QCS, so additional keystroke input will be necessary. The sample input form is not all-inclusive. In addition, additional submittals may be required by other parts of the contract. After award, the parties will meet to discuss contract specific (or task order specific for a task order contract) distribution for the submittals all-inclusive and additional submittals may be required by other parts of the contract. Develop and complete the submittal register as the design is completed. Submit it to the Contracting Officer with the un-reviewed final design package submission or as soon as the design specifications are completed, if before the final design submission. When applicable, if the Contractor elects to fast track design and construction, using multiple design package submissions,update the submittal register to reflect the submittals associated with each design submission, clearly denoting all revisions to the previous submission. The submittal register serves as a scheduling document for submittals and for control of submittal actions throughout the contract period. Coordinate the submit dates and need dates used in the submittal register with dates in the Contractor prepared progress schedule. Submit montly updates to the submittal register showing the Contractor action codes and actual dates with Government action codes and actual dates or until all submittals have been satisfactorily completed. Revise and submit the submittal register when revising the progress schedule.

1.9. SCHEDULING

Schedule submittals covering component items forming a system or items that are interrelated to be coordinated and submitted concurrently. Schedule certifications to be submitted with the pertinent drawings. Allow adequate time (a minimum of 15 calendar days exclusive of mailing time) and show on the register for those items requiring Government approval or concurrence. No delay damages or time extensions will be allowed for time lost in late submittals by the Contractor.

1.10. TRANSMITTAL FORM (ENG FORM 4025)

Use the transmittal form (ENG Form 4025) for submitting submittals in accordance with the instructions on the reverse side of the form. These forms will be furnished to the Contractor or are included in the QCS software if the Contractor is required to use QCS for this contract. Use a separate transmittal form for each specification section Complete this form by filling out all the heading blank spaces and identify each item submitted. Exercise special care to ensure proper listing of the specification paragraph and/or sheet number of the contract drawings pertinent to the data submitted for each item.

1.11. SUBMITTAL PROCEDURES

Make submittals as follows:

1.11.1. Procedures

The Government will further discuss detailed submittal procedures with the Contractor at the Post-Award Conference.

1.11.2. Deviations

For submittals which include proposed deviations requested by the Contractor, check the column "variation" of ENG Form 4025. Set forth in writing the reason for any deviations and annotate such deviations on the submittal. The Government reserves the right to rescind inadvertent approval of submittals containing unnoted deviations.

1.12. CONTROL OF SUBMITTALS

Carefully control his procurement operations to ensure that each individual submittal is made on or before the scheduled submittal date shown on the approved "Submittal Register."

1.13. GOVERNMENT APPROVED OR CONCURRED WITH SUBMITTALS

Upon completion of review of submittals requiring Government approval or concurrence, the Government will stamp and date the submittals as approved or concurred.. The Government will retain two (2) copies of the submittal and return two (2) copy(ies) of the submittal.

1.14. INFORMATION ONLY SUBMITTALS

Normally submittals for information only will not be returned. Approval of the Contracting Officer is not required on information only submittals. The Government reserves the right to require the Contractor to resubmit any item found not to comply with the contract. This does not relieve the Contractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contracting Officer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Contractor of the requirement to furnish samples for testing by the Government laboratory or for check testing by the Government in those instances where the technical specifications so prescribe. The Government will retain zero(0) copies of information only submittals.

1.15. STAMPS

Use stamps similar to the following on the submittal data to certify that the submittal meets contract requirements:

CONTRACTOR

(FIRM NAME)

_____ Approved

_____ Approved with corrections as noted on submittal data and/or attached sheet(s)

Signature: _____

Title: _____

Date: _____

For design-build construction, both the Contractor Quality Control System Manager and the Designer of Record shall stamp and sign to certify that the submittal meets contract requirements.

SECTION 01 33 16
DESIGN AFTER AWARD

1.0 GENERAL INFORMATION

1.1. INTRODUCTION

1.2. DESIGNER OF RECORD

2.0 PRODUCTS (Not Applicable)

3.0 EXECUTION

3.1. PRE-WORK ACTIVIES & CONFERENCES

3.1.1. Design Quality Control Plan

3.1.2. Post Award Conference

3.1.3. Partnering & Project Progress Processes

3.1.4. Initial Design Conference

3.1.5. Pre-Construction Conference

3.2. STAGES OF DESIGN SUBMITTALS AND OVER THE SHOULDER PROGRESS REVIEWS

3.2.1. Site/Utilities

3.2.2. Interim Design Submittals

3.2.3. Over-the-Shoulder Progress Reviews

3.2.4. Final Design Submissions

3.2.5. Design Complete Submittals

3.2.6. Holiday Periods for Government Review or Actions

3.2.7. Late Submittals and Reviews

3.3. DESIGN CONFIGURATION MANAGEMENT

3.3.1. Procedures

3.3.2. Tracking Design Review Comments

3.3.3. Design and Code Checklists

3.4. INTERIM DESIGN REVIEWS AND CONFERENCES

3.4.1. General

3.4.2. Procedures

3.4.3. Conference Documentation

3.5. INTERIM DESIGN REQUIREMENTS

3.5.1. Drawings

3.5.2. Design Analyses

3.5.3. Geotechnical Investigations and Reports

3.5.4. LEED Documentation

3.5.5. Energy Conservation

3.5.6. Specifications

3.5.7. Building Rendering

3.5.8. Interim Building Design Contents

3.6. FINAL DESIGN REVIEWS AND CONFERENCES

3.7. FINAL DESIGN REQUIREMENTS

3.7.1. Drawings

3.7.2. Design Analysis

3.7.3. Specifications

3.7.4. Submittal Register

3.7.5. Preparation of DD Form 1354 (Transfer of Real Property)

3.7.6. Acceptance and Release for Construction

3.8. DESIGN COMPLETE CONSTRUCTION DOCUMENT REQUIREMENTS

3.9. SUBMITTAL DISTRIBUTION, MEDIA AND QUANTITIES

3.9.1. Submittal Distribution and Quantities

3.9.2. Web based Design Submittals

3.9.3. Mailing of Design Submittals

3.10. AS-BUILT DOCUMENTS

ATTACHMENT A STRUCTURAL INTERIOR DESIGN (SID) REQUIREMENTS

ATTACHMENT B FURNITURE, FIXTURES AND EQUIPMENT REQUIREMENTS

ATTACHMENT C TRACKING COMMENTS IN DRCHECKS

ATTACHMENT D SAMPLE FIRE PROTECTION AND LIFE SAFETY CODE REVIEW

ATTACHMENT E LEED SUBMITTALS

ATTACHMENT F BUILDING INFORMATION MODELING REQUIREMENTS

ATTACHMENT G DESIGN SUBMITTAL DIRECTORY AND SUBDIRECTORY FILE ARRANGEMENT

1.0 GENERAL INFORMATION

1.1. INTRODUCTION

1.1.1. The information contained in this section applies to the design required after award. After award, the Contractor will develop the accepted proposal into the completed design, as described herein.

1.1.2. The Contractor may elect to fast track the design and construction that is, proceed with construction of parts of the sitework and facilities prior to completion of the overall design. To facilitate fast tracking, the Contractor may elect to divide the design into no more than six (6) design packages per major facility type and no more than three (3) design packages for site and associated work. Designate how it will package the design, consistent with its overall plan for permitting (where applicable) and construction of the project. See Sections 01 33 00 SUBMITTAL PROCEDURES and 01 32 01.00 10 PROJECT SCHEDULE for requirements for identifying and scheduling the design packaging plan in the submittal register and project schedule. See also Sections 01 10 00 STATEMENT OF WORK and 01 57 20.00 10 ENVIRONMENTAL PROTECTION for any specified permit requirements. If early procurement of long-lead item construction materials or installed equipment, prior to completion of the associated design package, is necessary to facilitate the project schedule, also identify those long-lead items and how it will assure design integrity of the associated design package to meet the contract requirements (The Contract consists of the Solicitation requirements and the accepted proposal). Once the Government is satisfied that the long-lead items meet the contract requirements, the Contracting Officer will allow the Contractor to procure the items at its own risk.

1.1.3. The Contractor may proceed with the construction work included in a separate design package after the Government has reviewed the final (100%) design submission for that package, review comments have been addressed and resolved to the Government's satisfaction and the Contracting Officer (or the Administrative Contracting Officer) has agreed that the design package may be released for construction.

1.1.4. INTEGRATED DESIGN. To the maximum extent permitted for this project, use a collaborative, integrated design process for all stages of project delivery with comprehensive performance goals for siting, energy, water, materials and indoor environmental quality and ensures incorporation of these goals. Consider all stages of the building lifecycle, including deconstruction.

1.2. DESIGNER OF RECORD

Identify, for approval, the Designer of Record (“DOR”) that will be responsible for each area of design. One DOR may be responsible for more than one area. Listed, Professional Registered, DOR(s) shall account for all areas of design disciplines shall be accounted for by a listed. The DOR’s shall stamp, sign, and date each design drawing and other design deliverables under their responsible discipline at each design submittal stage (see contract clause Registration of Designers). If the deliverables are not ready for release for construction, identify them as "preliminary" or "not for release for construction" or by using some other appropriate designation. The DOR(s) shall also be responsible for maintaining the integrity of the design and for compliance with the contract requirements through construction and documentation of the as-built condition by coordination, review and approval of extensions of design, material, equipment and other construction submittals, review and approval or disapproval of requested deviations to the accepted design or to the contract, coordination with the Government of the above activities, and by performing other typical professional designer responsibilities.

2.0 PRODUCTS (Not Applicable)

3.0 EXECUTION

3.1. PRE-WORK ACTIVITIES & CONFERENCES

3.1.1. Design Quality Control Plan

Submit for Government acceptance, a Design Quality Control Plan in accordance with Section 01 45 04.00 10 CONTRACTOR QUALITY CONTROL before design may proceed.

3.1.2. Post Award Conference

3.1.2.1. The government will conduct a post award contract administration conference at the project site, as soon as possible after contract award. This will be coordinated with issuance of the contract notice to proceed (NTP). The Contractor and major sub-contractor representatives shall participate. All designers need not attend this first meeting. Government representatives will include COE project delivery team members, facility users, facility command representatives, and installation representatives. The Government will provide an agenda, meeting goals, meeting place, and meeting time to participants prior to the meeting.

3.1.2.2. The post award conference shall include determination and introduction of contact persons, their authorities, contract administration requirements, discussion of expected project progress processes, and coordination of subsequent meetings for quality control (see Section 01 45 04.00 10 CONTRACTOR QUALITY CONTROL), Partnering (see below and SCR: Partnering), and the initial design conference (see below).

3.1.2.3. The government will introduce COE project delivery team members, facility users, facility command representatives, and installation representatives. The DB Contractor shall introduce major subcontractors, and other needed staff. Expectations and duties of each person shall be defined for all participants. A meeting roster shall be developed and distributed by the government with complete contact information including name, office, project role, phone, mailing and physical address, and email address.

3.1.3. Partnering & Project Progress Processes

3.1.3.1. The initial Partnering conference may be scheduled and conducted at any time with or following the post award conference. The Government proposes to form a partnership with the DB Contractor to develop a cohesive building team. This partnership will involve the COE project delivery team members, facility users, facility command representatives, installation representatives, Designers of Record, major subcontractors, contractor quality control staff, and contractor construction management staff. This partnership will strive to develop a cooperative management team drawing on the strengths of each team member in an effort to achieve a quality project within budget and on schedule. This partnership will be bilateral in membership and participation will be totally voluntary. All costs, excluding labor and travel expenses, shall be shared equally between the Government and the Contractor. The Contractor and Government shall be responsible for their own labor and travel costs. Normally, partnering meetings will be held at or in the vicinity of the project installation.

3.1.3.2. As part of the partnering process, the Government and Contractor shall develop, establish, and agree to comprehensive design development processes including conduct of conferences, expectations of design development at conferences, fast-tracking, design acceptance, Structural Interior Design (SID)/ Furniture, Fixtures & Equipment (FF&E) design approval, project closeout, etc. The government will explain contract requirements and the DB Contractor shall review their proposed project schedule and suggest ways to streamline processes.

3.1.4. Initial Design Conference

The initial design conference may be scheduled and conducted at the project installation any time after the post award conference, although it is recommended that the partnering process be initiated with or before the initial design conference. Any design work conducted after award and prior to this conference should be limited to site and is discouraged for other items. All Designers of Record shall participate in the conference. The purpose of the meeting is to introduce everyone and to make sure any needs the contractor has are assigned and due dates established as well as who will get the information. See also Attachment F, BUILDING INFORMATION MODELING REQUIREMENTS for discussion concerning the BIM Implementation Plan demonstration at this meeting. The DB Contractor shall conduct the initial design conference.

3.1.5. Pre-Construction Conference

Before starting construction activities, the Contractor and Government will jointly conduct a pre-construction administrative conference to discuss any outstanding requirements and to review local installation requirements for start of construction. It is possible there will be multiple Pre-Construction Conferences based on the content of the design packages selected by the Contractor. The Government will provide minutes of this meeting to all participants.

3.2. STAGES OF DESIGN SUBMITTALS AND OVER THE SHOULDER PROGRESS REVIEWS

The stages of design submittals described below define Government expectations with respect to process and content. The Contractor shall determine how to best plan and execute the design and review process for this project, within the parameters listed below. As a minimum, the Government expects to see at least one interim design submittal, at least one final design submittal before construction of a design package may proceed and at least one Design Complete submittal that documents the accepted design. The Contractor may sub-divide the design into separate packages for each stage of design and may proceed with construction of a package after the Government accepts the final design for that package. See discussion on waivers to submission of one or more intermediate design packages where the parties partner during the design process. See also Attachment F, BUILDING INFORMATION MODELING REQUIREMENTS for discussion concerning BIM and the various stages of design submittals and over-the-shoulder progress reviews**.**

3.2.1. Site/Utilities

To facilitate fast-track design-construction activities the contractor may submit a final (100%) site and utility design as the first design submittal or it may elect to submit interim and final site and utility design submittals as explained below. Following review, resolution, and incorporation of all Government comments, and submittal of a satisfactory set of site/utility design documents, after completing all other pre-construction requirements in this contract and after the pre-construction meeting, the Government will allow the Contractor to proceed with site development activities, including demolition where applicable, within the parameters set forth in the accepted design submittal. For the first site and utility design submission, whether an interim or final, the submittal review, comment, and resolution times from this specification apply, except that the Contractor shall allow the Government a 14 calendar day review period, exclusive of mailing time. No on-site construction activities shall begin prior to written Government clearance to proceed.

3.2.2. Interim Design Submittals

The Contractor may submit either a single interim design for review, representing a complete package with all design disciplines, or split the interim design into smaller, individual design packages as it deems necessary for fast-track construction purposes. As required in Section 01 32 01.00 10 PROJECT SCHEDULE, the Contractor shall schedule its design and construction packaging plan to meet the contract completion period. This submission is the Government's primary opportunity to review the design for conformance to the solicitation and to the accepted contract proposal and to the Building Codes at a point where required revisions may be still made, while minimizing lost design effort to keep the design on track with the contract requirements. The requirements for the interim design review submittals and review conferences are described hereinafter. This is not necessarily a hold point for the design process; the Contractor may designate the interim design submittal(s) as a snapshot and proceed with design development at its own risk. See below for a waiver, where the parties establish an effective over-the-shoulder progress review procedure through the partnering process that would eliminate the need for or expedite a formal intermediate design review on one or more individual design packages.

3.2.3. Over-the-Shoulder Progress Reviews

To facilitate a streamlined design-build process, the Government and the Contractor may agree to one-on-one reviewer or small group reviews, electronically, on-line (if available within the Contractor's standard design practices) or at the Contractor's design offices or other agreed location, when practicable to the parties. The Government and Contractor will coordinate such reviews to minimize or eliminate disruptions to the design process. Any data required for these reviews shall normally be provided in electronic format, rather than in hard copy. If the Government and Contractor establish and implement an effective, mutually agreeable partnering procedure for regular (e.g., weekly) over-the shoulder review procedures that allow the Government reviewers the opportunity to keep fully informed of the progress, contents, design intent, design documentation, etc. of the design package, the Government will agree to waive or to expedite the formal intermediate design review period for that package. The Contractor shall still be required to submit the required intermediate design documentation, however the parties may agree to how that material will be provided, in lieu of a formal consolidated submission of the package. It should be noted that Government funding is extremely limited for non-local travel by design reviewers, so the maximum use of virtual teaming methods must be used. Some possible examples include electronic file sharing, interactive software with on-line or telephonic conferencing, televideo conferencing, etc. The Government must still perform its Code and Contract conformance reviews, so the Contractor is encouraged to partner with the reviewers to find ways to facilitate this process and to facilitate meeting or bettering the design-build schedule. The Contractor shall maintain a fully functional configuration management system as described herein to track design revisions, regardless of whether or not there is a need for a formal intermediate design review. The formal intermediate

review procedures shall form the contractual basis for the official schedule, in the event that the partnering process determines that the formal intermediate review process to be best suited for efficient project execution. However, the Government pledges to support and promote the partnering process to work with the Contractor to find ways to better the design schedule.

3.2.4. Final Design Submissions

This submittal is required for each design package prior to Government acceptance of that design package for construction. The requirements for the final design submittal review conferences and the Government's acceptance for start of construction are described herein after.

3.2.5. Design Complete Submittals

After the final design submission and review conference for a design package, revise the design package to incorporate the comments generated and resolved in the final review conferences, perform and document a back-check review and submit the final, design complete documents, which shall represent released for construction documents. The requirements for the design complete submittals are described hereinafter.

3.2.6. Holiday Periods for Government Review or Actions

Do not schedule meetings, Government reviews or responses during the last two weeks of December or other designated Government Holidays (including Friday after Thanksgiving). Exclude such dates and periods from any durations specified herein for Government actions.

3.2.7. Late Submittals and Reviews

If the Contractor cannot meet its scheduled submittal date for a design package, it must revise the proposed submittal date and notify the government in writing, at least one (1) week prior to the submittal, in order to accommodate the Government reviewers' other scheduled activities. If a design submittal is over one (1) day late in accordance with the latest revised design schedule, or if notification of a proposed design schedule change is less than seven (7) days from the anticipated design submission receipt date, the Government review period may be extended up to seven (7) days due to reviewers' schedule conflicts. If the Government is late in meeting its review commitment and the delay increases the Contractor's cost or delays completion of the project, the Suspension of Work and Defaults clauses provide the respective remedy or relief for the delay.

3.3. DESIGN CONFIGURATION MANAGEMENT

3.3.1. Procedures

Develop and maintain effective, acceptable design configuration management (DCM) procedures to control and track all revisions to the design documents after the Interim Design Submission through submission of the As-Built documents. During the design process, this will facilitate and help streamline the design and review schedule. After the final design is accepted, this process provides control of and documents revisions to the accepted design (See Special Contract Requirement: Deviating From the Accepted Design). The system shall include appropriate authorities and concurrences to authorize revisions, including documentation as to why the revision must be made. The DCM data shall be available to the Government reviewers at all times. The Contractor may use its own internal system with interactive Government concurrences, where necessary or may use the Government's "DrChecks Design Review and Checking System" (see below and Attachment C).

3.3.2. Tracking Design Review Comments

Although the Contractor may use its own internal system for overall design configuration management, the Government and the Contractor shall use the DrChecks Design Review and Checking System to initiate, respond to, resolve and track Government design compliance review comments. This system may be useful for other data which needs to be interactive or otherwise available for shared use and retrieval. See Attachment C for details on how to establish an account and set-up the DrChecks system for use on the project.

3.3.3. Design and Code Checklists

Develop and complete various discipline-specific checklists to be used during the design and quality control of each submittal. Submit these completed checklists with each design submittal, as applicable, as part of the project documentation. See Section 01 45 04.00 10 Contractor Quality Control, Attachment D for a Sample Fire Protection and Life Safety Code review checklist and Attachment E for LEED SUBMITTALS.

3.4. INTERIM DESIGN REVIEWS AND CONFERENCES

3.4.1. General

At least one interim design submittal, review and review conference is required for each design package (except that, per paragraph 3.2.1, the Contractor may skip the interim design submission and proceed directly to final design on the sitework and utilities package). The DB Contractor may include additional interim design conferences or over-the-shoulder reviews, as needed, to assure continued government concurrence with the design work. Include the interim submittal review periods and conferences in the project schedule and indicate what part of the design work is at what percentage of completion. The required interim design conferences shall be held when interim design requirements are reached as described below. See also Paragraph: **Over-the-Shoulder Progress Reviews** for a waiver to the formal interim design review.

3.4.2. Procedures

After receipt of an Interim Design submission, allow the Government fourteen (14) calendar days after receipt of the submission to review and comment on the interim design submittal. For smaller design packages, especially those that involve only one or a few separate design disciplines, the parties may agree on a shorter review period or alternative review methods (e.g., over-the–shoulder or electronic file sharing), through the partnering process. For each interim design review submittal, the COR will furnish, to the Contractor, a single consolidated, validated listing of all comments from the various design sections and from other concerned agencies involved in the review process using the DrChecks Design Review and Checking System. The review will be for conformance with the technical requirements of the solicitation and the Contractor's RFP proposal. If the Contractor disagrees technically with any comment or comments and does not intend to comply with the comment, he/she must clearly outline, with ample justification, the reasons for noncompliance within five (5) days after receipt of these comments in order that the comment can be resolved. Furnish disposition of all comments, in writing, through DrChecks. The Contractor is cautioned that if it believes the action required by any comment exceeds the requirements of this contract, that it should take no action and notify the COR in writing immediately. The Interim Review conference will be held for each design submittal at the installation. Bring the personnel that developed the design submittal to the review conference. The conference will take place the week after the receipt of the comments by the Contractor. For smaller fast-track packages that involve only a few reviewers, the parties may agree to alternative conferencing methods, such as teleconferencing, or televideo, where available, as determined through Partnering.

3.4.3. Conference Documentation

3.4.3.1. In order to facilitate and accelerate the Government code and contract conformance reviews, identify, track resolution of and maintain all comments and action items generated during the design process and make this available to the designers and reviewers prior to the Interim and subsequent design reviews.

3.4.3.2. The DB Contractor shall prepare meeting minutes and enter final resolution of all comments into DrChecks. Copies of comments, annotated with comment action agreed on, will be made available to all parties before the conference adjourns. Unresolved problems will be resolved by immediate follow-on action at the end of conferences. Incorporate valid comments. The Government reserves the right to reject design document submittals if comments are significant. Participants shall determine if any comments are critical enough to require further design development prior to government concurrence. Participants shall also determine how to proceed in order to obtain government concurrence with the design work presented.

3.5. INTERIM DESIGN REQUIREMENTS

Interim design deliverables shall include drawings, specifications, and design analysis for the part of design that the Contractor considers ready for review.

3.5.1. Drawings

Include comments from any previous design conferences incorporated into the documents to provide an interim design for the “part” submitted.

3.5.2. Design Analyses

3.5.2.1. The designers of record shall prepare and present design analyses with calculations necessary to substantiate and support all design documents submitted. Address design substantiation required by the applicable codes and references and pay particular attention to the following listed items:

3.5.2.2. For parts including sitework, include site specific civil calculations.

3.5.2.3. For parts including structural work, include structural calculations.

(a) Identify all loads to be used for design.

(b) Describe the method of providing lateral stability for the structural system to meet seismic and wind load requirements. Include sufficient calculations to verify the adequacy of the method.

(c) Provide calculations for all principal roof, floor, and foundation members and bracing and secondary members.

(d) Provide complete seismic analyses for all building structural, mechanical, electrical, architectural, and building features as dictated by the seismic zone for which the facility is being constructed.

(e) Computer generated calculations must identify the program name, source, and version. Provide input data, including loads, loading diagrams, node diagrams, and adequate documentation to illustrate the design. The schematic models used for input must show, as a minimum, nodes/joints, element/members, materials/properties, and all loadings, induced settlements/deflections, etc., and a list of load combinations. Include an output listing for maximum/minimum stresses/forces and deflections for each element and the reactions for each loading case and combination.

(f) See also the Security (Anti-Terrorism) requirements below for members subject to Anti-Terrorist Force Protection (ATFP) and Progressive Collapse requirements.

(g) Fully coordinate and integrate the overall structural design between two different or interfacing construction types, such as modular and stick-built or multistory, stacked modular construction. Provide substantiation of structural, consolidation/settlement analysis, etc., as applicable, through the interfaces.

3.5.2.4. For Security (Anti-Terrorism): Provide a design narrative and calculations where applicable, demonstrating compliance with each of the 22 standards in UFC 4-010-01, which includes Design of Buildings to Resist Progressive Collapse (use the most recent version of UFC 4-023-03, regardless of references to any specific version in UFC 4-010-01). Where sufficient standoff distance is not being provided, show calculations for blast resistance of the structural system and building envelope. Show complete calculations for members subjected to ATFP loads, e.g., support members of glazed items (jambs, headers, sills) connections of windows to support members and connections of support members to the rest of the structure. For 3 story and higher buildings, provide calculations to demonstrate compliance with progressive collapse requirements.

3.5.2.5. For parts including architectural work, include building floor area analysis.

3.5.2.6. For parts including mechanical work, include HVAC analysis and calculations. Include complete design calculations for mechanical systems. Include computations for sizing equipment, compressed air systems, air duct design, and U-factors for ceilings, roofs and exterior walls and floors. Contractor shall employ commercially available energy analysis techniques to determine the energy performance of all passive systems and features. Use of hourly energy load computer simulation is required (see paragraph 3.5.5.2 for list of acceptable software). Based on the results of calculations, provide a complete list of the materials and equipment proposed with the manufacturer's published cataloged product installation specifications and roughing-in data.

3.5.2.7. For parts including life safety, include building code analysis and sprinkler and other suppression systems. Notwithstanding the requirements of the Codes, address the following:

(a) A registered fire protection engineer (FPE) must perform all fire protection analyses. Provide the fire protection engineer’s qualifications. See Section 01 10 00, paragraph 5 for qualifications.

(b) Provide all references used in the design including Government design documents and industry standards used to generate the fire protection analysis.

(c) Provide classification of each building in accordance with fire zone, building floor areas and height and number of stories.

(d) Provide discussion and description of required fire protection requirements including extinguishing equipment, detection equipment, alarm equipment and water supply. Alarm and detection equipment shall interface to requirements of Electronic Systems.

(e) Provide hydraulic calculations based on water flow test for each sprinkler system to insure that flow and pressure requirements can be met with current water supply. Include copies of Contractor's water flow testing done to certify the available water source.

3.5.2.8. For parts including plumbing systems:

(a) List all references used in the design.

(b) Provide justification and brief description of the types of plumbing fixtures, piping materials and equipment proposed for use.

(c) Detail calculations for systems such as sizing of domestic hot water heater and piping; natural gas piping; LP gas piping and tanks, fuel oil piping and tanks, etc., as applicable.

(d) When the geotechnical report indicates expansive soils are present, indicate in the first piping design submittal how piping systems will be protected against damage or backfall/backflow due to soil heave (from penetration of slab to the 5 foot building line).

3.5.2.9. For elevator systems:

(a) List all criteria codes, documents and design conditions used.

(b) List any required permits and registrations for construction of items of special mechanical systems and equipment.

3.5.2.10. For parts including electrical work, include lighting calculations to determine maintained foot-candle levels, electrical load analysis and calculations, electrical short circuit and protective device coordination analysis and calculations and arc fault calculations.

3.5.2.11. For parts including telecommunications voice/data (including SIPRNET, where applicable), include analysis for determining the number and placement of outlets

3.5.2.12. For Cathodic Protection Systems, provide the following stamped report by the licensed corrosion engineer or NACE specialist with the first design submission. The designer must be qualified to engage in the practice of corrosion control of buried or submerged metallic surfaces. He/she must be accredited or certified by the National Association of Corrosion Engineers (NACE) as a NACE Accredited Corrosion Specialist or a NACE certified Cathodic Protection Specialist, or must be a registered professional engineer with a minimum of five years experience in corrosion control and cathodic protection, Clearly describe structures, systems or components in soil or water to be protected. Describe methods proposed for protection of each.

3.5.3. Geotechnical Investigations and Reports:

3.5.3.1. The contractor’s licensed geotechnical engineer shall prepare a final geotechnical evaluation report, to be submitted along with the first foundation design submittal. Make this information available as early as possible during the over-the-shoulder progress review process. Summarize the subsurface conditions and provide recommendations for the design of appropriate utilities, foundations, floor slabs, retaining walls, embankments, and pavements. Include compaction requirements for fill and backfill under buildings, sidewalks, other structures and open areas. Recommend foundation systems to be used, allowable bearing pressures for footings, lateral load resistance capacities for foundation systems, elevations for footings, grade beams, slabs, etc. Provide an assessment of post-construction settlement potential including total and differential. Provide recommendations regarding lateral earth pressures (active, at-rest, passive) to be used in the design of retaining walls. Include the recommended spectral accelerations and Site Class for seismic design along with an evaluation of any seismic hazards and recommendations for mitigation, if required. Include calculations to support the recommendations for bearing capacity, settlement, and pavement sections. Include supporting documentation for all recommended

design parameters such as Site Class, shear strength, earth pressure coefficients, friction factors, subgrade modulus, California Bearing Ratio (CBR), etc. Provide earthwork recommendations, expected frost penetration, expected groundwater levels, recommendations for dewatering and groundwater control and the possible presence of any surface or subsurface features that may affect the construction of the project such as sinkholes, boulders, shallow rock, old fill, old structures, soft areas, or unusual soil conditions. Include pH tests, salinity tests, resistivity measurements, etc., required to design corrosion control and grounding systems. Include the raw field data. Arrange a meeting with the Government subsequent to completion and evaluation of the site specific geotechnical exploration to outline any differences encountered that are inconsistent with the Government provided preliminary soils information. Clearly outline differences which require changes in the foundation type, or pavement and earthwork requirements from that possible and contemplated using the Government furnished preliminary soils investigation, which result in a change to the design or construction. Any equitable adjustment is subject to the provisions of the contract's Differing Site Conditions Clause.

3.5.3.2. Vehicle Pavements: The Contractor's geotechnical report shall contain flexible and rigid pavement designs, as applicable for the project, including design CBR and modulus of subgrade reaction and the required compaction effort for subgrades and pavement layers. Provide Information on the types of base course materials available in the area and design strengths.

3.5.3.3. The Contractor and the professional geotechnical engineer consultant shall certify in writing that the design of the project has been developed consistent with the Contractor's final geotechnical report. The certification shall be stamped by the consulting professional geotechnical engineer and shall be submitted with the first design submission. If revisions are made to the initial design submission, a new certification shall be provided with the final design submission.

3.5.4. LEED Documentation:

Assign a LEED Accredited Professional, responsible to track LEED planning, performance and documentation for each LEED credit through construction closeout. Incorporate LEED credits in the plans, specifications and design analyses. Develop LEED supporting documentation as a separable portion of the Design Analysis and provide with each required design submittal. Include the LEED Project checklist for each non-exempt facility (one checklist may be provided for multiple facilities in accordance with the LEED-NC Application Guide for Multiple Buildings and On-Campus Building Projects and the LEED SUBMITTALS (Attachment E, herein) with each submittal. Final design submittal for each portion of the work must include all required design documentation relating to that portion of work (example - all site credit design documents with final site design). Submittal requirements are as indicated in Attachment E, LEED SUBMITTALS. Submit all documentation indicated on Attachment E as due at final design at final design submittal (for fast-track projects with multiple final design submittals, this shall be at the last scheduled final design submittal). All project documentation related to LEED shall conform to USGBC requirements for both content and format, including audit requirements and be separate from other design analyses. Maintain and update the LEED documentation throughout project progress to construction closeout and shall compile product data, receipts, calculations and other data necessary to substantiate and support all credits claimed. The Government may audit any or all individual credits. Audit documentation is not required to be submitted unless requested. These requirements apply to all projects. If the project requires the Contractor to obtain USGBC certification, the Contractor shall also be responsible for obtaining USGBC certification and shall provide written evidence of certification with the construction closeout LEED documentation submittal. Install the USGBC building plaque at the location indicated by the Government upon receipt. If Contractor obtains USGBC interim design review, submit the USGBC review to the Government within 30 days of receipt for information only.

3.5.4.1. LEED Documentation for Technology Solution Set. If the Solicitation provides a Prescriptive Technology Solution Set, use of the Technology Solution set has no effect on LEED documentation requirements. Provide all required LEED documentation, including energy analysis, in accordance with LEED requirements when using the Technology Solution Set.

3.5.5. Energy Conservation:

3.5.5.1. Refer to Section 01 10 00, Paragraph 5. Interim and Final Design submittals shall demonstrate that each building including the building envelope, HVAC systems, service water heating, power, and lighting systems meet the Mandatory Provisions and the Prescriptive Path requirements of ASHRAE 90.1. Use Compliance Documentation forms available from ASHRAE and included in the ASHRAE 90.1 User's Manual for this purpose. The Architectural Section of the Design Analysis shall include completed forms titled "Building Envelope

Compliance Documentation Parts I and II". The Heating Ventilating and Air Conditioning (HVAC) Section of the Design Analysis shall include a completed form titled "HVAC Simplified Approach Option - Part I" if this approach is allowed by the Standard. Otherwise, the HVAC Section of the Design Analysis shall include completed forms titled "HVAC Mandatory Provisions - Part II" and "HVAC Prescriptive Requirements - Part III". The Plumbing Section of the Design Analysis shall include a completed form titled "Service Water Heating Compliance Documentation". The Electrical Section of the Design Analysis shall include an explanatory statement on how the requirements of ASHRAE 90.1-2004 Chapter 8 Power were met. The Electrical Section of the Design Analysis shall also include a completed form titled "Lighting Compliance Documentation".

3.5.5.2. Interim and Final Design submittals which address energy consuming systems, (heating, cooling, service hot water, lighting, power, etc.) must also include calculations in a separate Energy Conservation Section of the Design Analysis which demonstrate and document (a) the baseline energy consumption for the facility or facilities under contract, that would meet the requirements of ANSI/ASHRAE/IESNA Standard 90.1 and (b) the energy consumption of the facility or facilities under contract utilizing the materials and methods required by this construction contract. Use the USGBC Energy and Atmosphere (EA) Credit 1 compliance template / form or an equivalently detailed form for documenting compliance with the energy reduction requirements. This template / form is titled PERFORMANCE RATING METHOD and is available when the project is registered for LEED. The calculation methodology used for this documentation and analysis shall follow the guidelines set forth in Appendix G of ASHRAE 90.1, with two exceptions: a) receptacle and process loads may be omitted from the calculation; and b) the definition of the terms in the formula for Percentage Improvement found in paragraph G1.2 are modified as follows: Baseline Building Performance shall mean the annual energy consumption calculated for a building design intended for use as a baseline for rating above standard design meeting the minimum requirements of the energy standard, and Proposed Building Performance shall mean annual energy consumption calculated for the proposed building design intended for construction. This calculation shall address all energy consuming systems in a single integrated methodology. Include laboratory fume hoods and kitchen ventilation loads in the energy calculation. They are not considered process loads. Individual calculations for heating, cooling, power, lighting, power, etc. systems will not be acceptable. The following building simulation software is acceptable for use in calculating building energy consumption: Hourly Analysis Program (HAP) by Carrier Corp., TRACE 700 by Trane Corp., DOE-2 by US Department of Energy, EnergyPlus by DOD/DOE.

3.5.6. Specifications

Specifications may be any one of the major, well known master guide specification sources (use only one source) such as MASTERSPEC from the American Institute of Architects, SPECTEXT from Construction Specification Institute or Unified Facility Guide Specifications (UFGS using MASTERFORMAT 2004 numbering system), etc. (including specifications from these sources). Manufacturers' product specifications, utilizing CSI's Manu-Spec, three part format may be used in conjunction with the selected specifications. The designers of record shall edit and expand the appropriate Specifications to insure that all project design requirements, current code requirements, and regulatory requirements are met. Specifications shall clearly identify, where appropriate, specific products chosen to meet the contract requirements (i.e., manufacturers' brand names and model numbers or similar product information).

3.5.7. Building Rendering

Present and provide a draft color computer, artist, or hand drawn rendering with the conceptual design submittal of the building exterior. Perspective renderings shall include a slightly overhead view of the entire building to encompass elevations and the roof configuration of the building. After Government review and acceptance, provide a final rendering, including the following:

Three (3) 18" x 24" color prints, framed and matted behind glass with project title underneath the print.

One (1) Image file (high resolution) in JPG format on CD for those in the submittal distribution list.

3.5.8. Interim Building Design Contents

The following list represents what the Government considers should be included in the overall completed design for a facility or project. It is not intended to limit the contractor from providing different or additional information as needed to support the design presented, including the require design analyses discussed above. As the Contractor develops individual design packages and submits them for Interim review, include as much of the applicable

information for an individual design package as is developed at the Interim design level for review purposes. These pieces shall be developed as the design progresses toward the design complete stage.

3.5.8.1. Lawn and Landscaping Irrigation System

3.5.8.2. Landscape, Planting and Turfing

3.5.8.3. Architectural

(a) Design Narrative

(b) Architectural Floor Plans, Typical Wall and Roof Sections, Elevations

(c) Finish schedule

(d) All required equipment

(e) Special graphics requirements

(f) Door and Window Schedules

(g) Hardware sets using BHMA designations

(h) Composite floor plan showing all pre-wired workstations

(i) Structural Interior Design (SID) package: See ATTACHMENT A for specific requirements

(j) Furniture, Fixtures & Equipment (FF&E) design package: See ATTACHMENT B for specific requirements

3.5.8.4. Structural Systems. Include:

(a) Drawings showing principal members for roof and floor framing plans as applicable

(b) Foundation plan showing main foundation elements where applicable

(c) Typical sections for roof, floor, and foundation conditions

3.5.8.5. Plumbing Systems

(a) Show locations and general arrangement of plumbing fixtures and major equipment

(b) Plan and isometric riser diagrams of all areas including hot water, cold water, waste and vent piping. Include natural gas (and meter as required), (natural gas and meter as required), (LP gas), (fuel oil) and other specialty systems as applicable.

(c) Include equipment and fixture connection schedules with descriptions, capacities, locations, connection sizes and other information as required

3.5.8.6. HVAC Systems

(a) Mechanical Floor Plans: The floor plans shall show all principle architectural features of the building which will affect the mechanical design. The floor plans shall also show the following:

(1) Room designations.

(2) Mechanical legend and applicable notes.

(3) Location and size of all ductwork and piping.

(4) Location and capacity of all terminal units (i.e., registers, diffusers, grilles, hydronic baseboards).

(5) Pre-Fabricated Paint Spray Booth (where applicable to project scope)

(6) Paint Preparation Area (where applicable to project scope)

(7) Exhaust fans and specialized exhaust systems.

(8) Thermostat location.

(9) Location of heating/cooling plant (i.e., boiler, chiller, cooling tower, etc).

(10) Location of all air handling equipment.

(11) Air balancing information.

(12) Flue size and location.

(13) Piping diagram for forced hot water system (if used).

(b) Equipment Schedule: Provide complete equipment schedules. Include:

(1) Capacity

(2) Electrical characteristics

(3) Efficiency (if applicable)

(4) Manufacturer's name

(5) Optional features to be provided

(6) Physical size

(7) Minimum maintenance clearances

(a) Details: Provide construction details, sections, elevations, etc., only where required for clarification of methods and materials of design.

(b) HVAC Controls: Submit complete HVAC controls equipment schedules, sequences of operation, wiring and logic diagrams, Input/Output Tables, equipment schedules, and all associated information. See the Statement of Work for additional specific requirements.

3.5.8.7. Fire Protection and Life Safety.

(a) Provide plan for each floor of each building that presents a compendium of the total fire protection features being incorporated into the design. Include the following types of information:

(1) The location and rating of any fire-resistive construction such as occupancy separations, area separations, exterior walls, shaft enclosures, corridors, stair enclosures, exit passageways, etc.

(2) The location and coverage of any fire detection systems

(3) The location and coverage of any fire suppression systems (sprinkler risers, standpipes, etc.)

(4) The location of any other major fire protection equipment

(5) Indicate any hazardous areas and their classification

(6) Schedule describing the internal systems with the following information: fire hazard and occupancy classifications, building construction type, GPM/square foot sprinkler density, area of operation and other as required

(b) Working plans and all other materials submitted shall meet NFPA 13 requirements, with respect to required minimum level of detail.

3.5.8.8. Elevators. Provide:

(a) Description of the proposed control system

(b) Description, approximate capacity and location of any special mechanical equipment for elevators.

3.5.8.9. Electrical Systems.

(a) Electrical Floor Plan(s): Show all principle architectural features of the building which will affect the electrical design. Show the following:

(1) Room designations.

(2) Electrical legend and applicable notes.

(3) Lighting fixtures, properly identified.

(4) Switches for control of lighting.

(5) Receptacles.

(6) Location and designation of panelboards. Clearly indicate type of mounting required (flush or surface) and reflect accordingly in specifications.

(7) Service entrance (conduit and main disconnect).

(8) Location, designation and rating of motors and/or equipment which requires electrical service. Show method of termination and/or connection to motors and/or equipment. Show necessary junction boxes, disconnects, controllers (approximate only), conduit stubs, and receptacles required to serve the motor and/or equipment.

(b) Building Riser Diagram(s) (from pad-mounted transformer to unit load center panelboard): Indicate the types and sizes of electrical equipment and wiring. Include grounding and metering requirements.

(c) Load Center Panelboard Schedule(s): Indicate the following information:

(1) Panelboard Characteristics (Panel Designation, Voltage, Phase, Wires, Main Breaker Rating and Mounting.

(2) Branch Circuit Designations.

(3) Load Designations.

(4) Circuit Breaker Characteristics. (Number of Poles, Trip Rating, AIC Rating)

(5) Branch Circuit Connected Loads (AMPS).

(6) Special Features

(d) Lighting Fixture Schedule(s): Indicate the following information:

(1) Fixture Designation.

(2) General Fixture Description.

(3) Number and Type of Lamp(s).

(4) Type of Mounting.

(5) Special Features.

(e) Details: Provide construction details, sections, elevations, etc. only where required for clarification of methods and materials of design.

3.5.8.10. Electronic Systems including the following responsibilities:

(a) Fire Detection and Alarm System. Design shall include layout drawings for all devices and a riser diagram showing the control panel, annunciator panel, all zones, radio transmitter and interfaces to other systems (HVAC, sprinkler, etc.)

(b) Fire Suppression System Control. Specify all components of the Fire Suppression (FS) System in the FS section of the specifications. Clearly describe how the system will operate and interact with other systems such as the fire alarm system. Include a riser diagram on the drawings showing principal components and interconnections with other systems. Include FS system components on drawing legend. Designate all components shown on floor plans “FS system components” (as opposed to “Fire Alarm components”). Show location of FS control panels, HVAC control devices, sensors, and 120V power panel connections on floor plans. Indicate zoning of areas by numbers (1, 2, 3) and detectors sub-zoned for cross zoning by letter designations (A and B). Differentiate between ceiling mounted and under floor detectors with distinct symbols and indicate sub-zone of each.

(c) Public Address System

(d) Special Grounding Systems. Completely reflect all design requirements in the specifications and drawings. Specifications shall require field tests (in the construction phase), witnessed by the Government, to determine the effectiveness of the grounding system. Include drawings showing existing construction, if any.

(e) Cathodic Protection.

(f) Intrusion Detection, Card Access System

(g) Central Control and Monitoring System

(h) Mass Notification System

(i) Electrical Power Distribution Systems

3.5.8.11. Separate detailed Telecommunications drawings for Information Systems including the following responsibilities:

(a) Telecommunications Cabling

(b) Supporting Infrastructure

(a) Outside Plant (OSP) Cabling - Campus or Site Plans - Exterior Pathways and Inter-Building Backbones

(a) Include a layout of the voice/data outlets (including voice only wall & pay phones) on telecommunication floor plan drawing, location of SIPRNET data outlets (where applicable), and a legend and symbol definition to indicate height above finished floor. Show size of conduit and cable type and size on Riser Diagram. Do not show conduit runs between backboard and outlets on the floor plans. Show underground distribution conduit and cable with sizing from point of presence to entrance facility of building.

(b) Layout of complete building per floor - Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways including Serving Zones Drawings - Drop Locations and Cable ID's

(c) Communication Equipment Rooms - Plan Views - Tech and AMEP/Elevations - Racks and Walls. Elevations with a detailed look at all telecomm rooms. Indicate technology layout (racks, ladder-racks, etc.), mechanical/electrical layout, rack elevation and backboard elevation. They may also be an enlargement of a congested area of T1 or T2 series drawing.

3.6. FINAL DESIGN REVIEWS AND CONFERENCES

A final design review and review conference will be held upon completion of final design at the project installation, or – where equipment is available - by video teleconference or a combination thereof, for any design package to receive Government acceptance to allow release of the design package for construction. For smaller separate design packages, the parties may agree on alternative reviews and conferences (e.g., conference calls and electronic file sharing, etc.) through the Partnering process. Include the final design conference in the project schedule and shall indicate what part of the design work is at 100% completion. The final design conference will be held after the Government has had seven (7) calendar days after receipt of the submission to review the final design package and supporting data. For smaller packages, especially those involving only one or a few design disciplines the parties may agree on a shorter period.

3.7. FINAL DESIGN REQUIREMENTS

Final design deliverables for a design package shall consist of 100% complete drawings, specifications, submittal register and design analyses for Government review and acceptance. The 100% design submission shall consist of drawings, specifications, updated design analyses and any permits required by the contract for each package submitted. In order to expedite the final design review, prior to the conference, ensure that the design configuration management data and all review comment resolutions are up-to-date. Include the 100% SID and 100% FF&E binders for government approval. The Contractor shall have performed independent technical reviews (ITR's) and back-checks of previous comment resolutions, as required by Section 01 45 04.00 10 CONTRACTOR QUALITY CONTROL, including providing documentation thereof. Use DrChecks or other acceptable comment tracking system during the ITR and submit the results with each final design package

3.7.1. Drawings

3.7.1.1. Submit drawings complete with all contract requirements incorporated into the documents to provide a 100% design for each package submitted.

3.7.1.2. Prepare all drawings with the Computer-Aided Design and Drafting (CADD)/Computer-Aided Design (CAD) system, organized and easily referenced electronically, presenting complete construction information.

3.7.1.3. Drawings shall be complete. The Contractor is encouraged to utilize graphics, views, notes, and details which make the drawings easier to review or to construct but is also encouraged to keep such materials to those that are necessary.

3.7.1.4. Provide detail drawings that illustrate conformance with the contract. Include room finish schedules, corresponding color/finish/special items schedules, and exterior finish schedules that agree with the submitted SID binders.

3.7.1.5. The design documents shall be in compliance with the latest version of the A/E/C CAD Standard, available at https://cadbim.usace.army.mil/CAD. Use the approved vertical Corps of Engineers title blocks and borders on all drawings with the appropriate firm name included within the title block area.

3.7.1.6. CAD System and Building Information Modeling (BIM) (NOTE: If this is a Single Award or Multiple Award, Indefinite Delivery/Indefinite Quantity Contract, this information will be provided for each task order.)

All CAD files shall be fully compatible with MicroStation V8 or higher. Save all design CAD files as MicroStation V8 or higher files. All submitted BIM Models and associated Facility Data shall be fully compatible with Bentley BIM file format and the USACE Bentley BIM v8 Workspace.

(a) CAD Data Final File Format: During the design development capture geo-referenced coordinates of all changes made to the existing site (facility footprint, utility line installations and alterations, roads, parking areas, etc) as a result of this contract. There is no mandatory methodology for how the geo-referenced coordinates will be captured, however, Engineering and Construction Bulletin No. 2006-15, Subject: Standardizing Computer Aided Design (CAD) and Geographic Information Systems (GIS) Deliverables for all Military Design and Construction Projects identifies the format for final as-built drawings and data sets to be delivered to the government. Close-out requirements at the as-built stage; require final geo-referenced GIS Database of the new facility along with all exterior modifications. The Government will incorporate this data set into the Installation's GIS Masterplan or Enterprise GIS System. See also, Section 01 78 02.00 10 Closeout Submittals.

(b) Electronic Drawing Files: In addition to the native CAD design files, provide separate electronic drawing files (in editable CAD format and Adobe Acrobat PDF version 7.0 or higher) for each project drawing.

(c) Each file (both CAD and PDF) shall represent one complete drawing from the drawing set, including the date, submittal phase, and border. Each drawing file shall be completely independent of any data in any other file, including fonts and shapes not included with the basic CAD software program utilized. Fonts that are not included as part of the default CAD software package installation or recognized as an allowable font by the A/E/C CAD Standard are not acceptable in delivered CAD files. All displayed graphic elements on all levels of the drawing files shall be part of the project drawing image. The drawing files shall not contain any graphic element that is not part of the drawing image.

(d) Deliver BIM Model and associated Facility Data files in their native format. At a minimum, BIM files shall address major architecture design elements, major structural components, mechanical systems and electrical/communication distribution and elements as defined in Attachment F. See Attachment F for additional BIM requirements.

(e) Drawing Index: Provide an index of drawings sheet in CAD as part of the drawing set, and an electronic list in Microsoft Excel of all drawings on the CD. Include the electronic file name, the sheet reference number, the sheet number, and the sheet title, containing the data for each drawing.

(f) Hard Copies: Plot submitted hard copy drawings directly from the "electronic drawing files" and copy for quantities and sizes indicated in the distribution list at the end of this specification section. The Designers of Record shall stamp, sign and date original hard copy sheets as Released For Construction, and provide copies for distribution from this set.

3.7.2. Design Analyses

3.7.2.1. The designers of record shall update, finalize and present design analyses with calculations necessary to substantiate and support all design documents submitted.

3.7.2.2. The responsible DOR shall stamp, sign and date the design analysis. Identify the software used where, applicable (name, version, vendor). Generally, provide design analyses, individually, in an original (file copy) and one copy for the assigned government reviewer.

3.7.2.3. All disciplines review the LEED design analysis in conjunction with their discipline-specific design analysis; include a copy of the separable LEED design analysis in all design analysis submittals.

3.7.2.4. Do not combine multi-disciplined volumes of design-analysis, unless multiple copies are provided to facilitate multiple reviewers (one copy per each separate design analysis included in a volume).

3.7.3. Specifications

Specifications shall be 100% complete and in final form.

3.7.4. Submittal Register

Prepare and update the Submittal Register and submit it with the 100% design specifications (see Specification Section 01 33 00, SUBMITTAL PROCEDURES) with each design package. Include the required submittals for each specification section in a design package in the submittal register.

3.7.5. Preparation of DD Form 1354 (Transfer of Real Property)

This form itemizes the types, quantities and costs of various equipment and systems that comprise the project, for the purpose of transferring the new construction project from the Corps Construction Division to the Installation's inventory of real property. The Government will furnish the DB Contractor's design manager a DD Form 1354 checklist to use to produce a draft Form 1354. Submit the completed checklist and prepared draft Form DD 1354 with the 100% design in the Design Analysis. The Corps will use these documents to complete the final DD 1354 upon completion of construction.

3.7.6. Acceptance and Release for Construction

3.7.6.1. At the conclusion of the Final Design Review (after resolutions to the comments have been agreed upon between DOR and Government reviewers), the Contracting Officer or the ACO will accept the Final Design Submission for the design package in writing and allow construction to start for that design package. The Government may withhold acceptance until all major corrections have been made or if the final design submission requires so many corrections, even though minor, that it isn't considered acceptably complete.

3.7.6.2. Government review and acceptance of design submittals is for contract conformance only and shall not relieve the Contractor from responsibility to fully adhere to the requirements of the contract, including the Contractor’s accepted contract proposal, or limit the Contractor’s responsibility of design as prescribed under Special Contract Requirement: “Responsibility of the Contractor for Design” or limit the Government’s rights under the terms of the contract. The Government reserves the right to rescind inadvertent acceptance of design submittals containing contract deviations not separately and expressly identified in the submittal for Government consideration and approval.

3.8. DESIGN COMPLETE CONSTRUCTION DOCUMENT REQUIREMENTS

After the Final Design Submission and Review Conference and after Government acceptance of the Final Design submission, revise the design documents for the design package to incorporate the comments generated and resolved in the final review conference, perform and document a back-check review and submit the final, design complete documents. Label the final design complete documents “FOR CONSTRUCTION” or use similar language. In addition to the final drawings and specifications, the following deliverables are required for distribution and field use. The deliverable includes all documentation and supporting design analysis in final form, as well as the final review comments, disposition and the back-check. As part of the quality assurance process, the Government may perform a back-check of the released for construction documentation. Promptly correct any errors or omissions found during the Government back-check. The Government may withhold retainage from progress payments for work or materials associated with a final design package until this submittal has been received and the Government determines that it is complete.

3.9. SUBMITTAL DISTRIBUTION, MEDIA AND QUANTITIES

3.9.1. Submittal Distribution and Quantities

General: The documents which the Contractor shall submit to the Government for each submittal are listed and generally described in preceding paragraphs in this Section. Provide copies of each design submittal and design substantiation as follows (NOTE: If this is a Single Award or Multiple Award, Indefinite Delivery/Indefinite Quantity Contract, this information will be provided for each task order):

Activity and Address	Drawing Size (Full Size) **Full** Full Sets/ *Partial Sets	Design Analyses & Specs Full Sets/ *Partial Sets	Drawing Size (Half Size) **Half** Full Sets/ *Partial Sets	Non-BIM Data CD-ROM or DVD as Necessary (PDF& **.dgn**)	Furniture Submittal (Per Attachment B)	Structural Interior Design Submittal	BIM Data DVD (Per Attach F)
Commander, U.S.Army Engineer District **[Not Supplied - DistrictInfoGeneral : CONSTRUCTION_DISTRICT]**	0/0	0/0	0/0	0	1	0	0
Commander, U.S.Army Engineer District, Center of Standardization **Huntsville**	0/0	2/2	2/2	2	N/A	0	0
Installation	0/0	0/0	0/0	0	2	0	0
U.S.Army Corps of Engineers Construction Area Office	1/1	3/3	3/3	4	1	0	0
Information Systems Engineering Command (ISEC)	0/0	0/0	0/0	1	N/A	N/A	1
Other Offices	0/0	0/0	0/0	0	N/A	0	0

***NOTE: For partial sets of drawings, specifications and design analyses, see paragraph 3.9.3.3, below.**

****NOTE: When specified below in 3.9.2, furnish Installation copies of Drawings as paper copies, in lieu of the option to provide secure web-based submittals.**

3.9.2. Web based Design Submittals

Except for full or half-sized drawings for Installation personnel, as designated in the Table above, Web based design submittals will be acceptable as an alternative to the paper copies listed in the Table above, provided a single hard-copy PDF based record set is provided to the Contracting Officer for record purposes. Where the contract requires the Contractor to submit documents to permitting authorities, still provide those authorities paper copies (or in an alternate format where required by the authority). Web based design submittal information shall be provided with adequate security and availability to allow unlimited access those specifically authorized to Government reviewers while preventing unauthorized access or modification. File sizes must be of manageable size for reviewers to quickly download or open on their computers. As a minimum, drawings shall be full scale on American National Standards Institute (ANSI) D sheets (34" x 22"). In addition to the optional website, provide the

BIM data submission on DVD to each activity and address noted above in paragraph 3.9.1 for each BIM submission required in Attachment F.

3.9.3. Mailing of Design Submittals

3.9.3.1. Mail all design submittals to the Government during design and construction, using an overnight mailing service. The Government will furnish the Contractor addresses where each copy shall be mailed to after award of the contract (or individual task order if this is an indefinite delivery/indefinite quantity, task order contract). Mail the submittals to two (2) different addresses. Assemble drawing sheets, specs, design analyses, etc. into individual sets; do not combine duplicate pages from individual sets so that the government has to assemble a set.

3.9.3.2. Each design submittal shall have a transmittal letter accompanying it indicating the date, design percentage, type of submittal, list of items submitted, transmittal number and point of contact with telephone number.

3.9.3.3. Provide partial sets of drawings, specifications, design analyses, etc., as designated in the Table in paragraph 3.9.1, to those reviewers who only need to review their applicable portions of the design, such as the various utilities. The details of which office receives what portion of the design documentation will be worked out after award.

3.10. AS-BUILT DOCUMENTS

Provide as-built drawings and specifications in accordance with Section 01 78 02.00 10, CLOSEOUT SUBMITTALS. Update LEED design phase documentation during construction as needed to reflect construction changes and advancing project completion status (example - Commissioning Plan updates during construction phase) and include updated LEED documentation in construction closeout submittal.

ATTACHMENT A
STRUCTURAL INTERIOR DESIGN (SID) REQUIREMENTS

1.0 GENERAL INFORMATION

Structural Interior Design includes all building related elements and components generally part of the building itself, such as wall finishes, ceilings finishes, floor coverings, marker/bulletin boards, blinds, signage and built in casework. Develop the SID in conjunction with the furniture footprint.

2.0 STRUCURAL INTERIOR DESIGN (SID) REQUIREMENTS FOR THE INTERIM AND FINAL DESIGN SUBMITTALS

2.1. FORMAT AND SCHEDULE

Prepare and submit for approval an interior and exterior building finishes scheme for an interim design submittal. The DOR shall meet with and discuss the finish schemes with the appropriate Government officials prior to preparation of the schemes to be presented. Present original sets of the schemes to reviewers at an interim design conference.

At the conclusion of the interim phase, after resolutions to the comments have been agreed upon between DOR and Government reviewers, the Contractor may proceed to final design with the interior finishes scheme presented.

The SID information and samples are to be submitted in 8 ½" x 11" format using three ring binders with pockets on the inside of the cover. When there are numerous pages with thick samples, use more than one binder. Large D-ring binders are preferred to O-ring binders. Use page protectors that are strong enough to keep pages from tearing out. Anchor large or heavy samples with mechanical fasteners, Velcro, or double-faced foam tape rather than rubber cement or glue. Fold out items must have a maximum spread of 25 ½". Provide cover and spine inserts sheets identifying the document as "Structural Interior Design" package. Include the project title and location, project number, Contractor/A/E name and phone number(s), submittal stage and date.

Design submittal requirements include, but are not limited to:

2.1.1. Narrative of the Structural Interior Design Objectives

The SID shall include a narrative that discusses the building related finishes. Include topics that relate to base standards, life safety, sustainable design issues, aesthetics, durability and maintainability, discuss the development and features as they relate to the occupants requirements and the building design.

2.1.2. Interior Color Boards

Identify and key each item item on the color boards to the contract documents to provide a clear indication of how and where each item will be used. Arrange finish samples to the maximum extent possible by room type in order to illustrate room color coordination. Label all samples on the color boards with the manufacturer's name, patterns and colors name and number. Key or code samples to match key code system used on contract drawings.

Material and finish samples shall indicate true pattern, color and texture. Provide photographs or colored photocopies of materials or fabrics to show large overall patterns in conjunction with actual samples to show the actual colors. Finish samples must be large enough to show a complete pattern or design where practical.

Color boards shall include but not be limited to original color samples of the following:

All walls finishes and ceiling finishes, including corner guards, acrylic wainscoting and wall guards/chair rail finishes

All tile information, including tile grout color and tile patterns.

- All flooring finishes, including patterns.
- All door, door frame finishes and door hardware finishes
- All signage, wall base, toilet partitions, locker finishes and operable/folding partitions and trim

- All millwork materials and finishes (cabinets, counter tops, etc.)
- All window frame finishes and window treatments (sills, blinds, etc.)

Color board samples shall reflect all actual finish textures, patterns and colors required as specified. Patterned samples shall be of sufficient size to adequately show pattern and its repeat if a repeat occurs.

2.1.3. Exterior Color Boards

Prepare exterior finishes color boards in similar format as the interior finishes color boards, for presentation to the reviewers during an interim design conference. Provide original color samples of all exterior finishes including but not limited to the following:

- All Roof Finishes
- All Brick and Cast Stone Samples
- All Exterior Insulation and Finish Samples
- All Glass Color Samples
- All Exterior Metals Finishes
- All Window & Door Frame Finishes
- All Specialty Item Finishes, including trim

Identify each item on the exterior finishes color boards and key to the building elevations to provide a clear indication of how and where each item will be used.

2.2. STRUCTURAL INTERIOR DESIGN DOCUMENTS

2.2.1. General

Structural interior design related drawings must indicate the placement of extents of SID material, finishes and colors and must be sufficiently detailed to define all interior work. The following is a list of minimum requirements:

2.2.2. Finish Color Schedule

Provide finish color schedule(s) in the contract documents. Provide a finish code, material type, manufacturer, series, and color designations. Key the finish code to the color board samples and drawings.

2.2.3. Interior Finish Plans

Indicate wall and floor patterns and color placement, material transitions and extents of interior finishes.

2.2.4. Furniture Footprint Plans

Provide furniture footprint plans showing the outline of all freestanding and systems furniture for coordination of all other disciplines.

2.2.5. Interior Signage

Include interior signage plans or schedules showing location and quantities of all interior signage. Key each interior sign to a quantitative list indicating size, quantity of each type and signage text.

2.2.6. Interior Elevations, Sections and Details

Indicate material, color and finish placement.

ATTACHMENT B
FURNITURE, FIXTURES & EQUIPMENT (FF&E) REQUIREMENTS

1.0 FF&E REQUIREMENTS FOR THE INTERIM AND FINAL DESIGN SUBMITTALS

1.1. FORMAT AND SCHEDULE

Prepare and submit for approval a comprehensive FF&E scheme for an interim design submittal. The Contractor's interior designer, not a furniture dealer, shall develop the design. FF&E is the selection, layout, specification and documentation of furniture includes but is not limited to workstations, seating, tables, storage and shelving, filing, trash receptacles, clocks, framed artwork, artificial plants, and other accessories. Contract documentation is required to facilitate pricing, procurement and installation. The FF&E package is based on the furniture footprint developed in the Structural Interior Design (SID) portion of the interior design. Develop the FF&E package concurrently with the building design to ensure that there is coordination between the electrical outlets, switches, J-boxes, communication outlets and connections, and lighting as appropriate. In addition, coordinate layout with other building features such as architectural elements, thermostats, location of TV's, GF/GI equipment (for example computers, printers, copiers, shredders, faxes), etc. Locate furniture in front of windows only if the top of the item falls below the window and unless otherwise noted, do not attach furniture including furniture systems to the building. If project has SIPRNET and/or NIPRNET, coordinate furniture layout with SIPRNET and NIPRNET separation requirements. Verify that access required by DOIM for SIPRNET box and conduit is provided. The DOR shall interview appropriate Government personnel to determine FF&E requirements for furniture and furnishings prior to preparation of the scheme to be presented. Determine FFE items and quantities by, but not limited to: (1) the number of personnel to occupy the building, (2) job functions and related furniture/office equipment to support the job function, (3) room functions, (4) rank and grade. Present original sets of the scheme to reviewers at an interim design conference upon completion of the interim architectural submittal or three months prior to the submittal of the final FF&E package (whichever comes first).

Design may proceed to final with the FF&E scheme presented at the conclusion of the interim phase, after resolutions to the comments have been agreed upon between DOR and Government reviewers.

Provide six copies of the electronic versions of all documents upon completion of the final architectural submittal or ten months prior to the contract completion date (whichever comes first), to ensure adequate time for furniture acquisition. Provide unbound, electronic drawings in CAD and BIM. Provide all files needed to v,/iew complete drawings. Submit all text documents in Microsoft Word or Excel..

Submit four copies of the final and complete FF&E information and samples in 8 ½" x 11" format using three ring binders with pockets on the inside of the cover upon completion of the final architectural submittal or ten months prior to the contract completion date (whichever comes first). Use more than one binder when there are numerous pages with thick samples. Large D-ring binders are preferred to O-ring binders. Use page protectors that are strong enough to keep pages from tearing out for upholstery and finish boards. Anchor large or heavy samples with mechanical fasteners, Velcro, or double-faced foam tape rather than rubber cement or glue. Fold out items must have a maximum spread of 25 ½". Provide cover and spine inserts sheets identifying the document as "Furniture, Fixtures & Equipment" package and include the project title and location, project number, Contractor/A/E name and phone number(s), submittal stage and date.

Provide electronic copies of all documents upon completion of the final architectural submittal or ten months prior to the contract completion date (whichever comes first), to ensure adequate time for furniture acquisition. Provide six compact disks with all drawings files needed to view the complete drawings unbound and in the latest version AutoCAD. Provide six additional compact disks of all text documents in Microsoft Word or Excel.

Design submittal requirements include, but are not limited to:

1.1.1. Narrative of Interior Design Objectives

Provide a narrative description of the furniture, to include functional, safety and ergonomic considerations, durability, sustainability, aesthetics, and compatibility with the building design.

1.1.2. Furniture Order Form

Prepare one Furnishings Order Form for each item specified in the design. This form identifies all information required to order each individual item. In addition to the project name and location, project number, and submittal phase, the order form must include:

(a) Furniture item illustration and code

(b) Furniture item name

(c) Job name, location, and date

(d) General Services Administration (GSA) FSC Group, part, and section

(e) Manufacturer, Product name and Product model number or National Stock Number (NSN)

(f) Finish name and number (code to finish samples)

(g) Fabric name and number, minimum Wyzenbeek Abrasion Test double rubs (code to fabric samples)

(h) Dimensions

(i) Item location by room number and room name

(j) Quantity per room

(k) Total quantity

(l) Special instructions for procurement ordering and/or installation (if applicable)

(m) Written Product Description: include a non-proprietary paragraph listing the salient features of the item to include but not limited to:

(1) required features and characteristics

(2) ergonomic requirements

(3) functional requirements

(4) testing requirements

(5) furniture style

(6) construction materials

(7) minimum warranty

The following is an example for “m” features and characteristics, ergonomic requirements and functional requirements:

Chair Description:

(1) Mid-Back Ergonomic Task Chair

(2) Pneumatic Gaslift; Five Star Base

(3) Mesh Back; Upholstered Seat

(4) Height and Width Adjustable Task Arms:

a. Arm Height: 6”- 11” (+-1/2”)

b. Arm Width: 2”– 4” adjustment

(5) Height Adjustable Lumbar Support

(6) Adjustable Seat Height 16”-21” (+- 1”)

(7) Sliding Seat Depth Adjustment 15”-18” (+-1”)

(8) Standard Hard Casters (for carpeted areas)

(9) Overall Measurements:

a. Overall width: 25” - 27”

b. Overall depth: 25”– 28”

(10) Must have a minimum of the following adjustments (In addition to the above):

a. 360 Degree Swivel

b. Knee-Tilt with Tilt Tension

c. Back angle

d. Forward Tilt

e. Forward Tilt and Upright Tilt Lock

For projects with systems furniture, also provide a written description of the following minimum requirements:

(1) Type furniture systems (panel, stacking panels, spine wall, desk based system, or a combination)

(2) Minimum noise reduction coefficient (NRC)

(3) Minimum sound transfer coefficient (STC)

(4) Minimum flame spread and smoke development

(5) UL testing for task lighting and electrical system

(6) Panel widths and heights and their locations (this may be done on the drawings)Worksurface types and sizes (this may be done on the drawings)

(7) Worksurface edge type

(8) Varying panel/cover finish materials and locations (locations may be shown on the drawings)

(9) Storage requirements

(10) Keyboard requirements

(11) Lock and keying requirements

(12) Accessory components (examples: tack boards, marker boards, paper management)

(13) Electrical and communication raceway requirement; type, capacity and location (base, beltline, below and/or above beltline)

(14) Locations of communication cables (base, beltline, below and/or above beltline, top channel)

(15) Types of electrical outlets

(16) Types of communication jacks; provided and installed by others

(17) Locations of electrical outlets and communication jacks (this may be done on the drawings)

(18) Type of cable (examples: Cat. 5, Cat. 6, fiber optic; UTP or STP, etc.) system needs to support; provided and installed by others

1.1.3. Alternate Manufacturer List

Provide a table consisting of major furniture items that lists the manufacturers products specified on the Order Form and two alternate manufacturers. Major furniture items include, but are not limited to, casegoods, furniture systems, seating, and tables. Organize matrix by item code and item name. Supply alternates that are available on GSA Schedule and meet the requirements of the Furniture Order Form. One of the two alternates must be from UNICOR if possible. Provide manufacturer name address, telephone number, product series and product name for each alternate manufacturer.

1.1.4. FF&E Procurement List

Provide a table that lists all FF&E furniture, mission unique equipment and building Contractor Furnished/Contractor Installed (CF/CI) items. Give each item a code and name and designate whether item will be procured as part of the FF&E furniture, mission unique equipment or the building construction contract. Use the item code to key all FF&E documents including location plans, color boards, data sheets, cost estimate, etc.

1.1.5. Points of Contact (POCs)

Provide a comprehensive list of POCs needed to implement the FF&E package. This would include but not be limited to appropriate project team members, using activity contacts, interior design representatives, construction contractors and installers involved in the project. In addition to name, address, phone, fax and email, include each contact's job function. Divide the FF&E package into different sections based on this listing, applies to order forms and cost estimates.

1.1.6. Color Boards

Provide color boards for all finishes and fabrics for all FF&E items. Finishes to be included but not limited to paint, laminate, wood finish, fabric, etc.

1.1.7. Itemized Furniture Cost Estimate

Provide an itemized cost estimate of furnishings keyed to the plans and specifications of products included in the package. This cost estimate should be based on GSA price schedules. The cost estimate must include separate line items for general contingency, installation, electrical hook-up for systems furniture or other furniture requiring hardwiring by a licensed electrician, freight charges and any other related costs. Installation and freight quotes from vendors should be use in lieu of a percentage allowance when available. Include a written statement that the pricing is based on GSA schedules. An estimate developed by a furniture dealership may be provided as support information for the estimate, but must be separate from the contractor provided estimate.

1.2. INTERIOR DESIGN DOCUMENTS

1.2.1. Overall Furniture and Area Plans

Provide floor Plans showing locations and quantities of all freestanding, and workstation furniture proposed for each floor of the building. Key each room to a large scale Furniture Placement Plan showing the furniture configuration, of all furniture. Provide enlarged area plans with a key plan identifying the area in which the building is located. Key all the items on the drawings by furniture item code. Do not provide manufacturer specific information such as product names and numbers on drawings, Drawings shall be non-proprietary. This is typical for FFE on all plans, including those mentioned below.

1.2.2. Workstation Plans

Show each typical workstation configuration in plan view, elevations or isometric view. Drawings shall illustrate panels and all major components for each typical workstation configuration. Identify workstations using the same numbering system as shown on the project drawings. Key components to a legend on each sheet which identifies and describes the components along with dimensions. Provide the plan, elevations and isometric of each typical workstation together on the same drawing sheet.

1.2.3. Panel Plans

Show panel locations and critical dimensions from finished face of walls, columns, panels including clearances and aisle widths. Key panel assemblies to a legend which shall include width, height, configuration of frames, panel fabric and finishes (if there are different selections existing within a project), powered or non-powered panel and wall mount locations.

1.2.4. Desk Plans

Provide typical free standing desk configurations in plan view, elevation or isometric view and identify components to clearly represent each desk configuration.

1.2.5. Reflected Ceiling Plans

Provide typical plans showing ceiling finishes and heights, lighting fixtures, heating ventilation and air conditioning supply and return, and sprinkler head placement for coordination of furniture.

1.2.6. Electrical and Telecommunication Plans

Show power provisions including type and locations of feeder components, activated outlets and other electrical componentsShow locations and quantities of outlets for workstations. Clearly identify different outlets, i.e. electrical, LAN and telecommunication receptacles indicating each type proposed. Show wiring configuration, (circuiting, switching, internal and external connections) and provide as applicable.

1.2.7. Artwork Placement Plans

Provide an Artwork Placement Plan to show location of artwork, assign an artwork item code to each piece of artwork. As an alternative, artwork can be located on the Furniture Plans. Provide a schedule that identifies each piece by room name and number. Provide installation instructions; include mounting height.

1.2.8. Window Drapery Plans

Provide Interior Window Drapery Plans. Key each drapery treatment to a schedule showing color, pattern, material, drapery size and type, draw direction, location and quantities.

1.3. FURNITURE SELECTION

1.3.1. Select furniture from the GSA Schedules. Specify furniture available open market when an item is not available on the GSA Schedules. Provide justification fort items not available on the GSA Schedules.

1.3.2. To the greatest extent possible when specifying furniture work within a manufacturer's family of furniture for selections, example: Steelcase, Turnstone, Brayton International, Metro, and Vecta are all Steelcase companies. Each alternate should also be specified from a manufacturer's family of furniture, example: first set of alternates would be specified from Knoll's family of furniture and the second from Herman Miller family of furniture. It may be necessary to make some selections from other than a manufacturer's family of furniture if costs are not reasonable for particular items, some items are not available or appropriate for the facility or the items are not on GSA Schedule. If this occurs, consider specifying product from an open line that is accessible by numerous dealerships. Select office furniture including case goods, tables, storage, seating, etc. that is compatible in style, finish and color. Select furniture that complies with ANSI/BIFMA and from manufacturer's standard product line as shown in the most recent published price list and/or amendment and not custom product.

1.4. CONSTRUCTION

1.4.1. Provide knee space at workstations and tables that is not obstructed by panels/legs that interfere with knee space of seated person and specificy modesty panels at walls to be of a height or be hinged to allow access to building wall electrical outlets and communication jacks. Provide desks, storage and tables with leveling devices to compensate for uneven floors.

1.4.2. Specify workstations and storage of steel construction. Provide worksurface tops constructed to prevent warpage. Provide user friendly features such as radius edges. Do not use sharp edges and exposed connections and ensure the underside of desks, tables and worksurfaces are completely and smoothly finished. Provide abutting worksurfaces that mate closely and are of equal heights when used in side-by-side configurations in order to provide a continuous and level worksurface.

1.4.3. Drawers shall stay securely closed when in the closed position and protect wires from damage during drawer operation. Include a safety catch to prevent accidental removal when fully open

1.4.4. Unless otherwise noted, provide lockable desks and workstations, filing cabinets and storage. Key all locks within a one person office the same; key all one person offices within a building differently. If an office or open office area has more than one workstation, key all the workstations differently, but key all locks within an individual workstation the same. Use tempered glass glazing when glazing is required. Use light-emitting diode (LED)/solid state lighting where task lighting is required in furniture.

1.5. FINISHES AND UPHOLSTERY

1.5.1. Specify neutral colors for casegoods, furniture systems, storage and tables. Specify desk worksurfaces and table tops that are not too light or too dark in color and have a pattern to help hide soiling. Accent colors are

allowed in break and lounge areas. Keep placement of furniture systems panel fabric accent colors to a minimum. All finishes shall be cleanable with ordinary household cleaning solutions.

1.5.2. Use manufacturer's standard fabrics; including textile manufacturers fabrics that have been graded into the furniture manufactures fabric grades and are available through their GSA Schedule. Customers Own Material (COM) can be used in headquarter buildings in command suites with executive furniture. Coordinate specific locations with Corps of Engineers Interior Designer.

1.5.3. Specify seating upholstery that meets Wyzenbeek Abrasion Test, 55,000 minimum rubs. Specify a soil retardant finish for woven fabrics if Crypton or vinyl upholstery is not provided for seating in dining areas. Use manufacturer's standard fabrics. This includes textile manufacturers fabrics that have been graded into the furniture manufactures fabric grades and are available through their GSA Schedule. Specify upholstery and finish colors and patterns that help hide soiling. Specify finishes that can be cleaned with ordinary household cleaning solutions.

1.6. ACCESSORIES

1.6.1. Specify all accessories required for completely finished furniture installation. Provide filing cabinets and storage for office supplies. Provide tack surfaces at workstations with overhead storage. Provide tackable surfaces at workstations with overhead storage.

1.6.2. Not Used.

1.6.3. Workstations are to be equipped with stable keyboard trays that have height adjustability, tilting capability, including negative tilt, have a mouse pad at same height as the keyboard tray that can accommodate both left and right handed users, and retractable under worksurface.

1.7. MISSION UNIQUE EQUIPMENT

Funding for FF&E furniture items and mission unique equipment (MUE) items are from two different sources. Separate the designs and procurement documentation for FFE items and MUE. MUE includes, but is not limited to, items such as industrial shelving, workbenches, appliances, fitness equipment, IT equipment and supporting carts. The User will purchase and install mission unique equipment items, unless otherwise noted. Identify locations of known MUE items such as industrial shelving, workbenches, appliances, etc. for space planning purposes.

1.8. SUSTAINABILITY

1.8.1. For all designs provided regardless of facility type, make every effort to implement all aspects of sustainability to the greatest extent possible for all the selections made in the FF&E package. This includes but is not limited to the selection of products that consider: **Material Chemistry and Safety of Inputs** (What chemicals are used in the construction of the selections?); **Recyclability** (Do the selections contain recycled content?); **Disassembly** (Can the selections be disassembled at the end of their useful life to recycle their materials?).

1.8.2. Make selections to the greatest extent possible of products that possess current McDonough Braungart Design Chemistry (MBDC) certification or other "third-party" certified Cradle to Cradle program, Forest Stewardship Council (FSC) certification, GREENGAURD certification or similar "third-party" certified products consisting of low-emitting materials.

1.9. FURNITURE SYSTEMS

1.9.1. General.

Where appropriate, design furniture systems in open office areas. Coordinate style and color of furniture systems with other storage, seating, etc. in open office areas. Minimize the number of workstation typicals and the parts and pieces required for the design to assist in future reconfiguration and inventorying.

1.9.2. Connector Systems.

Specify a connector system that allows removal of a single panel or spine wall within a typical workstation configuration without requiring disassembly of the workstation or removal of adjacent panels. Specify connector

system with tight connections and continuous visual seals. When Acoustical panels are used, provide connector system with continuous acoustical seals. Specify concealed clips, screws, and other construction elements, where possible.

1.9.3. Panels and Spine Walls

Specify panels and spine walls with hinged or removable covers that permit easy access to the raceway when required but are securely mounted and cannot be accidentally dislodged under normal conditions. Panels shall be capable of structurally supporting more than 1 fully loaded component per panel per side. Raceways are to be an integral part of the panel and must be able to support lay-in cabling and have a large capacity for electrical and IT. Do not thread cables through the frame.

1.9.4. Electrical And Information/Technology (IT)

Design furniture with electrical systems that meets requirements of UL 1286 when powered panels are required and UL approved task lights that meet requirements of NFPA 70. Dependent on user requirements and Section 01 10 00, paragraph 3 requirements, it is recommended that workstation electrical and IT wiring entry come from the building walls to eliminate the use of power poles and access at the floor. Design electrical and IT systems that are easily accessed in the spine wall and panels without having to move return panels and components. Electrical and IT management will be easily accessible by removable wall covers which can be removed while workstation components are still attached. Specify connector system that has continuation of electrical and IT wiring within workstations and workstation to workstation.

1.9.5. Pedestals

Specify pedestals that are interchangeable from left to right, and right to left, and retain pedestal locking system capability.

1.10. EXECUTIVE FURNITURE

1.10.1. Design for executive furniture in command areas, coordinate specific locations with Corps of Engineers Interior Designer. Use upgraded furniture, upholsteries and finishes in command suites. This includes but is not limited to wood casegoods, seating and tables. Select executive furniture casegoods from a single manufacturer and style line, to include workstations, credenzas, filing, and storage, etc.

1.10.2. Specify furniture with wood veneer finish (except worksurfaces) with mitered solid wood edge of same wood type. Provide worksurface plastic laminate that closely matches adjacent wood veneer. Other executive office furniture such as seating, tables, executive conference room furniture, etc. shall be compatible in style, finish and color with executive furniture casegoods.

1.11. SEATING

1.11.1. General

Specify appropriate chair casters and glides for the floor finish where the seating is located. Universal casters that are appropriate for both hard surface flooring and carpet are preferred. All seating shall support up to a minimum of 250 lbs.

1.11.2. Desk and Guest Seating

Select ergonomic desk chairs with casters, non-upholstered adjustable arms, waterfall front, swivel, tilt, variable back lock, adjustable back height or adjustable lumbar support, pneumatic seat height adjustment, and padded, contoured upholstered seat and back. Desk and guest chair backs may be other than upholstered such as mesh fabric if it is ergonomically designed, forms to back and is comfortable. Depending on scale of desk chair provide seat pan forward and back adjustment to increase or decrease depth of seat pan. All desk chairs shall have an adjustable seat height range of 4 1/2", range to include 16 1/2-20". Select guest chairs that are compatible in style, finish and color with the desk chairs.

1.11.3. Conference Room Seating

At tables, select ergonomic conference seating with casters, non-upholstered arms, waterfall front, swivel, tilt, pneumatic seat height adjustment, and padded, contoured seat and back, unless otherwise noted. Select arm height and/or design that allows seating to be moved up closely to the table top. Conference chair backs may be other than upholstered such as mesh fabric if it is ergonomically designed, forms to back and is comfortable. Perimeter conference chairs shall be compatible in style, finish and color with conference seating at the tables.

1.11.4. Lounge, Waiting and Reception Area Seating

Select seating with arms and cushioned, upholstered seat and back. In heavy use areas, arms shall be easily cleaned such as non-upholstered arms or upholstered arms with wood arm caps unless otherwise noted.

1.11.5. Break Room Seating

Select stackable seating that is easily cleaned. Seating shall be appropriate for table and counter heights as applicable with non-upholstered arms if arms are required. Chairs shall have metal legs and composite materials for seats.

1.11.6. Lounge, Waiting and Reception Furniture.

Design for end and coffee tables with plastic laminate tops that are compatible in style finish and color with the seating.

1.12. FILING AND STORAGE.

Select storage and shelving units that meet customer’s functional load requirements for stored items. Specify counterweights for filing cabinets when required by the manufacturer for stability. File drawers shall allow only one drawer to be opened at a time. Provide heavy duty storage and shelving if information is not available.

1.13. TRAINING TABLES.

Don’t use plastic laminate self edge. Training tables shall be reconfigurable, moveable and storable; lighter weight folding with dollies or castered as necessary. Specify dollies if required.

1.14. FURNITURE WARRANTIES.

Specify manufacturer's performance guarantees or warranties that include parts, labor and transportation as follows:

Furniture System, unless otherwise noted – 10 year minimum
Furniture System Task Lights – 2 year minimum, excluding bulbs
Furniture System Fabric – 3 year minimum
Desks - 10 year minimum
Seating, unless otherwise noted - 10 year minimum
Seating Mechanisms and Pneumatic Cylinders - 10 years
Fabric - 3 years minimum
Filing and Storage - 10 year minimum
Tables, unless otherwise noted - 10 year minimum
Table Mechanisms – 5 year
Table Ganging Device - 1 year
Items not listed above - 1 year minimum

ATTACHMENT C
TRACKING COMMENTS IN DRCHECKS

1.0 General

The Government and DB Contractor shall set up the project in Dr Checks. Throughout the design process, the parties shall enter, track, and back-check comments using the DrChecks system. Government reviewers enter design review comments into DrChecks. Designers of Record shall annotate comments timely and specifically to indicate exactly what action will be taken or why the action is not required. Comments considered critical by the conference participants shall be flagged as such.

2.0 DrChecks Review Comments

The Contractor and the Government shall monitor DrChecks to assure all comments are annotated and agreed to by the designers and reviewers prior to the next submittal. The DrChecks comments and responses shall be printed and included in the design analysis for record.

2.1. Conference participants (reviewers) will expect coordination between Design Analysis calculations and the submitted design. Reviewers will also focus on the design submittal's satisfaction of the contract requirements.

2.2. The Designers of Record shall answer each comment in DrChecks with a formal response prior to the next submittal, clearly indicating what action will be taken and what drawing/spec will change. Designers of Record are encouraged to directly contact reviewers to discuss and agree to the formal comment responses rather than relying only on DrChecks and review meetings to discuss comments. With the next design conference, reviewers will back-check answers to the comments against the submittal, in addition to reviewing additional design work.

2.3. Comments that, in the DB Contractor's opinion, require effort outside the scope of the contract shall be clearly indicated as such in DrChecks. The DB Contractor shall not proceed with work outside the contract until a modification to the contract is properly executed, if one is necessary.

3.0 DrChecks Initial Account Set-Up

To initialize an office's use of DrChecks, choose a contact person within the office to call the DrChecks Help Desk at 800-428-HELP, M-F, 8AM-5PM, Central time. This POC will be given an office password to distribute to others in the office. Individuals can then go to the hyperlink at http://www.projnet.org and register as a first time user. Upon registration, each user will be given a personal password to the DrChecks system.

3.1. Once the office and individuals are registered, the COE’s project manager or lead reviewer will assign the individuals and/or offices to the specific project for review. At this point, persons assigned can make comments, annotate comments, and close comments, depending on their particular assignment.

4.0 DrChecks Reviewer Role

The Contractor is the technical reviewer and the Government is the compliance reviewer of the DB designers design documents. Each reviewer enters their own comments into the Dr Checks system. To enter comments:

4.1. Log into DrChecks.

4.2. Click on the appropriate project.

4.3. Click on the appropriate review conference. An Add comment screen will appear.

4.4. Select or fill out the appropriate sections (particularly comment discipline and type of document for sorting) of the comment form and enter the comment in the space provided.

4.5. Click the Add Comment button. The comment will be added to the database and a fresh screen will appear for the next comment you have.

4.6. Once comments are all entered, exit DrChecks by choosing “My Account” and then Logout.

5.0 DrChecks Comment Evaluation

The role of the designers of record is to evaluate and respond to the comments entered by the Government reviewers and by the DB Contractor. To respond to comments:

5.1. Log into DrChecks.

5.2. Click on the appropriate project.

5.3. Under “Evaluate” click on the number under “Pending”.

5.4. Locate the comments that require your evaluation. (Note: If you know the comment number you can use the Quick Pick window on your home page in DrChecks; enter the number and click on go.)

5.5. Select the appropriate evaluation (concur, non-concur, for information only, or check and resolve) and add the response.

5.6. Click on the Add button. The evaluation will be added to the database and a fresh screen will appear with the next comment.

5.7. Once evaluations are all entered, exit DrChecks by choosing “My Account” and then Logout.

6.0 DrChecks Back-check

At the following design conference, participants will back-check comment annotations against newly presented documents to verify that the designers' responses are acceptable and completed. The Contractor and Government reviewers shall either enter additional back-check comments, as necessary or close those that are resolved as a result of the design conferences:

6.1. Log into DrChecks.

6.2. Click on the appropriate project.

6.3. Under “My Backcheck” click on the number under “Pending”.

6.4. If you agree with the designer’s response select “Close Comment” and add a closing response if desired.

6.5. If you do not agree with the designer’s response or the submittal does not reflect the response given, select “Issue Open”, enter additional information.

6.6. Click on the Add button. The back-check will be added to the database and a fresh screen will appear with the next comment.

6.7. Once back-checks are all entered, exit DrChecks by choosing “My Account” and then Logout. The design is completed and final when there are no pending comments to be evaluated and there are no pending or open comments under back-check.

ATTACHMENT D
SAMPLE FIRE PROTECTION AND LIFE SAFETY CODE REVIEW

Instructions: Use the information outlined in this document to provide the minimum requirement for development of Fire Protection and Life Safety Code submittals for all building projects. Additional and supplemental information may be used to further develop the code review. Insert N/A after criteria, which may be "not applicable".

1.0 SAMPLE FIRE PROTECTION AND LIFE SAFETY CODE REVIEW

1.1. Project Name (insert name and location)

1.2. Applicable Codes and Standards

1.2.1. Unified Facilities Criteria (UFC): 3-600-01, Design: Fire Protection Engineering For Facilities

1.2.2. International Building Code (IBC) for fire resistance requirements, allowable floor area, building height limitations and building separation distance requirements, except as modified by UFC 3-600-01.

1.2.3. National Fire Protection Association (NFPA) 101 Life Safety Code (latest edition), for building egress and life safety and applicable criteria in UFC 3-600-01.

1.2.4. ADA and ABA Accessiblity Guidelines. For Buildings and Facilities See Section 01 10 00, Paragraph 3 for facility specific criteria.

1.3. Occupancy Classification
IBC chapters 3 and 4

1.4. Construction Type
IBC chapter 6

1.5. Area Limitations
IBC chapter 5, table 503

1.6. Allowable Floor Areas
IBC section 503, 505

1.7. Allowable area increases
IBC section 506, 507

1.8. Maximum Height of Buildings
IBC section 504

1.9. Fire-resistive substitution

1.10. Occupancy Separations
IBC table 302.3.2

1.11. Fire Resistive Requirements

1.11.1. Exterior Walls - [_____] hour rating, IBC table 601, 602

1.11.2. Interior Bearing walls - [_____] hour rating

1.11.3. Structural frame - [_____] hour rating

1.11.4. Permanent partitions - [_____] hour rating

1.11.5. Shaft enclosures - [_____] hour rating

1.11.6. Floors & Floor-Ceilings - [_____] hour rating

1.11.7. Roofs and Roof Ceilings - [_____] hour rating

1.12. Automatic Sprinklers and others used to determine the need for automatic Extinguishing Equipment, Extinguishing Systems, Foam Systems, Standpipe

1.12.1. UFC 3-600-01, chapters 4 and 6 systems, wet chemical systems, etc. State which systems are required and to what criteria they will be designed.

1.12.2. UFC 3-600-01, Appendix B Occupancy Classification. Note the classification for each room. This may be accomplished by classifying the entire building and noting exceptions for rooms that differ (E.g. The entire building is Light Hazard except boiler room and storage rooms which are [_____], etc.)

1.12.3. UFC 3-600-01, Chapter 3 Sprinkler Design Density, Sprinkler Design Area, Water Demand for Hose Streams (supply pressure and source requirements).

1.12.4. UFC 3-600-01, Chapter 4 Coverage per sprinkler head. Extended coverage sprinkler heads are not permitted.

1.12.5. Available Water Supply. Provide the results of the water flow tests showing the available water supply static pressure and residual pressure at flow. Based on this data and the estimated flow and pressure required for the sprinkler system, determine the need for a fire pump.

1.12.6. NFPA 13, Para. 8.16.4.6.1. Provide backflow preventer valves as required by the local municipality, authority, or water purveyor. Provide a test valve located downstream of the backflow preventer for flow testing the backflow preventer at full system demand flow. Route the discharge to an appropriate location outside the building.

1.13. Kitchen Cooking Exhaust Equipment

Describe when kitchen cooking exhaust equipment is provided for the project. Type of extinguishing systems for the equipment should be provided. per NFPA 96. Show all interlocks with manual release switches, fuel shutoff valves, electrical shunt trips, exhaust fans, and building alarms.

1.14. Portable Fire Extinguishers, fire classification and travel distance. per NFPA 10

1.15. Enclosure Protection and Penetration Requirements. - Opening Protectives and Through Penetrations

1.15.1. IBC Section712, 715 and Table 715.3. Mechanical rooms, exit stairways, storage rooms, janitor [_____] hour rating. IBC Table 302.1.1

1.15.2. Fire Blocks, Draft Stops, Through Penetrations and Opening Protectives

1.16. Fire Dampers. Describe where fire dampers and smoke dampers are to be used (IBC Section 716 and NFPA 90A}. State whether isolation smoke dampers are required at the air handler.

1.17. Detection Alarm and Communication. UFC 3-600-01, (Chapter 5); NFPA 101 para. 3.4 (chapters 12-42); NFPA 72

1.18. Mass Notification. Describe building/facility mass notification system (UFC 4-021-01) type and type of base-wide mass notification/communication system. State whether the visible notification appliances will be combined with the fire alarm system or kept separate. (Note: Navy has taken position to combine visible notification appliances with fire alarm).

1.19. Interior Finishes (classification). NFPA 101.10.2.3 and NFPA 101.7.1.4

1.20. Means of Egress

1.20.1. Separation of Means of Egress, NFPA 101 chapters 7 and 12-42; NFPA101.7.1.3

1.20.2. Occupant Load, NFPA101.7.3.1 and chapters 12-42.

1.20.3. Egress Capacity (stairs, corridors, ramps and doors) NFPA101.7.3.3

1.20.4. Number of Means of Egress, NFPA101.7.4 and chapters 12-42.

1.20.5. Dead end limits and Common Path of Travel, NFPA 101.7.5.1.6 and chapters 12-42.

1.20.6. Accessible Means of Egress (for accessible buildings), NFPA101.7.5.4

1.20.7. Measurement of Travel Distance to Exits, NFPA101.7.6 and chapters 12-42.

1.20.8. Discharge from Exits, NFPA101.7.7.2

1.20.9. Illumination of Means of Egress, NFPA101.7.8

1.20.10. Emergency Lighting, NFPA101.7.9

1.20.11. Marking of Means of Egress, NFPA101.7.10

1.21. Elevators, UFC 3-600-01, Chapter 6; IBC and ASME A17.1 - 2000,(Safety Code for Elevators and Escalators)

1.22. Accessibility Requirements, ADA and ABA Accessibility Guidelines for Buildings and Facilities

1.23. Certification of Fire Protection and Life Safety Code Requirements. (Note: Edit the Fire team membership if necessary). Preparers of this document certify the accuracy and completeness of the Fire Protection and Life Safety features for this project in accordance with the attached completed form(s).

1.24. Designer of Record. Certification of Fire protection and Life Safety Code Requirements. (Note: Edit the Fire team members if necessary). Preparers of this document certify the accuracy and completeness of the Fire Protection and Life Safety features of this project.

Fire Protection Engineer of Record:

_____

Signature and Stamp

Date

OR

Architect of Record:

_____

Signature and Stamp

Date

Mechanical Engineer of Record:

_____

Signature and Stamp

Date

Electrical Engineer of Record:

_____

Signature/Date

ATTACHMENT E
LEED SUBMITTALS

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
GENERAL							
	GENERAL - All calculations shall be in accordance with LEED 2.2 Reference Guide.						
	GENERAL: Obtain excel version of this spreadsheet at http://en.sas.usace.army.mil/enWeb, "Engineering Criteria". OCT09REV						
	GENERAL - For all credits, narrative/comments may be added to describe special circumstances or considerations regarding the project's credit approach.						
	GENERAL - Include all required LEED drawings indicated below in contract drawings with applicable discipline drawings, labeled For Reference Only.						
	NOTE: Each submittal indicated with "**" differs from LEED certified project submittals by either having a different due date or being an added submittal not required by GBCI. OCT09REV						
	OCT09REV GENERAL - Audit documentation may include but is not limited to what is indicated in this table.						
			Closeout		List of all Final Design submittals revised after final design to reflect actual closeout conditions. Revised Final Design submittals. - OR - Statement confirming that no changes have been made since final design that effect final design submittal documents.		Proj Engr (PE)
CATEGORY 1 - SUSTAINABLE SITES							
SSPR1		Construction Activity Pollution Prevention (PREREQUISITE)	**Final Design		List of drawings and specifications that address the erosion control, particulate/dust control and sedimentation control measures to be implemented.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			**Final Design		Narrative that indicates which compliance path was used (NPDES or Local standards) and describes the measures to be implemented on the project. If a local standard was followed, provide specific information to demonstrate that the local standard is equal to or more stringent than the NPDES program.		CIV
SS1		Site Selection	Final Design		Statement confirming that project does not meet any of the prohibited criteria.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design	X	LEED Site plan drawing that shows all proposed development, line depicting boundary of all bodies of water and/or wetlands within 100 feet of project boundary and a line depicting 5' elevation above 100 year flood line that falls within project boundary. Not required if neither condition applies.		CIV
SS2		Development Density & Community Connectivity	Final Design		Option 1: LEED Site vicinity plan showing project site and surrounding development. Show density boundary or note drawing scale.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design		Option 1: Table indicating, for project site and all surrounding sites within density radius (keyed to site vicinity plan), site area and building area. Project development density calculation. Density radius calculation. Development density calculation within density radius.		CIV
			Final Design		Option 2: LEED Site vicinity plan showing project site, the 1/2 mile community radius, pedestrian walkways and the locations of the residential development(s) and Basic Services surrounding the project site.		CIV
			Final Design		Option 2: List (including business name and type) of all Basic Services facilities within the 1/2 mile radius, keyed to site vicinity plan.		CIV
SS3		Brownfield Redevelopment	Final Design		Narrative describing contamination and the remediation activities included in project. Include statement indicating how site was determined to be a brownfield.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
SS4.1		Alternative Transportation: Public Transportation Access	Final Design		Statement indicating which option for compliance applies. State whether public transportation is existing or proposed and, if proposed, cite source of this information.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design		Option 1: LEED Site vicinity plan showing project site, mass transit stops and pedestrian path to them with path distance noted.		CIV
			Final Design		Option 2: LEED Site vicinity plan showing project site, bus stops and pedestrian path to them with path distance noted.		CIV
SS4.2		Alternative Transportation: Bicycle Storage & Changing Rooms	Final Design		FTE calculation. Bicycle storage spaces calculation. Shower/changing facilities calculation.		CIV
			Final Design		List of drawings that show the location(s) of bicycle storage areas. Statement indicating distance from building entrance.		CIV
			Final Design		List of drawings that show the location(s) of shower/changing facilities and, if located outside the buiding, statement indicating distance from building entrance.		ARC
SS4.3		Alternative Transportation: Low Emitting & Fuel Efficient Vehicles	Final Design		Statement indicating which option for compliance applies. FTE calculation. Statement indicating total parking capacity of site.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design		Option 1: Low-emission & fuel-efficient vehicle calculation.		CIV

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Final Design		Option 1: List of drawings and specification references that show location and number of preferred parking spaces for low-emission & fuel-efficient vehicles and signage.		CIV
			Final Design		Option 1: Statement indicating quantity, make, model and manufacturer of low-emission & fuel-efficient vehicles to be provided. Statement confirming vehicles are zero-emission or indicating ACEEE vehicle scores.		CIV
			Final Design		Option 2: Low-emission & fuel-efficient vehicle parking calculation.		CIV
			Final Design		Option 2: List of drawings and specification references that show location and number of preferred parking spaces and signage.		CIV
			Final Design		Option 3: Low-emission & fuel-efficient vehicle refueling station calculation.		CIV
			Final Design		Option 3: List of drawings and specifications indicating location and number of refueling stations, fuel type and fueling capacity for each station for an 8-hour period.		CIV
			Closeout	X	Option 3: Construction product submittals indicating what was provided and confirming compliance with respect to fuel type and fueling capacity for each station for an 8-hour period.		CIV
SS4.4		Alternative Transportation: Parking Capacity	Final Design		Statement indicating which option for compliance applies.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design		Option 1: Preferred parking calculation including number of spaces required, total provided, preferred spaces provided and percentage.		CIV
			Final Design		Option 2: FTE calculation. Preferred parking calculation including number of spaces provided, preferred spaces provided and percentage.		CIV
			Final Design		Options 1 and 2: List of drawings and specification references that show location and number of preferred parking spaces and signage.		CIV
			Final Design		Option 3: Narrative indicating number of spaces required and provided and describing infrastructure and support programs with description of project features to support them.		CIV
SS5.1		Site Development: Protect or Restore Habitat	**Final Design		Option 1: List of drawing and specification references that convey site disturbance limits.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			**Final Design		Option 2: LEED site plan drawing that delineates boundaries of each preserved and restored habitat area with area (sf) noted for each.		CIV
			**Final Design		Option 2: Percentage calculation of restored/preserved habitat to total site area. List of drawings and specification references that convey restoration planting requirements.		CIV
SS5.2		Site Development: Maximize Open Space	Final Design		Option 2: LEED site plan drawing delineating boundary of vegetated open space adjacent to building with areas of building footprint and designated open space noted.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
SS6.1		Stormwater Design: Quantity Control	Final Design		Statement indicating which option for compliance applies.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design		Option 1: Indicate pre-development and post-development runoff rate(cfs) and runoff quantity (cf) -OR - Narrative describing site conditions, measures and controls to be implemented to prevent excessive stream velocities and erosion.		CIV
			Final Design		Option 2: Indicate pre-development and post-development runoff rate(cfs) and runoff quantity (cf). Indicate percent reduction in each.		CIV
SS6.2		Stormwater Design: Quality Control	Final Design		For non-structural controls, list all BMPs used and, for each, describe the function of the BMP and indicate the percent annual rainfall treated. List all structural controls and, for each, describe the pollutant removal and indicate the percent annual rainfall treated.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
SS7.1		Heat Island Effect: Non-Roof	**Final Design		LEED site plan drawing indicating locations and quantities of each paving type, including areas of shaded pavement. Percentage calculation indicating percentage of reflective/shaded/open grid area.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
SS7.2		Heat Island Effect: Roof	Final Design		Option 1: Percentage calculation indicating percentage of SRI compliant roof area. List of drawings and specification references that convey SRI requirements and roof slopes.		ARC

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Final Design OCT09REV		Option 1: List of specified roof materials indicating, for each, product type, manufacturer, product name and identification if known, SRI value and roof slope. OCT09REV		ARC
			**Closeout OCT09REV		Option 1: List of installed roof materials indicating, for each, manufacturer, product name and identification, SRI value and roof slope.		PE
			Closeout	X	Option 1: Manufacturer published product data or certification confirming SRI		PE
			Final Design		Option 2: Percentage calculation indicating percentage of vegetated roof area.		ARC
			Final Design		Option 3: Combined reflective and green roof calculation.		ARC
			Final Design OCT09REV		Option 3: List of specified roof materials indicating, for each, product type, manufacturer, product name and identification if known, SRI value and roof slope. OCT09REV		
			**Closeout OCT09REV		Option 3: List of installed roof materials indicating, for each, manufacturer, product name and identification, SRI value and roof slope.		PE
			Closeout	X	Option 3: Manufacturer published product data or certification confirming SRI		PE
SS8		Light Pollution Reduction	Final Design		Interior Lighting: List of drawings and specification references that convey interior lighting requirements (location and type of all installed interior lighting, location of non-opaque exterior envelope surfaces, allowing confirmation that maximum candela value from interiorfixtures does not intersect non-opaque building envelope surfaces). - OR - List of drawings and specification references that show automatic lighting controls that turn off non-essential lighting during non-business hours.		ELEC
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		ELEC
			Final Design		Exterior Lighting: List of drawings and specification references that convey exterior lighting requirements (location and type of all site lighting and building façade/landscape lighting).		ELEC
			Final Design		Exterior Site Lighting Power Density (LPD): Tabulation for exterior site lighting indicating, for each location identification or description, units of measure, area or distance of the location, actual LPD using units consistent with ASHRAE 90.1, and the ASHRAE allowable LPD for that type of location. Percentage calculation of actual versus allowable LPD for all site lighting.		ELEC
			Final Design		Exterior Building Facade/Landscape Lighting Power Density (LPD): Tabulation for exterior building facade/landscape lighting indicating, for each location identification or description, units of measure, area or distance of the location, actual LPD using units consistent with ASHRAE 90.1, and the ASHRAE allowable LPD for that type of location. Percentage calculation of actual versus allowable LPD for all building facade/landscape lighting.		ELEC
			Final Design		Exterior Lighting IESNA Zone: Indicate which IESNA zone is applicable to the project.		ELEC
			Final Design		Exterior Lighting Site Lumen table indicating, for each fixture type, quantity installed, initial lamp lumens per luminaire, initial lamp lumens above 90 degrees from Nadir, total lamp lumens and total lamp lumens above 90 degrees. Percentage of site lamp lumens above 90 degrees from nadir to total lamp lumens.		ELEC
			Final Design		Exterior Lighting Narrative describing analysis used for addressing requirements for light trespass at site boundary and beyond.		ELEC
CATEGORY 2 – WATER EFFICIENCY							
WE1.1		Water Efficient Landscaping: Reduce by 50%	Final Design		Statement indicating which option for compliance applies.		CIV
OCT09REV			**Final Design		Delineation and labeling of "LEED Project site boundary" on site plan.		CIV
			Final Design		Calculation indicating, for baseline and design case, total water applied, total potable water applied, total non-potable water applied. Design case percent potable water reduction. If nonpotable water is used, indicate source of nonpotable water.		CIV
			Final Design		List of landscape plan drawings.		CIV
			Final Design		Narrative describing landscaping and irrigation design strategies, including water use calculation methodology used to determine savings and, if non-potable water is used, specific information about source and available quantity.		CIV
WE1.2		Water Efficient Landscaping: No Potable Water Use or No Irrigation	Same as WE1.1		Same as WE1.1		CIV
WE2		Innovative Wastewater Technologies	Final Design		Statement confirming which option for compliance applies.		MEC

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Final Design		Statement confirming which occupancy breakdown applies (default or special). For special occupancy breakdown, indicate source and explanation for ratio.		MEC
			Final Design		Occupancy calculation including male/female numbers for FTEs, visitors, students, customers, residential and other type occupants/users		MEC
			Final Design		Statement indicating percent of male restrooms with urinals. Statement indicating annual days of operation.		MEC
			Final Design		Baseline flush fixture calculation spreadsheet indicating, for each fixture type, gender, flush rate, daily uses per person for each occupant type identified in occupancy calculation and annual baseline flush fixture water usage.		MEC
			Final Design		Design case flush fixture calculation spreadsheet indicating, for each fixture type, gender, fixture manufacturer, fixture model number, flush rate, percent of occupants using this fixture type, daily uses per person for each occupant type identified in occupancy calculation and annual design case flush fixture water usage.		MEC
			Final Design		Option 1: If onsite non-potable water is used, identify source(s), indicate annual quantity from each source and indicate total annual quantity from all onsite non-potable water sources.		MEC
			Final Design		Option 1: Summary calculation indicating baseline annual water consumption, design case annual water consumption, non-potable annual water consumption and total percentage annual water savings.		MEC
			Final Design		Option 2: Statement confirming on-site treatment of all generated wastewater to tertiary standards and all treated wastewater is either infiltrated or used on-site.		MEC
			Final Design		Option 2: List of drawing and specification references that convey design of on-site wastewater treatment features.		CIV
			Final Design		Option 2: On-site water treatment quantity calculation indicating all on-site wastewater source(s), annual quantity treated, annual quantity infiltrated and annual quantity re-used on site from each source and totals for annual quantity treated, annual quantity infiltrated and annual quantity re-used on site from all sources.		CIV
			Final Design		Option 2: Wastewater summary calculation indicating design case annual flush fixture water usage, annual on-site water treatment and percentage sewage convyance reduction.		MEC
			Final Design		Narrative describing project strategy for reduction of potable water use for sewage conveyance, including specific information on reclaimed water usage and treated wastewater usage.		MEC
WE3.1		Water Use Reduction: 20% Reduction	Final Design		Statement confirming which occupancy breakdown applies (default or special). For special occupancy breakdown, indicate source and explanation for ratio.		MEC
			Final Design		Occupancy calculation including male/female numbers for FTEs, visitors, students, customers, residential and other type occupants/users		MEC
			Final Design		Statement indicating percent of male restrooms with urinals. Statement indicating annual days of operation.		MEC
			Final Design		Baseline flush fixture calculation spreadsheet indicating, for each fixture type, gender, flush rate, daily uses per person for each occupant type identified in occupancy calculation and annual baseline flush fixture water usage.		MEC
			Final Design		Design case flush fixture calculation spreadsheet indicating, for each fixture type, gender, fixture manufacturer, fixture model number, flush rate, percent of occupants using this fixture type, daily uses per person for each occupant type identified in occupancy calculation and annual design case flush fixture water usage.		MEC
			Closeout	X	Manufacturer published product data or certification confirming fixture water usage.		PE
WE3.2		Water Use Reduction: 30% Reduction	Same as WE3.1		Same as WE3.1		MEC
CATEGORY 3 – ENERGY AND ATMOSPHERE							
EAPR1		Fundamental Commissioning of the Building Energy Systems (PREREQUISITE)	**Final Design		**Owner's Project Requirements document		ALL
			**Final Design		**Basis of Design document for commissioned systems		MEC, ELEC
			**Final Design		**Commissioning Plan		MEC, ELEC

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Closeout		Statement confirming all commissioning requirements have been incorporated into construction documents.		PE
			Closeout		Commissioning Report		PE
EAPR2		Minimum Energy Performance (PREREQUISITE)	Final Design		Statement listing the mandatory provisions of ASHRAE 90.1 that project meets relative to compliance with this prerequisite and indicating which compliance path was used.		MEC ELEC ARC
EAPR3		Fundamental Refrigerant Management (PREREQUISITE)	Final Design		Statement indicating which option for compliance applies.		MEC
			Final Design		Option 2: Narrative describing phase out plan, including specific information on phase out dates and refrigerant quantities.		MEC
EA1		Optimize Energy Performance	Final Design		Statement indicating which compliance path option applies.		MEC
			Final Design		Option 1: Statement confirming simulation software capabilities and confirming assumptions and methodology.		MEC
			Final Design		Option 1: General information including simulation program, principal heating source, percent new construction and renovation, weather file, climate zone and Energy Star Target Finder score.		MEC
			Final Design		Option 1: Space summary listing, for each building use, the conditioned area, unconditioned area and total area and include total area for each category		MEC
			Final Design		Option 1: List of all simulation output advisory message data and show difference between baseline and proposed design		MEC
			Final Design		Option 1: Comparison summary for energy model inputs including description of baseline and design case energy model inputs, showing both by element type		MEC
			Final Design		Option 1: Energy type summary lising, for each energy type, utility rate description, units of energy and units of demand		MEC
			Final Design		Option 1: Statement indicating whether project uses on-site renewable energy. If yes, list all sources and indicate, for each source, backup energy type, annual energy generated, rated capacity and renewable energy cost		MEC
			Final Design		Option 1: If analysis includes exceptional calculation methods, statement describing how exceptional calculation measure cost savings is determined		MEC
			Final Design		Option 1: If analysis includes exceptional calculation methods, for each exceptional calculation method indicate energy types and, for each energy type, annual energy savings, annual cost savings, and brief descriptive narrative		MEC
			Final Design		Option 1: Baseline performance rating compliance report table indicating, for each energy end use, whether it is a process load, energy type, annual and peak energy demand for all four orientations. For each orientation indicate total annual energy use for each orientation and total annual process energy use.		MEC
			Final Design		Option 1: Baseline energy cost table indicating, for each energy type, annual cost for all four orientations and building total energy cost.		MEC
			Final Design		Option 1: Proposed Design performance rating compliance report table indicating, for each energy end use, whether it is a process load, energy type, annual and peak energy demand, baseline annual and peak energy demand and percent savings. Indicate total annual energy use and total annual process energy use for both proposed design and baseline and percent savings.		MEC
			Final Design		Option 1: Proposed Design energy cost table indicating, for each energy type, annual cost for all four orientations and building total energy cost.		MEC
			Final Design		Option 1: Energy cost and consumption by energy type report indicating, for each energy type, proposed design and baseline annual use and annual cost, percent savings annual use and annual cost. Indicate for renewable energy annual energy generated and annual cost. Indicate exceptional calculations annual energy savings and annual cost savings. Indicate building total annual energy use, annual energy cost for proposed design and baseline and indicate percent savings annual energy use and annual energy cost.		MEC

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Final Design		Option 1: Compliance summaries from energy simulation software. If software does not produce compliance summaries provide output summaries and example input summaries for baseline and proposed design supporting data in the tables. Output summaries must include simulated energy consumption by end use and total energy use and cost by energy type. Example input summaries should represent most common systems and must include occupancy, use pattern, assumed envelope component sizes and descriptive features and assumed mechanical equipment types and descriptive features		MEC
			Final Design		Option 1: Energy rate tariff from project energy providers (only if not using LEED Reference Guide default rates)		MEC
EA2.1		On-Site Renewable Energy	Final Design		Statement indicating which compliance path option applies.		ELEC
			Final Design		List all on-site renewable energy sources and indicate, for each source, backup energy type, annual energy generated, rated capacity and renewable energy cost. Indicate total annual energy use (all sources), total annual energy cost (all sources) and percent renewable energy cost.		ELEC MEC
			Final Design		Option 1: Indicate, for renewable energy,proposed design total annual energy generated and annual cost.		ELEC MEC
			Final Design		Option 2: Indicate CBECS building type and building gross area. Provide the following CBECS data: median annual electrical intensity, median annual non-electrical fuel intensity, average electric energy cost, average non-electric fuel cost, annual electric energy use and cost, annual non-electric fuel use and cost.		ELEC MEC
			Final Design		Option 2: Narrative describing renewable systems and explaining calculation method used to estimate annual energy generated, including factors influencing performance.		ELEC MEC
EA2.2		On-Site Renewable Energy	Same as EA2.1		Same as EA2.1		ELEC MEC
EA2.3		On-Site Renewable Energy	Same as EA2.1		Same as EA2.1		ELEC MEC
EA3		Enhanced Commissioning	**Final Design		**Owner's Project Requirements document (OPR)		ALL
			**Final Design		**Basis of Design document for commissioned systems (BOD)		ELEC MEC
			**Final Design		**Commissioning Plan		ELEC MEC
			Closeout		Statement confirming all commissioning requirements have been incorporated into construction documents.		PE
			Closeout		**Commissioning Report		PE
			**Final Design		Statement by CxA confirming Commissioning Design Review		
			Closeout		Statement by CxA confirming review of Contractor submittals for compliance with OPR and BOD		PE
			Closeout		**Systems Manual		PE
			Closeout		Statement by CxA confirming completion of O&M staff and occupant training		PE
			Closeout		**Scope of work for post-occupancy review of building operation, including plan for resolution of outstanding issues		PE
			**Predesign		Statement confirming CxA qualifications and contractual relationships relative to work on this project, demonstrating that CxA is an independent third party.		MEC
EA4		Enhanced Refrigerant Management	Final Design		Refrigerant impact calculation table with all building data and calculation values as shown in LEED 2.2 Reference Guide Example Calculations		MEC
			Final Design		Narrative describing any special circumstances or explanatory remarks OCT09REV		
			Closeout	X	Cut sheets highlighting refrigerant data for all HVAC components.		PE
EA5		Measurement & Verification	Closeout		Statement indicating which compliance path option applies.		PE
			Closeout		Measurement and Verification Plan		PE
			Closeout		**Scope of work for post-occupancy implementation of M&V plan		PE
EA6		Green Power	Closeout		Statement indicating which compliance path option applies.		PE
			Closeout		Option 1: Indicate proposed design total annual electric energy usage		PE
			Closeout		Option 2: Indicate actual total annual electric energy usage		PE
			Closeout		Option 3: Calculation indicating building type, total gross area, median electrical intensity and annual electric energy use		PE

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Closeout		Green power provider summary table indicating, for each purchase type, provider name, annual quantity green power purchased and contract term. Indicate total annual green power use and indicate percent green power		PE
			Closeout		Narrative describing how Green Power or Green Tags are purchased		PE
CATEGORY 4 – MATERIALS AND RESOURCES							
MRPR1		Storage & Collection of Recyclables (PREREQUISITE)	Final Design		Statement confirming that recycling area will accommodate recycling of plastic, metal, paper, cardboard and glass. Narrative indicating any other materials addressed and coordination with pickup.		ARC
MR1.1		Building Reuse: Maintain 75% of Existing Walls, Floors & Roof	**Final Design		If project includes a building addition, confirm that area of building addition does not exceed 2x the area of the existing building.		ARC
			**Final Design		Spreadsheet listing, for each building structural/envelope element, the existing area and reused area. Total percent reused.		ARC
MR1.2		Building Reuse: Maintain 95% of Existing Walls, Floors & Roof	Same as MR1.1		Same as MR1.1		ARC
MR1.3		Building Reuse: Maintain 50% of Interior Non-Structural Elements	**Final Design		If project includes a building addition, confirm that area of building addition does not exceed 2x the area of the existing building.		ARC
			**Final Design		Spreadsheet listing, for each building interior non-structural element, the existing area and reused area. Total percent reused.		ARC
MR2.1		Construction Waste Management: Divert 50% From Disposal	**Preconstruction		Waste Management Plan		PE
			**Construction Quarterly and Closeout		Spreadsheet calculations indicating material description, disposal/diversion location (or recycling hauler), weight, total waste generated, total waste diverted, diversion percentage		PE
					OCT09REV		
			**Construction Quarterly and Closeout		Receipts/tickets for all items on spreadsheet		PE
MR2.2		Construction Waste Management: Divert 75% From Disposal	Same as MR2.1		Same as MR2.1		PE
MR3.1		Materials Reuse: 5%	Closeout		Statement indicating total materials value and whether default or actual.		PE
			Closeout		Spreadsheet calculations indicating, for each reused/salvaged material, material description, source or vendor, cost. Total reused/salvaged materials percentage.		PE
MR3.2		Materials Reuse: 10%	Same as MR3.1		Same as MR3.1		PE
MR4.1		Recycled Content: 10% (post-consumer + 1/2 pre-consumer)	Closeout		Statement indicating total materials value and whether default or actual.		PE
			Closeout		Spreadsheet calculations indicating, for each recycled content material, material name/description, manufacturer, cost, post-consumer recycled content percent, pre-consumer recycled content percent, source of recycled content data. Total post-consumer content materials cost, total pre-consumer content materials cost, total combined recycled content materials cost, recycled content materials percentage.		PE
			Final Design or NLT Preconstruction		**Purchasing Plan consisting of spreadsheet indicated above, filled in with estimated quantities to show strategy for achieving goal. OCT09REV		PE
			Closeout	X	Manufacturer published product data or certification, confirming recycled content percentages in spreadsheet		PE
MR4.2		Recycled Content: 20% (post-consumer + 1/2 pre-consumer)	Same as MR4.1		Same as MR4.1		PE
MR5.1		Regional Materials:10% Extracted, Processed & Manufactured Regionally	Closeout		Statement indicating total materials value and whether default or actual.		PE
			Closeout		Spreadsheet calculations indicating, for each regional material, material name/description, manufacturer, cost, percent compliant, harvest distance, manufacture distance, source of manufacture and harvest location data. Total regional materials cost, regional materials percentage.		PE
			Preconstruction OCT09REV		**Purchasing Plan consisting of spreadsheet indicated above, filled in with estimated quantities to show strategy for achieving goal. OCT09REV		PE
			Closeout	X	Manufacturer published product data or certification confirming regional material percentages in spreadsheet		PE

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
MR5.2		Regional Materials:20% Extracted, Processed & Manufactured Regionally	Same as MR5.1		Same as MR5.1		PE
MR6		Rapidly Renewable Materials	Closeout		Statement indicating total materials value and whether default or actual.		PE
			Closeout		Spreadsheet calculations indicating, for each rapidly renewable material, material name/description, manufacturer, cost, rapidly renewable content percent, rapidly renewable product value. Total rapidly renewable product value, rapidly renewable materials percentage.		PE
			Final Design OCT09REV		**Purchasing Plan consisting of spreadsheet indicated above, filled in with estimated quantities to show strategy for achieving goal. OCT09REV		ARC
			Closeout	X	Manufacturer published product data or certification confirming rapidly renewable material percentages in spreadsheet		PE
MR7		Certified Wood	Closeout		Statement indicating total materials value and whether default or actual.		PE
			Closeout		Spreadsheet calculations indicating, for each certified wood material, material name/description, vendor, cost, wood component percent, certified wood percent of wood component, FSC chain of custody certificate number. Total certified wood product value, certified wood materials percentage.		PE
			Final Design or NLT Preconstruction		**Purchasing Plan consisting of spreadsheet indicated above, filled in with estimated quantities to show strategy for achieving goal. OCT09REV		PE
			Closeout	X	Vendor invoices, FSC chain of custody certificates and anufacturer published product data or certification confirming all certified wood materials percentages in spreadsheet.		PE
CATEGORY 5 – INDOOR ENVIRONMENTAL QUALITY							
EQPR1		Minimum IAQ Performance (PREREQUISITE)	Final Design		Statement indicating which option for compliance applies, stating applicable criteria/requirement, and confirming that project has been designed to meet the applicable requirements.		MEC
			Final Design		Narrative describing the project's ventilation design, including specifics about fresh air intake volumes and special considerations.		MEC
EQPR2		Environmental Tobacco Smoke (ETS) Control (PREREQUISITE)	Final Design		Statement indicating which option for compliance applies, stating applicable criteria/requirement, and confirming that project has been designed to meet the applicable requirements.		ARC
			Final Design		List of drawing and specification references that convey conformance to applicable requirements (signage, exhaust system, room separation details, etc).		ARC
EQ1		Outdoor Air Delivery Monitoring	Final Design		Statement indicating which option for compliance applies and confirming that project has been designed to meet the applicable requirements.		MEC
			Final Design		List of drawing and specification references that convey conformance to applicable requirements.		MEC
			Final Design		Narrative describing the project's ventilation design and CO2 monitoring system, including specifics about monitors, operational parameters and setpoints.		MEC
			Closeout	X	Cut sheets for CO2 monitoring system.		PE
EQ2		Increased Ventilation	Final Design		Statement indicating which option for compliance applies and confirming that project has been designed to meet the applicable requirements.		MEC
			Final Design		Narrative describing the project's ventilation design, including specifics about zone fresh air intake volumes and demonstrating compliance.		MEC
			Final Design		Option 2: Narrative describing design method used for determining natural ventilation design, including calculation methodology/model results and demonstrating compliance.		MEC
			Final Design		List of drawing and specification references that convey conformance to applicable requirements.		MEC
EQ3.1		Construction IAQ Management Plan: During Construction	**Preconstruction		Construction IAQ Management Plan		PE
			Closeout		Statement confirming whether air handling units were operated during construction		PE
			Closeout		Dated jobsite photos showing examples of IAQ management plan practices being implemented. Label photos to indicate which practice they demonstrate. Minimum one photo of each practice at each building.		PE
			Closeout		Spreadsheet indicating, for each filter installed during construction, the manufacturer, model number, MERV rating, location installed, and if it was replaced immediately prior to occupancy.		PE
EQ3.2		Construction IAQ Management Plan: Before Occupancy	**Preconstruction		Construction IAQ Management Plan		PE

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
			Closeout		Statement indicating which option for compliance applies and confirming that required activities have occurred that meet the applicable requirements.		PE
			Closeout		Option 1a: Narrative describing the project's flushout process, including specifics about temperature, airflow and duration, special considerations (if any) and demonstrating compliance.		PE
			Closeout		Option 1b: Narrative describing the project's pre-occupancy and post-occupancy flushout processes, including specifics about temperature, airflow and duration, special considerations (if any) and demonstrating compliance.		PE
			Closeout		Option 2: Narrative describing the project's IAQ testing process, including specifics about contaminants tested for, locations, remaining work at time of test, retest parameters and special considerations (if any).		PE
			Closeout		Option 2: IAQ testing report demonstrating compliance.		PE
EQ4.1		Low Emitting Materials: Adhesives & Sealants	Closeout		Spreadsheet indicating, for each applicable indoor adhesive, sealant and sealant primer used, the manufacturer, product name/model number, VOC content, LEED VOC limit, and source of VOC data.		PE
			Closeout		Spreadsheet indicating, for each applicable indoor aerosol adhesive, the manufacturer, product name/model number, VOC content, LEED VOC limit, and source of VOC data - OR - Statement confirming no indoor aerosol adhesives were used for the project.		PE
			Closeout	X	Manufacturer published product data or certification confirming material VOCs in spreadsheet		PE
EQ4.2		Low Emitting Materials: Paints & Coatings	Closeout		Spreadsheet indicating, for each applicable indoor paint and coating used, the manufacturer, product name/model number, VOC content, LEED VOC limit, and source of VOC data.		PE
			Closeout		Spreadsheet indicating, for each applicable indoor anti-corrosive/anti-rust paint and coating used, the manufacturer, product name/model number, VOC content, LEED VOC limit, and source of VOC data - OR - Statement confirming no indoor anti-corrosive/anti-rust paints were used for the project .		PE
			Closeout	X	Manufacturer published product data or certification confirming material VOCs in spreadsheet		PE
EQ4.3		Low Emitting Materials: Carpet Systems	Closeout		Spreadsheet indicating, for each indoor carpet used, the manufacturer, product name/model number, if it meets LEED requirement (yes/no) and source of LEED compliance data.		PE
			Closeout		Spreadsheet indicating, for each indoor carpet cushion used, the manufacturer, product name/model number, if it meets LEED requirement (yes/no) and source of LEED compliance data - OR - Statement confirming no indoor carpet cushion was used for the project.		PE
			Closeout	X	Manufacturer published product data or certification confirming material CRI label in spreadsheet		PE
EQ4.4		Low Emitting Materials: Composite Wood & Agrifiber Products	Closeout		Spreadsheet indicating, for each indoor composite wood and agrifiber product used, the manufacturer, product name/model number, if it contains added urea formaldehyde (yes/no) and source of LEED compliance data.		PE
			Closeout	X	Manufacturer published product data or certification confirming material urea formaldehyde in spreadsheet		PE
EQ5		Indoor Chemical & Pollutant Source Control	Closeout OCT09REV		Spreadsheet indicating, for each permanent entryway system used, the manufacturer, product name/model number and description of system. Roll-up and carpet systems requiring weekly cleaning to earn this credit are not a permitted option for Army projects.		PE
			Final Design		List of drawing and specification references that convey locations and installation methods for entryway systems.		ARC
			Final Design		Spreadsheet indicating, for each chemical use area, the room number, room name, description of room separation features (walls, floor/ceilings, openings) and pressure differential from surrounding spaces with doors closed - OR - Statement confirming that project includes no chemical use areas and that no hazardous cleaning materials are needed for building maintenance.		ARC MEC
			Final Design		If project includes chemical use areas: List of drawing and specification references that convey locations of chemical use areas, room separation features and exhaust system.		ARC MEC
			Closeout OCT09REV		If project includes chemical use areas: Spreadsheet indicating, for AHUs/mechanical ventilation equipment serving occupied areas, the manufacturer, model number, MERV rating, location installed, and if it was replaced immediately prior to occupancy (yes/no) - OR - Statement confirming that project does not use mechanical equipment for ventilation of occupied areas.		PE

LEED Credit Paragraph	Contractor Check Here if Credit is Claimed	**LEED-NC v2.2 Submittals (OCT09REV)**		Provide for Credit Audit Only		Date Submitted (to be filled in by Contractor)	Government Reviewer's Use (OCT09REV)
PAR		**FEATURE**	**DUE AT**		**REQUIRED DOCUMENTATION**	**DATE**	**REV**
EQ6.1		Controllability of Systems: Lighting	Final Design		Calculation indicating total number of individual workstations, number of workstations with individual lighting controls and the percentage of workstations with individual lighting controls.		ELEC
			Final Design		For each shared multi-occupant space, provide a brief description of lighting controls.		ELEC
			Final Design		Narrative describing lighting control strategy, including type and location of individual controls and type and location of controls in shared multi-occupant spaces.		ELEC
EQ6.2		Controllability of Systems: Thermal Comfort	Final Design		Calculation indicating total number of individual workstations, number of workstations with individual thermal comfort controls and the percentage of workstations with individual thermal comfort controls.		MEC
			Final Design		For each shared multi-occupant space, provide a brief description of thermal comfort controls.		MEC
			Final Design		Narrative describing thermal comfort control strategy, including type and location of individual and shared multi-occupant controls.		MEC
EQ7.1		Thermal Comfort: Design	Final Design		Design criteria spreadsheet indicating, for spring, summer, fall and winter, maximum indoor space design temperature, minimum indoor space design temperature and maximum indoor space design humidity.		MEC
			Final Design		Narrative describing method used to establish thermal comfort control conditions and how systems design addresses the design criteria, including compliance with the referenced standard.		MEC
EQ7.2		Thermal Comfort: Verification	Final Design		Narrative describing the scope of work for the thermal comfort survey, including corrective action plan development		MEC
EQ8.1		Daylight & Views: Daylight 75% of Spaces	Final Design		Option 1: Table indicating all regularly occupied spaces with space area and space area with 2% daylighting factor. Sum of regularly occupied areas and regularly occupied areas with 2% daylighting factor. Percentage calculation of areas with 2% daylighting factor to total regularly occupied areas.		ARC
			Final Design		Option 1: Glazing factor calculation table		ARC
			Final Design		Option 2: Simulation model method, software and output data		ARC
			Final Design		Option 2: Table indicating all regularly occupied spaces with space area, space area with minimum 25 footcandles daylighting illumination, and method of providing glare control. Sum of regularly occupied areas and regularly occupied areas with 25 fc daylighting. Percentage calculation of areas with 25 fc daylighting to total regularly occupied areas.		ARC
			Final Design		For all occupied spaces excluded from the calculation, provide narrative indicating reasons for excluding the space.		ARC
			Final Design		List of drawing and specification references that convey exterior glazed opening head and sill heights and glazing performance properties.		ARC
			Closeout	X	Manufacturer published product data or certification confirming glazing Tvis in spreadsheet		PE
EQ8.2		Daylight & Views: Views for 90% of Spaces	Final Design		Table indicating all regularly occupied spaces with space area and space area with access to views. Sum of regularly occupied areas and regularly occupied areas with access to views. Percentage calculation of areas with views to total regularly occupied areas.		ARC
			Final Design		For all occupied spaces excluded from the calculation, provide narrative indicating reasons for excluding the space.		ARC
			Final Design		LEED Floor plan drawings showing line of sight diagramming of views areas in each regularly occupied space. List of drawing/specification references that convey exterior glazed opening head and sill heights.		ARC
CATEGORY 6 – FACILITY DELIVERY PROCESS							
IDc1.1		Innovation in Design	Final Design OCT09REV		Narrative decribing intent, requirement for credit, project approach to the credit. List of drawings and specification references that convey implementation of credit. All other documentation that validates claimed credit.		
IDc1.2		Innovation in Design	Final Design OCT09REV				
IDc1.3		Innovation in Design	Final Design OCT09REV				
IDc1.4		Innovation in Design	Final Design OCT09REV				
IDc2		LEED Accredited Professional	Final Design		Narrative indicating name of LEED AP, company name of LEED AP, description of LEED AP's role and responsiblilities in the project.		ARC

ATTACHMENT F
Version 07-07-2010

BUILDING INFORMATION MODELING REQUIREMENTS

1.0 Section 1 - Submittal Format

1.1. Design Deliverables. Develop all designs using Building Information Modeling (BIM) and Computer Aided Design (CAD) software. Design submittal drawings shall be Full size, suitable for half-size scaled reproduction.

2.0 Section 2 – Design Requirements

2.1. BIM Model and Facility Data. Contractor shall use BIM application(s) and software(s) to develop project designs. "Facility Data" is defined as associated intelligent attribute data. The "Model" is defined as 3D graphics that includes Facility Data and output as described in the paragraph 'Output' below. Contractors will use the Model to produce accurate Construction Documents. For each Center of Standardization (CoS) facility type included in this project, all BIM Models and associated Facility Data shall be submitted in Bentley Systems BIM [Not Supplied - SubmittalReqCADDSystem : BENTLEY_VERSION] with associated USACE Bentley BIM Workspace (which includes specific standard BIM libraries and definitions). This Workspace can be downloaded from the CAD/BIM Technology Center. [Where available, the workspace will be specific to this CoS Facility Standard Design. The Contractor will be provided a baseline multi-discipline BIM Project Model for the CoS Facility Standard Design type, where such a model exists (for the purposes of site adaptation).] The USACE Bentley BIM Workspace is dependent on specific versions of the Bentley BIM suite of products and only the versions of the software that are listed in the Contractor instructions included with the USACE BIM Workspace are permitted to be used.

2.1.1. Reference. Refer to ERDC TR-06-10, "U.S. Army Corps of Engineers Building Information Modeling Road Map" from the CAD/BIM Technology Center website for more information on the USACE BIM implementation goals.

2.2. Drawings. Deliver CAD files used for the creation of the Construction Documents Drawings per requirements in Section 01 33 16, the criteria of the USACE [Not Supplied - DistrictInfoGeneral : ISSUING_DISTRICT] District, and as noted herein. Specification of a CAD file format for these Drawings does not limit which BIM application(s) or software(s) may be used for project development and execution.

2.2.1. IFC Support. The Contractor's selected BIM application(s) and software(s) must support the IFC (Industry Foundation Class - see www.iai-tech.org). Submit any deviations from or additions to the IFC property sets for any new spaces, systems, and equipment for Government approval.

2.2.2. Submittal Requirements. BIM submittals shall be fully interoperable, compatible, and editable with the Bentley BIM tools. Use the specified version of the USACE Bentley BIM Workspace and conform to the requirements of **Sections 3 and 4 below**.

2.2.3. BIM Project Execution Plan.

2.2.3.1. Develop a BIM Project Execution Plan ("Plan" or "PxP") documenting the BIM and analysis technologies selected for the Project Model (integrated with the AEC CAD Standard) from concept development through As-Builts as a design, production, coordination, construction, and documentation tool and the collaborative process by which it shall be executed. See Section 7 for additional guidance on developing the Plan.

2.2.4. BIM Requirements..

2.2.4.1. Facility Data. Develop the Facility Data consisting of a set of intelligent elements for the Model (e.g., doors, air handlers, electrical panels). This Facility Data shall include all material definitions and attributes that are necessary for the Project facility design and construction. Additional data in support of Section 6 Contractor Electives is encouraged.

2.2.4.2. Model Content. The Model and Facility Data shall include, at a minimum, the requirements of Section 4 below.

2.2.4.3. Model Granularity. Models may vary in level of detail for individual elements within a model, but at a minimum must include all features that would be included on a quarter inch (1/4" = 1'0") scaled drawing (e.g. at least 1/16th, 1/8th and 1/4th), or appropriately scaled civil drawings.

2.2.4.4. Output. Submitted CAD drawings (e.g., plans, elevations, sections, schedules, details, etc.) shall be derived (commonly known as extractions, views or sheets) and maintained from the submitted Model and Facility Data.

2.3. Quality Control. Implement quality control (QC) parameters for the Model, including:

2.3.1. Model Standards Checks. QC validation used to ensure that the Project Facility Data set has no undefined, incorrectly defined or duplicated elements. Report non-compliant elements and corrective action plan to correct non-compliant elements. Provide the government with detailed justification and request government approval for any non-compliant element which the contractor proposes to be allowed to remain in the Model.

2.3.2. CAD Standards Checks. QC checking performed to ensure that the fonts, dimensions, line styles, levels and other construction document formatting issues are followed per the A/E/C CADD Standard.

2.3.3. Other Parameters. Develop such other QC parameters as Contractor deems appropriate for the Project and provide to the Government for concurrence.

2.4. Design and Construction Reviews. Perform design and construction reviews at each submittal stage under Section 3 to test the Model, including:

2.4.1. Visual Checks. Checking to ensure the design intent has been followed and that there are no unintended elements in the Model.

2.4.2. Interference Management Checks. Locate conflicting spatial data in the Model where two elements are occupying the same space. Log hard interferences (e.g., mechanical vs. structural or mechanical vs. mechanical overlaps in the same location) and soft interferences, (e.g., conflicts regarding equipment clearance, service access, fireproofing, insulation) in a written report and resolve.

2.4.3. IFC Coordination View. Provide an IFC Coordination View in IFC Express format for all deliverables. Provide exported property set data for all IFC supported named building elements.

2.4.4. Other Parameters. Develop such other Review parameters as the Contractor deems appropriate for the Project and provide to the Government for concurrence..

3.0 Section 3 – Design Stage Submittal Requirements

3.1. General Submittal Requirements.

3.1.1. Provide submittals in compliance with BIM Project Execution Plan deliverables at stages as described hereinafter.

3.1.2. At each Stage in Paragraphs 3.3 through 3.6, provide a Contractor-certified written report confirming that consistency checks as identified in Paragraphs 2.3 and 2.4 have been completed. This report shall be discussed as part of the review process and shall address cross-discipline interferences, if any.

3.1.3. At each Stage in Paragraphs 3.3 through 3.6, provide the Government with:

- The Model, Facility Data, Workspace and CAD Data files in native Bentley BIM/CAD.

- A 3-D interactive review format of the Model in Bentley Navigator, Autodesk Navisworks, Adobe 3D PDF 7.0 (or later), Google Earth KMZ or other format per Plan requirements. The file format for reviews can change between submittals.

- A list of all submitted files. The list should include a description, directory, and file name for each file submitted. For all CAD sheets, include the sheet title and sheet number. Identify files that have been produced from the submitted Model and Facility Data.

3.1.4. The Government will confirm acceptability of all submittals identified in Section 3 in coordination with the USACE [Not Supplied - DistrictInfoGeneral : ISSUING_DISTRICT] BIM Manager

3.2. Initial Design Conference Submittal.

3.2.1. Submit a digital copy of the Plan where, in addition to Paragraph 3.1.4, the USACE Geographic District BIM Manager will coordinate with the USACE CoS BIM Manager to confirm acceptability of the Plan or advise as to additional processes or activities necessary to be incorporated.

3.2.2. Within thirty (30) days after the approval of the Plan, conduct a demonstration to review the Plan for clarification, and to verify the functionality of Model technology workflow and processes. If modifications are required, the Contractor shall complete the modifications and resubmit the Plan and perform subsequent demonstration for Government acceptance. There will be no payment for design or construction until the Plan is acceptable to the Government. The Government may also withhold payment for design and construction for unacceptable performance in executing the approved Plan.

3.3. Interim Design Submittals.

3.3.1. BIM and CAD Data. The Model shall include the requirements identified in Paragraph 2.2.4 as applicable to the Interim Design package(s).

3.4. Final Design Submissions and Design Complete Submittals.

3.4.1. BIM and CAD Data. The Model shall include the requirements identified in Paragraph 2.2.4. Acceptance according to Paragraph 3.1.4 is required before commencement of construction, as described in Paragraph 3.7.6 of Section 01 33 16.

3.5. Construction Submittals – Over-The-Shoulder Progress Reviews. Periodic quality control meetings or construction progress review meetings shall include quality control reviews on the implementation and use of the Model, including interference management and design change tracking information.

3.6. Final As-Builts BIM and CAD Data Submittal. Submit the final Model, Facility Data, and CAD files reflecting as-built conditions for Government Approval, as specified in Section 01 78 02.00 10, PROJECT CLOSEOUT.

4.0 Section 4 – BIM Model Minimum Requirements and Output

4.1. General Provisions. The deliverable Model shall be developed to include the systems described below as they would be built and the processes of installing them, and to reflect final as-built conditions. The deliverable model at the interim design stage and at the final design stage (“released for construction”) shall be developed to include as many of the systems described below as are necessary and appropriate at that design stage.

4.2. Architectural/Interior Design. The Architectural systems Model may vary in level of detail for individual elements, but at a minimum must include all features that would be included on a quarter inch (1/4”=1’0”) scaled drawing. Additional minimum Model requirements include:

4.2.1. Spaces. The Model shall include spaces defining accurate net square footage and net volume, and holding data for the room finish schedule for including room names and numbers. Include Programmatic Information provided by the Government or validated program to verify design space against programmed space, using this information to validate area quantities.

4.2.2. Walls and Curtain Walls. Each wall shall be depicted to the exact height, length, width and ratings (thermal, acoustic, fire) to properly reflect wall types. The Model shall include all walls, both interior and exterior, and the necessary intelligence to produce accurate plans, sections and elevations depicting these design elements.

4.2.3. Doors, Windows and Louvers. Doors, windows and louvers shall be depicted to represent their actual size, type and location. Doors and windows shall be modeled with the necessary intelligence to produce accurate window and door schedules.

4.2.4. Roof. The Model shall include the roof configuration, drainage system, penetrations, specialties, and the necessary intelligence to produce accurate plans, building sections and generic wall sections where roof design elements are depicted.

4.2.5. Floors. The floor slab shall be developed in the structural Model and then referenced by the architectural Model for each floor of the Project building.

4.2.6. Ceilings. All heights and other dimensions of ceilings, including soffits, ceiling materials, or other special conditions shall be depicted in the Model with the necessary intelligence to produce accurate plans, building sections and generic wall sections where ceiling design elements are depicted.

4.2.7. Vertical Circulation. All continuous vertical components (i.e., non-structural shafts, architectural stairs, handrails and guardrails) shall be accurately depicted and shall include the necessary intelligence to produce accurate plans, elevations and sections in which such design elements are referenced.

4.2.8. Architectural Specialties and Woodwork. All architectural specialties (i.e., toilet room accessories, toilet partitions, grab bars, lockers, and display cases) and woodwork (i.e., cabinetry and counters) shall be accurately depicted with the necessary intelligence to produce accurate plans, elevations and sections in which such design elements are referenced.

4.2.9. Signage. The Model shall include all signage and the necessary intelligence to produce accurate plans and schedules.

4.2.10. Schedules. Provide door, window, hardware sets using BHMA designations, flooring, wall finish, and signage schedules from the Model, indicating the type, materials and finishes used in the design.

4.3. Furniture. The furniture systems Model may vary in level of detail for individual elements within a Model, but at a minimum must include all features that would be included on a quarter inch (1/4”=1’0”) scaled drawing, and have necessary intelligence to produce accurate plans. Representation of furniture elements is to be 2D. Contractor may provide a minimal number of 3D representations as examples. Examples of furniture include, but are not limited to, desks, furniture systems, seating, tables, and office storage.

4.3.1. Furniture Coordination. Furniture that makes use of electrical, data or other features shall include the necessary intelligence to produce coordinated documents and data.

4.4. Equipment. The Model may vary in level of detail for individual elements within a Model. Equipment shall be depicted to meet layout requirements with the necessary intelligence to produce accurate plans and minimum schedules depicting their configuration. Examples of equipment include but are not limited to copiers, printers, refrigerators, ice machines and microwaves.

4.4.1. Schedules. Provide furniture and equipment schedules from the model indicating the materials, finishes, mechanical, and electrical requirements.

4.5. Structural. The structural systems Model may vary in level of detail for individual elements, but at a minimum must include all features that would be included on a quarter inch (1/4”=1’0”) scaled drawing. Additional minimum Model requirements include:

4.5.1. Foundations. All necessary foundation and/or footing elements, with necessary intelligence to produce accurate plans and elevations

4.5.2. Floor Slabs. Structural floor slabs shall be depicted, including all necessary recesses, curbs, pads, closure pours, and major penetrations accurately depicted.

4.5.3. Structural Steel. All steel columns, primary and secondary framing members, and steel bracing for the roof and floor systems (including decks), including all necessary intelligence to produce accurate structural steel framing plans and related building/wall sections.

4.5.4. Cast-in-Place Concrete. All walls, columns, and beams, including necessary intelligence to produce accurate plans and building/wall sections depicting cast-in-place concrete elements.

4.5.5. Expansion/Contraction Joints. Joints shall be accurately depicted.

4.5.6. Stairs. The structural Model shall include all necessary openings and framing members for stair systems, including necessary intelligence to produce accurate plans and building/wall sections depicting stair design elements.

4.5.7. Shafts and Pits. The structural Model shall include all necessary shafts, pits, and openings, including necessary intelligence to produce accurate plans and building/wall sections depicting these design elements.

4.6. Mechanical. The mechanical systems Model may vary in level of detail for individual elements, but at a minimum must include all features that would be included on a quarter inch (1/4”=1’0”) scaled drawing. Small diameter (less than 1-1/2” NPS) field-routed piping is not required in the model. Additional minimum Model requirements include:

4.6.1. HVAC. All necessary heating, ventilating, air-conditioning and specialty equipment, including air distribution ducts for supply, return, and ventilation and exhaust ducts, including control system, registers, diffusers, grills and hydronic baseboards with necessary intelligence to produce accurate plans, elevations, building/wall sections and schedules.

4.6.1.1. Mechanical Piping. All necessary piping and fixture layouts, and related equipment, including necessary intelligence to produce accurate plans, elevations, building/wall sections, and schedules.

4.6.2. Plumbing. All necessary plumbing piping and fixture layouts, floor and area drains, and related equipment, including necessary intelligence to produce accurate plans, elevations, building/wall sections, riser diagrams, and schedules.

4.6.3. Equipment Clearances. All HVAC and Plumbing equipment clearances shall be modeled for use in interference management and maintenance access requirements.

4.6.4. Elevator Equipment. The Model shall include the necessary equipment and control system, including necessary intelligence to produce accurate plans, sections and elevations depicting these design elements.

4.7. Electrical/Telecommunications. The electrical systems Model may vary in level of detail for individual elements, but at a minimum must include all features that would be included on a quarter inch (1/4”=1’0”) scaled drawing. Small diameter (less than 1-1/2”Ø) field-routed conduit is not required in the model. Additional minimum Model requirements include:

4.7.1. Interior Electrical Power and Lighting. All necessary interior electrical components (i.e., lighting, receptacles, special and general purpose power receptacles, lighting fixtures, panelboards, cable trays and control systems), including necessary intelligence to produce accurate plans, details and schedules. Lighting and power built into furniture/equipment shall be modeled.

4.7.2. Special Electrical Systems. All necessary special electrical components (i.e., security, Mass Notification, Public Address, nurse call and other special occupancies, and control systems), including necessary intelligence to produce accurate plans, details and schedules.

4.7.3. Grounding Systems. Grounding Systems. All necessary grounding components (i.e., lightning protection systems, static grounding systems, communications grounding systems, bonding), including necessary intelligence to produce accurate plans, details and schedules.

4.7.4. Communications. All existing and new communications service controls and connections, both above ground and underground with necessary intelligence to produce accurate plans, details and schedules. Cable tray routing shall be modeled without detail of cable contents.

4.7.5. Exterior Building Lighting. All necessary exterior lighting with necessary intelligence to produce accurate plans, elevations and schedules. The exterior building lighting Model shall include all necessary lighting, relevant existing and proposed support utility lines and equipment required with necessary intelligence to produce accurate plans, details and schedules.

4.7.6. Equipment Clearances. The model shall incorporate and define all electrical and communications working spaces, clearances, and required access

4.8. Fire Protection. The fire protection system Model may vary in level of detail for individual elements, but at a minimum must include all features that would be included on a quarter inch (1/4”=1’0”) scaled drawing. Additional minimum Model requirements include:

4.8.1. Fire Protection System. All relevant fire protection components (i.e., branch piping, sprinkler heads, fittings, drains, pumps, tanks, sensors, control panels) with necessary intelligence to produce accurate plans, elevations, building/wall sections, riser diagrams, and schedules. All fire protection piping shall be modeled.

4.8.2. Fire Alarms. Fire alarm/mass notification devices and detection system shall be indicated with necessary intelligence to produce accurate plans depicting them.

4.9. Civil. The civil Model may vary in level of detail for individual elements, but at a minimum must include all features that would be included on a one inch (1”=100’) scaled drawing. Additional minimum Model requirements include:

4.9.1. Terrain (DTM). All relevant site conditions and proposed grading, including necessary intelligence to produce accurate Project site topographical plans and cross sections.

4.9.2. Drainage. All existing and new drainage piping, including upgrades thereto, including necessary intelligence to produce accurate plans and profiles for the Project site.

4.9.3. Storm Water and Sanitary Sewers. All existing and new sewer structures and piping, including upgrades thereto, on the Project site with necessary connections to mains or other distribution points as appropriate, including necessary intelligence to produce accurate plans and profiles for the Project site.

4.9.4. Utilities. All necessary new utilities connections from the Project building(s) to the existing or newly-created utilities, and all existing above ground and underground utility conduits, including necessary intelligence to produce accurate plans and site-sections.

4.9.5. Roads and Parking. All necessary roadways and parking lots or parking structures, including necessary intelligence to produce accurate plans, profiles and cross-sections.

5.0 Section 5 - Ownership and Rights in Data

5.1. Ownership. The Government has ownership of and rights at the date of Closeout Submittal to all CAD files, BIM Model, and Facility Data developed for the Project in accordance with FAR Part 27, clauses incorporated in Section 00 72 00, Contract Clauses and Special Contract Requirement 1.14 GOVERNMENT RE-USE OF DESIGN (Section 00 73 00). The Government may make use of this data following any deliverable.

6.0 Section 6 – Contractor Electives

6.1. Applicable Criteria. If the Contractor elected to include one or more of the following features as an elective in its accepted contract proposal for additional credit during the source selection, as described in the proposal submission requirements and evaluation criteria, the following criteria are requirements, as applicable to those elective feature(s).

6.2. COBIE Compliance. The Model and Facility Data for the Project shall fulfill Construction Operations Building Information Exchange (COBIE) requirements as defined by the Whole Building Design Guide organization, including all requirements for the indexing and submission of Portable Document Format (PDF) and other appropriate file formats that would otherwise be printed and submitted in compliance with Project operations and maintenance handover requirements.

6.3. Project Scheduling using the Model. In the BIM Execution Plan and during the Preliminary BIM Execution Plan Review, provide an overview of the use of BIM in the development and support of the project construction schedule.

6.3.1. Submittal Requirements. During the Submittal stages, the Contractor shall deliver the construction schedule with information derived from the Model.

6.3.1.1. Construction Submittals – Over-The-Shoulder Progress Reviews. Periodic quality control meetings or construction progress review meetings shall include quality control reviews on the implementation and use of the Model for project scheduling.

6.4. Cost Estimating. In the BIM Execution Plan and during the Preliminary BIM Execution Plan Review, provide an overview of the use of BIM in the development and support of cost estimating requirements, or other applications such as cost analysis and estimate validation.

6.4.1. Submittal Requirements. During the Submittal stages, the Contractor shall deliver cost estimating information derived from the Model.

6.4.2. Project completion. At project completion, the Contractor shall provide an MII (Micro Computer Aided Cost Estimating System Generation II) Cost Estimate which follows the USACE Cost Engineering Military Work Breakdown System (WBS), a modified Uniformat, to at least the sub-systems level and uses quantity information supplied directly from BIM output to the maximum extent possible, though other "Gap" quantity information will be included as necessary for a complete and accurate cost estimate.

6.4.2.1. Sub system level extracted quantities from the BIM for use within the estimate shall be provided according to how detailed line items or tasks should be installed/built so that accurate costs can be developed and/or reflected. Therefore, when developing a BIM, the designer shall be cognizant of what tasks need to be separated appropriately at the beginning stages of model development, such as tasks done on the first floor versus the same task on higher floors that will be more labor intensive and therefore need to have a separate quantity and be priced differently. Tasks and their extracted quantities from the BIM shall be broken done by their location (proximity in the structure) as well as the complexity of its installation.

6.4.2.2. At all design stages it shall be understood that BIM output as described in this document will not generate all quantities that are necessary in order to develop a complete and accurate cost estimate of the project based on the design. An example of this would be plumbing that is less than 1.5" diameter and therefore not expected to be modeled due to granularity; this information is commonly referred to as The Gap. Quantities from The Gap and their associated costs shall be included in the final project actual cost estimates as well.

6.5. Other Analyses and Reports. Structural, energy and efficiency, EPACT 2005 & EISA 2007, lighting design, daylighting, electrical power, psychrometric processing, shading, programming, LEED, fire protection, code compliance, Life Cycle Cost, acoustic, plumbing.

7.0 Section 7 – BIM Project Execution Plan Template

7.1. Contractors will utilize the latest version of the USACE BIM PROJECT EXECUTION PLAN (USACE PxP) Template to develop an acceptable Plan. The template can be downloaded from the CAD/BIM Technology Center website.

ATTACHMENT G
DESIGN SUBMITTAL DIRECTORY AND SUBDIRECTORY FILE ARRANGEMENT

Organize electronic design submittal files in a subdirectory/file structure in accordance with the following table. The Contractor may suggest a slightly different structure, subject to the discretion of the government.

Design Submittal Directory and Subdirectory File Arrangement.

Directory	Sub-Directory	Sub-Directory or Files	Files
Submittal/Package Name	Narratives	PDF file or files with updated design narrative for each applicable design discipline	
	Drawings	PDF (subdirectory)	Single PDF file with all applicable drawing sheets - bookmarked by sheet number and name
		BIM (subdirectory) See Attachment F.	BIM project folder (with files) per the USACE Workspace. Include an Excel drawing index file with each drawing sheet listed by sheet #, name and corresponding dgn file name (Final Design & Design Complete only)
	Design Analysis & Calculations	Individual PDF files containing design analysis and calculations for each discipline applicable to the submittal	
		PDF file with Fire Protection and Life Safety Code Review checklist	
	LEED	PDF file with updated Leed Check List	
		PDF file or files with LEED Templates for each point with applicable documentation included in each file.	
		LEED SUBMITTALS	
	Energy Analysis	PDF with baseline energy consumption analysis	
		PDF with actual building energy consumption analysis	
	Specifications	Single PDF file with table of contents and all applicable specifications sections.	
		Submittal Register (Final Design & Design Complete submittal only)	
	Design Quality Control	PDF file or files with DQC checklist(s) and/or statements	
	Building Rendering(s)	PDF file of rendering for each building type included in contract (Final Design & Design Complete).	

SECTION 01 45 01.10
QUALITY CONTROL SYSTEM (QCS)

1.0 GENERAL

1.1. CORRESPONDENCE AND ELECTRONIC COMMUNICATIONS

1.2. QCS SOFTWARE

1.3. SYSTEM REQUIREMENTS

1.4. RELATED INFORMATION

1.5. CONTRACT DATABASE

1.6. DATABASE MAINTENANCE

1.7. IMPLEMENTATION

1.8. DATA SUBMISSION VIA COMPUTER DISKETTE OR CD-ROM

1.9. MONTHLY COORDINATION MEETING

1.10. NOTIFICATION OF NONCOMPLIANCE

1.0 GENERAL

The Government will use the Resident Management System for Windows (RMS) to assist in its monitoring and administration of this contract. The Contractor shall use the Government-furnished Construction Contractor Module of RMS, referred to as QCS, to record, maintain, and submit various information throughout the contract period. The Contractor module, user manuals, updates, and training information can be downloaded from the RMS web site. This joint Government-Contractor use of RMS and QCS will facilitate electronic exchange of information and overall management of the contract. QCS provides the means for the Contractor to input, track, and electronically share information with the Government in the following areas:

- Administration
- Finances
- Quality Control
- Submittal Monitoring
- Scheduling
- Import/Export of Data
- Request for Information
- Accident Reporting
- Safety Exposure Manhours

1.1. CORRESPONDENCE AND ELECTRONIC COMMUNICATIONS

For ease and speed of communications, both Government and Contractor will exchange correspondence and other documents in electronic format. Correspondence, pay requests and other documents comprising the official contract record shall also be provided in paper format, with signatures and dates where necessary. Paper documents will govern, in the event of discrepancy with the electronic version.

1.2. OTHER FACTORS

Particular attention is directed to Contract Clause, "Schedules for Construction Contracts", Contract Clause, "Payments", Section 01 32 01.00 10, PROJECT SCHEDULE, Section 01 33 00, SUBMITTAL PROCEDURES, and Section 01 45 04.00 10, CONTRACTOR QUALITY CONTROL, which have a direct relationship to the reporting to be accomplished through QCS. Also, there is no separate payment for establishing and maintaining the QCS database; all costs associated therewith shall be included in the contract pricing for the work.

1.3. QCS SOFTWARE

QCS is a Windows-based program that can be run on a stand-alone personal computer or on a network. The Government will make available the QCS software to the Contractor after award of the construction contract. Prior to the Pre-Construction Conference, the Contractor shall be responsible to download, install and use the latest version of the QCS software from the Government's RMS Internet Website. Upon specific justification and request by the Contractor, the Government can provide QCS on CD-ROM. Any program updates of QCS will be made available to the Contractor via the Government RMS Website as they become available.

1.4. SYSTEM REQUIREMENTS

The following listed hardware and software is the minimum system configuration that the Contractor shall have to run QCS:

(a) Hardware

- IBM-compatible PC with 1000 MHz Pentium or higher processor
- 256 MB RAM for workstation / 512+ MB RAM for server
- 1 GB hard drive disk space for sole use by the QCS system
- Compact disk (CD) Reader, 8x speed or higher
- SVGA or higher resolution monitor (1024 x 768, 256 colors)
- Mouse or other pointing devise
- Windows compatible printer (Laser printer must have 4+ MB of RAM)
- Connection to the Internet, minimum 56K BPS

(b) Software

- MS Windows 2000 or higher
- MS Word 2000 or newer
- Latest version of : Netscape Navigator, Microsoft Internet Explorer, or other browser that supports HTML 4.0 or higher
- Electronic mail (E-mail), MAPI compatible
- Virus protection software that is regularly upgraded with all issued manufacturer's updates

1.5. RELATED INFORMATION

1.5.1. QCS USER GUIDE

After contract award, the Contractor shall download instructions for the installation and use of QCS from the Government RMS Internet Website. In case of justifiable difficulties, the Government will provide the Contractor with a CD-ROM containing these instructions.

1.5.2. CONTRACTOR QUALITY CONTROL (CQC) TRAINING

The use of QCS will be discussed with the Contractor's QC System Manager during the mandatory CQC Training class.

1.6. CONTRACT DATABASE

Prior to the pre-construction conference, the Government will provide the Contractor with basic contract award data to use for QCS. The Government will provide data updates to the Contractor as needed, generally by using the government's SFTP repository built into QCS import/export function. These updates will generally consist of submittal reviews, correspondence status, QA comments, and other administrative and QA data.

1.7. DATABASE MAINTENANCE

The Contractor shall establish, maintain, and update data for the contract in the QCS database throughout the duration of the contract. The Contractor shall establish and maintain the QCS database at the Contractor's site office. Data updates to the Government, e.g., daily reports, submittals, RFI’s, schedule updates, payment requests, etc. shall be submitted using the government's SFTP repository built into QCS export function. If permitted by the Contracting Officer, email or CD-ROM may be used instead (see Paragraph DATA SUBMISSION VIA CD-ROM). The QCS database typically shall include current data on the following items:

1.7.1. ADMINISTRATION

1.7.1.1. Contractor Information

The database shall contain the Contractor's name, address, telephone numbers, management staff, and other required items. Within 14 calendar days of receipt of QCS software from the Government, the Contractor shall deliver Contractor administrative data in electronic format.

1.7.1.2. Subcontractor Information

The database shall contain the name, trade, address, phone numbers, and other required information for all subcontractors. A subcontractor must be listed separately for each trade to be performed. Each subcontractor/trade shall be assigned a unique Responsibility Code, provided in QCS. Within 14 calendar days of receipt of QCS software from the Government, the Contractor shall deliver subcontractor administrative data in electronic format.

1.7.1.3. Correspondence

All Contractor correspondence to the Government shall be identified with a serial number. Correspondence initiated by the Contractor's site office shall be prefixed with "S". Letters initiated by the Contractor's home (main)

office shall be prefixed with "H". Letters shall be numbered starting from 0001. (e.g., H-0001 or S-0001). The Government's letters to the Contractor will be prefixed with "C".

All Requests For Information (RFI) shall be exchanged using the Built-in RFI generator and tracker in QCS.

1.7.1.4. Equipment

The Contractor's QCS database shall contain a current list of equipment planned for use or being used on the jobsite, including the most recent and planned equipment inspection dates.

1.7.1.5. Management Reporting

QCS includes a number of reports that Contractor management can use to track the status of the project. The value of these reports is reflective of the quality of the data input, and is maintained in the various sections of QCS. Among these reports are: Progress Payment Request worksheet, QA/QC comments, Submittal Register Status, Three-Phase Inspection checklists.

1.7.2. FINANCES

1.7.2.1. Pay Activity Data

The QCS database shall include a list of pay activities that the Contractor shall develop in conjunction with the design and construction schedule. The sum of all pay activities shall be equal to the total contract amount, including modifications. Pay activities shall be grouped by Contract Line Item Number (CLIN), and the sum of the activities shall equal the amount of each CLIN. The total of all CLINs equals the Contract Amount.

1.7.2.2. Payment Requests

All progress payment requests shall be prepared using QCS. The Contractor shall complete the payment request worksheet prompt payment certification, and payment invoice in QCS. The work completed under the contract, measured as percent or as specific quantities, shall be updated at least monthly. After the update, the Contractor shall generate a payment request report using QCS. The Contractor shall submit the payment request, prompt payment certification, and payment invoice with supporting data by using the government's SFTP repository built into QCS export function. If permitted by the Contracting Officer, E-mail or a CD-ROM may be used. A signed paper copy of the approved payment request is also required, which shall govern in the event of discrepancy with the electronic version.

1.7.3. Quality Control (QC)

QCS provides a means to track implementation of the 3-phase QC Control System, prepare daily reports, identify and track deficiencies, document progress of work, and support other contractor QC requirements. The Contractor shall maintain this data on a daily basis. Entered data will automatically output to the QCS generated daily report. The Contractor shall provide the Government a Contractor Quality Control (CQC) Plan within the time required in Section 01 45 04.00 10, CONTRACTOR QUALITY CONTROL. Within seven calendar days of Government acceptance, the Contractor shall submit a QCS update reflecting the information contained in the accepted CQC Plan: schedule, pay activities, features of work, submittal register, QC requirements, and equipment list.

1.7.3.1. Daily Contractor Quality Control (CQC) Reports

QCS includes the means to produce the Daily CQC Report. The Contractor may use other formats to record basic QC data. However, the Daily CQC Report generated by QCS shall be the Contractor's official report. Data from any supplemental reports by the Contractor shall be summarized and consolidated onto the QCS-generated Daily CQC Report. Daily CQC Reports shall be submitted as required by Section 01 45 04.00 10, CONTRACTOR QUALITY CONTROL. Reports shall be submitted electronically to the Government within 24 hours after the date covered by the report. The Contractor shall also provide the Government a signed, printed copy of the daily CQC report.

1.7.3.2. Deficiency Tracking

The Contractor shall use QCS to track deficiencies. Deficiencies identified by the Contractor will be numerically tracked using QC punch list items. The Contractor shall maintain a current log of its QC punch list items in the QCS database. The Government will log the deficiencies it has identified using its QA punch list items. The Government's QA punch list items will be included in its export file to the Contractor. The Contractor shall regularly update the correction status of both QC and QA punch list items.

1.7.3.3. QC Requirements

The Contractor shall develop and maintain a complete list of QC testing and required structural and life safety special inspections required by the International Code Council (ICC), transferred and installed property, and user training requirements in QCS. The Contractor shall update all data on these QC requirements as work progresses, and shall promptly provide this information to the Government via QCS.

1.7.3.4. Three-Phase Control Meetings

The Contractor shall maintain scheduled and actual dates and times of preparatory and initial control meetings in QCS.

1.7.3.5. Labor and Equipment Hours

The Contractor shall log labor and equipment exposure hours on a daily basis. This data will be rolled up into a monthly exposure report.

1.7.3.6. Accident/Safety Tracking Reporting

The Government will issue safety comments, directions, or guidance whenever safety deficiencies are observed. The Government's safety comments will be included in its export file to the Contractor. The Contractor shall regularly update the correction status of the safety comments. In addition, the Contractor shall utilize QCS to advise the Government of any accidents occurring on the jobsite. This supplemental entry is not to be considered as a substitute for completion of mandatory notification and reports, e.g., ENG Form 3394 and OSHA Form 300.

1.7.3.7. Features of Work

The Contractor shall include a complete list of the features of work in the QCS database. A feature of work may be associated with multiple pay activities. However, each pay activity (see subparagraph "Pay Activity Data" of paragraph "Finances") will only be linked to a single feature of work.

1.7.3.8. Hazard Analysis

The Contractor shall use QCS to develop a hazard analysis for each feature of work included in its CQC Plan. The hazard analysis shall address any hazards, or potential hazards, that may be associated with the work

1.7.4. Submittal Management

The Government will provide the submittal register form, ENG Form 4288, SUBMITTAL REGISTER, in electronic format. The Contractor and Designer of Record (DOR) shall develop and maintain a complete list of all submittals, including completion of all data columns and shall manage all submittals. Dates on which submittals are received and returned by the Government will be included in its export file to the Contractor. The Contractor shall use QCS to track and transmit all submittals. ENG Form 4025, submittal transmittal form, and the submittal register update, ENG Form 4288, shall be produced using QCS. QCS and RMS will be used to update, store and exchange submittal registers and transmittals, but will not be used for storage of actual submittals.

1.7.5. Schedule

The Contractor shall develop a design and construction schedule consisting of pay activities, in accordance with Section 01 32 01.00 10, PROJECT SCHEDULE, as applicable. This schedule shall be input and maintained in the QCS database either manually or by using the Standard Data Exchange Format (SDEF) (see Section 01 32 01.00 10 PROJECT SCHEDULE). The updated schedule data shall be included with each pay request submitted by the Contractor.

1.7.5.1. Import/Export of Data

QCS includes the ability to export Contractor data to the Government and to import submittal register and other Government-provided data from RMS, and schedule data using SDEF.

1.8. IMPLEMENTATION

Contractor use of QCS as described in the preceding paragraphs is mandatory. The Contractor shall ensure that sufficient resources are available to maintain its QCS database, and to provide the Government with regular database updates. QCS shall be an integral part of the Contractor's management of quality control.

1.9. DATA SUBMISSION VIA COMPUTER DISKETTE OR CD-ROM

The Government-preferred method for Contractor's submission of QCS data is by using the government's SFTP repository built into QCS export function.. Other data should be submitted using E-mail with file attachment(s). For locations where this is not feasible, the Contracting Officer may permit use of CD-ROM for data transfer. Data on CDs shall be exported using the QCS built-in export function. If used, CD-ROMs will be submitted in accordance with the following:

1.9.1. File Medium

The Contractor shall submit required data on CD-ROMs. They shall conform to industry standards used in the United States. All data shall be provided in English.

1.9.2. Disk Or Cd-Rom Labels

The Contractor shall affix a permanent exterior label to each diskette and CD-ROM submitted. The label shall indicate in English, the QCS file name, full contract number, contract name, project location, data date, name and telephone number of person responsible for the data.

1.9.3. File Names

The files will be automatically named by the QCS software. The naming convention established by the QCS software shall not be altered in any way by the Contractor.

1.10. MONTHLY COORDINATION MEETING

The Contractor shall update the QCS database each workday. At least monthly, the Contractor shall generate and submit an export file to the Government with schedule update and progress payment request. As required in Contract Clause "Payments", at least one week prior to submittal, the Contractor shall meet with the Government representative to review the planned progress payment data submission for errors and omissions.

The Contractor shall make all required corrections prior to Government acceptance of the export file and progress payment request. Payment requests accompanied by incomplete or incorrect data submittals will be returned. The Government will not process progress payments until an acceptable QCS export file is received.

1.11. NOTIFICATION OF NONCOMPLIANCE

The Contracting Officer will notify the Contractor of any detected noncompliance with the requirements of this specification. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification.

End of Section 01 45 01.10

SECTION 01 45 04.00 10
CONTRACTOR QUALITY CONTROL

1.0 GENERAL

1.1. REFERENCES

1.2. PAYMENT

2.0 PRODUCTS (NOT APPLICABLE)

3.0 EXECUTION

3.1. GENERAL REQUIREMENTS

3.2. QUALITY CONTROL PLAN

3.3. COORDINATION MEETING

3.4. QUALITY CONTROL ORGANIZATION

3.5. SUBMITTALS AND DELIVERABLES

3.6. CONTROL

3.7. TESTS

3.8. COMPLETION INSPECTION

3.9. DOCUMENTATION

3.10. NOTIFICATION OF NONCOMPLIANCE

1.0 GENERAL

1.1. REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. Refer to the latest edition, as of the date of the contract solicitation.

- ASTM INTERNATIONAL (ASTM)
- ASTM D 3740 Minimum Requirements for Agencies

  Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- ASTM E 329 Agencies Engaged in the Testing

  and/or Inspection of Materials Used in Construction
- U.S. ARMY CORPS OF ENGINEERS (USACE)

  ER 1110-1-12 Quality Management

1.2. PAYMENT

There will be no separate payment for providing and maintaining an effective Quality Control program. Include all costs associated therewith in the applicable unit prices or lump-sum prices contained in the Contract Line Item Schedule.

2.0 PRODUCTS (Not Applicable)

3.0 EXECUTION

3.1. GENERAL REQUIREMENTS

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system in compliance with the Contract Clause titled "Inspection of Construction." The quality control system shall consist of plans, procedures, and organization necessary to produce an end product, which complies with the contract requirements. The system shall cover all design and construction operations, both onsite and offsite, and shall be keyed to the proposed design and construction sequence. The site project superintendent is responsible for the quality of work on the job and is subject to removal by the Contracting Officer for non-compliance with the quality requirements specified in the contract. The site project superintendent in this context shall be the highest level manager responsible for the overall construction activities at the site, including quality and production. The site project superintendent shall maintain a physical presence at the site at all times, except as otherwise acceptable to the Contracting Officer, and shall be responsible for all construction and construction related activities at the site.

3.2. QUALITY CONTROL PLAN

Furnish for Government review, not later than 30 days after receipt of notice to proceed, the Contractor Quality Control (CQC) Plan proposed to implement the requirements of the Contract Clause titled "Inspection of Construction." The plan shall identify personnel, procedures, control, instructions, tests, records, and forms to be used. The Government will consider an interim plan for the first 30 days of operation. Design and construction may begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of work to be started. The Government will not permit work outside of the features of work included in an accepted interim plan to begin until acceptance of a CQC Plan or another interim plan containing the additional features of work to be started. Where the applicable Code issued by the International Code Council calls for an inspection by the Building Official, the Contractor shall include the inspections in the Quality Control Plan and shall perform the inspections. The Designer of Record shall develop a program for any special inspections required by the applicable International Codes and the Contractor shall perform these inspections, using qualified inspectors. Include the special inspection plan in the QC Plan.

3.2.1. Content of the CQC Plan

The CQC Plan shall include, as a minimum, the following to cover all design and construction operations, both onsite and offsite, including work by subcontractors, fabricators, suppliers, and purchasing agents subcontractors, designers of record, consultants, architect/engineers (AE), fabricators, suppliers, and purchasing agents:

3.2.1.1. A description of the quality control organization. Include a chart showing lines of authority and an acknowledgment that the CQC staff shall implement the three phase control system for all aspects of the work specified. A CQC System Manager shall report to the project superintendent or someone higher in the contractor's organization.

3.2.1.2. The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a CQC function. Also include those responsible for performing and documenting the inspections required by the International Codes and the special inspection program developed by the designer of record.

3.2.1.3. A copy of the letter to the CQC System Manager, signed by an authorized official of the firm, which describes the responsibilities and delegates sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop work which is not in compliance with the contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities, and responsibilities. Furnish copies of these letters.

3.2.1.4. Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers, and purchasing agents subcontractors, designers of record, consultants, architect engineers (AE), offsite fabricators, suppliers, and purchasing agents. These procedures shall be in accordance with Section 01 33 00 SUBMITTAL PROCEDURES.

3.2.1.5. Control, verification, and acceptance testing procedures for each specific test to include the test name, specification paragraph requiring test, feature of work to be tested, test frequency, and person responsible for each test. Use only Government approved Laboratory facilities.

3.2.1.6. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests including documentation.

3.2.1.7. Procedures for tracking design and construction deficiencies from identification through acceptable corrective action. These procedures shall establish verification that identified deficiencies have been corrected.

3.2.1.8. Reporting procedures, including proposed reporting formats.

3.2.1.9. A list of the definable features of work. A definable feature of work is a task, which is separate and distinct from other tasks, has separate control requirements, and may be identified by different trades or disciplines, or it may be work by the same trade in a different environment. Although each section of the specifications may generally be considered as a definable feature of work, there are frequently more than one definable feature under a particular section. This list will be agreed upon during the coordination meeting.

3.2.1.10. A list of all inspections required by the International Codes and the special inspection program required by the code and this contract.

3.2.2. Additional Requirements for Design Quality Control (DQC) Plan

The following additional requirements apply to the Design Quality Control (DQC) plan:

3.2.2.1. The Contractor's QCP Plan shall provide and maintain a Design Quality Control (DQC) Plan as an effective quality control program which will assure that all services required by this design-build contract are performed and provided in a manner that meets professional architectural and engineering quality standards. As a minimum, competent, independent reviewers identified in the DQC Plan shall review all documents. Use personnel who were not involved in the design effort to produce the design to perform the independent technical review (ITR). The ITR is intended as a quality control check of the design. Include, at least, but not necessarily limited to, a review of the contract requirements (the accepted contract or task order proposal and amended RFP), the basis of design, design calculations, the design configuration management documentation and check the design documents for

errors, omissions, and for coordination and design integration. The ITR team is not required to examine, compare or comment concerning alternate design solutions but should concentrate on ensuring that the design meets the contract requirements. Correct errors and deficiencies in the design documents prior to submitting them to the Government.

3.2.2.2. Include in the DQC Plan the discipline-specific checklists to be used during the design and quality control of each submittal. Submit these completed checklists at each design phase as part of the project documentation.

3.2.2.3. A Design Quality Control Manager, who has the responsibility of being cognizant of and assuring that all documents on the project have been coordinated, shall implement the DQC Plan This individual shall be a person who has verifiable engineering or architectural design experience and is a registered professional engineer or architect. Notify the Government, in writing, of the name of the individual, and the name of an alternate person assigned to the position.

3.2.3. Acceptance of Plan

Government acceptance of the Contractor's plan is required prior to the start of design and construction. Acceptance is conditional and will be predicated on satisfactory performance during the design and construction. The Government reserves the right to require the Contractor to make changes in his CQC Plan and operations including removal of personnel, as necessary, to obtain the quality specified.

3.2.4. Notification of Changes

After acceptance of the CQC Plan, notify the Government in writing of any proposed change. Proposed changes are subject to Government acceptance.

3.3. COORDINATION MEETING

After the Postaward Conference, before start of design or construction, and prior to acceptance by the Government of the CQC Plan, the Contractor and the Government shall meet and discuss the Contractor's quality control system. Submit the CQC Plan for review a minimum of 7 calendar days prior to the Coordination Meeting. During the meeting, a mutual understanding of the system details shall be developed, including the forms for recording the CQC operations, design activities, control activities, testing, administration of the system for both onsite and offsite work, and the interrelationship of Contractor's Management and control with the Government's Quality Assurance. The Government will prepare minutes of the meeting for signature by both parties. . The minutes shall become a part of the contract file. There may be occasions when either party will call for subsequent conferences to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures which may require corrective action by the Contractor.

3.4. QUALITY CONTROL ORGANIZATION

3.4.1. Personnel Requirements

The requirements for the CQC organization are a CQC System Manager, a Design Quality Manager, and sufficient number of additional qualified personnel to ensure contract compliance. The CQC organization shall also include personnel identified in the technical provisions as requiring specialized skills to assure the required work is being performed properly. The Contractor's CQC staff shall maintain a presence at the site at all times during progress of the work and have complete authority and responsibility to take any action necessary to ensure contract compliance. The CQC staff shall be subject to acceptance by the Contracting Officer. Provide adequate office space, filing systems and other resources as necessary to maintain an effective and fully functional CQC organization. Promptly furnish complete records of all letters, material submittals, shop drawing submittals, schedules and all other project documentation to the CQC organization. The CQC organization shall be responsible to maintain these documents and records at the site at all times, except as otherwise acceptable to the Contracting Officer.

3.4.2. CQC System Manager

Identify as CQC System Manager an individual within the onsite work organization who shall be responsible for overall management of CQC and have the authority to act in all CQC matters for the Contractor. The CQC System

Manager shall be a graduate engineer, graduate architect, or a BA/BS graduate of an ACCE accredited construction management college program. The CQC system Manager may alternately be an engineering technician with at least 2 years of college and an ICC certification as a Commercial Building Inspector (Residential Building Inspector certification will be required for Military Family Housing projects). In addition, the CQC system manager shall have a minimum of 5 years construction experience on construction similar to this contract. The CQC System Manager shall be on the site at all times during construction and shall be employed by the prime Contractor. Assign the CQC System Manager no other duties (except may also serve as Safety and Health Officer, if qualified and if allowed by Section 00 73 00). Identify an alternate for the CQC System Manager in the plan to serve in the event of the System Manager's absence. The requirements for the alternate shall be the same as for the designated CQC System Manager but the alternate may have other duties in addition to serving in a temporary capacity as the acting QC manager.

3.4.3. CQC Personnel

3.4.3.1. In addition to CQC personnel specified elsewhere in the contract provide specialized CQC personnel to assist the CQC System Manager in accordance with paragraph titled Area Qualifications.

3.4.3.2. These individuals may be employees of the prime or subcontractor; be responsible to the CQC System Manager; **are not intended to be full time, but must be physically present at the construction site during work on their areas of responsibility**; have the necessary education and/or experience in accordance with the experience matrix listed herein. These individuals may perform other duties but must be allowed sufficient time to perform their assigned quality control duties as described in the Quality Control Plan. **One person may cover more than one area, provided that they are qualified to perform QC activities for the designated areas below and provided that they have adequate time to perform their duties:**

3.4.4. Experience Matrix

3.4.4.1. Area Qualifications

3.4.4.1.1. Civil - Graduate Civil Engineer or (BA/BS) graduate in construction management with 4 years experience in the type of work being performed on this project or engineering technician with 5 yrs related experience.

3.4.4.1.2. Mechanical - Graduate Mechanical Engineer or (BA/BS) graduate in construction management with 4 yrs related experience or engineering technician with an ICC certification as a Commercial Mechanical Inspector with 5 yrs related experience.

3.4.4.1.3. Electrical - Graduate Electrical Engineer or (BA/BS) graduate in construction management with 4 yrs related experience or engineering technician with an ICC certification as a Commercial Electrical Inspector with 5 yrs related experience.

3.4.4.1.4. Structural - Graduate Structural Engineer or (BA/BS) graduate in construction management with 4 yrs related experience or person with an ICC certification as a Reinforced Concrete Special Inspector and Structural Steel and Bolting Special Inspector (as applicable to the type of construction involved) with 5 yrs related experience.

3.4.4.1.5. Plumbing - Graduate Mechanical Engineer or (BA/BS) graduate in construction management with 4 yrs related experience, or person with an ICC certification as a Commercial Plumbing Inspector with 5 yrs related experience.

3.4.4.1.6. Concrete, Pavements and Soils Materials Technician (present while performing tests) with 2 yrs experience for the appropriate area

3.4.4.1.7. Testing, Adjusting and Balancing Specialist must be a member (TAB) Personnel of AABC or an experienced technician of the firm certified by the NEBB (present while testing, adjusting, balancing).

3.4.4.1.8. Design Quality Control Manager Registered Architect or Professional Engineer (not required on the construction site)

3.4.4.1.9. Registered Fire Protection Engineer with 4 years related experience or engineering technician with 5 yrs related experience (but see requirements for Fire Protection Engineer of Record to witness final testing in Section 01 10 00, paragraph 5.10, Fire Protection).

3.4.4.1.10. QC personnel assigned to the installation of the telecommunication system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification. In lieu of BICSI certification, QC personnel shall have a minimum of 5 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. QC personnel shall witness and certify the testing of telecommunications cabling and equipment.

3.4.5. Additional Requirement

In addition to the above experience and/or education requirements the CQC System Manager shall have completed the course entitled "Construction Quality Management for Contractors". This course is periodically offered at [Not Supplied - ConstructionReqQC : COURSE_LOCATION]. Inquire of the District or Division sponsoring the course for fees and other expenses involved, if any, for attendance at this course.

3.4.6. Organizational Changes

When it is necessary to make changes to the CQC staff, the Contractor shall revise the CQC Plan to reflect the changes and submit the changes to the Contracting Officer for acceptance.

3.5. SUBMITTALS AND DELIVERABLES

Make submittals as specified in Section 01 33 00 ***SUBMITTAL PROCEDURES***. The CQC organization shall certify that all submittals and deliverables are in compliance with the contract requirements.

3.6. CONTROL

Contractor Quality Control is the means by which the Contractor ensures that the construction, to include that of subcontractors and suppliers, complies with the requirements of the contract. The CQC organization shall conduct at least three phases of control for each definable feature of the construction work as follows:

3.6.1. Preparatory Phase

Perform this phase prior to beginning work on each definable feature of work, after all required plans/documents/materials are approved/accepted, and after copies are at the work site. This phase shall include:

3.6.1.1. A review of each paragraph of applicable specifications, reference codes, and standards. Make a copy of those sections of referenced codes and standards applicable to that portion of the work to be accomplished in the field at the preparatory inspection. Maintain these copies in the field, available for use by Government personnel until final acceptance of the work.

3.6.1.2. A review of the contract drawings.

3.6.1.3. A check to assure that all materials and/or equipment have been tested, submitted, and approved.

3.6.1.4. Review of provisions that have been made to provide required control inspection and testing.

3.6.1.5. Examination of the work area to assure that all required preliminary work has been completed and is in compliance with the contract.

3.6.1.6. A physical examination of required materials, equipment, and sample work to assure that they are on hand, conform to approved shop drawings or submitted data, and are properly stored.

3.6.1.7. A review of the appropriate activity hazard analysis to assure safety requirements are met.

3.6.1.8. Discussion of procedures for controlling quality of the work including repetitive deficiencies. Document construction tolerances and workmanship standards for that feature of work.

3.6.1.9. A check to ensure that the portion of the plan for the work to be performed has been accepted by the Contracting Officer.

3.6.1.10. Discussion of the initial control phase.

3.6.1.11. Notify the Government at least 24 hours in advance of beginning the preparatory control phase. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. Document the results of the preparatory phase actions by separate minutes prepared by the CQC System Manager and attached to the daily CQC report. The Contractor shall instruct applicable workers as to the acceptable level of workmanship required in order to meet contract specifications.

3.6.2. Initial Phase

Accomplish this phase at the beginning of a definable feature of work. Include the following actions:

3.6.2.1. Check work to ensure that it is in full compliance with contract requirements. Review minutes of the preparatory meeting.

3.6.2.2. Verify adequacy of controls to ensure full contract compliance. Verify required control inspection and testing.

3.6.2.3. Establish level of workmanship and verify that it meets minimum acceptable workmanship standards. Compare with required sample panels as appropriate.

3.6.2.4. Resolve all differences.

3.6.2.5. Check safety to include compliance with and upgrading of the Accident Prevention plan and activity hazard analysis. Review the activity analysis with each worker.

3.6.2.6. Notify the Government at least 24 hours in advance of beginning the initial phase. The CQC System Manager shall prepare and attach to the daily CQC report separate minutes of this phase. Indicate exact location of initial phase for future reference and comparison with follow-up phases.

3.6.2.7. Repeat the initial phase any time acceptable specified quality standards are not being met.

3.6.3. Follow-up Phase

Perform daily checks to assure control activities, including control testing, are providing continued compliance with contract requirements, until completion of the particular feature of work. The checks shall be made a matter of record in the CQC documentation. Conduct final follow-up checks and correct deficiencies prior to the start of additional features of work which may be affected by the deficient work. Do not build upon nor conceal non-conforming work.

3.6.4. Additional Preparatory and Initial Phases

Conduct additional preparatory and initial phases on the same definable features of work if: the quality of on-going work is unacceptable; if there are changes in the applicable CQC staff, onsite production supervision or work crew; if work on a definable feature is resumed after a substantial period of inactivity; or if other problems develop.

3.7. TESTS

3.7.1. Testing Procedure

Perform specified or required tests to verify that control measures are adequate to provide a product which conforms to contract requirements and project design documents. Upon request, furnish to the Government

duplicate samples of test specimens for possible testing by the Government. Testing includes operation and/or acceptance tests when specified. The Contractor shall procure the services of a Corps of Engineers approved testing laboratory, or establish an approved testing laboratory at the project site. The Contractor may elect to use a laboratory certified and accredited by the Concrete and cement Reference Laboratory (CCRL) or by AASHTO Materials Reference Laboratory (AMRL) for testing procedures that those organizations certify. The Contractor shall perform the following activities and record and provide the following data:

3.7.1.1. Verify that testing procedures comply with contract requirements and project design documents.

3.7.1.2. Verify that facilities and testing equipment are available and comply with testing standards.

3.7.1.3. Check test instrument calibration data against certified standards.

3.7.1.4. Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.

3.7.1.5. Include results of all tests taken, both passing and failing tests, recorded on the CQC report for the date taken. Include specification paragraph reference, location where tests were taken, and the sequential control number identifying the test. If approved by the Contracting Officer, actual test reports may be submitted later with a reference to the test number and date taken. Provide an information copy of tests performed by an offsite or commercial test facility directly to the Contracting Officer. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this contract.

3.7.2. Testing Laboratories

3.7.2.1. Capability Check

The Government reserves the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract specifications and to check the laboratory technician's testing procedures and techniques. Laboratories utilized for testing soils, concrete, asphalt, and steel shall meet criteria detailed in ASTM D 3740 and ASTM E 329.

3.7.2.2. Capability Recheck

If the selected laboratory fails the capability check, the Government will assess the Contractor a charge of $1,375 to reimburse the Government for each succeeding recheck of the laboratory or the checking of a subsequently selected laboratory. Such costs will be deducted from the contract amount due the Contractor.

3.7.3. Onsite Laboratory

The Government reserves the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests, and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Government.

3.7.4. Furnishing or Transportation of Samples for Government Quality Assurance Testing

The Contractor is responsible for costs incidental to the transportation of samples or materials. Deliver samples of materials for test verification and acceptance testing by the Government to the Corps of Engineers Laboratory, f.o.b., at the following address:

- For delivery by mail:

  [Not Supplied - ConstructionReqQC : LAB_NAME]

  [Not Supplied - ConstructionReqQC : LAB_ATTN]

  [Not Supplied - ConstructionReqQC : LAB_MAIL]

  [Not Supplied - ConstructionReqQC : LAB_STATE]
- For other deliveries:

  [Not Supplied - ConstructionReqQC : LAB_NAME_OTHER]

[Not Supplied - ConstructionReqQC : LAB_ATTN_OTHER]

[Not Supplied - ConstructionReqQC : LAB_MAIL_OTHER]

[Not Supplied - ConstructionReqQC : LAB_STATE_OTHER]

The area or resident office will coordinate, exact delivery location, and dates for each specific test.

3.8. COMPLETION INSPECTION

3.8.1. Punch-Out Inspection

Near the end of the work, or any increment of the work established by a time stated in the SPECIAL CONTRACT REQUIREMENTS Clause, "Commencement, Prosecution, and Completion of Work", or by the specifications, the CQC Manager shall conduct an inspection of the work. Prepare a punch list of items which do not conform to the approved drawings and specifications and include in the CQC documentation, as required by paragraph DOCUMENTATION. The list of deficiencies shall include the estimated date by which the deficiencies will be corrected. The CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected. Once this is accomplished, the Contractor shall notify the Government that the facility is ready for the Government Pre-Final inspection.

3.8.2. Pre-Final Inspection

As soon as practicable after the notification above, the Government will perform the pre-final inspection to verify that the facility is complete and ready to be occupied. A Government Pre-Final Punch List may be developed as a result of this inspection. The Contractor's CQC System Manager shall ensure that all items on this list have been corrected before notifying the Government, so that a Final inspection with the customer can be scheduled. Correct any items noted on the Pre-Final inspection in a timely manner. Accomplish these inspections and any deficiency corrections required by this paragraph within the time slated for completion of the entire work or any particular increment of the work if the project is divided into increments by separate completion dates.

3.8.3. Final Acceptance Inspection

The Contractor's Quality Control Inspection personnel, plus the superintendent or other primary management person, and the Contracting Officer's Representative shall attend the final acceptance inspection. Additional Government personnel including, but not limited to, those from Base/Post Civil Facility Engineer user groups and major commands may also attend. The Government will formally schedule the final acceptance inspection based upon results of the Pre-Final inspection. Provide notice to the Government at least 14 days prior to the final acceptance inspection and include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection. Failure of the Contractor to have all contract work acceptably complete for this inspection will be cause for the Contracting Officer to bill the Contractor for the Government's additional inspection cost in accordance with the contract clause titled "Inspection of Construction".

3.9. DOCUMENTATION

3.9.1. Maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers using government-provided software, QCS (see Section 01 45 01.10). The report includes, as a minimum, the following information:

3.9.1.1. Contractor/subcontractor and their area of responsibility.

3.9.1.2. Operating plant/equipment with hours worked, idle, or down for repair.

3.9.1.3. Work performed each day, giving location, description, and by whom. When Network Analysis (NAS) is used, identify each phase of work performed each day by NAS activity number.

3.9.1.4. Test and/or control activities performed with results and references to specifications/drawings requirements. Identify the applicable control phase (Preparatory, Initial, Follow-up). List deficiencies noted, along with corrective action.

3.9.1.5. Quantity of materials received at the site with statement as to acceptability, storage, and reference to specifications/drawings requirements.

3.9.1.6. Submittals and deliverables reviewed, with contract reference, by whom, and action taken.

3.9.1.7. Offsite surveillance activities, including actions taken.

3.9.1.8. Job safety evaluations stating what was checked, results, and instructions or corrective actions.

3.9.1.9. Instructions given/received and conflicts in plans and/or specifications.

3.9.1.10. Provide documentation of design quality control activities. For independent design reviews, provide, as a minimum, identity of the ITR team, the ITR review comments, responses and the record of resolution of the comments.

3.9.2. Contractor's verification statement.

These records shall indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. Furnish the original and one copy of these records in report form to the Government daily within 24 hours after the date covered by the report, except that reports need not be submitted for days on which no work is performed. As a minimum, submit one report for every 7 days of no work and on the last day of a no work period. Account for all calendar days throughout the life of the contract. The first report following a day of no work shall be for that day only. The CQC System Manager shall sign and date reports. The report shall include copies of test reports and copies of reports prepared by all subordinate quality control personnel. The Contractor may submit these forms electronically, in lieu of hard copy.

3.10. NOTIFICATION OF NONCOMPLIANCE

The Contracting Officer will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such notice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Contracting Officer may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

End of Section 01 45 04.00 10

SECTION 01 50 02
TEMPORARY CONSTRUCTION FACILITIES

1.0 OVERVIEW

1.1. GENERAL REQUIREMENTS

1.2. AVAILABILITY AND USE OF UTILITY SERVICES

1.3. BULLETIN BOARD, PROJECT SIGN, AND PROJECT SAFETY SIGN

1.4. PROTECTION AND MAINTENANCE OF TRAFFIC

1.5. MAINTENANCE OF CONSTRUCTION SITE

1.0 OVERVIEW

1.1. GENERAL REQUIREMENTS

1.1.1. Site Plan

Prepare a site plan indicating the proposed location and dimensions of any area to be fenced and used by the Contractor, the number of trailers to be used, avenues of ingress/egress to the fenced area and details of the fence installation. Identify any areas which may have to be graveled to prevent the tracking of mud. Also indicate if the use of a supplemental or other staging area is desired.

1.2. AVAILABILITY AND USE OF UTILITY SERVICES

1.2.1. See Section 00 72 00, Contract Clauses and Section 00 73 00, Special Contract Requirements, for Utility Availability requirements.

1.2.2. Sanitation

Provide and maintain within the construction area minimum field-type sanitary facilities approved by the Contracting Officer. Government toilet facilities will not be available to Contractor's personnel.

1.2.3. Telephone

Make arrangements and pay all costs for desired telephone facilities.

1.3. BULLETIN BOARD, PROJECT SIGN, AND PROJECT SAFETY SIGN

1.3.1. Bulletin Board

Immediately upon beginning of onsite work, provide a weatherproof glass-covered bulletin board not less than 36 by 48 inches in size for displaying the Equal Employment Opportunity poster, a copy of the wage decision contained in the contract, Wage Rate Information poster, and other information approved by the Contracting Officer. Locate the bulletin board at the project site in a conspicuous place easily accessible to all employees, as approved by the Contracting Officer. Display legible copies of the aforementioned data until work is completed. Remove the bulletin board from the site upon completion of the project.

1.3.2. Project and Safety Signs

Erect a project sign and a site safety sign with informational details as provided by the Government at the Post award conference, within 15 days prior to any work activity on project site. Update the safety sign data daily, with light colored metallic or non-metallic numerals. Remove the signs from the site upon completion of the project. Engineer Pamphlet EP 310-1-6a contains the standardized layout and construction details for the signs. It can be found through a GOOGLE Search or try http://www.usace.army.mil/publications/eng-pamphlets/ep310-1-6a/s-16.pdf.

1.4. PROTECTION AND MAINTENANCE OF TRAFFIC

Provide access and temporary relocated roads as necessary to maintain traffic. Maintain and protect traffic on all affected roads during the construction period except as otherwise specifically directed by the Contracting Officer. Take measures for the protection and diversion of traffic, including the provision of watchmen and flagmen, erection of barricades, placing of lights around and in front of equipment and the work, and the erection and maintenance of adequate warning, danger, and direction signs, as required by the State and local authorities having jurisdiction. Protect the traveling public from damage to person and property.

The Contractor's traffic on roads selected for hauling material to and from the site shall interfere as little as possible with public traffic. Investigate the adequacy of existing roads and the allowable load limit on these roads. Repair any damage to roads caused by construction operations.

1.4.1. Haul Roads

The Contractor shall, at its own expense, construct access and haul roads necessary for proper prosecution of the work under this contract. Construct haul roads with suitable grades and widths. Avoid sharp curves, blind corners, and dangerous cross traffic. Provide necessary lighting, signs, barricades, and distinctive markings for the safe movement of traffic. The method of dust control, although optional, shall be adequate to ensure safe operation at all times. Location, grade, width, and alignment of construction and hauling roads shall be subject to approval by the Contracting Officer. Provide adequate lighting to assure full and clear visibility for full width of haul road and work areas during any night work operations. Remove haul roads designated by the Contracting Officer upon completion of the work and restore those areas.

1.4.2. Barricades

Erect and maintain temporary barricades to limit public access to hazardous areas. Barricades shall be required whenever safe public access to paved areas such as roads, parking areas or sidewalks is prevented by construction activities or as otherwise necessary to ensure the safety of both pedestrian and vehicular traffic. Securely place barricades clearly visible with adequate illumination to provide sufficient visual warning of the hazard during both day and night.

1.5. MAINTENANCE OF CONSTRUCTION SITE

Mow grass and vegetation located within the boundaries of the construction site for the duration of the project, from NTP to contract completion. Edge or neatly trim grass and vegetation along fences, buildings, under trailers, and in areas not accessible to mowers from NTP to contract completion.

End of Section 01 50 02

SECTION 01 57 20.00 10
ENVIRONMENTAL PROTECTION

1.0 GENERAL REQUIREMENTS

1.1. SUBCONTRACTORS

1.2. ENVIRONMENTAL PROTECTION PLAN

1.3. PROTECTION FEATURES

1.4. ENVIRONMENTAL ASSESSMENT OF CONTRACT DEVIATIONS

1.5. NOTIFICATION

2.0 PRODUCTS (NOT USED)

3.0 EXECUTION

3.1. LAND RESOURCES

3.2. WATER RESOURCES

3.3. AIR RESOURCES

3.4. CHEMICAL MATERIALS MANAGEMENT AND WASTE DISPOSAL

3.5. RECYCLING AND WASTE MINIMIZATION

3.6. HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

3.7. BIOLOGICAL RESOURCES

3.8. INTEGRATED PEST MANAGEMENT

3.9. PREVIOUSLY USED EQUIPMENT

3.10. MILITARY MUNITIONS

3.11. TRAINING OF CONTRACTOR PERSONNEL

3.12. POST CONSTRUCTION CLEANUP

1.0 GENERAL REQUIREMENTS

Minimize environmental pollution and damage that may occur as the result of construction operations. Protect the environmental resources within the project boundaries and those affected outside the limits of permanent work during the entire duration of this contract. Comply with all applicable environmental Federal, State, and local laws and regulations. The Contractor shall be responsible for any delays resulting from failure to comply with environmental laws and regulations

1.1. SUBCONTRACTORS

Ensure compliance with this section by subcontractors.

1.2. ENVIRONMENTAL PROTECTION PLAN

1.2.1. The purpose of the Environmental Protection Plan is to present a comprehensive overview of known or potential environmental issues which the Contractor must address during construction. Define issues of concern within the Environmental Protection Plan as outlined in this section. Address each topic in the plan at a level of detail commensurate with the environmental issue and required construction task(s). Identify and discuss topics or issues which are not identified in this section, but which the Contractor considers necessary, after those items formally identified in this section. Prior to commencing construction activities or delivery of materials to the site, submit the Plan for review and Government approval. The Contractor shall meet with the Government prior to implementation of the Environmental Protection Plan, for the purpose of discussing the implementation of the initial plan; possible subsequent additions and revisions to the plan including any reporting requirements; and methods for administration of the Contractor's Environmental Plans. Maintain and keep the Environmental Protection Plan current onsite.

1.2.2. Compliance

No requirement in this Section shall be construed as relieving the Contractor of any applicable Federal, State, and local environmental protection laws and regulations. During Construction, the Contractor shall be responsible for identifying, implementing, and submitting for approval any additional requirements to be included in the Environmental Protection Plan.

1.2.3. Contents

The plan shall include, but shall not be limited to, the following:

1.2.3.1. Name(s) of person(s) within the Contractor's organization who is(are) responsible for ensuring adherence to the Environmental Protection Plan.

1.2.3.2. Name(s) and qualifications of person(s) responsible for manifesting hazardous waste to be removed from the site, if applicable

1.2.3.3. Name(s) and qualifications of person(s) responsible for training the Contractor's environmental protection personnel

1.2.3.4. Description of the Contractor's environmental protection personnel training program

1.2.3.5. An erosion and sediment control plan which identifies the type and location of the erosion and sediment controls to be provided. Include monitoring and reporting requirements to assure that the control measures are in compliance with the erosion and sediment control plan, Federal, State, and local laws and regulations. A Storm Water Pollution Prevention Plan (SWPPP) may be substituted for this plan.

1.2.3.6. Drawings showing locations of proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials on the site

1.2.3.7. Traffic control plans including measures to reduce erosion of temporary roadbeds by construction traffic, especially during wet weather. Include measures to minimize the amount of mud transported onto paved public roads by vehicles or runoff.

1.2.3.8. Work area plan showing the proposed activity in each portion of the area and identifying the areas of limited use or nonuse. Include measures for marking the limits of use areas including methods for protection of features to be preserved within authorized work areas.

1.2.3.9. Drawing showing the location of on-installation borrow areas.

1.2.3.10. A spill control plan shall include the procedures, instructions, and reports to be used in the event of an unforeseen spill of a substance regulated by 40 CFR 68, 40 CFR 302, 40 CFR 355, and/or regulated under State or Local laws and regulations. The spill control plan supplements the requirements of EM 385-1-1. This plan shall include as a minimum:

(a) The name of the individual who will report any spills or hazardous substance releases and who will follow up with complete documentation. This individual shall immediately notify the Government and the local Fire Department in addition to the legally required Federal, State, and local reporting channels (including the National Response Center 1-800-424-8802) if a reportable quantity is released to the environment. The plan shall contain a list of the required reporting channels and telephone numbers.

(b) The name and qualifications of the individual who will be responsible for implementing and supervising the containment and cleanup

(c) Training requirements for Contractor's personnel and methods of accomplishing the training

(d) A list of materials and equipment to be immediately available at the job site, tailored to cleanup work of the potential hazard(s) identified.

(e) The names and locations of suppliers of containment materials and locations of additional fuel oil recovery, cleanup, restoration, and material-placement equipment available in case of an unforeseen spill emergency

(f) The methods and procedures to be used for expeditious contaminant cleanup

1.2.3.11. A solid waste management plan identifying waste minimization, collection, and disposals methods, waste streams (type and quantity), and locations for solid waste diversion/disposal including clearing debris and C&D waste that is diverted (salvaged, reused, or recycled). Detail the contractor's actions to comply with, and to participate in, Federal, state, regional, local government, and installation sponsored recycling programs to reduce the volume of solid waste at the source. Identify any subcontractors responsible for the transportation, salvage and disposal of solid waste. Submit licenses or permits for solid waste disposal sites that are not a commercial operating facility. Attach evidence of the facility's ability to accept the solid waste to this plan. A construction and demolition waste management plan, similar to the plan specified in the UFGS 01 74 19 (formerly 01572) may be used as the non-hazardous solid waste management plan. Provide a Non-Hazardous Solid Waste Diversion Report. Submit the report on the first working day after the first quarter that non-hazardous solid waste has been disposed and/or diverted and each quarter thereafter (e.g. the first working day of January, April, July, and October) until the end of the project. Additionally, a summary report, with all data fields, is required at the end of the project. The report shall indicate the total type and amount of waste generated, total type and amount of waste diverted, type and amount of waste sent to waste-to-energy facility and alternative daily cover, in tons along with the percent that was diverted. Maintain, track and report construction and demolition waste data in a manner such that the installation can enter the data into the Army SWAR database, which separates data by type of material. A cumulative report in LEED Letter Template format may be used but must be modified to include the date disposed of/diverted and include the above stated diversion data. NOTE: The Solid Waste Diversion Reports are separate documentation than the LEED documentation.

1.2.3.12. DELETED.

1.2.3.13. An air pollution control plan detailing provisions to assure that dust, debris, materials, trash, etc., do not become air borne and travel off the project site.

1.2.3.14. A contaminant prevention plan that: identifies potentially hazardous substances to be used on the job site; identifies the intended actions to prevent introduction of such materials into the air, water, or ground; and details provisions for compliance with Federal, State, and local laws and regulations for storage and handling of

these materials. In accordance with EM 385-1-1, include a copy of the Material Safety Data Sheets (MSDS) and the maximum quantity of each hazardous material to be on site at any given time in the contaminant prevention plan. Update the plan as new hazardous materials are brought on site or removed from the site. Reference this plan in the storm water pollution prevention plan, as applicable.

1.2.3.15. A waste water management plan that identifies the methods and procedures for management and/or discharge of waste waters which are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of ground water, disinfection water, hydrostatic test water, and water used in flushing of lines. If a settling/retention pond is required, include the design of the pond including drawings, removal plan, and testing requirements for possible pollutants. If land application will be the method of disposal for the waste water, include a sketch showing the location for land application along with a description of the pretreatment methods to be implemented and any required permits. If surface discharge will be the method of disposal, include a copy of the permit and associated documents as an attachment prior to discharging the waste water. If disposal is to a sanitary sewer, include documentation that the waste water treatment plant Operator has approved the flow rate, volume, and type of discharge.

1.2.3.16. A historical, archaeological, cultural resources biological resources and wetlands plan that defines procedures for identifying and protecting historical, archaeological, cultural resources, biological resources and wetlands known to be on the project site: and/or identifies procedures to be followed if historical archaeological, cultural resources, biological resources and wetlands not previously known to be onsite or in the area are discovered during construction. Include methods to assure the protection of known or discovered resources and shall identify lines of communication between Contractor personnel and the Government.

1.2.3.17. A pesticide treatment plan, updated, as information becomes available. Include: sequence of treatment, dates, times, locations, pesticide trade name, EPA registration numbers, authorized uses, chemical composition, formulation, original and applied concentration, application rates of active ingredient (i.e. pounds of active ingredient applied), equipment used for application and calibration of equipment. The Contractor is responsible for Federal, State, Regional and Local pest management record keeping and reporting requirements as well as any additional Installation specific requirements. Follow AR 200-1, Chapter 5, Pest Management, Section 5-4, “Program Requirements” for data required to be reported to the Installation.

1.3. PROTECTION FEATURES

This paragraph supplements the Contract Clause PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES AND IMPROVEMENTS. Prior to start of any onsite construction activities, the Contractor and the Government shall make a joint condition survey. Immediately following the survey, the Contractor shall prepare a brief report including a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the Contractor's assigned storage area and access route(s), as applicable. Both the Contractor and the Government will sign this survey, upon mutual agreement as to its accuracy and completeness. The Contractor develop a plan that depicts how it will protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference which their preservation may cause to the Contractor's work under the contract.

1.4. ENVIRONMENTAL ASSESSMENT OF CONTRACT DEVIATIONS

Any deviations, requested by the Contractor, from the drawings, plans and specifications which may have an environmental impact will be subject to approval by the Government and may require an extended review, processing, and approval time. The Government reserves the right to disapprove alternate methods, even if they are more cost effective, if the Government determines that the proposed alternate method will have an adverse environmental impact.

1.5. NOTIFICATION

The Government will notify the Contractor in writing of any observed noncompliance with Federal, State or local environmental laws or regulations, permits, and other elements of the Contractor's Environmental Protection plan. The Contractor shall, after receipt of such notice, inform the Government of the proposed corrective action and take such action when approved by the Government. The Government may issue an order stopping all or part of the

work until satisfactory corrective action has been taken. No time extensions shall be granted or equitable adjustments allowed to the Contractor for any such suspensions. This is in addition to any other actions the Government may take under the contract, or in accordance with the Federal Acquisition Regulation or Federal Law.

2.0 PRODUCTS (NOT USED)

3.0 EXECUTION

3.1. LAND RESOURCES

Confine all activities to areas defined by the drawings and specifications. Prior to the beginning of any construction, identify any land resources to be preserved within the work area. Except in areas indicated on the drawings or specified to be cleared, do not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without approval. Do not attach or fasten any ropes, cables, or guys to any trees for anchorage unless specifically authorized. Provide effective protection for land and vegetation resources at all times as defined in the following subparagraphs. Remove all stone, soil, or other materials displaced into uncleared areas..

3.1.1. Work Area Limits

Prior to commencing construction activities, mark the areas that need not be disturbed under this contract. Mark or fence isolated areas within the general work area which are not to be disturbed. Protect monuments and markers before construction operations commence. Where construction operations are to be conducted during darkness, any markers shall be visible in the dark. Personnel shall be knowledgeable of the purpose for marking and/or protecting particular objects.

3.1.2. Landscape

Clearly identify trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved by marking, fencing, or wrapping with boards, or any other approved techniques. Restore landscape features damaged or destroyed during construction operations outside the limits of the approved work area.

3.1.3. Erosion and Sediment Controls

Provide erosion and sediment control measures in accordance with Federal, State, and local laws and regulations. Coordinate with approving authorities (federal, state, etc.) for specific requirements to be included in the plan. The erosion and sediment controls selected and maintained by the Contractor shall be such that water quality standards are not violated as a result of the Contractor's construction activities. Keep the area of bare soil exposed at any one time by construction operations to a minimum necessary. Construct or install temporary and permanent erosion and sediment control best management practices (BMPs). BMPs may include, but not be limited to, vegetation cover, stream bank stabilization, slope stabilization, silt fences, construction of terraces, interceptor channels, sediment traps, inlet and outfall protection, diversion channels, and sedimentation basins. Remove any temporary measures after the area has been stabilized.

3.1.4. Contractor Facilities and Work Areas

Place field offices, staging areas, stockpile storage, and temporary buildings in areas designated on the drawings or as directed by the Government. Make only approved temporary movement or relocation of Contractor facilities. Provide erosion and sediment controls for on-site borrow and spoil areas to prevent sediment from entering nearby waters. Control temporary excavation and embankments for plant and/or work areas to protect adjacent areas.

3.2. WATER RESOURCES

Monitor construction activities to prevent pollution of surface and ground waters. Do not apply toxic or hazardous chemicals to soil or vegetation unless otherwise indicated. Monitor all water areas affected by construction activities. For construction activities immediately adjacent to impaired surface waters, the Contractor shall be capable of quantifying sediment or pollutant loading to that surface water when required by state or federally issued Clean Water Act permits.

3.2.1. Stream Crossings

Stream crossings shall allow movement of materials or equipment without violating water pollution control standards of the Federal, State, and local governments or impede state-designated flows.

3.2.2. Wetlands

Do not enter, disturb, destroy, or allow discharge of contaminants into any wetlands.

3.3. AIR RESOURCES

Comply with all Federal and State air emission and performance laws and standards for equipment operation, activities, or processes.

3.3.1. Particulates

Control dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials, such as from asphaltic batch plants, including weekends, holidays and hours when work is not in progress. Maintain excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and other work areas within or outside the project boundaries free from particulates which would cause the Federal, State, and local air pollution standards to be exceeded or which would cause a hazard or a nuisance. Sprinkling, chemical treatment of an approved type, baghouse, scrubbers, electrostatic precipitators or other methods are permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated to keep the disturbed area damp at all times. Provide sufficient, competent equipment available to accomplish these tasks. Perform particulate control as the work proceeds and whenever a particulate nuisance or hazard occurs. Comply with all State and local visibility regulations.

3.3.2. Odors

Control odors from construction activities at all times. Odors shall not cause a health hazard and shall be in compliance with State regulations and/or local ordinances.

3.3.3. Sound Intrusions

Keep construction activities under surveillance and control to minimize environment damage by noise. Comply with the provisions of the state and Installation rules.

3.3.4. Burning

Burning is not allowed on the project site unless specified in other sections of the specifications or by written authorization. Specific times, locations, and manners of burning shall be subject to approval.

3.4. CHEMICAL MATERIALS MANAGEMENT AND WASTE DISPOSAL

Disposal of wastes shall be as directed below, unless otherwise specified in other sections and/or shown on the drawings.

3.4.1. Solid Wastes

Place solid wastes (excluding clearing debris) in containers which are emptied on a regular schedule. Conduct handling, storage, and disposal to prevent contamination. Employ segregation measures so that no hazardous or toxic waste will become co-mingled with solid waste. Transport solid waste off Government property and dispose of it in compliance with Federal, State, and local requirements for solid waste disposal. The minimum acceptable off-site solid waste disposal option is a Subtitle D RCRA permitted landfill. Verify that the selected transporters and disposal facilities have the necessary permits and licenses to operate. Comply with Federal, State, and local laws and regulations pertaining to the use of landfill areas.

3.4.2. Chemicals and Chemical Wastes

Dispense chemicals, ensuring no spillage to the ground or water. Perform and document periodic inspections of dispensing areas to identify leakage and initiate corrective action. The Government may periodically review this documentation. Collect chemical waste in corrosion resistant, compatible containers. Monitor and remove collection drums to a staging or storage area when contents are within 6 inches of the top. Classify, manage, store, and dispose of wastes in accordance with Federal, State, and local laws and regulations.

3.4.3. Contractor Generated Hazardous Wastes/Excess Hazardous Materials

Hazardous wastes are defined in 40 CFR 261, or are as defined by applicable state and local regulations. Hazardous materials are defined in 49 CFR 171 - 178. At a minimum, manage and store hazardous waste in compliance with 40 CFR 262. Take sufficient measures to prevent spillage of hazardous and toxic materials during dispensing. Segregate hazardous waste from other materials and wastes; protect it from the weather by placing it in a safe covered location and take precautionary measures, such as berming or other appropriate measures, against accidental spillage. Store, describe, package, label, mark, and placard hazardous waste and hazardous material in accordance with 49 CFR 171 - 178, state, and local laws and regulations. Transport Contractor generated hazardous waste off Government property in accordance with the Environmental Protection Agency and the Department of Transportation laws and regulations. Dispose of hazardous waste in compliance with Federal, State and local laws and regulations. Immediately report spills of hazardous or toxic materials to the Government and the Facility Environmental Office. Contractor will be responsible for cleanup and cleanup costs due to spills. Contractor is responsible for the disposition of Contractor generated hazardous waste and excess hazardous materials.

3.4.4. Fuel and Lubricants

Conduct storage, fueling and lubrication of equipment and motor vehicles in a manner that affords the maximum protection against spill and evaporation. Manage and store fuel, lubricants and oil in accordance with all Federal, State, Regional, and local laws and regulations.

3.5. RECYCLING AND WASTE MINIMIZATION

Participate in State and local government sponsored recycling programs. The Contractor is further encouraged to minimize solid waste generation throughout the duration of the project. Line and berm fueling areas and establish storm water control structures at discharge points for site run-off. Keep a liquid containment clean-up kit available at the fueling area.

3.6. HISTORICAL, ARCHAEOLOGICAL, AND CULTURAL RESOURCES

Existing historical, archaeological, and cultural resources within the Contractor's work area are shown on the drawings. Protect and preserve these resources during the life of the Contract. Temporarily suspend all activities that may damage or alter such resources, if any previously unidentified or unanticipated historical, archaeological, and cultural resources are discovered or found during excavation or other construction activities. Resources covered by this paragraph include but are not limited to: any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; rock or coral alignments, pavings, wall, or other constructed features; and any indication of agricultural or other human activities. Upon such discovery or find, notify the Government so that the appropriate authorities may be notified and a determination made as to their significance and what, if any, special disposition of the finds should be made. Cease all activities that may result in impact to or the destruction of these resources. Secure the area and prevent employees or other persons from trespassing on, removing, or otherwise disturbing such resources.

3.7. BIOLOGICAL RESOURCES

Minimize interference with, disturbance to, and damage to fish, wildlife, and plants, including their habitat. Protect threatened and endangered animal and plant species including their habitat in accordance with Federal, State, Regional, and local laws and regulations.

3.8. INTEGRATED PEST MANAGEMENT

Coordinate, through the Government, with the Installation Pest Management Coordinator (IPMC) at the earliest possible time prior to pesticide application, in order to minimize impacts to existing fauna and flora. Discuss

integrated pest management strategies with the IPMC and receive concurrence from the IPMC, through the COR, prior to the application of any pesticide associated with these specifications. Give IMPC personnel the opportunity to be present at all meetings concerning treatment measures for pest or disease control and during application of the pesticide. The use and management of pesticides are regulated under 40 CFR 152 - 186.

3.8.1. Pesticide Delivery and Storage

Deliver pesticides, approved for use on the Installation, to the site in the original, unopened containers bearing legible labels indicating the EPA registration number and the manufacturer's registered uses.

3.8.2. Qualifications

Use the services of a subcontractor for pesticide application whose principal business is pest control. The subcontractor shall be licensed and certified in the state where the work is to be performed.

3.8.3. Pesticide Handling Requirements

Formulate, treat with, and dispose of pesticides and associated containers in accordance with label directions.

3.8.4. Application

A state certified pesticide applicator shall apply pesticides in accordance with EPA label restrictions and recommendations.

3.9. PREVIOUSLY USED EQUIPMENT

Clean all previously used construction equipment prior to bringing it onto the project site. Ensure that the equipment is free from soil residuals, egg deposits from plant pests, noxious weeds, and plant seeds. Consult with the USDA jurisdictional office for additional cleaning requirements.

3.10. MILITARY MUNITIONS

Immediately stop work in that area and immediately inform the Government, in the event military munitions, as defined in 40 CFR 260, are discovered or uncovered.

3.11. TRAINING OF CONTRACTOR PERSONNEL

Train personnel in all phases of environmental protection and pollution control. Conduct environmental protection/pollution control meetings for all Contractor personnel prior to commencing construction activities. Conduct additional meetings for new personnel and when site conditions change. The training and meeting agenda shall include methods of detecting and avoiding pollution; familiarization with statutory and contractual pollution standards; installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental protection/pollution control; anticipated hazardous or toxic chemicals or wastes, and other regulated contaminants; recognition and protection of archaeological sites, artifacts, wetlands, and endangered species and their habitat that are known to be in the area.

3.12. POST CONSTRUCTION CLEANUP

Clean up all areas used for construction in accordance with Contract Clause: "Cleaning Up". Unless otherwise instructed in writing , obliterate all signs of temporary construction facilities such as haul roads, work area, structures, foundations of temporary structures, stockpiles of excess or waste materials, and other vestiges of construction prior to final acceptance of the work. Grade, fill and seed the entire disturbed area, unless otherwise indicated.

SECTION 01 62 35
RECYCLED/RECOVERED MATERIAL

1.0 GENERAL

1.1. REFERENCES

1.2. OBJECTIVES

1.3. EPA DESIGNATED ITEMS INCORPORATED IN THE WORK

1.4. EPA PROPOSED ITEMS INCORPORATED IN THE WORK

1.5. EPA LISTED ITEMS USED IN CONDUCT OF THE WORK BUT NOT INCORPORATED IN THE WORK

1.0 GENERAL

1.1. REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

- U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)
- 40 CFR 247 Comprehensive Procurement Guideline for Products Containing Recovered Materials

1.2. OBJECTIVES

Government procurement policy is to acquire, in a cost effective manner, items containing the highest percentage of recycled and recovered materials practicable consistent with maintaining a satisfactory level of competition without adversely affecting performance requirements or exposing suppliers' employees to undue hazards from the recovered materials. The Environmental Protection Agency (EPA) has designated certain items which must contain a specified percent range of recovered or recycled materials. The Contractor shall make all reasonable efforts to use recycled and recovered materials in providing the EPA designated products and in otherwise utilizing recycled and recovered materials in the execution of the work.

1.3. EPA DESIGNATED ITEMS INCORPORATED IN THE WORK

Materials that have been designated by EPA as being products which are or can be made with recovered or recycled materials, when incorporated into the work under this contract, shall contain at least the minimum percentage of recycled or recovered materials indicated by EPA unless adequate justification (non-availability) for non-use is provided. When a designated item is specified as an option to a non-designated item, the designated item requirements apply only if the designated item is used in the work.

1.4. EPA PROPOSED ITEMS INCORPORATED IN THE WORK

Products other than those designated by EPA are still being researched and are being considered for future Comprehensive Procurement Guideline (CPG) designation. It is recommended that these items, when incorporated in the work under this contract, contain the highest practicable percentage of recycled or recovered materials, provided specified requirements are also met.

1.5. EPA LISTED ITEMS USED IN CONDUCT OF THE WORK BUT NOT INCORPORATED IN THE WORK

There are many products listed in 40 CFR 247 which have been designated or proposed by EPA to include recycled or recovered materials that may be use by the Contractor in performing the work but will not be incorporated into the work. These products include office products, temporary traffic control products, and pallets. It is recommended that these non-construction products, when used in the conduct of the work, contain the highest practicable percentage of recycled or recovered materials and that these products be recycled when no longer needed.

End of Section 01 62 35

SECTION 01 78 02.00 10
CLOSEOUT SUBMITTALS

1.0 OVERVIEW

1.1. SUBMITTALS

1.2. PROJECT RECORD DOCUMENTS

1.3. EQUIPMENT DATA

1.4. CONSTRUCTION WARRANTY MANAGEMENT

1.5. MECHANICAL TESTING, ADJUSTING, BALANCING, AND COMMISSIONING

1.6. OPERATION AND MAINTENANCE MANUALS

1.7. FIELD TRAINING

1.8. PRICING OF CONTRACTOR-FURNISHED AND INSTALLED PROPERTY AND GOVERNMENT-FURNISHED CONTRACTOR-INSTALLED PROPERTY

1.9. LEED REVIEW MEETINGS

1.10. RED ZONE MEETING

1.11. FINAL CLEANING

1.12. INTERIM FORM DD1354 "TRANSFER AND ACCEPTANCE OF MILITARY REAL PROPERTY

EXHIBIT 1 SAMPLE RED ZONE MEETING CHECKLIST

1.0 OVERVIEW

1.1. SUBMITTALS

Government approval is required for any submittals with a "G" designation; submittals not having a "G" designation are for Designer of Record approval or for information only. Submit the following in accordance with Section 01 33 00 submittals*:*

SD-02 Shop Drawings

– As-Built Drawings - G

▪ Drawings showing final as-built conditions of the project. Provide electronic drawing files as specified in Section 01 33 16, 3 sets of blue-line prints and one set of the approved working as-built drawings.

SD-03 Product Data

– As-Built Record of Equipment and Materials

▪ Two copies of the record listing the as-built materials and equipment incorporated into the construction of the project.

– Construction Warranty Management Plan

▪ Three sets of the construction warranty management plan containing information relevant to the warranty of materials and equipment incorporated into the construction project, including the starting date of warranty of construction. Furnish with each warranty the name, address, and telephone number of each of the guarantor's representatives nearest to the project location.

– Warranty Tags

▪ Two record copies of the warranty tags showing the layout and design.

– Final Cleaning

▪ Two copies of the listing of completed final clean-up items.

1.2. PROJECT RECORD DOCUMENTS

1.2.1. As-Built Drawings – G

An as-built drawing is a construction drawing revised to reflect the final as-built conditions of the project as a result of modifications and corrections to the project design required during construction. The final as-built drawings shall not have the appearance of marked up drawings, but that of professionally prepared drawings as if they were the "as designed" drawings.

1.2.2. Maintenance of As-Built Drawings

1.2.2.1. The Configuration Management Plan shall describe how the Contractor will maintain up-to-date drawings, how it will control and designate revisions to the drawings and specifications (In accordance with Special Contract Requirement: ***Deviating from the Accepted Design*** and Section 01 33 16: ***Design after Award***, the Designer of Record's approval is necessary for any revisions to the accepted design).

1.2.2.2. Make timely updates, carefully maintaining a record set of working as-built drawings at the job site, marked in red, of all changes and corrections from the construction drawings. Enter changes and corrections on drawings promptly to reflect "Current Construction". Perform this update no less frequently than weekly for the blue line drawings and update no less frequently than quarterly for the CADD/CAD and BIM files, which were prepared previously in accordance with Section 01 33 16. Include a confirmation that the as-builts are up to date with the submission of the monthly project schedule.

1.2.2.3. If the DB Contractor fails to maintain the as-built drawings as required herein, the Government will retain from the monthly progress payment, an amount representing the estimated monthly cost of maintaining the as-built drawings. Final payment with respect to separately priced facilities or the contract as a whole will be withheld until the Contractor submits acceptable as-built drawings and the Government approves them.

1.2.2.4. The marked-up set of drawings shall reflect any changes, alterations, adjustments or modifications. Changes must be reflected on all sheets affected by the change. Changes shall include marking the drawings to reflect structural details, foundation layouts, equipment sizes, and other extensions of design.

1.2.2.5. Typically, room numbers shown on the drawings are selected for design convenience and do not represent the actual numbers intended for use by the end user. Final as-built drawings shall reflect actual room numbers adopted by the end user.

1.2.2.6. If there is no separate contract line item (CLIN) for as-built drawings, the Government will withhold the amount of $35,000, or 1% of the present construction value, whichever is the greater, until the final as-built drawing submittal has been approved by the Government.

1.2.3. Underground Utilities

The drawings shall indicate, in addition to all changes and corrections, the actual location, kinds and sizes of all sub-surface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, the as-built drawings shall show, by offset dimensions to two permanently fixed surface features, the end of each run including each change in direction. Locate Valves, splice boxes and similar appurtenances by dimensioning along the utility run from a reference point. Record average elevation of the top of each run or underground structure..

1.2.4. Partial Occupancy

For projects where portions of construction are to be occupied or activated before overall project completion, including portions of utility systems, supply as-built drawings for those portions of the facility being occupied or activated at the time the facility is occupied or activated. Show this same as-built information previously furnished on the final set of as-built drawings.

1.2.5. As-Built Conditions That are Different From the construction Drawings

Accurately reflect all as-built conditions that are different, such as dimensions, road alignments and grades, and drainage and elevations, from the construction drawings on each drawing. If the as-built condition is accurately reflected on a shop drawing, then furnish that shop drawing in CADD format. Reference the final as-built construction drawing the shop drawing file that includes the as-built information. In turn, the shop drawing shall reference the applicable construction as-built drawing. Delete any options shown on drawings and not selected clearly reflect options selected on final as-built drawings.

1.2.6. Additional As-Built Information that Exceeds the Detail Shown on the construction Drawings:

These as-built conditions include those that reflect structural details, foundation layouts, equipment, sizes, mechanical and electrical room layouts and other extensions of design, that were not shown in the project design documents because the exact details were not known until after the time of approved shop drawings. It is recognized that these shop drawing submittals (revised showing as-built conditions) will serve as the as-built record without actual incorporation into the construction drawings, piping, and equipment drawings. Include locations of all explorations, logs of all explorations, and results of all laboratory testing, including those provided by the Government. Furnish all such shop drawings in CADD /CADformat. Include fire protection details, such as wiring, performed for the design of the project.

1.2.7. Final As-Built Drawings

Submit final as-built CADD/CAD and BIM Model(s) and Facility Data files at the time of Beneficial Occupancy of the project or at a designated phase of the project. In the event the Contractor accomplishes additional work after this submittal, which changes the as-built conditions, submit a new DVD with all drawing sheets and three blue-line copies of affected sheets which depict additional changes.

1.2.8. Title Blocks

In accordance with the configuration management plan, clearly mark title blocks to indicate final as-built drawings.

1.2.9. Other As-Built Documents

Provide scans of all other documents such as design analysis, catalog cuts, certification documents that are not available in native electronic format in an organized manner in Adobe.pdf format.

1.2.9.1. LEED Documentation

Update LEED documentation on at least a monthly basis and have it available for review by the Government on the jobsite at all times during construction. Submit the final LEED Project Checklist(s), final LEED submittals checklist and complete project documentation, verifying the final LEED score and establishing the final rating. Provide full support to the validation review process, including credit audits. See also the LEED documentation requirements in Section 01 33 16, DESIGN AFTER AWARD.

1.2.9.2. GIS Documentation

Provide final geo-referenced GIS database of the new building footprint along with any changes made to exterior of the building. The intent of capturing the final building footprint and exterior modifications in a GIS database is to provide the installation with a data set of the comprehensive changes made to the landscape as a result of the construction project. The Government will incorporate this data set into the installations existing GIS MasterPlan or Enterprise GIS system. The GIS database deliverable shall follow a standard template provided to the Contractor by the Government, adhere to detailed specifications outlined in ECB No 2006-15, and be documented using the Federal Geographic Data Committee (FGDC) metadata standard.

1.3. EQUIPMENT DATA

1.3.1. Real Property Equipment

Provide an Equipment-in-Place list of all installed equipment furnished under this contract. Include all information usually listed on manufacturer's name plate. Include the cost of each piece of installed property F.O.B. construction site. For each of the items which is specified herein to be guaranteed for a specified period from the date of acceptance thereof, provide the following information: The name, serial and model number address of equipment supplier, or manufacturer originating the guaranteed item. The Contractor's guarantee to the Government of these items will not be limited by the terms of any manufacturer's guarantee to the Contractor. Furnish the list as one (1) reproducible and three (3) copies thirty (30) calendar days before completion of any segment of the contract work which has an incremental completion date.

1.3.2. Maintenance and Parts Data

Furnish a brochure, catalog cut, parts list, manufacturer's data sheet or other publication showing detailed parts data on all other equipment subject to repair and maintenance procedures not otherwise required in Operations and Maintenance Manuals specified elsewhere in this contract. Distribution of directives shall follow the same requirements as listed in paragraph above.

1.3.3. Construction Specifications

Furnish permanent electronic files of final as-built construction specifications, including modifications thereto, with the as-built drawings.

1.4. CONSTRUCTION WARRANTY MANAGEMENT

1.4.1. Prior to the end of the one year warranty, the Government may conduct an infrared roof survey on any project involving a membrane roofing system. This survey will be conducted in accordance with ASTM C1153-90, "Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging". The Contractor shall replace all damaged materials and locate and repair sources of moisture penetration.

1.4.2. Management

1.4.2.1. Warranty Management Plan

Develop a warranty management plan containing information relevant to the clause ***Warranty of Construction*** in FAR 52.246-21. Submit the warranty management plan for Government approval at least 30 days before the planned pre-warranty conference. In the event of phased turn-over of the contract, update the Warranty Management Plan as necessary to include latest information required. Include all required actions and documents to assure that the Government receives all warranties to which it is entitled. The plan shall be in narrative form and contain sufficient detail to render it suitable for use by future maintenance and repair personnel, whether tradesmen, or of engineering background, not necessarily familiar with this contract. The term "status" as indicated below shall include due date and whether item has been submitted or was accomplished. Submit warranty information made available during the construction phase prior to each monthly pay estimate. Assemble information in a binder and turn over to the Government upon acceptance of the work. The construction warranty period shall begin on the date of project acceptance and shall continue for the full product warranty period. The Contractor, Government, including the Customer Representative shall jointly conduct warranty inspections, 4 months and 9 months, after acceptance. The warranty management plan shall include, but shall not be limited to, the following information:

(1) Roles and responsibilities of all personnel associated with the warranty process, including points of contact and telephone numbers within the organizations of the contractors, subcontractors, manufacturers or suppliers involved.

(2) Listing and status of delivery of all Certificates of Warranty for extended warranty items, to include roofs, HVAC balancing, pumps, motors, transformers, and for all commissioned systems such as fire protection and alarm systems, sprinkler systems, lightning protection systems, etc.

(3) A list for each warranted equipment, item, feature of construction or system indicating:

(i) Name of item.

(ii) Model and serial numbers.

(iii) Location where installed.

(iv) Name and phone numbers of manufacturers or suppliers.

(v) Names, addresses and telephone numbers of sources of spare parts.

(vi) Warranties and terms of warranty. Include one-year overall warranty of construction. Indicate those items, which have extended warranties with separate warranty expiration dates.

(vii) Cross-reference to warranty certificates as applicable.

(viii) Starting point and duration of warranty period.

(ix) Summary of maintenance procedures required to continue the warranty in force.

(x) Cross-reference to specific pertinent Operation and Maintenance manuals.

(xi) Organization, names and phone numbers of persons to call for warranty service.

(xii) Typical response time and repair time expected for various warranted equipment.

(4) The Contractor's plans for attendance at the 4 and 9 month post-construction warranty inspections conducted by the Government.

(5) Procedure and status of tagging of all equipment covered by extended warranties.

(6) Copies of instructions to be posted near selected pieces of equipment where operation is critical for warranty and/or safety reasons.

1.4.3. Performance Bond

1.4.3.1. The Contractor's Performance Bond will remain effective throughout the construction warranty period.

1.4.3.2. In the event the Contractor or his designated representative(s) fails to commence and diligently pursue any work required under this clause, and in a manner pursuant to the requirements thereof, the Government shall have

a right to demand that said work be performed under the Performance Bond by making written notice on the surety. If the surety fails or refuses to perform the obligation it assumed under the Performance Bond, the Government shall have the work performed by others, and after completion of the work, may make demand for reimbursement of any or all expenses incurred by the Government while performing the work, including, but not limited to administrative expenses.

1.4.3.3. In the event sufficient funds are not available to cover the construction warranty work performed by the Government at the Contractor's expense, the Government will have the right to recoup expenses from the bonding company.

1.4.3.4. Following oral or written notification of required warranty repair work, the Contractor will respond as dictated by para. 1.4.5. Written verification will follow oral instructions. Failure of the Contractor to respond will be cause for the Government to proceed against the Contractor as outlined in the paragraph 1.4.5.5 and/or above.

1.4.4. Pre-Warranty Conference

Prior to contract completion, or completion of any phase or portion of contract to be turned over, and at a time designated by the Contracting Officer, the Contractor shall meet with the Government to develop a mutual understanding with respect to the requirements of this clause. Communication procedures for Contractor notification of warranty defects, priorities with respect to the type of defect, reasonable time required for Contractor response, and other details deemed necessary by the Government for the execution of the construction warranty shall be established/reviewed at this meeting. In connection with these requirements and at the time of the Contractor's quality control completion inspection, the Contractor will furnish the name, telephone number and address of a licensed and bonded company which is authorized to initiate and pursue warranty work action on behalf of the Contractor. This point of contact will be located within the local service area of the warrantied construction, will be continuously available, and will be responsive to Government inquiry on warranty work action and status. This requirement does not relieve the Contractor of any of his responsibilities in connection with other portions of this provision.

1.4.5. Contractor's Response to Warranty Service Requirements.

Following Government oral or written notification, which may include authorized installation maintenance personnel, the Contractor shall respond to warranty service requirements in accordance with the "Warranty Service Priority List" and the three categories of priorities listed below. Submit a report on any warranty item that has been repaired during the warranty period. The report shall include the cause of the problem, date reported, corrective action taken, and when the repair was completed. If the Contractor does not perform the construction warranty within the timeframe specified, the Government will perform the work and backcharge the construction warranty payment item established.

1.4.5.1. First Priority Code 1 Perform onsite inspection to evaluate situation, and determine course of action within 4 hours, initiate work within 6 hours and work continuously to completion or relief.

1.4.5.2. Second Priority Code 2 Perform onsite inspection to evaluate situation, and determine course of action within 8 hours, initiate work within 24 hours and work continuously to completion or relief.

1.4.5.3. Third Priority Code 3 All other work to be initiated within 3 work days and work continuously to completion or relief.

1.4.5.4. The "Warranty Service Priority List" is as follows:

- Code 1 - Air Conditioning System

(a) Buildings with computer equipment.

(b) Barracks, mess halls (entire building down).

- Code 2 - Air Conditioning Systems

(a) Recreational support.

(b) Air conditioning leak in part of building, if causing damage.

(c) Air conditioning system not cooling properly

(d) Admin buildings with Automated Data Processing (ADP) equipment not on priority list.

- Code 1 - Doors

(a) Overhead doors not operational.

- Code 1 - Electrical

(a) Power failure (entire area or any building operational after 1600 hours).

(b) Traffic control devices.

(c) Security lights.

(d) Smoke detectors and fire alarm systems

(e) Power or lighting failure to an area, facility, portion of a facility, which may adversely impact health, safety, security, or the installation's mission requirement, or which may result in damage to property.

- Code 2 - Electrical

(a) Power failure (no power) for unoccupied buildings or portions thereof or branch circuits within occupied buildings, not listed as Code 1.

(a) Receptacle and lights, not listed as code 1.

- Code 3 - Electrical

(a) Street, parking area lights

- Code 1 - Gas

(a) Leaks and breaks.

(b) No gas to cantonment area.

- Code 1 - Heat

(a) Area power failure affecting heat.

(b) Heater in unit not working.

- Code 2 Heat

(a) All heating system failures not listed as Code 1.

- Code 3 - Interior

(a) Floor damage

(b) Paint chipping or peeling

- Code 1 - Intrusion Detection Systems - N/A.
- Code 2 - Intrusion Detection Systems other than those listed under Code 1
- Code 1 - Kitchen Equipment

(a) Dishwasher.

(b) All other equipment hampering preparation of a meal.

- Code 2 - Kitchen Equipment

(a) All other equipment not listed under Code 1.

- Code 2 - Plumbing

(a) Flush valves not operating properly

(b) Fixture drain, supply line commode, or water pipe leaking.

(c) Commode leaking at base.

- Code 3 - Plumbing

(a) Leaking faucets

- Code 1 - Refrigeration

(a) Mess Hall.

(b) Medical storage.

- Code 2 - Refrigeration

(a) Mess hall - other than walk-in refrigerators and freezers.

- Code 1 - Roof Leaks

(a) Temporary repairs will be made where major damage to property is occurring.

- Code 2 - Roof Leaks

(a) Where major damage to property is not occurring, check for location of leak during rain and complete repairs on a Code 2 basis.

- Code 1 - Sprinkler System

(a) All sprinkler systems, valves, manholes, deluge systems, and air systems to sprinklers.

- Code 1 - Tank Wash Racks (Bird Baths)

(a) All systems which prevent tank wash.

- Code 1 - Water (Exterior)

(a) Normal operation of water pump station.

- Code 2 - Water (Exterior)

(a) No water to facility.

- Code 1 - Water, Hot (and Steam)

(a) Barracks (entire building).

- Code 2 - Water, Hot

(a) No hot water in portion of building listed under Code 1

1.4.5.5. Should parts be required to complete the work and the parts are not immediately available, the Contractor shall have a maximum of 12 hours after arrival at the job site to provide the Government, with firm written proposals for emergency alternatives and temporary repairs for Government participation with the Contractor to provide emergency relief until the required parts are available on site for the Contractor to perform permanent warranty repair. The Contractors proposals shall include a firm date and time that the required parts shall be available on site to complete the permanent warranty repair. The Government will evaluate the proposed alternatives and negotiate the alternative considered to be in the best interest of the Government to reduce the impact of the emergency condition. Alternatives considered by the Government will include the alternative for the Contractor to "Do Nothing" while waiting until the required parts are available to perform permanent warranty repair. Negotiating a proposal which will require Government participation and the expenditure of Government funds shall constitute a separate procurement action by the using service.

1.4.6. Equipment Warranty Identification Tags

1.4.6.1. Provide warranty identification tags at the time of installation and prior to substantial completion shall provide warranty identification tags on all Contractor and Government furnished equipment which the Contractor has installed.

(a) The tags shall be suitable for interior and exterior locations, resistant to solvents, abrasion, and to fading caused by sunlight, precipitation, etc. These tags shall have a permanent pressure-sensitive adhesive back, and they shall be installed in a position that is easily (or most easily) noticeable. Tag each component of contractor furnished equipment that has differing warranties on its components.

(b) Submit sample tags, representing how the other tags will look, for Government review and approval.

(c) Tags for Warrantied Equipment: The tag for this equipment shall be similar to the following: Exact format and size will be as approved.

EQUIPMENT WARRANTY - CONTRACTOR FURNISHED EQUIPMENT

MFG NAME MODEL NO.

SERIAL NO.

CONTRACT NO.

CONTRACTOR NAME

CONTRACTOR WARRANTY EXPIRES

MFG WARRANTY(IES) EXPIRE

EQUIPMENT WARRANTY - GOVERNMENT FURNISHED EQUIPMENT

MFG NAME MODEL NO.

SERIAL NO.

CONTRACT NO.

DATE EQUIP PLACED IN SERVICE

MFG WARRANTY(IES) EXPIRE

(d) If the manufacturer's name (MFG), model number and serial number are on the manufacturer's equipment data plate and this data plate is easily found and fully legible, this information need not be duplicated on the equipment warranty tag

1.4.6.2. Execution: Complete the required information on each tag and install these tags on the equipment by the time of and as a condition of final acceptance of the equipment.

1.5. MECHANICAL TESTING, ADJUSTING, BALANCING, AND COMMISSIONING

Submit; all reports, statements, certificates, and completed checklists for testing, adjusting, balancing, and commissioning of mechanical systems prior to final inspection and transfer of the completed facility for approval, as specified in applicable technical specification sections.

1.6. OPERATION AND MAINTENANCE MANUALS

1.6.1. General Requirements

1.6.1.1. Inasmuch as the operations and maintenance manuals are required to operate and maintain the facility, the operations and maintenance (O&M) manuals will be considered a requirement prior to substantial completion of any facility to be turned over to the Government. Beneficial occupancy of all or portions of a facility prior to substantial completion will not relieve the Contractor of liquidated damages, if substantial completion exceeds the required completion date.

1.6.1.2. Provide one permanent electronic copy on CD-ROM and 2 hard copies of the Equipment Operating, Maintenance, and Repair Manuals. Provide separate manuals for each utility system as defined hereinafter. Submit Operations and Maintenance manuals for approval before field training or 90 days before substantial completion (whichever occurs earlier). If there is no separate CLIN for O&M Manuals, the Government will withhold an amount representing $20,000, as non-progressed work, until submittal and approval of all O&M manuals are complete.

1.6.2. Definitions

1.6.2.1. Equipment

A single piece of equipment operating alone or in conjunction with other equipment to accomplish a system function.

1.6.2.2. System

A combination of one or more pieces of equipment which function together to accomplish an intended purpose (i.e. HVAC system is composed of many individual pieces of equipment such as fans, motors, compressors, valves, sensors, relays, etc.)

1.6.3. Hard Cover Binders

The manuals shall be hard cover with posts, or 3-ring binders, so sheets may be easily substituted. Print the following identification on the cover: the words "EQUIPMENT OPERATING, MAINTENANCE, AND REPAIR MANUALS," the project name, building number, and an indication of utility or systems covered, the name of the Contractor, and the Contract number. Manuals shall be approximately 8-1/2 by 11-inches with large sheets folded in and capable of being easily pulled out for reference. All manuals for the project must be similar in appearance, and be of professional quality.

1.6.4. Warning Page

Provide a warning page to warn of potential dangers (if they exist, such as high voltage, toxic chemicals, flammable liquids, explosive materials, carcinogens, high pressures, etc.). Place the warning page inside the front cover and in front of the title page. Include any necessary Material Safety Data Sheets (MDSD) here.

1.6.5. Title Page

The title page shall include the same information shown on the cover and show the name of the preparing firm and the date of publication.

1.6.6. Table of Contents

Each volume of the set of manuals for this project shall include a table of contents, for the entire set, broken down by volume.

1.6.7. GENERAL

Organize manuals according to the following format, and include information for each item of equipment Submit a draft outline and table of contents for approval at 50% contract completion.

TABLE OF CONTENTS

PART I: Introduction

- Equipment Description
- Functional Description
- Installation Description

PART II: Operating Principles

PART III: Safety

PART IV: Preventive Maintenance

- Preventive Maintenance Checklist, Lubrication
- Charts and Diagrams

PART V: Spare Parts Lists

- Troubleshooting Guide
- Adjustments
- Common Repairs and Parts Replacement

PART VI: Illustrations

1.6.7.1. Part I-Introduction

Part I shall provide an introduction, equipment or system description, functional description and theory of operation, and installation instructions for each piece of equipment. Include complete instructions for uncrating, assembly, connection to the power source and pre-operating lubrication in the installation instructions as applicable. Illustrations, including wiring and cabling diagrams, are required as appropriate in this section. Include halftone pictures of the equipment in the introduction and equipment description, as well as system layout drawings with each item of equipment located and marked. Do not use copies of previously submitted shop drawings in these manuals.

1.6.7.2. Part II-Operating Principles

Part II shall provide complete instructions for operating the system, and each piece of equipment. Illustrations, halftone pictures, tables, charts, procedures, and diagrams are required when applicable. This will include step-by-step procedures for start-up and shutdown of both the system and each component piece of equipments, as well as adjustments required to obtain optimum equipment performance, and corrective actions for malfunctions. Show performance sheets and graphs showing capacity data, efficiencies, electrical characteristics, pressure drops, and flow rates here, also. Marked-up catalogs or catalog pages do not satisfy this requirement. Present performance information as concisely as possible with only data pertaining to equipment actually installed. Include actual test data collected for Contractor performance here.

1.6.7.3. Part III-Safety

Part III shall contain the general and specific safety requirements peculiar to each item of equipment. Repeat safety information as notes cautions and warnings in other sections where appropriate to operations described.

1.6.7.4. Part IV-Preventive Maintenance

Part IV shall contain a troubleshooting guide, including detailed instructions for all common adjustments and alignment procedures, including a detailed maintenance schedule. Also include a diagnostic chart showing symptoms and solutions to problems. Include test hookups to determine the cause, special tools and test equipment, and methods for returning the equipment to operating conditions. Information may be in chart form or in tabular format with appropriate headings. Include instructions for the removal, disassembly, repair, reassembly, and replacement of parts and assemblies where applicable and the task is not obvious.

1.6.7.5. Part V-Spare Parts List

Part V shall contain a tabulation of description data and parts location illustrations for all mechanical and electrical parts. The heading of the parts list shall clearly identify the supplier, purchase order number, and equipment. Include the unit price for each part. List parts by major assemblies, and arrange the listing in columnar form. Include names and addresses of the nearest manufacturer's representatives, as well as any special warranty information. Provide a list of spare parts that are recommended to be kept in stock by the Government installation.

1.6.7.6. Part VI-Illustrations

Part VI shall contain assembly drawings for the complete equipment or system and for all major components. Include complete wiring diagrams and schematics. Other illustrations, such as exploded views, block diagrams, and cutaway drawings, are required as appropriate.

1.6.8. Framed Instructions

Post framed instructions are required for substantial completion. Post framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, including equipment, ductwork, piping valves, dampers, and control sequence at a location near the equipment described. Prepare condensed operating instructions explaining preventive maintenance procedures methods of checking the system for normal safe operation, valve schedule and procedures for safely starting and stopping the system in type form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. Submit proposed diagrams, instructions, and other sheets prior to posting. Post the framed instructions before field training.

1.6.9. (Reserved. See 1.7 for Field Training)

1.6.10. System/Equipment Requirements

1.6.10.1. Facility Heating System

Provide information on the following equipment: boilers, water treatment, chemical feed pumps and tanks, converters, heat exchangers, pumps, unit heaters, fin-tube radiation, air handling units (both heating only and heating and cooling), and valves (associated with heating systems).

1.6.10.2. Air-Conditioning Systems

Provide information in chillers, packaged air-conditioning equipment, towers, water treatment, chemical feed pumps and tanks, air-cooled condensers, pumps, compressors, air handling units, and valves (associated with air-conditioning systems).

1.6.10.3. Temperature Control and HVAC Distribution Systems

Provide all information described for the following equipment: valves, fans, air handling units, pumps, boilers, converters and heat exchangers, chillers, water cooled condensers, cooling towers, and fin-tube radiation, control air compressors, control components (sensors, controllers, adapters and actuators), and flow measuring equipment.

1.6.10.4. Central Heating Plants

Provide the information described for the following equipment: boilers, converters, heat exchangers, pumps, fans, steam traps, pollution control equipment, chemical feed equipment, control systems, fuel handling equipment, de-aerators, tanks (flash, expansion, return waters, etc.), water softeners, and valves.

1.6.10.5. Heating Distribution Systems

Provide the information described for the following equipment: valves, fans, pumps, converters and heat exchangers, steam traps, tanks (expansion, flash, etc.), and piping systems.

1.6.10.6. Exterior Electrical Systems

Provide information on the following equipment: power transformers, relays, reclosers, breakers, and capacitor bank controls.

1.6.10.7. Interior Electrical Systems

Provide information on the following equipment: relays, motor control centers, switchgear, solid state circuit breakers, motor controller, EPS lighting systems, wiring diagrams and troubleshooting flow chart on control systems, and special grounding systems.

1.6.10.8. Energy Monitoring and Control Systems

The maintenance manual shall include descriptions of maintenance for all equipment, including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

1.6.10.9. Domestic Water Systems

Provide the identified information on the following equipment: tanks, unit process equipment, pumps, motors, control and monitoring instrumentation, laboratory test equipment, chemical feeders, valves, switching gear, and automatic controls.

1.6.10.10. Wastewater Treatment Systems

Provide the identified information on the following equipment: tanks, unit process equipment, pumps, motors, control and monitoring instrumentations, laboratory test equipment chemical feeders, valves, scrapers, skimmers, comminutors, blowers, switching gear, and automatic controls.

1.6.10.11. Fire Protection Systems

Provide information on the following equipment: alarm valves, manual valves, regulators, foam and gas storage tanks, piping materials, sprinkler heads, nozzles, pumps, and pump drivers.

1.6.10.12. Fire Alarm and Detection Systems

(1) The maintenance manual shall include description of maintenance for all equipment, including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

(2) Provide all software; database with complete identification of programmable portions of system equipment and devices, and all other system programming data on all modes of the system; connecting cables; and proprietary equipment necessary for the operation, maintenance, testing, repair and programming, etc. of the system and that may be required for implementation of future changes to the fire system (additional and/or relocated initiating devices, notification devices, etc.

(3) Provide all system and equipment technical data and computer software with the requisite rights to Government use, in accordance with the applicable contract clauses.

(4) Training shall include software and programming required for the effective operation, maintenance, testing, diagnostics and expansion of the system.

1.6.10.13. Plumbing Systems

Provide information on the following equipment: water heaters, valves, pressure regulators backflow preventors, piping materials, and plumbing fixtures.

1.6.10.14. Liquid Fuels Systems

Provide information on the following equipment: tanks, automatic valves manual valves, filter separators, pumps, mechanical loading arms, nozzles, meters, electronic controls, electrical switch gear, and fluidic controls.

1.6.10.15. Cathodic Protection Systems

Provide information on the following material and equipment: rectifiers, meters, anodes, anode backfill, anode lead wire, insulation material and wire size, automatic controls (if any), rheostats, switches, fuses and circuit breakers, type and size of rectifying elements, type of oil in oil-immersed rectifiers, and rating of shunts.

1.6.10.16. Generator Installations

Provide information on the following equipment: generator sets, automatic transfer panels, governors, exciters, regulators starting systems, switchgear, and protective devices.

1.6.10.17. Miscellaneous Systems

Provide information on the following: communication and ADP systems, security and intrusion alarm, elevators, material handling, active solar, photovoltaic, nurse call, paging, intercom, closed circuit TV, irrigation, sound and material delivery systems, kitchen, refrigeration, disposal, ice making equipment, and other similar type special systems not otherwise specified.

1.6.10.18. Laboratory, Environmental and Pollution Control Systems

Provide information on the following equipment: wet scrubbers, quench chambers, scrub tanks, liquid oil separators, and fume hoods.

1.7. FIELD TRAINING

Field Training is a requirement for substantial completion. Conduct a training course for the operating staff for each particular system. Conduct the training is to be conducted during hours of normal working time after the system is functionally complete. The field instructions shall cover all of the items contained in the Equipment Operating, Maintenance and Repair Manuals. The training will include both classroom and "hands-on" training. Submit a lesson plan outlining the information to be discussed during training periods. Submit this lesson plan for approval 90 days before contract completion before the field training occurs. Record training on DVD and furnish to the Government within ten (10) days following training. Document all training and furnish a list of all attendees.

1.8. PRICING OF CONTRACTOR-FURNISHED AND INSTALLED PROPERTY AND GOVERNMENT-FURNISHED CONTRACTOR-INSTALLED PROPERTY

Promptly furnish and require any sub-contractor or supplier to furnish, in like manner, unit prices and descriptive data required by the Government for Property Record purposes of fixtures and equipment furnished and/or installed by the Contractor or sub-contractor, except prices do not need to be provided for Government-Furnished Property.

1.9. LEED REVIEW MEETINGS

1.9.1. Pre-Closeout Meeting. Approximately 30 days before submittal of LEED closeout documentation, the Contractor and the Government's project delivery team (including Installation representative) will meet to review the documentation, determine which, if any, credits will be audited and identify any corrections/missing items prior to the closeout LEED documentation submittal.

1.9.2. Approximately 14 days after submittal of LEED closeout documentation, the Contractor and the Government's project delivery team (including Installation representative) will meet to review the LEED closeout

documentation. The review conference will include discussion of and resolution of all review comments to ensure consensus on achievement of credits and satisfactory documentation. At the review conference a final score will be determined and endorsed in writing by all parties.

1.10. RED ZONE MEETING

At approximately 80% of contract completion or 60 days before the anticipated Beneficial Occupancy Date (BOD), whichever occurs first, the Contractor and the Government's project delivery team will conduct what is known as the Red Zone Meeting to discuss the close-out process, to schedule the events and review responsibilities for actions necessary to produce a timely physical, as well as fiscal, project close-out. The Red Zone meeting derives its name from the football term used to describe the team effort to move the ball the last 20 yards into the end zone. The close-out of a construction project sometimes can be equally as hard and most definitely requires the whole team's efforts. The ACO will chair the meeting. If not already provided, shortly before the meeting, the Contractor shall provide an electronic copy or access to the CADD as-built drawings, completed commensurate with the amount of work completed at the time of the Red Zone Meeting, as an indicator of the Contractors' understanding of and ability to meet the USACE CADD Standards and to ensure that the Contractor is making progress with CADD As-Built requirements. EXHIBIT 1 is a generic meeting checklist.

1.11. FINAL CLEANING

Clean the premises in accordance with FAR clause 52.236-12 and additional requirements stated here. Remove stains, foreign substances, and temporary labels from surfaces. Vacuum carpet and soft surfaces. Clean equipment and fixtures to a sanitary condition. Clean or replace filters of operating equipment if cleaning isn't possible or practicable. Remove debris from roofs, drainage systems, gutters, and downspouts. Sweep paved areas and rake clean landscaped areas. Remove waste, surplus materials, and rubbish from the site. Remove all temporary structures, barricades, project signs, fences and construction facilities. Submit a list of completed clean-up items on the day of final inspection.

1.12. INTERIM FORM DD1354 "TRANSFER AND ACCEPTANCE OF MILITARY REAL PROPERTY

Near the completion of Project, but a minimum of 60 days prior to final acceptance of the work, complete, update draft provided with the final design package(s) (see Section 01 33 16, paragraph 3.7.5) and submit an accounting of all installed property on Interim Form DD1354 "Transfer and Acceptance of Military Real Property." Include any additional assets/improvements/alterations and cost updates from the Draft DD Form 1354. Contact the COR for any project specific information necessary to complete the DD Form 1354. This form will be a topic for the Red Zone Meeting discussed above. For information purposes, a blank DD Form 1354 (fill-able) in ADOBE (PDF) may be obtained at the following web site: http://www.dtic.mil/whs/directives/infomgt/forms/eforms/dd1354.pdf Submit the completed Checklist for Form DD1354 of Government-Furnished and Contractor-Furnished/Contractor Installed items. Attach this list to the updated DD Form 1354. Instructions for completing the form and a blank checklist (fill-able) in ADOBE (PDF) may be obtained at the following web site:
http://www.wbdg.org/ccb/DOD/UFC/ufc_1_300_08.pdf

EXHIBIT 1

SAMPLE

Red Zone Meeting Checklist

Date:_____

Contract No.	
Description / Location	
Contractor	
Contracting Officer	

Action	Completion Milestone	√
Inspections		
Fire		
Safety		
Pre-final		
Mechanical Test & Balance		
Commissioning		
Landscaping Complete		
Erosion Control		
Beneficial Occupancy Date (BOD)		
Furniture Installation		
Comm Installation		
As-Built Drawings		
Provide all O&M manuals, tools, shop drawings, spare parts, etc. to customer		
Training of O&M Personnel		
Provide Warranty documents to Customer		
Contract completion		

Ribbon cutting		
Payroll Clearances		
DD Form 2626 - Construction Contractor Performance Evaluation		
DD Form 2631 – A-E Performance Rated after Construction		
Status of Pending Mods and REA's/Claims		
Final Payment Completed		
Release of Claims		
Return of Unobligated Funds		
Move Project from CIP to General Ledger		
Financial completion		

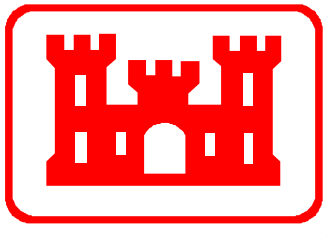
End of Section 01 78 02.00 10

FORT SAM HOUSTON, TEXAS

TRAINING SUPPORT CENTER

GOVERNMENT GEOTECHNICAL REPORT

FOR DESIGN-BUILD PROJECT RFP



PREPARED BY

U.S. ARMY CORPS OF ENGINEERS

FORT WORTH DISTRICT

ENGINEERING AND CONSTRUCTION DIVISION
ENGINEERING BRANCH

GEOTECHNICAL SECTION

CESWF-EC-DG

FEBRUARY 2010

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER

GOVERNMENT GEOTECHNICAL REPORT

1. General. The purpose of this report is to provide subsurface information, and foundation and pavement design considerations, guidance, and requirements for a new Training Support Center and associated pavement structures at Fort Sam Houston, Texas. The description of the project presented herein is based upon information provided in the Request for Proposal (RFP) document, to which the bidders should refer for specific facility descriptions. Based on information available at the time of this report, the new Training Support Center is anticipated to be a tall (maximum building height anticipated to be between 30 and 40 feet) single-story structure to be designed with a maximum total gross area of approximately 29,200 GSF. The new Training Support Center is anticipated to include a large warehouse area, as well as administrative areas (including offices, conference room, and break room), two classrooms, arms vault, restrooms, storage rooms, and mechanical/electrical/communications rooms. It is anticipated that the new building construction will match existing building architectural styles of the surrounding area. New rigid pavement structures include concrete aprons in front of loading docks and trash dumpster pads. New flexible pavement structures are anticipated to include a new privately-owned vehicle (POV) parking area and service drives. Support features include sidewalks, new utilities, landscaping, and site improvements.

The Training Support Center project site is located in the west central part of Fort Sam Houston. Specifically, the project site is located within an existing asphalt RV/trailer storage area that is bounded to the north by existing Building 3882 (and approximately by the alignment of McIdoe Road), to the east by a drainage channel, to the south approximately by the alignment of Taylor Road, and to the west by Garden Avenue. The existing asphalt pavement will be demolished for the new construction. Topographically, existing grades across the Training Support Center project site range from approximately 682.0 feet to 699.0 feet National Geodetic Vertical Datum (NGVD). Existing grades across the anticipated building footprint area range from approximately 682.0 feet to 687.0 feet (NGVD). The existing gradient in the area of the Training Support Center ranges from about 2 to 5 percent,

sloping generally toward the east. A finish floor elevation for the Training Support Center was not known at the time of this report. However, it is anticipated that several feet of fill placement, especially in the area of the building construction, will be required to bring the site to construction finish grade. Refer to the civil drawings provided elsewhere in this RFP Package for civil/site grading plans presenting the post-construction site grading.

2. Subsurface Investigation. The U.S. Army Corps of Engineers, Fort Worth District, drilled nine (9) test holes at the Training Support Center project site in December 2009. Specifically, borings 10A-1358 through 10A-1366 were drilled at the Training Support Center project site to determine subsurface conditions and to obtain representative soil and rock samples for laboratory testing. Test hole advancement and sample recovery was performed at the Training Support Center project site using 6- and 10-inch diameter short flight augers, a 4-inch carboloy bit core barrel sampler, and a nominal 3-inch diameter shelby tube sampler. Samples recovered from selective borings were sealed in airtight containers and taken to the laboratory of TEAM Consultants, Incorporated (Arlington, Texas) for testing. Borings were drilled to total depths ranging from 10.0 feet to 65.0 feet below existing grade.

The field investigation was performed using a Failing 1500 truck-mounted drill rig and conventional drilling attachments. Results of the field investigation are shown on the Boring Locations sheet, B101, and on the Logs of Borings Sheets, B201 and B202 (Appendix A).

a. Groundwater Conditions. Groundwater conditions were monitored during drilling operations, immediately upon completion of the test holes, and after observation periods of up to 2 days. Static water levels were measured in five of the nine borings drilled at the Training Support Center project site, with depths ranging from 4.9 feet to 53.0 feet below existing grade. Tabulated below are the static levels measured at the time of the field investigation. It should be noted that groundwater conditions are relative to the time of drilling, annual precipitation, and drainage conditions at the site.

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER

Boring	Static Level, feet
8A4C-1360	51.6
8A4C-1361	19.0
10A-1362	4.9
8A4C-1364	10.0
8A4C-1365	53.0

b. Dynamic Cone Penetrometer Testing. Dynamic Cone Penetrometer testing (DCP) was performed for pavement design considerations at the Training Support Center project site in borings 10A-1358, 10A-1359, 10A-1362, 10A-1363, 8A4C-1365, and 10A-1366. Results of DCP testing are presented in Appendix D and discussed in paragraphs 4 and 5.

c. Soil Resistivity Testing. Soil resistivity testing was performed at the Training Support Center project site at the approximate location of boring 8A4C-1360. The resistivity value measured in the field at this location is 814 ohm-cm (using a diode spacing of 2.5 feet). Soil resistivity test results are provided in the 'Remarks' column of the aforementioned log of boring (Appendix A).

3. Subsurface Conditions.

a. General Geology. Fort Sam Houston lies within the Balcones fault zone which separates the Edwards plateau province to the northwest from the Gulf Coastal plain province to the southeast. The Balcones zone comprises an area approximately 15 miles wide, trending northeast-southwest through Bexar County. Single faults within this zone exhibit displacements up to 690 feet, with a total displacement across the zone of approximately 1,475 feet.

The primary geologic formation underlying the overburden is assigned to the Taylor Formation of Upper Cretaceous age. In this area, the Taylor Formation consists of a clay shale which is soft to moderately hard (rock classification), calcareous, slightly silty, with occasional hard, marly zones up to 3 feet thick. The clay shale is generally jointed and weathered to a depth of 50 to 60 feet below ground surface. The Taylor Formation has an

estimated thickness of 210 feet in this area and is conformably underlain by the Anacacho Limestone Formation.

b. Site Conditions. The Training Support Center project site is located within an existing asphalt RV/trailer storage area. The existing asphalt pavement will be demolished for the new construction. It is unknown if additional above-ground features will require demolition in advance of the new facility construction. Topographically, existing grades across the Training Support Center project site range from approximately 682.0 feet to 699.0 feet National Geodetic Vertical Datum (NGVD). Existing grades across the anticipated building footprint area range from approximately 682.0 feet to 687.0 feet (NGVD). The existing gradient in the area of the Training Support Center ranges from about 2 to 5 percent, sloping generally toward the east. A finish floor elevation for the Training Support Center was not known at the time of this report. However, it is anticipated that several feet of fill placement, especially in the area of the building construction, will be required to bring the site to construction finish grade.

Stratigraphically, the site is characterized by high plasticity clay (CH) and clayey gravel/cobble overburden strata (encountered only at the location of boring 8A4C-1361, and deeper formations of weathered and unweathered clay shale primary. NOTE: Stratigraphic contact depths referenced herein are measured with respect to the original (pre-site construction) existing grades (i.e., the grades existing at the time of the geotechnical field investigation). The uppermost overburden stratum typically consists of high plasticity clay. The uppermost clay (i.e., within the upper 6 to 8 feet) is high plasticity (CH), stiff to very stiff, moist, black to very dark brown to dark brown, slightly sandy, and slightly gravelly. This dark brown to black, high plasticity clay overburden directly overlies the weathered shale primary at the locations of borings 10A-1358, 10A-1359, 8A4C-1360, 10A-1362, 8A4C-1364, and 8A4C-1365. Below the upper dark brown CH clay overburden at the locations of borings 8A4C-1361, 10A-1363, and 10A-1366, the high plasticity clay becomes yellow brown to light gray, stiff to very stiff, moist, slightly sandy, slightly gravelly, and slightly limy. At the locations of 10A-

1363 and 10A-1366, the yellow brown to gray CH clay directly overlies the weathered clay shale. However, at the location of boring 8A4C-1361, the yellow brown to gray CH clay is described as having the appearance of reworked clay shale primary (e.g., blocky structure was noted in the material), and the clay overlies a stratum of clayey and sandy gravel/cobble (for which see further discussion in the next paragraph). Liquid limits measured from representative samples of the high plasticity clays collected at the Training Support Center project site range from 73 to 92 percent, plastic limits vary from 23 to 32 percent (with plasticity indices ranging from 46 to 67 percent), and in situ moisture contents vary between 23 and 39 percent.

A stratum of clayey and sandy gravel and cobble is present between the high plasticity clay overburden and the underlying clay shale primary at the location of boring 8A4C-1361. The gravel and cobble was encountered at a depth of 19.0 feet below existing grade at this boring location. The thickness of the gravel/cobble stratum at this location is 4.5 feet (to the contact with the underlying weathered clay shale primary). The gravel/cobble stratum is described as medium dense to dense, coarse to fine, wet (the stratum was making water at 19.0 feet during drilling), yellow brown (clay and sand matrix), sandy, clayey to very clayey (with clayey seams), with cobbles up to at least 5.5 inches in diameter recovered during drilling. Although only encountered at the location of boring 8A4C-1361 during the geotechnical field investigation, it should be noted that the clayey and sandy gravel/cobble stratum is typically present at Fort Sam Houston, separating the overburden clays from the underlying clay shale primary, and should be anticipated during foundation construction for the project (if a drilled and underreamed pier deep foundation system is used). The presence of the gravel/cobble stratum and the appearance of the overlying clay material being reworked clay shale primary at the location of boring 8A4C-1361 is considered consistent with a depositional environment at this boring location, which appears to be close to the tributary drainage channels of Salado Creek (the broad fluviatile terrace of which underlies large portions of Fort Sam Houston). The gravel/cobble stratum is commonly limy, with caliched clay seams. It should be noted that

the gravel/cobble stratum is a known water-bearing stratum at Fort Sam Houston (as indicated by the observations made in boring 8A4C-1361 during the field investigation).

Beneath the overburden materials are formations of weathered and unweathered clay shale primary which are present to the total depth investigated (65.0 feet). The weathered clay shale primary was encountered at the Training Support Center site at depths ranging from 5.6 to 23.5 feet below existing grade at the boring locations. The clay shale is yellow brown and light gray to strong brown, very soft to soft (rock classification), massive, silty, sandy (with sandy zones), calcareous, with blocky structure. Healed and well healed fractures with slickensides are present throughout the weathered clay shale. It should be noted that water from the overlying gravel/cobble stratum is known to be able to migrate through the fractures within the clay shale. Liquid limits measured from representative samples of the weathered clay shale collected at the Training Support Center project site range from 59 to 79 percent, plastic limits vary from 20 to 27 percent (with plasticity indices ranging from 35 to 55 percent), and in situ moisture contents vary between 19 and 26 percent.

Dark gray unweathered clay shale was encountered in borings 8A4C-1360 and 8A4C-1365 at depths of 50.1 feet and 48.9 feet, respectively, below existing grade. The unweathered clay shale appears to be better cemented and unfractured compared to the overlying weathered clay shale. The unweathered clay shale is soft to moderately hard (rock classification), slightly fossiliferous, and unctuous. Liquid limits measured from representative samples of the unweathered clay shale collected at the Training Support Center project site range from 56 to 67 percent, plastic limits vary from 19 to 33 percent (with plasticity indices ranging from 33 to 43 percent), and in situ moisture contents vary between 15 and 18 percent.

Subsurface conditions representative of the project site are shown on the logs of borings, Sheets B201 and B202 (Appendix A). The legend on the individual boring logs show overburden materials as classified in the laboratory using procedures presented in ASTM D 2488. It should be noted that the actual interface between material types may be far more gradual or abrupt than presented; therefore, actual subsurface conditions in areas not sampled

may differ from those predicted. The nature and extent of variations across the sites may not become evident until construction commences, and the actual construction process may alter subsurface conditions as well. If variations become evident at the time of construction, CESWF-EC-DG should be contacted to determine if the recommendations presented in this report need to be reevaluated.

4. Testing.

a. Laboratory Testing. Representative soil and rock samples recovered from selective test holes were subjected to laboratory testing for identification, moisture content, grain-size distribution, Atterberg limits, density, and strength. The accumulative test results are tabulated and presented in Appendix C. Results of identification and moisture content testing are shown on the individual boring logs, Appendix A.

Results of laboratory testing performed on samples obtained from the Training Support Center site are presented graphically in Appendix B as follows: Plasticity characteristics are shown on Plate 1, Plasticity Chart. Moisture content values of representative samples are shown with respect to depth on Plate 2. Atterberg limits test results are shown with respect to depth on Plate 3. Dry density values of representative undisturbed samples and their corresponding moisture contents are shown with respect to depth on Plate 4. Ultimate compressive strengths of the clay shale primary are shown with respect to depth on Plate 5.

(1) Shear Strength Testing. Shear strength characteristics of the clay shale primary were analyzed in the laboratory using one-point unconsolidated-undrained triaxial compression testing, confining the specimens to overburden pressure and then loading to failure. Tabulated below are the ultimate compressive strengths and respective dry densities of the overburden clay and clay shale primary specimens. Shear strength test results are also presented in Appendix C at the end of this report.

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER

Boring	Depth, feet	γ_d, pcf	Q_u, tsf	Material Type
8A4C-1360	15.0	101.1	1.18	Weathered Shale
8A4C-1360	21.5	105.6	2.72	Weathered Shale
8A4C-1360	27.5	103.9	2.48	Weathered Shale
8A4C-1360	31.5	104.2	3.39	Weathered Shale
8A4C-1360	39.5	108.2	8.17	Weathered Shale
8A4C-1360	45.5	108.1	8.03	Weathered Shale
8A4C-1360	51.6	105.2	7.92	Unweathered Shale
8A4C-1360	57.5	112.3	15.02	Unweathered Shale
8A4C-1360	63.5	107.8	16.03	Unweathered Shale
8A4C-1361	27.5	102.7	3.82	Weathered Shale
8A4C-1361	33.5	107.4	3.30	Weathered Shale
8A4C-1364	13.5	104.3	2.37	Weathered Shale
8A4C-1364	19.5	97.1	1.88	Weathered Shale
8A4C-1364	25.6	100.8	3.83	Weathered Shale
8A4C-1364	31.6	99.7	4.04	Weathered Shale
8A4C-1365	16.5	103.5	2.61	Weathered Shale
8A4C-1365	22.5	102.9	1.96	Weathered Shale
8A4C-1365	28.5	101.9	4.07	Weathered Shale
8A4C-1365	34.5	103.3	4.70	Weathered Shale
8A4C-1365	40.5	107.4	9.38	Weathered Shale
8A4C-1365	46.5	107.7	15.28	Weathered Shale
8A4C-1365	52.6	116.6	19.53	Unweathered Shale
8A4C-1365	58.5	116.7	24.51	Unweathered Shale
8A4C-1365	64.5	114.2	24.82	Unweathered Shale

(2) Controlled Expansion-Consolidation Testing and Swell Pressure Testing. Controlled expansion-consolidation (CEC) testing was performed on one specimen of high plasticity (CH) clay overburden collected at the Training Support Center site.

A specimen of high plasticity (CH) clay overburden collected at a depth of 2.0 feet within boring 8A4C-1360 was subjected to controlled expansion-consolidation testing. This high plasticity clay specimen has a liquid limit of 90 percent, a plastic limit of 26 percent (PI = 64 percent), and a natural moisture content of approximately 30 percent. An expansion pressure (p_{exp}) of approximately 1.0 tsf was recorded during CEC testing of the high plasticity clay specimen. It should be noted that the geotechnical field investigation was completed during a period of high precipitation that followed a protracted severe drought (e.g., the moisture content of the specimen is considered higher than normally would be expected for this material and sample depth). A specimen of the CH clay overburden collected from a nearby project site during the drought, as discussed in Paragraph 5.a., below, is considered to

represent more closely the true expansion potential of the CH clay overburden. Conversely, the CH clay specimen collected from boring 8A4C-1360 is considered to represent the consolidation potential of the CH clay. Based on CEC test results, the high plasticity clay specimen collected at a depth of 2.0 feet within boring 8A4C-1360 has a very high expansion potential (C_s = 0.087; p_{exp}/p_0 = 8.8) and a very high consolidation potential (C_c = 0.340). Controlled expansion-consolidation test results are summarized in the table below and presented in Appendix C at the end of this report.

Controlled Expansion-Consolidation Test

Boring	Depth, feet	LL	PI	P_{exp}/P_o	C_s	C_c	Material Type
8A4C-1360	2.0	90	64	1.0	0.087	0.340	CH Clay Overburden

b. Field Testing. Dynamic Cone Penetrometer (DCP) testing was performed in borings 10A-1358, 10A-1359, 10A-1362, 10A-1363, 8A4C-1365, and 10A-1366 at the Training Support Center site for pavement design considerations. A DCP consists of a steel rod with a steel cone attached to one end and a sliding single-mass hammer. For this project, the DCP test was performed by driving the steel cone into the soil using a 10.1-pound sliding hammer dropped from a height of 22.6 inches (574 millimeters). The number of blows required for each 0.4 inch (10-mm) or higher of penetration was recorded as the "penetration per blow set"; therefore, the more penetration achieved per blow indicates that a "weaker" soil layer was encountered. Typically, penetration measurements are taken to a depth of 39.4 inches (1,000 millimeters) or when refusal is achieved. Refusal is defined as the point when the cone cannot penetrate the soil more than 0.4 inches (10 millimeters). Presented below are the average in situ strength parameters derived from the DCP tests. DCP test results are also presented in Appendix D at the end of this report.

Depth, in	CBR, %	k, pci
0 – 6	2 - 11	69 - 178
6 – 12	5 - 34	127 - 327
>12	5 - 12	139 - 218

5. Discussions. The following discussions are provided in support of the foundation and pavement design recommendations and requirements made herein for the proposed Training Support Center and appurtenant pavement structures. It should be noted that the discussions presented herein are based on the results of the Government geotechnical field investigation and laboratory testing program conducted at the site, as described previously in this report, as well as engineering studies, and previous engineering experience with similar structures at Fort Sam Houston. The Design-Build Contractor shall heed the information provided in this report and comply with the requirements and recommendations presented herein when developing his/her foundation and pavement designs. **The Design-Build Contractor's foundation and pavement designs are required to comply with and to meet or exceed the minimum foundation and pavement design requirements and recommendations presented herein.** The bidders for this design-build contract project may use the subsurface boring log and lab testing data as a basis to formulate their foundation and pavement designs for the purposes of developing a bid for the project Request for Proposal (RFP) solicitation. The successful Design-Build Contractor bidder may supplement the information provided herein by his/her own geotechnical field investigation and laboratory testing program for the purpose of supplementing and comparing with the data provided in this report, and to serve as a basis for the development of his/her final foundation and pavement designs. **Supplemental geotechnical field investigations conducted by the Design-Build Contractor shall be ONLY for the purpose of supplementing the data regarding the subsurface conditions provided by the Government geotechnical field investigation**. These supplemental efforts shall include conducting testing on soil and rock (clay shale) specimens as described in Section 4 (Testing). Additional test holes shall each be drilled to a minimum depth of 65 feet below existing grade. **All borings and test holes shall be grouted full depth with a lean grout mixture to seal holes from water penetration.** Tests on disturbed specimens of overburden soils shall include classification (ASTM D 2488), moisture content (ASTM D 2216), grain size analysis (ASTM D 422), and Atterberg limits (ASTM D 4318). Undisturbed (shelby tube)

specimens of the overburden soils shall also be collected; tests on undisturbed specimens of the overburden soil shall include the tests listed for disturbed specimens, as well as controlled expansion-consolidation testing (ASTM D 2435 and ASTM D 4546 (Method C)), density (Corps of Engineers Engineer Manual (EM) 1110-2-1906, Appendix II, Par. 4, Displacement Method), and strength testing (ASTM D 2850). Core specimens of at least 4-inch diameter of the clay shale primary shall be collected and subjected to testing to include moisture content (ASTM D 2216), Atterberg limits (ASTM D 4318), density (Corps of Engineers EM 1110-2-1906, Appendix II, Par. 4, Displacement Method), controlled expansion-consolidation (at least four specimens) (ASTM D 2435 and ASTM D 4546 (Method C)), and strength (ASTM D 2464).

Development of the final foundation and pavement designs is the responsibility of the Design-Build Contractor; however, the Design-Build Contractor's final foundation and pavement designs shall be in full compliance with the requirements prescribed herein (including foundation type, foundation design parameters, and minimum pavement sections and pavement design criteria and parameters). The Design-Build Contractor shall provide to the Government engineering studies and design calculations that support the foundation and pavement design recommendations they or their associates propose. The Design-Build Contractor's foundation and pavement design recommendations shall be reviewed for technical adequacy and compliance with the requirements and criteria established herein and in the Request for Proposal (RFP). Specific requirements for the Design-Build Contractor's foundation and pavement design analysis are provided in section 6.c.

a. Soil Activity Considerations. The Training Support Center site is characterized by a high plasticity clay overburden stratum, underlain by a clayey and sandy gravel/cobble stratum of variable thickness that is further underlain by formations of weathered and unweathered clay shale primary. The high plasticity overburden clay is typically present to depths ranging from 5.6 feet to 19.0 feet below existing grade across the Training Support Center site. The underlying clayey and sandy gravel/cobble stratum was encountered within boring 8A4C-1361

at a depth of 19.0 feet below existing grade and is approximately 4.5 feet in thickness (above the underlying weathered clay shale primary) at this location. The weathered clay shale was encountered at depths ranging from 5.6 feet to 23.5 feet below existing grade at the test hole locations drilled across the Training Support Center project site. The unweathered clay shale was encountered at depths of 50.1 feet and 48.9 feet at the locations of borings 8A4C-1360 and 8A4C-1365, respectively. The plasticity characteristics and in situ moisture contents of the high plasticity clay overburden and the weathered and unweathered clay shale primary have been discussed in detail in paragraph 3.b., above, and are summarized in the table below.

Range of Atterberg Limits and In Situ Moisture Contents Measured at the Training Support Center Project Site

Stratum	LL, %	PL, %	PI, %	w, %
CH Clay Overburden	73 – 92	23 – 32	46 – 67	23 – 39
Weathered Clay Shale	59 – 79	20 – 27	35 – 55	19 – 26
Unweathered Clay Shale	56 – 67	19 – 33	33 – 43	15 – 18

Moisture content and Atterberg limits test results indicate that these materials are potentially moisture deficient throughout the entire depth investigated (65.0 feet).

The results of controlled expansion-consolidation testing conducted on a specimen of the high plasticity clay overburden soil collected during the geotechnical field investigation at the Training Support Center site are discussed in paragraph 4.a.(2), above. Based on the results of controlled expansion-consolidation testing conducted on the CH clay specimen, the clay overburden has a very high potential for expansion and consolidation. For the weathered and unweathered clay shale strata, the expansive soils analysis is based upon the results of controlled expansion-consolidation testing performed on specimens of the weathered and unweathered clay shale primary with similar plasticity characteristics collected during previous USACE geotechnical field investigations at nearby project sites at Fort Sam Houston. As previously noted, the high plasticity clay specimen subjected to CEC testing for this project was collected following a period of heavy precipitation in the area. This factor is believed to

be responsible for the relatively very high in situ moisture content measured in the test specimen. Hence, the CH clay specimen collected at the Training Support Center site and subjected to CEC testing is believed to be in a super moisture-satisfied state. Therefore, the CEC test results for the specimen are believed to represent a lower end value for the recorded expansion pressure (1.0 tsf), and to represent the true consolidation potential of the CH clay stratum (C_c = 0.340). Based upon this, controlled expansion-consolidation testing data performed on a specimen of the CH clay overburden collected at the nearby Warriors in Transition Complex – Liberty Field site during the recent period of severe drought was also used in the expansive soils analysis. The CH clay specimen collected at the Warriors in Transition – Liberty Field site has plasticity characteristics similar to those at the Training Support Center site (LL = 69%; PL = 19%, PI = 50%, w = 17%; Cs = 0.062, Cc = 0.096), but, since the specimen was collected during a period of severe drought, the expansion pressure recorded in the desiccated CH clay specimen (p_{exp} = 8.3 tsf) is believed to more accurately represent the true expansion potential of the CH clay overburden soils to which the new facility will be subjected over its operational life. Based on the results of these controlled expansion-consolidation tests and a comparison with specimens collected at the Training Support Center project site, the weathered clay shale primary has a moderate to very high potential for expansion, and the unweathered clay shale has a low to high potential for expansion. Also, based on the cited testing data, the weathered clay shale has a low to moderate potential for consolidation, and the unweathered clay shale has a very low to moderate potential for consolidation.

An expansive soils analysis was performed to quantify the response of the active clay overburden and clay shale primary when subjected to increased load conditions during periods of seasonal moisture fluctuations. In the analysis, the plastic overburden soils and clay shale primary are assumed to be in a saturated condition, and initially, surcharge loads (fill and building) were neglected. Due to the fractured nature of the clay shale primary, particularly in the weathered zone, and the results of the previously discussed Atterberg limits, moisture

content, and controlled expansion-consolidation testing, the active zone is considered to potentially extend well into the unweathered clay shale. Hence, an active zone of at least 65.0 feet was used for the expansive soils analysis. As has been previously discussed, there is considerable variation in the contact depths of the strata across this site. The expansive soils analysis considers the following idealized stratigraphy: 0.0 feet to 7.0 feet – high plasticity (CH) clay; 7.0 feet to 50.0 feet – yellow brown and gray weathered clay shale; 50.0 feet to 65.0 feet – uniformly dark gray unweathered clay shale. The expansive soils analysis is based on the following material properties, by layer/depth interval:

Depth, feet	LL & PI		P_{exp}, tsf	P_{exp}/P_o	C_s & C_c		Material Type
0.0 – 7.0	90	64	1.0	8.8	0.087	0.340	CH Clay Overburden[1]
7.0 – 50.0	63	43	3.0	1.0	0.061	0.103	Weathered Shale[2]
50.0 – 65.0	72	53	2.2	0.6	0.027	0.055	Unweathered Shale[3]

1. Boring 8A4C-1360, specimen ST-1 (sample depth = 2.0 feet) – this investigation;
2. Boring 8A4C-1287, specimen C-3 (sample depth = 49.5 feet) – AIT Barracks Complex site investigation;
3. Boring 8A4C-1303, specimen C-7 (sample depth = 63.5 feet) – WT-Liberty Field site investigation.

As previously discussed, the following data were also used for the CH clay overburden to evaluate the expansion potential of this stratum in during dry periods:

Depth, feet	LL & PI		P_{exp}, tsf	P_{exp}/P_o	C_s & C_c		Material Type
0.0 – 7.0	69	50	8.3	16.6	0.062	0.096	CH Clay Overburden[4]

4. Boring 8A4C-1303, specimen ST-2 (sample depth = 8.0 feet) – WT-Liberty Field site investigation.

Based on these conditions, the heave potential of the overburden and primary materials within the active zone was determined to be between approximately 8.5 and 11.4 inches. Although the highly plastic overburden soils contribute the greater portion of heave potential, the contribution to total heave of the clay shale is also significant, despite the overburden pressure of the overlying strata. The expansive soils analyses determined that a residual heave potential ranging from approximately 7.7 to 10.6 inches is anticipated even with a building surcharge of

100 psf. It is anticipated that up to 5 feet of fill placement may be required to bring the building pad up to construction finish grade. Considering placement of up to 5 feet of engineered fill and a building surcharge of 100 psf, a residual heave potential of approximately 4.6 to 7.7 inches is anticipated. If a mat foundation loading of 2.0 ksf (net) is considered to bear at existing grade level, a residual heave potential of approximately 1.6 to 4.5 inches is anticipated. Considering placement of up to 5 feet of engineered fill and a mat loading foundation loading of 2.0 ksf (net), a residual heave potential of up to 3.5 inches is anticipated.

The compressibility characteristics of the upper CH clay were also evaluated using the controlled expansion-consolidation (CEC) testing data for the shelby tube specimen collected within boring 8A4C-1360 and the aforementioned data for the weathered and unweathered clay shale primary. Based upon this analysis, the settlement potential of the overburden clay and clay shale primary is anticipated to be about 1.2 inches considering a building surcharge of 100 psf. Considering fill surcharges (in addition to the building surcharge) ranging from 1 to 5 feet in thickness, the settlement potential of the overburden clay and clay shale primary is anticipated to range from approximately 2.2 inches to 4.7 inches. Considering a mat foundation with an allowable bearing capacity of 2.0 ksf (net) bearing at existing grade and on fill surcharges (above existing grade) ranging up to 5 feet in thickness below the base of the mat, the settlement potential of the overburden clay and clay shale primary is anticipated to range from approximately 8.3 inches to 9.6 inches. It should be noted that all but approximately 1 inch of the anticipated settlement is attributed to the CH clay overburden stratum. Fill surcharges (above existing grade) exceeding 5 feet below a ribbed mat slab or exceeding 3 feet below a flat mat slab are not anticipated, however, settlement potentials for greater fill surcharges can be provided by CESWF-EC-DG upon request.

The expansive soils analysis demonstrates the very high expansion potential of the overburden clay and the clay shale primary and very high consolidation potential of the overburden clay. Due to the high potential volumetric changes that may be expected of the high plasticity clay overburden and clay shale primary, special foundation, floor slab, and

subgrade preparation requirements for the Training Support Center are provided herein to withstand the effects of the highly expansive subsurface conditions.

b. Foundation Design Considerations. The foundation design recommendations and requirements presented in this report are based on criteria contained in *UFC 3-220-03FA, UFC 3-220-07*, and engineering judgment.

The foundation for the proposed facility must meet several criteria. The foundation must be compatible with the superstructure it supports, its movements must be within acceptable tolerances, it must meet functional requirements of the facility (such as a crawlspace, if used), and it must be economical. Based on information available at the time of this report, the Training Support Center is anticipated to be a tall one-story warehouse structure. Therefore, the column loads for the facility are anticipated to be low to moderate. Due to these potentially low to moderate anticipated column loads, the anticipated differential heave and settlement potential of the high plasticity clay and the relatively low allowable bearing capacity that can be assigned to this stratum, the intermittent presence, variable elevation, thickness, and consistency of the underlying gravel stratum, the heave potential of the underlying clay shale, and the cost of framework construction, a shallow foundation such as dug and formed spot and continuous spread footings is not considered a viable foundation system for the Training Support Center. Likewise, due to the extremely high expansion potential of the subsurface materials at the project site, straight-shaft piers (and any other straight-shaft/non-underreamed deep foundation system) are considered unsuitable for the proposed facility. Based on the results of the geotechnical field investigation and on the available facility information, three foundation systems are considered to be suitable for the Training Support Center, specifically a deep foundation system consisting of reinforced concrete drilled and underreamed piers, and a shallow foundation system consisting of either a reinforced concrete ribbed mat slab or a reinforced concrete flat mat slab. Considerations for each of these foundation systems are presented below.

(1) Reinforced Concrete Drilled and Underreamed Piers. A properly designed

and constructed deep foundation system consisting of drilled and underreamed piers has historically performed very well at Fort Sam Houston, can be assigned a larger allowable end-bearing value, and can be constructed economically compared to a shallow footing system. Therefore a reinforced concrete drilled and underreamed pier foundation is considered to be a suitable foundation system for the Training Support Center, providing the minimum column loads specified herein can be achieved.

There are two potential bearing strata for the drilled and underreamed piers, namely the weathered clay shale and the unweathered clay shale. The gravel/cobble stratum would normally be considered as a potential founding material since it can be assigned a substantial allowable bearing capacity and is above the highly expansive clay shale. Unfortunately, there are multiple problems associated with the gravel/cobble at this site. The first is that, although otherwise ubiquitous at Fort Sam Houston, the gravel/cobble stratum was only encountered in one of the borings (8A4C-1361). In the other eight borings, the high plasticity overburden clays directly overlie the weathered clay shale primary. Furthermore, the stratum was only 4.5 feet in thickness where encountered, which is considered an inadequate thickness on which to bear piers carrying the magnitude of loads anticipated for the proposed Training Support Center. Also, material inconsistencies within the stratum (e.g., clay seams) would require further reductions in allowable loads to limit differential settlements. In addition, the gravel/cobble stratum was observed as being water-bearing and is know for its susceptibility to collapse during augering, both of which would present great difficulties in properly constructing underreamed piers within the stratum. Based upon these factors, the gravel/cobble stratum shall not be considered as a bearing stratum.

The weathered and unweathered clay shales are considered potential bearing strata for drilled and underreamed piers. Selecting a bearing stratum/elevation for drilled piers in expansive clay shales, such as those present at this site, must take into account constructability, bearing capacity, settlement, potential heave, and cost. These can be conflicting requirements and the final selection must strike a reasonable compromise between

these considerations. The weathered shale has the obvious advantage of being shallower, thus piers would not have to extend as deep and would have a lesser cost. It has the disadvantages of being jointed and fissured with sandy zones (which present constructability problems with forming underreams), has lower shear strengths, is more compressible, and has a higher expansion potential when compared to the uppermost unweathered clay shale. In addition to having better engineering and constructability properties, the unweathered clay shale typically contains numerous cemented seams which are stronger, more incompressible, and less expansive than even the uncemented portions of the unweathered clay shale. These advantages make the unweathered clay shale a significantly better bearing material than the weathered clay shale. Founding piers at least three feet into the uniformly dark gray unweathered shale will place the piers a sufficient depth into the unweathered shale to allow the underream to be constructed without risk of sloughing and represents a reasonable economical extension from piers considered near the bottom of the weathered shale stratum. This bearing material has been used in the past at Fort Sam Houston and has provided a satisfactory response with respect to pier movement. The existing Brooke Army Medical Center is founded on drilled and underreamed piers founded at least three feet within the unweathered clay shale (and with very similar design parameters as those presented herein for the proposed facility). Based on a recent site visit, visual inspection, and discussions with Facility Operations personnel for Brooke Army Medical Center, the drilled and underreamed pier foundation system, in service for over a decade, has performed exceptionally well, with no evidence of piers experiencing detrimental differential movements. Therefore, if a reinforced concrete drilled and underreamed pier foundation system is used for the facility, the bearing stratum shall be the uniformly dark gray unweathered clay shale (with pier design and constructed in accordance with the requirements specified herein).

A deep foundation system consisting of drilled and underreamed piers shall be permitted **only** if column loads of **at least 200 kips** can be achieved (e.g., through widely-spaced piers). If column loads of at least 200 kips cannot be achieved, the acceptable

foundations systems shall be limited to either a reinforced concrete ribbed mat slab or a reinforced concrete flat mat slab. Design and construction of the foundations systems shall be in accordance with (shall meet or exceed) the recommendations and requirements specified herein by foundation system type.

(2) Reinforced Concrete Ribbed Mat and Reinforced Concrete Flat Mat Foundation. Properly designed and constructed reinforced concrete ribbed mat slab and reinforced concrete flat mat slab foundation systems have performed well at Fort Sam Houston, particularly for facilities with relatively light to moderate column loads (e.g., under 200 kips). These two shallow foundation systems, when properly designed and constructed, will act monolithically when subjected to shrink-swell movements of the subsurface materials, in contrast to other, unsuitable shallow foundation systems such as spot and continuous spread footings.

A deep foundation system is not considered well-suited to lightly-loaded facilities at Fort Sam Houston. Based on the extensive experience of the Fort Worth District with facility design and construction in the very highly expansive subsurface conditions present at Fort Sam Houston, several factors must be implemented to counteract uplift forces (amounting to several hundred tons) on pier foundations. The load on the piers must be maximized (i.e., piers must be heavily-loaded), with column loads not less than 200 kips transferred to the individual piers. Adequate reinforcing steel must be included in the piers to prevent failure due to tensile stress induced by heave forces. Also, fractures within the weathered clay shale are noted conduits for moisture. Changes in the in situ moisture regime facilitated by this condition can potentially affect the entire weathered clay shale stratum. Furthermore, occasional fractures that may penetrate the dark gray unweathered shale (as noted in boring 8A4C-1364), and moisture pathways along the surface of the pier concrete, can permit changes to the in situ moisture regime to occur within the dark gray unweathered shale, as well. Therefore, piers must be underreamed (not straight shaft), optimally within the dark gray unweathered clay shale, to provide adequate anchorage against uplift forces. In addition, the surface area upon which

uplift forces can act should be minimized (i.e., the pier shaft size should be minimized). It is anticipated that a properly designed monolithic shallow foundation system consisting of either a reinforced concrete ribbed mat or flat mat slab can be constructed as or more economically than a properly designed deep pier foundation, and provide equal or superior life-cycle performance for this facility than a pier foundation, depending on pier column loads. The foundation system selected for the Training Support Center shall be in accordance with (shall meet or exceed) the recommendations and requirements specified herein by foundation system type.

IT IS REQUIRED THAT ALL FOUNDATION, FLOOR SLAB, AND EARTHWORK DESIGNS AND CONSTRUCTION BY THE DESIGN-BUILD CONTRACTOR AND THEIR ASSOCIATES SHALL COMPLY WITH THE MINIMUM REQUIREMENTS PRESENTED HEREIN.

c. Pavement Design Considerations. The pavement designs presented in this report are based on criteria contained in *UFC 3-250-01FA, UFC 3-250-18FA*, and engineering judgment.

(1) Traffic Types and Conditions. Four (4) pavement structures were analyzed and designed for this project. New rigid pavement structures are anticipated to include new concrete loading dock aprons and aprons in front of trash dumpster pads. New flexible pavement structures are anticipated to include service drives and POV parking areas (approximately 70 to 75 POVs are anticipated to use the facility). Types of vehicles to occupy the pavement structures are anticipated to consist of tractor trailers, trash trucks, and passenger cars and trucks. Based on criteria contained in the aforementioned United Facilities Criteria, the following traffic conditions were assigned:

Pavement Structure	Traffic Category	Street Class	Design Index
Aprons (Loading Dock & Trash)/Service Drives	IVA	F	4
POV Parking Area	II	E	2

(2) Pavement Design Parameters. California Bearing Ratio (CBR) and plate bearing tests were not performed for this project. Instead, dynamic cone penetrometer (DCP) testing was conducted to evaluate the raw subgrade for pavement design considerations. The penetration resistance obtained from the DCP test is a measure of the soil's relative density, which in turn is used to derive "in situ" CBR and modulus of subgrade reaction values.

The average in situ CBR values measured within the upper 12 inches of soils tested at the Training Support Center site range from approximately 2 to 34 percent, and below this depth, CBR values ranging from 5 to 12 percent were recorded. Modulus of subgrade reaction values measured within the upper 12 inches of soils tested at the Training Support Center site range from 69 to 327 pci, and below this depth, modulus of subgrade reaction values ranging from 139 to 218 pci were recorded. In the past, the high plasticity clay subgrade indicative of Fort Sam Houston has been assigned CBR values ranging from 5 to 7 percent when compacted to 95 percent of laboratory maximum density, and 3 to 4 when compacted to 90 percent of laboratory maximum density. Previously conducted plate-bearing tests indicate that modulus of subgrade reaction values on the order of 75 pci to 125 pci can be assigned to the in situ soils when compacted to 90 percent and 95 percent, respectively, of laboratory maximum density. The CBR and subgrade modulus values determined from in situ DCP testing are variable and range higher than the historical CBR and subgrade modulus values described above. This is believed to be due to the presence of gravel in the near-surface soils at the boring locations. Based on the results of the geotechnical field investigation, the gravel content is quite variable across the project site. Based on these considerations, and the assumption that some or all of the pavement structures may be constructed on fill sections, design CBR and modulus of subgrade reaction values of 4 percent and 100 pci, respectively, were assigned to the raw subgrade for each site when compacted to 90 percent of laboratory maximum density (ASTM D 1557).

(3) Material Sources. Material sources in the San Antonio area are capable of producing a high quality crushed aggregate for concrete mixes to meet strength requirements.

For this reason, a concrete flexural strength of 650 psi at 28 days was considered in the design of rigid pavements. To date, Alkali/Silica Reaction with Portland Cement Concrete has never been a problem when using local aggregate sources.

6. Recommendations and Requirements. The following foundation and pavement design recommendations and requirements are based on results of the field investigation, laboratory testing, and engineering studies.

a. Foundation Design Recommendations and Requirements.

(1) Foundation System. The proposed Training Support Center shall be founded on either a reinforced concrete drilled and underreamed piers, or a reinforced concrete ribbed mat or flat mat foundation system in accordance with the recommendation and requirements specified herein. **NO OTHER FOUNDATION SYSTEMS SHALL BE ALLOWED FOR TRAINING SUPPORT CENTER.** ***THE FOLLOWING FOUNDATION SYSTEMS ARE SPECIFICALLY PROHIBITED: SPOT AND/OR CONTINUOUS SPREAD FOOTINGS, STRAIGHT-SHAFT DRILLED PIERS, DRIVEN OR CAST-IN-PLACE PILES, AND AUGER CAST PILES.***

(a) Reinforce Concrete Drilled and Underreamed Piers. The proposed Training Support Center can be supported on a reinforced concrete drilled and underreamed pier foundation system ***ONLY if column loads of at least 200 kips can be achieved***. **If column loads of at least 200 kips cannot be achieved, the facility shall be founded on either a reinforced concrete ribbed mat or flat mat foundation system, designed and constructed in accordance with the requirements specified herein.**

The optimum bearing stratum for the drilled and underreamed piers is the uniformly dark gray unweathered clay shale. Drilled and underreamed piers founded within the uniformly dark gray unweathered clay shale shall bear at a uniform elevation of 630.0 feet (NGVD) or at least 3 feet into the uniformly dark gray unweathered clay shale stratum, **whichever is deeper**. ***This elevation is based on the facility site layout available at the time of this report; these values shall be reevaluated for adequacy during reviews of the Design-***

Build Contractor's project design submittals. An allowable end bearing capacity of 25.0 ksf (net) should not be exceeded when sizing pier underreams founded within the uniformly dark gray unweathered clay shale at this elevation. The number/layout and sizing for piers/underreams should be designed, and pier loading should be distributed in such a manner as to maximize the loading to as close as possible to the allowable end bearing in order to counteract the uplift forces acting on the piers, in accordance with the requirements specified herein. It should be noted that these allowable bearing capacities, by stratum, are based on a factor of safety equal to 3 against shear failures. Based on structural requirements, the load used to size the piers shall consist of full dead load plus that portion of the live load that acts more or less continuously, usually 50 percent. For this project, the following allowable side shear values, by elevation, shall be used:

Elevation (ft. (NGVD))	Allowable Side Shear (ksf)
>650.0	0
650.0 – 635.0	2.0
<635.0	4.0

The effective length shall be considered to extend to one underream diameter above the top of the pier underream. If the piers are designed for both end bearing and skin friction (and it is required that they be), the foundation notes need to reflect this condition.

To facilitate clean out and inspection of the pier holes during construction, pier shafts shall be at least 24 inches in diameter; however, it is recommended that the smallest possible shaft diameter should be used to minimize the surface area on which pier heave can act. Pier underream diameters shall be at least 2.5 times the diameter of the pier shaft but shall not exceed 3.0 times the diameter of the pier shaft. Once design pier underream sizes are determined, they shall be fixed to that diameter in the field. A minimum 12-inch void shall be maintained beneath all grade beams, and the void area shall be protected with concrete retainer blocks as shown in the latest edition of the SWD-AEIM. ***The bottom of all grade beams shall***

be formed with carton forms to provide the 12-inch void.

To limit the potential for large differential movements from occurring, the following measures shall be implemented: (1) shaft diameters shall be the minimum required to limit the contact area with the surrounding expansive soils; (2) piers shall be widely spaced (not less than 20 feet center to center) in an attempt to impose a significant amount of dead load on the foundation; the most heavily loaded piers shall not be placed next to lightly loaded piers; (3) piers shall be properly reinforced to prevent stress (tensile) cracking within the pier concrete when subjected to uplift forces. Based on the results of analyses taking into account the expansion pressures of the soil and clay shale in combination with dead loads acting on individual piers, it was determined that ***for piers founded within the uniformly dark gray unweathered clay shale***: piers 24 inches in diameter (shaft size) require a minimum of 3.0 percent reinforcing steel, piers 30 inches in diameter require a minimum of 2.75 percent reinforcing steel, and piers 36 inches in diameter require a minimum of 2.25 percent reinforcing steel. ***For piers founded within the weathered clay shale***: piers 24 inches in diameter (shaft size) require a minimum of 3.0 percent reinforcing steel, piers 30 inches in diameter require a minimum of 2.75 percent reinforcing steel, and piers 36 inches in diameter require a minimum of 2.5 percent reinforcing steel. Piers smaller than 24 inches in diameter shall not be used based on the anticipated bearing depth (>40 feet). ***It is required that the structural designer submit the proposed pier loading scheme to CESWF-EC-DG prior to final design for review for compliance with these requirements.***

As previously noted, minimum pier spacing shall not be less than 20 feet (center-to-center). At expansion joints, the two piers on either side of the joint should be combined into one larger pier spanning across the joint. An additional concern that couples with the spacing requirements is lightly loaded piers. Lightly loaded piers (i.e., those with column loads less than 200 kips) dissipate most or all of their load in side shear and none of the end bearing will be mobilized. Thus, the expansive clay shale below the pier has no structural restraint when this material begins to heave and the full expansion potential of the material is realized. To

reduce this risk, any pier supporting a column load of less than 200 kips shall be deleted and the load redistributed to adjacent piers by grade beams. This normally requires special structural spans at stoops and elevator pits as well as not allowing grade beams to be supported independently from column locations. Transferring load by grade beams may not be economical, but is required for adequate performance of the foundation system. In addition, to minimize the effects of differential movements, large differences (>50%) in column loading between adjacent piers should be avoided. Compression or settlements of individual piers should be checked to ensure acceptable deflections which will not cause cracking or distress to the building structural wall/floor units and building facade. Perimeter piers at the ends of the building wings are typically less heavily loaded than adjacent piers; special attention should be paid to the pier and grade beam design to ensure that piers in these locations also achieve the loads specified herein.

Proper sizing of the piers, both shafts and bells, is essential. Shaft and bell diameters must be within -0 to +2 inches of the specified dimension. The contract shall require that the belling tool have some means, such as a chain, to restrict the travel of the underreamer to the required dimension.

Concrete slump for piers shall be from 6 to 8 inches.

The typical pier detail shall require the upper 5 feet of the pier shaft to be formed with a wax impregnated sonotube to eliminate a mushroom shaped pier top. The detail shall also show a wedge-shaped mound of Select Clay Backfill placed around the pier top that is 1 foot high and sloped at a 1V on 2H slope. This will prevent water from ponding directly around the top of the pier. These requirements are illustrated on ***Sheet B102***.

The contractor shall have temporary steel casing and pumps at the job site prior to construction of drilled piers. Groundwater should be anticipated during drilling operations; therefore, the above information should be provided in the contract documents as foundation notes. ***It should be assumed that approximately 100 percent of all piers will have to be cased to at least 50 feet below existing grade. If the stated bearing elevations do not reveal the***

bearing material, the Contractor shall coordinate with the Contracting Officer's representative. Final pier depths shall be subject to approval in the field by the Contracting Officer's representative.

Drilling equipment should be of suitable type and of sufficient size to satisfactorily perform the required drilling for the soil conditions identified. To this end, all drill rigs shall have a 6-inch Kelly bar and be capable of producing minimum torque and crowd capacities of 50,000 lb-ft and 30,000 lb-ft, respectively.

The Design-Build Contractor shall edit the drilled pier specification and add foundation notes to include the above criteria and requirements for drilled pier construction.

(b) Reinforced Concrete Ribbed Mat Slab and Reinforced Concrete Flat Mat Slab. The proposed Training Support Center can be supported on either a reinforced concrete ribbed mat slab or flat mat slab foundation system as an alternative to a deep foundation system consisting of reinforced concrete drilled and underreamed piers. However, as stated above, a reinforced concrete drilled and underreamed pier foundation system shall be permitted only if column loads of at least 200 kips can be achieved; if column loads of this magnitude cannot be achieved, a reinforced concrete ribbed or flat mat slab foundation system, as specified herein, shall be the only approved foundation systems. ***The mat slabs shall be conventionally reinforced – POST-TENSIONED SLABS ARE NOT ALLOWED.*** Based on the plasticity level of the near surface clayey and gravelly soils, the mat slabs shall be analyzed and designed for 1.0 inch of long-term differential movement. For this reason, interior ribs for ribbed mat slabs shall be spaced no further than 15 feet center-to-center, and diagonal stiffener ribs shall be placed at each corner of the mat slab. Design of the mat slabs shall meet the minimum requirements as presented in ***CESWD-ED-TS/G Criteria Letter, dated 29 January 1988 – Design Criteria for Ribbed Mat Foundations, SWDED-G Criteria Letter, dated 16 April 1987 – Criteria for Developing Geotechnical Design Parameters for SWD Ribbed Mat Design Methodology***, and the recommendations and requirements provided herein.

Interior and exterior beams for ribbed mat slabs should bottom a minimum of 24 inches below outside finished grade. An allowable bearing capacity of 2.0 ksf (net) shall be used to size the beams. For this phase of design, it should be noted that (1) the structural load is supported solely on the beam and the beam intersections, (2) load transfer occurs over the effective beam width, and (3) the beam and soil remain in contact. Beam intersections should be widened at column locations to accommodate the above allowable bearing value for the anticipated load condition. The load used to size the beams shall consist of full dead load plus that portion of the live load that acts more or less continuously, usually 50 percent.

The ribbed mat slab foundations shall incorporate adequate stiffness such that the deformations do not exceed the structural tolerance of any elements in the foundation or superstructure. Analyses shall consider a vertical separation of the foundation slab and beams from the subgrade of 1.0 inch at the outside of all perimeter beams, with loss of support beneath the foundation over a horizontal distance of not less than 6.5 feet. This loss of support condition corresponds to the **center lift mode**. Additionally, **edge lift analyses** shall consider an edge moisture variation distance equal to 3.0 feet, and an edge lift heave of 1.0 inch should be used in the design of the ribbed mat slab. This edge lift heave corresponds to an applied structural pressure of 100 psf. For edge lift considerations, two additional combinations of pressure and swell are required. For an allowable bearing capacity of 2.0 ksf, an edge lift heave of 0.75-inch can be expected to occur. At an ultimate bearing capacity of 6.0 ksf, 0.50-inch of heave should be anticipated. It should be noted that these anticipated heave amounts are based on the removal of a minimum of 6.0 feet of existing materials under building floor slabs and replacement with compacted nonexpansive fill, as required herein. If additional soils investigations, testing, and analyses show that a more stringent design is required to successfully mitigate total and differential movements due to settlement and/or heave, the foundation shall be designed accordingly.

A modulus of subgrade reaction equal to 200 psi/inch shall be used when analyzing the ribbed mat slabs to determine in-service deformations. This value, however, shall be factored

to account for width effects such that $k_{design}=k_1/(B_{eff})$, where B_{eff} is the effective beam width in feet. Design of the ribbed mat slabs may use the *SWD-AEIM* sections as a minimum stiffness "first approximation".

A flat mat shall have a uniform thickness of not less than 2.5 feet. An allowable bearing capacity of 2.0 ksf (net) shall be used to size the mat foundation. The mat should be tapered as required to ensure the perimeter of the slab extends to a constant elevation and is at least 24 inches below outside finish grade. Flat mat slabs also shall incorporate adequate stiffness such that the deformations do not exceed the structural tolerance of any element of the foundations or superstructures nor cosmetic cracking of interior and exterior finishes. Control joints/panels shall be incorporated within interior finishes and exterior facades to help control potential cracking due to slab movements. The load used to size the flat mat slab shall consist of full dead load plus that portion of the live load that acts more or less continuously, usually 50 percent.

The mat slabs will, by design, be supported on-grade. A polyethylene vapor barrier (10-mil minimum thickness) and a minimum 6-inch capillary water barrier should be placed beneath the mat slab.

(c) Small Support-type Structures. Small (≤500 GSF) support-type structures (if applicable) can be supported on a reinforced concrete slab-on-grade with turned-down edge beam foundation. The turned-down edge beam should extend a minimum of 12 inches below outside finished grade, and can be sized for a safe bearing pressure of 2,000 psf (net). Subgrade preparation should consist of removing at least 6.0 feet of existing materials within the building footprint, and replacing with at least 6.0 feet of compacted non-expansive fill. Any additional fill required to achieve the final subgrade elevation below the floor slab system shall be nonexpansive material as well. The upper 6 inches of existing subgrade exposed after excavation operations, or cleared prior to fill placement shall be scarified, moistened, manipulated, and recompacted to the same density required for nonexpansive fill materials. Nonexpansive fill shall be placed in controlled lifts not exceeding 8 inches in loose

thickness and compacted to at least 95 percent of laboratory maximum density (in accordance with ASTM D 1557).

(2) Ground-Level Floor Slab System. If a reinforced concrete drilled and underreamed pier foundation system is used for the Training Support Center, ground-level floor slabs within Training Support Center shall be supported above a minimum **12-inch** void or crawl space. The void area shall be protected with concrete retainer blocks as shown in the latest edition of the SWD-AEIM. The bottom of all grade beams and floor slabs shall be formed with carton forms to provide the 12-inch void. Stoops, porches, approaches, etc. shall also be structurally-supported to compensate for the active subgrade. The underfloor area shall be sloped to collection points and drained using sumps and pumps. Swales shall drain away from pier column locations such that ponded water never occurs adjacent to piers. The mat slab systems, if used for the Training Support Center, will, by design, be supported on-grade.

(3) Subgrade Preparation and Fill Requirements.

(a) Reinforced Concrete Drilled and Underreamed Pier Foundation/Structurally-Supported Floor Slabs (IF USED). The following subgrade preparation and fill requirements shall apply for the Training Support Center if a reinforced concrete drilled and underreamed pier foundation system with structurally-supported floor slabs is used. For portions of the building pad that will be in a fill section, subgrade preparation for Training Support Center shall consist of removing the upper 12 inches of existing materials and replacing with a compacted select backfill. Any additional fill required to raise the subgrade to the final elevation(s) below the building floor slab system shall be select material as well. Select fill should be placed in controlled lifts not exceeding 8 inches in loose thickness and compacted to at least 90 percent of laboratory maximum density as determined in accordance with ASTM D 1557. For portions of the building pad that will be a cut section, subgrade preparation should consist of removing all existing materials to a depth that allows a minimum 12-inch void to be formed below the floor slab system. The upper 6 inches of existing subgrade exposed after cut and/or fill operations shall be scarified,

moistened, and recompacted to the same density required for select fill.

(b) Reinforced Concrete Ribbed Mat Slab and Reinforced Concrete Flat Mat Slab (IF USED). For ribbed mat and flat mat slab foundations (if used), the upper 6.0 feet (minimum) of existing soils within the Training Support Center building footprint shall be removed and replaced with compacted nonexpansive backfill, which should limit the magnitude of predicted movement to approximately 1 inch or less. Any additional fill required to achieve the final subgrade elevation below the floor slab system shall be nonexpansive material as well. The upper 6 inches of existing subgrade exposed after excavation operations, or cleared prior to fill placement shall be scarified, moistened, manipulated, and recompacted to the same density required for nonexpansive fill materials. Nonexpansive fill shall be placed in controlled lifts not exceeding 8 inches in loose thickness and compacted to at least 95 percent of laboratory maximum density (in accordance with ASTM D 1557).

If additional investigations and/or analyses by the Design-Build Contractor's geotechnical firm indicate greater movements or more stringent requirements of mat stiffness are warranted, the mat shall be designed accordingly.

Based on previous experience, if nonexpansive fill is placed outside the limits of the building footprint, the relatively higher permeability of the nonexpansive fill will allow moisture to infiltrate to the highly expansive soils adjacent to and beneath the foundation, potentially resulting in heave of the foundation. To limit moisture penetration to the area around and beneath the foundation, excavated areas beyond the limits of the building footprint shall be backfilled with select clay backfill materials. This select clay cap shall be a minimum of 2 feet in thickness and shall extend from the building perimeter to the limits of the excavation (completely capping/covering the compacted nonexpansive fill). Select clay backfill materials should be compacted to at least 92 percent of laboratory maximum density (with all other subgrade preparation and fill placement requirements being the same as those for nonexpansive fill).

(4) Material Testing Requirements. Testing shall be the responsibility of the contractor to ensure that the subgrade, fill, and backfill materials are properly compacted. To this end, the Design-Build Contractor shall comply with the minimum testing frequencies specified in the RFP.

(5) Below-Grade Structures (Including Retaining Walls) (IF USED). The following parameters are provided for the design of all below-grade structures (including retaining wall construction), if used. For the high plasticity clay and badly weathered clay shale, an at-rest lateral earth pressure coefficient (K_o) of 0.7, an active earth pressure coefficient (K_a) of 0.7, an angle of internal friction (ϕ) of 10°, a cohesion value (c) of 100 psf, and an allowable bearing capacity of 2,000 psf shall be used. For cohesionless granular backfill placed behind retaining wall(s), an angle of internal friction (ϕ) of 30° should be used. The clay, clay shale, and backfill material should be assumed to have a moist unit weight of 125 lb/ft^3. All backfill shall be nonexpansive or select material. Drainage and backfill zoning details for below-grade wall (and retaining wall) construction are shown on ***Sheet B102*** (Below-Grade Wall Backfill Details). The Design-Build Contractor's retaining wall analyses and designs shall also account for surcharge loadings (e.g., due to vehicular traffic) where applicable.

(6) Drainage Conditions. Proper site drainage is imperative to ensure satisfactory long-term foundation performance. Exterior grading adjacent to the building shall be sloped away from the structure a minimum of 5 percent for the first 10 feet. Runoff from the roofs shall be adequately discharged away from foundation edges. In no case should water be allowed to pond adjacent to or beneath the building, both during and after construction.

(7) Care of Water. Drainage of ground and surface water from the project site continually throughout the construction contract is essential. The contractor shall be required to protect the excavation and all constructed work throughout the life of the contract by means of ditches, berms, sumps with pumps, and any other means required to continually and

effectively remove water from the site at all times. Ponding of water in the excavation or around the piers is unacceptable at any time. In addition, site excavations to include the crawl space excavation (if used), utility trenching, grading, and retention basins shall be constructed so as not to supply water directly or indirectly to the building or underlying active clay shale via the pervious gravel stratum. Such exposure of the underlying clay shale primary to surface runoff during construction could extend the active zone (via fractures) to much greater depths within the clay shale. This would activate these highly expansive materials and result in expansion pressures on the foundation elements that could create distress on the structural system of the facility. ***These requirements shall be reflected in the specifications and in the structural notes.***

The designer shall grade the site to ensure positive drainage of all water away from the structure. Underfloor areas, including crawl spaces (if used), beneath structurally-supported floor slabs shall be graded to collect water and carry it to sumps. The sumps shall drain by gravity or be equipped with automatic pumps to direct the water to the storm drainage system. Sumps shall be located at least 10 feet away from any pier in the underfloor area/crawlspace.

(8) Mechanical Connections. All exterior mechanical connections should be of the flexible type. Flexible connections shall be capable of resisting a minimum of 4 inches of both vertical and horizontal movement. All mechanical/structural connections between slabs on grade and structurally supported units or building perimeter entry/exit points must be designed and constructed to handle up to 4 inches of vertical movement. All condensate lines shall drain away from foundation edges. It is recommended that below-grade utility lines connecting to the buildings be aligned under the centerline of the respective building footprints. The use of exterior lines connecting to the buildings by numerous utility trenches is discouraged, as this would create high permeability pathways for moisture to gain access to, and activate, the expansive clay and clay shale materials within the building footprint.

(9) Backfill Adjacent to Exterior Grade Beam Excavation. Use select clay backfill adjacent to exterior grade beam excavation to minimize water penetration to expansive subsoils. Reference below-grade wall backfill details shown on Sheet B102.

(10) Foundation Material Definitions.

(a) Satisfactory Materials. Satisfactory materials include materials classified in ASTM D 2487 as GW, GM, GC, GP, SW, SP, SM, SC, CL, and CH and shall be free of trash, debris, roots or other organic matter, or stones larger than 3 inches in any dimension.

(b) Unsatisfactory Materials. Unsatisfactory materials include materials classified in ASTM D 2487 as Pt, OH, OL, ML, MH and any other materials not defined as satisfactory.

(c) Nonexpansive Soils. Nonexpansive soils should meet the requirements of Texas Department of Transportation Standard Specification for Base Course, Item 247, Type A, Grade 1 or 2, with plasticity index of not less than 4 percent nor greater than 12 percent when tested in accordance with ASTM D 4318.

(d) Select Soils. Select soils are satisfactory material having a liquid limit of 35 percent or less and a plasticity index not less than 8 nor greater than 18 when tested in accordance with ASTM D 4318.

(e) Select Clay Backfill. Select clay backfill shall be a satisfactory material having a liquid limit of 35 percent or less, and a plasticity index of not less than 8 nor greater than 20 when tested in accordance with ASTM D 4318, and classifying as a CL in accordance with ASTM D 2487.

(f) Cohesionless and Cohesive Materials. Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic.

(g) Capillary Water Barrier. Capillary Water Barrier shall consist of clean, crushed, nonporous rock, crushed gravel, or uncrushed gravel. The maximum particle size shall be 1.5 inches and no more than 2 percent by weight shall pass the 3/16-inch size (No. 4) sieve.

The Design-Build Contractor shall utilize and comply with above material definitions, subgrade preparation procedures, and material testing requirements.

(11) Instrumentation. Perimeter grade beam benchmarks, as shown in the SWD-AEIM, Chapter IV (Plate S53), shall be installed around the perimeter of the Training Support Center at select pier and grade beam locations. Additional benchmarks similar in design shall be installed on select interior columns. ***Final location of the benchmarks shall be determined by CESWF-EC-DG during the development of the Design-Build Contractor's structural design.*** The benchmarks should be surveyed to the nearest $1/100^{th}$ of a foot from a permanent benchmark as soon as the forms are stripped and shall be surveyed monthly throughout the remainder of the construction contract from a permanent deep benchmark. Elevations for the benchmarks shall be supplied to the contracting officer for forwarding to CESWF-EC-DG within 7 days of completing the survey. ***A typical construction detail for the benchmarks and the benchmark installation locations shall be presented in the construction drawings***.

b. Pavement Design Recommendations and Requirements. The minimum pavement sections presented below are based on criteria contained in *UFC 3-250-01FA, UFC 3-250-18FA*, and engineering judgment. The Design-Build Contractor is responsible for developing the final pavement designs. The Design-Build Contractor shall use the subsurface conditions and laboratory testing data provided in this report, as well as his/her own supplemental subsurface investigations and testing, in accordance with the requirements specified herein, and any supplemental information regarding traffic loading conditions and requirements (beyond that provided herein) to develop the final pavement designs. The Design-Build Contractor shall use the United Facilities Criteria (UFCs) cited herein, as well as Pavement-

Transportation Computer Assisted Structural Engineering (PCASE) software (available at ***https://transportation.wes.army.mil/triservice/pcase/*** as a free download) to develop the final pavement designs. However, **it is required that the Design-Build Contractor's final pavement sections meet (or exceed) the minimum pavement sections specified herein.**

(1) Rigid Pavement. The following minimum pavement section shall be used for loading dock aprons and for aprons for a minimum distance of 15 feet in front of trash dumpster pads. The rigid pavement design considers a modulus of subgrade reaction equal to 100 pci for the raw subgrade when compacted to 90 percent of laboratory maximum density, and a concrete flexural strength of 650 pci at 28 days.

(a) Loading Dock Aprons and Aprons in Front of Trash Dumpster Pads. The rigid pavement design is based on Category IVA Traffic and a Class F Street (DI = 4).

6" Portland Cement Concrete reinforced with No. 4 bars spaced 16 inches o.c.e.w.

6" Aggregate Base Course compacted to at least 95 percent of maximum laboratory density (ASTM D 1557)

6" Raw Subgrade compacted to at least 90 percent of maximum laboratory density (ASTM D 1557)

Reinforcement for odd-shaped slabs, joint design, joint spacing, and other details shall be in accordance with the latest edition of the SWD-AEIM and UFC 3-250-01FA, where applicable. The reinforcement bars shall be placed a minimum of 1.5 inches clear distance from the surface of the pavement.

(2) Flexible Pavement. The following minimum pavement sections shall be used for service drives and for the POV parking area. The flexible pavement designs consider a CBR value of 4 percent for the raw subgrade when compacted to 90 percent of laboratory maximum density.

(a) Service Drives. The design is based on Category IVA Traffic and a Class F Street (DI=4).

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER

2" Hot-Mix Surface Course

6" Aggregate Base Course compacted to at least 100 percent of maximum laboratory density (ASTM D 1557)

6" Lime-Stabilized Subgrade compacted to at least 95 percent of maximum laboratory density (ASTM D 1557)

6" Lime-Stabilized Subgrade compacted to at least 95 percent of maximum laboratory density (ASTM D 1557)

6" Raw Subgrade compacted to at least 90 percent of maximum laboratory density (ASTM D 1557)

(b) POV Parking Areas. The design is based on Category II Traffic and a Class E Street (DI=2).

1.5" Hot-Mix Surface Course

8" Aggregate Base Course compacted to at least 100 percent of maximum laboratory density (ASTM D 1557)

6" Lime-Stabilized Subgrade compacted to at least 95 percent of maximum laboratory density (ASTM D 1557)

6" Raw Subgrade compacted to at least 90 percent of maximum laboratory density (ASTM D 1557)

The following notes should be incorporated as part of the pavement details shown on the contract drawings.

"1. The moisture content shall be at least 1 percent above optimum during compaction of the raw subgrade."

A 6-inch thick (compacted thickness; loose thickness shall be no greater than 8 inches) layer of lime-stabilized subgrade, compacted to at least 95 percent of maximum laboratory density (in accordance with ASTM D 1557) can be used beneath the aggregate base course layer (and above the compacted raw subgrade) for rigid pavements. ***Lime-stabilized subgrades shall extend well beyond pavement borders to help mitigate moisture changes in the***

underlying subgrade. The designer shall establish this distance, but in no case shall it be smaller than 2 feet from the back of the curb.

(3) Pavement Material Definitions.

(a) Portland Cement Concrete. The maximum nominal size coarse aggregate shall be 1.5 inches, and the mixture shall be designed to attain a flexural strength of 650 psi at 28 days, as determined by tests made in accordance with ***ASTM C 78*** of beams fabricated and cured in accordance with ***ASTM C 192/C 192M***. Cementitious admixtures shall be limited to Class F fly ash; Class C fly ash shall not be used.

(b) Hot-Mix Surface Course (50 Blow Mix). Aggregates and asphaltic materials shall conform to the requirements of the Texas Department of Transportation, Standard Specifications for Construction of Highways, Streets and Bridges, (TXDOT, Std Spec), Items 300 and 340. The paving mixture shall conform to the requirements for Type "D" (Fine-Graded surface course) grading. Asphaltic material for the paving mixture should be asphaltic cement, viscosity grade AC-20, or performance grade PG64-22. The specifications shall incorporate the above requirements for Hot-Mix Surface Course**.**

(c) Prime and Tack Coats. Asphaltic material for the prime coat shall be cut-back asphalt, grade MC-30, conforming to the requirements of TXDOT, Std Spec, Item 300, Asphalts, Oils, Emulsions. Prime coat should be applied to the surface of the aggregate base coarse. Asphaltic material for the tack coat shall be cut-back asphalt, grade RC-250, or emulsified asphalt, grade SS-1, conforming to the requirements of TXDOT, Std Spec, Item 300, Asphalts, Oils, Emulsions. Tack coat should be applied to all surfaces that contact new asphalt pavement. The specifications shall incorporate the above requirements for Prime and Tack Coats.

(d) Aggregate Base Course. Aggregates shall conform to the requirements presented herein. The gradation should conform to the requirements of TXDOT, Std Spec, Item 247, for Type "A", Grade 1 Material with a plasticity index not greater than 10. Aggregates shall not show more than 50 percent loss when subjected to the Los Angeles

abrasion test in accordance with ASTM C 131. The amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the piece. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve.

(e) Raw Subgrade. Material should conform to the requirements of Satisfactory Materials, as specified herein.

(f) Lime-Stabilized Subgrade. The material shall consist of a mixture of raw subgrade and hydrated lime. The application rate of lime should be 6 percent by dry weight of the raw soil.

(4) Vehicular Pavement Material Testing Requirements. Testing shall be the responsibility of the contractor to ensure that the subgrade, aggregate base course, lime-stabilized subgrade, and Portland cement concrete are properly constructed. To this end, the following testing requirements shall be included in the contract specifications as a minimum:

- In-place density testing of the subgrade, aggregate base course, and lime-stabilized subgrade shall be performed, at a minimum, every 600 square yards per lift in accordance with ASTM D 1556 and ASTM D 2922. ASTM D 1556 shall be used as a check at least once per lift for each 3,000 square yards of completed subgrade, aggregate base course, and lime-stabilized subgrade.

- Before starting work, at least one sample of aggregate base course material and lime-stabilized subgrade shall be tested in accordance with ASTM C 136. After the initial test, a minimum of one sieve analysis (ASTM C 136 and ASTM D 422) shall be performed for each 1,000 tons of aggregate base course and lime-stabilized subgrade placed, with a minimum of one analysis performed for each day's run until the course is completed. One liquid limit and plasticity index shall be performed for each sieve analysis per ASTM D 4318

- Wear tests shall be performed in accordance with ASTM C 131. A minimum of one test per aggregate base course material source shall be run.

- Thickness of the aggregate base course and lime-stabilized subgrade shall be measured for each 600 square yards of material placed. Compacted thickness of the aggregate base and lime-stabilized subgrade shall be as presented in this report and the completed section shall be within 3/8-inch of the thickness presented.

- Hot Bin gradations for the asphalt wearing course shall be tested in accordance with ASTM C 136 and ASTM C 117. A minimum of one test shall be conducted. Marshall specimens shall be taken in accordance with methods described in AI MS-2. At least two sets of specimens shall be taken. Asphalt extractions shall be performed in accordance with ASTM D 2172, Method A or B. At least one asphalt extraction shall be conducted. Field density tests shall be conducted in accordance with ASTM D 2950. One test shall be conducted for each 300 square yards of pavement placed. The mat density shall be 97.5 to 100.5 percent and the joint density shall be 95.5 to 100.5 percent of the density obtained from laboratory-compacted specimens. Thickness measurements shall be taken at a minimum of one measurement for each 1,000 square yards of pavement placed.

- The Job Mix Formula for the bituminous mixture shall be furnished to the Contraction Officer for approval. The formula will indicate the percentage of each stockpile and mineral filler, the percentage of each size aggregate, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. The Contractor shall file with the Contracting Officer certified delivery tickets for all aggregates and bituminous materials actually used in construction. The finished mixture shall be designed using procedures contained in AI MS-2 and the criteria shown below.

Test Property	50 Blows
Stability (minimum), lbs	500
Flow (maximum), 1/100-inch	8-18
Air Voids, percent	3% to 5%
Percent Voids in mineral aggregate	14
TSR, minimum percent	75

- The contractor shall be responsible for the development of the mixture proportion study for cementitious materials and chemical admixtures. The concrete mix design shall include a statement giving the maximum nominal coarse aggregate size and the proportions of all ingredients that will be used in the manufacture of concrete at least 60 days prior to commencing concrete operations. Trial design batches, mixture proportioning studies, and testing requirements shall be the responsibility of the Contractor. Strength requirements shall be based on flexural strength. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in ACI 211.1, modified as necessary to accommodate flexural strength. The maximum water-cementitious material ratio is 0.45. Coarse and fine aggregates shall have a satisfactory service record of at least 5 years successful service in three paving projects, or if a new source is used,

shall meet the requirements when tested for resistance to freezing and thawing. Coarse and fine aggregates not having a satisfactory demonstrable service record shall have a durability factor of 50 when subjected to freezing and thawing in concrete in accordance with COE CRD-C 114 (Test Method for Soundness of Aggregates by Freezing and Thawing of Concrete Specimens).

- Smoothness measurements shall be taken in successive positions parallel to the pavement (flexible and rigid) centerline with a 12-foot straightedge. Measurements shall be taken perpendicular to the pavement (flexible and rigid) centerline at 15-foot intervals. Surface smoothness shall not exceed 3/8-inch.

c. Requirements for the Design-Build Contractor's Foundation and Pavement Design Analysis. The successful proposer shall provide a Foundation and Pavement Design Analysis after contract award. ***The geotechnical firm responsible for the geotechnical design shall have demonstrated successful performance in design of at least five (5) projects of similar type and scope in expansive soil environments in Texas.*** The Foundation and Pavement Design Analysis (Report) shall include a description of the project, including a discussion of any unusual features of the project, a discussion for each structure that requires a foundation system, and a discussion of each pavement type.

(1) **Foundation System.** ***The foundation system selected for the Training Support Center shall be limited to reinforced concrete drilled and underreamed piers, a reinforced concrete ribbed mat slab, or a reinforced concrete flat mat slab foundation system, designed and constructed in accordance with the requirements, recommendations, and design parameters provided in this report.***

(2) **Floor Slab System and Subgrade Preparation.** ***The Design-Build Contractor shall comply with the floor slab system, subgrade preparation, and fill requirements specified in this report. If the Training Support Center is founded on reinforced concrete drilled and underreamed piers, ground-level floor slabs (and grade beams) for the Training Support Center shall be structurally-supported above a minimum 12-inch void. Slab-on-grade construction of ground-level floor slabs shall not be permitted for the Training Support Center if a drilled and underreamed pier foundation system is used. If the Training Support Center is founded on a reinforced concrete ribbed or flat mat***

foundation system, the mat slab foundations will, by design, be supported on-grade. Excavation/removal of existing soil, compaction requirements for the raw subgrade, fill, and backfill materials, and foundation and pavement material definitions shall be as specified herein. Compaction shall be in accordance with the modified Proctor method (ASTM D 1557).

(3) **Pavement Sections.** The Design-Build Contractor shall provide separate subparagraphs for each pavement structure included in the project, ***using the pavement sections provided in this report as minimum sections***. The Design-Build Contractor shall use the UFCs cited herein and PCASE pavement design software to develop the final pavement designs, and shall present PCASE design output data tables in their report documentation for review by the Government. Each pavement design shall include as a minimum the following items: traffic types, road classifications and design indexes; subgrade strength values (CBR and modulus of subgrade reaction values for the specified compactive effort); pavement material thicknesses and compaction requirements; and concrete flexural strength for designated time frame.

(4) Exhibits to be Included in the Design-Build Contractor's Foundation and Pavement Design Analysis. The following exhibits shall be included in the Design-Build contractor's Foundation and Pavement Design Analysis. The Design-Build contractor may use the information provided in this report to partially satisfy these requirements, but shall supplement the information provided herein with additional subsurface drilling and testing, as described in the first paragraph of Section 5 of this report. Required exhibits to be included with the Design-Build contractor's Foundation and Pavement Design Analysis include:

- Site Plan with Boring Locations and Legend;
- Boring Logs;
- Plasticity Chart;
- Standard Penetration Tests versus Depth of Boring (if applicable);
- Moisture Content versus Depth (Chart);
- Moisture Content-Liquid Limit-Plastic Limit versus Depth (Chart);

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER

- Strength Tests Results versus Depth (Chart);
- Tabulation of Laboratory Test Results (to include Boring Number, Sample Number, Depth, Laboratory Classification, Visual Descriptions, Grain Size Analysis (%Gravel, %Sand, %Fines), LL, PL, PI, MC, Unit Weight, and Strength Test Data;
- Consolidation-Expansion Tests/Swell Pressure Tests (if applicable).

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER

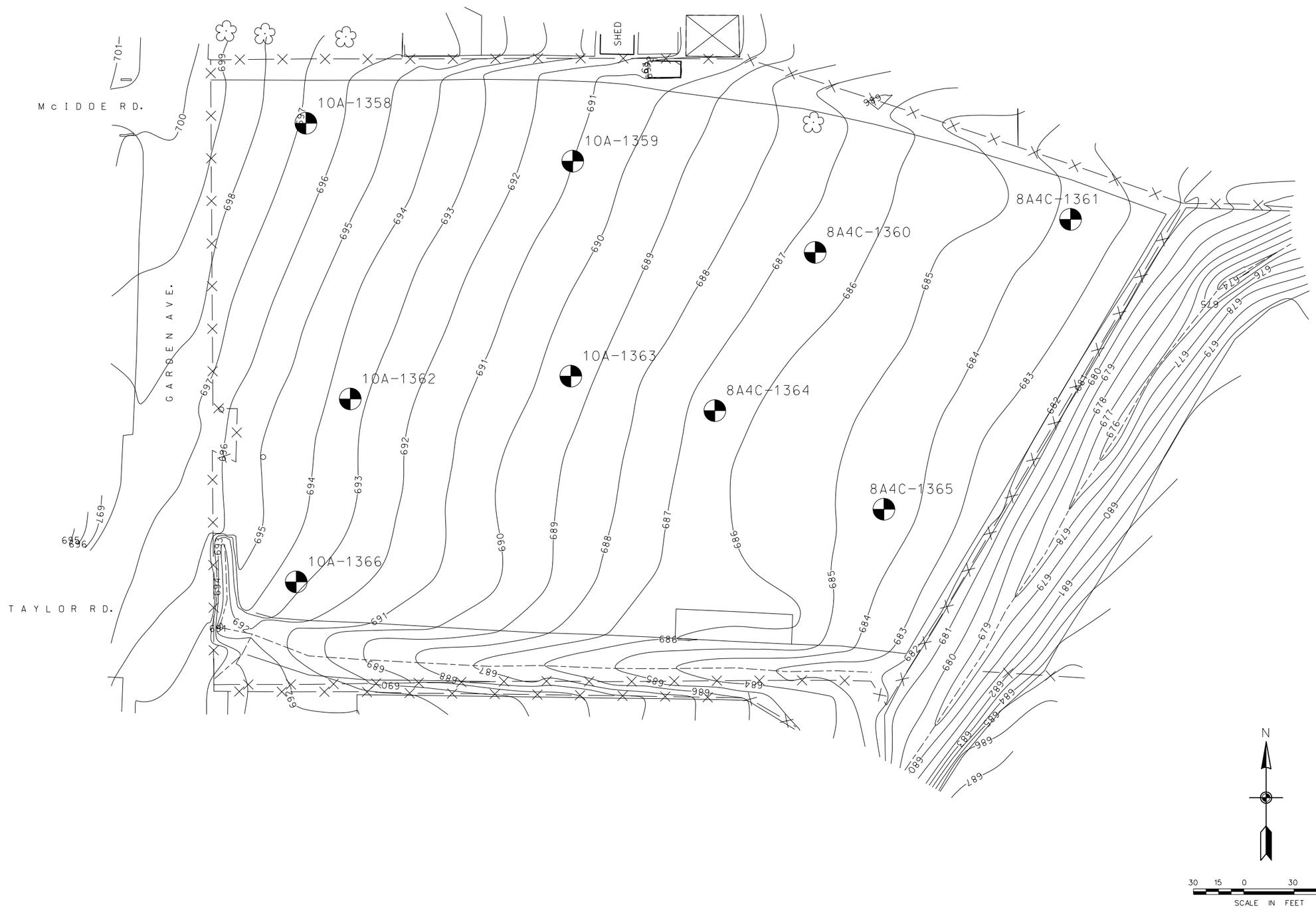
References:

- TEAM Consultants, Incorporated Report No. 092131
- UFC 3-220-03FA – Soils and Geology Procedures for Foundation Design of Buildings and Other Structures (Except Hydraulic Structures)
- UFC 3-220-07 – Foundations in Expansive Soils
- UFC 3-250-01FA – Pavement Design for Roads, Streets, Walks, and Open Storage Areas
- UFC 3-250-18FA – General Provisions and Geometric Design For Roads, Streets, Walks, and Open Storage Areas
- CESWD-ED-TS/G Criteria Letter, dated 29 January 1988 – Design Criteria for Ribbed Mat Foundations
- SWDED-G Criteria Letter, dated 16 April 1987 – Criteria for Developing Geotechnical Design Parameters for SWD Ribbed Mat Design Methodology
- Texas Department of Transportation - Standard Specifications For Construction of Highways, Streets and Bridges
- SWD-AEIM Architectural-Engineering Manual
- UFGS Guide Specifications For Construction

FORT WORTH DISTRICT
FEBRUARY 2010

APPENDIX A

BORING LOCATIONS & LOGS OF BORINGS



NOTE: USE THIS SHEET FOR BORING LOCATIONS ONLY.

US Army Corps of Engineers
Fort Worth District

Symbol	Description	Tracking No.	Action	Date

Designed by: J. PICKERING
Dwn by: J. PICKERING
Reviewed by: K. McCLESKEY
Submitted by: RAMANUJA C. KANNAN, P.E., CHIEF, GEOTECHNICAL SECTION
Date: FEB 2010
Sol No.
Contr No.
Rev.
File name:
Plot date: $$date$$
Plot scale:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION ENGINEERING BRANCH

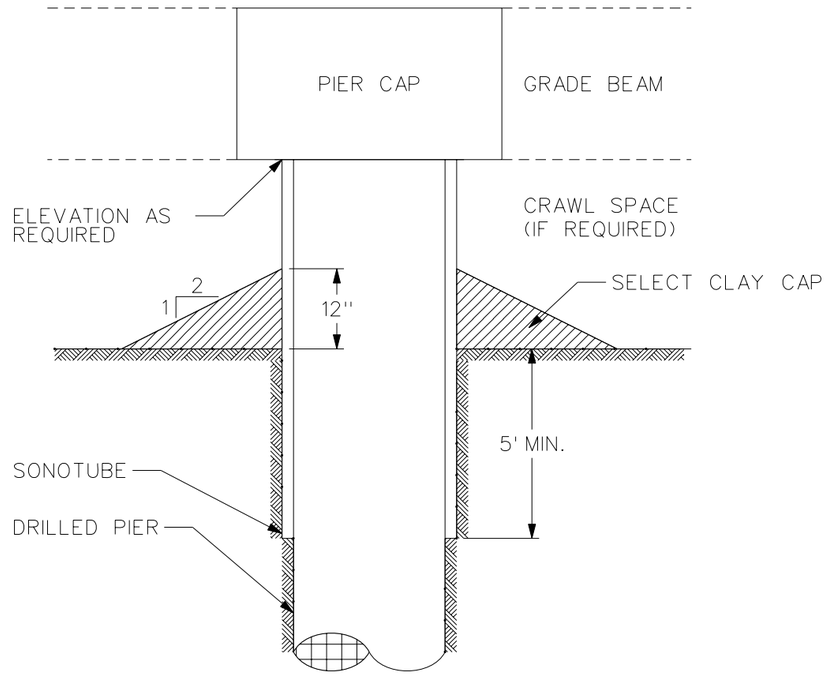
FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER
PN: 071116

BORING LOCATIONS

Sheet reference number:
B101

DESIGN FILE: $$cadd file name$$

Contr No.



SONOTUBE FORMING AND CLAY CAP DETAILS

NOT TO SCALE

NOTE: REFER TO THE GOVERNMENT GEOTECHNICAL REPORT FOR SELECT CLAY FILL MATERIAL DEFINITIONS AND REQUIREMENTS, AND FOR COMPLETE FILL AND SUBGRADE PREPARATION MINIMUM REQUIREMENTS.

US Army Corps of Engineers
Fort Worth District

Symbol	Tracking No.	Action	Date

Date: FEB 2010
Sol No. ---
Contr No. ---
Rev. --
File name:
Plot date: $$date$$
Plot scale:

Designed by: J. PICKERING
Dwn by: J. PICKERING
Reviewed by: K. McCLESKEY
Submitted by: RAMANUJA C. KANNAN, P.E. CHIEF, GEOTECHNICAL SECTION

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION ENGINEERING BRANCH

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER
PN: 071116

SONOTUBE FORMING AND CLAY CAP DETAILS

Sheet reference number:
B102

Contr No. ---

DESIGN FILE: $$cadd file name$$

$$time$$
$$date$$
$$user$$
$$cadd file name$$

REFERENCE FILES:
$$REFERENCEFILE10$$
$$REFERENCEFILE11$$
$$REFERENCEFILE12$$
$$REFERENCEFILE13$$
$$REFERENCEFILE14$$
$$REFERENCEFILE15$$
$$REFERENCEFILE5$$
$$REFERENCEFILE6$$
$$REFERENCEFILE7$$
$$REFERENCEFILE8$$
$$REFERENCEFILE9$$
$$REFERENCEFILE1$$
$$REFERENCEFILE2$$
$$REFERENCEFILE3$$
$$REFERENCEFILE4$$

Hole No. 10A-1358

DRILLING LOG	DIVISION SWD	INSTALLATION FORT WORTH DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT TRAINING SUPPORT CENTER		10. SIZE AND TYPE OF BIT 6" AUGER	
2. LOCATION (Coordinates or Station) FORT SAM HOUSTON, TEXAS		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USACE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) 10A-1358		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2	UNDISTURBED 0
5. NAME OF DRILLER SALIK		14. TOTAL NUMBER CORE BOXES 0	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER DRY	
		16. DATE HOLE: STARTED 15 DEC 09	COMPLETED 15 DEC 09
7. THICKNESS OF OVERBURDEN 6.3'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK 3.7'		18. TOTAL CORE RECOVERY FOR BORING N/A %	
9. TOTAL DEPTH OF HOLE 10.0'		19. SIGNATURE OF INSPECTOR BOB MCVEY	

% MOISTURE CONTENT (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOV-ERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
		VISUAL	0.0' TO 0.15' - ASPHALT.			JAR SAMPLES
34.4			0.15' TO 0.5' - BASE GRAVEL - COARSE TO FINE, DAMP, RED BROWN TO BROWN, VERY SANDY.		A	A. 0.5' TO 6.3'
			0.5' TO 6.3'			B. 6.3' TO 10.0'
24.6	10		CLAY - HIGH PLASTICITY, STIFF, MOIST, BLACK TO VERY DARK BROWN, SLIGHTLY SANDY TO GRAVELLY.		B	
			6.3' TO 10.0'			
			SHALE - WEATHERED YELLOW BROWN TO LIGHT GRAY, MOSIT, VERY SOFT (ROCK CLASSIFICATION), SILTY TO SANDY, BLOCKY.			
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT TSC, FSH | HOLE NO. 10A-1358

Hole No. 10A-1359

DRILLING LOG	DIVISION SWD	INSTALLATION FORT WORTH DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT TRAINING SUPPORT CENTER		10. SIZE AND TYPE OF BIT 6" AUGER	
2. LOCATION (Coordinates or Station) FORT SAM HOUSTON, TEXAS		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USACE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) 10A-1359		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2	UNDISTURBED 0
5. NAME OF DRILLER SALIK		14. TOTAL NUMBER CORE BOXES 0	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER DRY	
		16. DATE HOLE: STARTED 15 DEC 09	COMPLETED 15 DEC 09
7. THICKNESS OF OVERBURDEN 5.6'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK 4.4'		18. TOTAL CORE RECOVERY FOR BORING N/A %	
9. TOTAL DEPTH OF HOLE 10.0'		19. SIGNATURE OF INSPECTOR BOB MCVEY	

% MOISTURE CONTENT (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOV-ERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
		VISUAL	0.0' TO 0.15' - ASPHALT.			JAR SAMPLES
38.0			0.15' TO 0.6' - BASE GRAVEL - COARSE TO FINE, DAMP, BROWN, SANDY AND CLAYEY.		A	A. 0.6' TO 5.6'
			0.6' TO 5.6'			B. 5.6' TO 10.0'
25.7	10		CLAY - HIGH PLASTICITY, STIFF, MOIST, BLACK, SLIGHTLY SANDY TO GRAVELLY.		B	
			5.6' TO 10.0'			
			SHALE - WEATHERED TO A VERY STIFF TO HARD CLAY CONSISTENCY. POSSIBLY REWORKED 5.6' TO 9.0', GOOD BLOCKY STRUCTURE AFTER 9.0', MOIST, YELLOW BROWN AND LIGHT GRAY, SILTY.			
	20					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT TSC, FSH | HOLE NO. 10A-1359

Hole No. 8A4C-1360

DRILLING LOG	DIVISION SWD	INSTALLATION FORT WORTH DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT TRAINING SUPPORT CENTER		10. SIZE AND TYPE OF BIT SEE REMARKS	
2. LOCATION (Coordinates or Station) FORT SAM HOUSTON, TEXAS		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USACE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) 8A4C-1360		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0	UNDISTURBED 2
5. NAME OF DRILLER SALIK		14. TOTAL NUMBER CORE BOXES 0	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER SEE REMARKS	
		16. DATE HOLE: STARTED 2 DEC 09	COMPLETED 2 DEC 09
7. THICKNESS OF OVERBURDEN 6.7'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK 58.3'		18. TOTAL CORE RECOVERY FOR BORING 98 %	
9. TOTAL DEPTH OF HOLE 65.0'		19. SIGNATURE OF INSPECTOR BOB McVEY	

% MOISTURE CONTENT (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOV-ERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
		VISUAL	0.0' TO 0.15' - ASPHALT.			DRILLING
30.1			0.15' TO 0.6' - BASE GRAVELS - COARSE TO FINE, MOIST, BROWN, SANDY.		S-1	0.0' TO 8.0' - 10" AUGER WITH 3" SHELBY PUSH, SET 9' OF 8" CASING AND CIRCULATION PAN
			0.6' TO 6.7'			8.0' TO 11.5' - CLEAN WITH AUGER
22.8			CLAY		S-2	11.5' TO 65.0' - 4" CORE CARBOLOGY BIT
	10		0.6 TO 1.0' - SUBBASE - HIGH PLASTICITY, GRAVELLY.			WATER LEVEL
			1.0' TO 6.7' - HIGH PLASTICITY, DARK GRAY GRADES TO BROWN, SLIGHTLY SANDY TO GRAVELLY.			BAILED TO 60.0' 24-HR CHECK AT 57.6' 48-HR CHECK AT 51.6' BAIL AND GROUT TO SURFACE
24.0			6.7' TO 65.0'		C-1	RESISTIVITY TEST
			SHALE			2.5' X 191.5 X ONE MULTIPLIER X 1.7 ZERO = 814 OHMS.CM
	20		6.7' TO 50.1' - WEATHERED YELLOW BROWN, LIGHT GRAY WITH STRONG BROWN AND BLACK STAINS, MASSIVE, BLOCKY STRUCTURE, SILTY TO SANDY, CALCAREOUS, HIGH ANGLE HEALED FRACTURES NOTED, GYPSUM VEINLETS BELOW 45.0', DARK GRAY SEAMS AT 48.0'.		C-2	SHELBY TUBE SAMPLES
21.9						ST-1. 1.1' TO 3.0' PENETROMETER = 3.1
						ST-2. 2.8' TO 10.0' PENETROMETER = 4.2
22.5					C-3	CARTON SAMPLES
	30		50.1' TO 65.0' - AS ABOVE, EXCEPT UNWEATHERED DARK GRAY WITH NO GYPSUM OR FRACTURES, UNCTUOUS, SLIGHTLY FOSSILIFEROUS (SHELLS).			C-1. 14.6' TO 15.5' C-2. 21.1' TO 22.0' C-3. 27.1' TO 28.0' C-4. 33.1' TO 34.0' C-5. 39.1' TO 40.0' C-6. 45.1' TO 46.0' C-7. 51.2' TO 52.0' C-8. 57.1' TO 58.0' C-9. 63.1' TO 64.0'
22.7					C-4	
	40				C-5	
20.3						
					C-6	
19.9	50					
					C-7	
17.6						
					C-8	
17.4	60					
					C-9	
18.2						
	70					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT TSC, FSH | HOLE NO. 8A4C-1360

Hole No. 8A4C-1361

DRILLING LOG	DIVISION SWD	INSTALLATION FORT WORTH DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT TRAINING SUPPORT CENTER		10. SIZE AND TYPE OF BIT SEE REMARKS	
2. LOCATION (Coordinates or Station) FORT SAM HOUSTON, TEXAS		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USACE		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) 8A4C-1361		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3	UNDISTURBED 0
5. NAME OF DRILLER SALIK		14. TOTAL NUMBER CORE BOXES 0	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 19.0'	
		16. DATE HOLE: STARTED 8 DEC 09	COMPLETED 9 DEC 09
7. THICKNESS OF OVERBURDEN 23.5'		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK 11.5'		18. TOTAL CORE RECOVERY FOR BORING 96 %	
9. TOTAL DEPTH OF HOLE 35.0'		19. SIGNATURE OF INSPECTOR BOB MCVEY	

% MOISTURE CONTENT (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOV-ERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
		VISUAL	0.0' TO 0.2' - ASPHALT.			DRILLING
36.8			0.2' TO 2.0' - BASE GRAVELS - COARSE TO FINE, MOIST, VERY CLAYEY, BLACK TO BROWN, SANDY.		A	0.0' TO 8.0' - 10" AUGER, SET 9' OF CASING AND CIRCULATION PAN
			2.0' TO 19.0'			8.0' TO 11.0' - CLEAN WITH AUGER
			CLAY			11.0' TO 19.0' - 4" CORE
31.1	10		2.0' TO 7.3' - HIGH PLASTICITY, MEDIUM STIFF, MOIST, BLACK TO DARK GRAY, SLIGHTLY SANDY AND GRAVELLY.		B	19.0' TO 26.0' - WATER-BEARING GRAVEL AT 19'; PULL CASING - 10" AUGER TO 24', SET 25' CASING AND PAN, CLEAN TO 26'
			7.3' TO 19.0' - HIGH PLASTICITY, STIFF TO VERY STIFF, MOIST, YELLOW BROWN, LIGHT GRAY AND STRONG BROWN, SANDY TO SILTY, SLIGHTLY GRAVELLY, SLIGHTLY LIMY, SOME BLOCKY STRUCTURE, REWORKED SHALE.			26.0' TO 35.0' - 4" CORE
39.4					C	NOTE: WATER AT 19.0' DURING DRILLING. BAIL AND GROUT TO SURFACE
	20					JAR SAMPLES
		VISUAL	19.0' TO 23.5'			A. 2.0' TO 7.3' B. 7.3' TO 13.0' C. 13.0' TO 19.0'
			GRAVEL/COBBLE - COARSE TO FINE, WET, YELLOW BROWN, VERY CLAYEY WITH CLAY SEAMS, SANDY, CHERT CLASTS UP TO 5.5", MEDIUM DENSE TO DENSE.		C-1	CARTON SAMPLES
23.1			23.5' TO 35.0'			C-1. 27.1' TO 28.0' C-2. 33.1' TO 34.0'
	30		SHALE - WEATHERED YELLOW BROWN, LIGHT GRAY AND STRONG BROWN, MASSIVE, BLOCKY STRUCTURE, SOFT (ROCK CLASSIFICATION), SILTY AND SANDY, CALCAREOUS, SLIGHTLY MOIST, BREAKAGE AT A 35° DIP.		C-2	
22.7						
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT TSC, FSH | HOLE NO. 8A4C-1361

NOTES:

1. USE THIS SHEET FOR BORING LOGS ONLY.
2. MOISTURE CONTENT, WHERE SHOWN, IS EXPRESSED AS PERCENT DRY WEIGHT AT TIME OF LABORATORY CLASSIFICATION.
3. LEGEND SHOWS OVERBURDEN MATERIALS CLASSIFIED ACCORDING TO ASTM D 2487 AND ASTM D 2488.
4. DESCRIPTION OF OVERBURDEN MATERIALS CHANGED TO CORRESPOND WITH LABORATORY CLASSIFICATION AS NECESSARY.
5. ORIGINAL DRILLING LOGS AVAILABLE AT CORPS OF ENGINEERS OFFICES.

US Army Corps of Engineers
Fort Worth District

Symbol	Description	Tracking No.	Action	Date

Designed by: M. SMITH	Date: FEB 2010	Rev.
Drawn by: M. SMITH	Sol No.	
Reviewed by: K. McCLESKEY	Contr No.	
Submitted by: RAMANUJA C. KANNAN, P.E. CHIEF, GEOTECHNICAL SECTION	File name: $$dat1$$ Plot date: $$dat2$$ Plot scale:	

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/ CONSTRUCTION DIVISION ENGINEERING BRANCH

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER
PN: 071116

LOGS OF BORINGS - SHEET 1 OF 2

Sheet reference number: B201

Contr No.

DESIGN FILE: $$cadd file name$$

REFERENCE FILES:
$$REFERENCEFILE1$$
$$REFERENCEFILE2$$
$$REFERENCEFILE3$$
$$REFERENCEFILE4$$
$$REFERENCEFILE5$$

$$time$$ $$date$$ $$user$$ $$cadd file name$$

DRILLING LOG — Hole No. 10A-1362

Field	Value
DIVISION	SWD
INSTALLATION	FORT WORTH DISTRICT
SHEET	1 OF 1 SHEETS
1. PROJECT	TRAINING SUPPORT CENTER
2. LOCATION (Coordinates or Station)	FORT SAM HOUSTON, TEXAS
3. DRILLING AGENCY	USACE
4. HOLE NO. (As shown on drawing title and file number)	10A-1362
5. NAME OF DRILLER	SALIK
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	6.7'
8. DEPTH DRILLED INTO ROCK	3.3'
9. TOTAL DEPTH OF HOLE	10.0'
10. SIZE AND TYPE OF BIT	6" AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 2 / UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	4.9'
16. DATE HOLE	STARTED 15 DEC 09 / COMPLETED 15 DEC 09
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	N/A %
19. SIGNATURE OF INSPECTOR	BOB MCVEY

% MOISTURE CONTENT	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
		VISUAL	0.0' TO 0.15' - ASPHALT.			JAR SAMPLES
25.0			0.15' TO 0.6' - BASE GRAVEL - COARSE TO FINE, DAMP, BROWN, CLAYEY AND SANDY.		A	A. 0.6' TO 6.7' B. 6.7' TO 10.0'
24.2	10		0.6' TO 6.7' CLAY - HIGH PLASTICITY, STIFF, MOIST, VERY DARK BROWN AND BLACK, SLIGHTLY SANDY TO GRAVELLY.		B	
	20		6.7' TO 10.0' SHALE - WEATHERED TO A VERY STIFF TO HARD CLAY CONSISTENCY, MOIST, YELLOW BROWN AND LIGHT GRAY, LIMY, SANDY AND SILTY, BLOCKY.			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: SAM HOUSTON TSC. HOLE NO.: 10A-1362

DRILLING LOG — Hole No. 10A-1366

Field	Value
DIVISION	SWD
INSTALLATION	FORT WORTH DISTRICT
SHEET	1 OF 1 SHEETS
1. PROJECT	TRAINING SUPPORT CENTER
2. LOCATION (Coordinates or Station)	FORT SAM HOUSTON, TEXAS
3. DRILLING AGENCY	USACE
4. HOLE NO.	10A-1366
5. NAME OF DRILLER	SALIK
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	9.5'
8. DEPTH DRILLED INTO ROCK	0.5'
9. TOTAL DEPTH OF HOLE	10.0'
10. SIZE AND TYPE OF BIT	6" AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 2 / UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	DRY
16. DATE HOLE	STARTED 15 DEC 09 / COMPLETED 15 DEC 09
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	N/A %
19. SIGNATURE OF INSPECTOR	BOB MCVEY

% MOISTURE CONTENT	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS
		VISUAL	0.0' TO 0.15' - ASPHALT.			JAR SAMPLES
29.6			0.15' TO 0.6' - BASE GRAVEL - COARSE TO FINE, DAMP, BROWN, SANDY AND CLAYEY.		A	A. 0.6' TO 6.2' B. 6.2' TO 10.0'
32.9	10		0.6' TO 9.5' CLAY 0.6' TO 6.2' - HIGH PLASTICITY, STIFF, MOIST, VERY DARK BROWN TO DARK BROWN, SLIGHTLY SANDY AND GRAVELLY.		B	
	20		6.2' TO 9.5' - HIGH PLASTICITY, STIFF, MOIST, YELLOW BROWN AND LIGHT GRAY WITH BLACK, SLIGHTLY SANDY AND GRAVELLY, SILTY.			
	30		9.5' TO 10.0' SHALE - WEATHERED, VERY SOFT (ROCK CLASSIFICATION), BLOCKY, SILTY, SLIGHTLY MOIST, YELLOW BROWN AND LIGHT GRAY.			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: TSC, FSH. HOLE NO.: 10A-1366

DRILLING LOG — Hole No. 10A-1363

Field	Value
DIVISION	SWD
INSTALLATION	FORT WORTH DISTRICT
SHEET	1 OF 1 SHEETS
1. PROJECT	TRAINING SUPPORT CENTER
2. LOCATION (Coordinates or Station)	FORT SAM HOUSTON, TEXAS
3. DRILLING AGENCY	USACE
4. HOLE NO.	10A-1363
5. NAME OF DRILLER	SALIK
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	9.0'
8. DEPTH DRILLED INTO ROCK	1.0'
9. TOTAL DEPTH OF HOLE	10.0'
10. SIZE AND TYPE OF BIT	6" AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 3 / UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	DRY
16. DATE HOLE	STARTED 15 DEC 09 / COMPLETED 15 DEC 09
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	N/A %
19. SIGNATURE OF INSPECTOR	BOB MCVEY

% MOISTURE CONTENT	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS
		VISUAL	0.0' TO 0.15' - ASPHALT.			JAR SAMPLES
32.8			0.15' TO 0.6' - BASE GRAVEL - COARSE TO FINE, DAMP, BROWN, CLAYEY TO SANDY.		A	A. 0.6' TO 5.5' B. 5.5' TO 6.6' C. 6.6' TO 9.0'
36.9			0.6' TO 9.0' CLAY		B	
23.4	10		0.6' TO 6.6' - HIGH PLASTICITY, MEDIUM STIFF TO STIFF, MOIST, VERY DARK BROWN, SLIGHTLY SANDY TO GRAVELLY, GRADES TO DARK GRAY.		C	
			6.6' TO 9.0' - HIGH PLASTICITY, VERY STIFF, MOIST, YELLOW BROWN AND LIGHT GRAY, SLIGHTLY SANDY TO GRAVELLY, NO STRUCTURE.			
	20		9.0' TO 10.0' SHALE - WEATHERED YELLOW BROWN, LIGHT GRAY WITH STRONG BROWN, BLOCKY, SILTY, VERY SOFT (ROCK CLASSIFICATION).			
	30					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: TSC, FSH. HOLE NO.: 10A-1363

DRILLING LOG — Hole No. 8A4C-1364

Field	Value
DIVISION	SWD
INSTALLATION	FORT WORTH DISTRICT
SHEET	1 OF 1 SHEETS
1. PROJECT	TRAINING SUPPORT CENTER
2. LOCATION (Coordinates or Station)	FORT SAM HOUSTON, TEXAS
3. DRILLING AGENCY	USACE
4. HOLE NO.	8A4C-1364
5. NAME OF DRILLER	SALIK
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	6.5'
8. DEPTH DRILLED INTO ROCK	28.5'
9. TOTAL DEPTH OF HOLE	35.0'
10. SIZE AND TYPE OF BIT	SEE REMARKS
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 1 / UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	SEE REMARKS
16. DATE HOLE	STARTED 5 DEC 09 / COMPLETED 6 DEC 09
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	94 %
19. SIGNATURE OF INSPECTOR	BOB MCVEY

% MOISTURE CONTENT	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS
		VISUAL	0.0' TO 0.2' - ASPHALT.			DRILLING 0.0' TO 8.0' - 10" AUGER, SET 9' OF CASING AND CIRCULATION PAN 8.0' TO 11.0' - CLEAN WITH AUGER 11.0' TO 35.0' - 4" CORE
32.8			0.2' TO 1.0' - BASE GRAVELS - COARSE TO FINE, MOIST, BROWN, CLAYEY AND SANDY, COBBLES.		A	
	10		1.0' TO 6.5' CLAY - FILL TO APPROXIMATELY 3', HIGH PLASTICITY, MOIST, MEDIUM STIFF, VERY DARK BROWN TO GRAY BROWN BY 3', SLIGHTLY SANDY.			WATER LEVEL BAIL TO 27.0' 24-HR CHECK AT 10.0' GROUT TO SURFACE
22.6			6.5' TO 35.0' SHALE - WEATHERED YELLOW BROWN, LIGHT GRAY AND STRONG BROWN, MASSIVE, BLOCKY STRUCTURE, CALCAREOUS, SILTY TO SANDY, SLIGHTLY MOIST, MOSTLY SOFT (ROCK CLASSIFICATION) WITH FEW THIN (0.2' THICK) VERY SOFT SEAMS, LIMONITIC, GYPSUM, VEINS AFTER 25.7', SCATTERED WELL-HEALED FRACTURES.		C-1	JAR SAMPLE A. 1.0' TO 6.5'
24.9	20				C-2	CARTON SAMPLES C-1. 13.1' TO 14.0' C-2. 19.1' TO 20.0' C-3. 25.2' TO 26.0' C-4. 31.2' TO 32.0'
23.3					C-3	
22.5	30				C-4	
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: TSC, FSH. HOLE NO.: 8A4C-1364

DRILLING LOG — Hole No. 8A4C-1365

Field	Value
DIVISION	SWD
INSTALLATION	FORT WORTH DISTRICT
SHEET	1 OF 1 SHEETS
1. PROJECT	TRAINING SUPPORT CENTER
2. LOCATION (Coordinates or Station)	FORT SAM HOUSTON, TEXAS
3. DRILLING AGENCY	USACE
4. HOLE NO.	8A4C-1365
5. NAME OF DRILLER	SALIK
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	7.7'
8. DEPTH DRILLED INTO ROCK	57.3'
9. TOTAL DEPTH OF HOLE	65.0'
10. SIZE AND TYPE OF BIT	SEE REMARKS
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 0 / UNDISTURBED 1
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	53.0'
16. DATE HOLE	STARTED 6 DEC 09 / COMPLETED 8 DEC 09
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	96 %
19. SIGNATURE OF INSPECTOR	BOB MCVEY

% MOISTURE CONTENT	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS
		VISUAL	0.0' TO 0.15' - ASPHALT.			DRILLING 0.0' TO 8.0' - 10" AUGER WITH 3" SHELBY PUSH, SET 9' OF CASING AND CIRCULATION PAN 8.0' TO 11.0' - CLEAN WITH AUGER 11.0' TO 65.0' - 4" CORE
25.6			0.15' TO 0.5' - BASE GRAVEL - COARSE TO FINE, MOIST, BROWN, SANDY, COBBLES TO 4".		S-1	
		VISUAL	0.5' TO 7.7' CLAY			BAIL AND GROUT TO SURFACE
	10		0.5' TO 1.1' - SUBBASE - HIGH PLASTICITY, MEDIUM STIFF, MOIST, BLACK, GRAVELLY.			SHELBY TUBES ST-1. 1.3' TO 5.0' PENETROMETER = 4.1
			1.1' TO 7.7' - HIGH PLASTICITY, STIFF TO VERY STIFF, MOIST, BLACK, SLIGHTLY SANDY AND GRAVELLY.			CARTON SAMPLES
23.4			7.7' TO 65.0' SHALE		C-1	C-1. 16.1' TO 17.0' C-2. 22.1' TO 23.0' C-3. 28.1' TO 29.0' C-4. 34.1' TO 35.0' C-5. 40.1' TO 41.0' C-6. 46.1' TO 47.0' C-7. 52.2' TO 53.0' C-8. 58.1' TO 59.0' C-9. 64.1' TO 65.0'
22.2	20		7.7' TO 48.9' - WEATHERED YELLOW BROWN, LIGHT GRAY, STRONG BROWN WITH BLACK STAINS IN FRACTURES AND JOINTS, FRACTURES ARE WELL-HEALED, CALCAREOUS, SANDY TO SILTY, MASSIVE, BLOCKY STRUCTURE, SOFT (ROCK CLASSIFICATION), SCATTERED VERY SOFT (PLASTIC) SEAMS UP TO 0.2' THICK, GYPSUM VEINLETS AFTER 16.5' (USUALLY 35-40° DIP), SOME DARK GRAY AFTER 33.5' (SEAMS UP TO 1' THICK).		C-2	
23.2	30				C-3	
22.9			48.9' TO 65.0' - AS ABOVE EXCEPT AN UNWEATHERED DARK GRAY, SLIGHTLY FOSSILIFEROUS (SHELLS), UNCTUOUS, SOFT TO MODERATELY HARD (ROCK CLASSIFICATION), FRACTURES WITH MINOR WEATHER STAINS UNTIL 53.0'.		C-4	
19.7	40				C-5	
19.2					C-6	
16.7	50				C-7	
15.5	60				C-8	
17.0	70				C-9	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: TSC, FSH. HOLE NO.: 8A4C-1365

NOTES:

1. USE THIS SHEET FOR BORING LOGS ONLY.
2. MOISTURE CONTENT, WHERE SHOWN, IS EXPRESSED AS PERCENT DRY WEIGHT AT TIME OF LABORATORY CLASSIFICATION.
3. LEGEND SHOWS OVERBURDEN MATERIALS CLASSIFIED ACCORDING TO ASTM D 2487 AND ASTM D 2488.
4. DESCRIPTION OF OVERBURDEN MATERIALS CHANGED TO CORRESPOND WITH LABORATORY CLASSIFICATION AS NECESSARY.
5. ORIGINAL DRILLING LOGS AVAILABLE AT CORPS OF ENGINEERS OFFICES.

US Army Corps of Engineers
Fort Worth District

Symbol	Description	Tracking No.	Action	Date

Designed by: M. SMITH | Date: FEB 2010 | Rev.
Dwn by: M. SMITH | Sol No.
Reviewed by: K. McCLESKEY | Contr No.
Submitted by: RAMANUJA C. KANNAN, P.E. CHIEF, GEOTECHNICAL SECTION | File name: $$cadd file name$$ | Plot date: $$date$$ | Plot scale:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

ENGINEERING/CONSTRUCTION DIVISION ENGINEERING BRANCH

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER
PN: 071116
LOGS OF BORINGS - SHEET 2 OF 2

Sheet reference number: B202

DESIGN FILE: $$cadd file name$$

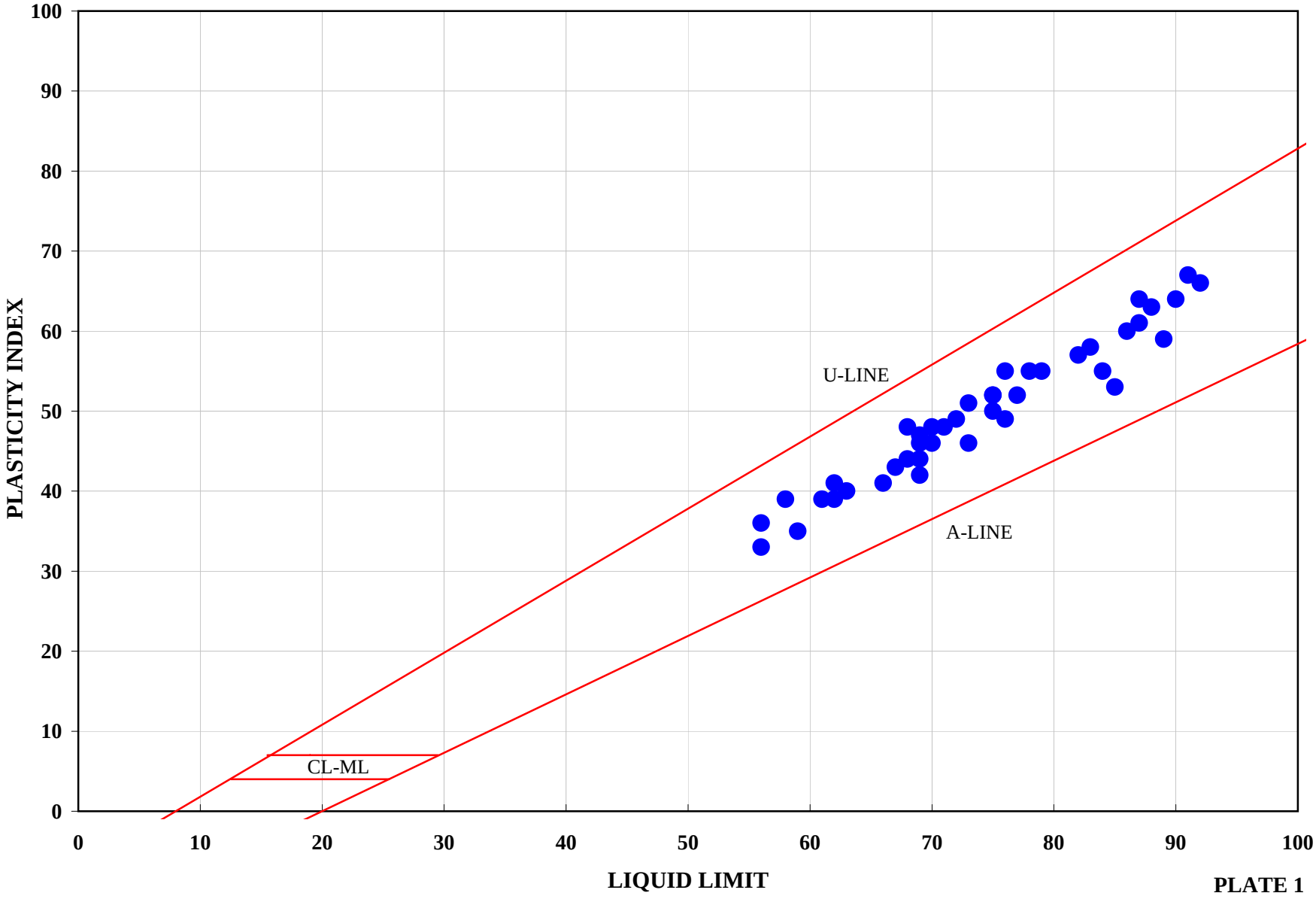
Contr No.

REFERENCE FILES: $$REFERENCEFILE01$$ $$REFERENCEFILE02$$ $$REFERENCEFILE03$$ $$REFERENCEFILE04$$ $$REFERENCEFILE05$$

APPENDIX B

LABORATORY TESTING DATA PLOTS

TRAINING SUPPORT CENTER
PLASTICITY CHART



TRAINING SUPPORT CENTER
MOISTURE CONTENT VS DEPTH

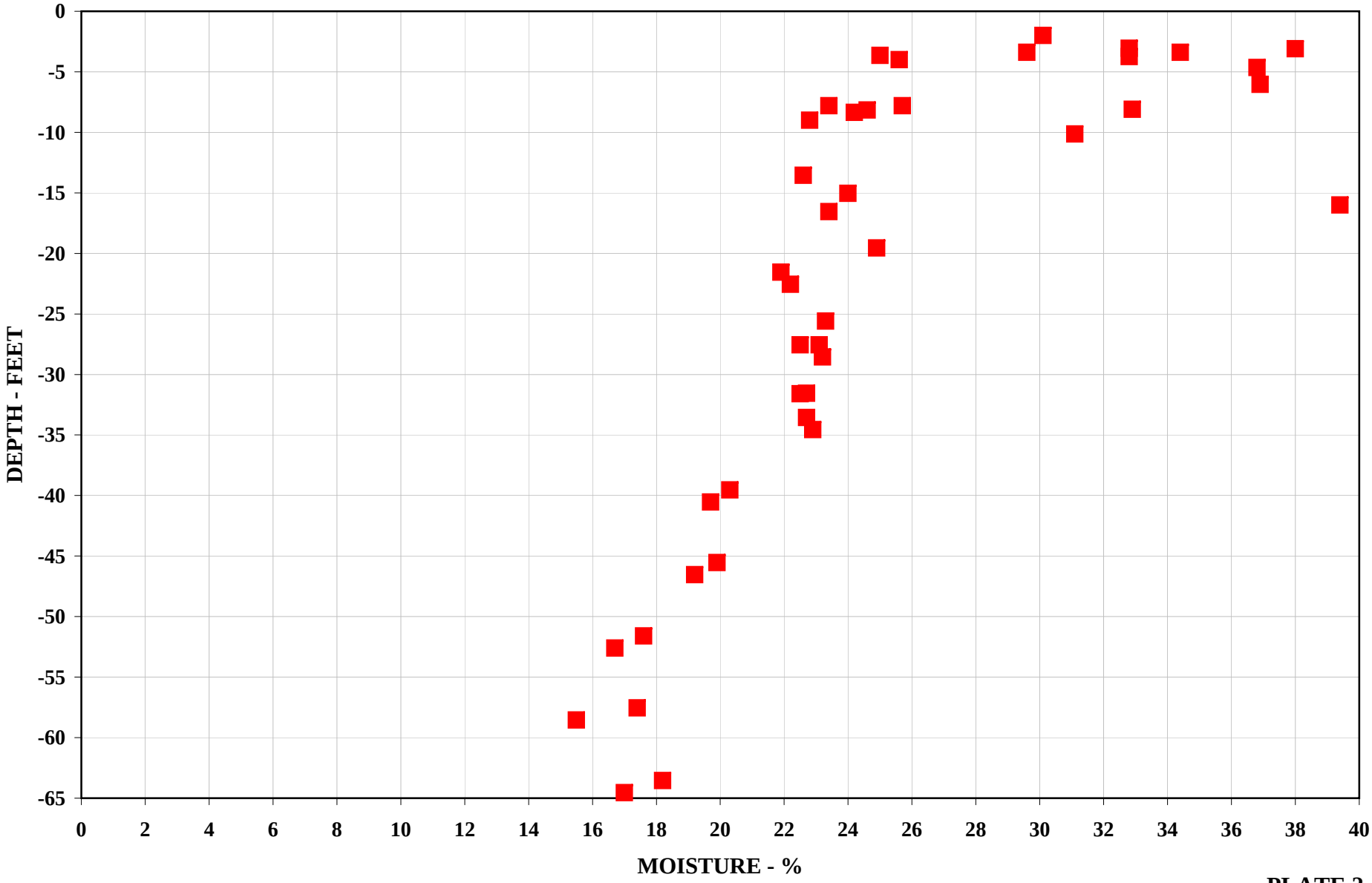


PLATE 2

TRAINING SUPPORT CENTER
ATTERBERG LIMITS VS DEPTH

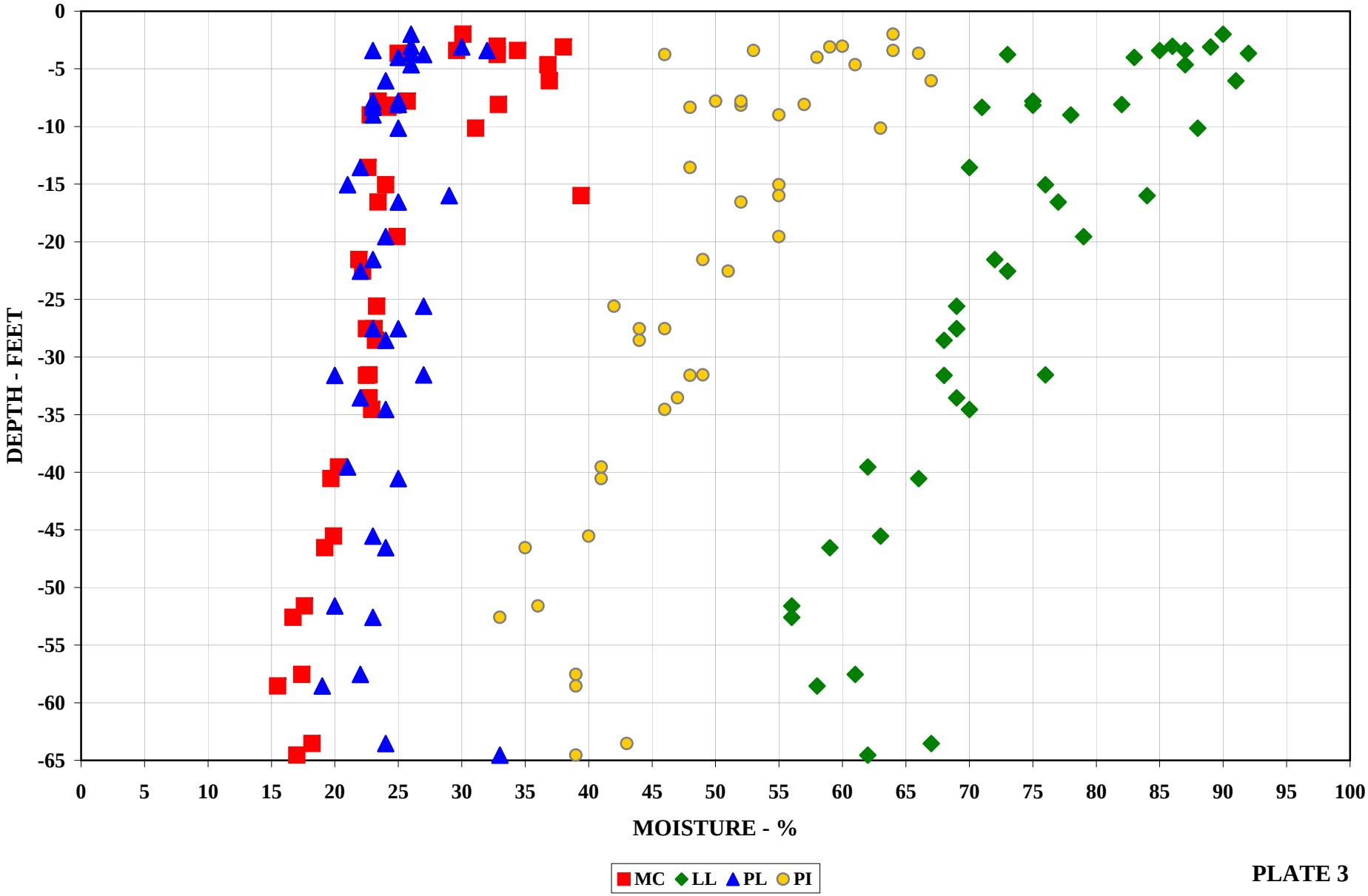


PLATE 3

TRAINING SUPPORT CENTER
MOISTURE CONTENT - DRY DENSITY VS DEPTH

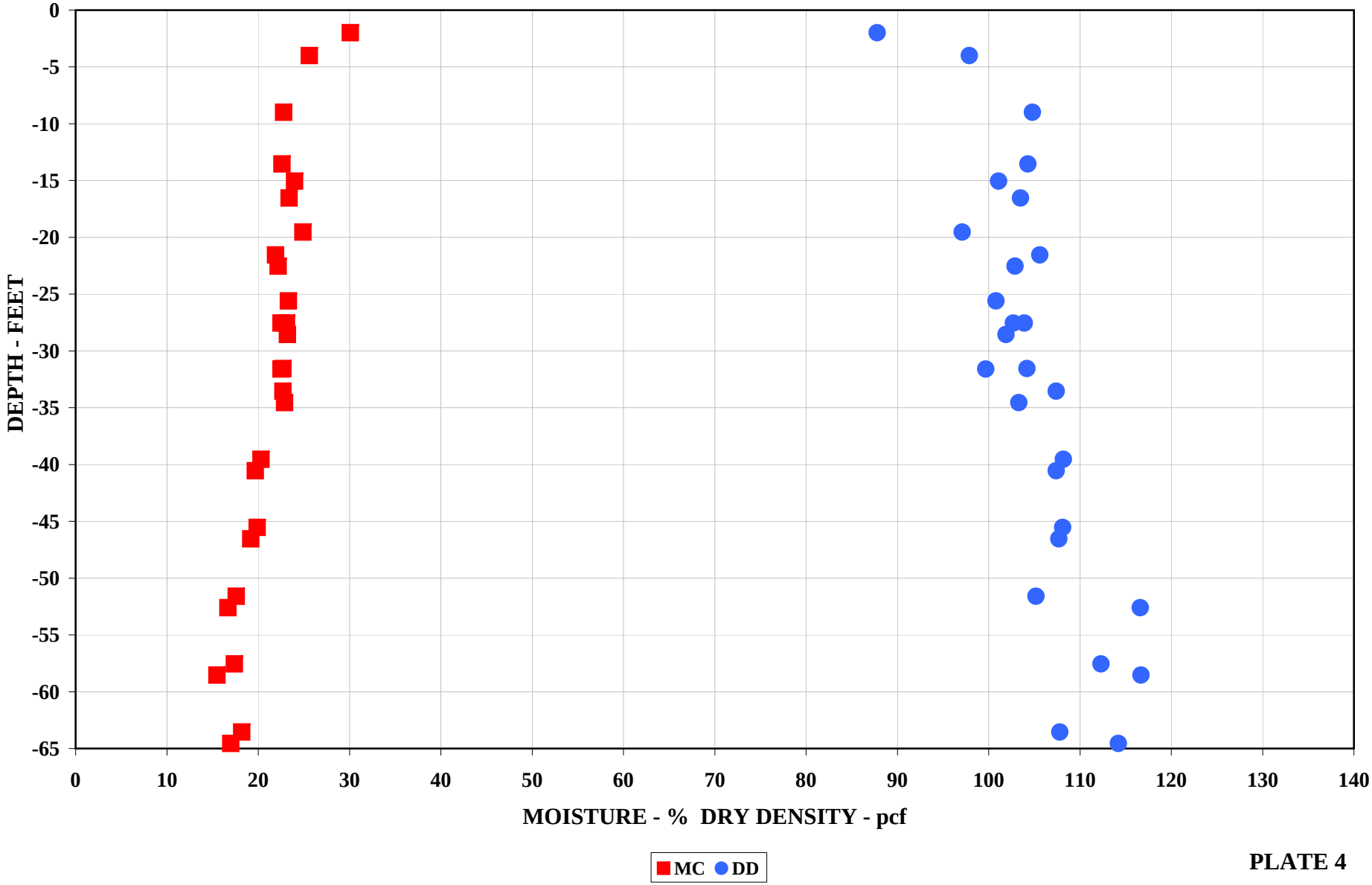


PLATE 4

TRAINING SUPPORT CENTER
ULTIMATE COMPRESSIVE STRENGTH VS DEPTH

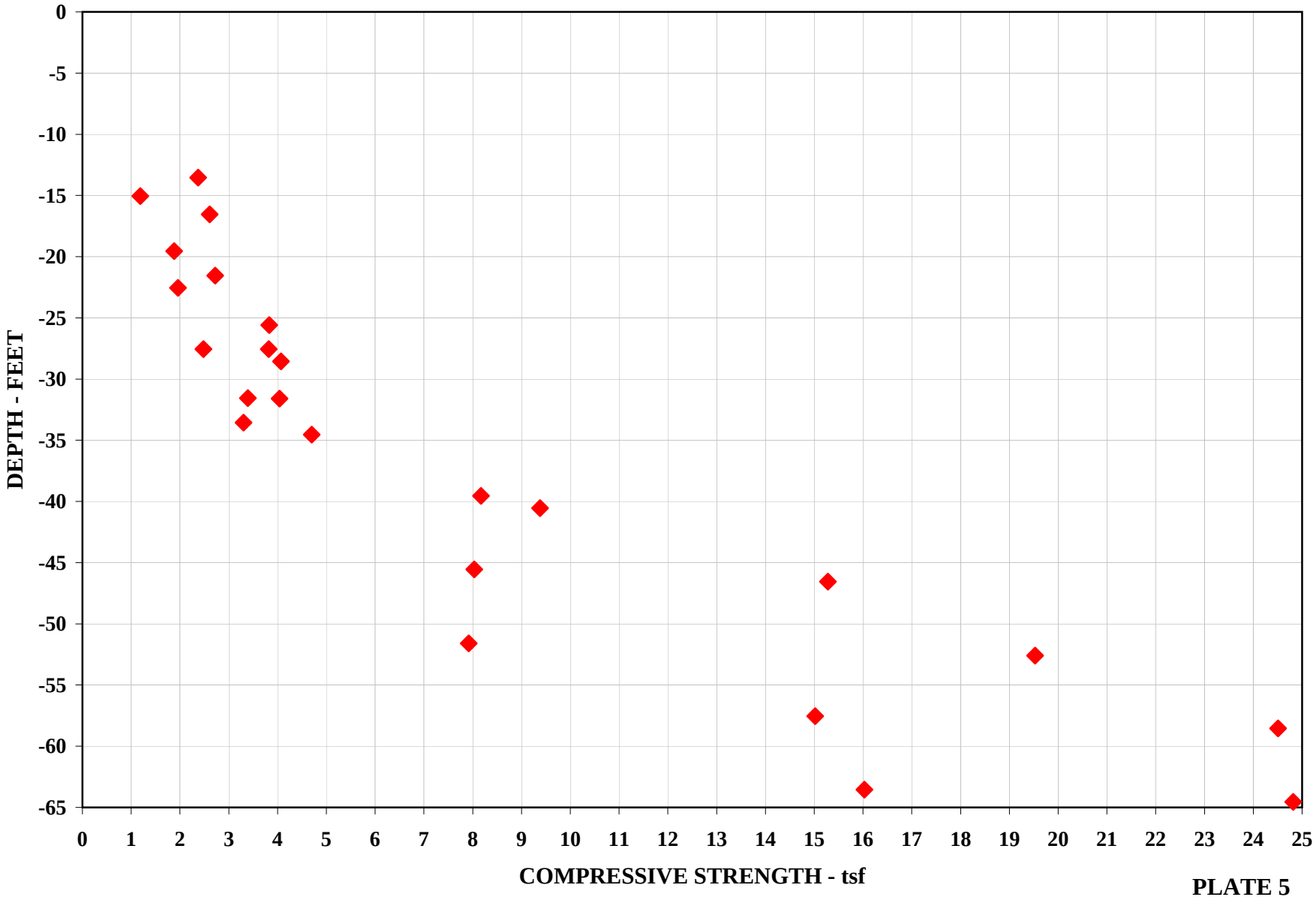


PLATE 5

APPENDIX C

LABORATORY TESTING DATA

SUMMARY OF LABORATORY TEST RESULTS

LABORATORY TESTING SERVICES
TRAINING SUPPORT CENTER
FORT SAM HOUSTON, TEXAS

Boring No.	Sample No.	Sample Depth (ft.)	Visual Description & Unified Soil Classification (ASTM D-2487)		Percent Passing Sieve #4	#10	#20	#40	#60	#80	#100	#200
10A-1358	A	0.5-6.3	Dark brown clay	CH	99.2	98.8	98.3	98.0	97.6	97.9	96.8	94.4
	B	6.3-10	Tan and light gray silty clay	CH	---	---	---	---	---	---	---	---
10A-1359	A	0.6-5.6	Dark brown clay	CH	99.7	99.2	98.8	98.4	98.2	97.9	97.8	95.8
	B	5.6-10	Tan and light gray silty clay	CH	---	---	---	---	---	---	---	---
8A4C-1360	ST-1	1-3	Dark brown clay	CH	95.3	94.8	94.1	93.6	93.2	92.8	92.5	90.0
	ST-2	8-10	Tan and gray silty clay	CH	---	---	---	---	---	---	---	---
	C-1	14.6-15.5	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-2	21.1-22	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-3	27.1-28	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-4	33.1-34	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-5	39.1-40	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-6	45.1-46	Tan and gray weathered shale	N/A	---	---	---	---	---	---	---	---
	C-7	51.2-52	Dark gray shale	N/A	---	---	---	---	---	---	---	---
	C-8	57.1-58	Dark gray shale	N/A	---	---	---	---	---	---	---	---
	C-9	63.1-64	Dark gray shale	N/A	---	---	---	---	---	---	---	---
8A4C-1361	A	2-7.3	Dark gray clay	CH	99.8	99.4	99.2	99.0	98.7	98.2	97.9	95.2
	B	7.3-13	Tan and gray silty clay	CH	100.0	100.0	99.9	99.8	99.7	99.6	99.6	98.0
	C	13-19	Tan silty clay	CH	98.2	97.5	96.9	96.4	96.1	95.7	95.6	94.3
	C-1	27.1-28	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-2	33.1-34	Tan and light gray weathered shale	N/A	---	---	---	---	---	---	---	---
10A-1362	A	0.6-6.7	Dark brown gravelly clay with sand	CH	75.9	75.4	74.8	74.3	74.1	73.5	73.3	67.4
	B	6.7-10	Tan and light gray silty clay	CH	---	---	---	---	---	---	---	---
10A-1363	A	0.6-5.5	Dark brown clay	CH	95.5	94.0	92.4	91.0	90.1	89.2	88.8	85.4
	B	5.5-6.6	Dark gray clay	CH	99.6	98.7	97.8	97.4	96.9	96.4	96.3	95.9
	C	6.6-9.0	Tan and brown clay with gravel	CH	78.6	78.4	78.2	78.0	77.8	77.6	77.4	75.7

SUMMARY OF LABORATORY TEST RESULTS

LABORATORY TESTING SERVICES
TRAINING SUPPORT CENTER
FORT SAM HOUSTON, TEXAS

Boring No.	Sample No.	Sample Depth (ft.)	Visual Description & Unified Soil Classification (ASTM D-2487)		Percent Passing Sieve #4	#10	#20	#40	#60	#80	#100	#200
8A4C-1364	A	1-6.5	Dark brown clay	CH	98.1	96.2	94.8	93.4	91.9	90.6	90.0	86.1
	C-1	13.1-14	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-2	19.1-20	Tan and light gray weathered shale	N/A	---	---	---	---	---	---	---	---
	C-3	25.2-26	Tan weathered shale with gypsum seams	N/A	---	---	---	---	---	---	---	---
	C-4	31.2-32	Tan weathered shale with gypsum seams	N/A	---	---	---	---	---	---	---	---
8A4C-1365	ST-1	3-5	Dark gray clay with gravel and sand	CH	81.0	78.4	76.6	75.6	74.7	74.1	73.5	71.4
	C-1	16.1-17	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-2	22.1-23	Tan weathered shale	N/A	---	---	---	---	---	---	---	---
	C-3	28.1-29	Tan and light gray weathered shale	N/A	---	---	---	---	---	---	---	---
	C-4	34.1-35	Tan and gray weathered shale	N/A	---	---	---	---	---	---	---	---
	C-5	40.1-41	Tan and gray weathered shale	N/A	---	---	---	---	---	---	---	---
	C-6	46.1-47	Tan and dark gray weathered shale	N/A	---	---	---	---	---	---	---	---
	C-7	52.2-53	Dark gray shale	N/A	---	---	---	---	---	---	---	---
	C-8	58.1-59	Dark gray shale	N/A	---	---	---	---	---	---	---	---
	C-9	64.1-65	Dark gray shale	N/A	---	---	---	---	---	---	---	---
10A-1366	A	0.6-6.2	Dark brown clay with sand and occasional gravel	CH	91.6	89.9	88.5	87.4	86.5	85.7	85.3	83.0
	B	6.2-10	Tan and brown silty clay	CH	99.5	99.1	98.8	98.5	98.2	97.9	97.8	96.3

SUMMARY OF LABORATORY TEST RESULTS

LABORATORY TESTING SERVICES
TRAINING SUPPORT CENTER
FORT SAM HOUSTON, TEXAS

Boring No.	Sample No.	Sample Depth (ft.)	Visual Description & Unified Soil Classification (ASTM D-2488)		Moisture Content (%)	Unit Dry Weight (pcf)	Atterberg Limits LL	PL	PI	Remarks
10A-1358	A	0.5-6.3	Dark brown clay	CH	34.4	---	85	32	53	
	B	6.3-10	Tan and light gray silty clay	CH	24.6	---	75	23	52	
10A-1359	A	0.6-5.6	Dark brown clay	CH	38.0	---	89	30	59	
	B	5.6-10	Tan and light gray silty clay	CH	25.7	---	75	25	50	
8A4C-1360	ST-1	1-3	Dark brown clay	CH	30.1	87.8	90	26	64	*
	ST-2	8-10	Tan and gray silty clay	CH	22.8	104.8	78	23	55	
	C-1	14.6-15.5	Tan weathered shale	N/A	24.0	101.1	76	21	55	
	C-2	21.1-22	Tan weathered shale	N/A	21.9	105.6	72	23	49	
	C-3	27.1-28	Tan weathered shale	N/A	22.5	103.9	69	25	44	
	C-4	33.1-34	Tan weathered shale	N/A	22.7	104.2	76	27	49	
	C-5	39.1-40	Tan weathered shale	N/A	20.3	108.2	62	21	41	
	C-6	45.1-46	Tan and gray weathered shale	N/A	19.9	108.1	63	23	40	
	C-7	51.2-52	Dark gray shale	N/A	17.6	105.2	56	20	36	
	C-8	57.1-58	Dark gray shale	N/A	17.4	112.3	61	22	39	
	C-9	63.1-64	Dark gray shale	N/A	18.2	107.8	67	24	43	
8A4C-1361	A	2-7.3	Dark gray clay	CH	36.8	---	87	26	61	
	B	7.3-13	Tan and gray silty clay	CH	31.1	---	88	25	63	
	C	13-19	Tan silty clay	CH	39.4	---	84	29	55	
	C-1	27.1-28	Tan weathered shale	N/A	23.1	102.7	69	23	46	
	C-2	33.1-34	Tan and light gray weathered shale	N/A	22.7	107.4	69	22	47	
10A-1362	A	0.6-6.7	Dark brown gravelly clay with sand	CH	25.0	---	92	26	66	
	B	6.7-10	Tan and light gray silty clay	CH	24.2	---	71	23	48	
10A-1363	A	0.6-5.5	Dark brown clay	CH	32.8	---	86	26	60	
	B	5.5-6.6	Dark gray clay	CH	36.9	---	91	24	67	
	C	6.6-9.0	Tan and brown clay with gravel	CH	23.4	---	75	23	52	

* See attached "Laboratory Test Data Sheets" for Consolidation Test Results

SUMMARY OF LABORATORY TEST RESULTS

LABORATORY TESTING SERVICES
TRAINING SUPPORT CENTER
FORT SAM HOUSTON, TEXAS

Boring No.	Sample No.	Sample Depth (ft.)	Visual Description & Unified Soil Classification (ASTM D-2488)		Moisture Content (%)	Unit Dry Weight (pcf)	Atterberg Limits LL	PL	PI	Remarks
8A4C-1364	A	1-6.5	Dark brown clay	CH	32.8	---	73	27	46	
	C-1	13.1-14	Tan weathered shale	N/A	22.6	104.3	70	22	48	
	C-2	19.1-20	Tan and light gray weathered shale	N/A	24.9	97.1	79	24	55	
	C-3	25.2-26	Tan weathered shale with gypsum seams	N/A	23.3	100.8	69	27	42	
	C-4	31.2-32	Tan weathered shale with gypsum seams	N/A	22.5	99.7	68	20	48	
8A4C-1365	ST-1	3-5	Dark gray clay with gravel and sand	CH	25.6	97.9	83	25	58	
	C-1	16.1-17	Tan weathered shale	N/A	23.4	103.5	77	25	52	
	C-2	22.1-23	Tan weathered shale	N/A	22.2	102.9	73	22	51	
	C-3	28.1-29	Tan and light gray weathered shale	N/A	23.2	101.9	68	24	44	
	C-4	34.1-35	Tan and gray weathered shale	N/A	22.9	103.3	70	24	46	
	C-5	40.1-41	Tan and gray weathered shale	N/A	19.7	107.4	66	25	41	
	C-6	46.1-47	Tan and dark gray weathered shale	N/A	19.2	107.7	59	24	35	
	C-7	52.2-53	Dark gray shale	N/A	16.7	116.6	56	23	33	
	C-8	58.1-59	Dark gray shale	N/A	15.5	116.7	58	19	39	
	C-9	64.1-65	Dark gray shale	N/A	17.0	114.2	62	33	39	
10A-1366	A	0.6-6.2	Dark brown clay with sand and occasional gravel	CH	29.6	---	87	23	64	
	B	6.2-10	Tan and brown silty clay	CH	32.9	---	82	25	57	

SUMMARY OF LABORATORY TEST RESULTS

LABORATORY TESTING SERVICES
TRAINING SUPPORT CENTER
FORT SAM HOUSTON, TEXAS

Boring No.	Sample No.	Sample Depth (ft.)	Visual Description & Unified Soil Classification (ASTM D-2488)		Moisture Content (%)	Unit Dry Weight (pcf)	Confining Pressure (tsf)	Q (tsf)	Strain @ Failure (%)	Type Failure
10A-1358	A	0.5-6.3	Dark brown clay	CH	34.4	---	---	---	---	
	B	6.3-10	Tan and light gray silty clay	CH	24.6	---	---	---	---	
10A-1359	A	0.6-5.6	Dark brown clay	CH	38.0	---	---	---	---	
	B	5.6-10	Tan and light gray silty clay	CH	25.7	---	---	---	---	
8A4C-1360	ST-1	1-3	Dark brown clay	CH	30.1	87.8	---	---	---	
	ST-2	8-10	Tan and gray silty clay	CH	22.8	104.8	---	---	---	
	C-1	14.6-15.5	Tan weathered shale	N/A	24.0	101.1	0.941	1.18	6.4	Angular (70°)
	C-2	21.1-22	Tan weathered shale	N/A	21.9	105.6	1.347	2.72	3.1	Angular (80°)
	C-3	27.1-28	Tan weathered shale	N/A	22.5	103.9	1.722	2.48	4.3	Vertical
	C-4	33.1-34	Tan weathered shale	N/A	22.7	104.2	2.097	3.39	4.3	Angular (70°)
	C-5	39.1-40	Tan weathered shale	N/A	20.3	108.2	2.472	8.17	6.9	Angular (60°)
	C-6	45.1-46	Tan and gray weathered shale	N/A	19.9	108.1	2.847	8.03	4.8	Angular (75°)
	C-7	51.2-52	Dark gray shale	N/A	17.6	105.2	3.225	7.92	15.0	Internal
	C-8	57.1-58	Dark gray shale	N/A	17.4	112.3	3.597	15.02	3.8	Vertical
	C-9	63.1-64	Dark gray shale	N/A	18.2	107.8	3.972	16.03	2.5	Angular (60°)
8A4C-1361	A	2-7.3	Dark gray clay	CH	36.8	---	---	---	---	
	B	7.3-13	Tan and gray silty clay	CH	31.1	---	---	---	---	
	C	13-19	Tan silty clay	CH	39.4	---	---	---	---	
	C-1	27.1-28	Tan weathered shale	N/A	23.1	102.7	1.722	3.82	12.9	Angular (60°)
	C-2	33.1-34	Tan and light gray weathered shale	N/A	22.7	107.4	2.097	3.30	5.2	Angular (45°)
10A-1362	A	0.6-6.7	Dark brown gravelly clay with sand	CH	25.0	---	---	---	---	
	B	6.7-10	Tan and light gray silty clay	CH	24.2	---	---	---	---	
10A-1363	A	0.6-5.5	Dark brown clay	CH	32.8	---	---	---	---	
	B	5.5-6.6	Dark gray clay	CH	36.9	---	---	---	---	
	C	6.6-9.0	Tan and brown clay with gravel	CH	23.4	---	---	---	---	

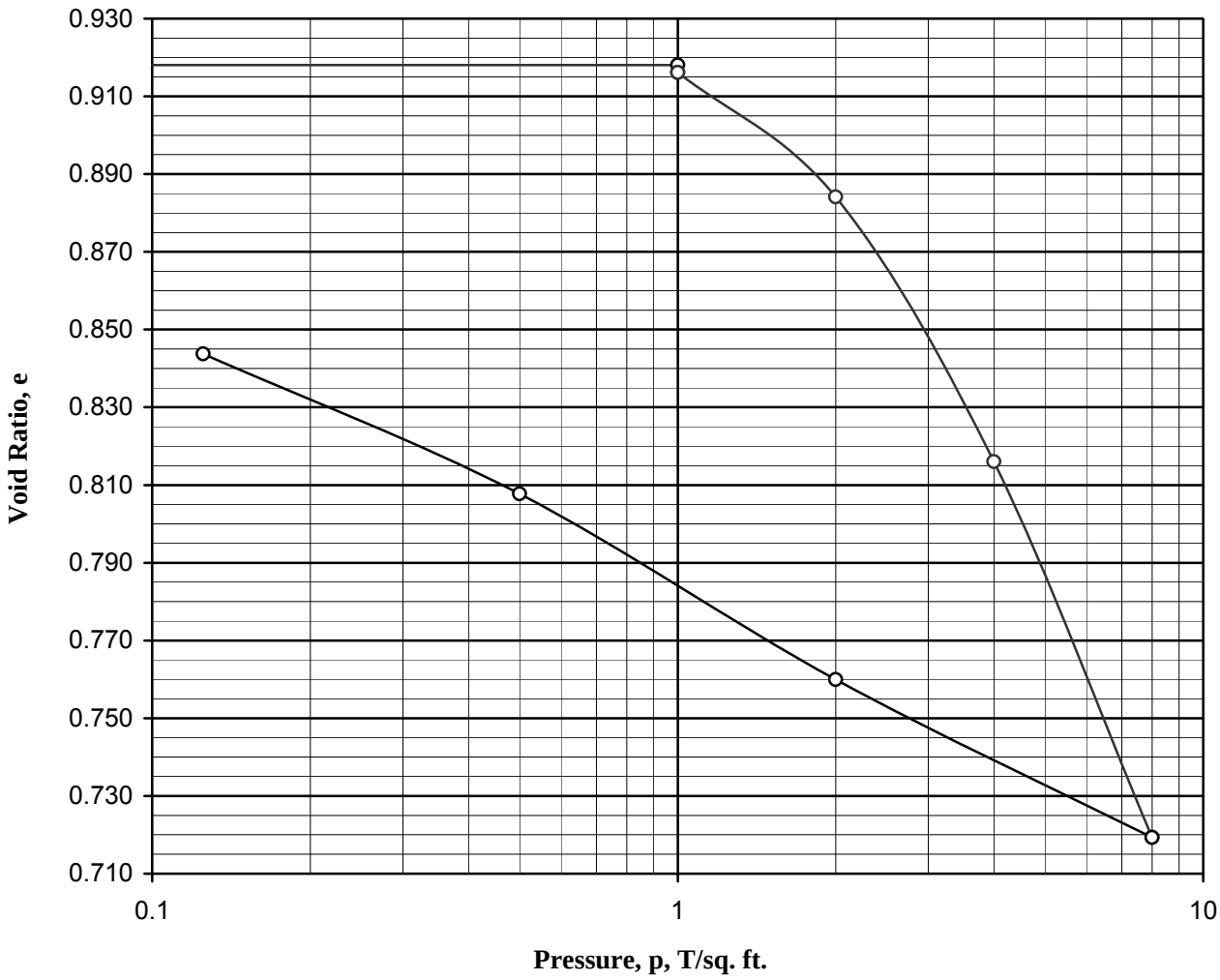
SUMMARY OF LABORATORY TEST RESULTS

LABORATORY TESTING SERVICES
TRAINING SUPPORT CENTER
FORT SAM HOUSTON, TEXAS

Boring No.	Sample No.	Sample Depth (ft.)	Visual Description & Unified Soil Classification (ASTM D-2488)		Moisture Content (%)	Unit Dry Weight (pcf)	Confining Pressure (tsf)	Q (tsf)	Strain @ Failure (%)	Type Failure
8A4C-1364	A	1-6.5	Dark brown clay	CH	32.8	---	---	---	---	
	C-1	13.1-14	Tan weathered shale	N/A	22.6	104.3	0.847	2.37	4.3	Angular (45°)
	C-2	19.1-20	Tan and light gray weathered shale	N/A	24.9	97.1	1.222	1.88	15.0	Angular (70°)
	C-3	25.2-26	Tan weathered shale with gypsum seams	N/A	23.3	100.8	1.600	3.83	5.6	Angular (75°)
	C-4	31.2-32	Tan weathered shale with gypsum seams	N/A	22.5	99.7	1.975	4.04	15.0	Angular (50°)
8A4C-1365	ST-1	3-5	Dark gray clay with gravel and sand	CH	25.6	97.9	---	---	---	
	C-1	16.1-17	Tan weathered shale	N/A	23.4	103.5	1.034	2.61	5.8	Angular (45°)
	C-2	22.1-23	Tan weathered shale	N/A	22.2	102.9	1.409	1.96	6.8	Angular (45°)
	C-3	28.1-29	Tan and light gray weathered shale	N/A	23.2	101.9	1.784	4.07	14.7	Angular (45°)
	C-4	34.1-35	Tan and gray weathered shale	N/A	22.9	103.3	2.159	4.70	3.6	Angular (45°)
	C-5	40.1-41	Tan and gray weathered shale	N/A	19.7	107.4	2.534	9.38	5.1	Angular (60°)
	C-6	46.1-47	Tan and dark gray weathered shale	N/A	19.2	107.7	2.909	15.28	4.3	Angular (60°)
	C-7	52.2-53	Dark gray shale	N/A	16.7	116.6	3.288	19.53	3.2	Vertical
	C-8	58.1-59	Dark gray shale	N/A	15.5	116.7	3.659	24.51	2.8	Vertical
	C-9	64.1-65	Dark gray shale	N/A	17.0	114.2	4.034	24.82	3.3	Vertical
10A-1366	A	0.6-6.2	Dark brown clay with sand and occasional gravel	CH	29.6	---	---	---	---	
	B	6.2-10	Tan and brown silty clay	CH	32.9	---	---	---	---	

TEAM Consultants, Inc.

Geotechnical, Environmental, Construction Materials Testing



Type of specimen: Undisturbed				Before Test		After Test	
Diam. 2.50 in.	Ht. 0.501 in.			Water Content, w_o	30.05%	W_f	31.29%
Overburden Pressure, P_o		T/sq. ft.		Void Ratio, e_o	0.9180	e_f	0.8437
Preconsol. Pressure, P_c		T/sq. ft.		Saturation, S_o	88.4%	S_f	100.1%
Compression Index, C_c				Dry Density, γd	87.8 lb/ft^3		
Classification Dark brown clay							
LL 90	G_s 2.700 (assumed)			Project	Fort Hood TSC		
PL 26					Team Project No.: 092131		
Remarks				Boring No: 8A4C-1360		Sample No.: ST-1	
				Depth: 1-3'		Date: 12/18/09	
				CONSOLIDATION TEST REPORT			

Thursday, October 28, 2010

APPENDIX D

DYNAMIC CONE PENETROMETER (DCP) TESTING DATA PLOTS

DCP TEST DATA

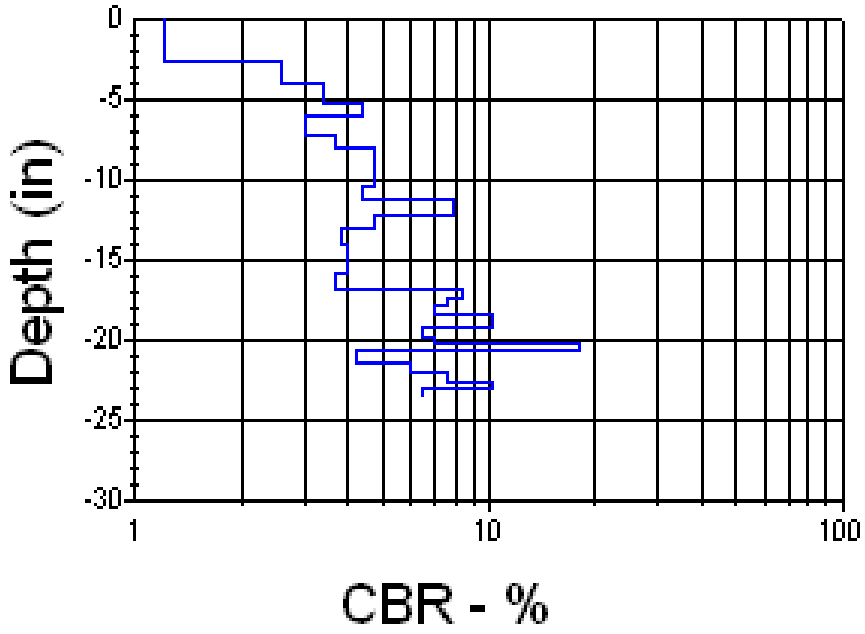
Project: Training Support Center

Date: 15 December 2009

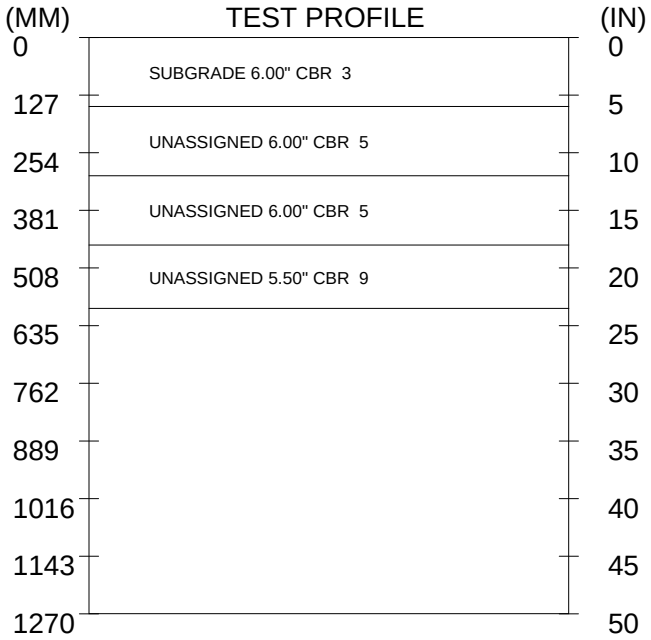
Feature: 10A-1358

Station: 10A-1358

CBR VS DEPTH



TEST PROFILE



DCP TEST DATA

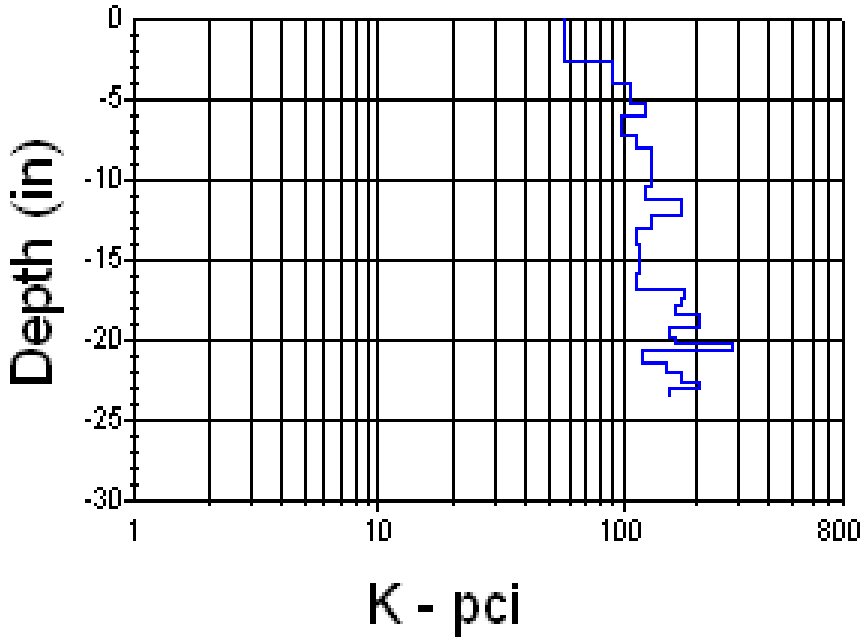
Project: Training Support Center

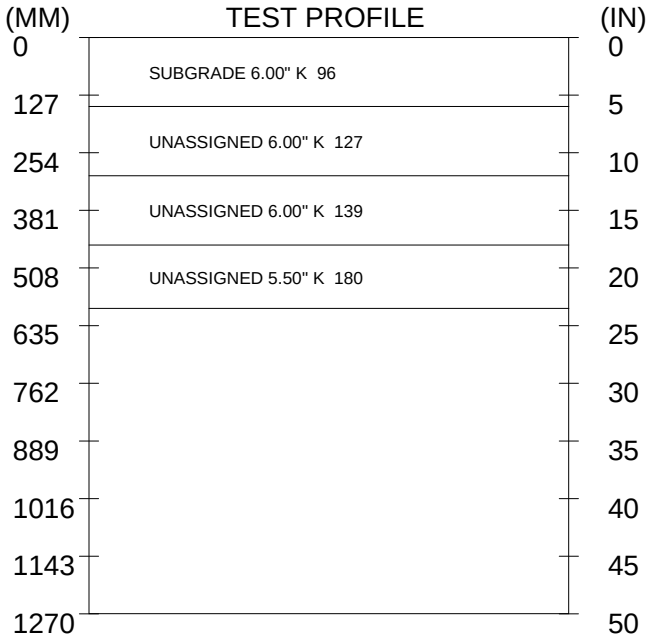
Date: 15 December 2009

Feature: 10A-1358

Station: 10A-1358

SUBGRADE MODULUS VS DEPTH





DCP TEST DATA

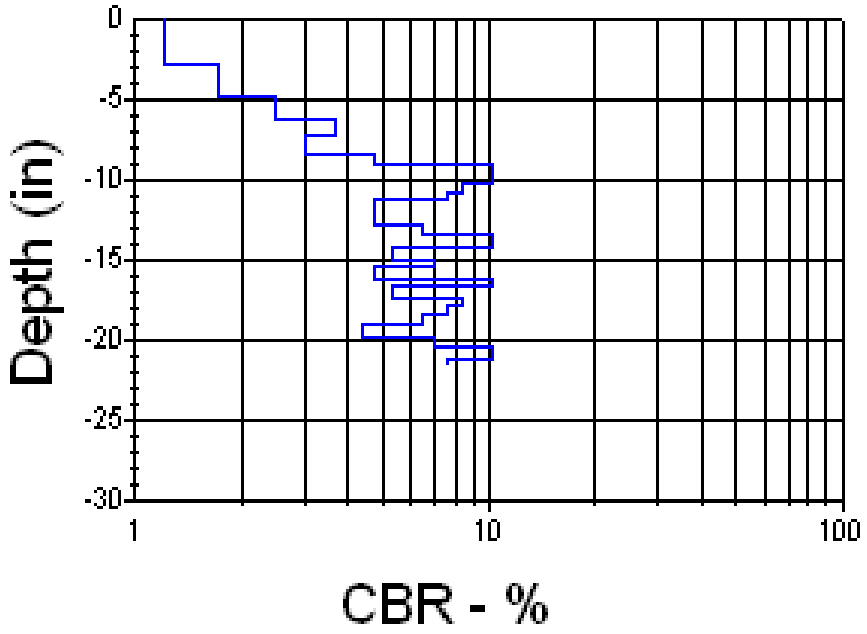
Project: Training Support Center

Date: 15 December 2009

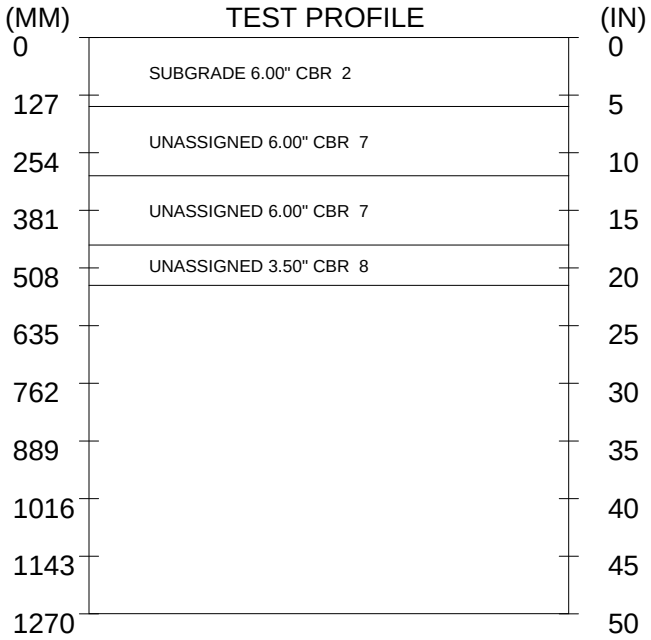
Feature: 10A-1359

Station: 10A-1359

CBR VS DEPTH



TEST PROFILE



DCP TEST DATA

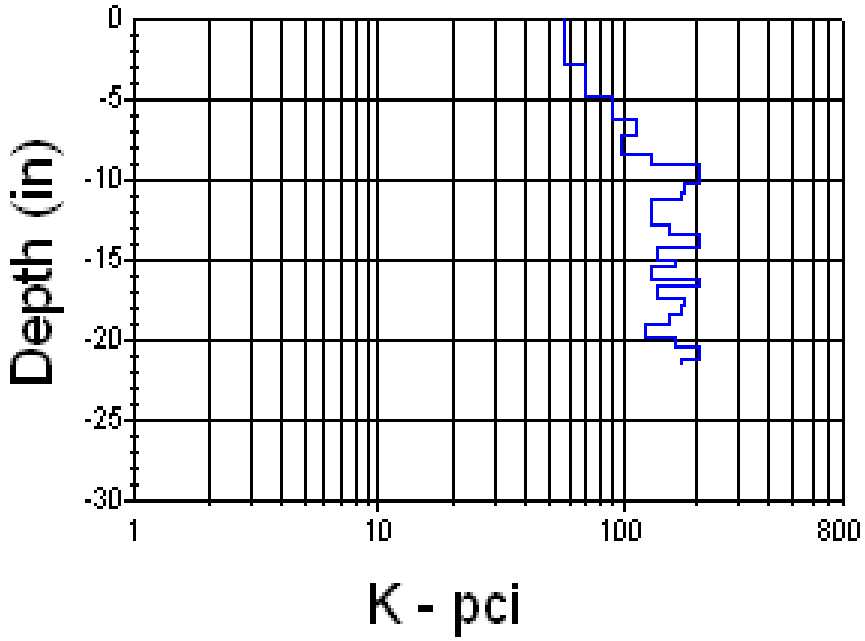
Project: Training Support Center

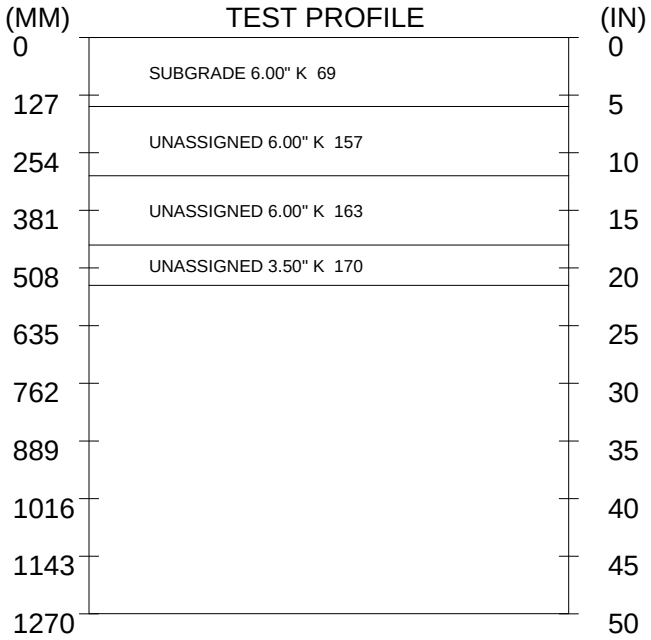
Date: 15 December 2009

Feature: 10A-1359

Station: 10A-1359

SUBGRADE MODULUS VS DEPTH





DCP TEST DATA

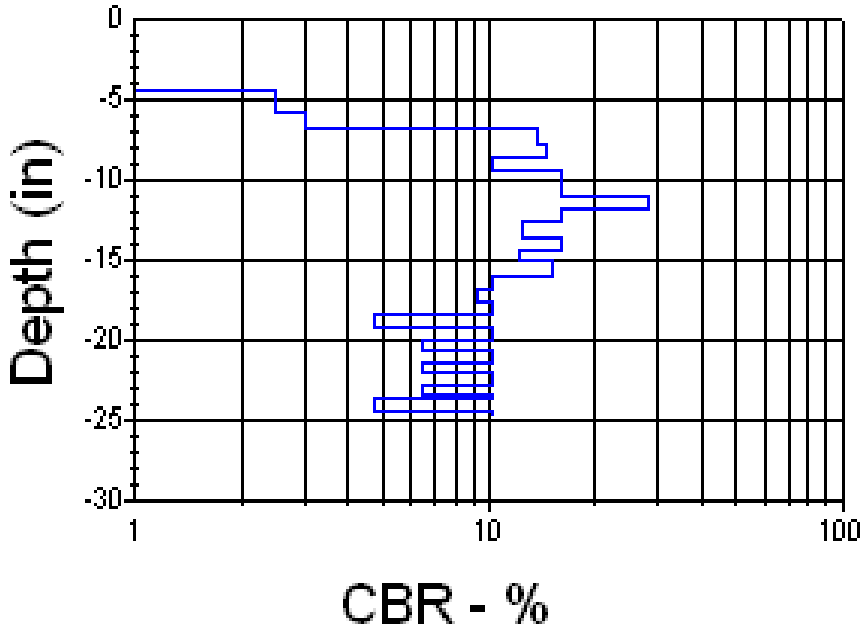
Project: Training Support Center

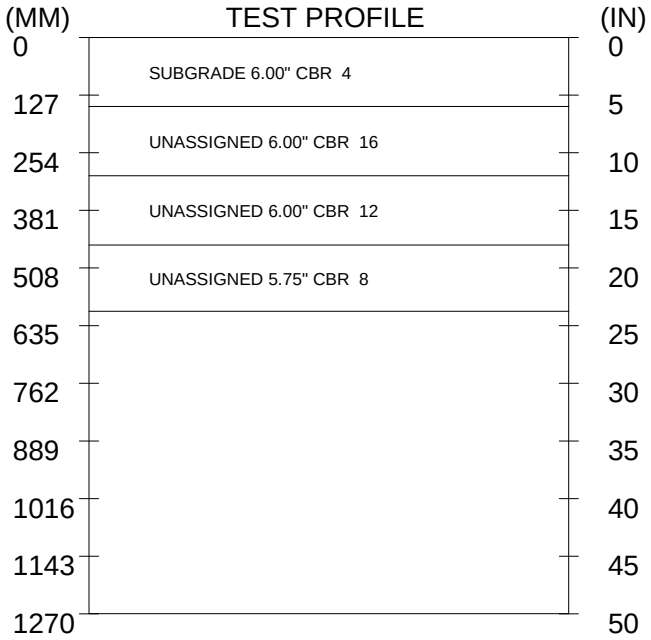
Date: 15 December 2009

Feature: 10A-1362

Station: 10A-1362

CBR VS DEPTH





DCP TEST DATA

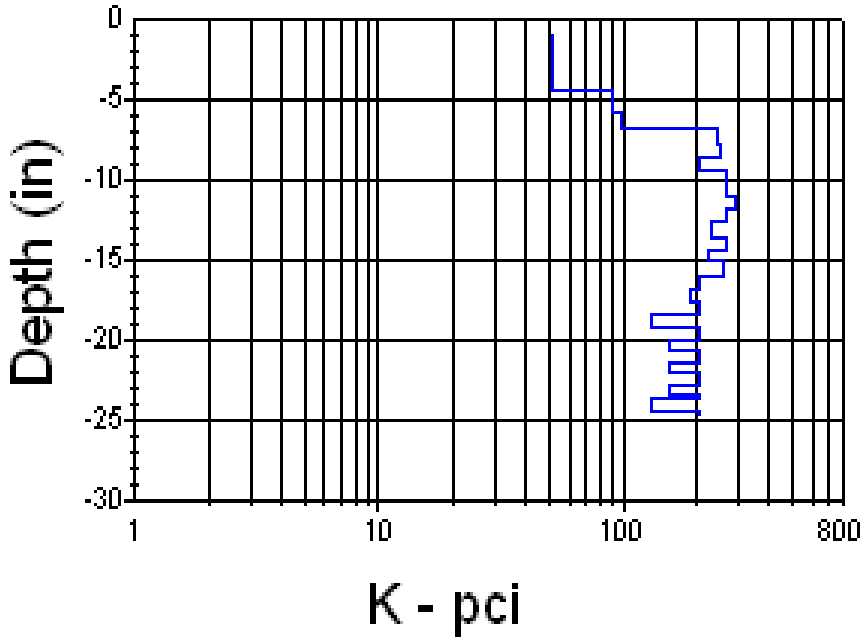
Project: Training Support Center

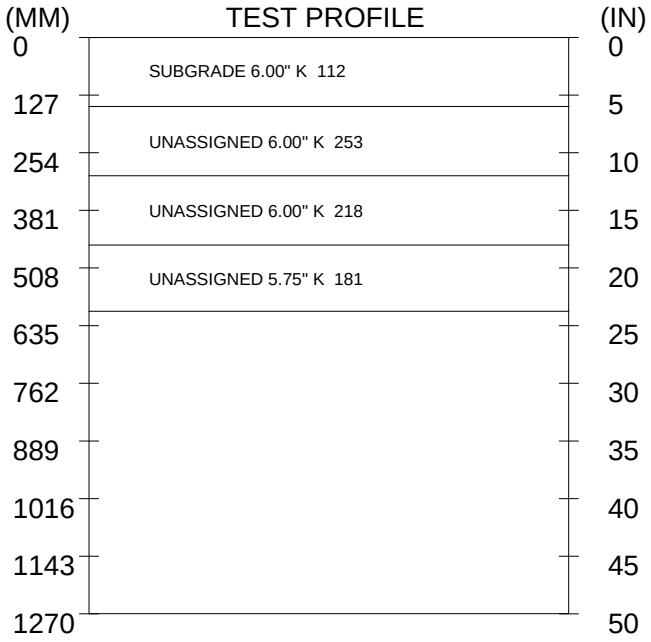
Date: 15 December 2009

Feature: 10A-1362

Station: 10A-1362

SUBGRADE MODULUS VS DEPTH





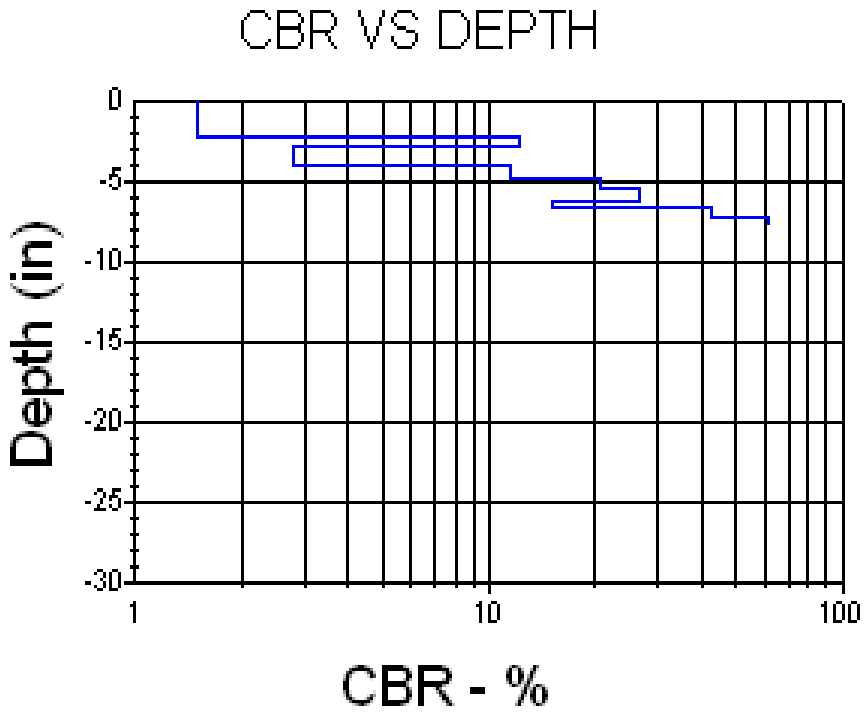
DCP TEST DATA

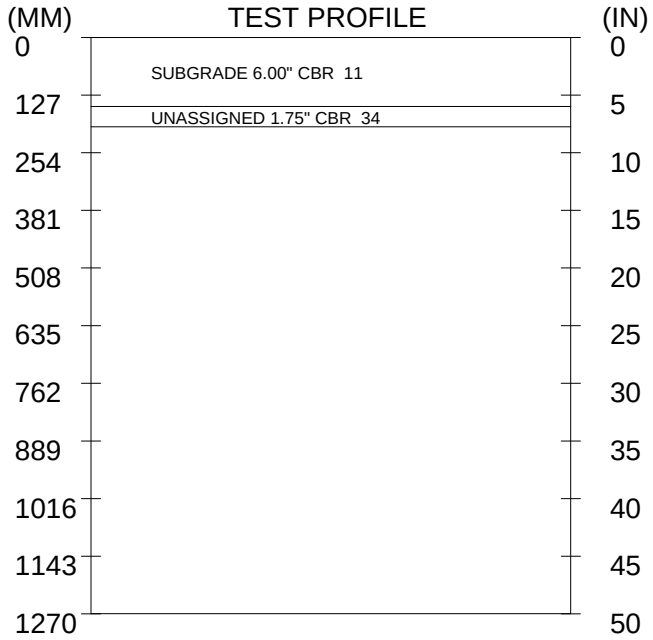
Project: Training Support Center

Date: 15 December 2009

Feature: 10A-1363

Station: 10A-1363





DCP TEST DATA

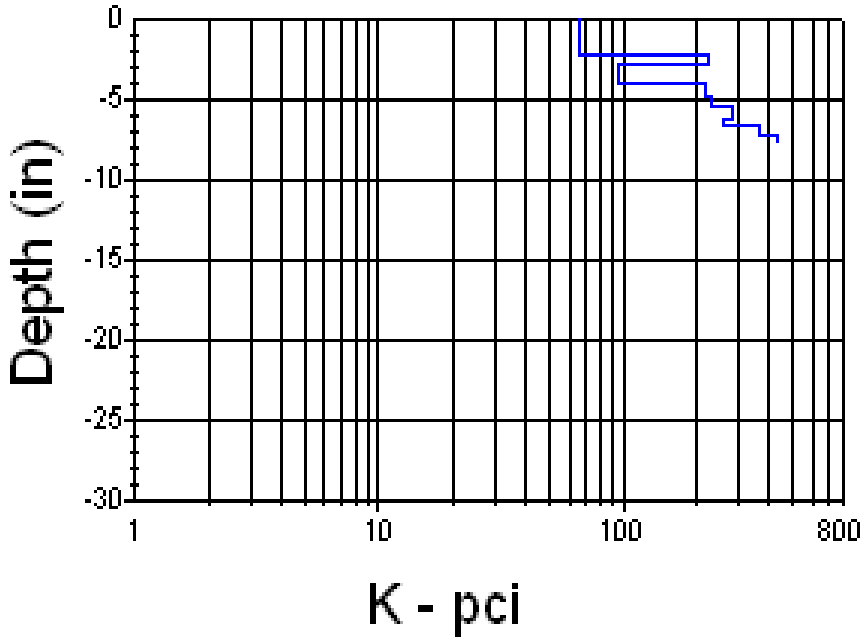
Project: Training Support Center

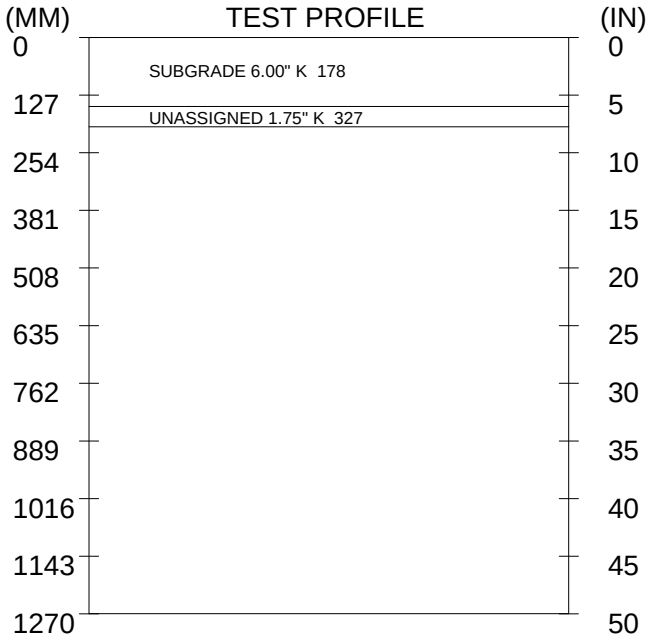
Date: 15 December 2009

Feature: 10A-1363

Station: 10A-1363

SUBGRADE MODULUS VS DEPTH





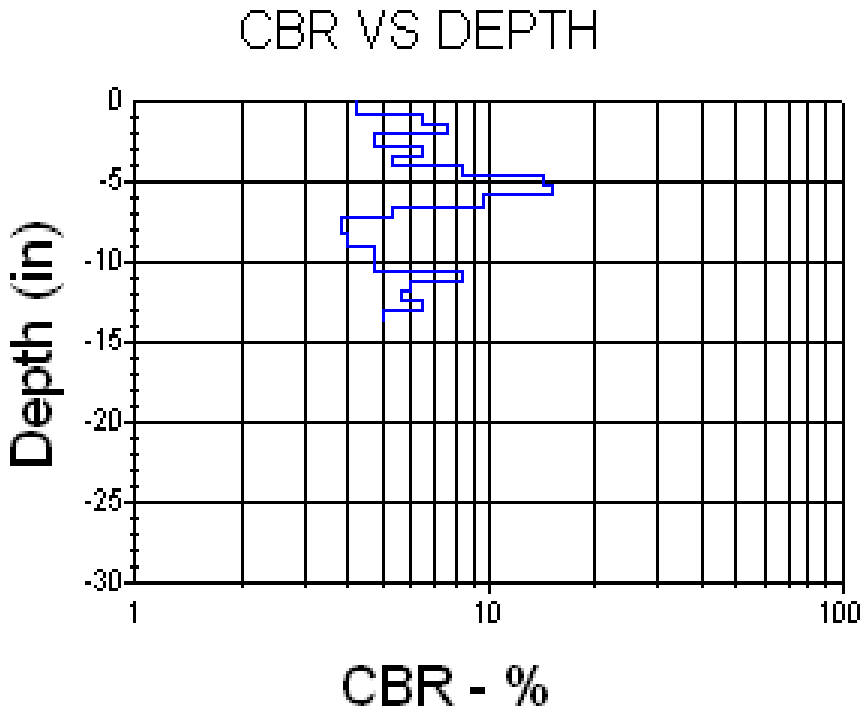
DCP TEST DATA

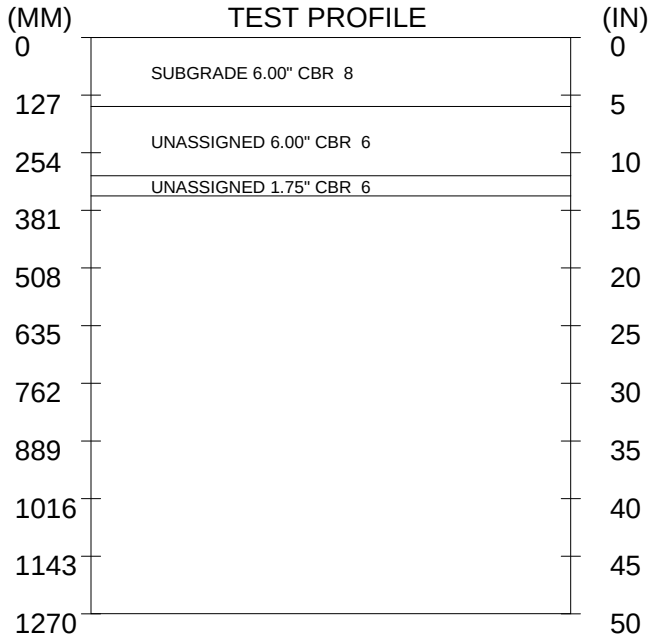
Project: Training Support Center

Date: 6 December 2009

Feature: 8A4C-1365

Station: 8A4C-1365





DCP TEST DATA

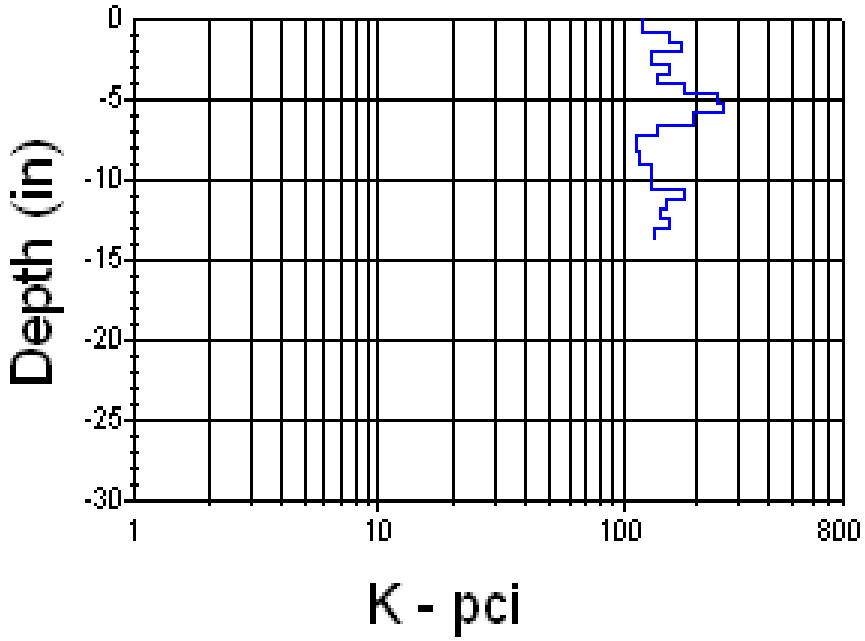
Project: Training Support Center

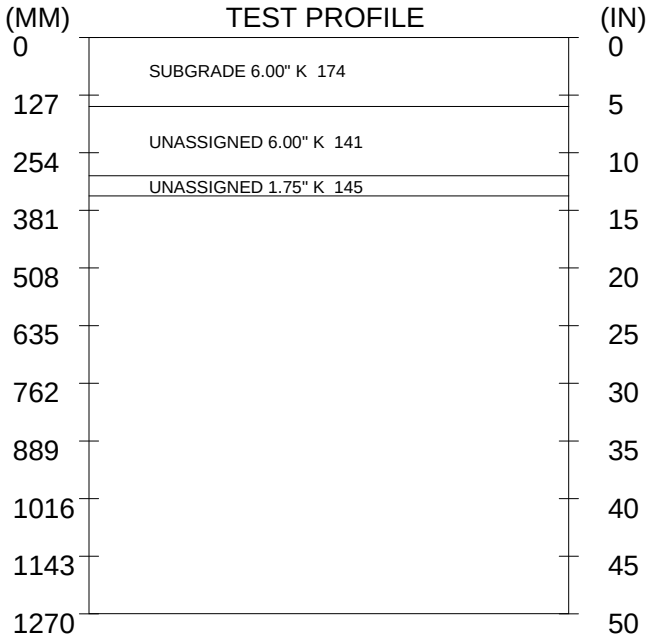
Date: 6 December 2009

Feature: 8A4C-1365

Station: 8A4C-1365

SUBGRADE MODULUS VS DEPTH





DCP TEST DATA

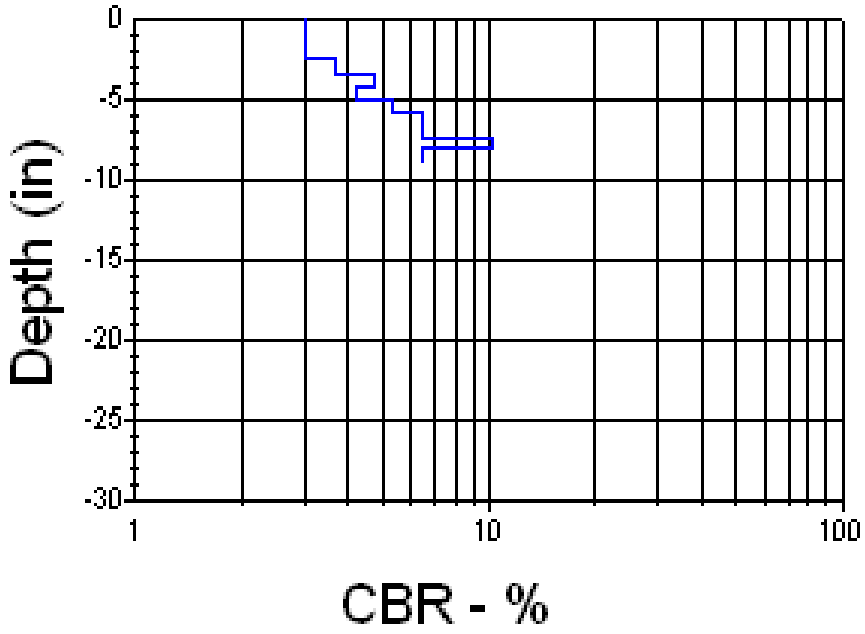
Project: Training Support Center

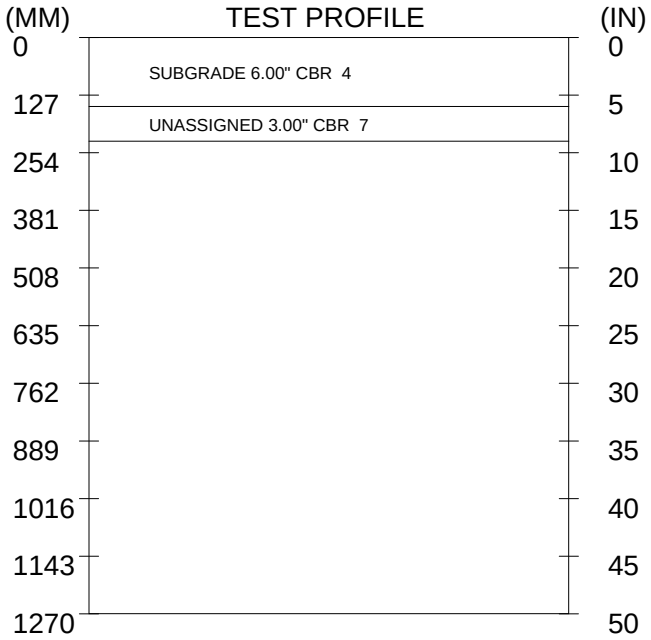
Date: 15 December 2009

Feature: 10A-1366

Station: 10A-1366

CBR VS DEPTH





DCP TEST DATA

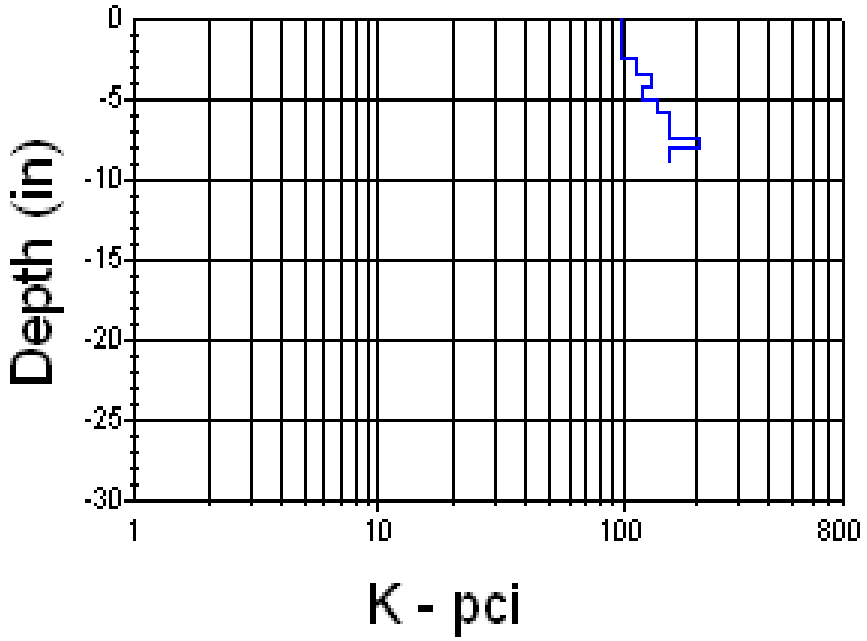
Project: Training Support Center

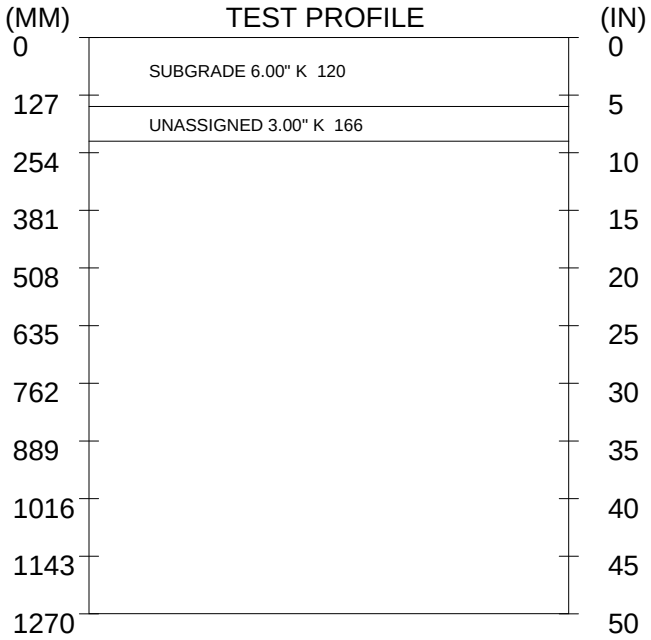
Date: 15 December 2009

Feature: 10A-1366

Station: 10A-1366

SUBGRADE MODULUS VS DEPTH





APPENDIX E

MAT FOUNDATION DESIGN CRITERIA

WALLACE

DEPARTMENT OF THE ARMY
SOUTHWESTERN DIVISION, CORPS OF ENGINEERS
1114 COMMERCE STREET
DALLAS, TEXAS 75242-0216

REPLY TO
ATTENTION OF

CESWD-ED-TS/G (415a)

29 JAN 1988

MEMORANDUM FOR:

Commander, Albuquerque District, ATTN: CESWA-ED
Commander, Fort Worth District, ATTN: CESWF-ED-DT
Commander, Galveston District, ATTN: CESWG-ED
Commander, Little Rock District, ATTN: CESWL-ED
Commander, Tulsa District, ATTN: CESWT-ED

SUBJECT: Design Criteria for Ribbed Mat Foundations

1. This letter supersedes criteria letter, SWDED-TS/G, 23 Dec 1986, SAB.

2. The enclosed criteria shall be used for design of all ribbed mat foundations. This criteria has been revised to conform with the definition of swell pressure (soil-beam interface pressure) as presented in criteria letter, SWDED-G, 16 Apr 1987, subject: Criteria for Developing Geotechnical Design Parameters for SWD Ribbed Mat Design Methodology. Also, clarification has been provided for application of the PTI design method to family housing.

3. This criteria is furnished to addressees only.

FOR THE COMMANDER:

ARTHUR D. DENYS, P.E.
Chief, Engineering Division

Encl

DESIGN OF RIBBED MAT FOUNDATIONS

BY

JOSEPH P. HARTMAN

AND

B. H. JAMES

U.S. ARMY CORPS OF ENGINEERS

SOUTHWESTERN DIVISION

DALLAS, TEXAS

REVISED

JANUARY 1988

CONTENTS

PART I - GENERAL REQUIREMENTS FOR RIBBED MATS

1. References
2. Background
3. Design Methods
   - 3.1 Expansive Soils
     - 3.1.1 Behavior
     - 3.1.2 SWD Method
     - 3.1.3 PTI Method
     - 3.1.4 BRAB Method
     - 3.1.5 Computer Method
     - 3.1.6 Load Factors
   - 3.2 Non-Expansive Soils
   - 3.3 Soil Properties
4. Minimum Requirements
   - 4.1 Subgrade Preparation
   - 4.2 Slab
   - 4.3 Grid Geometry
   - 4.4 Rib Size
   - 4.5 Rib Capacity
   - 4.6 Prestressed Mats
   - 4.7 Construction Details

PART II - ANALYSIS OF RIBBED MAT FOUNDATIONS ON EXPANSIVE SOILS

1. Scope
2. General Information
   - 2.1 Notation
   - 2.2 Units
   - 2.3 Rib Definitions
   - 2.4 Strip Analysis
   - 2.5 Soil Edge Profile
3. Analysis Method
   - 3.1 Transverse Rib - Center Lift
   - 3.2 Transverse Rib - Edge Lift
   - 3.3 Perimeter Rib
   - 3.4 Diagonal Rib
   - 3.5 Interior Rib

APPENDIX A - COMMENTARY ON PART II

APPENDIX B - DESIGN EXAMPLE

PART I - GENERAL REQUIREMENTS FOR RIBBED MATS

1. REFERENCES.

1.1 Engineering Instruction Manual, Corps of Engineers, Southwestern Division, (latest edition).

1.2 "Criteria for Selection and Design of Residential Slabs-on-Ground," Building Research Advisory Board (BRAB), Report No. 33 to the Federal Housing Administration, 1968.

1.3 "Design and Construction of Post-Tensioned Slabs-on-Ground," Post Tensioning Institute (PTI), 1980.

1.4 TM 5-818-7, Foundations in Expansive Soils, Corps of Engineers, 1983.

1.5 Letter, SWDED-G, 16 April 1987, Criteria for Developing Geotechnical Design Parameters for Ribbed Mat Design Methodology (Criteria Letter XV 7-12).

2. BACKGROUND.

Ribbed mat foundations consist of a thin slab on grade which acts monolithically with a grid of stiffening beams beneath the slab. The beams (ribs) are cast in trenches dug in the foundation soil. Ribbed mats combine the economic advantages of shallow foundations with the performance advantages of monolithic floors. Ribbed mats are especially useful for minimizing differential foundation movements in areas with expansive soils.

3. DESIGN METHODS.

3.1 EXPANSIVE SOILS.

3.1.1 Behavior.

3.1.1.1 Center Lift. In the center lift condition the soil near the edge of the slab drops in relation to the soil near the center. This is due to moisture retention by the interior soils and the drying and shrinking of perimeter soils. As this occurs, the perimeter soil provides less support for the edge of the slab which then acts as a cantilever. This is illustrated in Figure A1 of Appendix A.

3.1.1.2 Edge Lift. In the edge lift condition the soil near the edge of the slab rises in relation to the soil near the center. This is due to the increasing moisture content and subsequent swelling of soil near the edge. The swelling soil raises the edge of the slab, causing some of the slab to lift off the soil. Interior loads cause the slab to sag and recontact the soil at some interior location. The slab thus tends to act as

a beam, simply supported by the soil at the edge, and by soil towards the center of the slab. The amount of support at the center depends on numerous parameters such as interior loads, rib bending stiffness, soil swell pressures, and the magnitude of soil swelling. Typical edge lift behavior is illustrated in Figure A3 of Appendix A.

3.1.2 SWD Method. All ribbed mats on expansive soils, except for family housing, shall be designed in accordance with the provisions of Part II of this report. Ribbed mats for family housing may be designed in accordance with Part II or paragraphs 3.1.3 or 3.1.4.

3.1.3 PTI Method. The PTI method (reference 1.3) may only be used for design of family housing foundations on expansive soils. Specifically, slab width (short dimension) should not exceed 40 feet, rib depths should not exceed 30 inches, loading should consist only of perimeter loads and light interior distributed loads (DL+LL$\leq$100 psf), soils should be fairly weak in-situ materials with no extensive substitution of non-expansive fill. When using the PTI method, the following provisions shall apply: Rib spacing shall not exceed 15 feet; concrete tensile stress shall not exceed $4\sqrt{f'c}$; the minimum effective prestress shall be 100 psi.

3.1.4 BRAB Method. The BRAB report (reference 1.2) may only be used for design of foundations for family housing. However, the PTI method is preferred, since the BRAB method may produce unreasonable results for large foundations.

3.1.5 Computer Method. In lieu of paragraph 3.1.2, ribbed mats may be designed using appropriate computer programs. Such programs must be capable of modeling the variable soil swell due to moisture changes, and the non-linear soil-structure interaction near the perimeter of the foundation. One such computer program is CBEAMC, program X0050 in the Corps of Engineers Civil Engineering Library.

3.1.6 Load Factors. When using the above methods to design ribbed mats for center lift and edge lift conditions, load factors may be multiplied by .75 (strength method) or allowable stresses may be increased by one-third (working stress method). This provision does not apply to the allowables given for the PTI method, since those allowables have already been increased from the usual provisions of ACI.

3.2 NON-EXPANSIVE SOILS. Ribbed mat slabs on non-expansive soils need not be designed for bending due to center lift or edge lift conditions. Beam on elastic foundation analyses may be used to determine the effects of concentrated loads on ribs, or ribs may be designed as conventional strip or spot footings.

3.3 SOIL PROPERTIES. Soil properties for design of ribbed mats will be provided in the Foundation Design Analysis by the Corps of Engineers. Criteria for developing these properties is included in reference 1.5. The properties necessary for design in accordance with paragraph 3.1.2 consist of the following, which are defined in Appendix A:

qa - allowable bearing pressure
k - subgrade modulus
Ym - soil heave
Lm - edge moisture variation distance
Psw - pressure of swelling soil acting on perimeter rib

4. MINIMUM REQUIREMENTS.

4.1 SUBGRADE PREPARATION. A vapor barrier, capillary water barrier, and a minimum of 18 inches of non-expansive fill will normally be used beneath ribbed mats. Additional non-expansive fill will often be used to lessen the effects of highly expansive soils. These requirements will be detailed in the Foundation Design Analysis.

4.2 SLAB. For family housing and other small lightly loaded buildings a 4 inch slab may be used. For other buildings the minimum slab thickness will be 5 inches. Minimum slab reinforcing shall be 0.2 percent. Where slabs are subjected to vehicular loading they must be designed for the maximum wheel load, similar to paving. Use 650 psi flexural strength concrete for slabs subject to wheel loads.

4.3 GRID GEOMETRY. Ribs should be located to form a continuous grid. Rib spacing should not exceed 20 feet in expansive soils, or 25 feet in non-expansive soils. Locations of ribs should conform to significant wall and column loads, and may be used to resist thrusts from rigid frame reactions. Ribs should be provided around large openings in the slab. In expansive soils diagonal ribs are required at exterior corners.

Expansion joints should be provided at 250 foot intervals, and should also be used to break irregularly shaped buildings into rectangular segments. Foundations for family housing do not require expansion joints due to irregular shapes.

4.4 RIB SIZE. Minimum rib depth is 20 inches. Rib depths should usually not exceed 3 feet to minimize construction difficulties related to placing reinforcement and maintaining trench walls. If deeper ribs are used, rib width should also be increased. Minimum rib width is 12 inches except for family housing foundations, where 10 inch ribs may be used. Sufficient rib width must also be provided to transfer wall and column loads to the soil as strip footings. The allowable soil bearing capacity may not be exceeded when considering the width of the rib plus an effective slab width on each side of the rib. The

effective slab width for bearing is limited to the thickness of the slab. At column locations an alternate is to provide fillets at rib intersections, sufficient to act as spot footings for column loads.

4.5 RIB CAPACITY. Concrete should have a minimum compressive strength of f'c=3000 psi at 28 days. Reinforcing shall be grade 60, except ties may be grade 40. Minimum reinforcing ratio (As/Ag) shall be .0033 top and .0033 bottom, this may be reduced to .005 total in non-expansive soils. Use #3 ties at 24 inches, minimum. These minimums should be sufficient for shrinkage stresses and for unpredictable soil behavior.

4.6 PRESTRESSED MATS. For prestressed ribbed mats, not designed per PTI, all the above minimum requirements apply except that slab and rib top reinforcement may be deleted and replaced by appropriate post-tensioning strands. Mild steel shall still be provided in the bottom of ribs. Minimum effective prestress shall be 100 psi on the gross area of the slab, including effects of subgrade friction as calculated by the PTI method, reference 1.3. Concrete tensile stress shall be limited to $3\sqrt{f'c}$ and shear stress limited to $1.1\sqrt{f'c}$. A one-third overstress may be allowed per paragraph 3.1.6.

4.7 CONSTRUCTION DETAILS.

4.7.1 Conventionally Reinforced. Construction joint spacing should not exceed 50 feet in either direction. A horizontal construction joint may be provided in the ribs at the base of the capillary water barrier when unstable trench walls may cause construction difficulties. However, this joint is discouraged because of increased potential for shrinkage cracks in the slab.

4.7.2 Prestressed. Construction joint spacing shall not exceed 75 feet in either direction. Tendons within each placement shall be stressed to 15 percent of the final prestress not more than 24 hours after the concrete has attained sufficient strength to withstand the partial prestress. Other construction procedures for prestressed ribbed mats shall conform to reference 1.3.

4.7.3 Contractor Designs. Ribbed mat foundations may be designed as prestressed or conventionally reinforced as selected by the engineer. The plans and specifications shall not include the option of changing the ribbed mat from one type to another. The reason for this prohibition is that design parameters (e.g., moments of inertia) may be dependent on the type of ribbed mat being designed and may affect calculated shears and moments. This does not prohibit revisions of the slab type as a result of contractor value engineering proposals. However, such revisions must include a complete design of the ribbed mat foundation using appropriate design parameters in accordance with this report.

PART II - ANALYSIS OF RIBBED MAT FOUNDATIONS ON EXPANSIVE SOILS

1. SCOPE. This part of the report contains the basic rules for design of ribbed mats in expansive soils. This method may be used to predict shears, moments and deflections in ribs subject to soil movement due to changing moisture content. For a commentary on the design method refer to Appendix A; for example design calculations refer to Appendix B. The design method from Part II should be used in conjunction with the "minimum requirements" for ribbed mats, as presented in Part I.

2. GENERAL

2.1 NOTATION.

	C	= Correction factor for equivalent cantilever length
	D	= Beam deflection (IN)
	I	= Moment of inertia per foot, I=Ir/S (IN^4/FT)
	Ir	= Moment of inertia of rib (IN^4)
*	k	= Modulus of subgrade reaction (PCI)
	Lo	= Basic length of cantilever (FT)
	Lc	= Equivalent length of cantilever, center lift (FT)
	Le	= Equivalent length of simple beam, edge lift (FT)
	Li	= Distance from perimeter to location of interior load (FT)
*	Lm	= Edge moisture variation distance (FT)
	Lb	= Width of soil bearing at perimeter, edge lift (FT)
	M	= Bending moment per foot (FT-LB/FT)
	Mr	= Bending moment per rib, Mr=MxS (FT-LB)
	Pi	= Interior load (PLF)
	Pp	= Perimeter load (PLF)
*	Psw	= Pressure of swelling soil on perimeter rib (PSF)
	R	= End reaction at perimeter for equivalent simple beam (PLF)
	S	= Rib spacing (FT)
	w	= Uniform load (PSF)
	V	= Shear per foot (LB/FT)
	Vr	= Shear per rib, Vr=VxS (LB)
*	Ym	= Soil heave (IN)
	θ	= Rotation of support of equivalent cantilever (RAD)

* q_a = ALLOWABLE BEARING PRESSURE (PSF)

2.2 UNITS. The equations presented in section 3 are written for units as defined in the above notation. If other units are used the equations must be modified appropriately.

2.3 RIB DEFINITIONS. Ribs are defined as perimeter, transverse or diagonal as shown in Figure 1. Note that transverse refers to ribs parallel to either axis of the building.

* VALUES NEEDED FROM GEOTECH

FIGURE 1 - RIB DEFINITIONS

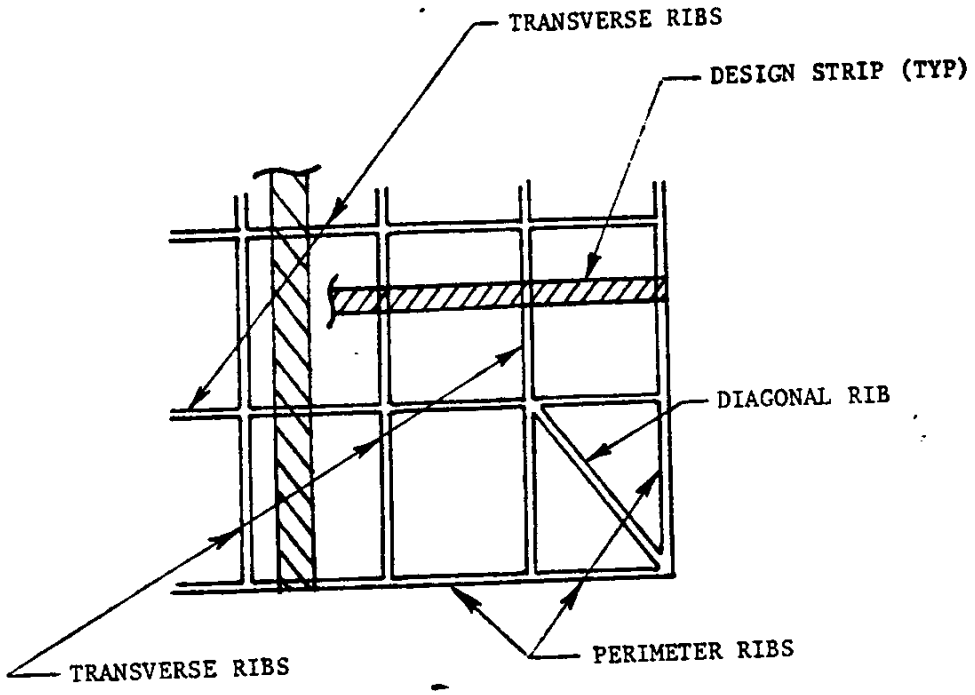
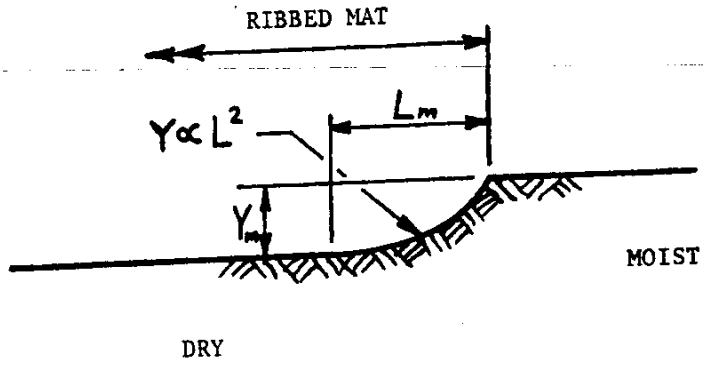


FIGURE 2 - SOIL EDGE PROFILE



2.4 STRIP ANALYSIS. The analysis is based on a strip assumption, ignoring the effects of the grid configuration of the ribs. The formulas and examples presented below are for an equivalent 1-foot strip, using "per foot" values for loads and stiffness.

2.5 SOIL EDGE PROFILE. For edge lift the maximum swell occurs at the perimeter and decreases rapidly toward the interior. The soil profile is assumed to be parabolic (in the unloaded condition) and is illustrated in Figure 2.

3. ANALYSIS METHOD.

3.1 TRANSVERSE RIB - CENTER LIFT.

3.1.1 General. Center lift analysis is based on an equivalent cantilever beam to determine moments, shears and deflections.

3.1.2 Moment. The length of the equivalent cantilever can be calculated as:

$$Lc = C \times Lo$$

where: $$Lo = 2.3 + .4\ Lm$$

$$C = .8\ Ym^{.12}\ I^{.16} / Pp^{.12}$$

The maximum moment may then be calculated from statics using conventional cantilever formulas such as:

$$M = Pp\ Lc + 1/2\ w\ Lc^2$$

The moment can then be assumed to be constant for a distance Lc/2 and then to decrease linearly to zero at a distance 5Lc from the perimeter. To obtain the design moment for a given rib, multiply the calculated per-foot moment by the appropriate rib spacing ($Mr = M \times S$).

3.1.3 Shear. The maximum shear may be calculated from statics using the same equivalent cantilever as for moment.

$$V = Pp + w\ Lc$$

The shear may then be assumed to decrease linearly from V at the cantilever support, to zero at a distance 5Lc from the perimeter. To obtain the design shear for a given rib, multiply the calculated per-foot shears by the appropriate rib spacing ($Vr = V \times S$).

3.1.4 Deflection. Deflection at the perimeter is the sum of three components: bending deflection of the equivalent cantilever, vertical translation of the cantilever support, and rotation

of the cantilever support. Rotation of the support may be calculated as:

$$\theta = M^{1.4} / 9800\ I\ k^{.5}$$

The perimeter deflection is then:

$$D = .11 + 12\ Lc\ \theta$$

where .11 inches is an approximation for the support translation plus the cantilever bending, and (12 Lc) is the length in inches.

Use the deflection calculated above to compare with allowable deflection. The allowable deflection may be determined by using 4Lc as the length between points of zero and maximum deflection.

3.2 TRANSVERSE RIB - EDGE LIFT.

3.2.1 General. Edge lift analysis is based on an equivalent simple beam, supported at the perimeter and at some interior location.

3.2.2 Deflection. The first step in calculating deflection is to determine the length of the equivalent simple beam. The appropriate length depends on many parameters, including the deflection. Therefore, deflection must first be estimated to determine equivalent length, then a deflection is calculated based on that length. The process is repeated until calculated deflection matches the assumed deflection. The equivalent simple beam length may be calculated as:

$$Le = 7.5\ I^{.17}\ Li^{.37}\ D^{.12} / w^{.07}\ pi^{.11}$$

The perimeter end reaction for this beam may be calculated from statics. For a given case the reaction may be:

$$R = Pp + 1/2\ w\ Le + Pi(Le-Li)/Le$$

The width of soil bearing at the perimeter can be approximated as:

$$Lb = 1.1\ (R/Psw)$$

where Psw is selected from a curve of heave versus bearing pressure, corresponding to the estimated deflection used during this iteration (see reference 1.5).

The edge deflection is found by determining the soil swell at a distance Lb from the perimeter, based on the parabolic swell profile:

$$D = Ym(Lm-Lb)^2/Lm^2$$

When satisfying deflection criteria, use the calculated deflection and equivalent simple beam length.

3.2.3 Moment. Once the simple beam equivalent length has been determined, the bending moments may be calculated based on statics. To obtain rib design moments, multiply per-foot moments by the rib spacing.

3.2.4 Shear. Once the simple beam equivalent length has been determined, the shears may be calculated based on statics. To obtain rib design shears, multiply per-foot shears by the rib spacing. Near the interior support the design shear need not exceed:

$$V = Pi + w(Le-Li)$$

This is due to the effects of the actual distributed soil support, rather than the point support assumed in the simple beam analysis.

3.2.5 Special Cases. If Pi=0 or if Li>Le make the following substitution in the equation for Le:

$$1.4 = Li^{.37} / Pi^{.11}$$

The equation for the simple beam length then becomes:

$$Le = 10.5\ I^{.17}\ D^{.12} / w^{.07}$$

3.3 PERIMETER RIB.

3.3.1 Center Lift. For center lift the perimeter rib will have no support from the soil and must be designed to span between transverse ribs for the perimeter wall loads.

3.3.2 Edge Lift. For edge lift the soil pressure on the perimeter rib will exceed the applied perimeter loads. The perimeter rib must designed to span between transverse ribs for this net upward force.

3.4 DIAGONAL RIB. Diagonal ribs are used to support exterior corners for center lift conditions, if loss of support occurs under both perimeter ribs. Diagonal ribs must be designed to provide the same moment and shear capacity as the larger of the two adjacent transverse ribs.

3.5 INTERIOR RIB. Interior ribs and rib intersections should be located at significant wall and column loads. The ribs can be designed for these loads as strip or spot footings, using beam-on-elastic-foundation methods. Differential soil movement due to moisture change is assumed not to occur except at the perimeter. However, to account for unpredictable interior soil movements, interior ribs must have the minimum size and capacity as required in Part I.

APPENDIX A - COMMENTARY ON PART II

1. SCOPE. Actual behavior of ribbed mats in expansive soils involves complex, non-linear, soil-structure interaction. The best solution for such behavior is provided by computer programs. The hand design method has been developed to approximate such computer results. Hand solutions have been checked by computer analyses; results have been within acceptable limits of error. However, such checks have been made only for a limited range for each design parameter, as shown in Table A1, corresponding to the usual values for military construction within Southwestern Division. If a wider range of parameters is applied to the hand design formulas, the results may be less accurate.

TABLE A1

Parameter	Units	Minimum	Maximum
k	pci	50	200
Ym	in	0.5	3.0
Lm	ft	2	8
I	in^4/ft	750	6000
Pp	lb/ft	1000	5000
Pi	lb/ft	0	5000
Li	ft	6	20
w	psf	100	250
Psw	psf	2000	8000

2. GENERAL.

2.1 NOTATION.

Ir = moment of inertia of rib. For non-prestressed rib mats Ir should be the effective moment of inertia, calculated per ACI 318, Section 9.5.2.3.

k = Modulus of subgrade reaction. This parameter is the ratio of the soil pressure at the base of the concrete and the corresponding settlement. Since modulus values are typically determined by plate-load test at the ground surface, they should be corrected for depth and for footing size (expected high pressure area between concrete and soil). Analyses have indicated that the high bearing pressure area for center lift conditions will occur in an area several feet long parallel to the transverse rib and several feet on each side of the rib. A crude approximation for this area would be 5 feet square. This approximation should be adequate for design, since calcualations are not sensitive to small changes in the modulus of subgrade reaction.

qa = Allowable bearing pressure. This is the safe bearing capacity of the soil at the base of the ribs. A factor of safety of 3.0 is recommended for computing this value.

Lm = Edge moisture variation distance. This represents the distance, inward from the edge of the slab, over which the moisture content of the soil changes. Much judgement is required in determining this value.

Psw = Pressure of swelling soil on perimeter rib. This is the interface pressure between the soil and the base of the exterior rib, due to an increase in soil moisture content. The pressure which can be exerted by the swelling soil is dependent on the amount the surface of the soil is allowed to rise. Therefore Psw is usually presented as a curve of pressure versus heave, as described in reference 1.5 of Part I. The actual upward deflection of the edge of the slab is a complex interaction between swell potential, structural loads, and mat stiffness, all of which combine to determine the interface pressure near the perimeter.

Ym = Soil heave. This is the differential vertical movement of the soil representing either soil heave (edge lift) or soil shrinkage (center lift). The magnitude of Ym is the computed vertical movement of a particle of soil at the ground surface due to a change in moisture content. This value should be based on the accumulation of potential volume changes for the full thickness of the active zone (Za), with no significant loads applied to the foundation. The value of Ym may differ for edge lift and center lift conditions.

Pi, Pp, w = Applied loads. Loads should consist of full dead plus live loads, including dead load of the slab and ribs.

2.2 UNITS.

2.3 RIB DEFINITIONS.

2.4 STRIP ANALYSIS. The hand solution formulas have been developed for analysis of an equivalent 1 foot strip. This is convenient for uniform loads and for soil properties, but requires some calculations for appropriate concentrated loads and bending stiffness. Rib stiffness must be divided by rib spacing to get the per-foot stiffness. If column loads exist they must also be divided by the rib or column spacing to provide an equivalent load per foot. If interior wall loads are parallel to the transverse rib, they must be divided by the rib spacing. These calculations are illustrated in Appendix B.

2.5 SOIL EDGE PROFILE. The edge lift condition occurs when increased moisture content swells exterior soils, and this effect extends under the edge of the slab. The center lift condition occurs when soils under the slab are generally moist and seasonal drying occurs on the exterior, again extending under the slab. This causes the soil to shrink away from the edge of the slab.

The analysis method is based on an assumed parabolic swell profile which occurs uniformly along the perimeter. This is a convenient idealization of actual soil behavior, which is certainly more erratic. However, the parabolic profile has better correlation with measured swells than do other possible edge profile assumptions. Note that the soil profile is not used in the hand design formulas for center lift. However, a parabolic profile was used in the computer analyses for center lift, which formed the basis for the hand design forumlas.

3. ANALYSIS METHOD. Many of the formulas for shears, moments and reactions are idealized, assuming Pp and R are exactly at the perimeter and that w extends to the perimeter. These approximations should usually be acceptable, but the formulas may be modified to account for actual load patterns.

3.1 TRANSVERSE RIB - CENTER LIFT

3.1.1 General. Typical behavior of a transverse rib for center lift conditions is shown in Figure A1. This illustrates the soil bearing pressure and the shear, moment and deflection. Note that the effects of the soil movement extend much farther than the moisture variation distance. The moment and shear distribution close to the edge resemble cantilever behavior.

3.1.2 Moment. The extent of significant moments is illustrated in Figure A1. The length of the equivalent cantilever can be taken as a basic length (Lo) which is dependent on the moisture variation distance, times a correction factor (C) which accounts for secondary effects of several parameters. The value of the correction factor will usually be slightly greater or less than unity. The correction factor was developed to permit accurate approximations of computer results. It was developed from the ratios of actual values to usual values for significant parameters. For example, the "usual" values are: Ym = 1 in, I = 1500 in^4/ft, Pp = 3000 lb/ft. Thus:

$$C = (Ym/1.0)^{.12} (I/1500)^{.16} (3000/Pp)^{.12}$$

$$C = .8\ Ym^{.12}\ I^{.16}/\ Pp^{.12}$$

A similar approach was used to develop all the formulas in Part II which have an exponential format.

3.1.3 Shear. Maximum shear occurs near the support of the equivalent cantilever. The extent of significant shears is illustrated in Figure A1.

3.1.4 Deflection. Formulas for deflection include an assumed concrete modulus of elasticity Ec = 3,320,000 psi, for both center lift and edge lift.

Vertical movement at the perimeter is much greater than the bending deflection of the equivalent cantilever. To predict the deflection it is necessary to consider translation and rotation at the support of the equivalent beam. The most significant component is due to rotation at the support. These

components of deflection are shown in Figure A2. The sum of the cantilever bending and the support translation are approximated by the value 0.11 inch. The percent error due to this approximation is negligible when total deflections are large. The percent error is greater when total deflections are small, but then the deflections are not significant anyway.

Allowable deflections (see Part I, reference 1.1) are expressed as a ratio of the difference in vertical movement at any two points, compared to the distance between those points. For example: $D \leq L/600$, where D is the differential displacement. In such formulas it is appropriate to use the point of maximum deflection and a point of near-zero deflection as the two measuring points. For center lift behavior the maximum deflection occurs at the perimeter, and deflections tend to die out at approximately 4Lc (four times the equivalent cantilever length) from the perimeter. Therefore, the ratio D/4Lc is appropriate for comparison with allowable deflections.

3.2 TRANSVERSE RIB - EDGE LIFT.

3.2.1 General. Typical behavior of a transverse rib for edge lift conditions is shown in Figure A3. This illustrates the soil bearing pressure and the shear, moment and deflection. Soil swell lifts the edge of the ribbed mat, which actually rises off the soil for some distance from the perimeter. For shear and moment, this portion of the rib acts as a simply supported beam spanning between soil support at the perimeter and at an interior location.

3.2.2 Deflection. Vertical movement at the perimeter is driven by the tendency of the soil to swell, and is resisted by the downward loads applied on the soil. As the soil swells at the perimeter the slab is lifted off the interior soil. This concentrates soil reactions near the edge, causing very high pressures. The pressures rise so high that they limit the capacity of the soil to swell. Thus, the soil cannot swell as much as it would if not loaded. Deflections can be predicted by balancing the upward force of the soil (the swell pressure times the bearing width) with the downward force of applied loads. This downward force can be determined from statics once an equivalent simple beam length is determined. The method for determining the deflection is shown in Figure A4.

Allowable deflections are expressed as ratios, as discussed in the commentary on paragraph 3.1.4. From Figure A3 it can be seen that the appropriate values for this ratio are the edge deflection and the equivalent simple beam length (D/Lc).

Edge lift deflections are mainly a function of soil properties and applied loads, bending stiffness of the ribs has only a secondary effect. Therefore, it may not be possible to control deflections by increasing the rib stiffness. It may be necessary to accommodate calculated deflections by using a less brittle superstructure or by detailing the superstructure to make it less sensitive to deflections. Or it may be necessary to modify soil properties to minimize the edge heave.

3.2.3 Moment. The moments can be calculated by statics, using the equivalent simple beam. The maximum moment will occur at the point of zero shear. Note that the maximum moment is quite sensitive to the beam length, therefore the iterative solution for deflection and appropriate swell pressure must converge accurately before calculating moments.

3.2.4 Shear. Shears can also be calculated by statics from the equivalent simple beam. Note that shears will reduce gradually to near-zero around the interior end of the beam because of the distributed soil support.

3.2.5 Special Cases. If no concentrated interior load exists, or if it is very far from the perimeter, the formula for the simple beam length must be adjusted as shown. This adjusted formula was also developed to duplicate results from computer solutions.

3.3 PERIMETER RIB.

3.4 DIAGONAL RIB.

3.5 INTERIOR RIB. Potential soil heaves in the interior are unpredicatable and are generally due to localized moisture conditions, for example, due to a leaking pipe. Such conditions cannot be accounted for by design forumlas. Adequate strength and stiffness for such unpredictable heaves should be supplied by the minimum requirements listed in Part I of the report. For interior wall or column loads the interior ribs should be designed in accordance with Part I, section 3.2.

FIGURE A1 - CENTER LIFT BEHAVIOR

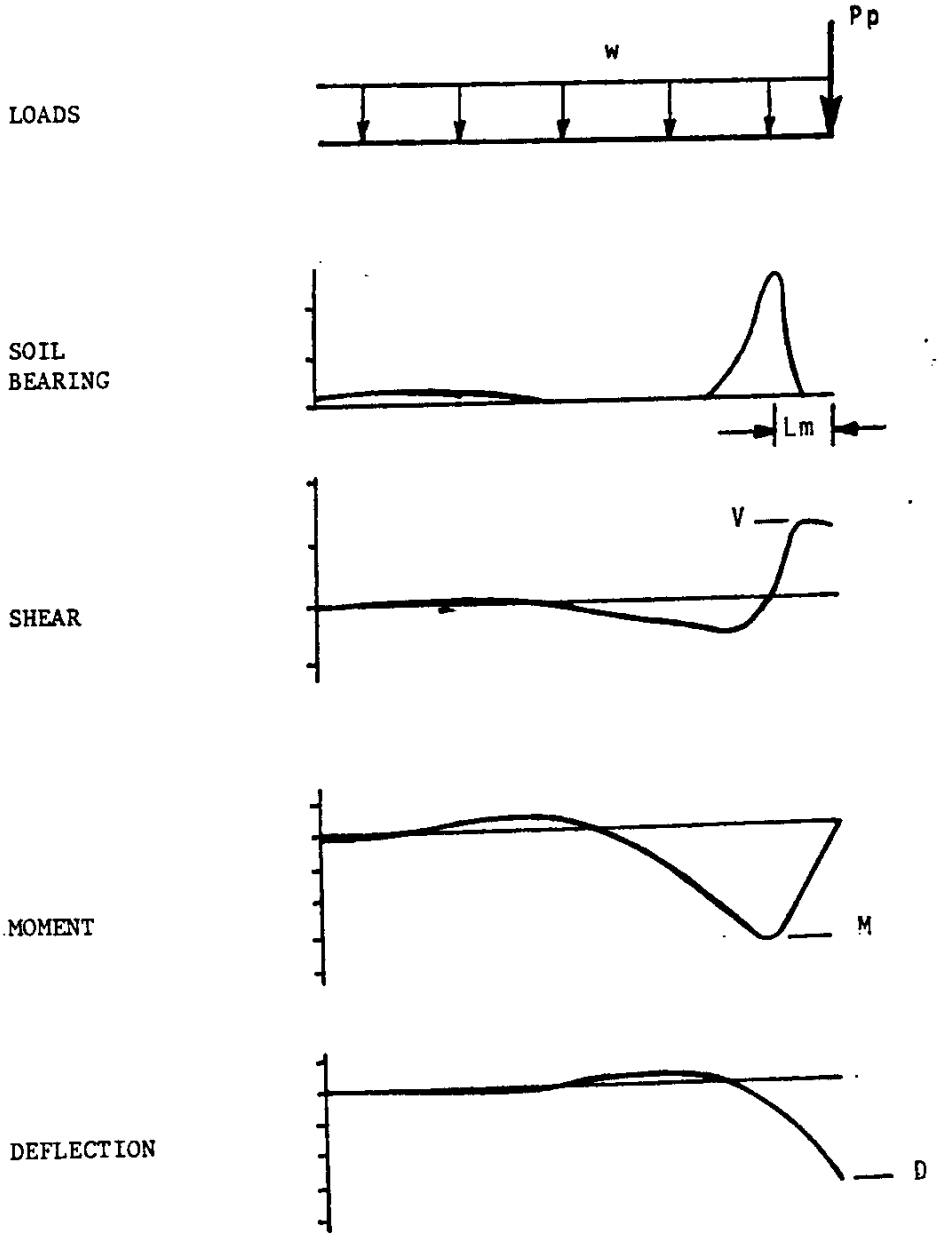
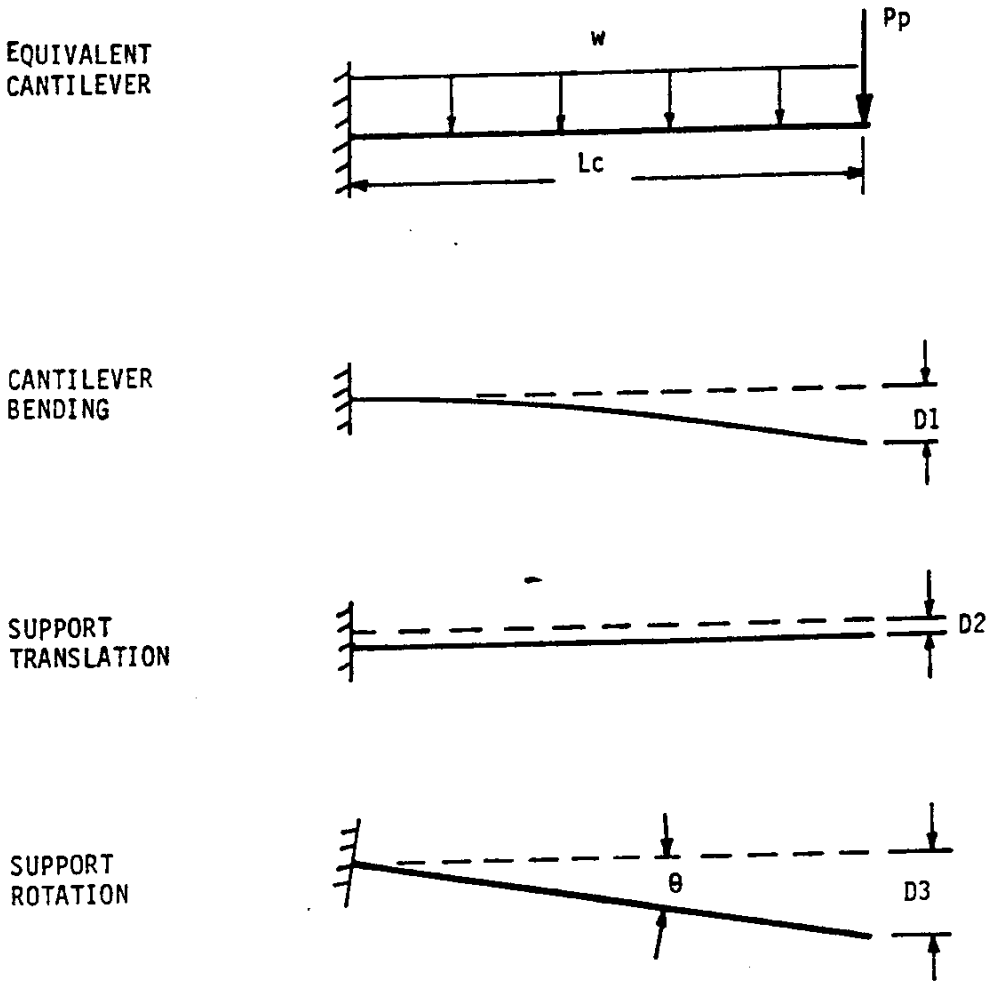


FIGURE A2 - CENTER LIFT DEFLECTION



$$D = D1 + D2 + D3$$

$$D1 + D2 = .11$$

$$D3 = 12\ Lc\ \theta$$

FIGURE A3 - EDGE LIFT BEHAVIOR

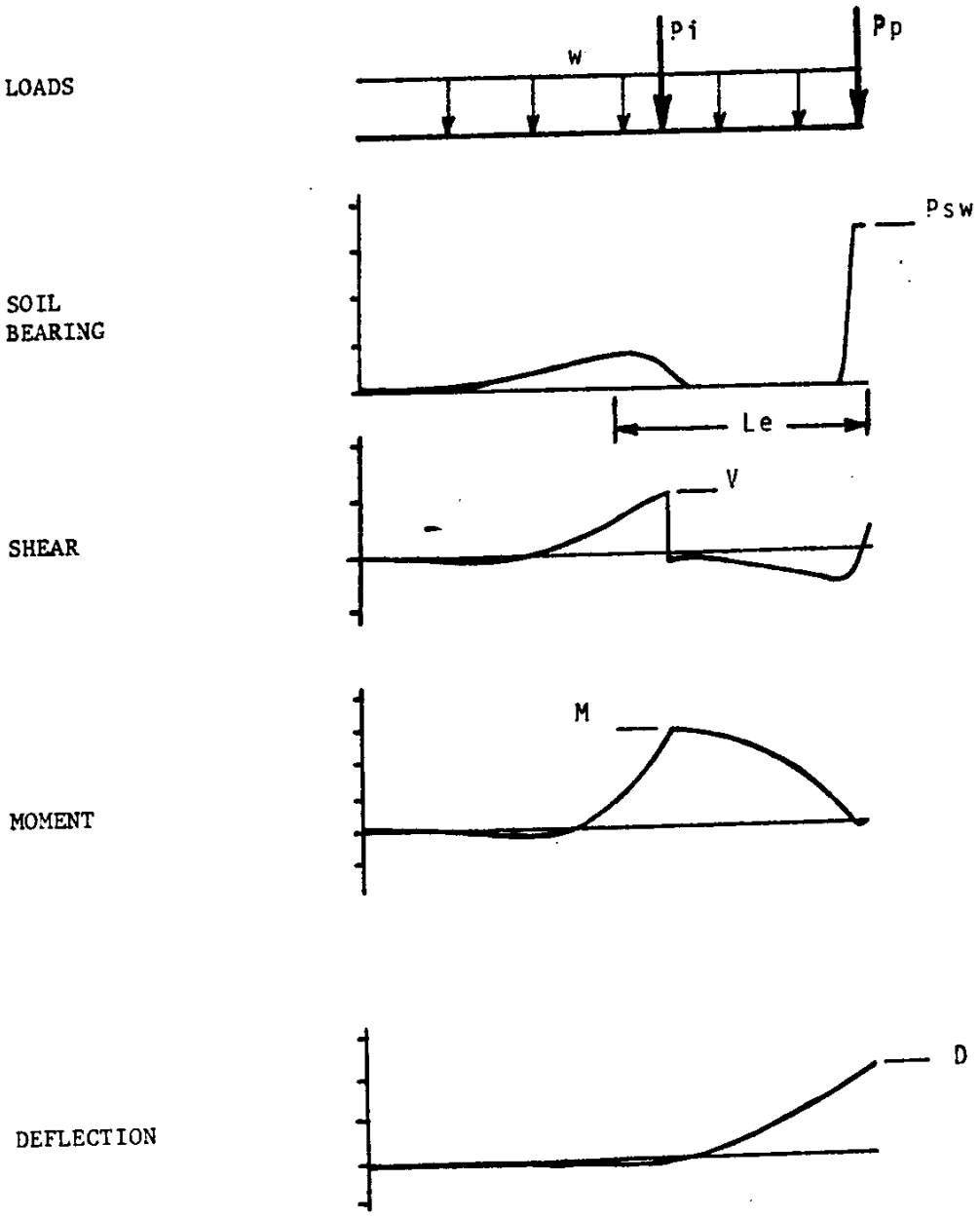
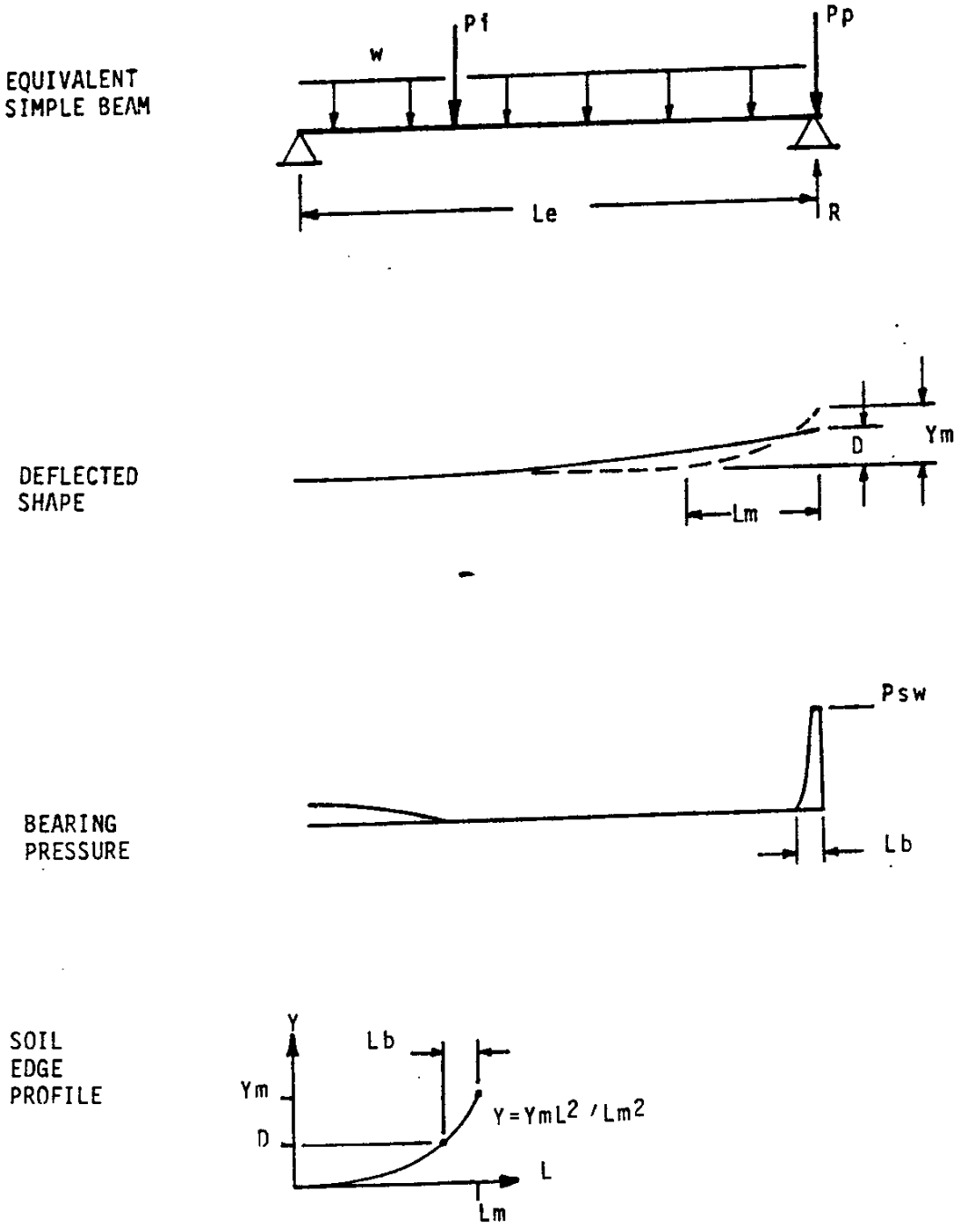


FIGURE A4 - EDGE LIFT DEFLECTION



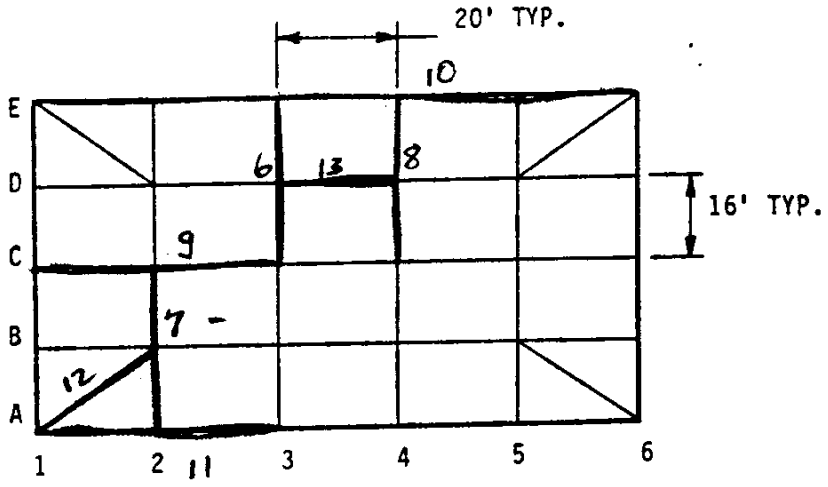
APPENDIX B - DESIGN EXAMPLE

(RIBBED MAT DESIGN IN EXPANSIVE SOIL)

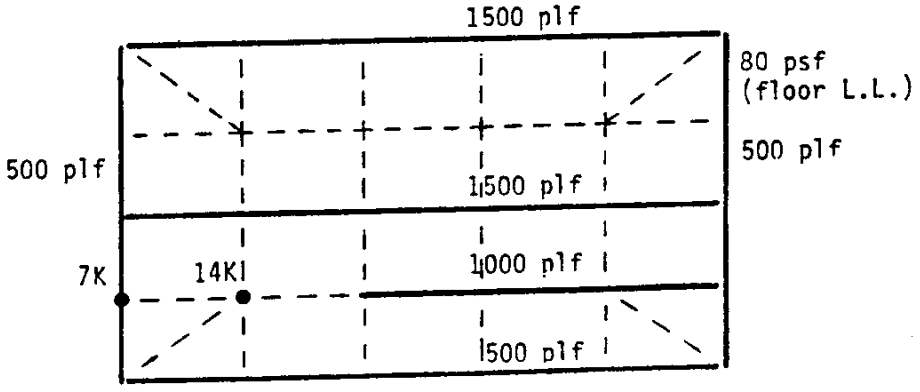
1. SOIL DATA (ref. Part I - 3.3)

qa = 2000 psf
Psw = (see page B9)
k = 100 pci
Lm = 6 ft
Ym = 1.5 in for center lift
Ym = 1.0 in for edge lift

2. FOUNDATION PLAN (ref. Part I - 4.3)



3. LOADS



4. BEARING DESIGN FOR RIBS (ref. Part I - 4.4)

Maximum wall load (P) = 1500 plf

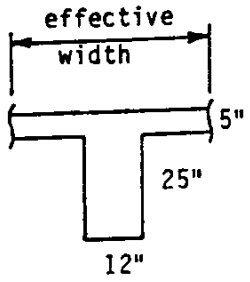
Width $\geq$ P/qa = 1500/2000 = .75 ft

Use 12 inch wide ribs (minimum)

5. INTERIOR RIB PROPERTIES (ref. Appendix A - 2.1)

Ec = 3,320,000 psi

(effective flange width per ACI 318, section 8.10.2 For "span length" use 4Lc for center lift or Le for edge lift)



Let Ir = 36,000 in^4 for center lift
Ir = 24,000 in^4 for edge lift
(ref. ACI 318, section 9.5.2.3, verify Ir after calculating M)

I = Ir/S (in^4/ft):

Rib spacing	16 ft	20 ft
Center lift	2250	1800
Edge lift	1500	1200

6. CENTER LIFT DESIGN - RIB E3/C3

6.1 Loads (ref. Appendix A - 2.1)

slab weight = 150 pcf x 5/12 ft = 62 psf

w = DL + LL = 62 + 80 = 142 psf

rib weight = 150 pcf x 2.5 ft x 1.0 ft = 375 plf

Pp = rib + wall = 375 + 1500 = 1875 plf

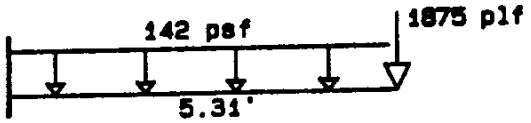
6.2 Equivalent cantilever (ref. Part II - 3.1)

$Lo = 2.3 + .4\ Lm = 2.3 + (.4 \times 6) = 4.7$ ft

$C = .8\ Ym^{.12}\ I^{.16} / Pp^{.12}$

$C = .8 \times 1.5^{.12} \times 1800^{.16} / 1875^{.12} = 1.13$

$Lc = Lo\ C = 4.7 \times 1.13 = 5.31$ ft



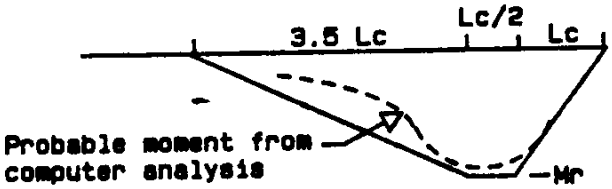
6.3 Moment (ref. Part II - 3.1.2)

$M = Pp\ Lc + 1/2\ w\ Lc^2$

$M = 1875 \times 5.31 + 1/2 \times 142 \times 5.31^2 = 12{,}000$ ft-lb/ft

$Mr = M \times S = 12000 \times 20 = 240{,}000$ ft-lb/rib

Design moments:

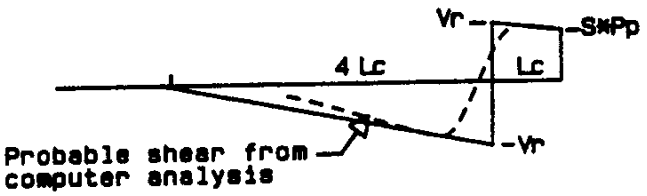


6.4 Shear (ref. Part II - 3.1.3)

$V = Pp + w\ Lc = 1875 + 142 \times 5.31 = 2630$ lb/ft

$Vr = V \times S = 2630 \times 20 = 52{,}600$ lb/rib

Design shears:



6.5 Reinforcing in rib (ref. Part I - 3.1.6 and 4.5)

As = (Mr/ad)/1.33

As = 240 / (1.76 x 28 x 1.33) = 3.66 in^2 (top)

use 3 #10 bars

v = Vr/bd = 52600 / (12 x 28) = 157 psi

vc = $(1.1\sqrt{f'c})1.33$ = 80 psi

Av = (v-vc)b s/(fs 1.33)

Av = (157-80) 12 x 12 / (24000 x 1.33) = .35 in^2/ft

use #4 stirrups @ 12 in

6.6 Deflection (ref. Part II - 3.1.4)

$\theta = M^{1.4} / 9800\ I\ k^{.5}$

$\theta = 12000^{1.4} / (9800 \times 1800 \times 100^{.5})$ = .0021 .0029 radians

D = .11 + 12 Lc θ = .11 + 12 x 5.31 x .0029 = .29 in

D/4Lc = .29 / (4 x 5.31 x 12) = 1/879 O.K.

1062

7. EDGE LIFT DESIGN - RIB A2/C2

7.1 Loads

w = 142 psf (same as above)

Pp = rib + wall = 375 + 500 = 875 plf

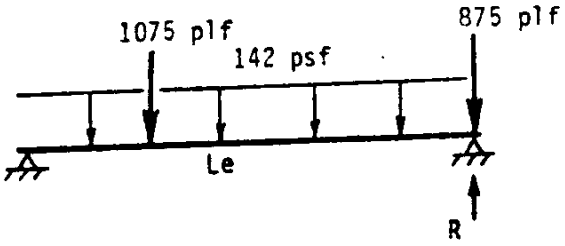
Pi = rib + wall* = 375 + 700 = 1075 plf

* equivalent wall load = column load / rib spacing

14000/20 = 700 plf (ref. Appendix A - 2.4)

Li = 16 ft

7.2 Equivalent simple beam (ref. Appendix A - 3.2.1)



7.3 Deflection (ref. Part II - 3.2.2)

$Le = 7.5\ I^{.17}\ Li^{.37}\ D^{.12} / w^{.07}\ Pi^{.11}$

$Le = 7.5 \times 1200^{.17} \times 16^{.37} \times D^{.12} / 142^{.07} \times 1075^{.11}$

$Le = 22.9\ D^{.12}$

assume D = .50 in (somewhat less than Ym = 1.0 in)

$Le = 22.9 \times .50^{.12} = 21.1$ ft

$R = Pp + 1/2\ w\ Le + Pi(Le-Li)/Le$

$R = 875 + (142 \times 21.1)/2 + 1075(21.1-16.0)/21.1 = 2633$ plf

from heave/pressure curve (p B9), for D=.50 find Psw=2000

$Lb = 1.1(R/Psw) = 1.1(2633/2000) = 1.45$ ft

$D = Ym(Lm-Lb)^2/Lm^2$

$D = 1.0(6.0-1.45)^2/6.0^2 = .575$ in $\neq$ .50 inch assumed!

assume D = .54 in

$Le = 22.9 \times .54^{.12} = 21.3$ ft

$R = Pp + 1/2\ w\ Le + Pi(Le-Li)/Le$

$R = 875 + (142 \times 21.3)/2 + 1075(21.3-16.0)/21.3 = 2655$ plf

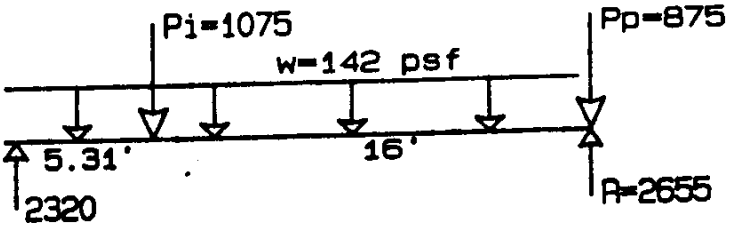
from heave/pressure curve, for D=.54 find Psw=1800 psf

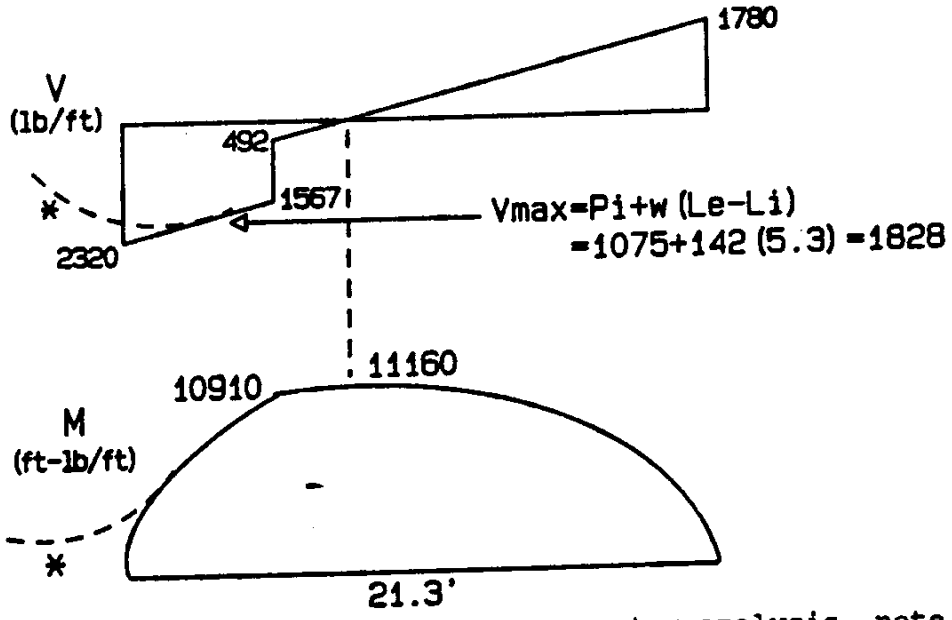
$Lb = 1.1(R/Psw) = 1.1(2655/1800) = 1.62$ ft

$D = 1.0(6.0-1.62)^2/6.0^2 = .533$ in CONVERGED!

D/Le = .54/(21.3x12) = 1/473 O.K. for non-brittle walls

7.4 Moment and shear (ref. Part II - 3.2.3 and 3.2.4)





* probable shear and moment from computer analysis, note that calculated V=2320 lb will not occur, due to the effects of distributed support from the soil

8. EDGE LIFT DESIGN - RIB E4/C4

8.1 Loads

w = 142 psf (same as above)

Pp = 1875 plf (same as rib E3/C3)

Li = 32 ft (wall along rib C1/C6)

8.2 Deflection

since Li>Le use:

$Le = 10.5\ I^{.17}\ D^{.12} / w^{.07}$ (ref. Part II - 3.2.5)

$Le = 10.5 \times 1200^{.17} \times D^{.12} / 142^{.07} = 24.77\ D^{.12}$

assume D = .48 in

then $Le = 24.77 \times .48^{.12} = 22.7$ ft

$R = Pp + 1/2\ w\ Le = 1875 + (142 \times 22.7)/2 = 3485$ plf

from heave/pressure curve, for D=.48 find Psw=2100 psf

$Lb = 1.1(R/Psw) = 1.1(3485/2100) = 1.825$ ft

$D = Ym(Lm-Lb)^2/Lm^2$

$D = 1.0(6.0-1.825)^2/6.0^2 = .484$ inch CONVERGED!

8.3 Find shears and moments by statics, similar to rib A2/C2.

9. CENTER LIFT DESIGN - RIB C1/C3

9.1 Loads

$w = slab + LL + wall^* = 62 + 80 + 94 = 236$ psf

* wall = wall load / rib spacing = 1500/16 = 94 psf
(ref. Appendix A - 2.4)

$Pp = rib + wall = 375 + 500 = 875$ plf

9.2 Equivalent cantilever

$Lo = 2.3 + .4\ Lm = 2.3 + (.4 \times 6) = 4.7$ ft

$C = .8\ Ym^{.12}\ I^{.16} / Pp^{.12}$

$C = .8 \times 1.5^{.12} \times 2250^{.16} / 875^{.12} = 1.28$

$Lc = Lo\ C = 4.7 \times 1.28 = 6.02$ ft

9.3 Moment

$M = Pp\ Lc + 1/2\ w\ Lc^2$

$M = 875 \times 6.02 + (236 \times 6.02^2)/2 = 9544$ ft-lb/ft

$Mr = M \times S = 9544 \times 16 = 153{,}000$ ft-lb/rib

9.4 Shear

$V = Pp + w\ Lc = 875 + (236 \times 6.02) = 2296$ plf

$Vr = V \times S = 2296 \times 16 = 36{,}700$ lb/rib

9.5 Deflection

$\theta = M^{1.4} / 9800\ I\ k^{.5}$

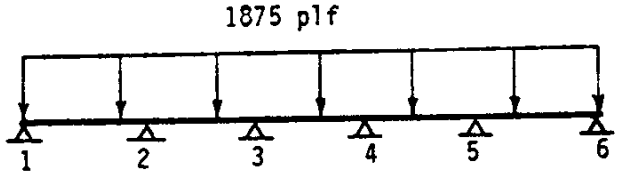
$\theta = 9544^{1.4} / 9800 \times 2250 \times 100^{.5} = .0017$ radian

$D = .11 + 12\ Lc\ \theta = .11 + (12 \times 6.02 \times .0017) = .23$ in

10. CENTER LIFT DESIGN - PERIMETER RIB E1/E6 (ref. Part II-3.3.1)

10.1 Span between transverse ribs

Pp = 1875 plf (from calculations for rib E3/C3)

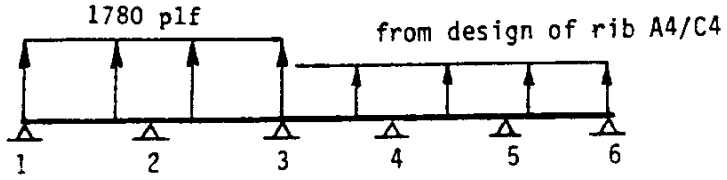


10.2 Analyze by conventional methods

11. EDGE LIFT DESIGN - PERIMETER RIB A1/A3 (ref. Part II - 3.3.2)

11.1 Span between transverse ribs for net upward force (from calculations on rib A2/C2)

R - Pp = 2655 - 875 = 1780 plf (upward)



11.2 Analyze by conventional methods

12. CENTER LIFT DESIGN - DIAGONAL RIB A1/B2 (ref. Part II - 3.4)

12.1 Provide the larger shear and moment capacity of rib B1/B2 or rib A2/B2.

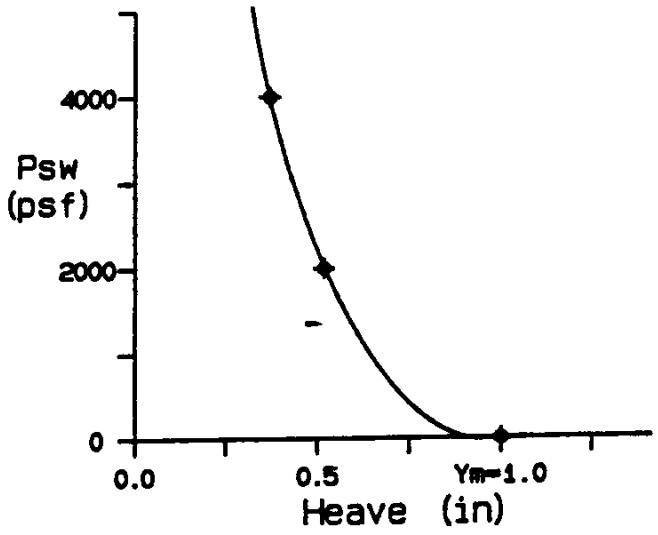
13. RIB D3/D4 (ref. Part I - 4.5)

13.1 Interior rib with no wall or column loads

$A_s \geq .0033\ A_g = .0033 \times 12 \times 30 = 1.20\ in^2$ (top and bot.)

This is the typical minimum reinforcement for the full length of all ribs.

14. HEAVE VERSUS SWELL PRESSURE CURVE (ref. Appendix A - 2.1)



DEPARTMENT OF THE ARMY
SOUTHWESTERN DIVISION, CORPS OF ENGINEERS
1114 COMMERCE STREET
DALLAS, TEXAS 75242-0216

REPLY TO
ATTENTION OF

16 APR 1987

SWDED-G

SUBJECT: Criteria for Developing Geotechnical Design Parameter for SWD Ribbed Mat Design Methodology

Commander, Albuquerque District, ATTN: SWAED-TA
Commander, Fort Worth District, ATTN: SWFED-F
Commander, Galveston District, ATTN: SWGED-G
Commander, Little Rock District, ATTN: SWLED-G
Commander, Tulsa District, ATTN: SWTED-G

1. Reference is made to criteria letter SWDED-TS/G dated 23 December 1986, subject "Design Criteria for Ribbed Mat Foundation".

2. The above reference criteria letter require certain geotechnical parameters be furnished in the Foundation Design Analysis when a ribbed mat slab foundation is recommended in expansive soil areas. Enclosure 1, for addressees only, provides guidance for development of these parameters. These procedures were developed by the Ft. Worth District with review in the Southwestern Division. Questions and/or comments should be directed to either Mr. A.L. Branch, FTS 334-2117 or Mr. Jack Fletcher, FTS 729-6365.

FOR THE COMMANDER:

William [signature]
for ARTHUR D. DENYS, P.E.
Chief, Engineering Division

Encl

YEARS OF SERVICE ... THE SOUTHWEST

CONTENTS

1. REFERENCES

2. BACKGROUND

3. SOIL-STRUCTURE INTERACTION MODES

3.1. Center Lift

3.2. Edge Lift

4. DETERMINATION OF CENTER LIFT AND EDGE LIFT PARAMETER FOR STRUCTURAL DESIGN

4.1. Center Lift

4.1.1. Modulus of Subgrade Reaction

4.1.2. Design Allowable Bearing Pressure

4.1.3. Center Lift Heave Potential

4.1.4. Loss of Support Distance

4.2. Edge Lift

4.2.1. Modulus of Subgrade Reaction

4.2.2. Soil-Beam Interface Pressure

4.2.3. Edge Moisture Variation Distance

4.3 Summary

5. APPENDIX A

5.1 EXAMPLE PROBLEM

DEVELOPMENT OF GEOTECHNICAL DESIGN PARAMETERS FOR RIBBED MAT FOUNDATIONS

1. REFERENCE.

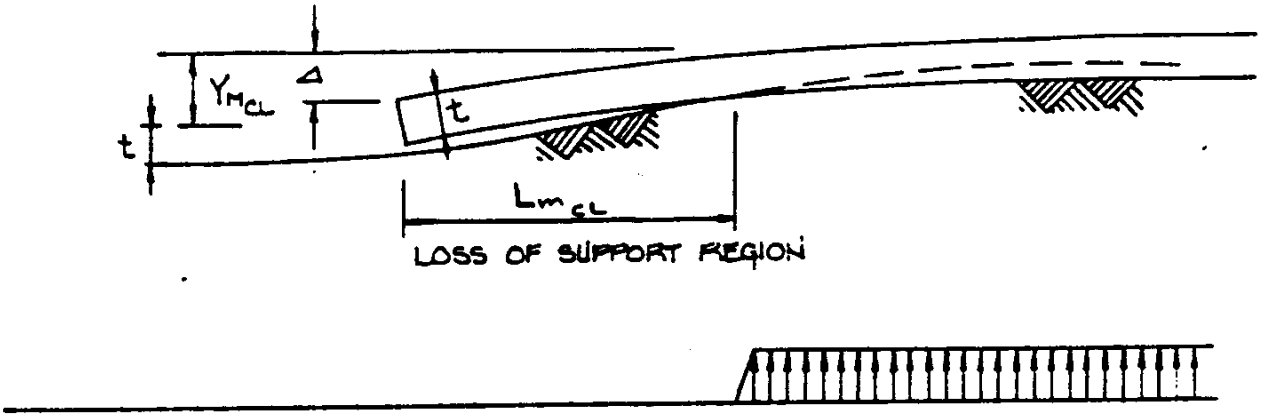
1.1 SWDED-TS/G, Design Criteria for Ribbed Mat Foundations, dated 23 Dec 86.

1.2 TM 5-818-7, Foundations in Expansive Soils, Corps of Engineers, 1983.

2. BACKGROUND. The recently developed structural design methodology (reference 1) models the interaction of a ribbed mat slab on an expansive subgrade for purposes of structural design. This method appears equally suited to stiffened mat systems such as flat mats, modified flat mats and inverted ribbed mats. Utilization of the methodology requires the expansion and refinement of the geotechnical design parameters furnished in the foundation design analysis. The purpose of this report is to (1) identify and (2) provide a rational method of determining these parameters.

3. SOIL-STRUCTURE INTERATION MODES. Two heave induced deformation conditions appropriate for ribbed mat slab structural analysis are (a) center lift and (b) edge lift.

3.1 CENTER LIFT. Center lift considers doming of the foundation in the interior region of a slab on grade differentially to the perimeter region as depicted on figure 1. This may be caused either by drying of the expansive subgrade around the perimeter beam or by wetting of the dry expansive subgrade in the interior region. Perimeter drying results from (1) below average precipitation and/or (2) reduced or no landscape watering and/or



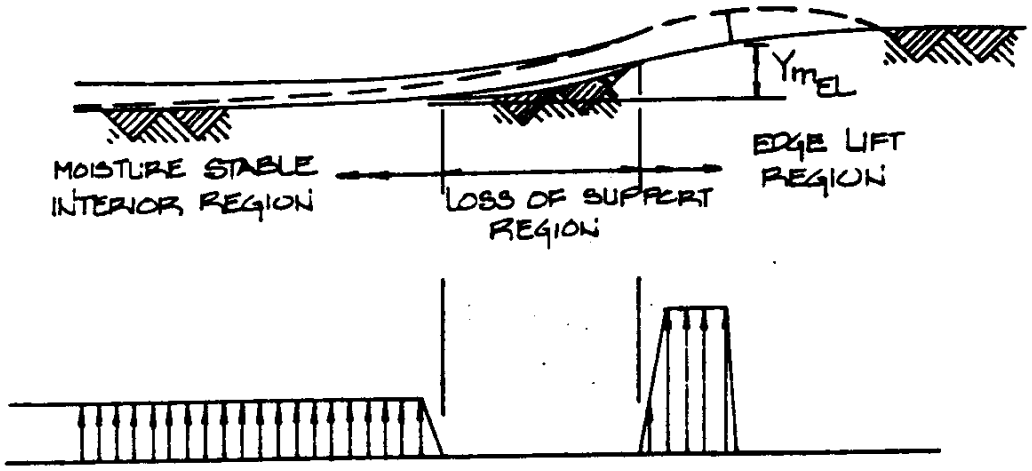
CENTER LIFT

FIGURE 1

(3) removal of old paving or hard stand. Interior wetting results from (1) disruption of the site moisture equilibrium by "capping" the site with the relatively impervious slab or by removal of thick brush or trees from the site (thus eliminating evapo-transportation) and/or (2) leaky inservice or abandoned utilities. Loss of support along perimeter and first interior transverse stiffener beam results if (1) the magnitude of center lift heave is large enough and (2) the beams are sufficiently rigid to cantilever from the supported interior region.

3.2 **EDGE LIFT**. Edge lift involves more complex soil-structure interactions than does center lift. In edge lift, the structure is supported by heaving subgrade in the perimeter region and in the relatively moisture stable interior region. Loss of support develops when (1) the edge lift heave deformation

is large enough and (2) the spanning beam is sufficiently rigid. Edge lift mode is depicted on figure 2.



EDGE LIFT
FIGURE 2

Soil-structure interaction within the interior supported region is reasonably represented as a beam on non-linear subgrade. Soil-structure interaction in the perimeter region is somewhat more complex because the soil deflects under the structural load as a beam on non-linear subgrade, but also the swelling soil either loads and/or deflects the beam upward. To further complicate matters, the amount of edge lift heave and the soil-beam interface pressure are interrelated and unique for each specific site. Background parameter studies for reference 1 indicate that the structural analyses are particularly sensitive

to edge lift parameters (edge lift heave magnitude and limiting beam-soil interface pressure). For example, large values for these may cause the solution to either fail to converge or indicate that the beam must be very deep and/or very heavily reinforced. While site conditions may sometimes dictate massive, very rigid stiffener beams, this is not generally the case. Generally, edge lift heave of less than 1.0 to 1.5 inches used in the design method given in reference 1 produce reasonable, constructable beams.

4. DETERMINATION OF CENTER LIFT AND EDGE LIFT PARAMETERS FOR STRUCTURAL DESIGN.

4.1 CENTER LIFT - Center lift parameters to be provided in the foundation design analysis includes (1) modulus of subgrade reaction (K_1), (2) design allowable bearing for beams (q_{all}), (3) magnitude of center lift (Y_{mcL}) and (4) loss of support distance around the perimeter (L_{mcL}).

4.1.1 MODULUS OF SUBGRADE REACTION - The modulus of subgrade reaction should be taken as K_1 = 200 pci for beams up to 12 inches wide bearing on compacted, nonexpansive fill. Higher values may be justified for granular nonexpansive fills consisting of gravel, crushed rock or limestone screenings or for cement stabilized materials if these materials extend significantly ($D \geq 3B$) below the stiffener beam of width B. The foundation design analysis should direct that K_1 values be factored to account for width effects such that $K_{design} = K_1/B$, where B is the effective beam width in feet for soil structure interaction. Note that the resultant effective beam width may include a significant width of the slab and is therefore

significantly greater than actual beam width. Studies indicate that significant load distribution occurs over an "effective" width of approximately five. It should be noted that structural design calculations are not sensitive to K value.

4.1.2 DESIGN ALLOWABLE BEARING. A design allowable bearing value (q_{all}) has historically been assigned for sizing of stiffener beams, perimeter beams and enlarged beam intersections beneath columns. Values are typically given considering the beam to be a continuous strip footing or the beam intersection to be a spot footing (carrying either line or concentrated loads, respectively). The allowable bearing value is typically developed based on the average strength of engineered fill at shallow depth with a factor of safety of not less than 3.0. Design loads typically include full dead load plus half live load. The purpose in sizing the beams and beam intersections for this design allowable is to provide uniform contact pressures at the beam-soil interface therefore limiting inservice differential settlement. The assumptions of minimal load sharing between the slab and beams, ample safety factor on the fill strength, and minimum beam widths specified in the SWD EIM combine to limit the mobilized soil strains to low levels. This leads to very small structurally induced deflections given uniform, nominal fill depths. Actual values assigned for design bearing allowables have seldom exceeded q_{all} = 2.0 KSF although values as high as 3.0 KSF have been assigned in limited cases where required and justifiable. Seldom are there structural requirements for larger allowables bearing values since specified minimum beam widths generally govern.

4.1.3 MAGNITUDE OF CENTER LIFT HEAVE POTENTIAL. - The magnitude of center lift heave potential (Y_{mcL}) given in the foundation design analysis should be the residual heave potential at the site. The value of Y_{mcL} should include effects due to subgrade removal and replacement criteria, any surcharge effects due to fill above original subgrade and the weight of the proposed structure. Maximum design value for center lift potential should not exceed 1.5 inches. Where attainable with reasonable removal/replacement depths (≤36 inches), it is desirable to limit Y_{mcL} to not more than 1.0 inch, which is well within the "tolerable" inservice deformation range of most structures. Minimum remove/replace depth should be taken to the bottom elevation of the ribbed mat slab beams.

The heave potential is determined by three soil parameters: the coefficient of swell (C_s), depth of active zone (X_a) and expansion pressure (P_{exp}).

Caution should be used in selecting coefficient of swell (C_s) values for heave analyses since swell pressure test results significantly underestimate C_s values compared to controlled expansion-consolidation-rebound tests. Additionally, both test methods tend to give low C_s values since most rebound time curves are terminated well before primary swell is completed.

An appropriate design value of the depth of the active zone (X_a) typically lies between the present depth to the stable relative moisture content (estimated by observing the relationship of moisture content to the plastic limit) and the maximum depth observed, such as the maximum depth of weathering. Typical X_a values for the central and north Texas regions and

central Oklahoma region appear to vary from about 10 to 15 feet. These values have been estimated for (1) regression heave analyses for distressed structures and (2) depth of moisture variation versus approximate return/duration interval studies. Values smaller than 14 feet may be applicable in specific cases such as where the active zone is the distance between the structural foundation element or slab on grade and a perched water table; a condition common in these regions.

Center lift heave analyses should consider "saturated" conditions to a depth of X_a. If a nominal remove/replace depth and saturated subgrade assumptions indicate unreasonable residual heave potential, consider increasing the depth of remove/replace and/or recommending a more defensive design to prevent saturation of the subgrade.

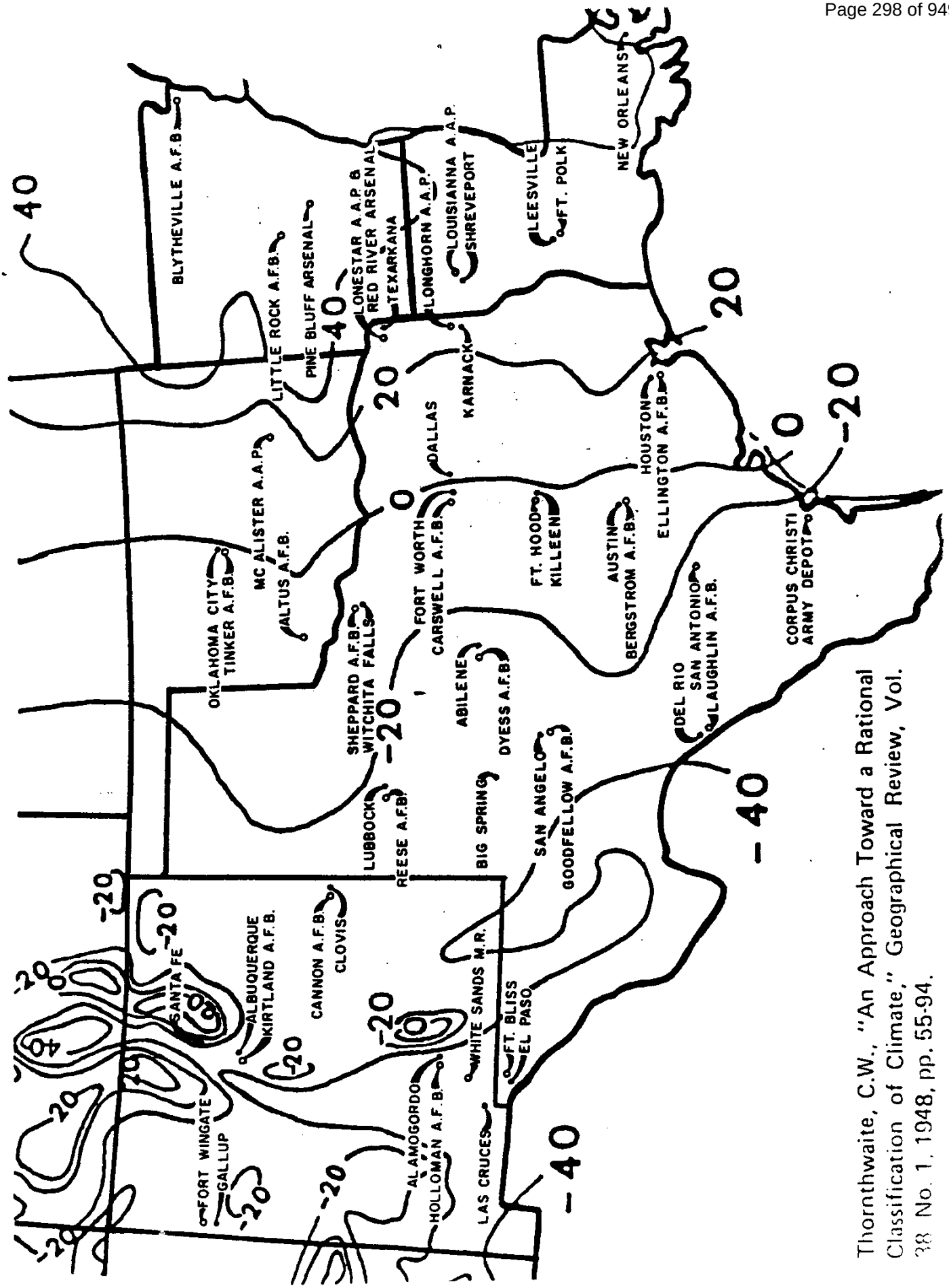
Expansion pressures should be developed versus depth using small depth intervals. These should be developed from laboratory data for the site. Additionally, these may be supplemented using proper correlations with nearby, preferably adjacent sites.

4.1.4 EDGE MOISTURE VARIATION DISTANCE. The edge moisture variation distance (L_{mcL}) may control the design of interior stiffener beams which are adjacent to the perimeter. The maximum moments and shear are induced in the transverse beams when these elements cantilever free of foundation support from the interior supported region to the outside of the perimeter beam. The length of cantilver is largely controlled by the value of L_{mcL}. SWD adopted this concept from Post-Tensioning Institute (PTI) guidelines, originally developed for lightly loaded flexible mats in the late 1970's and early 1980's. Standard practice in the

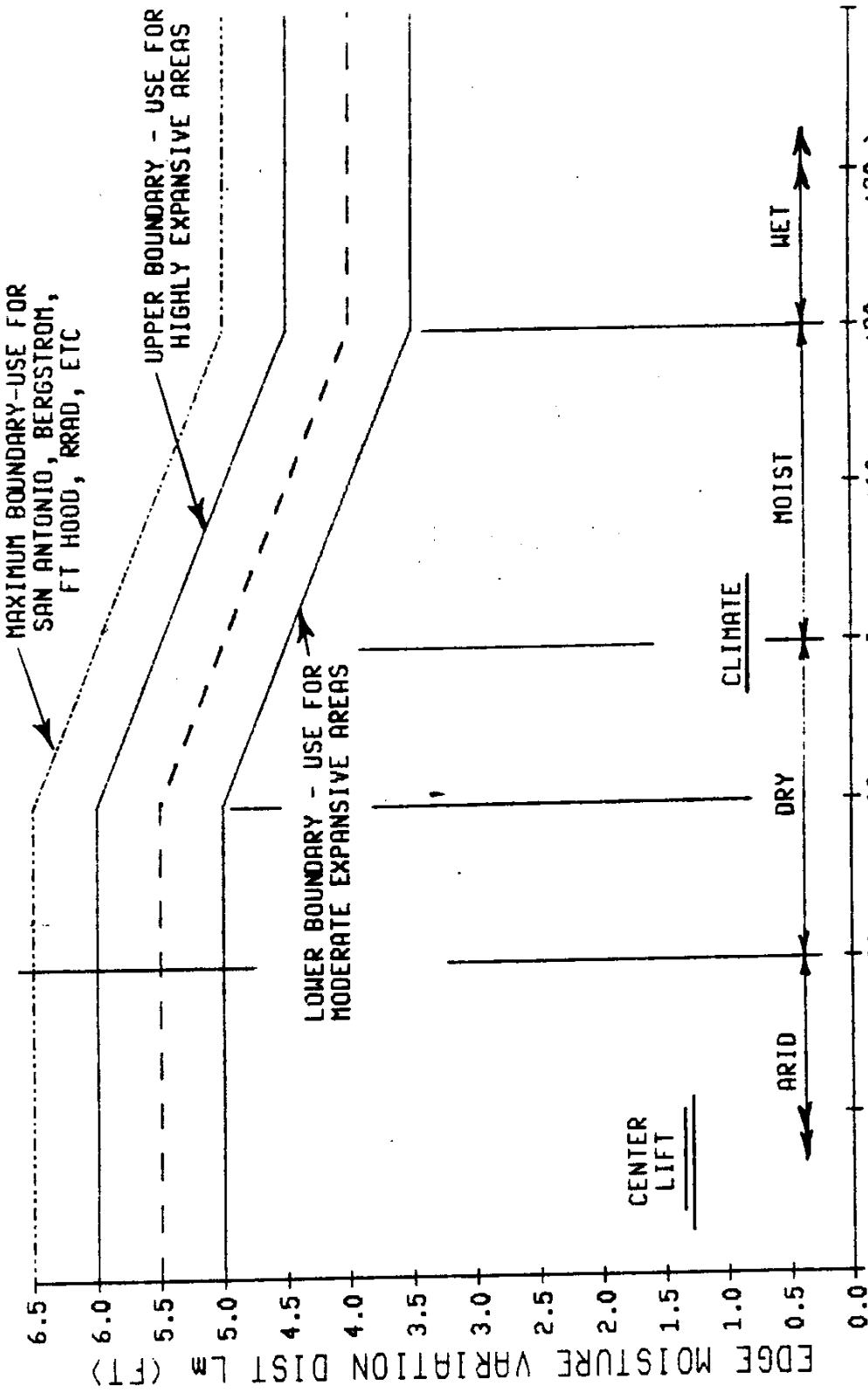
San Antonio area has been to assign upper or near upper bound values from TMI for design L_{mCL} values. At least two aspects of designs probably tend to moderate the actual edge moisture variation distance experienced; these being (1) relatively deep perimeter beams which act as a physical barrier and (2) the non-expansive fill blanket which tends to make changes in moisture content (and therefore any resultant heave or shrinkage) more uniform and provide a surcharge effect as well. Other factors, however, tend to offset these moderating effects. These include very short return interval of edge moisture variation events presented in TMI (reported by some sources to range from 1 to 2 years). Typical project design life of projects exceeds 20 or 30 years and, since we're still using many World War II facilities, it may well exceed 50 years. Estimated edge moisture variation values considering a 100 percent probability of experiencing a 20 to 30-year return interval event may well be twice typical TMI values.

Based on a subjective combination of all factors, it is suggested that L_{mCL} be taken as the edge moisture variation distance determined using figures 3 and 4. These values should be modified, either up or down, based on site secific soils investigations and engineering judgement.

4.2 EDGE LIFT - Edge lift parameters to be provided in the foundation design analysis include (1) modulus of subgrade reaction (K_1), (2) magnitude of edge lift heave (Y_{mEL}), (3) limiting soil-beam interface pressure (P_{sw}) for that portion of the beam being acted on by the heaving subgrade and (4) a value for edge moisture variation distance (L_{mEL}).



Thornthwaite, C.W., "An Approach Toward a Rational Classification of Climate," Geographical Review, Vol. 38 No. 1, 1948, pp. 55-94.



APPROXIMATE RELATIONSHIP BETWEEN THORNWAITE INDEX AND MOISTURE VARIATION DISTANCE

FIGURE 4

4.2.1 MODULUS OF SUBGRADE REACTION. - Values given for center lift are considered appropriate for edge lift also. $K_1 = 200$ pci

4.2.2 SOIL-BEAM INTERFACE PRESSURE. Discussion of both limiting soil-beam interface pressure and magnitude of edge lift heave parameters (Psw and YmsL) are best handled concurrently since both are intimately related and the analysis necessary for solution determines both simultaneously.

The area of soil-beam contact in the swelling perimeter region involves a somewhat complex soil-structure interaction situation. As edge lift develops and loss of support occurs between the perimeter and interior regions, the heaving soil may well exert a pressure on the stiffener beams well in excess of typical design interface pressures (qall). As the soil column swells and lifts the overlying beam, the soil-beam contact area increases toward the interior region to accommodate the greater structural reaction.

The soil-structure interaction in the edge lift region can be visualized as a three-component system; (1) a structural element (a beam or mat strip), (2) an element of nonexpansive fill beneath the structural element plus that piece of the expansive subgrade restrained against heave by the weight of the overlying fill and the stresses induced beneath the structural element, and (3) the heaving column of soil to a depth of Xa beneath the bottom of the nonexpansive fill blanket (figure 5).

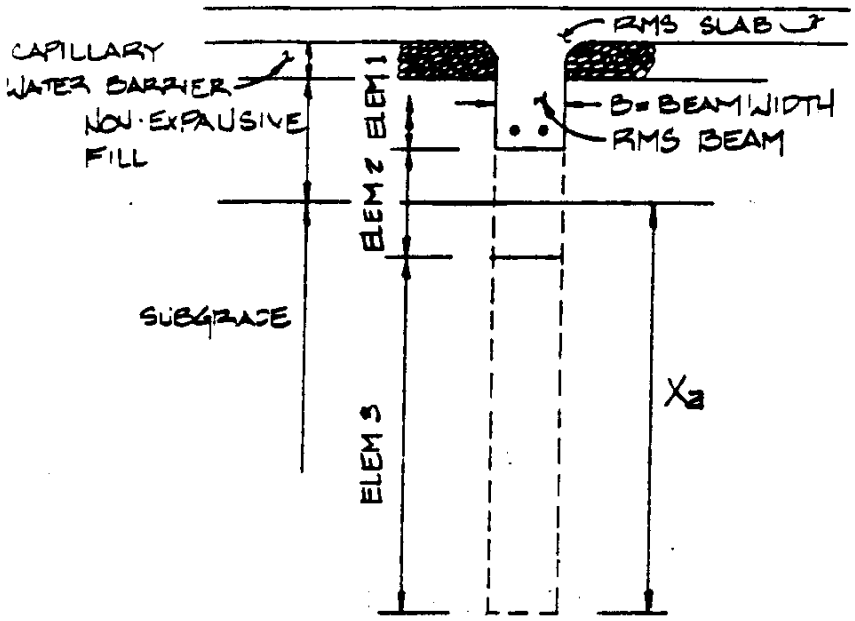


FIGURE 5

The load-deformation relationship of element 1 interacting with element 2 can be represented by a P-Y curve shown in figure 6.

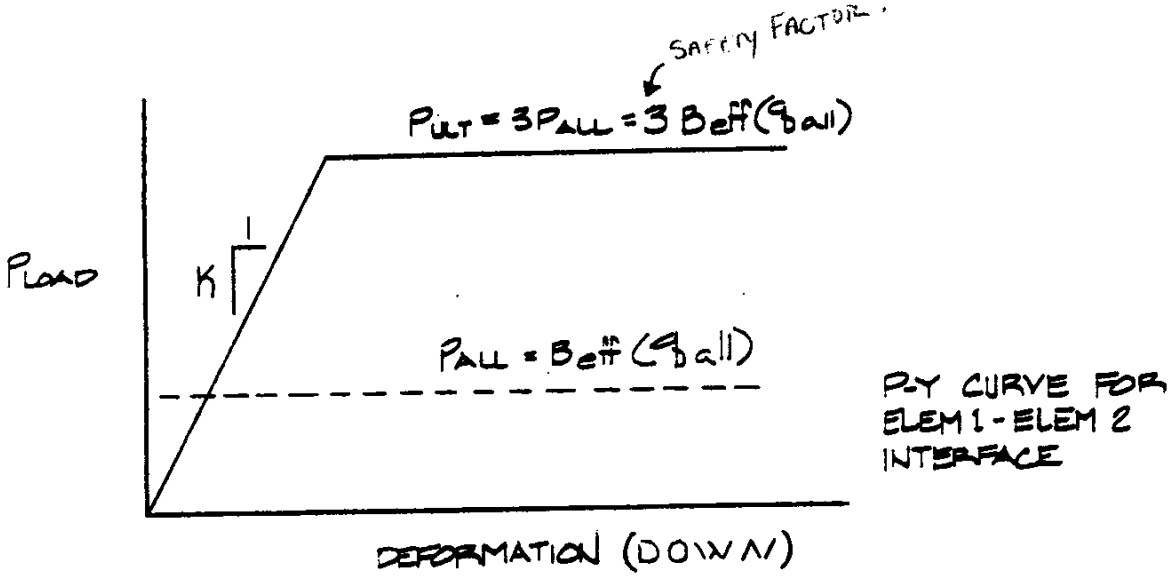


FIGURE 6

The load-deformation relationship of element 3 interacting with elements 1 and 2 in the column immediately below the beam as shown on figure 7. The plot consists of the net heave potential of the swelling soil column versus those forces resisting the tendency to swell, taken at the base of the structural beam.

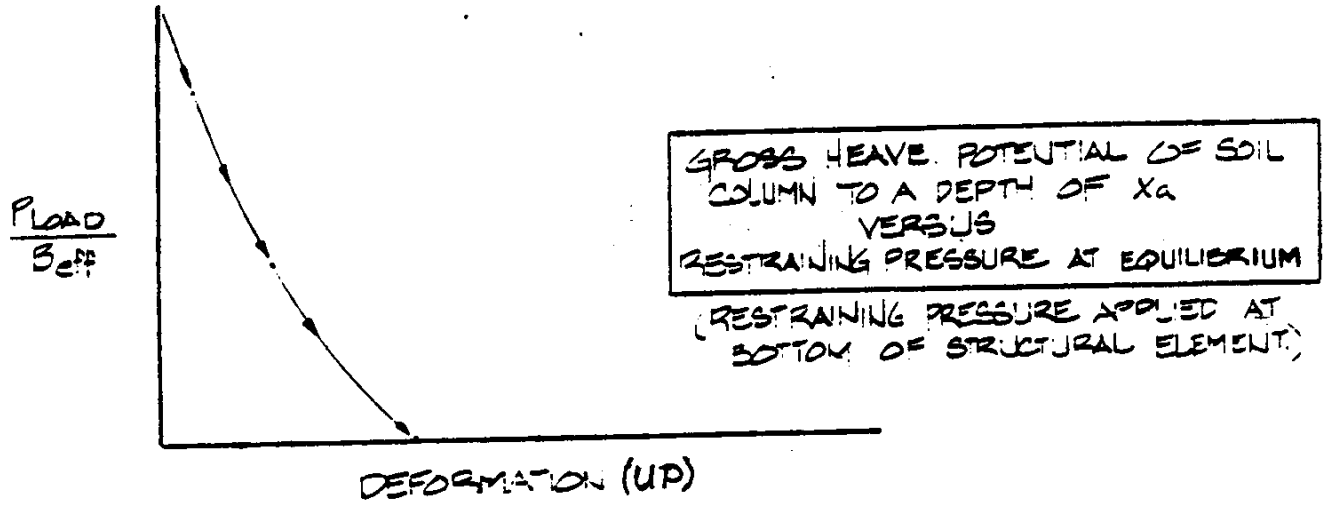
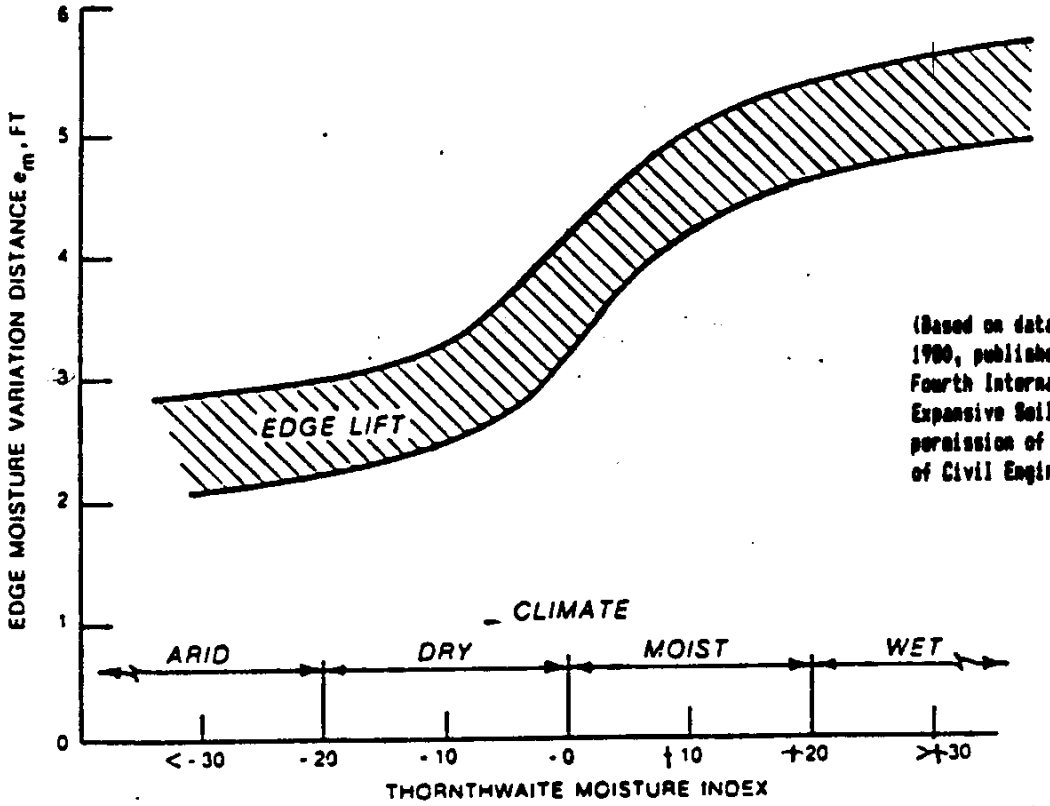


FIGURE 7

These relationships can be added algebracially to produce a composite p-y curve which can be easily utilized by available soil-structure interaction programs for structural analysis. Since such analysis is within the purview of the structural engineer, the geotechnical engineer need only furnish the pressure heave relationship in useable form in the Foundation Design Analysis. It is suggested that this information be provided in a tabulated format giving coordinates for at least three points. These minimum three points should be the Psw and Yme coordinates for (1) pressure equal to Pult, (2) pressure equal to Pall and (3) pressure equal to zero.

Pult = F.S. x Pallow

4.2.3 EDGE MOISTURE VARIATION DISTANCE. Edge moisture variation distance (L_{mL}) appropriate for edge lift analysis may be taken from the TMI chart given in figure 8.



(Based on data from W. K. Wray, 1980, published in Proceedings, Fourth International Conference on Expansive Soils, Vol. 1, with permission of the American Society of Civil Engineers)

Approximate relationship between the Thornthwaite Moisture Index and the edge lift-off distance.

FIGURE 8

The TMI values represent approximate environmentally induced events. As a result, upper bound values should be selected for design. It is recommended, however, that average values be used for all SWD projects. Additionally, recommendations should be made in the foundation design analysis to limit the potential for developing "hot spots" due to long term sources of free water around the building perimeter.

function of the type of bldg, ie, Brick stucco or not

4.3 Certain structure-site situations may well warrant deleting edge lift analyses as follows:

4.3.1 Where the proposed structure is a pre-engineered metal building without interior masonry walls or heavy interior dead or permanent live loads.

4.3.2 Where defensive design efforts have been incorporated and reasonable confidence exists that these will be constructed and maintained as intended.

4.3.3 Where minor architectural distress (such as cracking of masonry walls, plaster walls, tiled surfaces) is not likely to cause undue user concern or raise inservice maintenance requirements significantly.

5. APPENDIX A

5.1 EXAMPLE PROBLEM. An example problem is provided in Appendix A.

APPENDIX A

EXAMPLE PROBLEM

1. Required. - Develop geotechnical parameters for the structural design of a ribbed mat slab given the following:

a. Proposed Structure. - Office/Administration type structure located in San Antonio, Texas, 60X150 feet in plan. The structure is to consist of double wythe masonry (face brick over CMU) load bearing exterior walls and isolated interior colums at 20 ft. centers.

b. Proposed Site. - One acre, minimal topographic relief, site covered with mesquite trees.

c. Subsurface Conditions. - Drilling program (5 borings) indicates the foundation materials consist of (1) a surface stratum of high plasticity clay grading into medium plasticity clay with depth to a total thickness of 14 feet, (2) a water bearing sand and gravel stratum from 1 to 7 feet thick overlying, (3) an expansive clay shale formation.

d. Summary Laboratory Test Data. -

Stratum	Depth (ft)	USCS	$\bar{W}_o$ (%)	γ_d (pcf)	LL	PI	P_{exp} (tsf) (net)	C_s	C_c	Cu (ts
1	0-4	CH	25	105	65	45	0.8 -1.0	0.06	0.02	0.
2	4-14	CL	14	108	44	30	0.6	0.06	0.18	0.
3	14-20	GC	6	-	25	12	0	-	-	5C B/
4	20 plus	Wea. Clay Shale	22	110	70	52	2.0	0.09	0.22	1.

2. Determine Parameters Required for Center Lift Analysis:

a. Modulus of Subgrade Reaction (K_1). - Mat slab will be founded on nonexpansive fill, therefore it is reasonable to assign a valve of K_1 = 200 PCI. The structural engineer should factor this value based on effective beam width such that $K_{design} = K_1$ (1ft/Beff, ft).

b. Design Bearing Allowable (q_{all}). - Since beams will be supported on nonexpansive fill and the building loads will range from light to moderate, it appears that a design bearing allowable of q_{all} = 2.0 KSF is appropriate.

c. Magnitude of Center Lift Heave Potential (Y_{mcl}). -

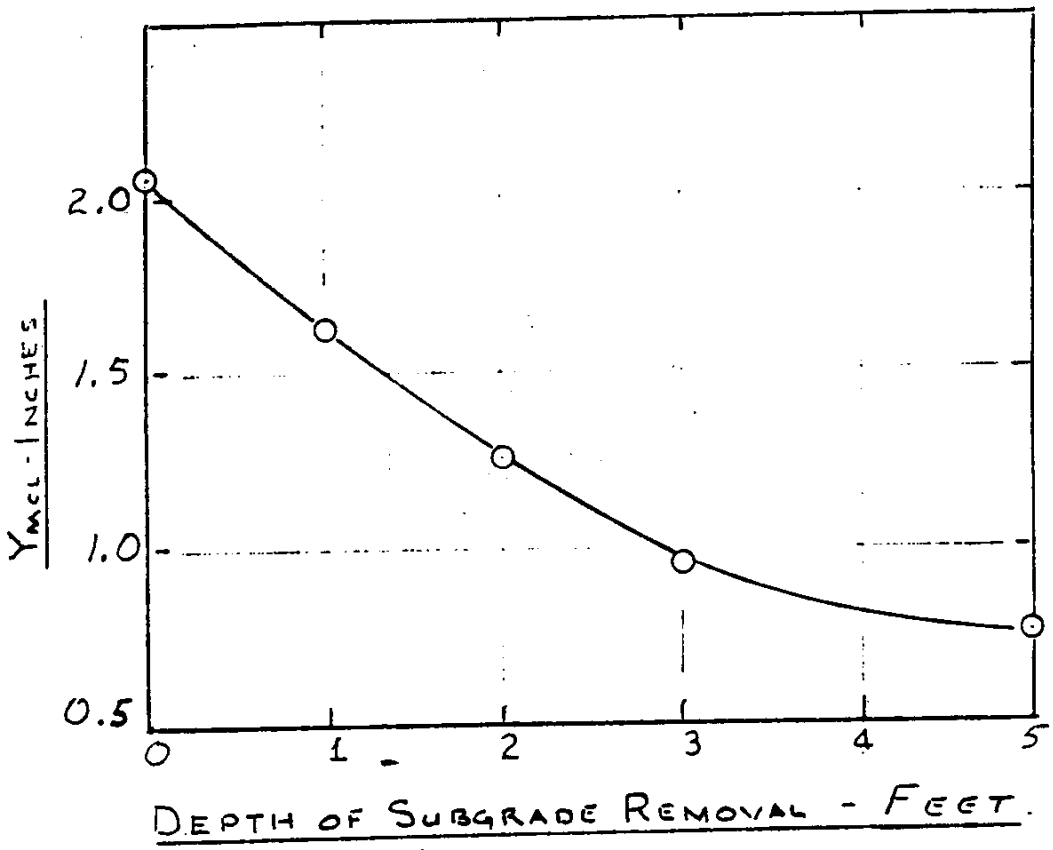
(a) Calculate site heave potential

Given: C_s = 0.06, e_o = 0.60, P_o = effective overburden pressure, P_{srp} = gross swell pressure, P_f = effective pressure resisting heave beneath mat including P_o, (surcharge due to fill and structural dead load, h_i = heave for soil layer h inches thick, and an X_a = 10 feet.

$C_s = .06$
$e_o = .60$

z (ft)	z (ft)	Po (tsf)	Pexp (tsf)	Pf (tsf)	h (in)	$h_i = \frac{C_{sh}}{1 + e_o} \log_{10} \frac{P_{exp}}{P_f}$ (inches)	h_i (bottom to top) (inches)
0-1	0.5	0.03	1.0	.07+.03 0.1	12	0.45	2.07
1-2	1.5	0.1	1.0	.07+.1 0.17	12	0.35	1.62
2-3	2.5	0.17	1.1	.07+.17 0.24	12	0.30	1.27
3-4	3.5	0.23	0.8	0.3	12	0.19	0.97
4-6	5	0.33	0.9	0.4	24	0.31	0.78
6-8	7	0.46	1.0	0.53	24	0.25	0.47
8-10	9	0.6	1.2	0.67	24	0.22	0.22
10-12	11	0.73	1.35	0.8	24	0.2	N/A
12-14	13	0.86	0.9	0.93	24	N/A	N/A

Determine required depth of subgrade replacement and residual heave potential after replacement with nonexpansive fill. A plot of replacement depth versus residual heave taken from the above table follows:



Removal and replacement to 3.0 feet will reduce the heave potential to approximately 1.0 inch, thus Y_{mc1} = 1.0 inch. Note that significant additional removal would be required to reduce the residual heave potential any sigificant additional amount.

d. Edge Moisture Variation Distance (Lmel) - taken from figures 3 and 4 as Lmel = 6.5 feet.

3. Determine parameters required for Edge Lift analyses:

a. Modulus of Subgrade Reaction (Kl). - Same as for Center Lift.

b. Design Allowable Bearing (qall). - Same as for Center Lift.

c. Soil - Beam Interface Pressure (Psw) and Magnitude of Edge Lift Heave Potential (Ymel). -

Determine the residual heave potential for the soil column beneath a typical beam for a range of assumed interface pressures.

A summary of calulations and results is presented in tabulated form on page 6. A plot of soil-beam interface pressure versus heave potential is shown on page 7. A reasonable bilinear representation of the results, for use by the structural engineer, can be developed assuming a linear relationship between the following points:

Psw, TSF	Ymel, Inches
0.0	Ymel = 1.25
qall = 1.00	Ymel = 1.0
qult = 3(qall) = 3.00	Ymel = 0.6

d. Edge Moisture Variation Distance, (Lmel). The edge moisture variation distance is taken from figure 8 as Lmel = 3.0 feet.

Given: D_f = 2.0ft B = 1.0ft

C_s = 0.06 e_o = 0.60

γ_m = 125pcf

Z ft	$\bar{Z}$ ft	h in	$\frac{\bar{Z}-D_f}{B}$	I_s	P_o tsf	P_o+P_s tsf	P_{exp} tsf	q_{app} = 0.5tsf: ΔP tsf	P_f tsf	Δh_i in	q_{app} = 1.0tsf: ΔP tsf	P_f tsf	Δh_i in	q_{app} = 2.0tsf: ΔP tsf	P_f tsf	Δh_i in	q_{app} = 4.0tsf: ΔP tsf	P_f tsf	Δh_i in
0-3	<----------COMPACTED NONEXPANSIVE FILL TO A DEPTH OF 3.0 FT.---------->																		
3-4	3.5	12	1.5B	0.28	0.23	0.30	0.8	0.14	0.37	0.15	0.28	0.51	0.08	0.56	0.79	0	1.12	1.35	0
4-6	5.0	24	3.0B	0.15	0.33	0.40	0.9	0.07	0.40	0.32	0.15	0.48	0.25	0.30	0.63	0.14	0.60	0.93	0
6-8	7.0	24	5.0B	0.09	0.46	0.53	1.0	0.05	0.53	0.25	0.09	0.55	0.23	0.18	0.64	0.17	0.36	0.82	0.09
8-10	9.0	24	7.0B	0.07	0.60	0.67	1.2	0.04	0.67	0.23	0.07	0.67	0.23	0.14	0.74	0.19	0.28	0.88	0.12
10-12	11.0	24	9.0B	0.05	0.73	0.80	1.35	0.03	0.80	0.20	0.05	0.80	0.20	0.1	0.83	0.2	0.20	0.93	0.16
12-14	13.0	24	11.0B	0.04	0.83	0.90	0.9	0.02	0.90	0.0	0.04	0.90	0.0	0.08	0.91	0	0.16	0.99	0
								$\Sigma\Delta h_i$ = 1.15			$\Sigma\Delta h_i$ = 0.99			$\Sigma\Delta h_i$ = 0.7			$\Sigma\Delta h_i$ = 0.38	

Where:

Z = depth interval

$\bar{Z}$ = mean depth

B = beam width

D_f = beam depth

σ_z = stress with depth

P_o = overburden pressure

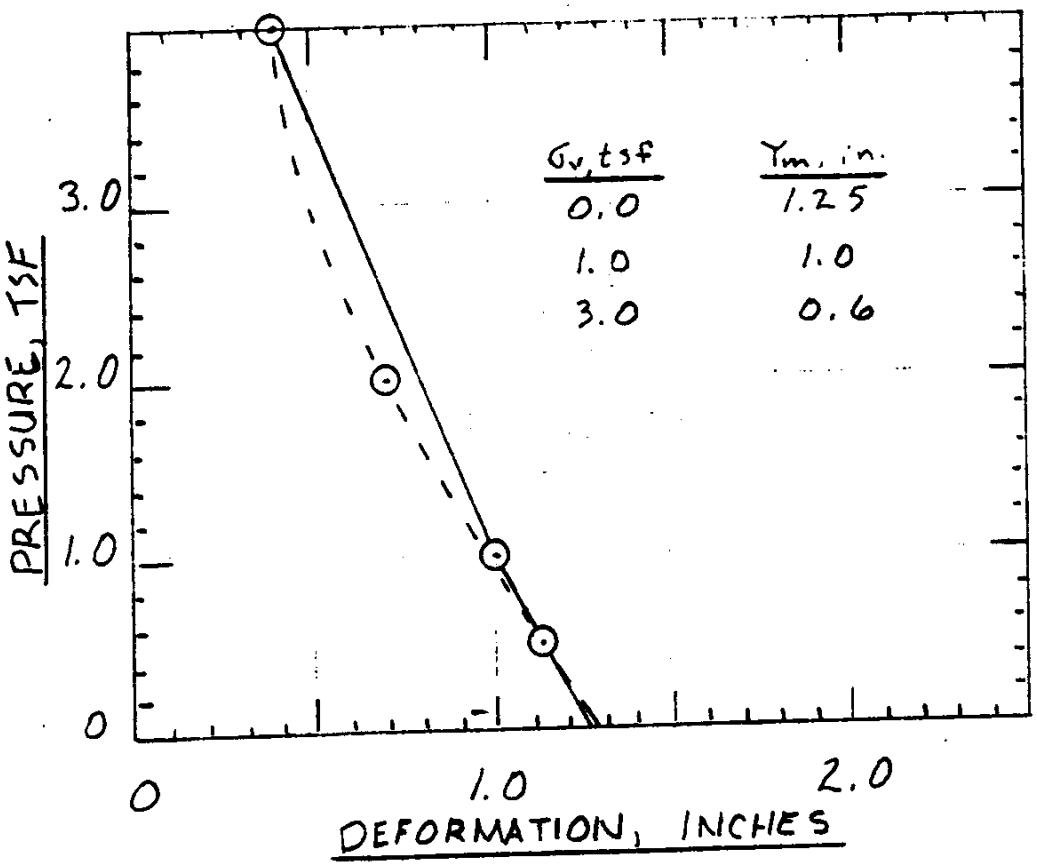
P_s = surcharge pressure next to beam

P_{exp} = expansion pressure

P_f = vertical pressure resisting heave below beam

P = stress @ depth due to to q_{app} $\Delta P = (I_s)(q_{app})$

P_f = { $\Delta P + P_o$ or $P_o + P_s$ | whichever is greater }



EDGE LIFT PARAMETER

EXAMPLE PROBLEM

Appendix B

Drawings

G-200	Site Location
CS-100	Site Layout Plan
CG-100	Grading and Drainage Layout Plan
CU-100	Utility Layout Plan
1A-100	Building Layout Plan – Option A
1A-100	Building Layout Plan – Option B
1A-500	Pallet Rack Sections and Details
1A-110	Composite Floor Plan

Appendix C

Utility Connections

Electrical: Electrical power is provided by CPS Energy and is available above ground along Garden Avenue. Power may be run above/below ground to a pad-mounted transformer at the TSC facility. Primary voltage is 13.8/ 7.9 kV nominal.

Domestic Water Service: Fort Sam Houston has a base-wide potable water system owned and operated by the base. Presently no water lines of sufficient size are located in the immediate area of the new TSC facility. An existing 16" domestic water main located approximately 1,500 feet north of the site at the intersection of Garden Avenue and Schofield Road shall be the connection point. A new water line of adequate size for fire protection and domestic service shall be run from the connection point along Garden Avenue to the new TSC. Domestic water service and meter for the TSC facility shall be installed per the UFC criteria. A new reduced pressure principle backflow preventer will be installed at the domestic water service entrance to the building.

Fire Protection Water Service: A new potable water line serving the building from the connection point shall be used to supply fire protection water. The new water line will extend to the new facility and a double check type backflow preventer will be installed at fire water service entrance to the building.

Natural Gas Service: Fort Sam Houston has a base-wide natural gas system that is privatized (CPS Energy). Natural gas will be extended from the existing distribution system running along Garden Avenue to the new TSC facility. A gas meter will be installed at the new facility.

Sanitary Sewer: Fort Sam Houston has a base-wide sanitary sewer system owned and operated by the base. There is an existing sanitary sewer manhole and 20" sanitary sewer line (vitrified clay pipe, 40-50 years old) running from north to south across the middle of the site that may have to be relocated depending on location of new TSC facility. Sanitary waste from the building will connect to a new or existing sanitary sewer manhole.

APPENDIX D

Results of Fire Flow Tests

Flow Test Data and Fire Department Access Requirements for Fort Sam Houston TSC Facilities

Hydrant Flow Data
The below hydrant flow info is for the area of the new Training Support Center. These are located in the 1100 area.

Hydrant 1111 is at Zinn & Garden,

Hydrant 1116 is at McIdoe & Garden.

These are the closest hydrants to the proposed site. There must be a fire hydrant within 150 ft. of the fire department sprinkler connection and a fire hydrant at least 350 ft. from the building.

Fire Apparatus Access:

NFPA 1, Chapter 18 states -

18.2.3.4.1.1 Fire Department access roads shall have an unobstructed width of not less than 20 ft.

18.2.3.4.1.2 Fire Department access roads shall have an unobstructed vertical clearance of not less than 13 ft. 6 in.

18.2.3.4.2 Surface. Fire department access roads shall be designed and maintained to support the imposed loads of fire apparatus and shall be provided with an all-weather driving surface.

18.2.3.4.4 Dead Ends. Dead-end fire department access roads in excess of 150 ft. in length shall be provided with approved provisions for the fire apparatus to turn around.

18.3.1 An approved water supply capable of supplying the required fire flow for fire protection shall be provided to all premises upon which

facilities, buildings, or portions of buildings are hereafter constructed or moved into the jurisdiction.

Fort Sam Houston Fire & Emergency Services

Hydrant Flow Test By Hydrant

Hydrant Number = "1111 "

1111	00001111 S S OF GARDEN / ZINN RD. STA S			05		CLOW	
Date	Static	Residual	Pitot	Pitot 2	GPM	20 PSI	10 PSI	0 PSI
05/10/2004	70	52	70.00	0.00	1404	2438	2690	2923
30	Unknown Name							
Subtotal Flow Tests:		1		Min:	1404	2438	2690	2923
				Max:	1404	2438	2690	2923
				Avg:	1404	2438	2690	2923

Total Flow Tests: 1

* Scheduled Flow Test

Fort Sam Houston Fire & Emergency Services

Hydrant Flow Test By Hydrant

Hydrant Number = "1116 "

1116	00001116 ST GARDEN / MCINDOE ST ST			02		MUELLER	
Date	Static	Residual	Pitot	Pitot 2	GPM	20 PSI	10 PSI	0 PSI
05/10/2004	60	54	60.00	0.00	1300	3621	4085	4508
30	Unknown Name							
07/16/2007	55	30	35.00	0.00	993	1191	1364	1520
9413	Estrada, Valde M.							
Subtotal Flow Tests:		2		Min:	993	1191	1364	1520
				Max:	1300	3621	4085	4508
				Avg:	1146	2406	2724	3014

Total Flow Tests: 2

12/02/2008 11:13 Page 1

* Scheduled Flow Test

12/02/2008 Flow test data provided via email by

Terry L. Davis, YN-0081-1
Assistant Fire Chief, Prevention
Fire & Emergency Services Division
3201 Schofield Road
Fort Sam Houston, TX 78234
Physical Location - B-131, 1st Floor
Office 210-221-5452
Fax 210-221-3927
terry.davis7@us.army.mil

Web Site
http://www.samhouston.army.mil/lec/fire_department_default.htm

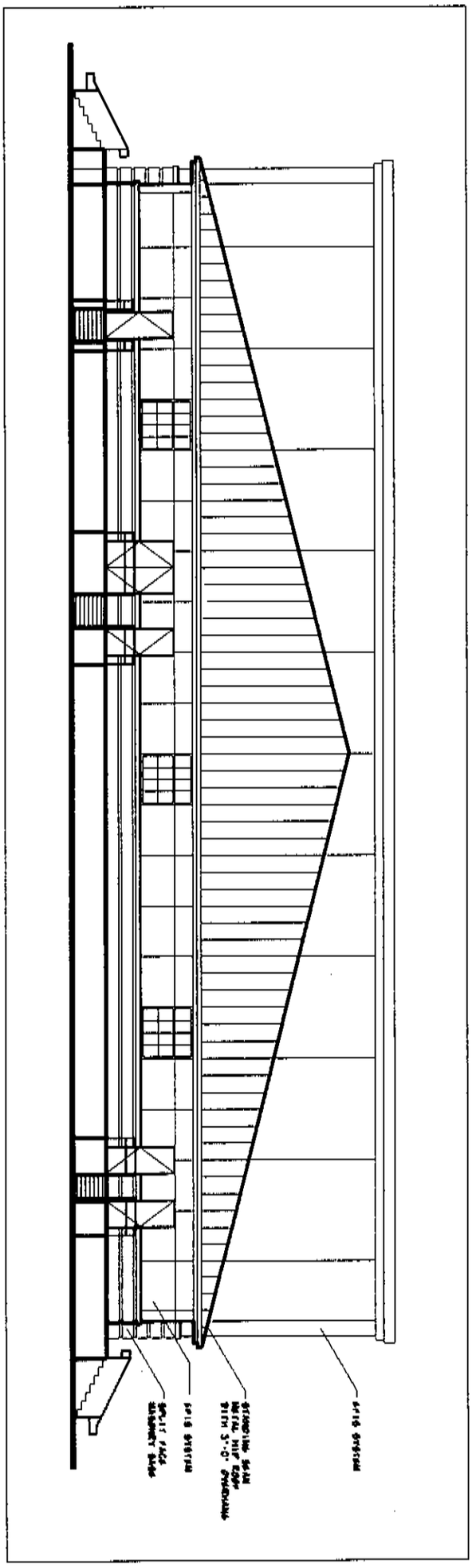
APPENDIX E
Environmental Information

Not Used

Thursday, October 28, 2010

Thursday, October 28, 2010

Thursday, October 28, 2010



APPENDIX G
GIS Data

Not Used

Appendix H – Exterior Signage

Refer to the Ft. Sam Houston Installation Design Guide, Chapter 11 Site Elements Design Standards, paragraph 11.4 and the “Technical Manual (TM) 5-807-10, Signage” for Exterior Signage requirements.

Below are two samples of the Construction Project Identification sign showing how this panel is adaptable for use to identify either military (top) or civil works projects (bottom). The graphic format for this 4'x 6' sign panel follows the legend guidelines and layout as specified below. The large 4'x 4' section of the panel on the right is to be white with black legend. The 2'x 4' section of the sign on the left with the full Corps Signature (reverse version) is to be screen-printed Communication Red on the white background The designation of a sponsor in the area indicated is optional with Military or Civil Works construction signs. Signs may list one sponsoring entity. If agreement on a sponsor designation cannot be achieved, the area should be left blank.

This sign is to be placed with the Safety Performance sign shown on the following page. Mounting and fabrication details are provided on page 16-4.

Special applications or situations not covered in these guidelines should be referred to the district Sign Program Manager.

Legend Group 1: One- to two-line description of Corps relationship to project.
Color: White
Typeface: 1.25" Helvetica Regular
Maximum line length: 19"

Legend Group 2: Division or District Name (optional). Placed below 10.5" reverse Signature (6" Castle).
Color: White
Typeface: 1.25" Helvetica Regular

Legend Group 2a: One- to three-line identification of Military or Civil Works sponsor (optional). Place below Corps Signature to cross-align with Group 5a-b.
Color: White
Typeface: 1.25" Helvetica Regular
Maximum line length: 19"

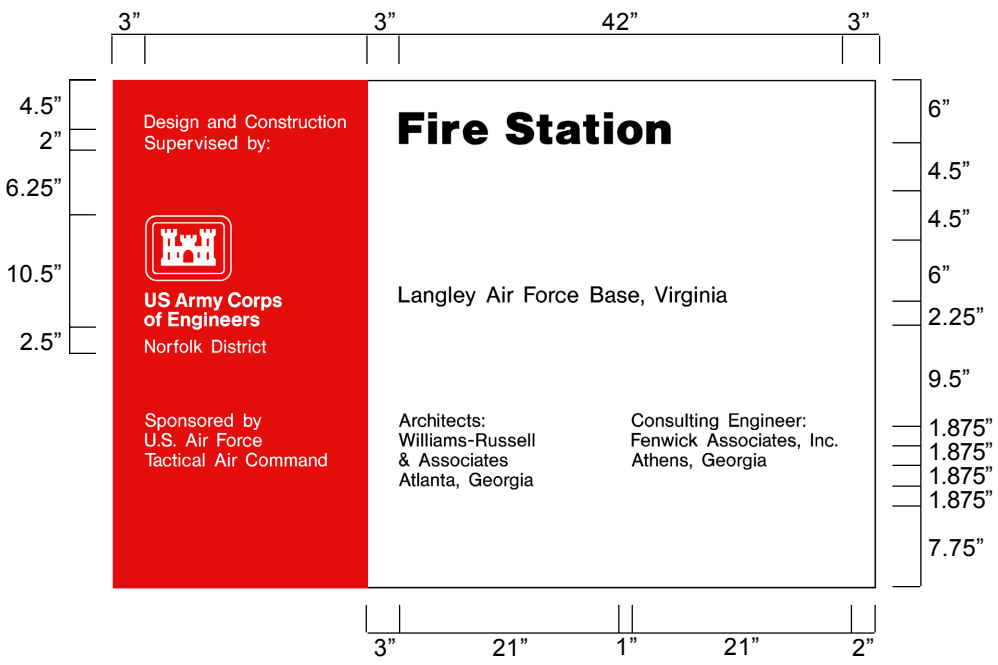
Legend Group 3: One- to three-line project title legend describes the work being done under this contract.
Color: Black
Typeface: 3" Helvetica Bold
Maximum line length: 42"

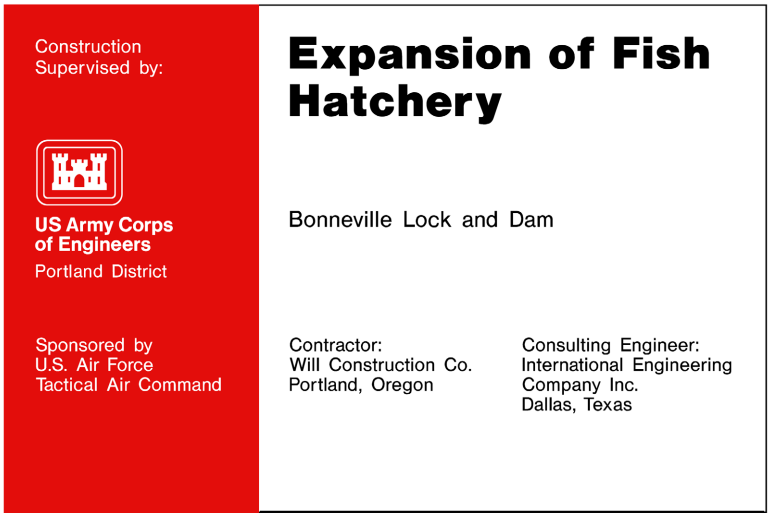
Legend Group 4: One- to two-line identification of project or facility (civil works) or name of sponsoring department (military).
Color: Black
Typeface: 1.5" Helvetica Regular
Maximum line length: 42"

Cross-align the first line of Legend Group 4 with the first line of the Corps Signature (US Army Corps) as shown.

Legend Groups 5a-b: One- to five-line identification of prime contractors including: type (architect, general contractor, etc.), corporate or firm name, city, state. Use of Legend Group 5 is optional.
Color: Black
Typeface: 1.25" Helvetica Regular
Maximum line length: 21"

All typography is flush left and rag right, upper and lower case with initial capitals only as shown. Letter- and word-spacing to follow Corps standards as specified in Appendix D.





Sign Type	Legend Size (A)	Panel Size	Post Size	Specification Code	Mounting Height	Color Bkg/Lgd
CID-01	various	4'x6'	4"x4"	HDO-3	48"	WH-RD/BK

Recommended Native and Adaptive Landscape Plants for Central Texas

TREES
***Althea**
Apple
Catalpa
Carolina Buckthorn
***Chinese Photinia**
***Crape Myrtle**
***Desert Willow**
Elm
***Eve's Necklace**
***Holly**
Magnolia
Mexican Buckeye
Oak, Lacey
Peach
Pear
Plum
***Pomegranate**
***Redbud**
Sumac
Vitex

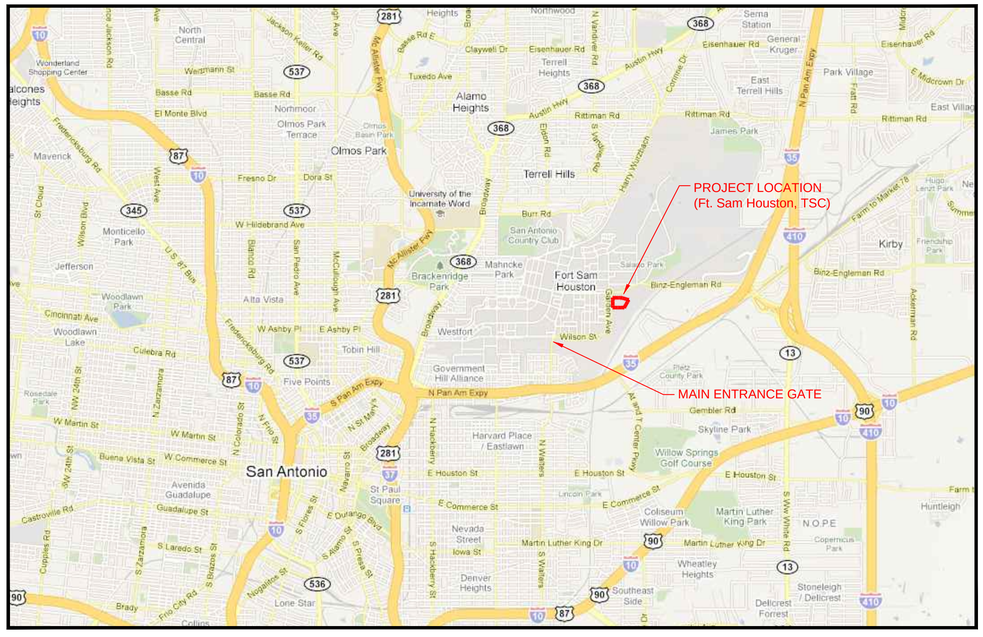
Shrubs
*Abelia
AmericanBeautyberry
*Aralia
*Artemisia
*Aspidistra
Aucuba
Bluebeard Spirea
Bridalwreath Spirea
Candletree (Cassia)
Cleyera
*Cyperus
*Crape myrtle
*Germander
*Holly
Lavendar
*Ligustrum, variegated
*Ligustrum, wax
Mahonia, leatherleaf
*Nandina
Oregano
Pampas grass
Pyracantha
Red Yucca
*Rosemary
Sage
*Santolina
Texas Sage
Viburnum
Wax Myrtle
Wisteria
Yucca

Flowers
Alyssum
Begonia
*Blackfoot Daisy
Bluebonnet
*Cactus
Caladium
Canna
Celosia
Chrysanthemum
Clematis
*Coleus
Columbine
Cosmos
*Daffodil
Dianthus
Dusty Miller
Engelmannia
Heuchara
Hibiscus
Honeysuckle
*Ice Plant
Impatiens
Indian Blanket
*Iris
*Lantana
Larkspur
Mandevilla
*Mexican Heather
*Mullein
Nierembergia
Pansy
Periwinkle
Petunia

*Portulaca *Purple Coneflower Rose *Ruellia *Salvia *Skullcap Sweet Potato Vine Zinnia

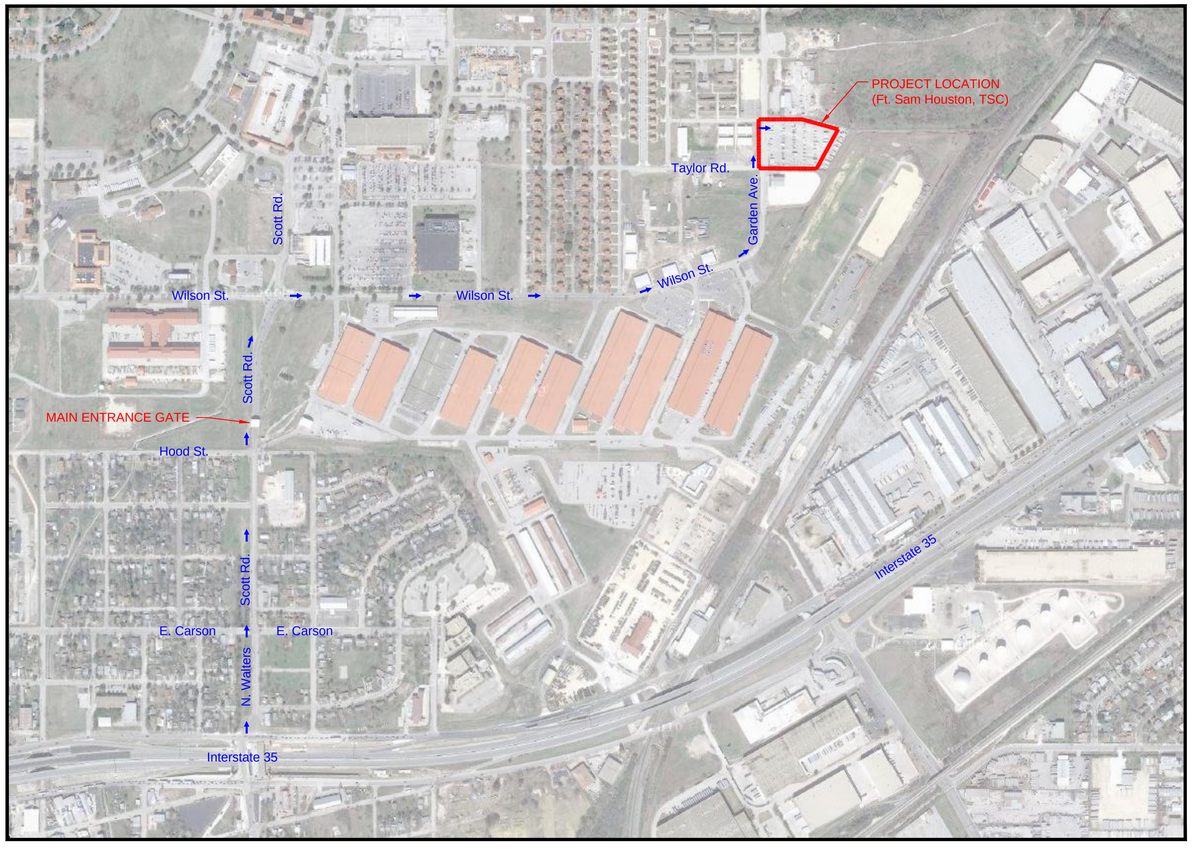
Groundcovers
*Asian Jasmine Ficus Pumila (Creeping Fig) *Germander *Hedera (English Ivy) Lambs Ear Lemon Balm *Liriope Mint *Purple Jew *Rosemary (creeping) *Sedum Thyme

GRAPHIC SCALE: N.T.S.



VICINITY MAP

GRAPHIC SCALE: 1"=500'



LOCATION MAP

US Army Corps of Engineers
Fort Worth District

FOR DEMONSTRATION PURPOSES ONLY
(NOT FOR CONSTRUCTION)

Symbol	Description	D.O. No.	Action	Date

Designed by: C. HAYMAN
Dwn by: C. HAYMAN
Reviewed by: S. ARTMAN
Submitted by: C.D.PEEK
Date: MARCH 2010
Sol No.
Contr No.
File name: SPLISS
Plot date: SDATES
Plot scale:
Rev. 30%DB

U.S. ARMY ENGINEER DISTRICT,
CORPS OF ENGINEERS
FORT WORTH, TEXAS

HSW ENGINEERING, INC.
3820 Northdale Blvd., Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street Suite 1300
Lexington, Kentucky 40507

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

LOCATION MAP
(30% DESIGN BUILD)

Sheet reference number:
G-200

30' 15' 0 30' 60' 90'
GRAPHIC SCALE: 1"=30'-0"

US Army Corps of Engineers
Fort Worth District

LEGEND

(#) NUMBER OF PARKING SPACES (70 Total)
(67) REGULAR - 9'x18'
(3) HANDICAP ACCESSIBLE

LIMITS OF CLEARING (TYP)
DOUBLE SWING GATE
12' GRAVEL FIRE ACCESS & SERVICE ROAD
6" CONCRETE CURB (TYP)
ASPHALT SURFACE
STORMWATER TREATMENT AREA "A"
STORMWATER TREATMENT AREA "B"
STORMWATER TREATMENT AREA "C"
STORMWATER TREATMENT AREA "D"
5' CONCRETE SIDEWALK
5' CONCRETE SIDEWALK (TYP)
ASPH. PARKING
TRAINING SUPPORT CENTER (TSC)
29,200 sq. ft.
(Includes Dock & Storage Shed)
CONCRETE LOADING DOCK
DUMPSTER PAD
10' CONCRETE DRIVE (RAMP) (For Lift Truck Traffic)
CONCRETE LOADING DOCK AREA
STORAGE SHED
REMOTE CONTROL ELECTRICALLY OPERATED GATE
24' (TYP)
12' (TYP)
136'
127'
24" TREE
8" OAK
CONC.
ASPH.
SHED
COVERED CONC. PAD
EDGE OF ASPHALT
CONC. FOOTING
M c I D O E R D.
T A Y L O R R D.
HEADQUARTERS SIGN
SIGN
KEY PAD
430
RIM=697.39
BOTTOM=688.03
G A R D E N A V E. (ASPH. PAVEMENT)
E400_FINAL.DGN (POVIDED BY CORP 3-27-07)
NOT FIELD VERIFIED
6' CHAIN LINK FENCE
7' CHAIN LINK FENCE
NATURAL GROUND
HIGH BANK OF DITCH
FL OF DITCH
CONC. PAD
PP

FOR DEMONSTRATION PURPOSES ONLY
(NOT FOR CONSTRUCTION)

Symbol	Description	D.O. NO.	Action	Date

Date: MARCH 2010
Sol No.
Contr No.
File name: 30%DB
Plot date: 4/28/2010
Plot scale:
Rev. 30%DB

Designed by: C. HAYMAN
Drwn by: C. HAYMAN
Reviewed by: S. ARTMAN
Submitted by: C.D. PEEK

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

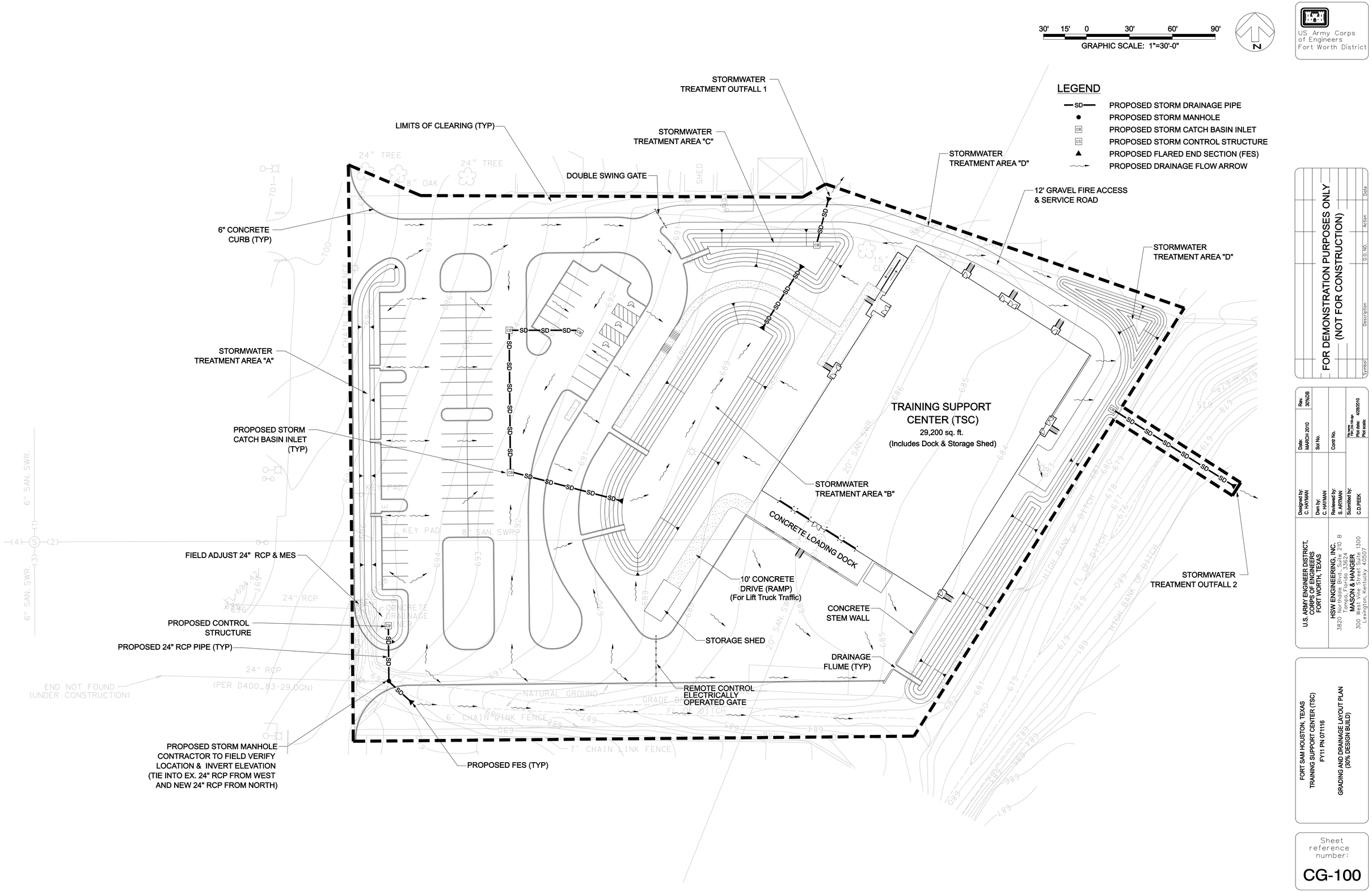
HSW ENGINEERING, INC.
3820 Northside Blvd, Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street, 1300
Lexington, Kentucky 40507

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

SITE LAYOUT PLAN
(30% DESIGN BUILD)

Sheet reference number:
CS-100

P:\TBF5 USACE\TBF501202 - FSH TSC DB RFP\CAD\30% TSC\sheet files\FSH_CS-100.dgn
4/28/2010
10:33:37 AM



FOR DEMONSTRATION PURPOSES ONLY (NOT FOR CONSTRUCTION)

Symbol	Description	D.O. NO.	Action	Date

Designed by: C. HAYMAN
Dwn by: C. HAYMAN
Reviewed by: S. ARTMAN
Submitted by: C.D.PEEK
Date: MARCH 2010
Sol No.
Contr No.
Rev. 30%DB
File name: FSH_CG-100.dgn
Plot date: 4/28/2010
Plot scale:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS FORT WORTH, TEXAS

HSW ENGINEERING, INC.
3820 Northdale Blvd., Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street Suite 1300
Lexington, Kentucky 40507

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

GRADING AND DRAINAGE LAYOUT PLAN (30% DESIGN BUILD)

Sheet reference number:
CG-100

P:\IBF5 USACE\IBF501202 - FSH TSC DB RFP\CAD\30% TSC\sheet files\FSH_CG-100.dgn
4/28/2010
10:33:23 AM

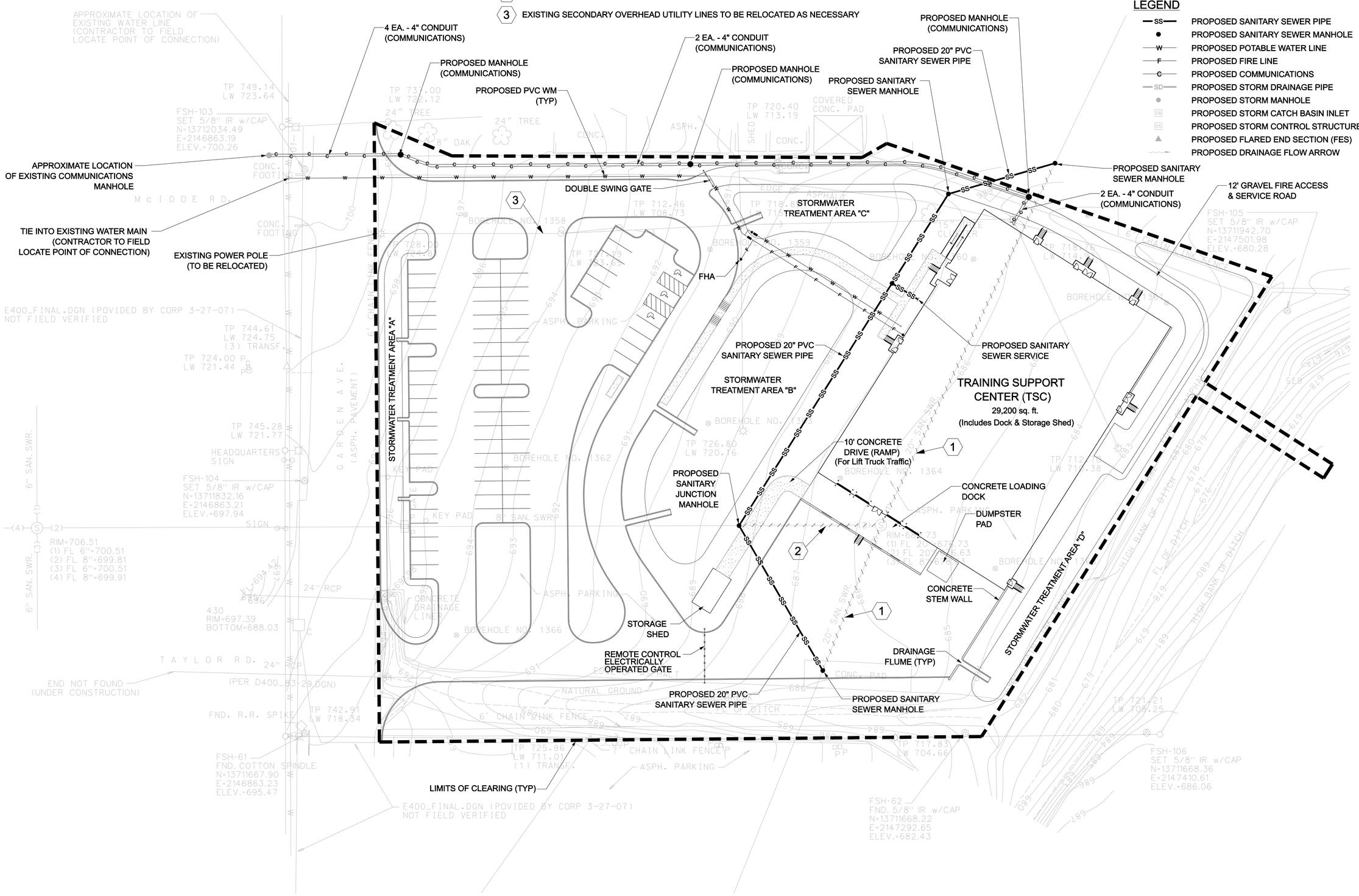
NOTES

1. EXISTING 20" SANITARY SEWER PIPE TO REMOVED
2. EXISTING 8" SANITARY SEWER PIPE TO REMOVED
3. EXISTING SECONDARY OVERHEAD UTILITY LINES TO BE RELOCATED AS NECESSARY

30' 15' 0 30' 60' 90'
GRAPHIC SCALE: 1"=30'-0"

LEGEND

- SS — PROPOSED SANITARY SEWER PIPE
- PROPOSED SANITARY SEWER MANHOLE
- W — PROPOSED POTABLE WATER LINE
- F — PROPOSED FIRE LINE
- C — PROPOSED COMMUNICATIONS
- SD — PROPOSED STORM DRAINAGE PIPE
- PROPOSED STORM MANHOLE
- CB — PROPOSED STORM CATCH BASIN INLET
- CS — PROPOSED STORM CONTROL STRUCTURE
- PROPOSED FLARED END SECTION (FES)
- PROPOSED DRAINAGE FLOW ARROW



US Army Corps of Engineers
Fort Worth District

FOR DEMONSTRATION PURPOSES ONLY
(NOT FOR CONSTRUCTION)

Symbol	Description	D.O. NO.	Action	Date

Designed by: C. HAYMAN
Dwn by: C. HAYMAN
Reviewed by: S. ARTMAN
Submitted by: C.D.PEEK
Date: MARCH 2010
Sol No.
Contr No.
Rev. 30%DB
File name: FSH_CU-100.dgn
Plot date: 4/28/2010
Plot scale:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

HSW ENGINEERING, INC.
3820 Northdale Blvd., Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street Suite 1300
Lexington, Kentucky 40507

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

UTILITY LAYOUT PLAN
(30% DESIGN BUILD)

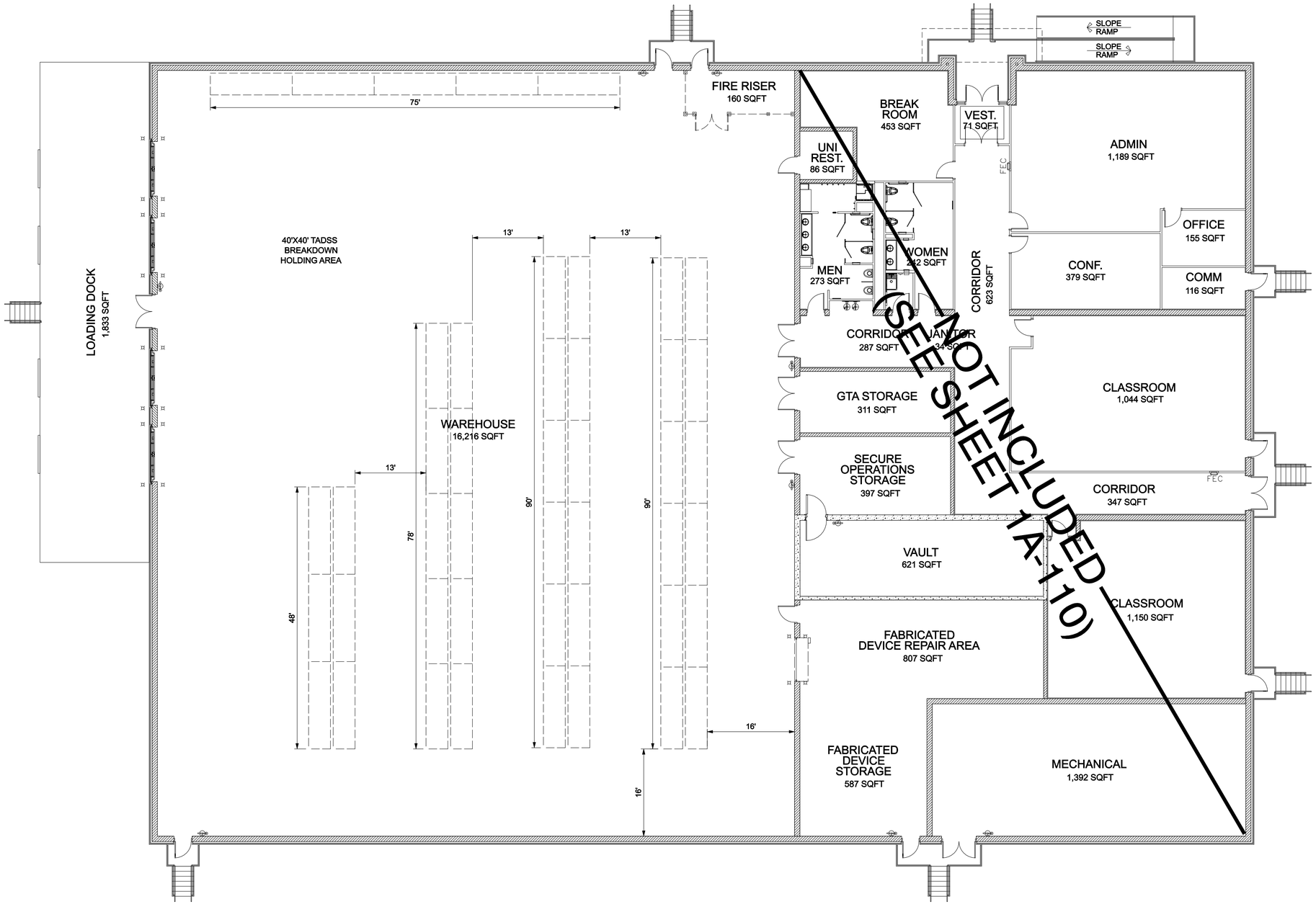
Sheet reference number:
CU-100

P:\IBF5 USACE\IBF501202 - FSH TSC DB RFP\CAD\30% TSC\sheet files\FSH_CU-100.dgn
4/28/2010
10:33:03 AM

10' 5' 0 10' 20' 30'
GRAPHIC SCALE: 1"=10'-0"

N

US Army Corps of Engineers
Fort Worth District



FOR DEMONSTRATION PURPOSES ONLY
(NOT FOR CONSTRUCTION)

Symbol	Description	D.O. NO.	Action	Date

PRELIMINARY - OPTION "A" (FOR DEMONSTRATION PURPOSES ONLY)

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

BUILDING LAYOUT PLAN
(30% DESIGN BUILD)

Sheet reference number:
1A-100

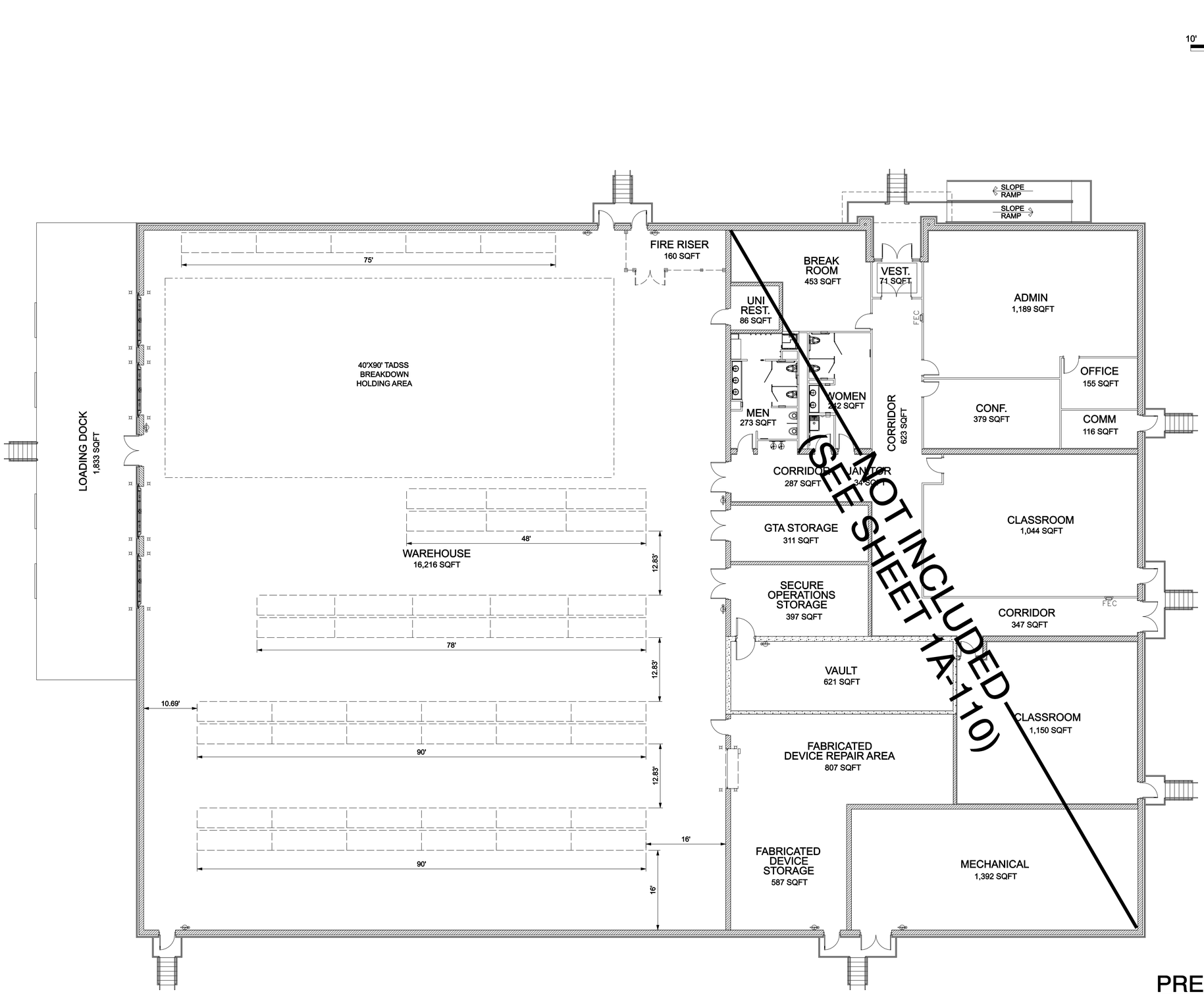
U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

HSW ENGINEERING, INC.
3820 Northdale Blvd, Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street, Suite 1300
Lexington, Kentucky 40507

Designed by:	Dwn by:	Reviewed by:	Submitted by:
C. HAYMAN	C. HAYMAN	S. ARTMAN	C.D. PEEK

Date: MARCH 2010
Sol No.
Contr No.
Rev. 30%DB
Plotted: Thursday, October 28, 2010
Plot date: 4/29/2010
Plot scale:

P:\1BF5 USACE\1BF501202 - FSH TSC DB RFP\CAD\30% TSC\sheet files\OPT A FSH_1A-100.dgn
4/29/2010
2:38:19 PM



PREFERRED LAYOUT

US Army Corps of Engineers
Fort Worth District

FOR DEMONSTRATION PURPOSES ONLY
(NOT FOR CONSTRUCTION)

Symbol	Description	D.O. NO.	Action	Date

Designed by: C. HAYMAN
Dwn by: C. HAYMAN
Reviewed by: S. ARTMAN
Submitted by: C.D.PEEK
Date: MARCH 2010
Rev. 30%DB
Sol No.
Contr No.
File name: OPT B FSH_1A-100.dgn
Plot date: 4/29/2010
Plot scale:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

HSW ENGINEERING, INC.
3820 Northdale Blvd., Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street Suite 1300
Lexington, Kentucky 40507

PRELIMINARY - OPTION "B" (FOR DEMONSTRATION PURPOSES ONLY)

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

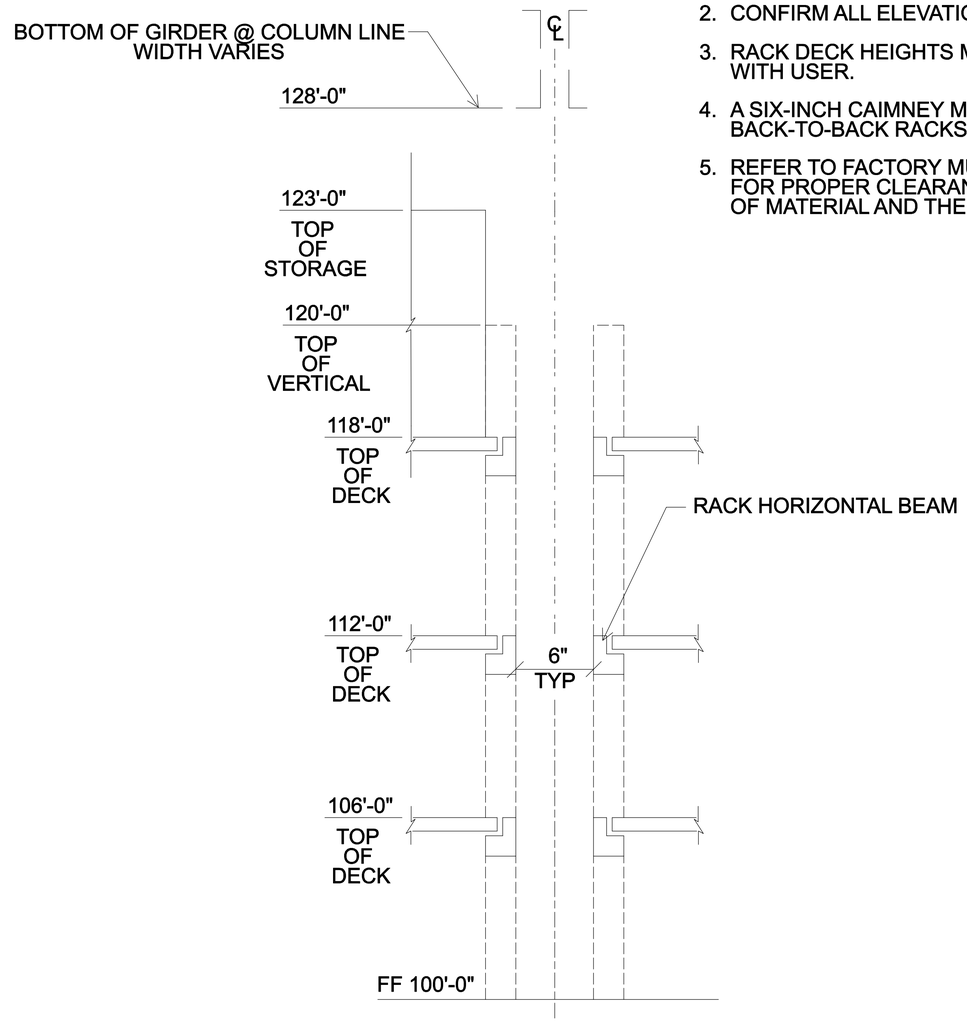
BUILDING LAYOUT PLAN
(30% DESIGN BUILD)

Sheet reference number:
1A-100

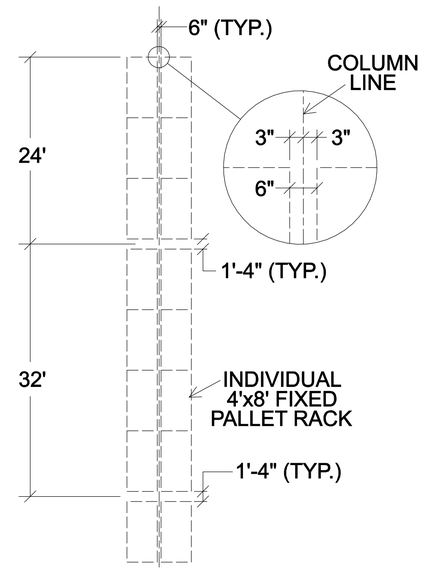
P:\1BF5 USACE\1BF501202 - FSH TSC DB RFP\CAD\30% TSC\sheet files\OPT B FSH_1A-100.dgn
4/29/2010
2:39:08 PM

NOTES:

1. HOLD SPRINKLER HEAD AS CLOSE TO ROOF DECK AS ALLOWED BY CODE & DESIGN TYPICALLY 6" BELOW DECK.
2. CONFIRM ALL ELEVATIONS WITH USACE.
3. RACK DECK HEIGHTS MAY VARY - CONFIRM WITH USER.
4. A SIX-INCH CAIMNEY MUST BE MAINTAINED BETWEEN BACK-TO-BACK RACKS.
5. REFER TO FACTORY MUTUAL PUBLICATIONS FOR PROPER CLEARANCE BETWEEN THE TOP OF MATERIAL AND THE BOTTOM OF STEEL.



TYPICAL SECTION THROUGH RACKS ON COLUMN LINE



TYPICAL FIXED DETAIL PALLET RACK

US Army Corps of Engineers
Fort Worth District

FOR DEMONSTRATION PURPOSES ONLY
(NOT FOR CONSTRUCTION)

Symbol	Description	D.O. NO.	Action	Date

Designed by: C. HAYMAN
Dwn by: C. HAYMAN
Reviewed by: S. ARTMAN
Submitted by: C.D.PEEK
Date: MARCH 2010
Rev. 30%DB
Sol No.
Contr No.
File name: FSH_1A-500.dgn
Plot date: 4/28/2010
Plot scale:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

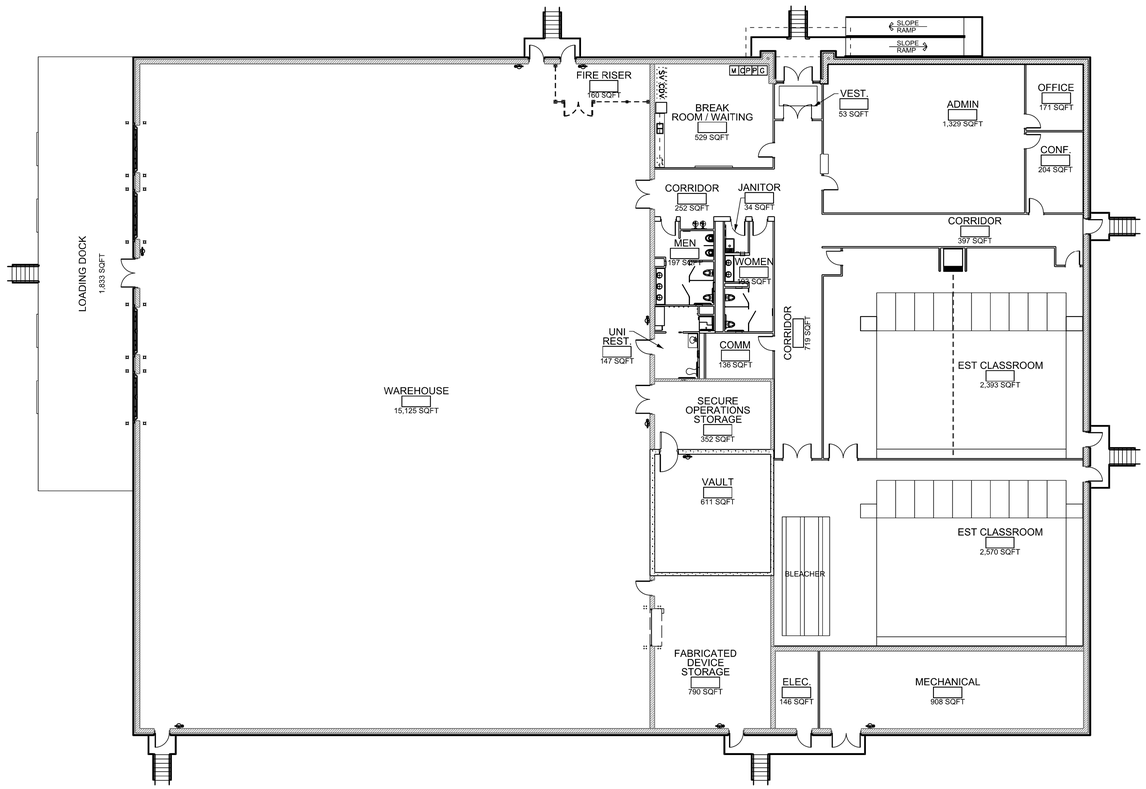
HSW ENGINEERING, INC.
3820 Northdale Blvd., Suite 210 B
Tampa, Florida 33624
MASON & HANGER
300 West Vine Street Suite 1300
Lexington, Kentucky 40507

FORT SAM HOUSTON, TEXAS
TRAINING SUPPORT CENTER (TSC)
FY11 PN 071116

PALLET RACK SECTIONS & DETAILS
(30% DESIGN BUILD)

Sheet reference number:
1A-500

P:\IBF5 USACE\IBF501202 - FSH TSC DB RFP\CAD\30% TSC\sheet files\FSH_1A-500.dgn
4/28/2010
11:25:05 AM



COMPOSITE FLOOR PLAN

SCALE: 1/16" = 1'-0"

16' 8' 0 16' 32' 48'

GRAPHIC SCALE: 1/16"=1'-0"

US Army Corps of Engineers
Fort Worth District

Symbol	Description	D.O. NO.	Action	Date

Date: APRIL 2010
Sol No.
Contr No.
Rev.
Plot date: 4/28/2010
Plot scale:

Designed by: T. REDMON
Drawn by: T. REDMON
Reviewed by: A. McCOY
Submitted by:

U.S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS
FORT WORTH, TEXAS

HSW ENGINEERING, INC.
3820 Northdale Blvd., Suite 210 B
Tampa, Florida 33624

MASON & HANGER
300 West Vine Street, Suite 1300
Lexington, Kentucky 40507

FORT SAM HOUSTON, TX
TRAINING SUPPORT CENTER
PN XXXXX

COMPOSITE FLOOR PLAN

Sheet reference number:
1A-110

P:\009503 Ft. Sam Houston TSC\CADD\SAMT\SAMT_1A-110.dgn
4/28/2010
1:45:22 PM

APPENDIX K
Fuel Cost Information

The following utility rates for this installation are provided for design

Electrical:
Demand Charge - none

Energy Charge - $0.09 per kilowatt-hour

Natural Gas:
Commodity Charge Rate - $ 1.25 per hundred cubic feet

Water:
Commodity Charge Rate - $2.678 per thousand gallons

Sewer:
Commodity Charge Rate - $3.292 per thousand gallons

APPENDIX L

LEED Project Credit Guidance

This spreadsheet indicates Army required credits, Army recommendations regarding preference and avoidance of individual credits, project-specific ranking of individual point preferences, discussion of Installation roles in support of individual credits, and issues that Government Project Delivery Teams (PDTs) need to be aware of relating to individual credits. The Resources section that follows provides references and resources that relate to LEED, including policy and legal requirements, design guides and documentation resources.

LEED 2.2 Credit Paragraph	**LEED Project Credit Guidance**	**Army Guidance:** Required - Preferred - Avoid	**Project Preference Ranking**: (1=most preferred, blank=no preference, X=preference not applicable to this credit, Rqd=required)	
PAR	**FEATURE**			**REMARKS**
CATEGORY 1 - SUSTAINABLE SITES (14 POSSIBLE POINTS)				
SSPR1	Construction Activity Pollution Prevention (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met. Related to compliance with 40 CFR 122.26 (Clean Water Act).
SS1	Site Selection		X	See paragraph LEED CREDITS COORDINATION for information relating to this credit.

SS2	Development Density & Community Connectivity - OPTION 1 DENSITY		X	Credit is determined by Installation's site selection. See paragraph LEED CREDITS COORDINATION for information relating to this credit.
	Development Density & Community Connectivity - OPTION 2 CONNECTIVITY		X	Credit is determined by Installation's site selection. See paragraph LEED CREDITS COORDINATION for information relating to this credit.
SS3	Brownfield Redevelopment		X	Credit is determined by Installation's site selection. See paragraph LEED CREDITS COORDINATION for information relating to this credit.
SS4.1	Alternative Transportation: Public Transportation Access		X	Credit is determined by Installation's site selection. See paragraph LEED CREDITS COORDINATION for information relating to this credit.
SS4.2	Alternative Transportation: Bicycle Storage & Changing Rooms	Pref		
SS4.3	Alternative Transportation: Low Emitting & Fuel Efficient Vehicles - OPTION 1			Requires provision of vehicles, which cannot be purchased with construction funds. Assume Government will not provide vehicles unless indicated otherwise.
SS4.3	Alternative Transportation: Low Emitting & Fuel Efficient Vehicles - OPTION 2	Pref		
SS4.3	Alternative Transportation: Low Emitting & Fuel Efficient Vehicles - OPTION 3			Requires provision of vehicle refueling stations. Installation must support type of fuel and commit to maintaining/supporting refueling stations.
SS4.4	Alternative Transportation: Parking Capacity	Pref		
SS5.1	Site Development: Protect or Restore Habitat			
SS5.2	Site Development: Maximize Open Space	Pref		Assume AGMBC option for aggregated open space at another location on the installation is not available to the project unless indicated otherwise.
SS6.1	Stormwater Design: Quantity Control	Pref		Related to compliance with 40 CFR 122.26 (Clean Water Act).

SS6.2	Stormwater Design: Quality Control			
SS7.1	Heat Island Effect: Non-Roof	Pref		
SS7.2	Heat Island Effect: Roof	Pref		Coordinate with nearby airfield requirements, which may preclude this credit.
SS8	Light Pollution Reduction	Pref		
CATEGORY 2 – WATER EFFICIENCY (5 POSSIBLE POINTS)				
WE1.1	Water Efficient Landscaping: Reduce by 50%	Pref		Project must include landscaping to be eligible for this credit.
WE1.2	Water Efficient Landscaping: No Potable Water Use or No Irrigation	Pref		Project must include landscaping to be eligible for this credit.
WE2	Innovative Wastewater Technologies - OPTION 1			
WE2	Innovative Wastewater Technologies - OPTION 2			
WE3.1	Water Use Reduction: 20% Reduction	Pref		Related to Army mandate for waterless urinals beginning FY10.
WE3.2	Water Use Reduction: 30% Reduction	Pref		
CATEGORY 3 – ENERGY AND ATMOSPHERE (17 POSSIBLE POINTS)				
EAPR1	Fundamental Commissioning of the Building Energy Systems (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met.
EAPR2	Minimum Energy Performance (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met.
EAPR3	Fundamental Refrigerant Management (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met.
EA1	Optimize Energy Performance	Rqd	Rqd	Earning of LEED EA1 points as indicated in paragraph ENERGY CONSERVATION, as a minimum, is required. Note that LEED points calculation is based on energy cost reduction.
EA2.1	On-Site Renewable Energy			

EA3	Enhanced Commissioning			The Commissioning Authority may be provided through the Design-Build Contractor only if in accordance with USGBC Credit Interpretation Ruling (CIR) dated 9/15/06. Commissioning Authority activities begin during design phase and continue well beyond beneficial occupancy. Assume Government will not provide CxA post-occupancy activities unless indicated otherwise.
EA4	Enhanced Refrigerant Management			
EA5	Measurement & Verification			Credit relates to EPACT metering requirements. Provider and funding of post-occupancy activities must be coordinated. Assume Government will not provide post-occupancy activities unless indicated otherwise.
EA6	Green Power		X	Credit is determined by Installation's purchase of green power. See paragraph LEED CREDITS COORDINATION for information relating to this credit.
CATEGORY 4 – MATERIALS AND RESOURCES (13 POSSIBLE POINTS)				
MRPR1	Storage & Collection of Recyclables (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met. Installation provides collection service and outside receptacle needs coordination.
MR1.1	Building Reuse: Maintain 75% of Existing Walls, Floors & Roof			
MR1.2	Building Reuse: Maintain 95% of Existing Walls, Floors & Roof			
MR1.3	Building Reuse: Maintain 50% of Interior Non-Structural Elements			
MR2.1	Construction Waste Management: Divert 50% From Disposal	Pref	1	See paragraph CONSTRUCTION AND DEMOLITION (C&D) WASTE MANAGEMENT for project requirement.
MR2.2	Construction Waste Management: Divert 75% From Disposal	Pref		

MR3.1	Materials Reuse: 5%			
MR3.2	Materials Reuse: 10%			
MR4.1	Recycled Content: 10% (post-consumer + 1/2 pre-consumer)	Pref		Relates directly to EPA CPG compliance. Federal regulation as well as Federal, DOD and Army policies require purchase of products that contribute to this credit.
MR4.2	Recycled Content: 20% (post-consumer + 1/2 pre-consumer)	Pref		Relates directly to EPA CPG compliance.
MR5.1	Regional Materials:10% Extracted, Processed & Manufactured Regionally			
MR5.2	Regional Materials:20% Extracted, Processed & Manufactured Regionally			
MR6	Rapidly Renewable Materials			Relates directly to USDA FB4P biobased materials compliance.
MR7	Certified Wood			
CATEGORY 5 – INDOOR ENVIRONMENTAL QUALITY (15 POSSIBLE POINTS)				
EQPR1	Minimum IAQ Performance (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met. Related to compliance with 10 CFR 434 (Federal Energy Code).
EQPR2	Environmental Tobacco Smoke (ETS) Control (PREREQUISITE)	Rqd	Rqd	All LEED prerequisites are required to be met. Assume all buildings are smoke free unless indicated otherwise. Family housing, barracks and other lodging are facility types where smoking may be permitted in some cases. If Statement of Work indicates smoking is permitted in these types of facilities, the requirements of LEED-NC 2.2 Option 3 apply.
EQ1	Outdoor Air Delivery Monitoring			
EQ2	Increased Ventilation			May adversely effect ability to earn energy optimization credits.
EQ3.1	Construction IAQ Management Plan: During Construction	Pref		
EQ3.2	Construction IAQ Management Plan: Before Occupancy	Pref		Construction schedule must accommodate activities required for this credit.

EQ4.1	Low Emitting Materials: Adhesives & Sealants	Pref		
EQ4.2	Low Emitting Materials: Paints & Coatings	Pref		
EQ4.3	Low Emitting Materials: Carpet Systems	Pref		
EQ4.4	Low Emitting Materials: Composite Wood & Agrifiber Products	Pref		
EQ5	Indoor Chemical & Pollutant Source Control	Pref		System requiring weekly cleaning to earn this credit is not a permitted option for Army projects.
EQ6.1	Controllability of Systems: Lighting			
EQ6.2	Controllability of Systems: Thermal Comfort			
EQ7.1	Thermal Comfort: Design			
EQ7.2	Thermal Comfort: Verification			Project must earn credit EQ7.1 to be eligible for this credit. Assume Government will not provide post-occupancy activities unless indicated otherwise.
EQ8.1	Daylight & Views: Daylight 75% of Spaces	Pref		
EQ8.2	Daylight & Views: Views for 90% of Spaces	Pref		
CATEGORY 6 – FACILITY DELIVERY PROCESS (5 POSSIBLE POINTS)				
IDc1.1	Innovation in Design			
IDc1.2	Innovation in Design			
IDc1.3	Innovation in Design			
IDc1.4	Innovation in Design			
IDc2	LEED Accredited Professional	Rqd	Rqd	LEED AP during design and construction is required.

Resources. Following are resources with web links, discussion of Federal and Army mandates and policies that relate to LEED, sources of design guidance and documentation tools to assist the PDT. Use of/compliance with documents indicated in this appendix is not required unless indicated in RFP. In the event of conflict between RFP and this appendix, RFP takes precedence.

Federal Mandates

EPA, *Environmentally Preferable Purchasing* (EPP) Program (EPA), available through URL: http://www.epa.gov/oppt/epp/ . Resulting from Executive Order [EO] 13101 *Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition* (White House, 14 September 1998), it establishes basic guidelines for EPP as well as forms the basis for Comprehensive Procurement Guidelines (see below).

Comprehensive Procurement Guidelines [CPG], www.epa.gov/cpg.

The EPA publishes the Comprehensive Procurement Guidelines (CPGs), found in 40 CFR 247, that provide a list of products that must contain recovered material. **This is required regardless of whether the LEED recycled content credit is pursued or not.** Recommendations for the percentages of recovered materials are published in a companion document titled the Recovered Materials Advisory Notice (RMAN). Additional products are added every 2-3 years. The CPGs currently include several commonly used construction products (such as concrete, floor tiles, and roofing materials) and landscaping products (such as site furnishings and landscaping timbers).
EPA requires that the purchase of products listed on the CPG contain at least the recycled content indicated in the CPG when practicable. For every project, designer must review the current CPG list and, unless designer determines that justification for non-use exists, ensure that the technical specifications require at least the recycled content indicated in the CPG. The following are considered adequate justifications for non-use:

a. The product does not meet appropriate performance standards.
b. The product is not available within a reasonable time frame.
c. The product is not available competitively (from two or more sources).
d. The product is only available at an unreasonable price (compared with a comparable non-recycled content product).

Applicable FAR provisions and clauses: FAR Part 23.4, *Use of Recovered Materials,* 52.223-4, *Recovered Material Certification,* 52.223-9, *Estimate of Percentage of Recovered Material Content for EPA-Designated Products*. Note that although EPA designated recycled content products contribute to the LEED recycled content credit, satisfying this requirement does not guarantee that the project will reach the cumulative total required to earn the LEED credit.

USDA Federal Biobased Products Preferred Procurement Program (FB4P)
http://www.biobased.oce.usda.gov

The USDA has a program similar to the EPA CPG, found in 7 CFR 2902, that provides a list of designated products that must contain bio-based material with recommendations for the percentages of bio-based content. The rules for use of designated products are the same as EPA CPG. Currently the only designated construction product is roof coatings, however additional products may be added. For every project, designer must review the current USDA designations for products applicable to the project and, if any are found, unless designer determines that justification for non-use exists, ensure that the technical specifications require at least the bio-based content indicated in the designation.

All Federal contracts that involve the use or purchase of USDA- designated products must specify that the associated procurement requirements be met and must include applicable FAR provisions and clauses (currently not yet published). Note that although USDA designated bio-based content products contribute to the LEED rapidly renewable materials credit, satisfying this requirement does not guarantee that the project will reach the cumulative total required to earn the LEED credit.

Army Policy and Mandates

ECB 2006-7R Army Standard for Urinals (09 AUG2006) www.hnd.usace.army.mil/techinfo “Publications”, “Engineering and Construction Bulletins”. Mandates waterless urinals beginning FY10.

United States Green Building Council/LEED

USGBC Website – http://www.usgbc.org

LEED-NC (New Construction) v.2.2 Rating System, October 2005 -- https://www.usgbc.org/ShowFile.aspx?DocumentID=1095

LEED-NC v.2.2 Registered Project Checklist -- https://www.usgbc.org/FileHandling/show_general_file.asp?DocumentID=1096

LEED-NC v.2.2 Reference Guide – Available by purchase from the USGBC at: http://www.usgbc.org/b2c/b2c/mainFS.jsp

LEED Letter Templates – Use of LEED Letter Templates for projects not registered with USGBC is a copyright infringement and is not permitted. Samples of the templates are available for review only at: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1447. (Fully functional access to LEED On-Line is only available to projects registered with the USGBC.)

LEED Credit Interpretations (CIRs) – Available on the members only side of the USGBC website. Click 'My Account' from the USGBC main web page (log-in and look for CIRs under 'My Resources.'

LEED Application Guide for Multiple Buildings and On-Campus Building Projects https://www.usgbc.org/FileHandling/show_general_file.asp?DocumentID=1097. Provides direction in applying LEED-NC v2.1 and v2.2 to projects in a campus or multi-building setting such as corporate campuses, college campuses, and government installations (i.e. there is one owner or common property management and control).

General Resources

Unified Facilities Guide Specifications (UFGS) www.wbdg.org/ccb

UFGS are non-proprietary guide specifications covering a broad range of products and systems and incorporating agency–specific guidance and many sustainability updates. They are used and maintained by USACE, NAVFAC, AFCESA and NASA.

UFGS are in the process of being updated to include Specifier notes relating to all current EPA CPG product designations, but this process is not complete yet. Designer MUST address EPA CPG requirements in specifications on a product-by-product basis.

UFGS 01 33 29 *LEED ™ Documentation.* This section includes overview and documentation requirements plus credit-specific requirements.

UFGS 01 62 35 *Recycled/Recovered Materials*. This section addresses EPA CPG compliance requirements.

UFGS 02 42 00 *Construction and Demolition Waste Management.* For DB and DBB use. This section includes requirement for waste management plan, diversion requirements and reporting.

UFGS 23 08 00.00 10 *Commissioning of HVAC Systems*. This section includes qualifications, standards and documentation, also includes several test checklists. Because it is limited to HVAC only it **does not** by itself satisfy the LEED fundamental commissioning requirement. Commissioning of other LEED required systems and coordination of documentation associated with this additional commissioning must be addressed.

USACE LEED Credit Documentation Tools

LEED 2.2 Documentation Requirements and Submittals Checklist. USACE Spreadsheet is available at http://en.sas.usace.army.mil to fill in for project submittals.

Commissioning Plan Document for LEED Fundamental Commissioning USACE template available at http://en.sas.usace.army.mil to edit to create project-specific document.

Owners Project Requirements Document for LEED Fundamental Commissioning. USACE template available at http://en.sas.usace.army.mil for Design Agent/Owner to edit to create project-specific document. Completed document should be included in DB RFPs or provided to Design Team at start of design.

Basis of Design Document for LEED Fundamental Commissioning. USACE template available at http://en.sas.usace.army.mil for Designer of Record to edit to create project-specific document.

APPENDIX M
LEED Owner's Project Requirements

Not Used

APPENDIX N
LEED Requirements for Multiple Contractor Combined Projects

Not Used

APPENDIX O
LEED Strategy Tables

Not Used

APPENDIX P

LEED Registration of Army Projects

15 April 2010

Number of Registrations

Each building must be registered separately, except multiple instances of a standard building on a shared site may be registered as a single project. If a single registration for multiple buildings is chosen, all buildings under the single registration must earn exactly the same points. Do not register buildings that are exempt from a specific LEED achievement requirement.

Typical Registration Procedure

1. Login, complete the online registration form (see guidance below) at the GBCI LEED Online website http://www.gbci.org/DisplayPage.aspx?CMSPageID=174 and submit it online.
2. Pay the registration fee via credit card (USACE staff: credit card PR&C is funded by project design or S&A funds).
3. GBCI will follow up with a final invoice, the LEED-online passwords and template information.
4. The individual who registers the project online is, by default, the Project Administrator.

Completing the Registration Form

BEFORE YOU BEGIN:
Create a personal account with USGBC if you do not have one.
You will need the following information:
Project name as it appears in P2 (obtain from USACE Project Manager)
Building number/physical address of project
Zip code for Installation/project location
Anticipated construction start and end dates
Total gross area all non-exempt buildings in registration
Total construction cost all non-exempt buildings only (see Project Details Section instructions below)

ACCOUNT/LOGIN INFORMATION

1. The person registering the project **must have an account with USGBC** (login and password) to complete the form. Go to http://www.gbci.org/ , click on “register a project” at the drop-down menu for project certification (at the top of the page) and select “register now for LEED 2009” to start the project registration process. If you have an account, login with your email address and password and select “register new project” to proceed. If you do not have an account, you may select “register a new account” and follow the instructions. It is recommended that you create an account separately on the USGBC website before you start the form. IMPORTANT: USACE team members are members of USGBC and are eligible for Member prices. USACE team members registering projects should be sure to include the USACE Corporate Access ID in their personal account profile (if you do not have it contact richard.l.schneider@usace.army.mil or judith.f.milton@usace.army.mil for the number).
2. The Account/Login Information section is filled out by the person registering the project. It may be a Contractor or a USACE staff member.

ELIGIBILITY SECTION

Follow directions (accepting the terms and conditions)
Review your profile information and make corrections if needed

RATING SYSTEM SELECTION SECTION

Select single project registration and I know which rating system.
Select the rating system - currently only LEED-NC and LEED for Homes are approved for Army use without special approval.
LEED Minimum Program Requirements: select YES

RATING SYSTEM RESULTS SECTION

Confirm selected rating system.

PROJECT INFORMATION SECTION

Project Title: Begin the project title with a one-word identifier for the Installation. Do not include the word “Fort”. After this match the project name used in P2 (contact the USACE Project Manager for this information) and identify the building being registered. Example: “Stewart 4th IBCT - DFAC”.
Project Address 1 and 2: This is the physical location of the project. Provide building number, street address, block number or whatever is known to best describe the location of the project on the Installation.
Project City: Installation Name
State, Country, Zip Code: Self-explanatory
Anticipated Construction Start and End Dates: Self-explanatory – give your best guess if unknown. Note that required data entry format is: 1 or 2 digit month/1 or 2 digit date/4 digit year (example 3/23/2010)
Gross Square Footage: Provide total area all buildings in LEED project. Exclude the area of any buildings that are exempt from the LEED achievement requirement (for example, exclude an unconditioned storage shed to be constructed with a barracks complex).
Is Project Confidential: Indicate NO except, if project has security sensitivity (elements that are FOUO or higher security), indicate YES.
Notification of Local Chapter: Indicate NO unless Government/USACE Project Manager requests you to indicate YES.
Anticipated Project Type: Select the most appropriate option from the drop-down menu.
Anticipated Certification Level: Select the applicable option from the drop-down menu (Silver is the usual level).

PROJECT OWNER INFORMATION SECTION

Project Owner First Name, Last Name, email, phone, address: The Project Owner is the USACE Project Manager. Obtain this info from the USACE Project Manager.
Organization: U.S. Army Corps of Engineers. This field MUST be completed this way because it will be used as a search field by higher HQ to find all USACE registered projects. You may supplement it with district name at the end but DO NOT revise or use an acronym.
May we publish Owner information: Indicate NO
Owner Type: Pick Federal Government from drop-down menu.
Project Owner Assertion: Check the box

PAYMENT INFORMATION

Self-explanatory

APPENDIX Q
REV 2.1 – 30 SEP 2010
AREA COMPUTATIONS

Computation of Areas: Compute the "gross area" and "net area" of facilities (excluding family housing) in accordance with the following subparagraphs:

(1) Enclosed Spaces: The "gross area" is the sum of all floor spaces with an average clear height ≥6'-11" (as measured to the underside of the structural system) and having perimeter walls which are ≥4'-11". The area is calculated by measuring to the exterior dimensions of surfaces and walls.

(2) Half-Scope Spaces: Areas of the following spaces shall count as one-half scope when calculating "gross area":

- Balconies
- Porches
- Covered exterior loading platforms or facilities
- Covered but not enclosed spaces, canopies, training, and assembly areas
- Covered but not enclosed passageways and walks
- Open stairways (both covered and uncovered)
- Covered ramps
- Interior corridors (Unaccompanied Enlisted Personnel Housing Only)

(3) Excluded Spaces: The following spaces shall be excluded from the "gross area" calculation:

- Crawl spaces
- Uncovered exterior loading platforms or facilities
- Exterior insulation applied to existing buildings
- Open courtyards
- Open paved terraces
- Uncovered ramps
- Uncovered stoops
- Utility tunnels and raceways
- Roof overhangs and soffits measuring less than 3'-0" from the exterior face of the building to the fascia

(4) Net Floor Area: Where required, "net area" is calculated by measuring the inside clear dimensions from the finish surfaces of walls. If required, overall "assignable net area" is determined by subtracting the following spaces from the "gross area":

- Basements not suited as office, special mechanical, or storage space
- Elevator shafts and machinery space
- Exterior walls
- Interior partitions
- Mechanical equipment and water supply equipment space
- Permanent corridors and hallways
- Stairs and stair towers
- Janitor closets
- Electrical equipment space
- Electronic/communications equipment space

APPENDIX R

Preliminary Submittal Register

NOTE TO SPECIFIER:

1. Appendix R" will be a Adobe Acrobat pdf version of the Specifier completed "Sample Preliminary Submittal Register." The Sample Register is Excel Spreadsheet format of the RMS Input Form 4288A, which serves two purposes.

2. First, The Register allows the both Government and the Proposers to see and estimate the cost of the Division 00 and Division 01 submittals required by the contract in addition to the Contractor generated submittal register items developed during Design After Award.

3. Secondly, after award, the Government will provide the Contractor the actual Excel Spreadsheet for the Contractor to input the data into RMS to create the Submittal Register used during contract performance. See Section 01 33 00 (Submittal Procedures), paragraph 1.8 (Submittal Register) for the contract requirements.

4. For the contract or task order Solicitation, the Specifier must complete APPENDIX R, found at the following link: http://rfpwizard.cecer.army.mil/HTML/Docs/Refs/Sample%20Preliminary%20Submittal%20Register.xls , save it as a PDF file and then upload it into the Wizard as Appendix R.

5. The RMS Input Form initially includes submittals required by the standardized Model RFP Division 00 and Division 01 Sections, except Section 01 10 00, paragraph 3. Examine the Special Contract Requirements, paragraphs 3 and 6 and any other locally developed portions of the RFP for required submittals and add them to the Input Form. Do not duplicate submittals already listed in the standardized RMS Input Form, because the Contractor needs to submit this information only once.

6. After award, the Government provides the Excel spreadsheet to the selected contractor to develop and input the RMS Input form for the submittal register required by paragraph 1.8 of Section 01 33 00, Submittals.

Appendix AA: Reference Materials

DD1391 for Infrastructure for TSC, 15 Aug 2008

Design Directive, Project # 71116, 2 September 2008

Training Support Center Criteria Design Guide Nov. 2007

EST Data Requirements

Programmable Logic Control for HVAC

Stormwater Criteria

EISA 438

Low Impact Development Guidance

Outside Plant Communications Criteria

Value Engineering Study

2011 71116C REVISION DATE: 31 DEC 2009
ARMY MCA (AS OF 01/08/2010 AT 16:31:47) 16 DEC 2007
LAF=.94 UM=E

Fort Sam Houston
Texas Training Support Center

141 29 71116 6,200

PRIMARY FACILITY				4,386
Training Aids Center	SF	29,200	137.73	(4,022)
Storage Shed, Covered	SF	364	45.14	(16)
Special Foundations	SF	29,200	5.00	(146)
IDS Installation	SF	29,200	.28	(8)
EMCS Connection	EA	29,200	.92	(27)
Total from Continuation page				(167)
SUPPORTING FACILITIES				1,009
Electric Service	LS	--	--	(91)
Water, Sewer, Gas	LS	--	--	(94)
Paving, Walks, Curbs And Gutters	LS	--	--	(329)
Storm Drainage	LS	--	--	(83)
Site Imp(223) Demo( )	LS	--	--	(223)
Information Systems	LS	--	--	(174)
Antiterrorism Measures	LS	--	--	(15)

ESTIMATED CONTRACT COST	5,395
CONTINGENCY (5.00%)	270
SUBTOTAL	5,665
SUPERVISION, INSPECTION & OVERHEAD (5.70%)	323
DESIGN/BUILD - DESIGN COST (4.0000%)	227
TOTAL REQUEST	6,215
TOTAL REQUEST (ROUNDED)	6,200
INSTALLED EQT-OTHER APPROPRIATIONS	(16)

Construct a standard design Training Aids Center (TAC). Primary facilities include the TAC, storage shed, installation of Intrusion Detection System (IDS), connection to Energy Monitoring and Control System (EMCS), antiterrorism measures and building information systems. Supporting facilities include electric service, water, paving, walks, curbs and gutters, sanitary sewer, site preparation/improvements and information systems. Heating and air conditioning will be provided by self contained systems. Access for individuals with disabilities will be provided. Sustainable Design and Development (SDD) and Energy Policy Act of 2005 (EPAct05) features will be provided. Comprehensive building and furnishings related interior design services are required. Special foundations are required. Air Conditioning (Estimated 36 Tons).

---

11. REQ: 29,200 SF ADQT: NONE SUBSTD: 17,220 SF
PROJECT:
Construct a standard design Training Aids Center at Fort Sam Houston, TX.
(Current Mission)

2011 71116C REVISION DATE: 31 DEC 2009
ARMY MCA (AS OF 01/08/2010 AT 16:31:47) 16 DEC 2007
LAF= UM=E

Fort Sam Houston
Texas

Training Support Center 71116

9. COST ESTIMATES (CONTINUED)

Item	U/M	QTY	Unit COST	Cost ($000)
PRIMARY FACILITY (CONTINUED)				167
SDD and EPAct05	LS	--	--	(79)
Antiterrorism Measures	LS	--	--	(50)
Building Information Systems	LS	--	--	(38)

REQUIREMENT:
Army relocations to Fort Sam Houston will increase the quantity and type of live and virtual training devices used. Additional storage is needed to support the increases in training aid devices and to protect the investment for those devices.

CURRENT SITUATION:
Existing substandard warehouse buildings do not have additional capacity to support increased training aids and devices. Current warehouse buildings are fully engaged supporting existing missions.

IMPACT IF NOT PROVIDED:
If this project is not provided, Fort Sam Houston will not be able to protect the training aid and device investment. Training components will be exposed to the elements drastically reducing useful life and compromising reliable use for training.

ADDITIONAL:
This project has been coordinated with the installation physical security plan, and all physical security measures are included. All required antiterrorism protection measures are included. Alternative methods of meeting this requirement have been explored during project development. This project is the only feasible option to meet the requirement. The Deputy Assistant Secretary of the Army (Installations and Housing) certifies that this project has been considered for joint use potential. The facility will be available for use by other components. A parametric cost estimate based upon project engineering design was used to develop this budget estimate. Sustainable principles, to include Life Cycle cost-effective practices, will be integrated into the design, development, and construction of the project in accordance with Executive Order 13423, 10 USC 2802(c), and other applicable laws and Executive Orders.

2011 71116C REVISION DATE: 31 DEC 2009
ARMY MCA (AS OF 01/08/2010 AT 16:31:47) 16 DEC 2007
LAF= UM=E

Fort Sam Houston
Texas

Training Support Center 71116

ESTIMATED CONSTRUCTION START:	MAR 2011	INDEX: 2531
ESTIMATED MIDPOINT OF CONSTRUCTION:	SEP 2011	INDEX: 2553
ESTIMATED CONSTRUCTION COMPLETION:	MAR 2012	INDEX: 2575

2011 71116C REVISION DATE: 31 DEC 2009
ARMY MCA (AS OF 01/08/2010 AT 16:31:47) 16 DEC 2007
LAF= UM=E

Fort Sam Houston
Texas

Training Support Center 71116

	U/M	Qty	Unit Cost	Cost ($000)
PRIMARY FACILITY.				
GENERAL.				
14129 Training Aids Center	SF	29,200	137.73	(4,022)
1) 14129 Training Aids Center	SF	29,200	137.73	4,022
44222 Storage Shed, Covered	SF	364	45.14	(16)
1) 44222 Storage Shed, Covered	SF	364	45.14	16
14129 Special Foundations	SF	29,200	5.00	(146)
1) Special Foundations, Training A	SF	29,200	5.00	146
88040 IDS Installation	SF	29,200	.28	(8)
1) IDS Installation, Training Aids	SF	29,200	.28	8
89220 EMCS Connection	EA	29,200	.92	(27)
1) EMCS Connections, Training Aids	SF	29,200	.92	27
00005 SDD and EPAct05	LS	--	--	(79)
1) SDD & EPAct05, Training Aids Ce	SF	29,200	2.71	79
88041 Antiterrorism Measures	LS	--	--	(50)
1) AT Measures, Training Aids Cent	SF	29,200	1.71	50
INFORMATION SYSTEMS.				
80800 Building Information Systems	LS	--	--	(38)
SUPPORTING FACILITIES.				
Electric Service	LS	--	--	(91)
1) 81242 UG Ducts 2-way-4"	LF	1,000	29.19	29
2) 81360 Transformers - 150 kVA	EA	1	11,838	12
3) 81230 Exterior Lighting	LF	850	41.70	35
4) 93410 Cut and Fill	CY	100	7.64	1
5) Primary Electrical Wire	LF	30	455.00	14
Water, Sewer, Gas	LS	--	--	(94)
1) 82410 Black Steel, Schedule 40	LF	500	17.32	9
2) 82410 Gas Regulator & Meter	EA	1	3,648	4
3) 83210 Plastic Reinforced	LF	1,000	22.77	23
4) 83210 Concrete Plain	LF	750	30.81	23
5) 83210 Concrete Manholes, PCST, Over 8	LF	40	412.42	16
6) Trench and Backfill	CY	150	20.00	3
7) Valves and Cleanouts	EA	5	873.00	4
8) 89240 Fire Hydrants	EA	4	3,088	12
Paving, Walks, Curbs And Gutters	LS	--	--	(329)
1) 85110 Concrete	SY	8,307	10.62	88
2) 85210 Concrete	SY	213	30.62	7
3) 85211 Curb/Gutter 6" X 8"	LF	3,000	16.27	49
4) 87210 Chain Link 6 FT High	LF	1,200	19.14	23

2011 71116C REVISION DATE: 31 DEC 2009
ARMY MCA (AS OF 01/08/2010 AT 16:31:47) 16 DEC 2007
LAF= UM=E

Fort Sam Houston
Texas

Training Support Center 71116

	U/M	Qty	Unit Cost	Cost ($000)
5) 87250 Gates - 24 ft pair	EA	2	1,506	3
6) 87250 Gates - 4 ft wide	EA	2	312.91	1
7) 85110 Base Course (Crushed Stone)	SY	8,307	19.14	159
Storm Drainage	LS	--	--	(83)
1) 87110 Concrete Reinforced	LF	750	46.12	35
2) 87110 Concrete Headwalls	EA	4	1,200	5
3) 87110 Excavation and Backfill	CY	516	15.64	8
4) 83210 Catch Basins, 4' Deep	EA	14	2,503	35
Site Improvement	LS	--	--	(223)
1) 93210 Site Clearing & Grubbing	AC	3.50	4,012	14
2) 93210 Grading Rough	SY	5,389	2.58	14
3) 93210 Grading Fine	SY	11,551	1.24	14
4) Concrete Pads	EA	2	7,818	16
5) Dumpster Enclosure	EA	1	13,030	13
6) 93210 Borrow	CY	3,245	17.22	56
7) 93410 Excavation Common Earth	CY	3,245	8.42	27
8) 93220 Seeding/Grass Hyd w/Fertilizer	SY	5,176	.77	4
9) 93220 Haul & Spread/Topsoil	CY	3,245	20.09	65
Information Systems	LS	--	--	(174)
1) 80800 Information Systems	LS	--	--	174
Antiterrorism Measures	LS	--	--	(15)
1) 88040 Manual Pop-up Bollard System 30	EA	6	2,540	15

Directive Date		Project Number
2008, SEP 2	DESIGN DIRECTIVE	071116

1. Addressees

Job Series: DES-2011-MCA-071116-FT SAM HOUS-MAP-03
From Office: CEMP-SWD, Military Program Manager
To Office: USAED - SOUTHWESTERN (CESWD-PMM-M)
Information: USAED - FORT WORTH (CESWF-PM-JM) (KF)
USAED - FORT WORTH (CESWF-PM-JM) (JR)
SWF-PM-JM - FORT WORTH (BB)

2. Project Data

Project Number: 071116
Project Description: Trng Supt Cent
Design Agent: SWF - Fort Worth District
Construction Agent: SWF - Fort Worth District
Command - Using Service: 71 - MAP
Category Code: 14129
Installation/Location: 48399 - Ft Sam Hous
Approp Program Id: MCA - Military Construction, Army
Directed Release Code: 7 - RFP
Directed FY: 2011

The following field is in ($000)

Directed PA ($000): 6,400
Appropriation Code:

The following fields are in whole dollars

Previous Funds: 0
Funds This Directive: 0
Total Funds: 0

Directive Date		Project Number
2008, SEP 2	DESIGN DIRECTIVE	071116

Job Series: DES-2011-MCA-071116-FT SAM HOUS-MAP-03

3. References:

CAPCES Release Report Dated 29 Jul 2008.

CEMP-II E-mail (M. Delaney), 01 Sep 2008

4. Description of Authorization:

5. Special Instructions:

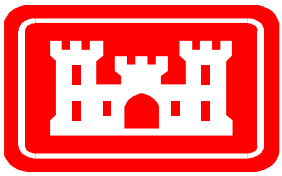
The project is programmed for FY11. Please complete the parametric design by Dec 08 (that is, a project definition report by 1 Dec 08) and ENG 3086 by Mid Feb 09.

6. Release Comments:

Informational - The following fields are in ($000)

DD1391 Block 8 Cost:	6,400
CECW-EI Approved Estimated Cost:	0
HQDA/ACSIM Prog Amt (PA):	6,400
Congress Appropriation Request:	6,400
Current CWE:	0
Pending CWE:	0
ACSIM Programmed FY:	2011

James Wang, P.E.
Program Manager
SWD RIT
For: Directorate of Military Programs



U.S. Army
Corps of Engineers
Huntsville Center
Installation Support Center of Expertise (ISCX)

Training Support Center (TSC)

Army Criteria Tracking System
Standard Information
Category Code 14129
November 2007

Table of Contents

CHAPTER 1 – CATEGORY CODE DATA. **3**
CHAPTER 2 – DESCRIPTION & INTERNAL FUNCTIONS. **3**
CHAPTER 3 – BASIC CRITERIA. **6**
CHAPTER 4 – DESCRIPTION & EXTERIOR SUPPORT CRITERIA. **13**
CHAPTER 5 – LAND USE CRITERIA. **14**

1 CATEGORY CODE DATA

Chapter 1 – Category Code Data.

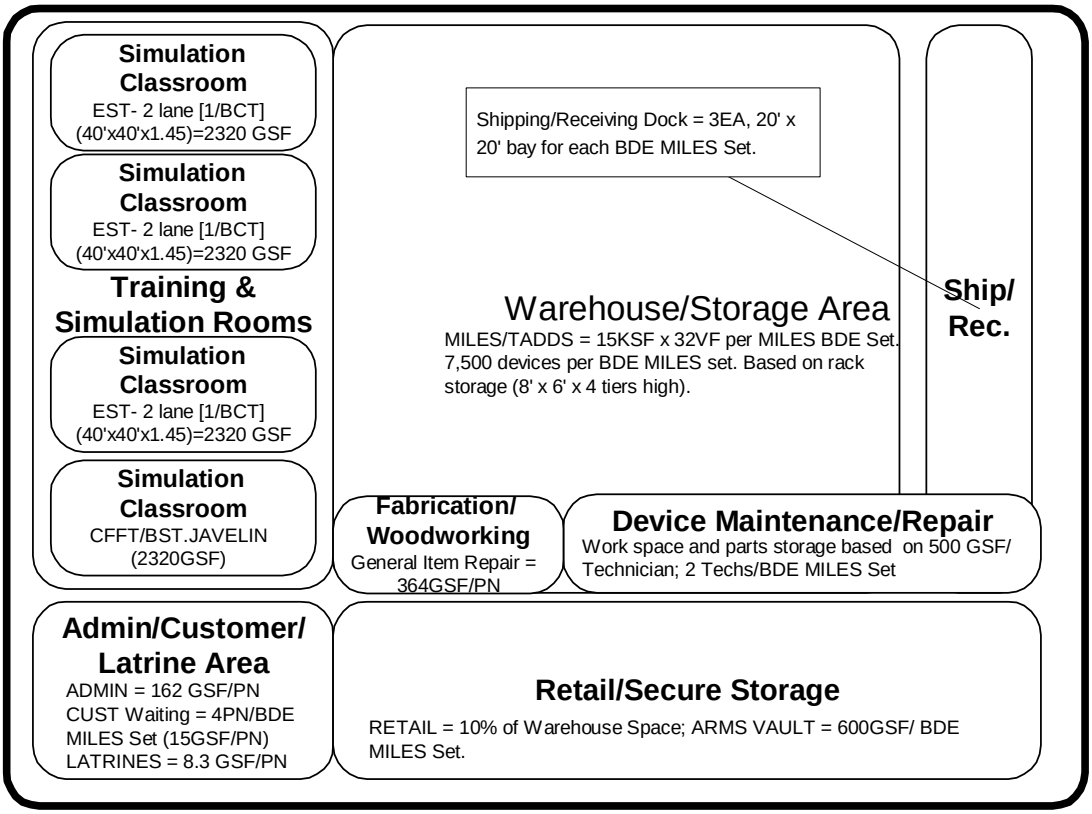
1.1 Category Code 141.29, Training Support Center (TSC)
1.2 Area UM = SF
1.3 Other UM = PN
1.4 Program UM = SF
1.5 Type = B – Building
1.6 Glac = 1730 – Building
1.7 Proponent = DCS Army G3
1.8 IC = 01 –Aviation & Operation Facilities
1.9 FCC = 141 –Operations Buildings
1.10 FCG = 14129 – Training Support Center
1.10.1. FAC = 1732 – Training Aides Center
1.11 ISR Facility Class = 1100 – Operations and Training
1.12 ISR Category = 1120 – Training Instruction Facilities
1.13 ISR Subcategory = 1123 –Training/Training Support Facilities
1.14 DA Pam 415-28 (*Category Code*) A building that is used to fabricate, maintain, store, and issue training devices including Multiple Integrated Laser Engagement System (MILES); it also provides the administrative space for the training support division management staff.

2 DESCRIPTION & INTERNAL FUNCTIONS

Chapter 2 – Description & Internal Functions.

2.1 DESCRIPTION. DA PAM 415-28: A building that is used to fabricate, maintain, store, and issue training devices including Multiple Integrated Laser Engagement System (MILES); it also provides the administrative space for the training support division management staff. Common training device used to establish requirement for facility is the authorized Brigade Sets of MILES equipment. The average of 5,000 components associated with a standard Brigade MILES Set is used to size Training Support Real Property as defined herein.

2.2 INTERNAL FUNCTIONAL ELEMENTS. A facility that includes primarily warehouse space for storage, issue and maintenance of training devices and components. The facility may include: warehousing space, shipping/receiving areas, device fabrication (woodworking and plastics), general item repair, general purpose administrative space, sensitive item storage (arms vaults) multi purpose classrooms/work centers, break areas, and latrines. This is a general purpose facility intended for use by installation Directorate of Plans and Training (DPT). Figure 2.2 demonstrates functional relationships of notional design space.



Training Support Center
Notional Design.
February 2006

Figure 2.2

.

2.1 INPUTS. Number of Government and Contractor support personnel found in the TDA paragraphs and contract documents; number of authorized Brigade MILES Sets.

2.1.1. Training Support Center.

2.1.1.1. TDA STAFF: The full time staff required to support Training Support Center device sustainment; store, issue, receive, account, maintain and fabricate training devices; and support all training events. This category includes contractor support and government management. Based on validated staffing metrics.

2.1.1.2. CONTRACTOR STAFF: Total number of contractors authorized to work in a TSC environment.

2.1.1.3. APPROVED BRIGADE MILES SETS: ACOM approved distribution for Brigade MILES Sets is the baseline for real property sizing. Each Brigade Set provides space for storage, issue, turn-in, maintenance, repair, and prepare for issue and turn-in and general support space. Other training devices are factored as a component of a BCT MILES Set in determining space requirements/allowances.

3 BASIC CRITERIA

Chapter 3 – Basic Criteria.

3.1 The US Army Standard Design Criteria, Army Criteria Tracking System for: General Purpose Administration, category code 61050; General and Multi Purpose Classrooms, category code 17119 & 17120; Latrines, Janitor Closets from ACTS for Category Codes 17119; and General Item Repair from ACTS for category code 21414. General Supply and Storage Category Code 44220 requirement derived from physical measurement of standard Brigade Combat Team (BCT) MILES Set, average of 5,000 components, container stored, issued and accounted for, vertical (cubic) storage and associated material handling equipment (MHE) factored. Retail space derived as a percentage (10%) of General Warehouse/Storage Category Code 44220 requirement. 10% factor derived from physical measurement of related and support components for standard BCT MILES Set and other training devices. Secure Storage (Arms Vault) derived based on large size standard weapons storage vault for each BCT MILES set authorized. Physical measurement of component storage was used to determine sizing for sensitive item storage. Device Maintenance & Repair derived by physical measurement of space associated with MILES and related training device maintenance and repair. Shipping/Receiving space derived from physical measurement of BCT MILES Set requirements for staging, issue and condition inspection device turn-in activities. Fabrication/Woodworking derived from Category Code 21414 for gross space allocation for each assigned TDA staff plus 200 gross square feet for general supplies storage and device staging. Simulation Classrooms derived from Army criteria and from physical space requirements from the simulation device material fielding plans.

3.2 STANDARD DESIGN CRITERIA.

3.2.1 TRAINING SPACE, CLASSROOM.

3.2.1.1. General instruction rooms are space that includes primarily classroom space for multipurpose training instruction. These general purpose rooms are intended for use by organizations which serve a large population for classroom and device simulation instruction. These rooms are distinct from organizational classroom areas (F17119) associated with battalion headquarters and trainee barracks. The primary method used for sizing classrooms is the Engagement Skills Trainer (EST) simulation device. Two 20 x 40 foot lanes per Brigade Combat Team (total is 40' x 40' plus 45% for circulation) equals (1600 GSF x 1.45) = 2,320 GSF for each classroom.

Figure 3.2.1.1

# BCT Sets	EST Allowance	Gross Area (SF)
1	2,320	2.320
2	2,320	4,640
3	2,320	6,960
4	2,320	9,280

3.3.1 ADMINISTRATIVE SPACES.

3.3.1.1. Customer Waiting Area. Customers factored based on 4 personnel for each Brigade Combat Team (BCT) MILES Set authorized. A factor of 15 GSF per customer used to calculate this space allowance. Figure 3.3.1.1 shows allowance:

Figure 3.3.1.1

#BCT Sets	Customers	Gross Area (SF)
1	4	60
2	8	120
3	12	180
4	16	240

3.3.1.2. Administration Offices. Space for building operations, budget, scheduling, technical support, contracting officer representative, program and training administration. A factor of 162 GSF per staff member used to calculate this space allowance Figure 3.3.1.2 shows allowance for each facility size.

Figure 3.3.1.2

Size of TSC	Staff	Gross Area (SF)
Small	1-12	162-1944
Medium	13-22	2106-3564
Large	23-30	3726-4860

3.3.1.3. Device Maintenance and Repair Area. Device set-up, storage, maintenance and repair. Provides work bench, storage, tools storage and repair parts storage areas. Contract maintenance assumes 2 technicians for each Brigade MILES Set. Actual number of contract personnel must be used to factor actual requirement. A factor of 500 GSF per repair person used to calculate this space allowance Figure 3.3.1.3 shows allowance for each facility size.

Figure 3.3.1.3

#BCT Sets	# of Repair PN	Gross Area (SF)
1	2	1,000
2	4	2,000
3	6	3,000
4	8	4,000

3.4.1 WAREHOUSING AND STORAGE.

3.4.1.1. Shipping/Receiving Loading Dock. A loading dock is important for new stand-alone facilities. It should be remote from the customer entrance and collocated with supply/storage area. A 20’ x 20’ bay size for staging MILES containers and other training devices is needed to support issue and turn-in functions. Three (3) bays are required for each Brigade MILES Set authorized.. Figure 3.4.1.1 shows allowance for each facility size.

Figure 3.4.1.1		
#BCT Sets	**# of Bays**	**Gross Area (SF)**
1	3	1,200
2	6	2,400
3	9	3,600
4	12	4,800

3.4.1.2. Device Fabrication (woodworking/plastics). Training aids are fabricated using woodworking tools, bench fabrication, tools used are saws, drills, sanders, routers. Plastics fabrication uses injection molding, roto molding, and other similar tools and setups. Installations with an Armywide fabrication mission require space for plastics manufacturing. Figure 3.4.1.2 shows allowance for each facility size where “A” designates a TSC with an Armywide fabrication mission and “L” is for TSCs with local fabrication only.

Figure 3.4.1.2		
Armywide mission/ Local	**# of FABR PN**	**Gross Area (SF)**
A	6-10	3000-5000
L	1-5	500-2500

3.4.1.3. Warehouse/Storage Area. General Purpose Warehouse requirement based on physical measurement of standard BCT MILES Set, average of 5,000 components, containerized and stored on racks four tiers high. Floor space for 4-tier racks and material handling equipment access/circulation plus other training device storage equates to 15,000 GSF/BDE Set. Figure 3.4.1.3 shows allowance for each facility size.

Figure 3.4.1.3		
#BCT Sets	**MILES Set Allowance**	**Gross Area (SF)**
1	15000	15000
2	15000	30000
3	15000	45000
4	15000	60000

3.5.1 SPECIAL FUNCTIONAL USE AREAS.

3.5.1.1. Latrines. Male and female latrines with standard fixtures. Allowance is derived from ACTS and is 8.3 GSF/PN. Figure 3.5.1.1 shows allowance:

Figure 3.5.1.1		
Size of TSC	**Staff**	**Gross Area (SF)**
Small	1-12	8.3-99.6
Medium	13-22	107.9-182.6
Large	23-30	190.9-249

3.5.1.2. Student/Staff Break Areas. Refrigerator, sink, microwave, vending, phones, television. Lounge type furniture w/ tables and with seating for personnel. Break Room/lounge allowance is 8.7 GSF/PN. Figure 3.5.1.2 shows allowance for each facility size.

Figure 3.5.1.2		
Size of TSC	**Staff**	**Gross Area (SF)**
Small	1-12	8.7-104.4
Medium	13-22	113.1-191.4
Large	23-30	200.1-261

3.5.1.3. Secure Operations Storage. Secure storage area for sensitive devices and other sensitive communication and automation components. Allowance derived using measured area and is based on standard size large weapons storage vault at 600GSF/BCT MILES Set. Figure 3.5.1.3 shows allowance for each facility size.

Figure 3.5.1.3		
#BCT Sets	**Allowance Each BCT MILES Set**	**Net Area (SF)**
1	600	600
2	600	1200
3	600	1800
4	600	2400

3.5.1.4. Retail Device Storage. Retail space derived as a percentage (10%) of General Warehouse/Storage Category Code 44220 requirement. 10% factor derived from physical measurement of related and support components for standard BCT MILES Set and all other Training Aide devices. Figure 3.5.1.4 shows allowances for each facility size.

Figure 3.5.1.4

#BCT Sets	Warehouse Allowance	10% of Warehouse Gross Area (SF)
1	15000	1500
2	30000	3000
3	45000	4500
4	60000	6000

3.5.1.5 Hazardous Material Storage Area: Hazardous materials used by the training support center include, but not limited to, propane, polyurethane, and oxygen. Storage area will be in compliance with existing government safety regulations. This storage area will not be included in the square footage of the training support center facility, but requirements for space will be annotated on the 1391. A separate facility will be required for this storage area and this facility can be acquired through the Government Services Administration (GSA) retail catalog using OMA funding.

3.6.1 SUPPORT SPACES.

3.6.1.1. Janitor Closet. Provide one at each toilet. Allowance is based on 0.3 GSF per building occupant, from ACTS for CC17119. Figure 3.6.1.1 shows allowances:

Figure 3.6.1.1

Size of TSC	Staff	Gross Area (SF)
Small	1-12	0.3-3.6
Medium	13-22	3.9-6.6
Large	23-30	6.9-9

3.6.1.2. Mechanical/Electrical Space. Provide dedicated interior spaces and exterior areas for plumbing, fire protection, and HVAC equipment. Allowances based on industry averages as

follows: Buildings less than 50,000 GSF use 7% of gross space; less than 100,000 GSF use 5% of gross space; greater than 100,000 GSF use 3% of gross space. Figure 3.6.1.2 shows allowance for each facility size.

Figure 3.6.1.2

Size of TSC	Factor	Average Gross Area (SF)	Average Mechanical Space (GSF)
Small	7%	26,000	1,820
Medium	5%	70,500	3,525
Large	3%	121,000	3,630

3.7.1 Gross Area Factor. Used to convert net areas to gross 1.45.

3.8.1 OCONUS Exceptions, None.

3.9.1 PRIMARY FACILITY TOTALS.

Figure 3.9.1

Size of TSC	Average Gross Area (SF)
S	27,820
M	74,025
L	124,630

4 DESCRIPTION AND EXTERIOR SUPPORT CRITERIA

Chapter 4 – Description & Exterior Support Criteria.

4.1 TRAINING SUPPORT CENTER (TSC) is an emerging training support environment. Current exterior training support features and functional space will continue to change. The current criteria are derived from actual field investigations and surveys from how units are training in 2006 and obtaining training devices to support that training.

4.2 Primary functional areas are: Issue/receiving of devices with primary emphasis on MILES equipment; device fabrication mission; POV and Tactical vehicle parking associated with on-site simulation and device training.

4.3 Telecommunications provide access to post voice and data systems. Interior telecommunications provided voice and data services, wireless (as needed) and primary facility intercom system connectivity.

5 LAND USE CRITERIA

Chapter 5 – Land Use Criteria.

5.1 PLANNING CONSIDERATIONS – Troop Housing/Command & Control Land Use or Heavy to Light Industrial. Priority for land use is associated with moderate acreage requirements to support the full range of Training Support Center (TSC) functions. Each facility and support area must factor as a minimum 100% land area for future expansion. TSC is a training magnet of functional space and provides increasing opportunity for simulation and virtual training. Troop Housing/ Command & Control land use is first priority based on proximity to troop densities to support TSC needs. Second order priority would be for light industrial land use based on potential for large acreage tracts availability. Preferred land use is to establish a new category titled 'Training Campus Land Use' situated in close proximity to troop housing and light industrial land use areas. Direct access for troops is the priority for proximity. Consideration must be made for tactical vehicle access.

5.2 LAND REQUIREMENTS. Components of land requirements are: primary facility; site egress and ingress; utility access; Installation Design Guide standards; POV parking; Tactical vehicle parking; and, force protection stand-off distances. Future expansion needs should factor a minimum 100% expansion of each functional component. Figure 5.2 established site selection quantity ranges for each TSC size:

Figure 5.2

Size of TSC	Bldg (SF)	60% Occupant POV (35SY/VH)	6 VEH BCT.Set Tactical (35SY/VH)	CirculationFactor @ 15% (SY)	Gross Area (AC)
S	27,820	12 (420)	6 (210)	95	725
M	74,025	22 (770)	12 (420)	179	1369
L	124,630	30 (1050)	18 (630)	1150	2830

5.3. AFFINITIES. Training Support Centers should be located in close proximity to other training facilities: classroom and simulations. Integration of tactical vehicles for daily parking to access simulation systems evokes proximity needs for existing tactical vehicle maintenance facilities.

5.4 INFRASTRUCTURE. Utilities requirements must consider water for fire protection and potable needs; waste water treatment, electrical power, 3-phase; primary heating commodity for geographic area; and most importantly, voice and data connectivity to the post wide infrastructure.

EST
2000

ISSUES

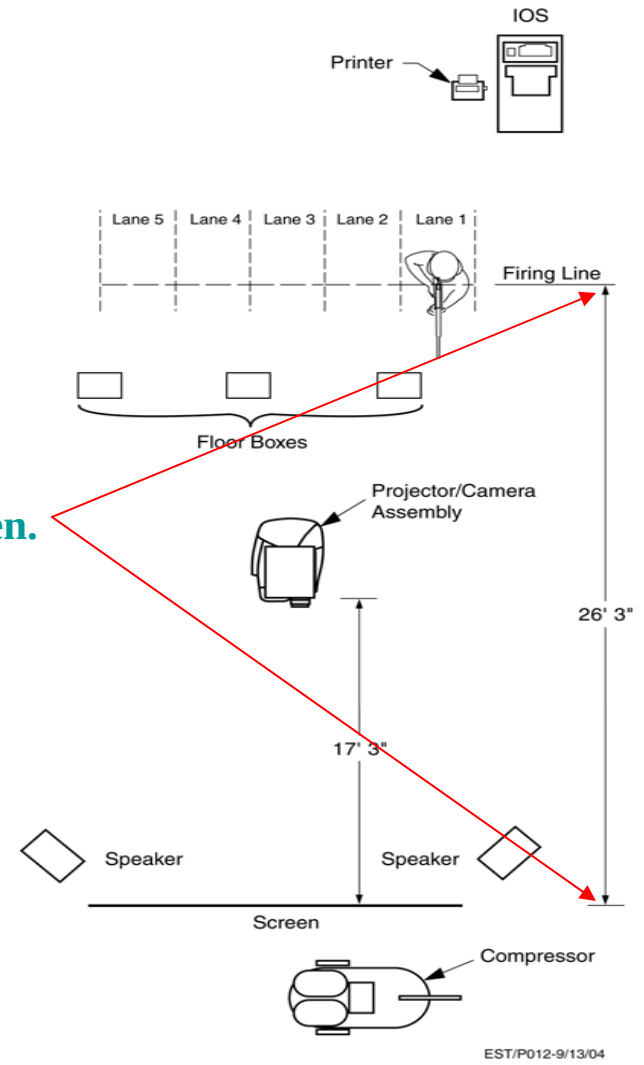
- Elevated firing line for need 10 lane needs steps built on like bldg 724
- Floor needs to be painted Flat Black in front & Gray in back (Concrete Paint)
- Need Racks made for ARMS Room & shelves for crew serve weapon
- Ceilings requirements

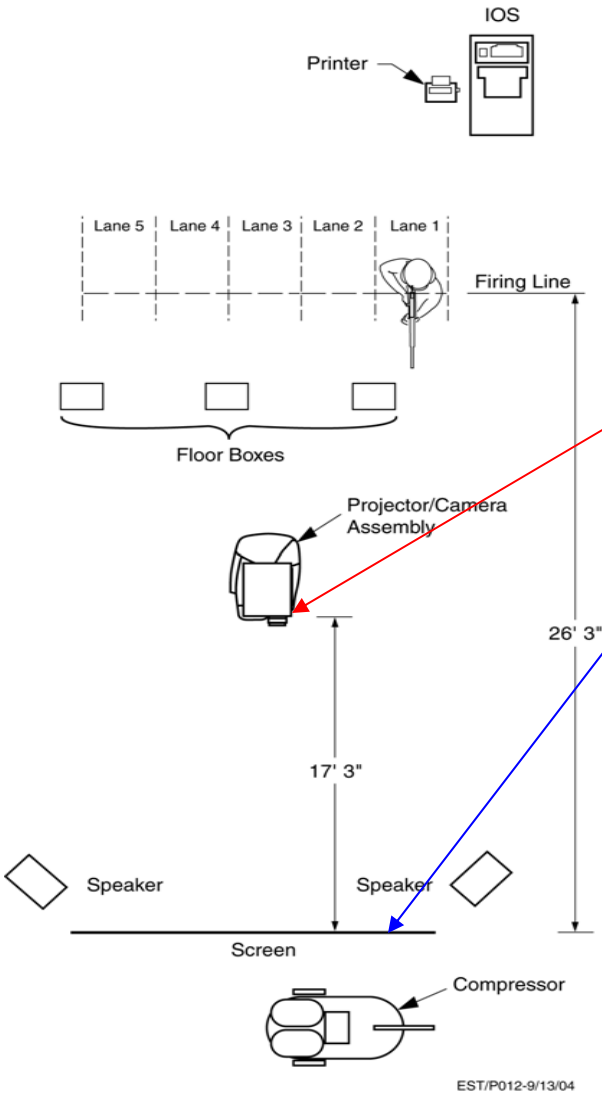
Suggestions

- Provide area for crew serve weapons storage (Shelves) on Range
- Need to have the ability to control Heating & Cooling in side Room
- Track lighting on firing line use same as in Bldg 724 but back line can be different
- Need to be able to mount Projectors & speakers on ceiling if possible

5-Lane System

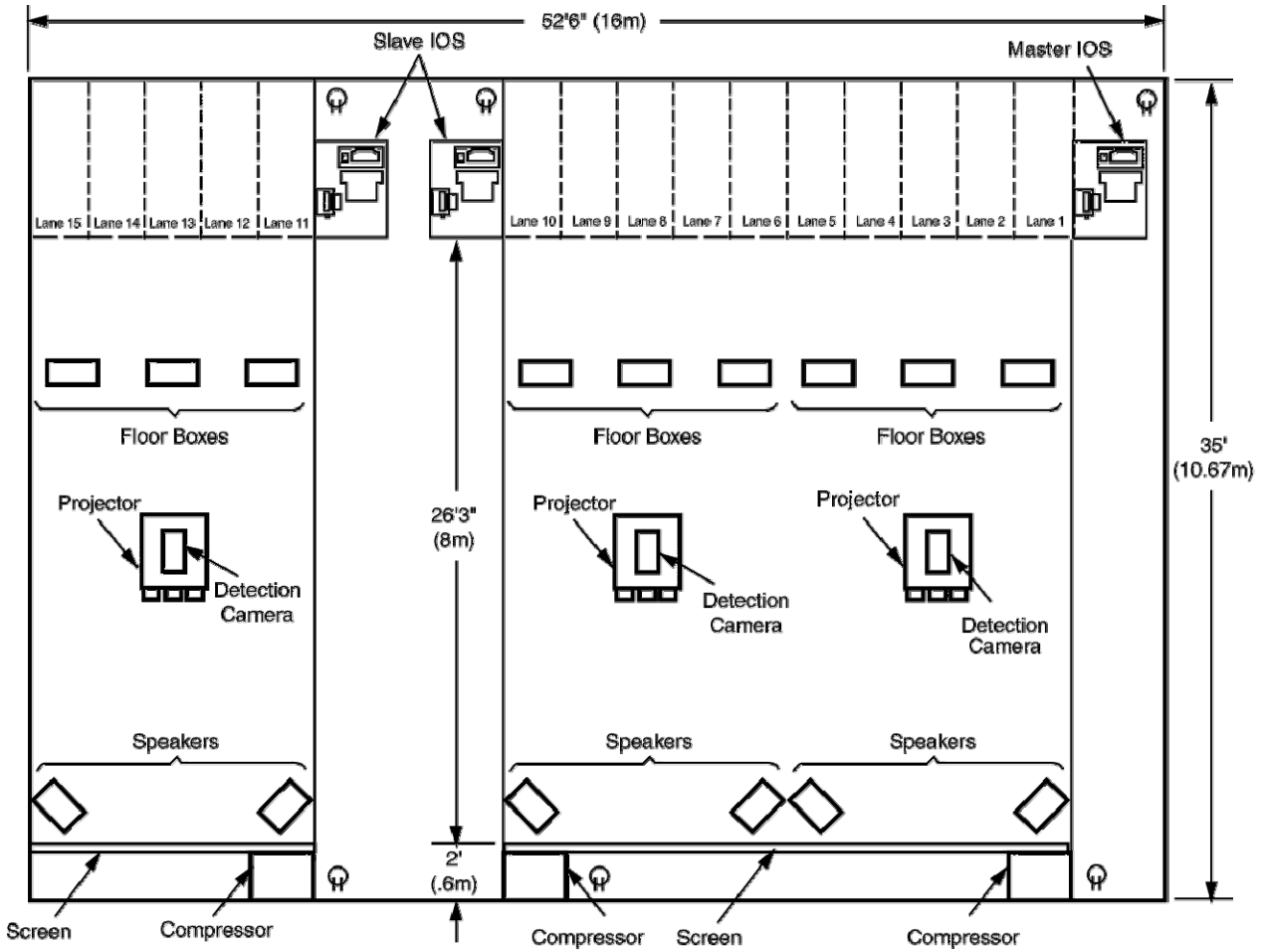
- **Firing Line needs to be 26’3’’ from Screen.**





***Projection Screen (Approximately 13’ x 8’)**
***The Projector must be 17’ 3’’ from Screen to calibrate System.**

Major Components



Requirements

Area Requirement (15 Lane system):

- **10 Lane plate form is 40’ long & 8’ wide, 18” high.**
- **5 Lane no plate form but needs at least 20 feet of space.**
- **Ceiling no lower than 9’ high**

Power Requirement:

- **1 dedicated 110VAC 15A circuit for each IOS (3)**
- **1 dedicated 110VAC 20A circuit for each Air Compressor (3)**

NOTE:

- Area Requirement is 80’ long & 60’ wide (optional)
- Track Lighting required to operate system on firing line & briefing area
- NO Windows in Room, or at least box them up so no light interferes

ENVIRONMENTAL REQUIREMENTS are:

- Acceptable operating temperature:

  59° to 95° F

- Acceptable storage temperature:

  5° to 95° F

- **A**cceptable humidity range:

  20% to 80%

- **Note for best performance we keep the Range at 62 to 65 degrees when operating**

Site Preparation

ROOM SIZE

- **5 Lane - 35.0’ length, 17.5’ width, 9.0’ height (Minimum)**
- **10 Lane - 35.0’ length, 35.0’ width, 9.0’ height (Minimum)**
- **15 Lane - 35.0’ length, 52.5’ width, 9.0’ height (Minimum)**

LIGHTING

Minimize direct light on screen
Windows blocked
Fluorescent lighting provides better performance
Dimmable Incandescent lighting only acceptable if shielded from screen (i.e. track lighting over firing line)

2 TELEPHONE LINES

1 for Operator
1 for Modem

Engagement Skills Trainer (EST) 2000 Facility Notes

June 2008

This document was prepared by the US Army Program Executive Office, Simulation, Training and Instrumentation (PEO STRI), ATTN: Product Manager, Ground Combat Tactical Trainers (PM GCTT), Materiel Developer of the EST 2000 System.

Engagement Skills Trainer (EST) 2000 Facility Notes

FACILITIES OVERVIEW
This document was prepared by the US Army Program Executive Office, Simulation, Training and Instrumentation (PEO STRI), ATTN: Product Manager, Ground Combat Tactical Trainers (PM GCTT), Materiel Developer of the EST 2000 System. This document is provided as a guide for designing/preparing an EST 2000 training area. Guidance and specific details are provided to ensure all aspects of the room are suitable and will not impact the operation of the EST 2000.

Prior to modifying a training area or building an EST 2000 classroom, installations are welcome to forward their facilities plans to PEO STRI, ATTN: PM GCTT for review. Call (407) 384-3899, Gary Stevenson, Acquisition Logistics, (gary.p.stevenson@us.army.mil) to arrange for facilities plan review.

ROOM LOCATION, SIZE AND CONFIGURATION
The EST 2000 training area should be situated in a location that provides easy access for potential users. The location should be noise isolated (system firing noise may be objectionable for nearby office spaces), with controlled lighting (see Lighting).

An interior (windowless) room is preferable so the environment may be developed to optimize all aspects of the EST 2000 system capabilities. Room size will vary depending on training usage, number of subsystems networked and space availability. A typical full featured fixed room for a three (3) subsystem configuration will require more floor space than a room optimized for a single subsystem.

The EST 2000 facility area is best configured as two separate rooms. The rooms include the EST 2000 training room with a small adjacent room (such as a closet) dedicated for storage of weapons and transportable cases. The recommended room configuration size provided includes room for access to equipment for daily readiness checks.

LIGHTING
Proper lighting is one of the most important elements for optimizing the room for the EST 2000 use. All light should be extinguished from beyond the firing line and all windows should be blocked to prevent the entry of light from washing out the projection screen and interfering with the hit detect system camera.

Incandescent directional lighting controlled by a dimmer switch, such as tract lights located above the firing line, can be used without system interference. The dimmer allows for the adjustment of ambient light levels such that the weapon front sight post is adequately illuminated without interfering with the clarity of distant targets on the screen. Additionally fluorescent lights with dimmers or zoned with multiple switch controls can be used.

Excessive ambient light levels make detection of distant targets on the projection screen difficult. No mercury vapor lighting fixtures can be used. Therefore the EST 2000 room may need wall and floor surfaces treated or covered to reduce reflection and reduce levels of ambient light on the projection screen. If available, camouflage-netting on the floor between the firing line and screen adds to realism and diffuses ambient lighting reflected by the floor.

SYSTEM ACOUSTIC & MECHANICAL VIBRATION NOISE PRODUCTION AND ISOLATION
The EST 2000 is capable of producing noise levels up to 107 dB when firing machine guns. Speaker volume is adjustable by the instructor but sound and vibration due to weapon mechanical movements is not. The room should be located in a space such that the sound and mechanical vibration of simulated weapon fire does not interfere with other activities in adjacent office spaces. If sound spillover into nearby areas is unacceptable, then sound-proofing techniques should be employed.

EST 2000 HVAC ISSUES
The EST 2000 is designated by the Operation Requirements Document (ORD) to be operated in a military classroom environment. The Heating, Ventilation and Air Conditioning (HVAC) system must be

adequate to handle the equipment and body heat load of the space. The EST 2000 is particularly susceptible to heat related failures if operated without a properly designed and operating HVAC system to regulate the operational classroom environment.

Supply air into the space should be directed in the back of the room closest to the firing line. Supply air should not be directed to the front of the room because air movement could cause screen movement (i.e. rippling effect), which could degrade system accuracy.

The system should provide adequate heat load compensation with a continuous exchange of fresh air being desirable. A 20 percent air exchange per hour is desirable. Supply chilled air must be capable of compensating for the body load of meeting participants and heat dissipation of the lighting and electronic equipment.

As a general guide, 640 BTU should be added to normal calculated heat load for the space per person per the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) guidelines (Example: 21 people times 640 equals an extra 13440 total supply BTUs of cooling). The total power draw to compensate for equipment should be calculated by totaling the power draw in watts and multiplying the result times 3.14 to yield the additional BTU loading compensation required.

Typical power load for a three (3) subsystem EST 2000 equipment is about 4500 watts or 14,130 BTUs. A typical three (3) subsystem EST 2000 would require approximately (27,570 BTUs) 2.3 Tons of cooling in addition to capacity based on facility room size, lighting load and construction. Operation of the EST 2000 outside of the identified temperature and humidity parameters can result in equipment failures that may not be covered by vendor warranty.

The EST 2000 is capable of operation in a facility with the following climatic conditions:

- Operating temperature of $+60^0$F to $+95^0$F
- Storage temperature of $+5^0$F to $+95^0$F
- Relative humidity (non-condensing) between 20% - 80% for both operation and storage

The EST 2000 Instructor/Operator System, being comprised of commercial computer and electronic equipment requires reasonable care. The HVAC system must be operational year round to properly regulate the classroom environment.

ELECTRICAL REQUIREMENTS

The electronic equipment used in the EST 2000 system is not sensitive to normal line voltage fluctuations and is minimally conditioned to protect the equipment and limit network interference. Adequate electrical outlets are required to accommodate equipment and support components.

Each subsystem requires at least two (2) outlets be provided in the training room on separate circuits. Each IOS is capable of operation on a 15 Amp circuit with the outlet located within 20 feet of the IOS location. Each compressor requires a separate, dedicated 20 Amp circuit with the outlet located within six feet of the compressor location. Unused outlets on a duplex receptacle where electronic equipment is attached should not be utilized for such items as vacuum cleaners, floor polishers, microwave ovens and coffee pots, because of facilities circuit breaker overload or damaging electrical transients.

For optimum operation IO subsystem power circuits should be connected only to a well balanced load center with a maximum neutral elevation referencing earth ground of .5 volts. This is important as the National Electric Code allows neutral elevation with in a range of three percent of the nominal circuit supply voltage. This is suitable for code compliance but can cause induced hum in the audio system.

TELECOMMUNICATIONS SERVICE

The EST 2000 training room should have a minimum of two (2) voice grade telephone lines. One line is required for connection to the PC modem attachment in order to take advantage of remote diagnostics. The other is for the Instructor Operator to use to communicate with the 24-hour help desk service provider during the course of setup, Line Replaceable Unit (LRU) swap-out or trouble shooting. Note: the modem

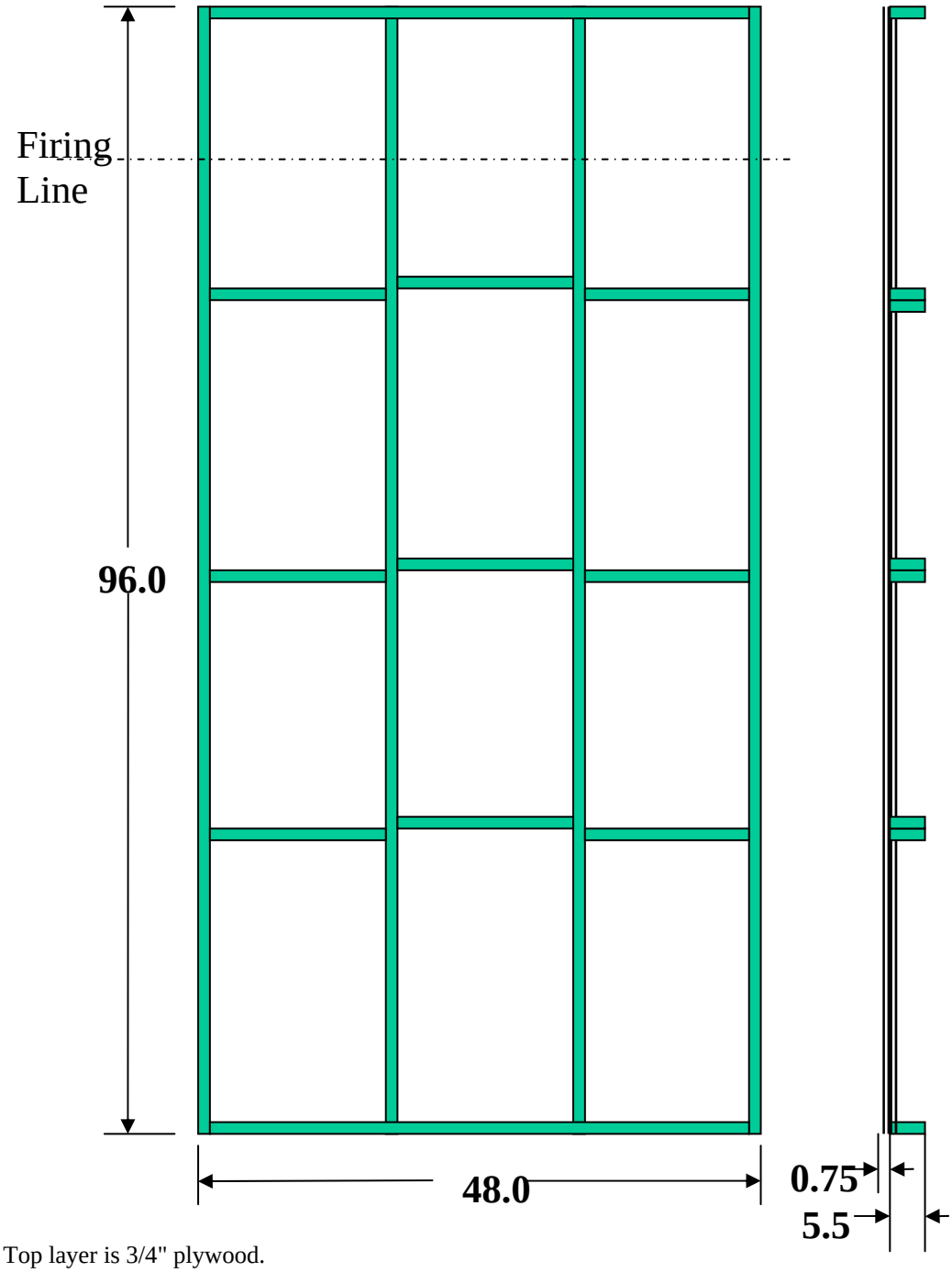
line should be connected to the left most networked subsystem for the diagnostics to remotely access all subsystems.

OTHER CONSIDERATIONS
The EST 2000 room, if carpeted with heavy carpet or thick padding may cause excessive projector movement during training. This can be corrected by isolating the projector on a suitably sized square of 3/4" plywood placed on top of the carpet. Minimum size of this plywood should be 2' X 3'.

Shooting platforms can be utilized if desired. The use of a shooting platform will more accurately reflect conditions at a shooting range. The attached sketch has been included to aid you in constructing your own platforms.

Warning: Operating the EST 2000 in a facility that does not conform to the environmental parameters may result in equipment failure that will void the system warranty. Repair costs associated with equipment failures, determined to be the result of such operator negligence, will be the responsibility of the receiving units.

This shooting platform is suggested, but not required and is not part of the delivered system. This sketch has been included to aid you in constructing your own platforms.



1. Top layer is 3/4" plywood.
2. Support bracing is 2X6 wood.
3. Screw and glue all together.
4. Three platforms required per each 5 lane EST 2000 subsystem.

TD-07-6910-702-10

TECHNICAL MANUAL

OPERATOR'S MANUAL

ENGAGEMENT SKILLS TRAINER 2000
DEVICE NO. DVC 07-129

Cubic Simulation Systems, Inc. (CSSI)
Contract No.: N61339-01-D-0720-0004

DISTRIBUTION STATEMENT: This data furnished in connection with the Engagement Skills Trainer (EST 2000) Contract No. N61339-01-D-0720-0004, shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than to operate and maintain the EST 2000. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained in this document.

Lot 6 **June 2006**

THIS PAGE INTENTIONALLY LEFT BLANK

TD-07-6910-702-10

TECHNICAL MANUAL

OPERATOR'S MANUAL

ENGAGEMENT SKILLS TRAINER 2000
DEVICE NO. DVC 07-129

Cubic Simulation Systems, Inc. (CSSI)
Contract No.: N61339-01-D-0720-0004

TD-07-6910-702-10

LIST OF EFFECTIVE PAGES

INSERT LATEST CHANGE PAGES. DESTROY SUPERSEDED PAGES

NOTE: The portion of the text that was affected by the change is identified by a vertical line in the margin of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas.

Dates of issue for original and changed pages are:
Change 1 . . . 0 . . . November 2006.

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 198 CONSISTING OF THE FOLLOWING:

Page No.	* Change No.	Page No.	*Change No.	Page No.	*Change No.
v	1				

*Zero in this column indicates an original page.

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Equipment Technical Publications) located in the back of this manual directly to PEOSTRI, ATTN: AMSTI-LDT, 12350 Research Parkway, Orlando, Florida 32826-3276. A reply will be furnished to you.

June 2006

OPERATOR'S MANUAL
FOR
ENGAGEMENT SKILLS TRAINER 2000
DEVICE NO. DVC 07-129

TABLE OF CONTENTS

Section/Title/Page

1. SYSTEM INTRODUCTION 1-1
1.1. PURPOSE 1-1
1.2. LEVEL OF TRAINING 1-1
1.3. HOW TO USE THIS MANUAL 1-1
1.4. ORGANIZATION 1-1
1.4.1. Chapters 1-1
1.4.2. Index 1-2
1.4.3. Appendices 1-3
1.4.4. Attachments 1-3

2. DESCRIPTION OF TRAINER 2-1
2.1. SECURITY CLASSIFICATION 2-1
2.2. PURPOSE AND CAPABILITIES 2-2
2.3. TECHNICAL CHARACTERISTICS 2-2
2.4. EQUIPMENT SUPPLIED 2-2
2.5. EQUIPMENT REQUIRED BUT NOT SUPPLIED 2-2
2.6. SYSTEM FACILITY REQUIREMENTS 2-2
2.7. SINGLE AND MULTIPLE SUBSYSTEM FACILITY REQUIREMENTS 2-3
2.8. ENVIRONMENTAL CONDITIONS 2-3
2.9. SUBSYSTEM FUNCTIONAL DESCRIPTION 2-4

3. OPERATING INSTRUCTIONS 3-1
3.1. PREPARATION FOR OPERATION 3-1
3.1.1. Power Requirements 3-1
3.1.2. Installation 3-1
3.1.2.1. Shipping/Receiving configuration (Typical) 3-1
3.1.2.2. Tools required for assembly 3-4
3.1.2.3. Marking key component locations 3-4
3.1.2.4. Component unpacking 3-5
3.1.2.5. Air Compressor setup 3-5
3.1.2.6. Projection Screen Assembly and positioning 3-6
3.1.2.7. Speaker positioning 3-7
3.1.2.8. Projector/IR Camera Assembly positioning 3-12
3.1.2.9. Floor box positioning 3-12
3.1.2.10. IOS positioning 3-13
3.1.2.11. Monitor placement and connection 3-13
3.1.2.12. Printer placement and connection 3-13
3.1.2.13. Cable bundle connections 3-16
3.1.2.13.1. Speaker connections 3-16
3.1.2.13.2. Floor box connections 3-17
3.1.2.13.3. Air supply line connections 3-17
3.1.2.13.4. Projector and IR Camera connections 3-18
3.1.2.14. Facility power source connection 3-18
3.1.2.15. Shooting Platform (Optional) 3-19
3.1.3. Multi-subsystem Configurations 3-29
3.1.3.1. Networking subsystems 3-29
3.1.3.1.1. EST 2000 Trainer Configuration 3-30

3.1.3.1.2. Configure New Subsystems 3-30
3.1.3.1.3. Reconfigure Subsystems 3-31
3.1.3.2. Joining multiple screens 3-31
3.2. OPERATOR CONTROLS AND INDICATORS 3-41
3.2.1. Instructor/Operator Station (IOS) 3-41
3.2.1.1. Display Controller Computer 3-41
3.2.1.2. Autotracker (ATTR) 3-42
3.2.1.3. Rack Distribution Unit (RDU) 3-42
3.2.1.4. AC Power Distribution Unit (ACPDU) 3-42
3.2.1.5. Monitor, keyboard, and mouse 3-42
3.2.1.6. 24V Power Supply 3-42
3.2.1.7. Modem 3-42
3.2.2. Printer 3-42
3.2.3. Projector/IR Camera Assembly 3-42
3.2.3.1. Projector 3-43
3.2.3.2. Projection Screen 3-43
3.2.3.3. IR detection camera 3-43
3.2.4. Audio System 3-43
3.2.5. Air Compressor 3-43
3.2.6. Floor Boxes 3-43
3.2.7. Simulated Weapons 3-44
3.2.8. Optical and Night Vision Devices 3-44
3.2.8.1. M68 Close Combat Optics (CCO) 3-44
3.2.8.2. M145 Telescope, Machine Gun Optics (MGO) 3-44
3.2.8.3. AN/PVS-4 Night Vision Sight 3-44
3.2.8.4. AN/TVS-5 Night Vision Sight 3-44
3.2.8.5. Night Vision Devices 3-44
3.3. OPERATOR INSTRUCTIONS 3-59
3.3.1. Weapon Safety 3-59
3.3.2. Laser safety 3-59
3.4. TRAINING SYSTEM OPERATION 3-60
3.4.1. Preparation for Training 3-60
3.4.2. Training Operation Procedures 3-61
3.4.2.1. Start-up Procedures 3-61
3.5. PRACTICE TYPES 3-65
3.5.1. Marksmanship Mode 3-65
3.5.1.1. EST Tool Bar 3-65
3.5.1.1.1. IOS drop down menu 3-66
3.5.1.1.1.1. Preferences 3-66
3.5.1.1.1.2. Return to Main Menu 3-66
3.5.1.1.2. Hardware drop down menu 3-66
3.5.1.1.2.1. Calibrate Autotracker 3-66
3.5.1.1.2.2. Check Weapon Laser Alignment 3-66
3.5.1.1.2.3. Toggle Screens 3-66
3.5.1.1.2.4. Microphone On 3-67
3.5.1.2. Training Control Menus 3-67
3.5.1.2.1. Assign Firers 3-67
3.5.1.2.2. Select Roster 3-68
3.5.1.2.3. Load Practice 3-68
3.5.1.2.4. Setup 3-68
3.5.1.2.5. Run Practice 3-68
3.5.1.2.6. Practice replay 3-69
3.5.1.2.7. Performance table window 3-69
3.5.1.2.8. Saving a completed practice 3-70
3.5.1.2.9. Results Table and Scorecards 3-70

3.5.1.2.10. Printing - Marksmanship mode 3-70
3.5.1.3. Switching between Training Modes 3-70
3.5.2. Collective mode 3-113
3.5.2.1. Tandem Weapon Capabilities 3-113
3.5.2.2. EST Tool Bar 3-113
3.5.2.2.1. IOS drop down menu 3-114
3.5.2.2.1.1. Preferences 3-114
3.5.2.2.1.2. Return to Main Menu 3-114
3.5.2.2.2. Hardware drop down menu 3-114
3.5.2.2.2.1. Calibrate Autotracker 3-114
3.5.2.2.2.2. Check Weapon Laser Alignment 3-114
3.5.2.2.3. Toggle Screens 3-114
3.5.2.2.3.1. Microphone On 3-114
3.5.2.3. Training Control Menus 3-115
3.5.2.3.1. Assign Firers 3-115
3.5.2.3.2. Select Roster 3-116
3.5.2.3.3. Load Practice 3-116
3.5.2.3.4. Setup 3-116
3.5.2.3.5. Run Practice 3-116
3.5.2.3.6. Practice replay 3-117
3.5.2.3.7. Performance table window 3-117
3.5.2.3.8. Saving a completed practice 3-117
3.5.2.3.9. Results Table 3-118
3.5.2.3.10. Printing - Collective mode 3-118
3.5.2.4. Switching between Training Modes 3-118
3.5.3. Shoot/Don't Shoot mode 3-131
3.5.3.1. EST Tool Bar 3-131
3.5.3.1.1. IOS drop down menu 3-131
3.5.3.1.1.1. Return to Main Menu 3-131
3.5.3.1.2. Hardware drop down menu 3-131
3.5.3.1.2.1. Calibrate Autotracker 3-131
3.5.3.1.2.2. Toggle Screens 3-132
3.5.3.1.2.3. Microphone On 3-132
3.5.3.2. Training Control Menus 3-132
3.5.3.2.1. Assign Firers 3-132
3.5.3.2.2. Select Roster 3-133
3.5.3.2.3. Load Practice 3-133
3.5.3.2.4. Setup 3-133
3.5.3.2.5. Run Practice 3-133
3.5.3.2.6. Practice replay 3-134
3.5.3.2.7. Saving a completed practice 3-134
3.5.3.2.8. Results Table 3-134
3.5.3.3. Switching between Training Modes 3-134
3.6. ROSTER AND TRAINING HISTORY 3-141
3.6.1. Roster and Training History Tool Bar 3-141
3.6.1.1. File drop down menu 3-141
3.6.1.1.1. Open 3-141
3.6.1.1.2. Save as 3-141
3.6.1.1.3. Empty Main EST Datebase 3-141
3.6.1.1.4. Exit 3-141
3.6.1.2. Tools drop down menu 3-141
3.6.1.2.1. Compact Database 3-141
3.6.1.2.2. Repair Database 3-141
3.6.2. Manage Rosters 3-141
3.6.2.1. Store Roster 3-142

3.6.2.2. Import/Retrieve Roster 3-142
3.6.2.3. Add, Edit, Delete, Print, Generate Roster 3-142
3.6.2.4. Export Shooter data 3-142
3.6.2.5. Import Shooter data 3-143
3.6.2.6. Add, Edit, Delete, and Firer Details 3-143
3.6.3. View Saved Practices 3-143
3.6.4. Standalone Roster Tool 3-143
3.7. EST MAINTENANCE MENU 3-156
3.7.1. Trainer Maintenance 3-156
3.7.2. Change Password 3-156
3.7.3. Change Date/Time 3-156
3.7.4. Enable Remote Connection 3-156
3.7.5. Disable Remote Connection 3-157
3.7.6. Import/Export Data 3-157
3.7.7. Software Update Utility 3-157
3.8. INTEGRATED COURSEWARE (ICW) 3-157
3.9. Help 3-165
3.10. EXIT 3-165
3.11. MONITORING PROCEDURES 3-165
3.11.1. Recovery Procedures 3-165
3.12. EMERGENCY OPERATIONS 3-165
3.13. SYSTEM SHUTDOWN 3-165

4. MAINTENANCE INSTRUCTIONS 4-1
4.1. PREVENTIVE MAINTENANCE 4-1
4.1.1. PMCS Procedures and Table 4-1
4.2. LIST OF CONSUMABLE MATERIALS AND SUPPLIES 4-1
4.3. Remote Access Procedures 4-1
4.4. CORRECTIVE MAINTENANCE 4-3
4.4.1. Troubleshooting Procedures 4-3
4.4.2. Remove and Replace Procedures 4-23
4.4.2.1. Remove and replace Air Compressor assembly 4-23
4.4.2.1.1. Remove Air Compressor assembly 4-23
4.4.2.1.2. Replace Air Compressor assembly 4-23
4.4.2.2. Remove and replace floor box 4-23
4.4.2.2.1. Remove floor box 4-23
4.4.2.2.2. Replace floor box 4-23
4.4.2.3. Remove and replace IR camera assembly 4-24
4.4.2.3.1. Remove IR camera assembly 4-24
4.4.2.3.2. Replace IR camera assembly 4-24
4.4.2.4. Remove and replace projector assembly 4-24
4.4.2.4.1. Remove projector assembly 4-24
4.4.2.4.2. Replace projector assembly 4-25
4.4.2.5. Remove and replace IOS monitor 4-25
4.4.2.5.1. Remove IOS monitor assembly 4-25
4.4.2.5.2. Replace IOS monitor assembly 4-25
4.4.2.6. Remove and replace printer assembly 4-25
4.4.2.6.1. Remove printer assembly 4-25
4.4.2.6.2. Replace printer assembly 4-25
4.4.2.7. Remove and replace screen assembly 4-26
4.4.2.7.1. Remove screen assembly 4-26
4.4.2.7.2. Replace screen assembly 4-26
4.4.2.8. Remove and replace speaker 4-26
4.4.2.8.1. Remove speaker 4-26
4.4.2.8.2. Replace speaker 4-26

APPENDICES / ATTACHMENTS

APPENDIX A. REFERENCE AND TEXT MATERIAL A-1

APPENDIX B. SAMPLE PRACTICE: BATTLESIGHT ZERO COURSE OF FIRE B-1

APPENDIX C. OPERATING PROCEDURE OVERVIEW. C-1

APPENDIX D. SCENARIO EDITOR D-1

APPENDIX E. EST 2000 DIAGNOSTICS E-1

APPENDIX F. PRINTER MAINTENANCE DATA F-1

APPENDIX G. AIR COMPRESSOR MAINTENANCE DATA G-1

APPENDIX H. OCONUS PECULIAR SETUP H-1

APPENDIX I. SHOOT/DON'T SHOOT FLOWCHARTS I-1

APPENDIX J. MONITOR MAINTENANCE DATA J-1

ATTACHMENT 1. FATS Simulated Weapon Operator's Manual – M16A2 ..... Att 1-1

ATTACHMENT 2. FATS Simulated Weapon Operator's Manual – M4 ..... Att 2-1

ATTACHMENT 3. FATS Simulated Weapon Operator's Manual – M9 ..... Att 3-1

ATTACHMENT 4. FATS Simulated Weapon Operator's Manual – M249 ..... Att 4-1

ATTACHMENT 5. FATS Simulated Weapon Operator's Manual – M60 ..... Att 5-1

ATTACHMENT 6. FATS Simulated Weapon Operator's Manual – M240B ..... Att 6-1

ATTACHMENT 7. FATS Simulated Weapon Operator's Manual – M2 ..... Att 7-1

ATTACHMENT 8. FATS Simulated Weapon Operator's Manual – MK19 ..... Att 8-1

ATTACHMENT 9. FATS Simulated Weapon Operator's Manual – M203/M16A2 ..... Att 9-1

ATTACHMENT 10. FATS Simulated Weapon Operator's Manual – M136 ..... Att 10-1

ATTACHMENT 11. FATS Simulated Weapon Operator's Manual – M1200 ..... Att 11-1

ATTACHMENT 12. CUBIC Simulated Weapon Operator's Manual – M16/M4/M203 ..... Att 12-1

ATTACHMENT 13. CUBIC Simulated Weapon Operator's Manual – M1200 ..... Att 13-1

ATTACHMENT 14. CUBIC Simulated Weapon Operator's Manual – AT4 ..... Att 14-1

ATTACHMENT 15. CUBIC Simulated Weapon Operator's Manual – M9 ..... Att 15-1

ATTACHMENT 16. CUBIC Simulated Weapon Operator's Manual – MK19 ..... Att 16-1

ATTACHMENT 17. CUBIC Simulated Weapon Operator's Manual – M240 ..... Att 17-1

TD-07-6910-702-10

LIST OF ILLUSTRATIONS

Number/Title/Page

Figure 3-1. EST 2000 Composite View – 5-Lane 3-2
Figure 3-2. System Layout Diagram – 5-Lane 3-3
Figure 3-3. Air Compressor Setup (Sheet 1 of 2) 3-8
Figure 3-3. Air Compressor Setup (Sheet 2 of 2) 3-9
Figure 3-4. Projection Screen Assembly (Sheet 1 of 2) 3-10
Figure 3-4. Projection Screen Assembly (Sheet 2 of 2) 3-11
Figure 3-5. Monitor Connections 3-14
Figure 3-6. Printer Connections 3-15
Figure 3-7. Cable Bundle Overview 3-20
Figure 3-8. Speaker Connections 3-21
Figure 3-9. Projector/Camera Assembly Connections 3-22
Figure 3-10. Floor Box Connections 3-23
Figure 3-11. IOS RDU and ACPDU 3-24
Figure 3-12. ACPDU Connections 3-25
Figure 3-13. RDU Connections 3-26
Figure 3-14. Air Line Routing 3-27
Figure 3-15. Shooting Platform 3-28
Figure 3-16. System Layout Diagram – 10-lane 3-32
Figure 3-17. System Layout Diagram – 15-lane 3-33
Figure 3-18. Joining Multiple Screens 3-34
Figure 3-19. 10-lane Network Cable Connections 3-35
Figure 3-20. 15-lane Network Cable Connections 3-36
Figure 3-21. IP Address Conflict 3-37
Figure 3-22. Subsystem Configuration 3-38
Figure 3-23. Configured Dialog Box 3-39
Figure 3-24. Configure Message 3-40
Figure 3-25. Instructor/Operator Station (IOS) 3-45
Figure 3-26. Display Controller Computer 3-46
Figure 3-27. Autotracker (ATTR) 3-47
Figure 3-28. AC Power Distribution Unit 3-48
Figure 3-29. Monitor, Keyboard, Mouse (Sheet 1 of 2) 3-49
Figure 3-29. Monitor, Keyboard, Mouse (Sheet 2 of 2) 3-50
Figure 3-30. Printer 3-51
Figure 3-31. Projection System (Sheet 1 of 2) 3-52
Figure 3-31. Projection System (Sheet 2 of 2) 3-53
Figure 3-32. Speaker 3-54
Figure 3-33. Air Compressor 3-55
Figure 3-34. Floor Box 3-56
Figure 3-35. IR Filter Assembly 3-57
Figure 3-36. System Navigation Block Diagram 3-62
Figure 3-37. Login Screen (Menu Selected) 3-63
Figure 3-38. Login Screen (Training Selected) 3-64
Figure 3-39. Select Practice Screen (Marksmanship Selected) 3-76
Figure 3-40. Subsystem Allocation Screen 3-77
Figure 3-41. EST Projector – Initializing Screen 3-78
Figure 3-42. Assign Firers Screen (typical) 3-79
Figure 3-43. EST Main Toolbar 3-80
Figure 3-44. IOS Preferences Screen 3-81
Figure 3-45. Sight Aim Point 3-82
Figure 3-46. Add Firer 3-83
Figure 3-47. Firer Data 3-84

Figure 3-48. Generate Roster Screen....3-85
Figure 3-49. Delete Firer from Entire System....3-86
Figure 3-50. Load Practice Screen (Marksmanship Mode)....3-87
Figure 3-51. Setup Screen....3-88
Figure 3-52. Current Conditions Screen....3-89
Figure 3-53. Weapon Settings Screen....3-90
Figure 3-54. Lock and Load Screen....3-91
Figure 3-55. NOT READY Screen....3-92
Figure 3-56. READY Screen....3-93
Figure 3-57. Run Practice Screen (Multi-lane Status)....3-94
Figure 3-58. Run Practice Screen (Multi-lane Targets)....3-95
Figure 3-59. Run Practice Screen (Single Lane Details)....3-96
Figure 3-60. Table or Task Complete Screen....3-97
Figure 3-61. Range Target – Projection Screen Display....3-98
Figure 3-62. Range Target – IOS Display - Single Lane Details....3-99
Figure 3-63. Single Lane Details - Shot Chart....3-100
Figure 3-64. Grouping Circle – IOS Single Lane Display....3-101
Figure 3-65. Single Lane Details - Grouping Chart....3-102
Figure 3-66. Single Lane Details - Performance Chart....3-103
Figure 3-67. Single Lane Details - Sensors Chart....3-104
Figure 3-68. Single Lane Details - Profile Chart....3-105
Figure 3-69. Single Lane Details - Weapon Chart....3-106
Figure 3-70. Sample Results Table....3-107
Figure 3-71. Sample Scorecard....3-108
Figure 3-72. Course/Practice Description....3-109
Figure 3-73. Return to Main Menu Screen....3-110
Figure 3-74. Exit Screen....3-111
Figure 3-75. Select Practice Screen (Collective Selected)....3-127
Figure 3-76. Load Practice Screen (Collective Mode)....3-128
Figure 3-77. Practice Replay (Pulldown Menu)....3-129
Figure 3-78. Practice Replay Screen (Collective Mode)....3-130
Figure 3-79. Select Practice Screen (Shoot/Don't Shoot Selected)....3-138
Figure 3-80. Shoot/Don't Shoot Scoring (Projector) Screen....3-139
Figure 3-81. EST Main Menu....3-144
Figure 3-82. Selecting Roster and Training History....3-145
Figure 3-83. Roster Management Screen....3-146
Figure 3-84. Roster and Training History Tool Bar....3-147
Figure 3-85. Store Roster Type Screen....3-148
Figure 3-86. Store Roster....3-149
Figure 3-87. Retrieve Roster....3-150
Figure 3-88. Roster Management Pop-up Screens....3-151
Figure 3-89. Export Firer....3-152
Figure 3-90. Import Firer....3-154
Figure 3-91. View Saved Practices Screen....3-155
Figure 3-92. EST Maintenance Menu....3-159
Figure 3-93. Operational Readiness Test....3-160
Figure 3-94. Password Maintenance Screen....3-161
Figure 3-95. Date/Time Maintenance Screen....3-162
Figure 3-96. Shutdown Screen....3-166
Figure 3-97. Shutdown Cool Down Screen....3-167
Figure 4-1. Product Configuration Id Screen....4-3

TD-07-6910-702-10

LIST OF TABLES

Number/Title/Page

Table 2-1. Equipment Specifications 2-4
Table 3-1. Marksmanship Core Scenarios....3-71
Table 3-2. Collective Core Scenarios 3-119
Table 3-3. Shoot/Don't Shoot Core Scenarios....3-135
Table 3-4. Summary of Exported Shooter Data....3-153
Table 4-1. Preventive Maintenance Checks and Services. 4-4
Table 4-2. Troubleshooting Failure Table. 4-9
Table 4-3. Troubleshooting AC Power Problems 4-10
Table 4-4. Troubleshooting the Pneumatics System 4-13
Table 4-5. Troubleshooting the Audio System....4-14
Table 4-6. Troubleshooting the Video System....4-15
Table 4-7. Troubleshooting the Targeting System....4-16
Table 4-8. Troubleshooting an Autotracker Calibration Failure 4-17
Table 4-9. Troubleshooting a Simulated Weapon Failure 4-19

SAFETY SUMMARY

The following warnings and cautions must be read and understood by operating and maintenance personnel prior to operation or maintenance of the trainer. If these warnings and cautions are not followed serious injury or death to personnel and/or damage to equipment may result.

WARNING

HIGH VOLTAGE is used in the operation of this equipment. DEATH ON CONTACT may result if personnel fail to observe safety precautions. Learn the areas containing high voltage in each piece of equipment. Be careful not to contact high-voltage connections when installing or operating this equipment.

WARNING

The weight of the Air Compressor exceeds single person lifting limits. To avoid potential injury to personnel and/or damage to equipment, there must be two persons to lift the Air Compressor from its shipping case.

WARNING

The weight of the speaker in the shipping case exceeds single person lifting limits. To avoid potential injury to personnel and/or damage to equipment, there must be two persons to lift the speaker while in the shipping case.

WARNING

The weight of the projector/IR camera assembly in the shipping case exceeds single person lifting limits. To avoid potential injury to personnel and/or damage to equipment, there must be two persons to lift the projector/IR camera assembly in the shipping case.

WARNING

Trainer is powered by HIGH VOLTAGE. Failure to disconnect power prior to maintenance procedures may result in serious injury or death to personnel and/or damage to equipment .

SAFETY SUMMARY - continued

WARNING

Do not spill liquids on the trainer. Liquids can short out parts, causing fire or electric shock and result in serious injury or death. If liquid is spilled, disconnect trainer power cable from wall receptacle, clean spills and notify maintenance personnel prior to powering up the trainer.

WARNING

Laser light is used in the operation of this equipment. Injury may result if personnel fail to observe safety precautions. Never stare into the laser beam, look down the barrel of the simulated weapon, or directly view the laser beam with optical instruments. Avoid direct eye exposure. No one should be allowed beyond the firing line. The Instructor/Operator and NCOIC should ensure that all persons entering the training room are aware that laser radiation is present.

WARNING

Do not use wax/grease remover or lens cleaner near spark or open flame. Use only in well-ventilated area. Avoid contact with eyes or skin. Wash affected area with warm water if contact occurs.

WARNING

Disconnect power cable from wall receptacle before checking cables. Electricity from damaged cable can cause serious injury or death to personnel.

WARNING

Avoid cleaning or performing maintenance on a simulated weapon that is connected to the electrical or pneumatic umbilical cables. Severe injury may result.

WARNING

Never use oil that contains any type of solvent as it may damage the electronic components.

SAFETY SUMMARY - continued

WARNING

Damage to personnel or equipment may occur if the data cable is removed or inserted with power applied.

CAUTION

Refer to Appendix H for 220 VAC, 50 Hz OCONUS setup. Failure to comply with preparation instructions will severely damage the equipment.

CAUTION

Do not use an extension cord to operate the Air Compressor. Heat damage may occur.

CAUTION

Ensure hands are clean and dry prior to handling projection screen material.

CAUTION

Lift the projector/IR camera assembly by grasping the body of the projector. Do not lift the assembly by grasping the lens or packing material.

CAUTION

Do not wrap umbilical around the simulated weapon. Damage may occur.

CAUTION

Do not use substitutes for the recommended cleaning agents to clean exterior surfaces. Some agents will dissolve the plastic surfaces.

CAUTION

Do not use spray cleaner directly on system components. Liquids may run into internal components, causing damage.

SAFETY SUMMARY - continued

CAUTION

Some detergents contain significant amounts of alcohol-based solvent, which can damage (color change) or crack the monitor case. The antiglare/anti-static surface coating on the CDT may also be affected.

CAUTION

Do not touch the projector lens, oils in fingerprints can damage the lens.

CAUTION

Do not use water, detergent, lens tissue, or commercial lens cleaner on the projector's lens. Use of such material will damage the lens.

CAUTION

When shipping the Projector Assembly for repair, the Projector Assembly Lens must be removed from the Projector Assembly prior to packing. Pack the Projector Assembly Lens in its own box before placing it in the Projector Assembly Shipping Case. Failure to remove the Projector Assembly Lens from the Projector Assembly prior to shipping will result in damage to the Projector Assembly Lens and/or Projector Assembly.

CHAPTER 1. INTRODUCTION

1. SYSTEM INTRODUCTION

The Engagement Skills Trainer 2000 (EST 2000) is being fielded to U.S. Army force units, both active and reserve, to institutional schools, and to U.S. Army National Guard units. The EST 2000 provides the means to conduct weapons training indoors in a controlled environment, without expending live ammunition, and without subjecting tactical weapons to wear and tear. It may be used to provide weapons handling, safety, and familiarization training, or to provide instant evaluation and feedback from individual training for initial entry soldiers. The system may also be used to provide sustainment training in preparation for weapons qualification. It IS NOT intended to replace live-fire requirements or qualification.

1.1. PURPOSE

This technical manual is for use when operating and maintaining the Engagement Skills Trainer (EST) 2000, device no. DVC 07-129. This manual fully describes the EST 2000 capabilities including computer controlled fire mission exercises that simulate various entry-level marksmanship qualification training, collective gunnery and tactical training exercises, and Shoot/Don't Shoot engagement scenarios. This manual also includes procedures for operating, cleaning, testing, inspecting, and adjusting the trainer at the organizational level (Instructor/Operator level maintenance).

1.2. LEVEL OF TRAINING

This manual is intended for authorized military training device Instructor/Operators following successful completion of the New Equipment Training (NET).

1.3. HOW TO USE THIS MANUAL

The safest, easiest, and best way to learn to operate the trainer is to use this manual. Learning to use this technical manual is as easy as reading through the next few pages. Knowing the contents of this manual and how to apply them will save time and prevent on-the-job hazards.

1.4. ORGANIZATION

This manual provides all information necessary for the Instructor/Operator to operate, maintain, and troubleshoot the trainer. Information is provided for power-up, operational readiness test, operation, and equipment shutdown. This manual also contains Instructor/Operator level maintenance activities including troubleshooting and preventive/corrective maintenance instructions. This manual is divided into four chapters, an index, nine appendices, and sixteen attachments.

1.4.1. Chapters

a. Chapter 1, Introduction

   General information, including the purpose and organization of the manual, equipment model, and training level.

b. Chapter 2, Equipment Description

   Description of Trainer

   Security Classification

   Purpose and Capabilities

   Technical Characteristics

   Equipment Supplied

Equipment Required But Not Supplied

System Facility Requirements

Single and Multiple Subsystem Facility Requirements

Environmental Conditions

Subsystem Functional Description

c. Chapter 3, Operating Instructions

Operating Instructions

Preparation for Operation

Operator Controls and Indicators

Operator Instructions

EST 2000 Trainer Configuration

Training System Operation

Practice Types

Roster and Training History

Maintenance

Integrated Courseware

Help

Exit

Monitoring Procedures

Emergency Operations

System Shutdown

d. Chapter 4, Maintenance Instructions

Preventive and Corrective Maintenance Procedures

1.4.2. Index

Refer to the alphabetical index at the back of manual for key nouns. The alphabetical index lists each noun under one or more headings.

1.4.3. Appendices

a. Appendix A, Reference and Text Materials
This appendix lists all publications referenced in the manual and required by the Instructor/Operator to operate and maintain the equipment.

b. Appendix B, Sample Battlesight Zero Course of Fire
This appendix provides a step by step example of how to initiate and perform a typical EST 2000 Marksmanship training practice.

c. Appendix C, Operating Procedure Overview
This appendix provides a brief overview of the EST 2000 operating procedures.

d. Appendix D, Scenario Editor
This appendix provides the Marksmanship and Collective Scenario Editor of the EST 2000 operating procedures.

e. Appendix E, EST 2000 Diagnostics
This appendix provides a description of the EST 2000 diagnostic procedures.

f. Appendix F, Printer Maintenance Data
This appendix provides maintenance data for the EST 2000 printer.

g. Appendix G, Air Compressor Maintenance Data
This appendix provides troubleshooting procedures for the EST 2000 Air Compressor.

h. Appendix H, OCONUS Peculiar Setup
This appendix provides OCONUS peculiar setup procedures.

i. Appendix I. Shoot/Don't Shoot Flowcharts
This appendix provides Shoot/Don't Shoot flowcharts.

j. Appendix J. Monitor Maintenance Data
This appendix provides the Monitor Maintenance Data.

1.4.4. Attachments

Attachments 1 through 11 provide the operator's manuals for the FATS simulated weapons. Attachements 12 through 16 provide the operator's manuals for the CUBIC simulated weapons.

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 2. SYSTEM DESCRIPTION

2. DESCRIPTION OF TRAINER

The EST 2000 consists of an Instructor/Operator Station (IOS), modified weaponry, floor boxes, high-resolution COHU infra-red (IR) camera and Barco projector, projection screen, speakers, air compressor, and associated cabling and air lines. Weapon modifications include an eye-safe laser, sensors to measure trigger pressure, weapon cant angle and ammunition magazine/belt status (as well as status of safety and firing mode selection switches), and a compressed air operating system. Depending upon the site location/mission, one or more of the following modified weapon models are included with this system: M16A2 rifle, M16A4 rifle, M16A4/M203, M4 carbine, M4/M203, M9 pistol, M249 AR, M60 machine-gun, M240B machine-gun, M2 machine-gun, MK19, M136 (AT4), and the M1200 shotgun.

The following components make up a 5-lane EST 2000 subsystem (typical shipping/receiving configuration):

- AIR COMPRESSOR SHIPPING CASE
  - ✓ Air Compressor
- SPEAKER SHIPPING CASES (2)
  - ✓ Speakers
- IOS SHIPPING CASE
  - ✓ Display Controller Computer Assembly
  - ✓ Autotracker Assembly (ATTR)
  - ✓ Keyboard and Mouse
  - ✓ AC Power Distribution Unit (ACPDU)
  - ✓ Rack Distribution Unit (RDU)
- IOS MONITOR SHIPPING CASE
  - ✓ IOS Monitor
- PROJECTOR/IR CAMERA ASSEMBLY SHIPPING CASE
  - ✓ Projector/IR Camera Assembly
- PROJECTION SCREEN SHIPPING CASES (2)
  - ✓ Projection Screen Assembly
- FLOOR BOX SHIPPING CASE
  - ✓ Floor Box Assemblies (3)
- PRINTER SHIPPING CASE
  - ✓ Printer
- SYSTEM CABLING SHIPPING CASE
  - ✓ System Cables and Air Lines
  - ✓ Interactive Courseware (ICW) (provided on CD ROM)
  - ✓ Assembly/Disassembly Video (provided on CD ROM)
- SIMULATED WEAPONS SHIPPING CASE
  - ✓ Simulated Weapons

2.1. SECURITY CLASSIFICATION

The security classification for the EST 2000 hardware, software, and associated documentation is UNCLASSIFIED.

2.2. PURPOSE AND CAPABILITIES

The EST 2000 is designed for use as a unit and institutional trainer. The indoor, multipurpose, multilane EST 2000 design provides for individual small arms, crew served, and individual anti-tank training. The system is comprised of multiple independent subsystems that can be networked and configured in any of the three operational modes (practice types) including Marksmanship, Unit Collective Squad Level and Shoot/Don't Shoot as described in Paragraph 3.5. When using multiple subsystem configurations for training, the graphics system produces a seamless image on the wider viewing area with targets moving freely and without distortion as they cross from one projection screen to another.

2.3. TECHNICAL CHARACTERISTICS

Refer to Table 2-1 for EST 2000 equipment specifications.

2.4. EQUIPMENT SUPPLIED

The following equipment is supplied with the EST 2000:

- One, two, or three 5-lane EST 2000 subsystems,
- Operator's Manual (provided as embedded documentation on the EST 2000 System),
- Instructor's Guide (provided as embedded documentation on the EST 2000 System),
- Assembly/Disassembly video (provided on CD ROM),
- Interactive Courseware (ICW) (provided on CD ROM).

2.5. EQUIPMENT REQUIRED BUT NOT SUPPLIED

The following equipment is required but not supplied with the EST 2000:

- Common hand tools
  - ✓ Tape Measure
  - ✓ 9/16" Wrench or Socket
  - ✓ #2 Phillips Screwdriver
  - ✓ Band Cutter
  - ✓ 7/8" Open-end or Socket Wrench

- Small Table (System Printer)

  Note: Only one table is required even if more than one subsystem is installed.

2.6. SYSTEM FACILITY REQUIREMENTS

- Room Size

	Length	Width	Height
5-Lane	35.0'	17.5'	8.0'
10-Lane	35.0'	35.0'	8.0'
15-Lane	35.0'	52.5'	8.0'

- Lighting
  - ✓ Eliminate direct light on projection screen.
  - ✓ Windows blocked.
  - ✓ Minimum lighting over firing line only.

- Two telephone lines (recommended)
  - ✓ One for Instructor/Operator voice communications with EST Help Desk.
  - ✓ One for Modem connection to allow for remote diagnostics conducted by Help Desk personnel.

Note: Only two lines are required even if more than one subsystem is installed. The line connected to the Modem must be capable of receiving incoming calls. In multiple subsystem installations, 10-lane and 15-lane, the telephone line must be connected to the Modem in the left IOS (lanes 1 – 5).

2.7. SINGLE AND MULTIPLE SUBSYSTEM FACILITY REQUIREMENTS

Each subsystem must have two separate dedicated facility power sources: one for the IOS and one for the Air Compressor. Do not operate any other equipment on these two dedicated power sources.

The following provides the power requirements necessary to operate the EST 2000:

- 5-lane – two 110 or 220 VAC dedicated power sources
- 10-lane – four 110 or 220 VAC dedicated power sources
- 15-lane – six 110 or 220 VAC dedicated power sources

CAUTION

Refer to Appendix H for 220 VAC, 50 Hz OCONUS setup. Failure to comply with preparation instructions will severely damage the equipment.

IOS

- 110 VAC, 60 Hz, 15 Amp circuit
- or 220 VAC, 50 Hz, 7.5 Amp circuit
- Outlet located within 20 ft. (6 m) of IOS

Air Compressor

- 110 VAC, 60 Hz, 20 Amp circuit
- or 220 VAC, 50 Hz, 10 Amp circuit
- Outlet located within 8 ft. (2.5m) of Air Compressor

CAUTION

Do not use an extension cord to operate the Air Compressor. Heat damage may occur.

2.8. ENVIRONMENTAL CONDITIONS

- Operating Temperature: +15°C to +35°C (+59°F to +95°F).
- Storage Temperature: Capable of operation within 5 hours after being removed from storage in a temperature of -15°C to +35°C (+5°F to +95°F).
- Relative Humidity: Capable of operation and storage in a non-condensing humidity between 20% and 80%.

2.9. SUBSYSTEM FUNCTIONAL DESCRIPTION

Each EST 2000 subsystem consists of an IOS, modified weapons, floor boxes, high-resolution projector camera assembly, speakers, air compressor, projection screen, and associated cabling and air lines. Weapon modifications include an eye-safe laser, sensors to measure trigger pressure, weapon cant angle and ammunition magazine/belt status (as well as status of safety and firing mode selection switches), and a compressed air operating system. The RDU located in the IOS serves as the main signal interface between components. Refer to Table 2-1 for equipment specifications.

Table 2-1. Equipment Specifications

ITEM	MODEL	DESCRIPTION
ATTR Assembly	CSSD Assembly 921340235	ASUS nForce motherboard, AMD XP Thoroughbred 2400 Processor (266 FSB), 256 MB DDR 3200 RAM, 40 GB HDD.
Color Inkjet Printer	HP6122 DeskJet or equivalent	Printer used to provide hardcopy records of student performance.
Jun-Air Air Compressor	12-50	Electrical Air Compressor unit used to provide recoil effect for the simulated weapons.
Display Controller Computer	Custom	AMD motherboard, AMD XP Thoroughbred 2400 Processor (266 FSB), (2) 256 MB DDR 3200 RAM, 60 GB HD, and CD-RW/DVD-ROM
Samsung Speaker	XP200	Self-powered loudspeaker with 160 Watt amplifier (low frequency transducer) and 40 Watt amplifier (high frequency driver).
Rack Distribution Unit	Dflex-4	Multi-port serial communication adapter which provides cable routing and signal connections between EST 2000 subassemblies.
Samsung Monitor	SyncMaster 204T	On Screen Display (OSD) color monitor.
Keyboard	N/A	Enhanced 104 keyboard.
Mouse	N/A	2 button mouse.
BARCO Projector	IQR 350	High fidelity video projection system with fully automatic convergence and geometry subsystems.
Camera Box Assembly	CSSD Assembly 921340156-019	Infrared detection camera assembly used to provide the input signal for ATTR processing.
FATS Simulated Weapons	M16A2, M9, M249, M4, M60, M240B, M2, MK19, M203/M16A2, M136, M1200.	Computer monitored simulated weapons equipped with lasers and pneumatically simulated recoil.
CUBIC Simulated Weapons	M16A2, M16A4, M16A4/M203, M4, M4/M203, M9, M1200, M136(AT4), MK19	Computer monitored simulated weapons equipped with lasers and pneumatically simulated recoil.
Floor Box Assembly	CSSD Assembly 921340153	Interface hardware used to supply and regulate voltage to the weapon laser and regulate weapon recoil air pressure.

CHAPTER 3. OPERATING INSTRUCTIONS

3. OPERATING INSTRUCTIONS

This chapter provides information on setup and installation procedures for the EST 2000. It also provides basic information required by the Instructor/Operator to conduct training exercises using the EST 2000.

3.1. PREPARATION FOR OPERATION

The following subparagraphs provide procedures required to prepare the EST 2000 for operation. Refer to Appendix H for OCONUS peculiar setup.

CAUTION

Refer to Appendix H for 220 VAC, 50 Hz OCONUS setup. Failure to comply with preparation instructions will severely damage the equipment.

3.1.1. Power Requirements

The EST 2000 is designed for operation at both CONUS and OCONUS locations and operates on either a 120 volt, 60 hertz, 15/20 amp power supply or a 220 volt, 50 hertz, 7.5/10 amp power supply. Each subsystem requires two separate dedicated 120 or 220 volt services (one service for the Air Compressor, one service for the IOS). Do not operate any other equipment on these two dedicated power sources.

	CONUS	OCONUS
IOS	120V, 60Hz, 15A	220V, 50Hz, 7.5A
Air Compressor	120V, 60Hz, 20A	220V, 50Hz, 10A

WARNING

HIGH VOLTAGE is used in the operation of this equipment. DEATH ON CONTACT may result if personnel fail to observe safety precautions. Learn the areas containing high voltage in each piece of equipment. Be careful not to contact high-voltage connections when installing or operating this equipment.

3.1.2. Installation

Figure 3-1 provides a composite view of the EST 2000. Figure 3-2 provides the system layout for a 5-lane EST 2000 configuration. Use these figures as an overall guide to equipment positioning while following the assembly procedures below.

Note: All references to 'Right' and 'Left' in this manual's installation instructions will be in relationship to the system being viewed from the firing line towards the projection screen.

3.1.2.1. Shipping/Receiving configuration (Typical)

- AIR COMPRESSOR SHIPPING CASE
  - ✓ Air Compressor
- FLOOR BOX SHIPPING CASE
  - ✓ Floor Boxes Assemblies (3)

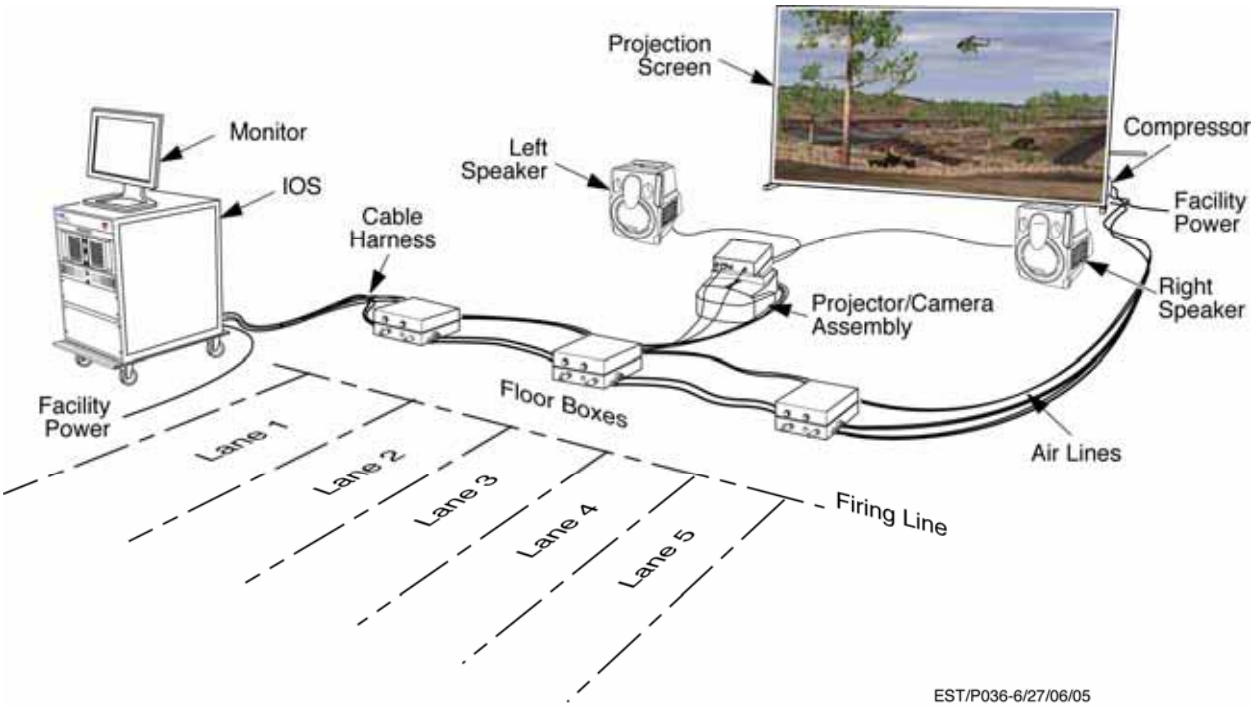


Figure 3-1. EST 2000 Composite View – 5-Lane

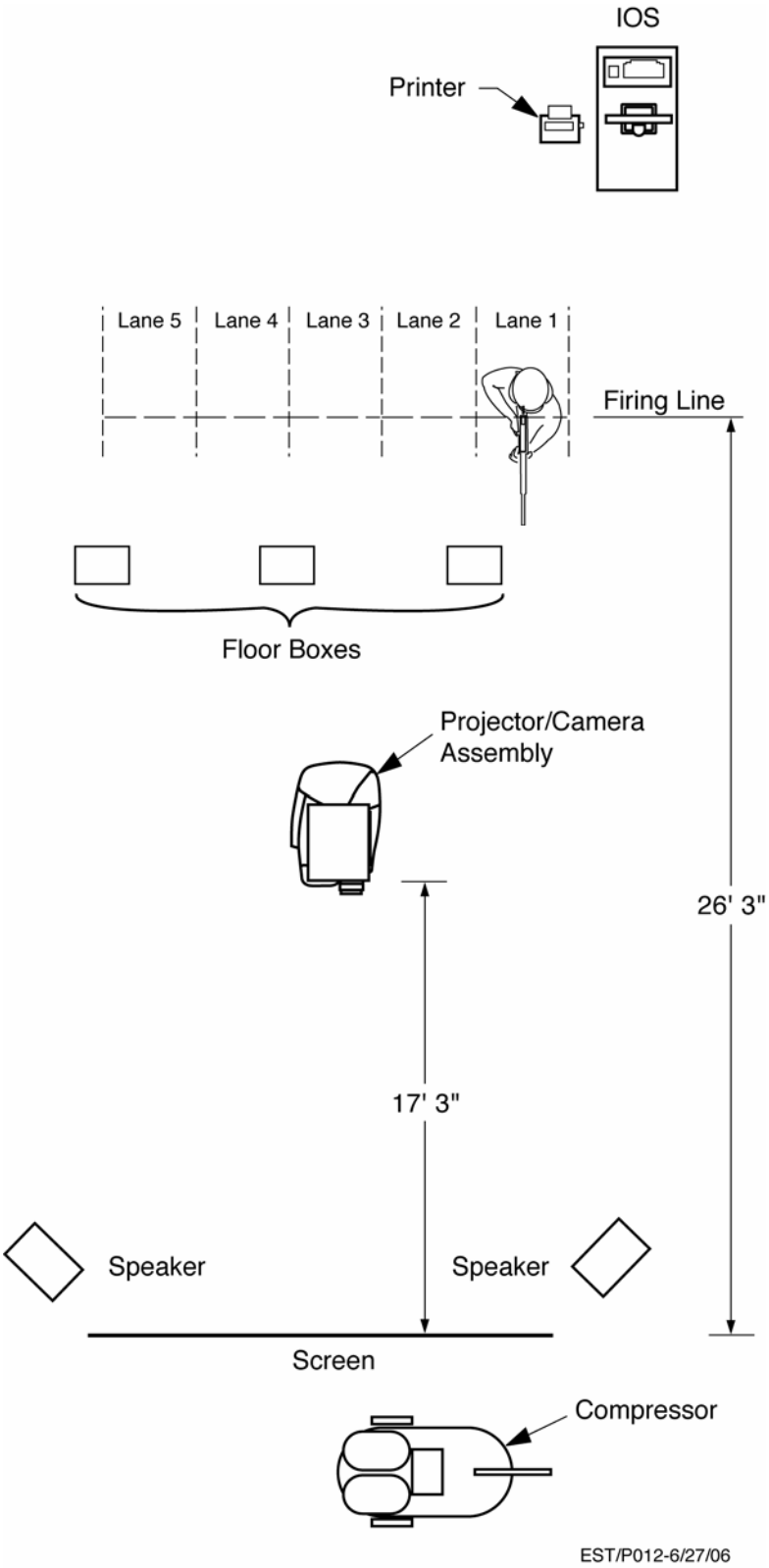


Figure 3-2. System Layout Diagram – 5-Lane

- PROJECTION SCREEN SHIPPING CASES (2)
  - ✓ Projection Screen Assembly
- SPEAKER SHIPPING CASES (2)
  - ✓ Speakers
- PROJECTOR/ IR CAMERA ASSEMBLY SHIPPING CASE
  - ✓ Projector/IR Camera Assembly
- IOS SHIPPING CASE
  - ✓ Display Controller Computer Assembly
  - ✓ Autotracker Assembly (ATTR)
  - ✓ Keyboard and mouse
  - ✓ AC Power Distribution Unit (ACPDU)
  - ✓ Rack Distribution Unit (RDU)
- IOS MONITOR SHIPPING CASE
  - ✓ IOS Monitor
- PRINTER SHIPPING CASE
  - ✓ Printer
- SYSTEM CABLING SHIPPING CASE
  - ✓ System Cables and Air Lines
  - ✓ Interactive Courseware (ICW) (provided on CD ROM)
  - ✓ Assembly/Disassembly Video (provided on CD ROM)
- SIMULATED WEAPONS SHIPPING CASE
  - ✓ Simulated Weapons

3.1.2.2. Tools required for assembly

- Tape Measure (not supplied)
- 9/16” Wrench or Socket (not supplied)
- 5/32” Allen Wrench (supplied)
- #2 Phillips Screwdriver (not supplied)
- Band Cutter (not supplied)
- 7/8” Open-end or Socket Wrench (not supplied)

3.1.2.3. Marking key component locations

Note: Reference Figure 3-2 as a guide to mark key component locations.

a. Using masking tape or similar material, mark the area for the projection screen approximately 2’ from the front (target) wall.

   Note: The assembled projection screen is 13’ 2” wide.

b. Mark the location of the Projector/IR Camera Assembly on the floor, with the Projector lens centered on and 17’ 3” in front of the projection screen.
c. Identify the firing line by measuring out 26’ 3” from each end of the projection screen location.
d. Connect the two measured points (firing line) and affix tape to the floor.

3.1.2.4. Component unpacking

Note: Prior to unpacking and installing the EST 2000, inspect shipping cases for damage.

a. Remove all system components from the shipping cases as directed in the procedures listed below.
b. Ensure all components listed on the shipping case labels are present.
c. Inspect for damage as each component is removed from shipping cases during the installation procedure.

Note: If components are missing or damaged contact the Help Desk for guidance and instructions.

3.1.2.5. Air Compressor setup

Note: Reference Figure 3-1, Figure 3-2, and Figure 3-3 for Air Compressor placement and setup.

a. Open the Air Compressor shipping case with a #2 Phillips screwdriver (not provided) and inspect the Air Compressor for damage.
b. Cut the banding holding the Air Compressor to the pallet.
c. Remove the Air Compressor's front handle from under the Air Compressor, inspect it for damage and install it on the handle-receiver post and hand-tighten the built-in locking bolt.

WARNING

The weight of the Air Compressor exceeds single person lifting limits. To avoid potential injury to personnel and/or damage to equipment, there must be two persons to lift the Air Compressor from its shipping case.

d. With one person on the front handle and a second person on the “T” handle at the rear of the Air Compressor remove the Air Compressor from the shipping pallet.
e. Remove the regulator assembly from the shipping case and inspect for damage.
f. Install and hand-tighten the regulator assembly on the air outlet.
g. Position the Air Compressor against the front (target) wall, directly behind the area to be occupied by the projection screen.
h. Remove the plastic bag containing the air intake filters from the shipping case.
i. Remove the threaded shipping cap from each pump’s air inlet pipe and place the shipping caps in the plastic bag. Remove the air intake filters from the plastic bag and slide one onto each pump's air inlet (air intake filters are not threaded, ensure they are against the pump housing after installing on the air inlet pipe).
j. Ensure that the Air Compressor oil levels are in the middle of both oil sight glass windows. Use only the SJ-27 oil supplied with the Air Compressor. Access to the pump oil reservoir is on the top of each pump. Remove the oil inlet caps using a 7/8" wrench or socket, (not provided) and add oil to bring the oil level to the center of the sight glass.
k. Close the main air valve.

Note: Placement of the Air Compressor is limited only by the power source and length of the air lines.

l. Ensure that both the master power switch and the power selection switch are in the “OFF” position and then select the appropriate power cable, either 110 or 220 volt.

CAUTION

Refer to Appendix H for 220 VAC, 50 Hz OCONUS setup. Failure to comply with preparation instructions will severely damage the equipment.

m. Set the power selection switch to the appropriate position for operation on 110 or 220 volts.

CAUTION

Do not use an extension cord to operate the Air Compressor. Heat damage may occur.

n. Connect the appropriate power cable to facility power and turn the master power switch to "AUTO" to start the Air Compressor and allow it to start building pressure.
o. Put the plastic bag containing the shipping plugs and the regulator assembly packing material into the shipping case, close the case and set it aside to be moved to storage after system setup is completed.

3.1.2.6. Projection Screen Assembly and positioning

Note: Reference Figure 3-4 for Projection Screen assembly and Figure 3-1 and/or Figure 3-2 for Projection Screen positioning.

a. Remove projection screen assembly components from shipping cases, close and set the cases aside for movement to storage after system setup is completed.

Note: The hardware package contains all the small items needed to assemble the projection screen frame. Find and remove the following items and set them aside in an easily accessible location:

1	⅛" hex key
24	¼ - 20 x ¼" lg socket set screws
8	¼ - 20 x ¾" lg wing bolts
4	¼ - 20 x 2 ¾" lg knob screws
4	5/16 -18 x 1 ½" leveling pads
4	⅜ -16 x 3" lg hex head bolts
4	⅜" bolt flat washers
2	stiffener angles
4	corner connector type A (Tapped)
4	corner connector type B (Plain)
2	in-line connector type T (Tapped)
2	in-line connector type P (Plain)
2	u-clamps
6	endcaps

b. Lay the frame pieces in their approximate locations with the rear of the frame facing up.
c. Join one in-line connector type T and in-line connector type P to create the in-line connector set.
d. Join Frame A and Frame B using the in-line connector set.
e. Install the four socket set screws securing Frame A, Frame B, and the in-line connector set together to create a horizontal frame piece.
f. Repeat steps c. through e. to create the second horizontal frame piece.
g. Join one corner connector type A and corner connector type B to create a corner connector set; repeat.

h. Place the two corner connectors sets in a vertical frame as shown in Figure 3-4.
i. Join the vertical frame to the two horizontal frames; be sure the joints are square.
j. Install the eight socket set screws securing the vertical frame, two horizontal frames, and the corner connector sets together.
k. Repeat steps g. through j. for the second vertical frame.
l. Adjust the squareness and straightness of the complete frame as necessary before continuing.
m. Insert each stiffener angle into the channel of the two horizontal frames and align as shown in Figure 3-4.
n. Install the four wing bolts securing each stiffener angle to the horizontal frames.
o. Align the stand base on the stand vertical leg.
p. Install the two hex head bolts and flat washers securing the stand vertical leg to the stand base.
q. Install the two leveling pads in stand base.
r. Ensure the three caps are installed on the stand assembly as shown in Figure 3-4.
s. Repeat steps o. through r. for the second stand assembly.

Note: Note the position of the adjustment holes on the stand assemblies as shown in Figure 3-4.

t. Using two people, align the frame on the two stand assemblies.
u. Install the four knob screws securing the frame to the two stand assemblies.

CAUTION

Ensure hands are clean and dry prior to handling projection screen material.

v. Attach the screen material to the frame starting at the top horizontal frame, then to the vertical frames, and then to the bottom horizontal frame.
w. Remove wrinkle areas and re-apply screen fabric as necessary to smooth out the screen surface.
x. Position the assembled projection screen 2 feet in front of the wall. Check vertical level and distance from each end of projection screen to wall. Adjust the stand assembly level pads as necessary.
y. As necessary, assemble more one or two more projection screen assemblies.
z. Install two u-clamps on side-by-side projection screen assemblies as shown in Figure 3-4.
aa. Install the wing bolt securing each u-clamp in place.

3.1.2.7. Speaker positioning

Note: Reference Figure 3-1 and/or Figure 3-2 for Speaker placement.

WARNING

The weight of the speaker in the shipping case exceeds single person lifting limits. To avoid potential injury to personnel and/or damage to equipment, there must be two persons to lift the speaker while in the shipping case.

a. Lift the speakers from their shipping case and inspect for damage
b. Place the speakers on their sides approximately 10’ in front and to the left and right of the projection screen. This position should not block the view of a firer in the prone position.
c. Turn the speakers slightly inward to direct the sound toward the firing line.
d. Close and set the empty cases aside to be moved to storage after system setup is complete.

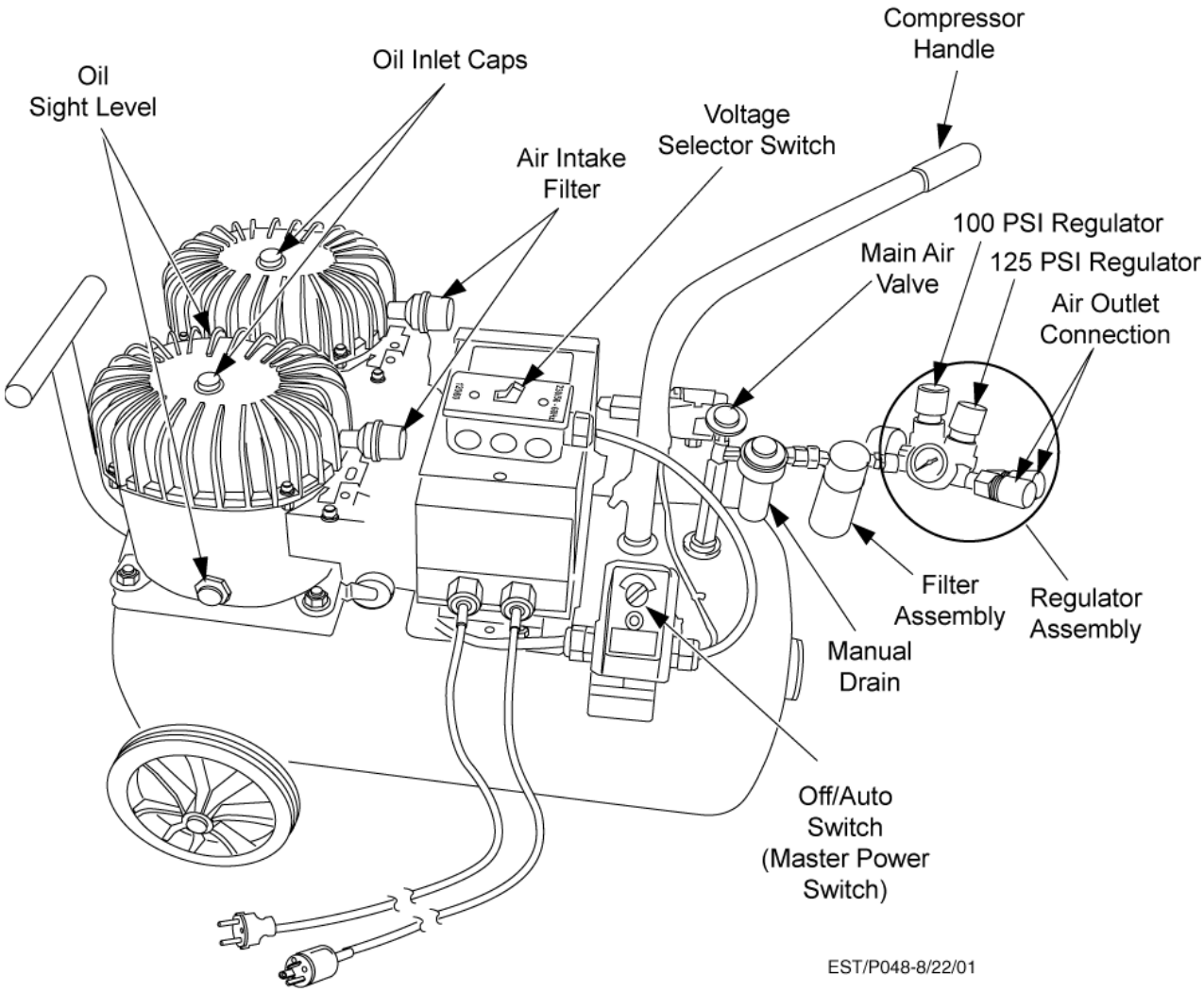


Figure 3-3. Air Compressor Setup (Sheet 1 of 2)

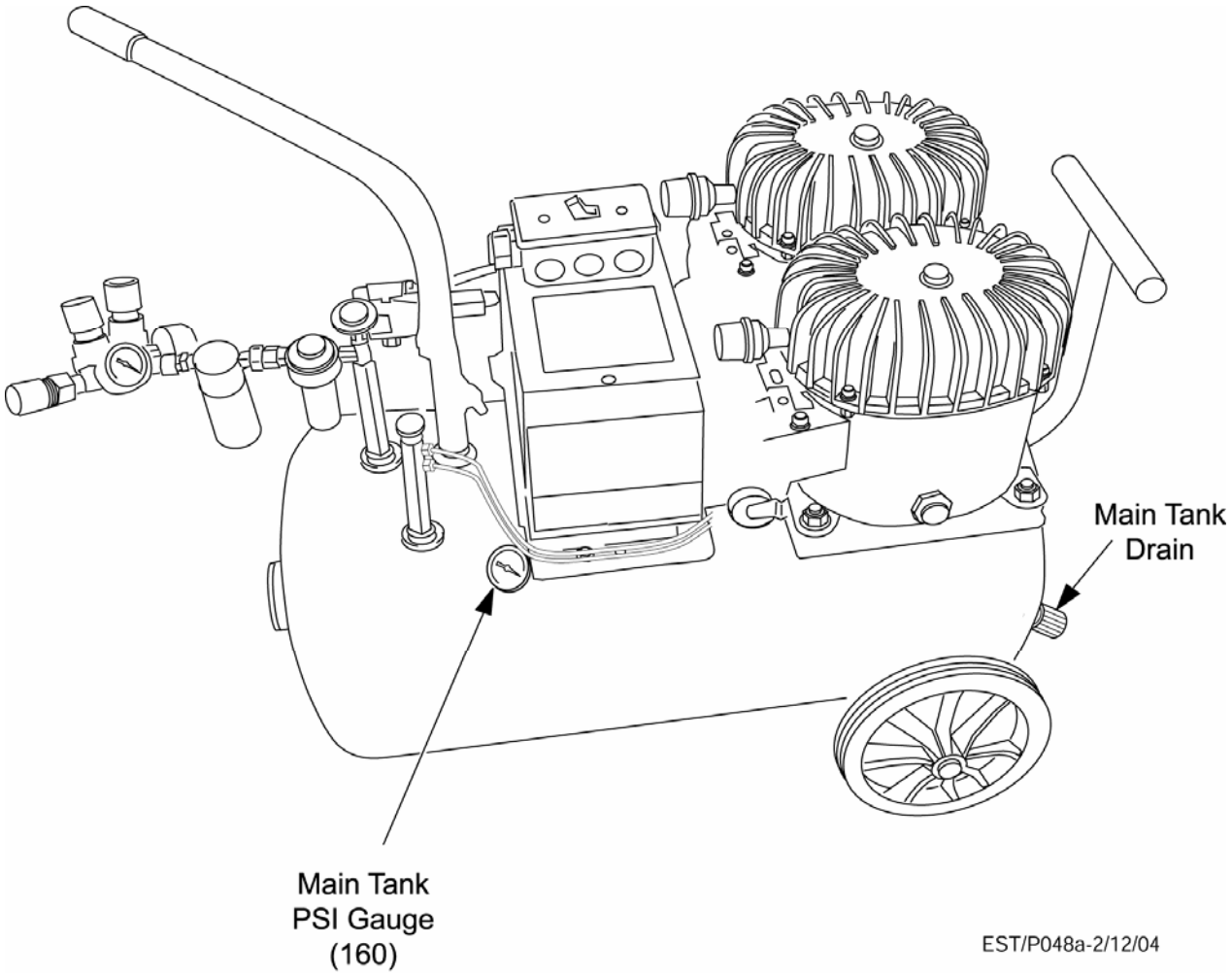


Figure 3-3. Air Compressor Setup (Sheet 2 of 2)

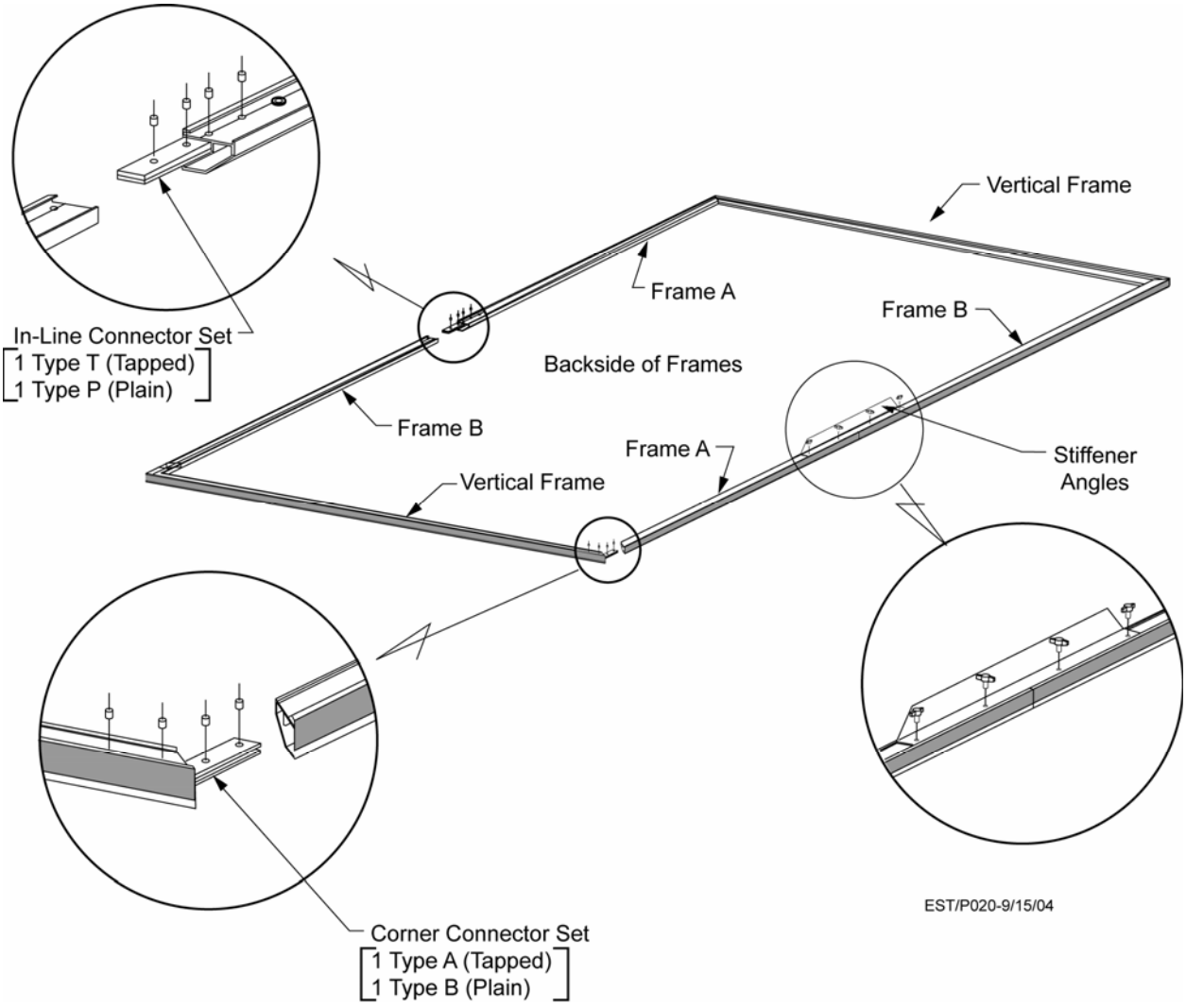


Figure 3-4. Projection Screen Assembly (Sheet 1 of 2)

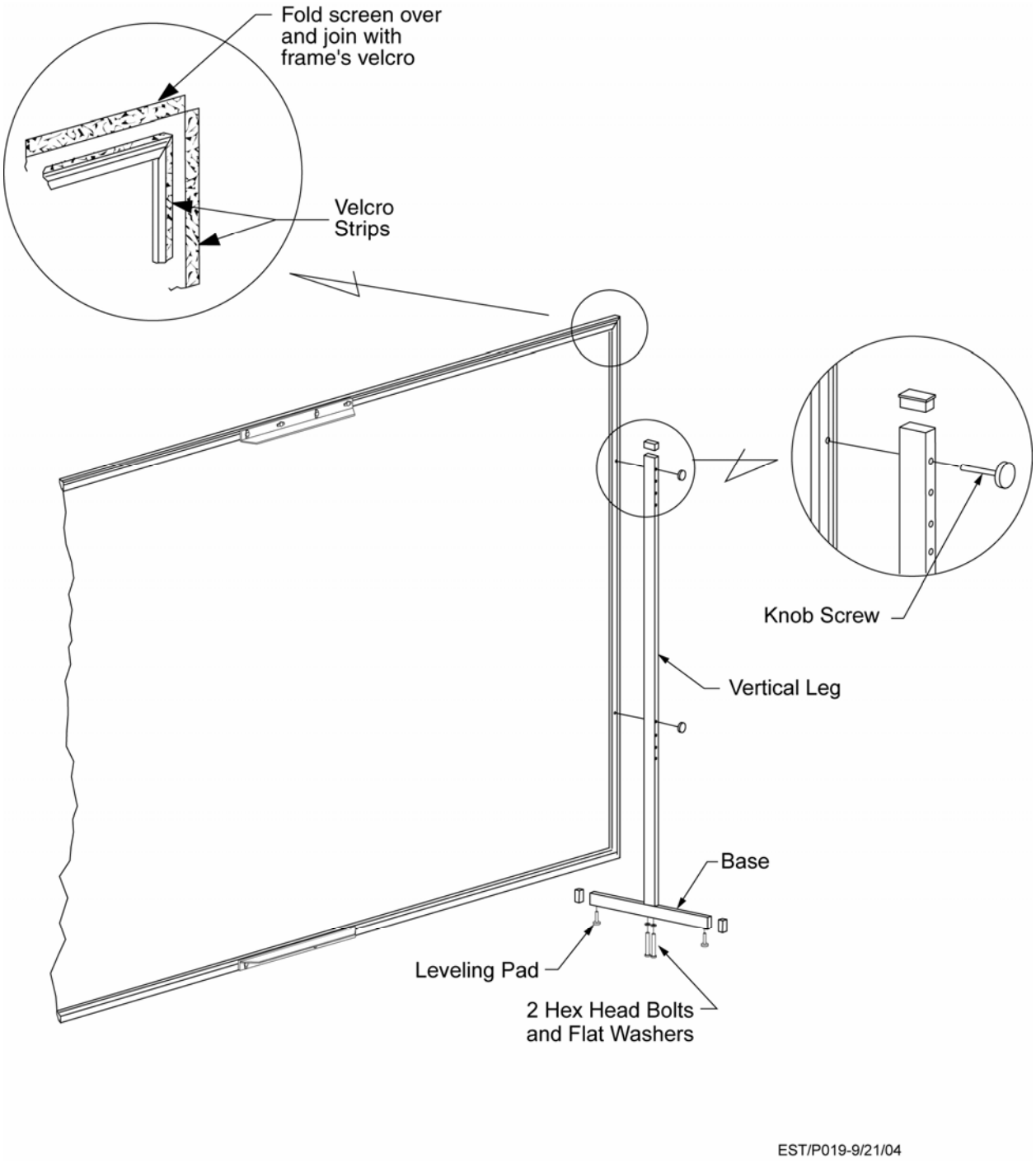


Figure 3-4. Projection Screen Assembly (Sheet 2 of 2)

3.1.2.8. Projector/IR Camera Assembly positioning

Note: Reference Figure 3-1 and/or Figure 3-2 for Projector/IR Camera assembly placement.

a. Using two people, position the Projector/IR Camera Assembly case at the previously measured mark, in front of, and centered on the projection screen.

b. Remove the IR camera assembly, projector lens, and IF filter assembly from the shipping case.

   Note: The Projector Assembly lens and IR filter assembly are shipped uninstalled.

c. Remove the projector assembly from the shipping case.

CAUTION

Lift the Projector Assembly by grasping the body of the projector. Do not lift the Projector Assembly by grasping the packing material.

d. Inspect Projector/IR Camera Assembly for damage.
e. Remove the four screws securing the IR camera assembly upper housing to the lower housing.
f. Remove the IR Camera assembly upper housing.
g. Align the IR camera assembly on the projector assembly adapter bracket.
h. Install the three push rivets securing the IR camera assembly to the projector assembly adapter bracket.
i. Reinstall the IR camera assembly upper housing on the lower housing and secure with the four screws.
j. Install the Projector Assembly lens and on the Projector Assembly.
k. Position the Projector/IR Camera Assembly lens centered on the projection screen with the bottom front edge 17'3" from the projection screen.
l. Ensure the Projector Assembly lens cover and IR filter assembly are set near the Projector/ IR Camera Assembly for use when required.
m. Close and set the empty case aside to be moved to storage after system setup is complete.

3.1.2.9. Floor box positioning

Note: Reference Figure 3-1 and/or Figure 3-2 for Floor Box placement.

a. Remove the floor boxes from their shipping case and inspect for damage.
b. The floor boxes should be placed 2'6" in front of the firing line as follows:
   - The left box centered between lanes 1 and 2.
   - The middle box centered between lanes 3 and 4.
   - The right box in front of lane 5.

   Note: These positions will most easily accommodate the connections from the simulated weapons.

c. Close and set the empty case aside to be moved to storage after system setup is complete.

3.1.2.10. IOS positioning

Note: Reference Figure 3-1 and/or Figure 3-2 for IOS placement.

a. Inspect the IOS shipping case for damage.
b. Use the casters on the IOS shipping case to roll the IOS case behind and to the left of firing lane number 1 and lock the wheel casters in place.
c. Release the four latches on the front and rear covers, then remove the covers. Set the covers aside to be moved to storage after system setup is complete.

3.1.2.11. Monitor placement and connection

Note: Reference Figure 3-1 for IOS Monitor placement and Figure 3-5 for IOS Monitor connections.

a. Remove the monitor from the shipping case. Inspect it for damage and then place the monitor on top of the IOS.
b. Unwrap the monitor's signal cable and connect it to D-sub 15-pin port on the monitor and the IOS RDU (J9).
c. Remove the monitor's power cable from the shipping case and connect it to the monitor and IOS ACPDU (J5).
d. Turn Monitor hard power switch on the rear of the monitor to "ON" and press the power button on the front of the monitor (Power On: Green color).
e. Remove the microphone cable from the shipping case, attach to the monitor, and connect to the IOS RDU (J8).
f. Close and set the empty case aside to be moved to storage after system setup is complete.

3.1.2.12. Printer placement and connection

Note: Reference Figure 3-2 for Printer placement and Figure 3-6 for Printer connections.

a. Remove the printer from the shipping case and inspect it for damage.
b. Place the printer on a small table in close proximity to the IOS.
c. Remove the printer power cable from the shipping case and connect it to the printer and IOS ACPDU (J6).
d. Remove the printer data cable from the shipping case and connect it to the printer and IOS RDU (J15).
e. Turn the printer power switch to "ON".
f. Close and set the empty case aside to be moved to storage after system setup is complete.

Note: If you do not have access to a small table for the printer, you may use the Air Compressor's empty wooden case.

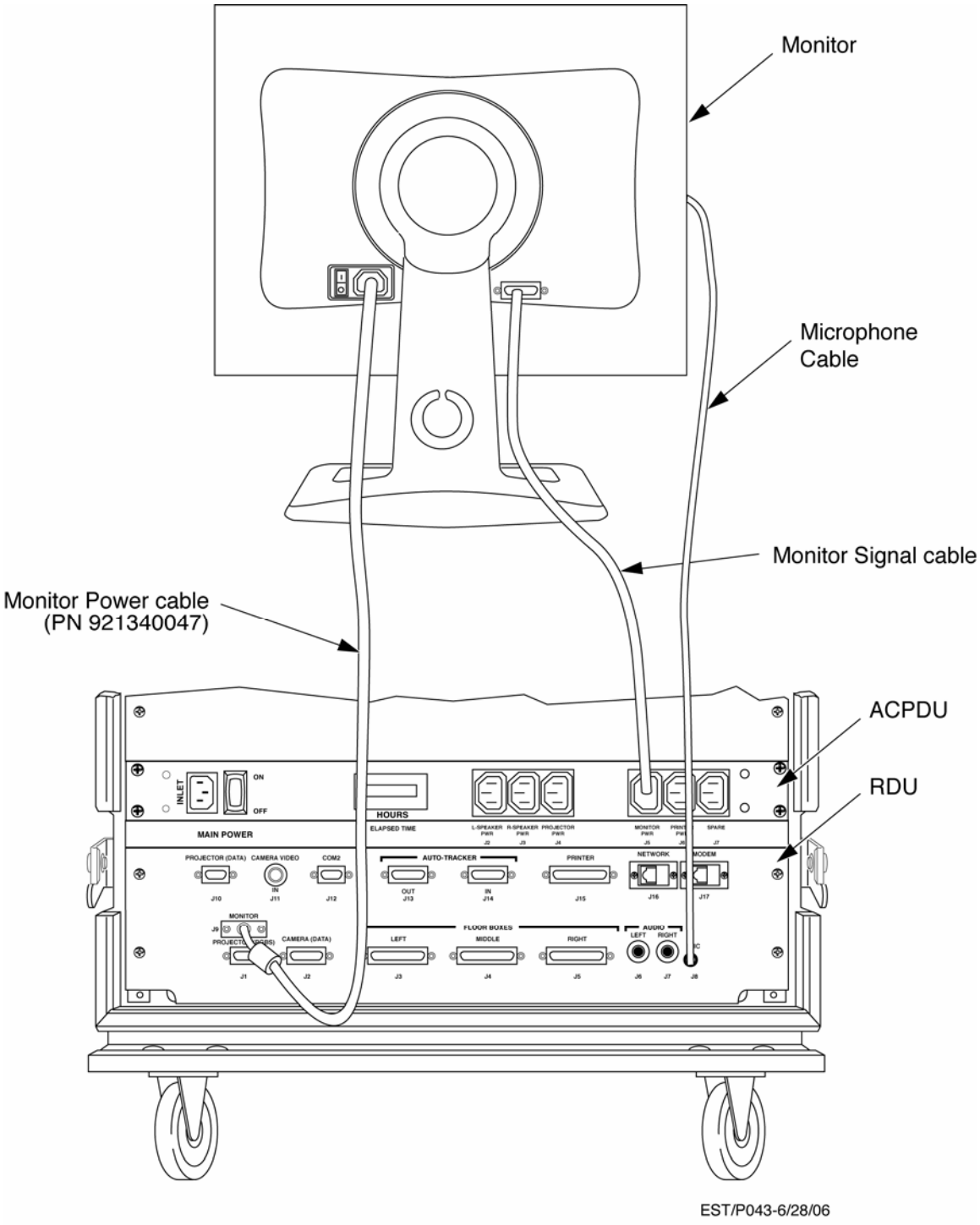


Figure 3-5. Monitor Connections

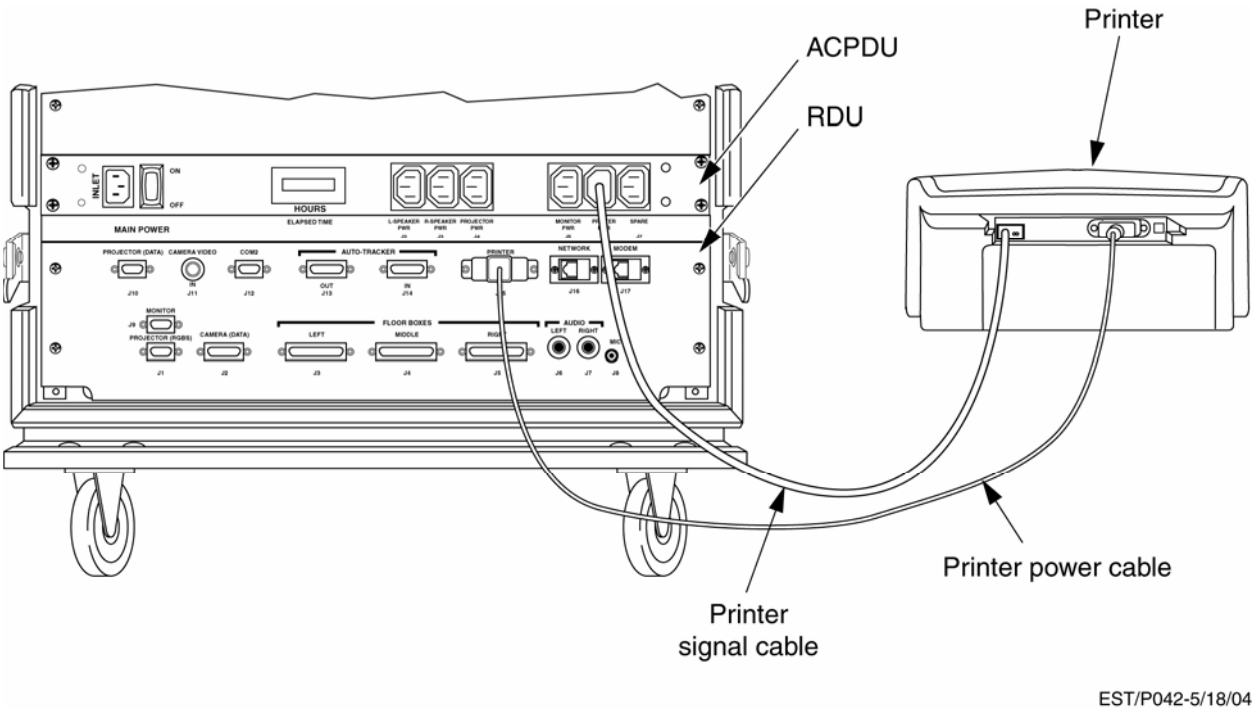


Figure 3-6. Printer Connections

3.1.2.13. Cable bundle connections

Note: Reference Figure 3-7 for an overview of cable bundle routing. Figure 3-8 through Figure 3-10 provide illustrations of individual component power and signal cables connections. Refer to Figure 3-11 for the locations of the ACPDU and RDU on the IOS. Refer to Figure 3-12 and Figure 3-13 for ACPDU and RDU connections.

Note: Do not connect system to facility power until after all cable bundle connections have been made.

a. Remove the air lines from the shipping case and place them in a convenient location near the training system.
b. Remove the cables from the shipping case and extend them in a convenient location near the training system.
c. Inspect the cables for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs.
d. Start with the speakers and work toward the IOS connecting the cables to their components. Ensure the speaker's voltage selection switch is set to the correct voltage position.
e. Identify the cables that connect to the RDU and ACPDU. Lay these ends near the IOS and run the cables to the other components. The longest cables should run down the center of the system and branch left and right to the speakers.
f. Place the power switches on the speakers, the projector, and the printer to the "ON" position during system installation.
g. Place the speaker’s voltage selection switches to appropriate voltage setting during system installation.
h. Connect the telephone line to the Modem port on the rear of the IOS.

Note: The RDU connection point labeled COM2 is a spare connection. No cable bundle connector should be plugged in to this port.

Note: To provide a safer training environment and expedite future assembly and disassembly, bundle the cables with cable ties.

3.1.2.13.1. Speaker connections

Note: Reference Figure 3-7 for an overview of cable bundle routing, Figure 3-8 provides an illustration of individual component power and signal cable connections for the speakers. Refer to Figure 3-12 and Figure 3-13 for ACPDU and RDU connections.

a. Select the speaker power (1W4 for right speaker) (1W5 for left speaker) and audio (1W8 for right speaker) (1W9 for left speaker) cables from the cable bundle.
b. Inspect the cables for loose, exposed or frayed wires, and bent or loose connectors/plugs.
c. Connect the P1 plugs of the power and audio cables to the Power and Line-in jacks on the right speaker (Figure 3-8).

CAUTION

Refer to Appendix H for 220 VAC, 50 Hz OCONUS setup. Failure to comply with preparation instructions will severely damage the equipment.

d. Set the right speaker’s voltage selection switch to local voltage, 110VAC or 220VAC.
e. Turn the right speaker’s power switch to “ON”.
f. Connect the P1 plugs of the power and audio cables to the Power and Line-in jacks on the left speaker (Figure 3-8).
g. Set the left speaker’s voltage selection switch to local voltage, 110VAC or 220VAC.
h. Turn the left speaker’s power switch to “ON”.
i. When ready, connect P2 of the power cables to ACPDU jacks J2 (Left speaker) and J3 (Right speaker) (Figure 3-12).
j. When ready, connect P2 of the audio cables to RDU jacks J6 (Left speaker) and J7 (Right speaker) (Figure 3-13).

3.1.2.13.2. Floor box connections

Note: Reference Figure 3-7 for an overview of cable bundle routing, Figure 3-10 provides an illustration of the cable connections for the Floor Boxes. Refer to Figure 3-13 for Floor Box connections at the RDU.

a. Select the floor box cables from the cable bundle.
b. Floor Box cables 1W11, 1W12, and 1W13 connect to the left, middle, and right floor boxes in that sequence.
c. Inspect the cables for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs.
d. Connect the P1 plugs of the floor box cables to the J3 jacks located on the rear of the floor boxes starting with 1W11 (left floor box), 1W12 (right floor box), and 1W13 (right floor box) (Figure 3-10).
e. Connect the P2 plug of the Left Floor Box cable (1W11) to the J3 jack located on the RDU (Figure 3-13).
f. Connect the P2 plug of the Middle Floor Box cable (1W12) to the J4 jack located on the RDU (Figure 3-13).
g. Connect the P2 plug of the Right Floor Box cable (1W13) to the J5 jack located on the RDU (Figure 3-13).

3.1.2.13.3. Air supply line connections

Note: Figure 3-14 illustrates layout with the Air Compressor set up on the right side of the of a five-lane subsystem. If the Air Compressor is set up on the left side simply exchange ‘right’ for ‘left’ in the steps listed below.

a. Retrieve and inspect the air supply lines for cracks, kinks, or other damage. Ensure the lines have square cut ends.
b. Lay the long air supply lines between the Air Compressor and the right floor box.
c. Lay the short air supply lines near the floor boxes.
d. Connect the long air-supply lines to the right-hand side of the right floor box and to the regulator assembly on the Air Compressor by firmly pushing them into their correct fittings. You will be able to feel them "seat" when they are properly connected. Verify a secure line by lightly pulling on the line.
e. Termination plugs should be placed in the left-hand side of the left floor box, (right-hand side of right floor box if compressor is set up on the system’s left).
f. Use the short air-supply lines to connect the three floor boxes by firmly pushing the lines into their correct fittings. You will be able to feel them "seat" when they are properly connected. Verify a secure line by lightly pulling on the line.

   Note: A ½" (100 psi) line and a ⅝" (125 psi) line connect to each floor box.

3.1.2.13.4. Projector and IR Camera connections

Note: Reference Figure 3-7 for an overview of cable bundle routing, Figure 3-9 provides an illustration of the projection and camera power and data cable connections. Refer to Figure 3-12 and Figure 3-13 for ACPDU and RDU connections.

a. Retrieve the projector data cable (1W6). Inspect cable for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs. Connect 1W6-P2 to the projector data jack (J10) on the top left side of the RDU (Figure 3-13).
b. Retrieve the projector signal cable (1W7). Inspect cable for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs. Connect 1W7-P5 to the jack (J1) marked Projector (RGBS) on the bottom left side of the RDU, underneath the monitor connection (Figure 3-13).
c. Connect 1W6-P1 of the projector data cable to the RS 232 C jack on the front left side of the projector assembly (Figure 3-9).
d. Remove the Projector Assembly cable cover.
e. Connect the projector signal cable to the Projector Assembly as follows: 1W7-P1 (red) to R-PR, 1W7-P2 (green) to G/Y, 1W7-P3 (blue) to B/PB, and 1W7-P4 (black) to Hs/Cs (Figure 3-9).

   Note: If using more than one subsystem, connect the remote control cable to the remote control and to the RC jack on the Projector Assembly. This will prevent accidental control of the wrong projector.

f. Replace the Projector Assembly cable cover.
g. Retrieve the IR Camera Data cable (1W10). Inspect cable for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs. Connect P2 of this cable to the Camera (DATA) jack (J2) on the RDU, bottom left, between the projector (RGBS) and the left floor box jacks (Figure 3-13).
h. Retrieve the IR Camera Video cable (1W15). Inspect cable for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs. Connect P2 of this cable to the camera video jack (J11) on the RDU, top left, alongside the projector (DATA) jack (Figure 3-13).
i. Connect 1W10-P1 of the camera data cable to the camera signal jack on the left rear of the IR camera (Figure 3-9).
j. Connect 1W15-P2 of the camera video cable to the camera video jack on the right rear of the IR camera (Figure 3-9).
k. Retrieve the Projector Power cable (1W3). Inspect cable for loose, exposed, or frayed wires, bent pins, and bent or loose connectors/plugs. Connect 1W3-P2 to the projector power jack (J4) on the ACPDU (Figure 3-12).

   Note: There are three power cables that are identical in appearance, 1W3, 1W4, and 1W5. Power cable 1W3 is the shortest of the three.

l. P1 of 1W3 mates with the projector power plug on front of projector (Figure 3-9).
m. Turn the projector power switch to "ON".

3.1.2.14. Facility power source connection

CAUTION

Refer to Appendix H for 220 VAC, 50 Hz OCONUS setup. Failure to comply with preparation instructions will severely damage the equipment.

a. The final step in assembling the 5-lane system is to connect to the facility power source. Check the position of the Master power switch (IOS) to ensure it is in the “OFF” position. The Master power switch is located on the left side of the ACPDU alongside the Main power jack (Figure 3-11).

b. Retrieve the appropriate IOS power cable, 110VAC or 220VAC. Inspect cable for loose, exposed, or frayed wires, and bent or loose connectors/plugs. Connect 1W1-P2 to Main Power jack on the ACPDU (Figure 3-11).
c. Lay out the IOS power cable where it will not be a trip hazard, and connect it to the facility power source.
d. The EST 2000 5 lane multipurpose weapons trainer is now assembled and ready. Move all empty shipping cases to storage.

WARNING

Trainer is powered by HIGH VOLTAGE. Failure to disconnect power prior to maintenance procedures may result in serious injury or death to personnel and/or damage to equipment .

WARNING

Do not spill liquids on the trainer. Liquids can short out parts, causing fire or electric shock and result in serious injury or death. If liquid is spilled, disconnect trainer power cable from wall receptacle, clean spills and notify maintenance personnel prior to powering up the trainer.

3.1.2.15. Shooting Platform (Optional)

A shooting platform is recommended for optimal comfort of the shooters. This platform is not required and is not part of the delivered system. Refer to Figure 3-15 for a sketch with dimensions to aid you in constructing your own platform(s).

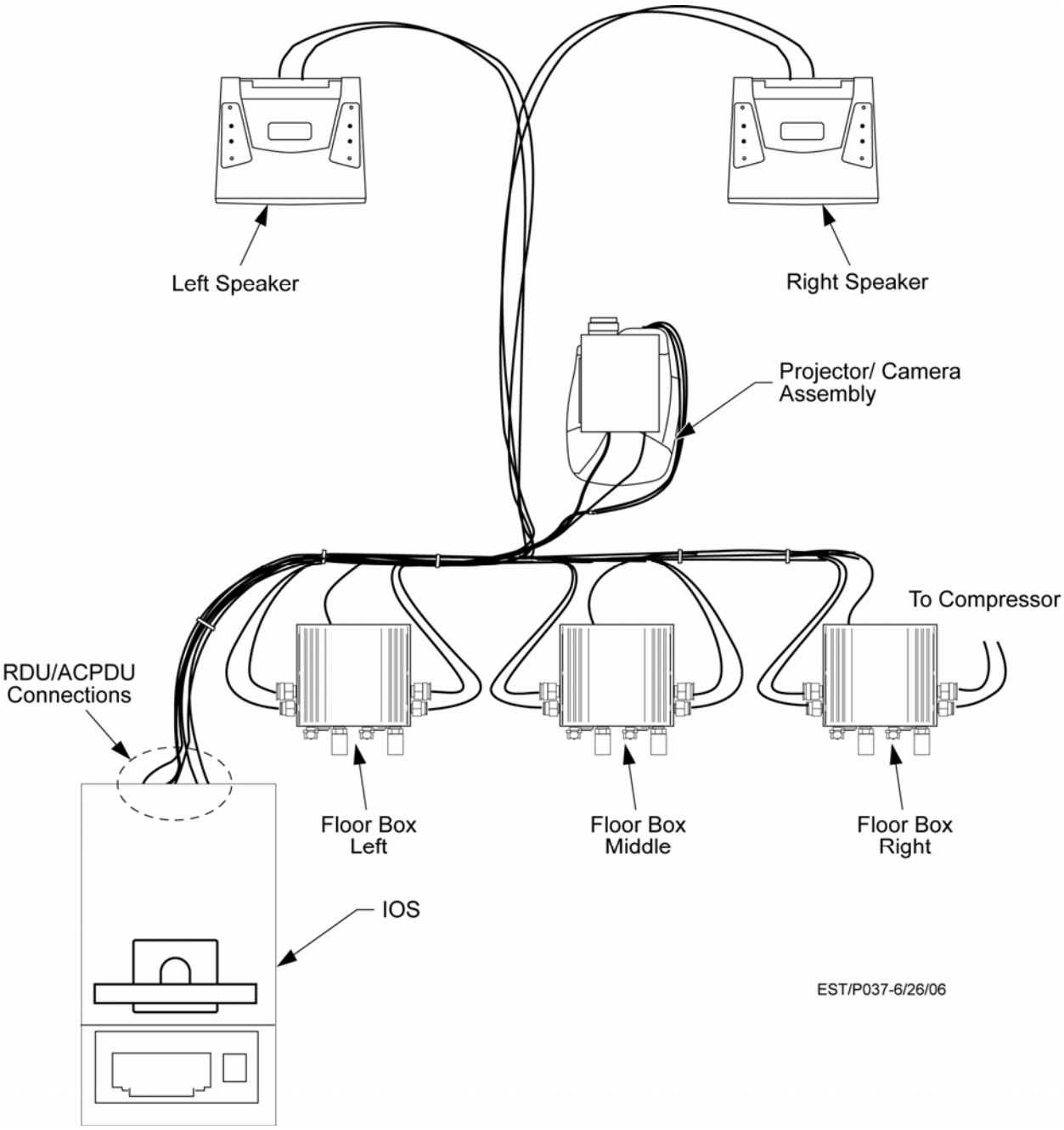


Figure 3-7. Cable Bundle Overview

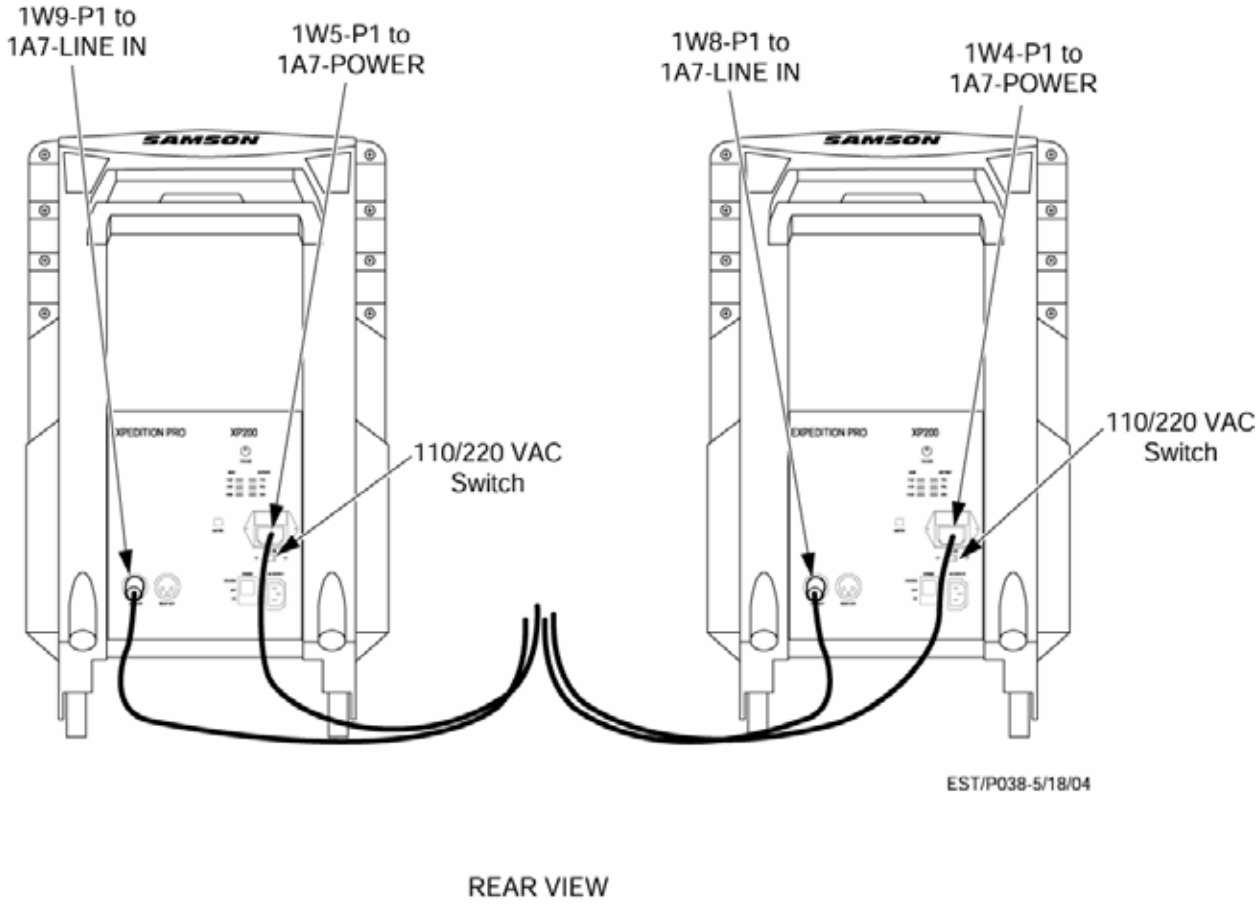


Figure 3-8. Speaker Connections

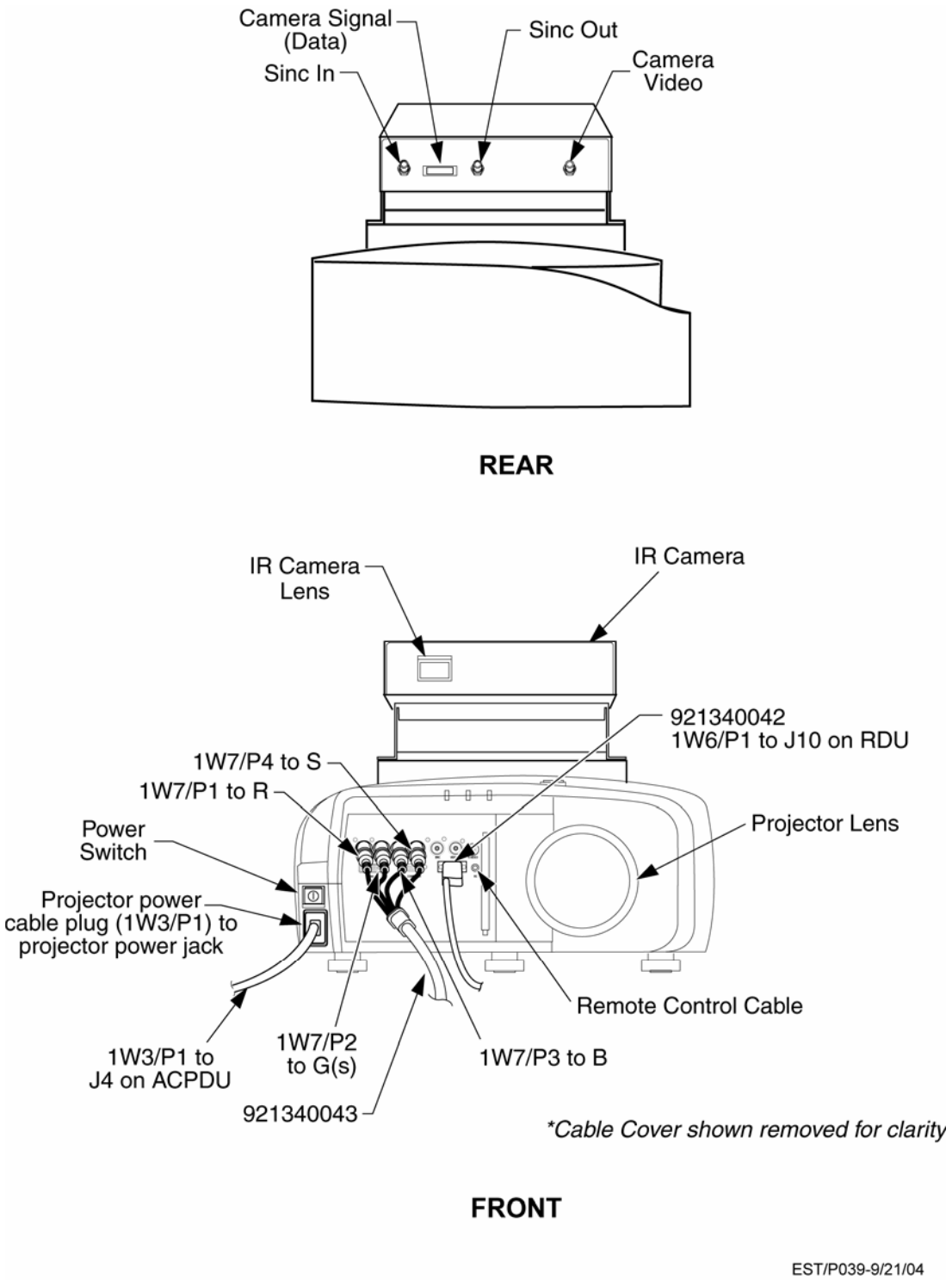


Figure 3-9. Projector/Camera Assembly Connections

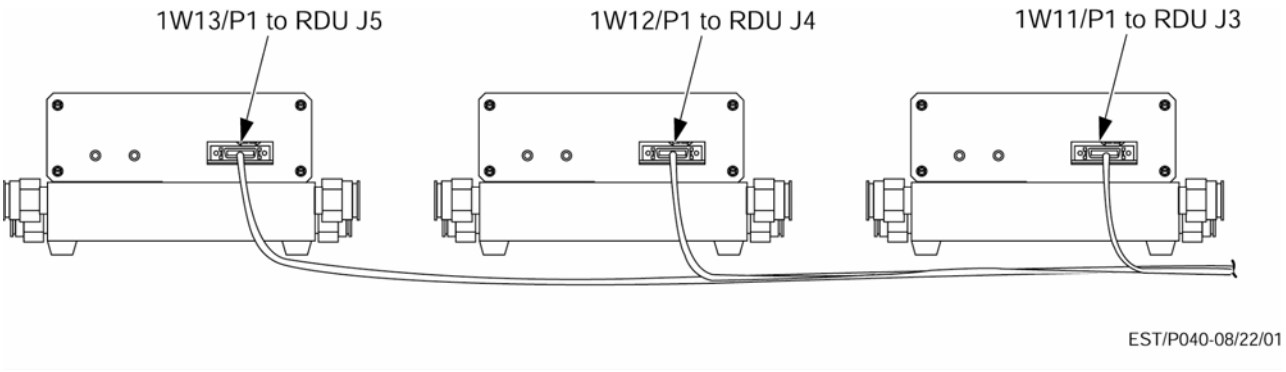


Figure 3-10. Floor Box Connections

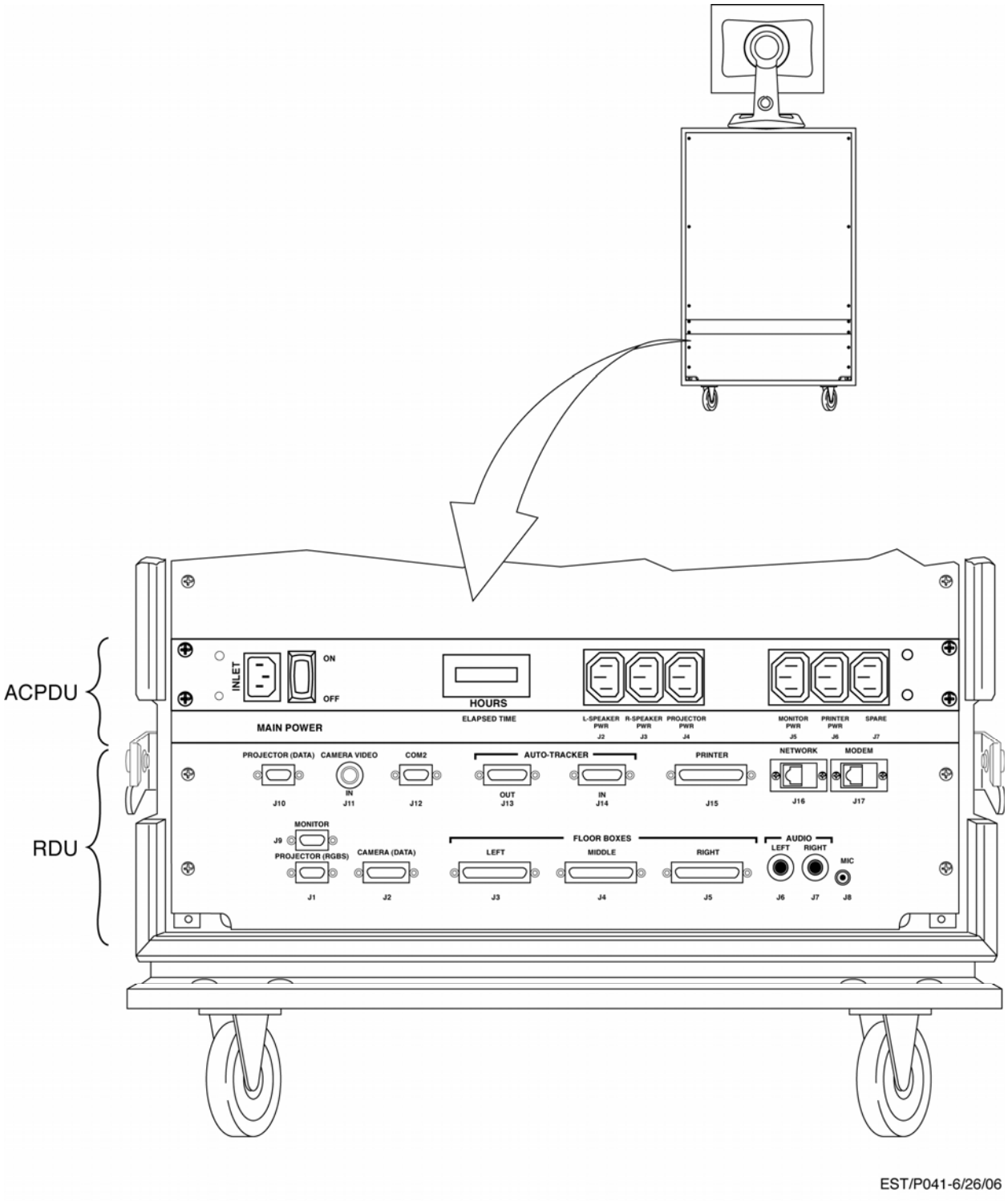
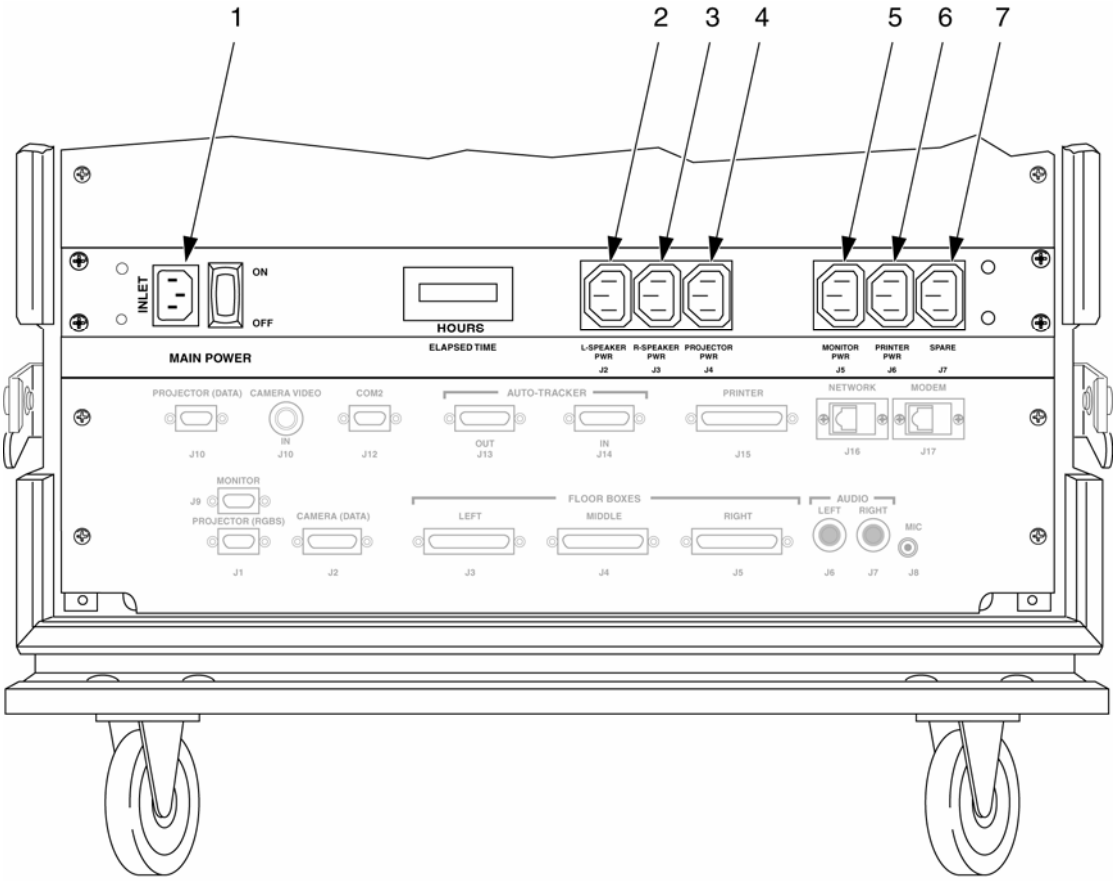


Figure 3-11. IOS RDU and ACPDU

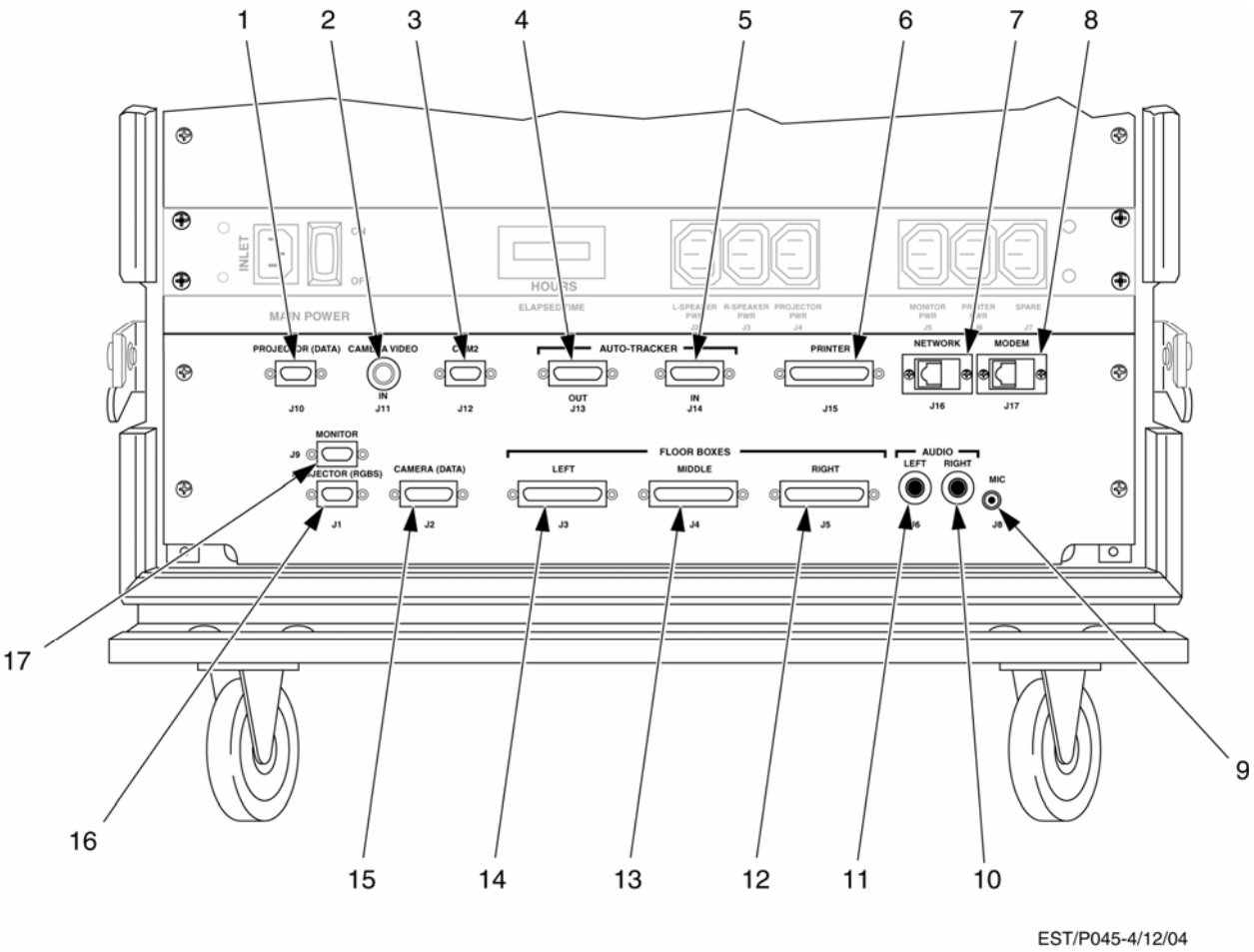


EST/P044-4/12/04

Item	ACPDU Jack	Mates with
1.	Main Power	1W1P2
2.	J2	1W5P2
3.	J3	1W4P2
4.	J4	1W3P2
5.	J5	1W14P2
6.	J6	Printer power cable plug
7.	J7	Spare

Figure 3-12. ACPDU Connections

TD-07-6910-702-10



Item	RDU Jack	Mates with
1.	J10	1W6P2
2.	J11	1W15P2
3.	J12	Spare
4.	J13	Spare
5.	J14	Spare
6.	J15	1W17P2
7.	J16	1W19P2
8.	J17	Modem
9.	J8	Mic
10.	J7	1W9P2
11.	J6	1W8P2
12.	J5	1W13P2
13.	J4	1W12P2
14.	J3	1W11P2
15.	J2	1W10P2
16.	J1	1W7P5
17.	J9	Monitor

Figure 3-13. RDU Connections

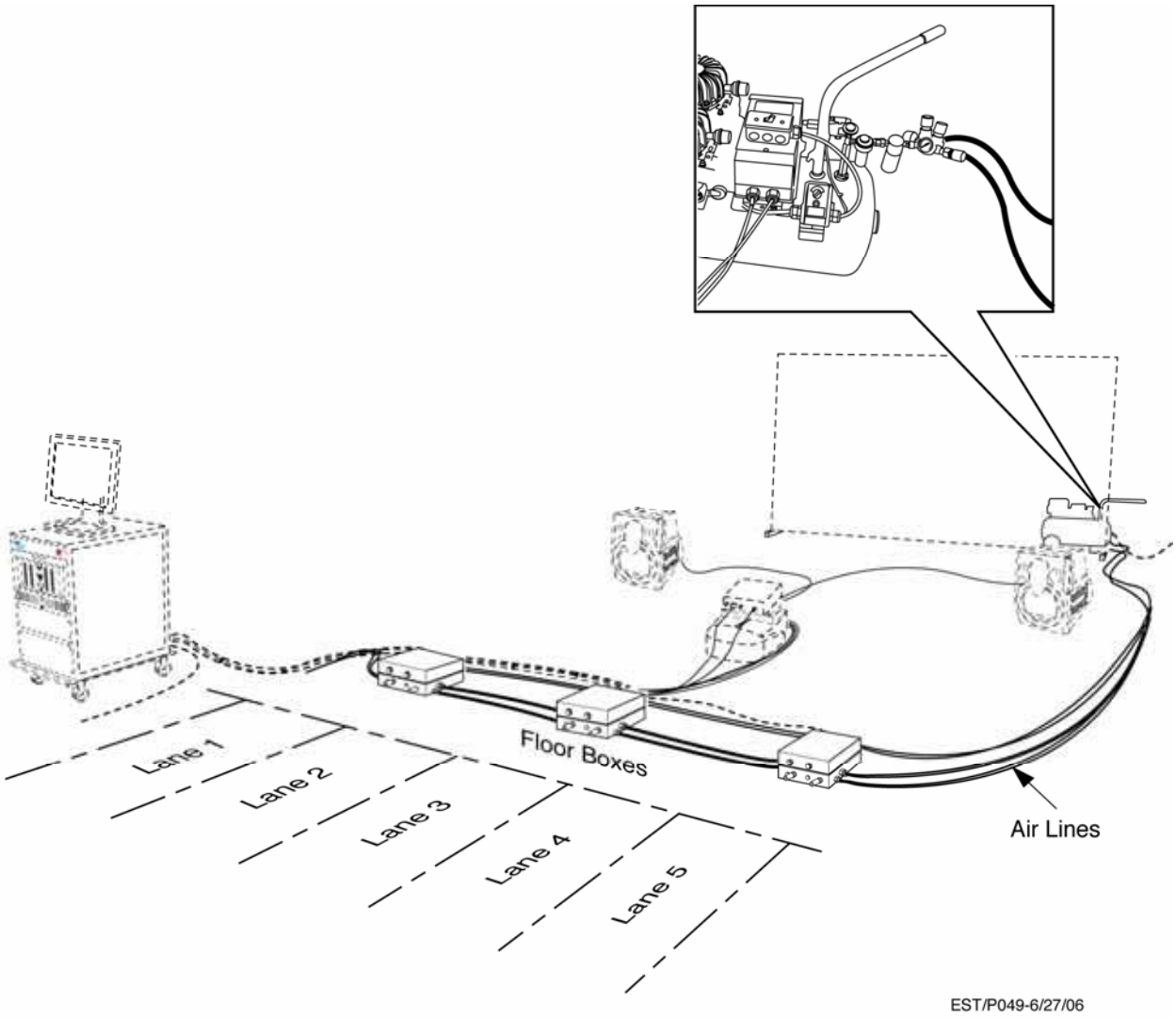
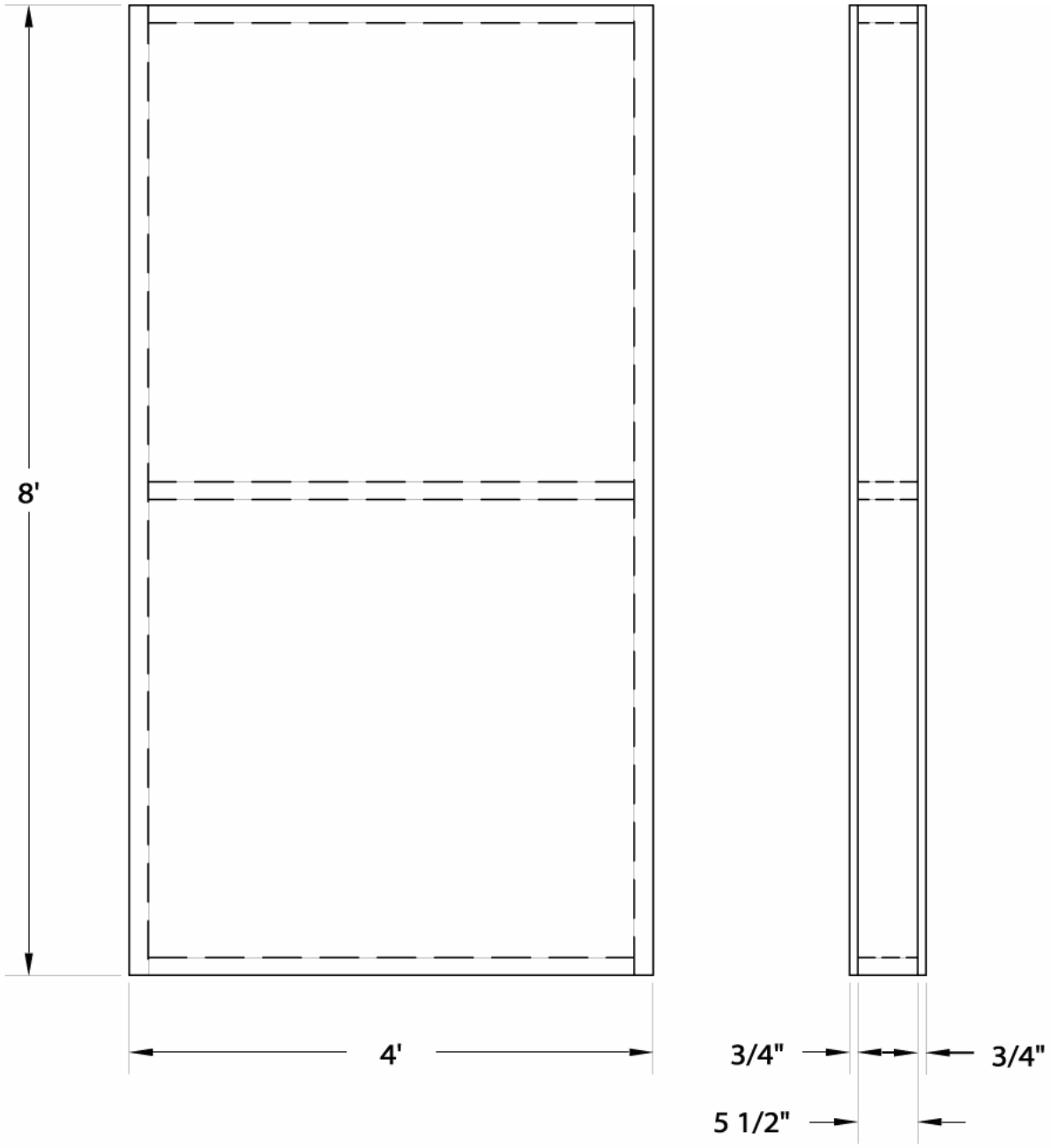


Figure 3-14. Air Line Routing

TD-07-6910-702-10



1. Top and Bottom layers are 3/4" plywood.
2. Middle layers are 2" x 6" wood.
3. Screw and glue all together.
4. Three platforms needed per 5 lane EST2000 system.

Figure 3-15. Shooting Platform

3.1.3. Multi-subsystem Configurations

The EST 2000 sub-systems may be joined to create 10 and 15-lane training systems. EST 2000 system layouts are shown in Figure 3-16 (10 lanes) and Figure 3-17 (15 lanes). Setup of an additional sub-system has only minor changes from the previous connection instructions:

a. Recommended placement of the air compressor in an expansion to a 10-lane system is behind the right side of the second projection screen (Figure 3-16).
b. Placement of the second IOS is behind and to the right of what is now lane 10 (Figure 3-16).
c. The two or three projection screens are joined together using two u-clamps and wing bolts (Figure 3-18).
d. Networks are connected using network cables (1W19) and a 10-lane Network Coupler (Figure 3-19). Network Coupler is located under the Mouse Pad Platform on the IOS Keyboard Tray (Figure 3-29).
e. IR cameras are connected using the 1W20 cable connecting SYNC OUT on camera 1 to SYNC IN on camera 2 (Figure 3-19). You now have a 10-lane system for training (Figure 3-16).
f. Recommended placement of the air compressor in an expansion to a 15-lane system is behind the right side of the third projection screen (Figure 3-17).
g. Placement of the third IOS is behind and to the right of what is now lane 15 (Figure 3-17).
h. The third projection screen is added using two u-clamps and wing bolts (Figure 3-18).
i. The Network Coupler connecting IOS 1 and IOS 2 is removed and the network cables, 1W19, on all 3 IOS units are connected into a Network Hub (Figure 3-20).
j. The third IR camera is connected using the 1W20 cable connecting SYNC OUT on camera 2 to SYNC IN on camera 3 (Figure 3-20). You now have a 15-lane system for training (Figure 3-17).

Detailed procedures for networking subsystems together are provided in paragraph 3.1.3.1 and 3.1.3.2.

3.1.3.1. Networking subsystems

Networking of multiple EST 2000 subsystems is required in order to run 10 and 15-lane EST 2000 configurations.

Note: Reference Figure 3-7 for an overview of cable bundle routing. Figure 3-8 through Figure 3-10 provide illustrations of individual component power and signal cables connections. Refer to Figure 3-11 for the locations of the ACPDU and RDU on the IOS. Refer to Figure 3-12 and Figure 3-13 for ACPDU and RDU connections. Multiple EST 2000 system layouts are shown in Figure 3-16 (10 lanes) and Figure 3-17 (15 lanes). Reference Figure 3-19 for 10-lane network cable connections and Figure 3-20 for 15-lane network cable connections.

Any connections not mentioned here remain the same as in a 5-lane configuration. To network multiple subsystems, perform the following steps:

a. Connect network cable to J16 and connect to the Network Coupler for 10 lanes and The Network Coupler connecting IOS 1 and IOS 2 is removed and the network cables, 1W19, on all 3 IOS units are connected into a Network Hub (Figure 3-20).
b. Connect cable plug 1W19-P2 to jack J16 on IOS 1 RDU (Figure 3-13) and cable plug 1W19-P1 to the Network Coupler (Figure 3-19).
c. Connect the cable plug 1W19-P2 to jack J16 on IOS 2 RDU (Figure 3-13) and cable plug P1 to the Network Coupler (Figure 3-19).

   Note: The Network Coupler is stored under the Mouse Pad Platform on the IOS keyboard tray during initial shipment (Figure 3-29).

d. Connect cable plug 1W20-P2 to IR camera 1 (SYNC OUT) and cable plug 1W20-P1 to the added IR camera 2 (SYNC IN) (Figure 3-19).

Note: The completion of steps e. through j., is required for a 15-lane networked configuration.

e. Disconnect network cables from the Network Coupler. For a 15-lane configuration, a Network Hub is used.
f. Connect the cable plug 1W19-P2 to jack J16 on IOS 1 RDU (Figure 3-13) and cable plug 1W19-P1 to the network hub (Figure 3-20).
g. Connect the cable plug 1W19-P2 to jack J16 on IOS 2 RDU (Figure 3-13) and cable plug 1W19-P1 to the subsystem network hub (Figure 3-20).
h. Connect the cable plug 1W19-P2 to jack J16 on the added subsystem's IOS (IOS 3-Lanes 11-15) RDU (Figure 3-13) and cable plug 1W19-P1 to subsystem network hub (Figure 3-20).
i. Connect cable plug 1W20-P2 to IR camera 2 (SYNC OUT) and cable plug 1W20-P1 to the added IR camera 3 (SYNC IN) (Figure 3-20).

Note: Each installed EST 2000 subsystem must be powered up in order to complete the networking connection. In a networked configuration, the IOS controlling lanes 1 through 5 generally serves as the master IOS. However, control of the EST 2000 simulation may be initiated, controlled, and monitored from any installed IOS. The IOS at which the Instructor/ Operator logs onto the system will, by default, become the master IOS.

j. Connect the projector assembly remote control cable to the projector assembly remote control and to the RC jack on the Projector Assembly.

Note: Use of the remote control cable will prevent accidental control of the wrong projector.

3.1.3.1.1. EST 2000 Trainer Configuration

EST 2000 subsystems may be set up alone (5-lane) (Figure 3-2), in pairs (10-lane) (Figure 3-16), or in threes (15-lanes) (Figure 3-17). An individual IOS may be the 'Left', 'Middle', or 'Right' IOS within the 'System' depending on the number of lanes utilized. The following assumes the subsystem(s) have been assembled and are prepared to be configured or reconfigured, as the case may be.

Each new subsystem will need to be configured when first installed or reconfigured when the existing physical configuration is changed (i.e. Add an additional subsystem or change out an existing subsystem's IOS). Listed below are the steps to configure a new system and reconfigure a previously configured system.

3.1.3.1.2. Configure New Subsystems

a. At the IOS, power-up the system by positioning the switch located at the rear of the IOS on the ACPDU to the "ON" position.
b. The computer will complete system "boot-up" and the following message will appear on the subsystem(s) IOS monitor: "This machine has not yet been configured for use. Would you like to configure it now?" (Figure 3-24).

Note: If utilizing multiple subsystems, each system will have to be configured.

c. Select 'Yes' (By selecting 'No', the EST 2000 will not be properly configured, and the Instructor/Operator will be asked to configure each time the system is started). Upon selecting 'Yes' the Subsystem Configuration Screen appears (Figure 3-22).
d. To configure a subsystem in a multiple subsystem setup, select the total number of subsystems in the setup you are currently configuring. Then select "Left", "Middle", or "Right" as appropriate for the IOS you are configuring in the overall system setup.
e. The subsystem's computer will reboot and will present a confirmation message indicating the system has been configured (Figure 3-23). Select "OK" to dismiss the message, and the EST 2000 Login Screen will appear (Figure 3-37 and Figure 3-38).
f. Repeat the configuring steps for each IOS in the system.

3.1.3.1.3. Reconfigure Subsystems

To reconfigure a previously configured subsystem;

a. At the IOS, power-up the system by positioning the switch located at the rear of the IOS on the ACPDU to the “ON” position.
b. The computer will complete system “boot-up”

   Note: If utilizing multiple subsystems, each subsystem will have to be reconfigured.

c. If IP Address Conflict error message appears (Figure 3-21) select "OK" and the Subsystem Configuration Screen will appear (Figure 3-22).
d. Follow steps in 3.1.3.2.1.c., d., and e., above to complete reconfiguration.
e. If the EST 2000 Login Screen appears (Figure 3-37 or Figure 3-38) instead of the IP Address Conflict error message (Figure 3-21) type "configure" as the Password, select “OK”, and the Subsystem Configuration Screen will appear (Figure 3-22).
f. Follow steps in 3.1.3.2.1.c., d., and e., above to complete reconfiguration.
g. Repeat the reconfiguring steps for each IOS in the system.

3.1.3.2. Joining multiple screens

Two screens must be joined in order to properly configure a 10-lane system. Three screens are required for 15-lane configurations. Join screens as shown in Figure 3-18.

TD-07-6910-702-10

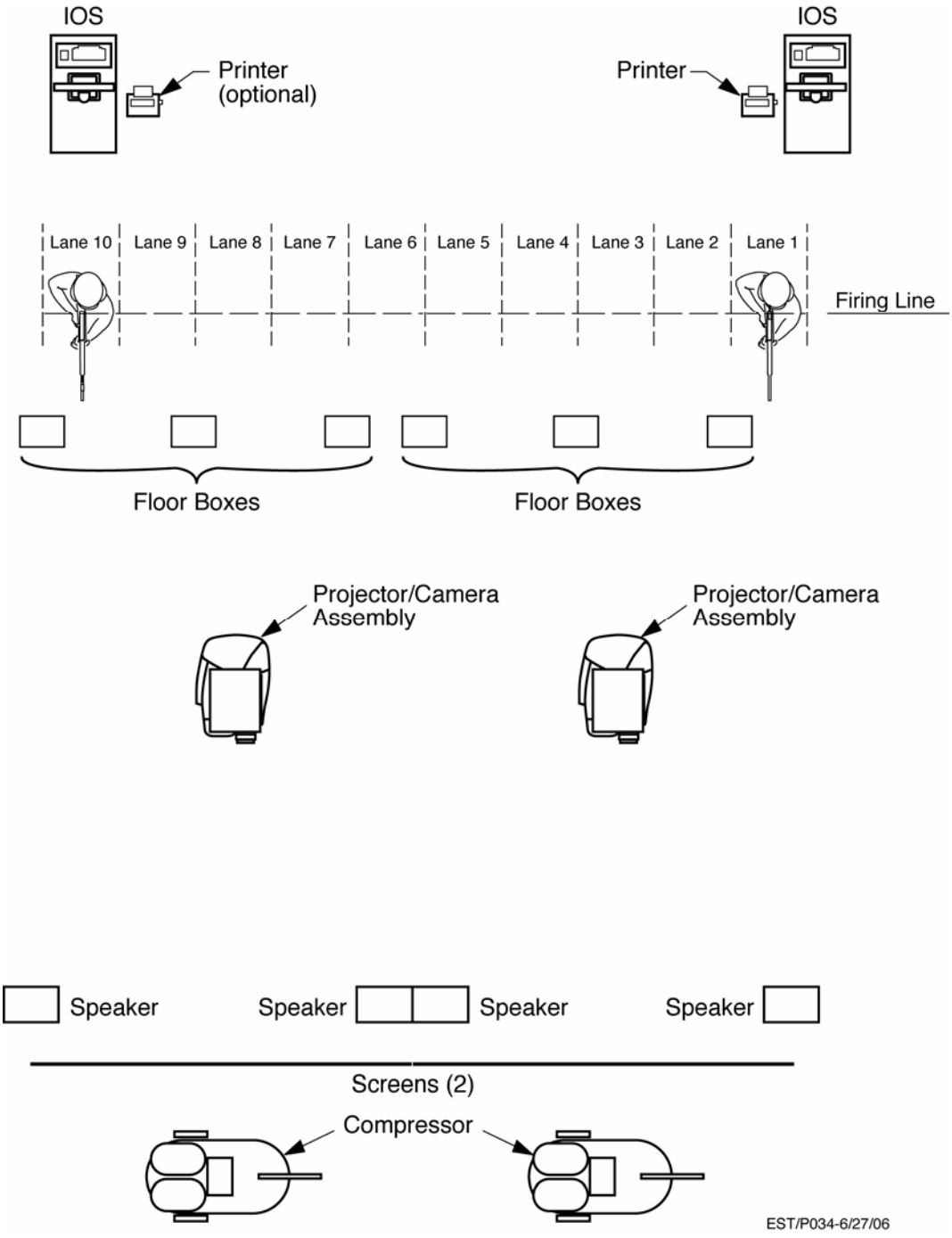


Figure 3-16. System Layout Diagram – 10-lane

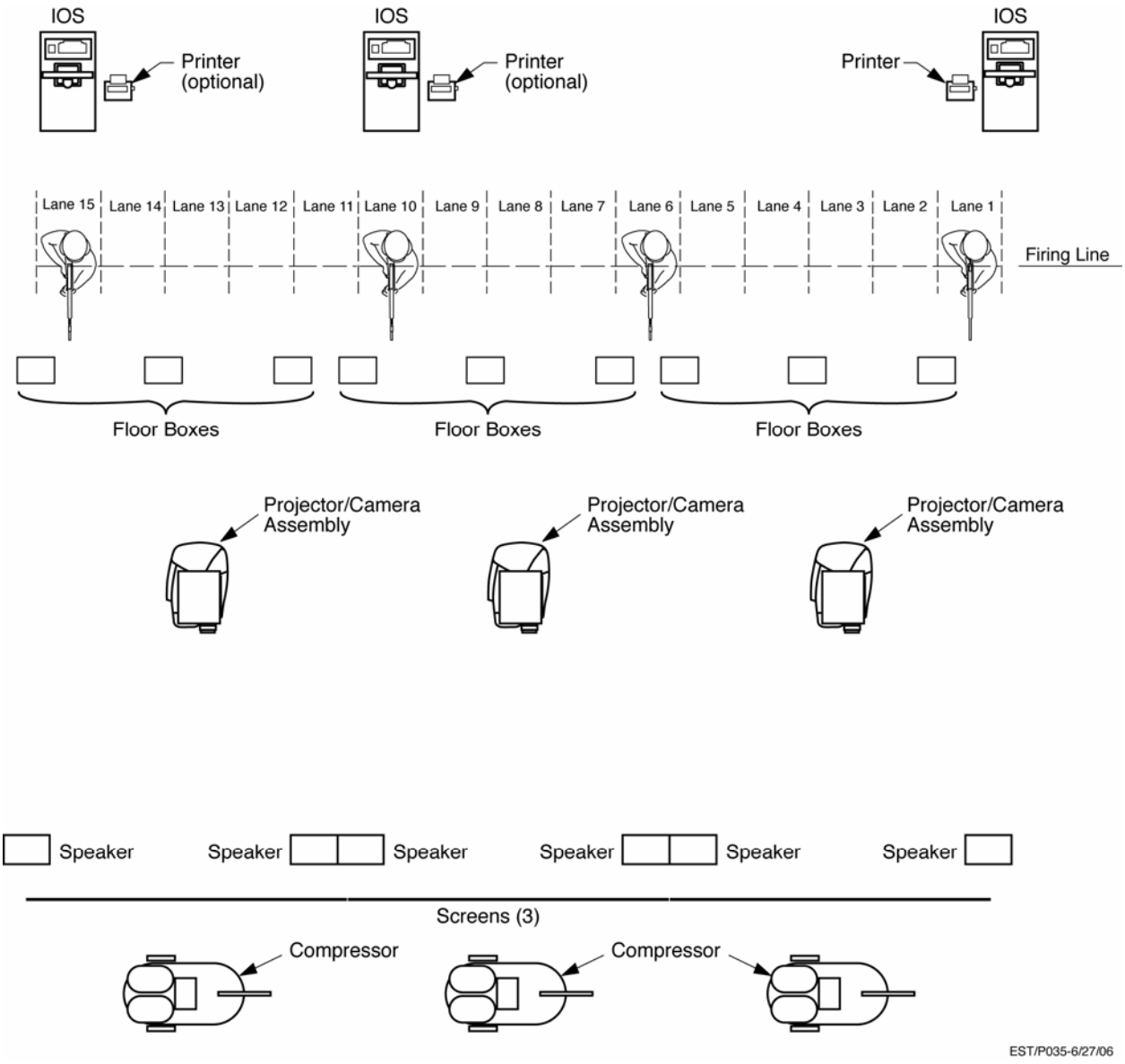


Figure 3-17. System Layout Diagram – 15-lane

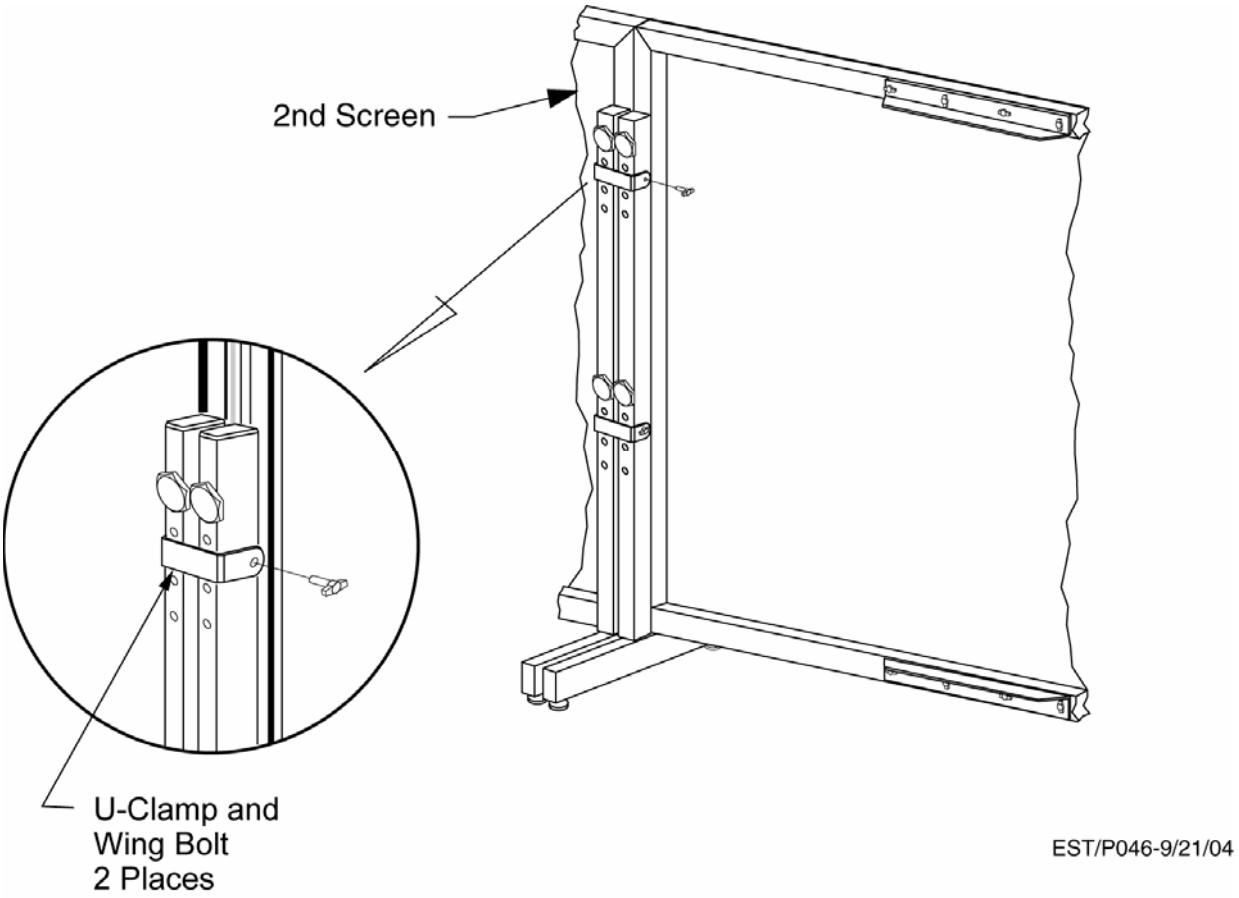


Figure 3-18. Joining Multiple Screens

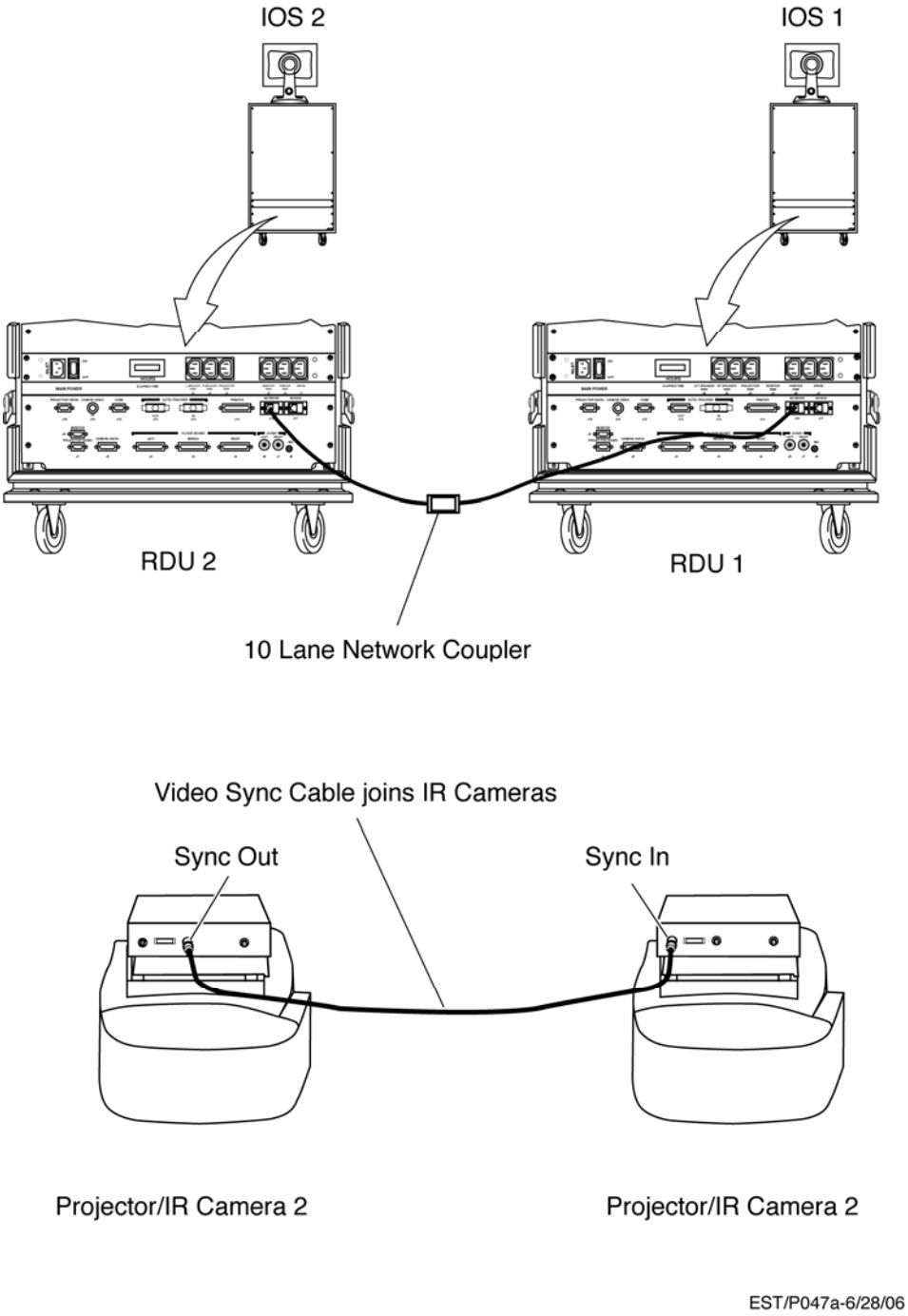


Figure 3-19. 10-lane Network Cable Connections

TD-07-6910-702-10

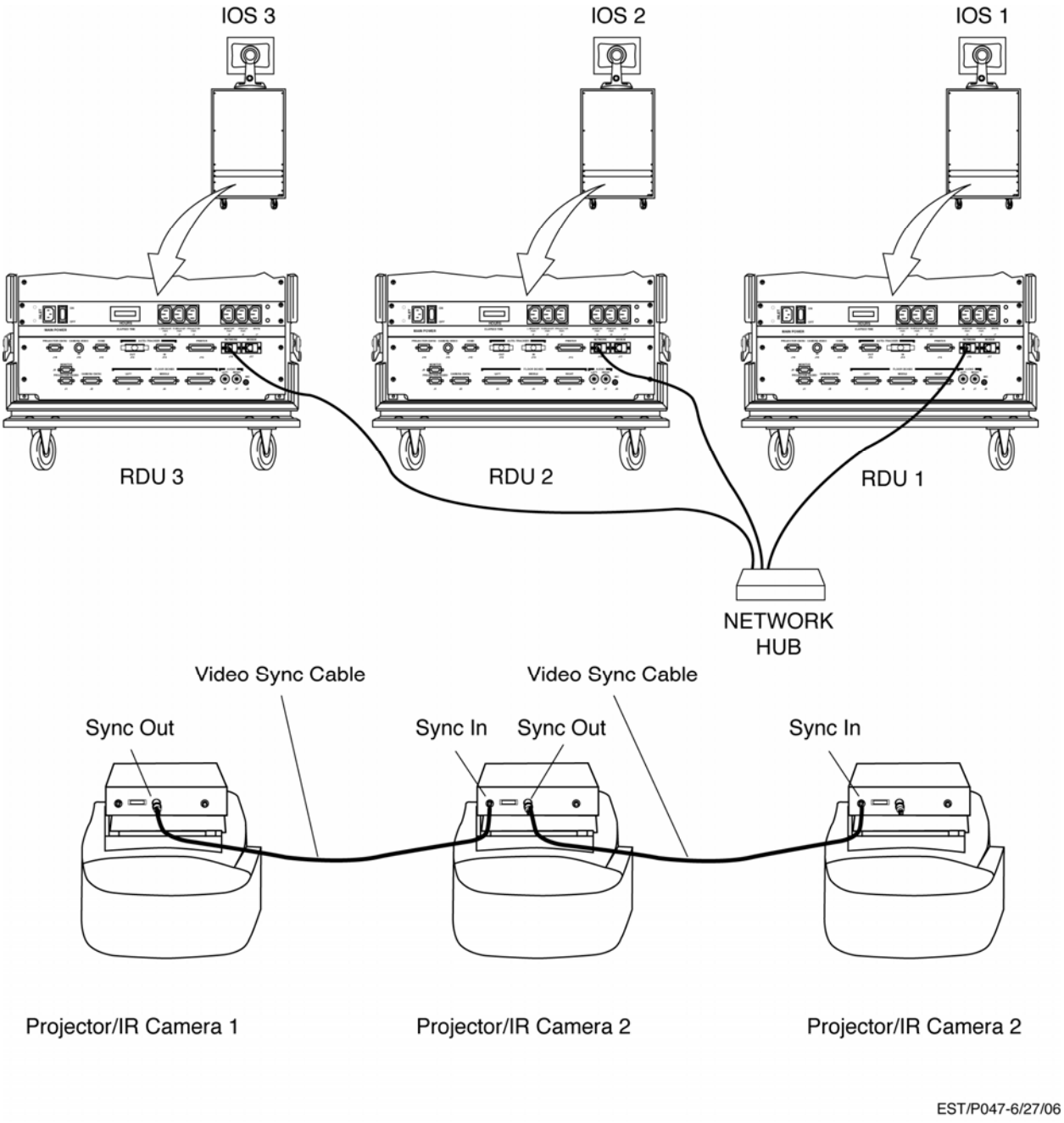


Figure 3-20. 15-lane Network Cable Connections

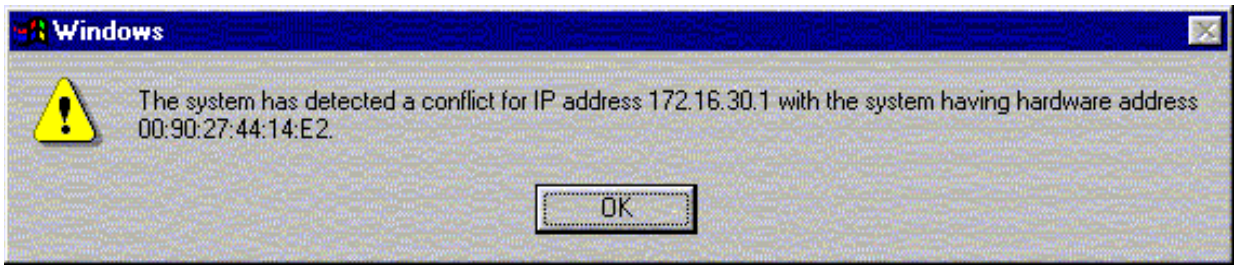


Figure 3-21. IP Address Conflict

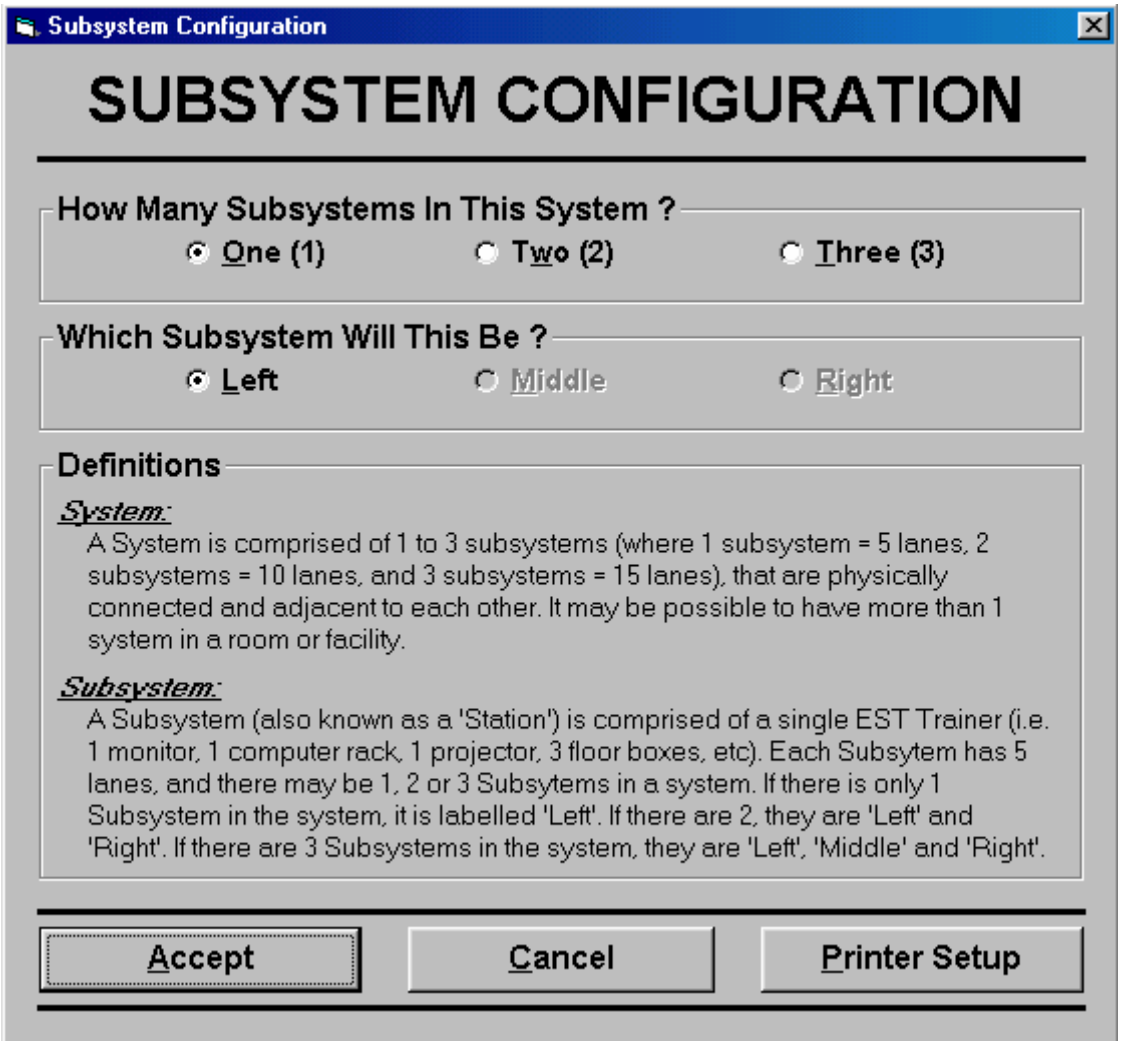


Figure 3-22. Subsystem Configuration

Figure 3-23. Configured Dialog Box

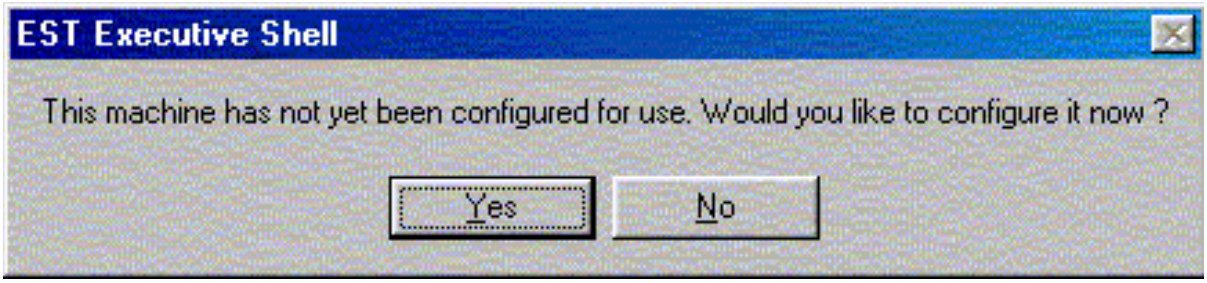


Figure 3-24. Configure Message

3.2. OPERATOR CONTROLS AND INDICATORS

Operator controls and indicators are provided in the following paragraphs and figures.

3.2.1. Instructor/Operator Station (IOS)

The IOS allows the Instructor/Operator to power up the trainer, confirm trainer operational readiness, perform lane allocation and student roster assignments, initiate training, stop all electrical activity in the event of an emergency; monitor, record, and control the training simulation; and perform normal training device shutdown procedures. The IOS (Figure 3-25) consists of the following:

- Monitor
- Keyboard and mouse
- Autotracker (ATTR)
- Display controller computer
- Rack Distribution Unit (RDU).
- AC Power Distribution Unit (ACPDU).

3.2.1.1. Display Controller Computer

Display controller computer basic specifications* are as follows.

- Intel based motherboard with onboard sound and NIC
- Intel P4 3.0 GHz Processor, includes heatsink and fan
- Microsoft Windows XP Pro WITH Service Pack 2
- (2) DDR II - 256 MB or greater memory
- 160 GB Hard disk drive (HDD) with cables
- CD-RW/DVD-ROM drive with cables
- 1.44 MB 3.5” Floppy drive with cables
- 3D PCIEx16 graphics card (N Vidia)
- DVI-I to VGA dongle
- MPEG 2 Decoder (PCI)
- Com Port Card
- Sound Card
- RS-232 to USB adapter with bracket and cable
- Enermax EG365AX-VE (W) autosensing power supply
- 2 button PS-2 mouse with scroll wheel

Note: Specifications listed are minimum requirements, future builds (Lots) may exceed listed specifications. Computer controls and indicators are shown in Figure 3-26.

3.2.1.2. Autotracker (ATTR)

The ATTR is used for generating weapon aim point data and laser modulation signals for each weapon connected to the system. The lasers mounted on each weapon produce an IR spot representing the weapon aim point on the projection screen. The aim point information is supplied to the ATTR in the form of a video signal from each of the IR cameras. The video signal is processed by the ATTR and continually updated to produce real-time coordinate information for the location of each IR spot on the projection screen. ATTR controls and indicators are shown in Figure 3-27. ATTR computer basic specifications* are as follows.

- ASUS A8N-VM CSM motherboard with embedded video, network, and audio
- AMD Athelon 64 Processor, includes heatsink and fan
- Microsoft Windows XP Pro
- (1) DDR 256 MB PC3200 memory
- 80 GB HDD with cables
- CD-RW drive with cables (48x12x48 minimum)
- Cyberoptics PCX200AF video capture card
- CyberResearch PCIDIO-ISO32 I/O card
- Power supply, at least 30 autosensing
- Back plate power ACC for C-Molex-10
- USB to RS-232 Adapter

Note: Specifications listed are minimum requirements, future builds (Lots) may exceed listed specifications.

3.2.1.3. Rack Distribution Unit (RDU)

The RDU provides power and signal cable connections between the various system assemblies. The RDU includes a 15vdc power supply, RDU board assembly, 56K modem, and a 5-port ethernet hub switch assembly. There are no controls or indicators located on the RDU.

3.2.1.4. AC Power Distribution Unit (ACPDU)

The ACPDU provides multiple electrical outlets for the various EST 2000 components under control of a single circuit breaker. ACPDU controls and indicators are shown in Figure 3-28.

3.2.1.5. Monitor, keyboard, and mouse

The IOS utilizes an Autoscan On Screen Display (OSD) flat screen LCD color monitor with enhanced 104 keyboard and mouse. The keyboard, mouse, and controls and indicators for the monitor are shown in Figure 3-29.

3.2.1.6. 24V Power Supply

The 15V power supply provides primary and backup power to the RDU. There are no controls located on the power supply, however, there is a red LED which indicates that power is being supplied.

3.2.1.7. Modem

The modem is used for remote diagnostics. There are no controls or indicators located on the modem.

3.2.2. Printer

The EST 2000 printer is an HP6122 DeskJet printer with a modification made to the AC power cord. The printer is used to provide a hardcopy record of student performance. Controls and indicators for the printer are shown in Figure 3-30.

3.2.3. Projector/IR Camera Assembly

The EST 2000 projection system consists of the BARCO iQ Reality 350 projector assembly, IR camera assembly, and screen.

3.2.3.1. Projector

The projector assembly provides high fidelity video presentations and incorporates a fully automatic convergence and geometry subsystem. A resident diagnostic program provides self-test and troubleshooting capabilities. The projector can be controlled via the Remote Control Unit (RCU). Figure 3-31 provides an illustration of the projector system controls and indicators.

3.2.3.2. Projection Screen

The projection screen provided with the EST 2000 is a standard COTS product with minor modifications made to accommodate shipping. The screen frame is self-supporting and constructed of tubular aluminum fitted with quick assembly hand screws. Velcro® is affixed to the outside edges of the frame and mates with the Velcro® backing on the edge of the screen material.

3.2.3.3. IR detection camera

An IR detection camera is mounted on the top of the projector. The camera can be configured to be sensitive to visible or IR radiation by the position of an IR filter located in front of the camera. A control signal generated by the ATTR is used to energize a solenoid in the camera box, which changes the position of the filter. The IR filter is normally positioned in front of the camera lens so that the camera will only see the IR spots produced by the weapon laser when it is being aimed at the projection screen. Two micro switches monitor the position of the filter. One of the switches provides feedback information to the system to indicate that the filter is in the required position. The second micro switch is connected to the camera to select a longer integration time when the camera is viewing in the visible region of the spectrum. The video output from each camera provides the input signal for the ATTR assembly where processing is performed to determine coordinate information of the laser spots detected by the camera. This coordinate information therefore represents the aim point of each weapon. During installation of the EST 2000, the camera is accurately aligned with the corresponding projector image on the projection screen. This establishes the required relationship between the camera field of view and the projection screen so that the weapon aim point determined from the camera video output can be precisely related to the image. There are no controls and indicators located on the IR detection camera.

3.2.4. Audio System

Aural cues and sound effects for the EST 2000 are provided through the use of a self-powered loudspeaker system that incorporates a 160-watt amplifier for the low frequency transducer and a 40-watt amplifier for the high frequency driver. An illustration of the speaker is provided in Figure 3-32.

3.2.5. Air Compressor

The Air Compressor consists of a JUN-AIR model Air Compressor. The Air Compressor operates at 115V, 60Hz 20 amp or 220V 50 Hz 10 amp and has a maximum pressure rating of 160 psi. The unit is used to provide recoil for the simulated weapons. Compressed air is delivered via a trainer peculiar umbilical cord attached to each weapon and cycles the bolt as each round is fired (applicable weapon types only). Standard operating pressures for the EST 2000 system are 100 psi and 125 psi. The pressure regulator for the larger diameter outlet is set for 125 psi. The pressure regulator for the smaller diameter outlet is 100 psi. Controls and indicators for the Air Compressor unit are illustrated in Figure 3-33.

3.2.6. Floor Boxes

Each weapon is connected to the EST 2000 via a floor box. The floor box contains a Single Board Computer (SBC) which monitors the status of the weapon sensors and continually transmits this data back to the display controller computer via the RDU and serial link. The SBC also controls the supply voltage to the weapon laser and will inhibit this supply if the laser modulation signal drifts outside set limits or if the laser power level exceeds the value at which it would no longer be eye safe. A valve in the floor box, which allows the compressed air source to be applied to the weapon recoil piston, regulates weapon recoil. The valve is controlled by a solenoid, which is energized by the SBC when a trigger pull is detected. Controls and indicators for the floor boxes are illustrated in Figure 3-34.

3.2.7. Simulated Weapons

The EST 2000 simulated weapons are highly modified simulations of the actual equipment and possess the same feel, form, fit, and function as the live weapon. Simulated weapons will not accept live ammunition, blanks, or standard magazines. The simulated weapons cycle and produce recoil using a pneumatic actuator and compressed air. A pneumatic hose and electrical umbilical cord attached to the simulated weapon connect it to the compressed air supply and electrical system controls. Weapon operational characteristics are modeled to realistically simulate those of the actual weapon. Modifications to the weapons maximize user interface, do not impede the firer, and do not significantly alter the weight or balance of the weapon. The firer can perform normal procedures such as loading, cocking, selecting the firing mode, aiming with iron or optical sights, firing, clearing, unloading, and rendering the weapon safe. Detailed information concerning the operation of the simulated weapons is contained in Attachments 1 through 16.

3.2.8. Optical and Night Vision Devices

The EST 2000 enables the use of specific optical and night vision devices as detailed in the following paragraphs. Before installing each device the weapon should be zeroed with the iron sights on the appropriate range.

3.2.8.1. M68 Close Combat Optics (CCO)

The M68 Close Combat Optics (CCO) can be installed on the M16A2 or the M4 using the appropriate hardware supplied with the device. Refer to TM 9-1240-413-12&P for installation and operation procedures.

3.2.8.2. M145 Telescope, Machine Gun Optics (MGO)

The M145 Machine Gun Optics (MGO) can be installed on the M60, the M240B, and M249 in the light machine gun role. Refer to TM 9-1240-415-13&P for installation and operation procedures. For use with the M60 the M60 Mounting Bracket, part number (80063) A3170620, is required.

3.2.8.3. AN/PVS-4 Night Vision Sight

The AN/PVS-4 Night Vision Sight can be installed on the M16A2, M4, M249, M60 and M240B. Refer to TM 11-5855-213-10 for installation and operation procedures. For use with the M4, M249 and M240B the spacer (NSN 5365-01-447-8991) and rail grabber (NSN 5340-01-449-8533) is required. For use with the M60 the M60 Mounting Bracket (NSN 5855-01-046-7272) is required.

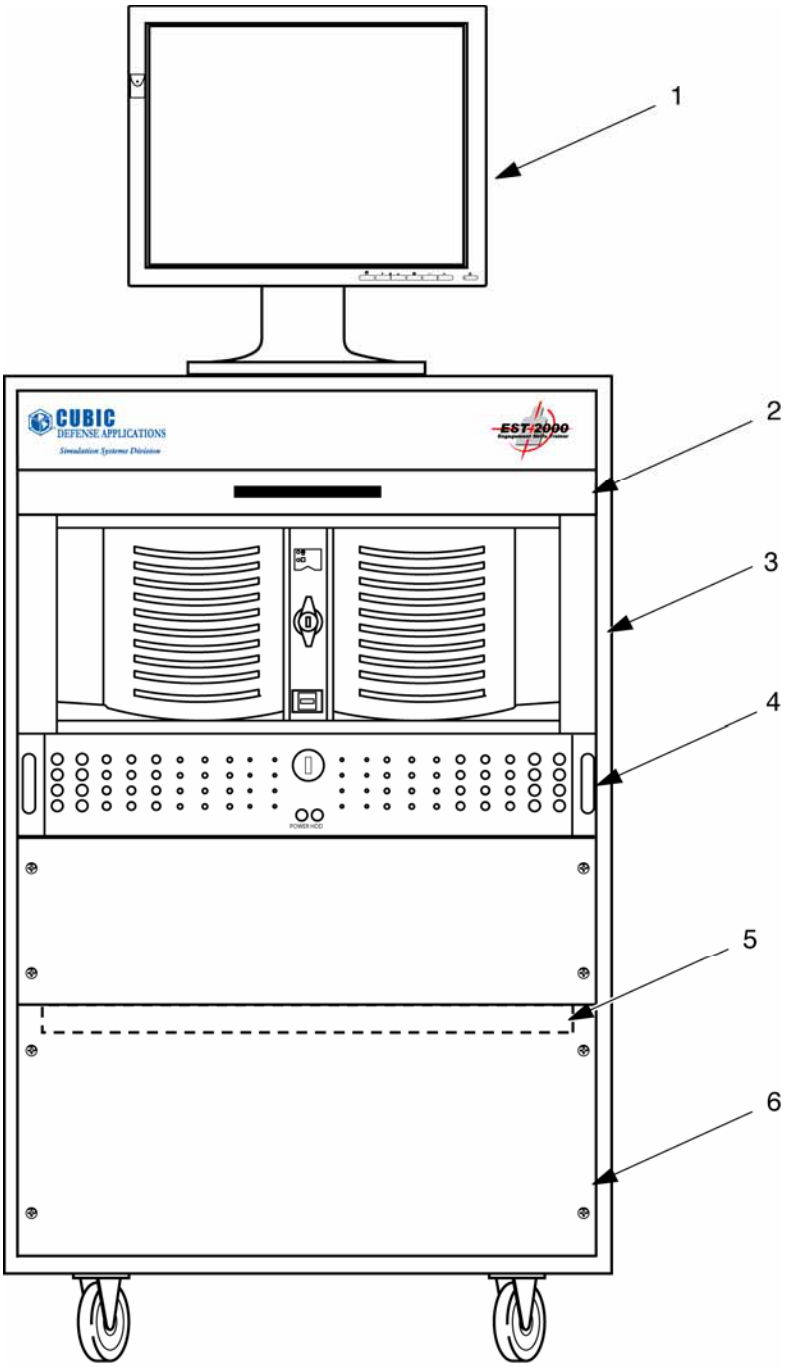
3.2.8.4. AN/TVS-5 Night Vision Sight

The AN/TVS-5 Night Vision Sight can be installed on the M2 and the MK19. Refer to TM 11-5855-214-10 for installation and operation procedures. Both weapons require the M2 mounting bracket (NSN 5855-01-045-5482).

3.2.8.5. Night Vision Devices

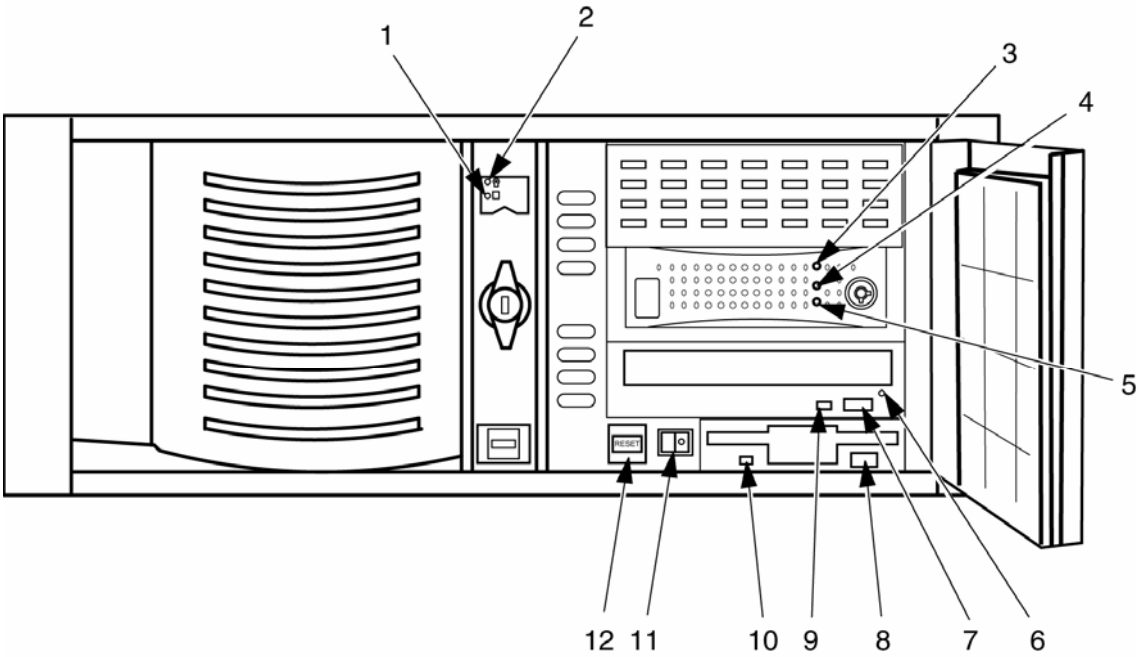
To use night vision devices, the IR filter assembly must be installed on the lens of the Projector Assembly. Any exercise originally run in daylight will now be compatible with the night vision devices. Special filters for specific sights are available through STRICOM. These filters will remove the trainer unique aiming laser spot from the trainees' view.

a. Install the IR filter assembly on the projector assembly lens (Figure 3-35).
b. Tighten the four thumbscrews securing the IR filter assembly to the projector assembly lens.
c. When night training is completed, loosen the four thumbscrews and remove the IR filter assembly from the projector assembly lens.



1.	Monitor
2.	Keyboard and Mouse
3.	Display Controller Computer
4.	Autotracker Assembly (ATTR)
5.	Rack Distribution Unit (RDU) – Rear of IOS
6.	AC Power Distribution Unit (ACPDU) – Rear of IOS

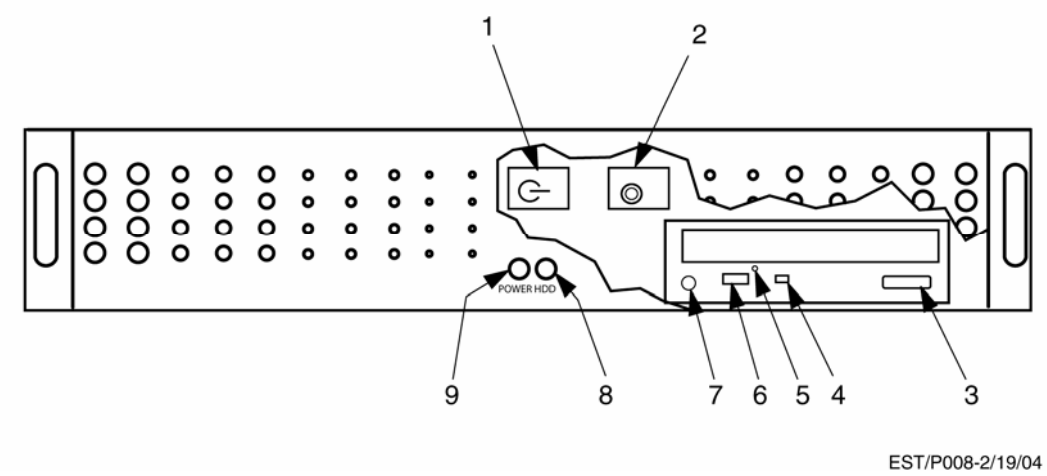
Figure 3-25. Instructor/Operator Station (IOS)



Item	Control/Indicator	Function
1	Power indicator LED	Green LED illuminates when power is on.
2	HDD indicator LED (external)	Red LED flashes during hard drive activity.
3	HDD indicator LED (internal)	Red LED flashes during hard drive activity.
4	HDD reset switch	Push switch used to reset the HDD.
5	HDD access LED	LED illuminates green indicating HDD is on. LED illuminates amber indicating fan failure/overheating. LED illuminates red indicating HDD failure.
6	CD/DVD emergency eject hole	Used when loading tray will not open when load/unload button is pressed.
7	CD/DVD load/unload button	Push switch used to open the loading tray.
8	3.5” disk eject button	Push switch used to eject 3.5” floppy disk.
9	CD/DVD activity LED	LED illuminates green or amber when CD/DVD is operating. LED illuminates amber when drive is writing.
10	3.5” floppy drive activity LED	Red LED illuminates when floppy drive is accessed.
11	Power switch	Black momentary rocker switch used to start system computer.
12	Reset switch	Red Pushbutton switch used to reboot the CPU operating system.

Note: Actual switch and Drive (CD and Floppy) positions may differ slightly from those shown.

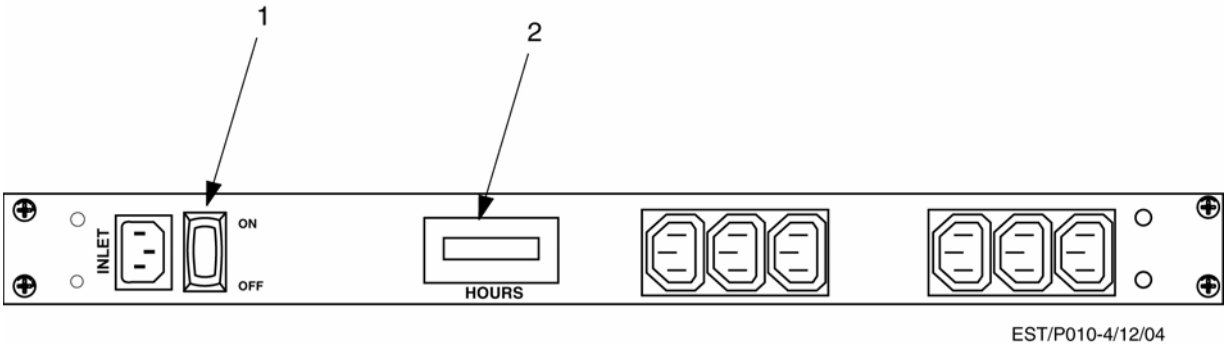
Figure 3-26. Display Controller Computer



Item	Control/Indicator	Function
1	Power switch	Black momentary rocker switch used to start system computer. (Internal)
2	Reset switch	Black momentary rocker switch used to reboot the ATTR operating system. (Internal)
3	CD load/unload button	Push switch used to open the loading tray. (Internal)
4	CD activity LED	LED illuminates green or amber when CD/DVD is operating. LED illuminates amber when drive is writing. (Internal)
5	CD emergency eject hole	Used when loading tray will not open when load/unload button is pressed. (Internal)
6	CD volume control	Potentiometer (thumbwheel switch) used for volume control. (Internal)
7	CD connector jack	Connector used to connect headphones. (Internal)
8	HDD indicator	Red lamp. Flashes each time the program is run.
9	Power indicator	Green lamp. Illuminates when on.

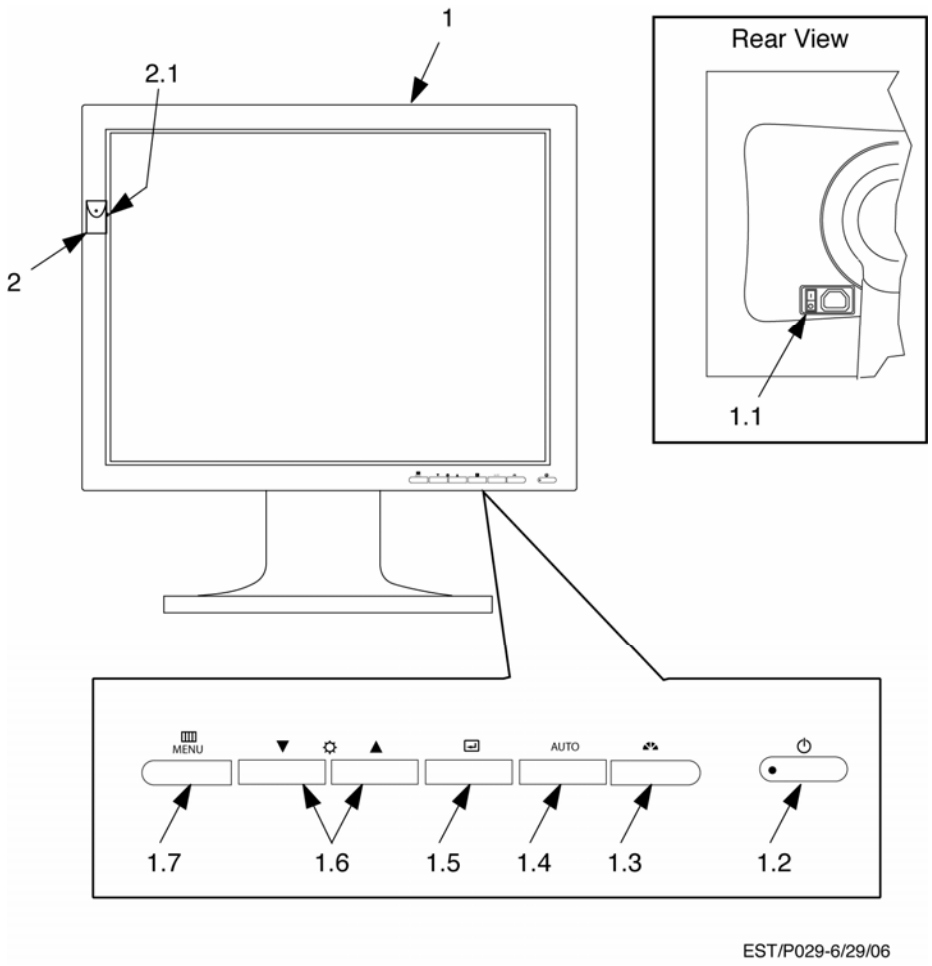
Note: Actual switch and Drive (CD) positions may differ slightly from those shown.

Figure 3-27. Autotracker (ATTR)



Item	Control/Indicator	Function
1	Power switch.	2-position switch.
2	Digital Counter	Digital counter used to indicate elapsed operation time.

Figure 3-28. AC Power Distribution Unit



Item	Control/Indicator	Function
1	Monitor	19” color monitor
1.1	Power Switch	2-position hard power switch
1.2	Power button	Hybernate power switch (Power On: Green)
1.3	MagicBright button	MagicBright is a new feature providing optimum viewing environment depending on the contents of the image you are watching.
1.3	Auto button	When the 'AUTO' button is pressed, the Auto Adjustment screen appears as shown in the animated screen on the center. Auto adjustment allows the monitor to self-adjust to the incoming video signal. The values of fine, coarse and position are adjusted automatically. (Available in analog mode only)
1.4	Enter button/Source button	Activates a highlighted menu item. / Push and then select the video signal while the OSD is off. (When the source button is pressed to change the input mode, a message appears in the upper left of the screen displaying the current mode -- analog or digital input signal.) Note : If you select the digital mode, you must connect your monitor to the graphic card's DVI port using the DVI cable.
1.5	Brightness buttons	Adjust items in the menu. When OSD is not on the screen, push the button to adjust brightness.
1.6	Menu button	Opens the OSD menu, exits the OSD menu, or return to the previous menu.
2	Microphone	Mountable microphone
2.1	Power Switch	2-position switch

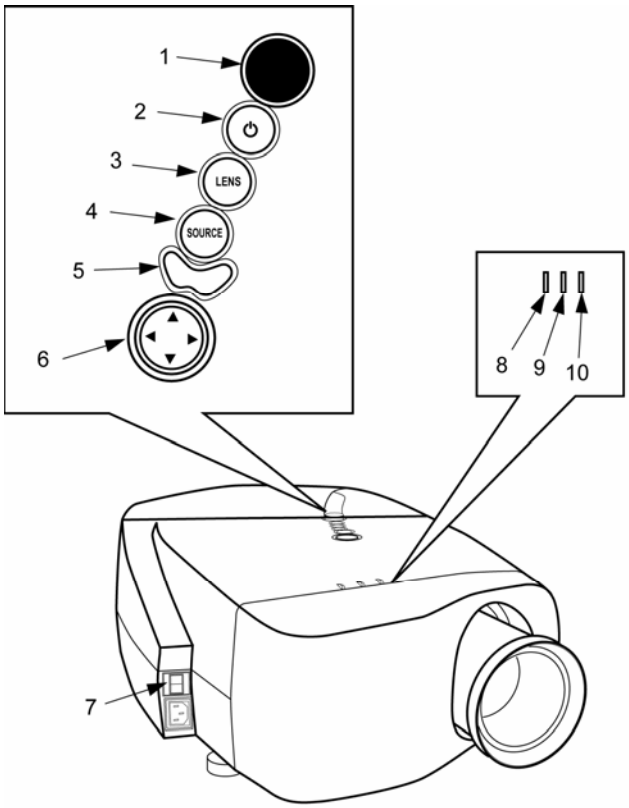
Figure 3-29. Monitor, Keyboard, Mouse (Sheet 1 of 2)

Item	Control/Indicator	Function
3	Keyboard	Enhanced 104 keyboard.
4	Mouse Pad Platform	Rigid mouse pad platform.
5	Mouse	2-button mouse.

Figure 3-29. Monitor, Keyboard, Mouse (Sheet 2 of 2)

Item	Control/Indicator	Function
1.	Cancel Button	Cancels the current print job.
2.	Print Cartridge Status Light	The light inside the Print Cartridge Status symbol flashes when a print cartridge is low on ink or incorrectly installed, or the printer's top cover is open.
3.	Resume Button and Light	Flashes to indicate an action is required such as loading paper or clearing a paper jam. When the action is completed, press the Resume button to continue printing.
4.	Power Button and Light	Turns power on and off. The green light next to the Power Button flashes when the printer is progressing.
5.	Activity Light	Flashes when the printer is receiving or transmitting data over the ethernet connection..
6.	Link Light	Link light is solid when the printer is powered on and connected to an ethernet network

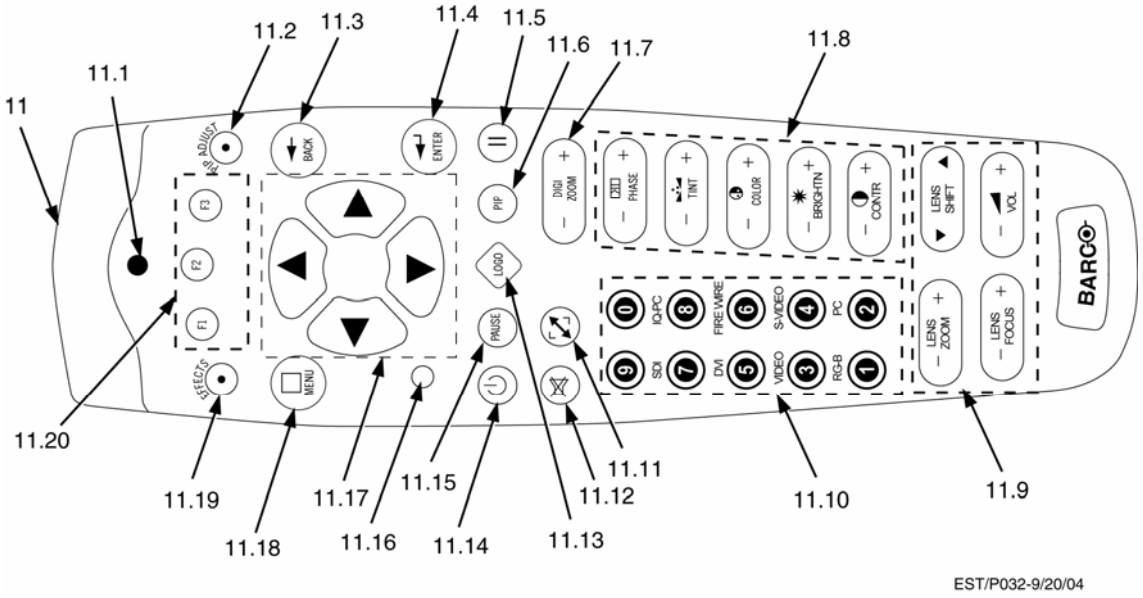
Figure 3-30. Printer



*Items 1 through 6 are shown for clarity reasons only. Under normal operation, these buttons will be covered by the Camera Assembly and not accessible.

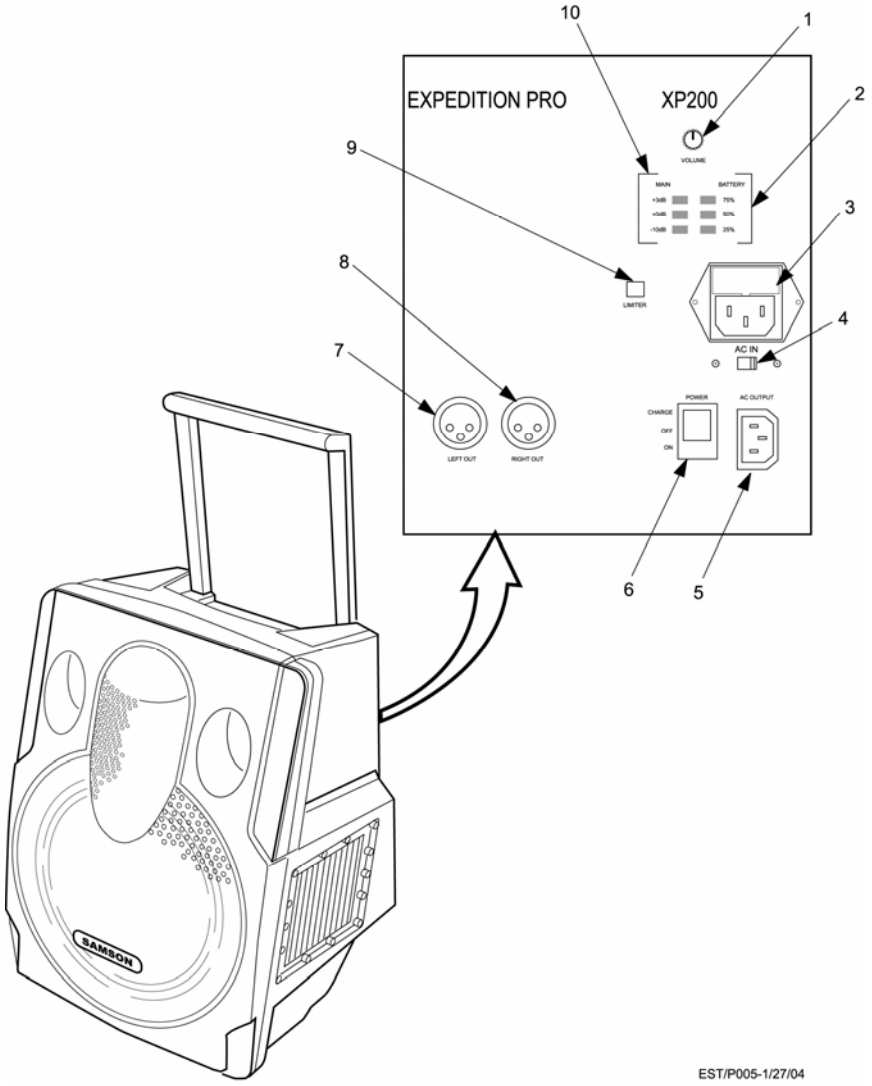
Item	Control/ Indicator	Function					
1*	IR receiver	IR receiver					
2*	STBY	Used to initiate remote power up operation or stop projection without main power off. When the projector is running, press for 2 seconds to switch to Standby mode.					
3*	Lens Control	Used to obtain the desired ZOOM, SHIFT, FOCUS.					
4*	SOURCE button	Allows the user to switch through the active inputs.					
5*	Back	Used to leave the selected menu or item (go upwards to the previous menu).					
6*	Cursor keys	Used to make menu selections or access the toolbar.					
7	On/Off Switch	Power control switch.					
		Powered Off	**Standby**	**Turning On**	**On**	**Pause**	**Cooling Down**
8	LED 1	Off	Off	Off	Off	Off	Flashing Green
9	LED 2	Off	Off	Off	Off	Off	Off
10	LED 3	Off	Red	Amber then Green	Off	Off	Red

Figure 3-31. Projection System (Sheet 1 of 2)



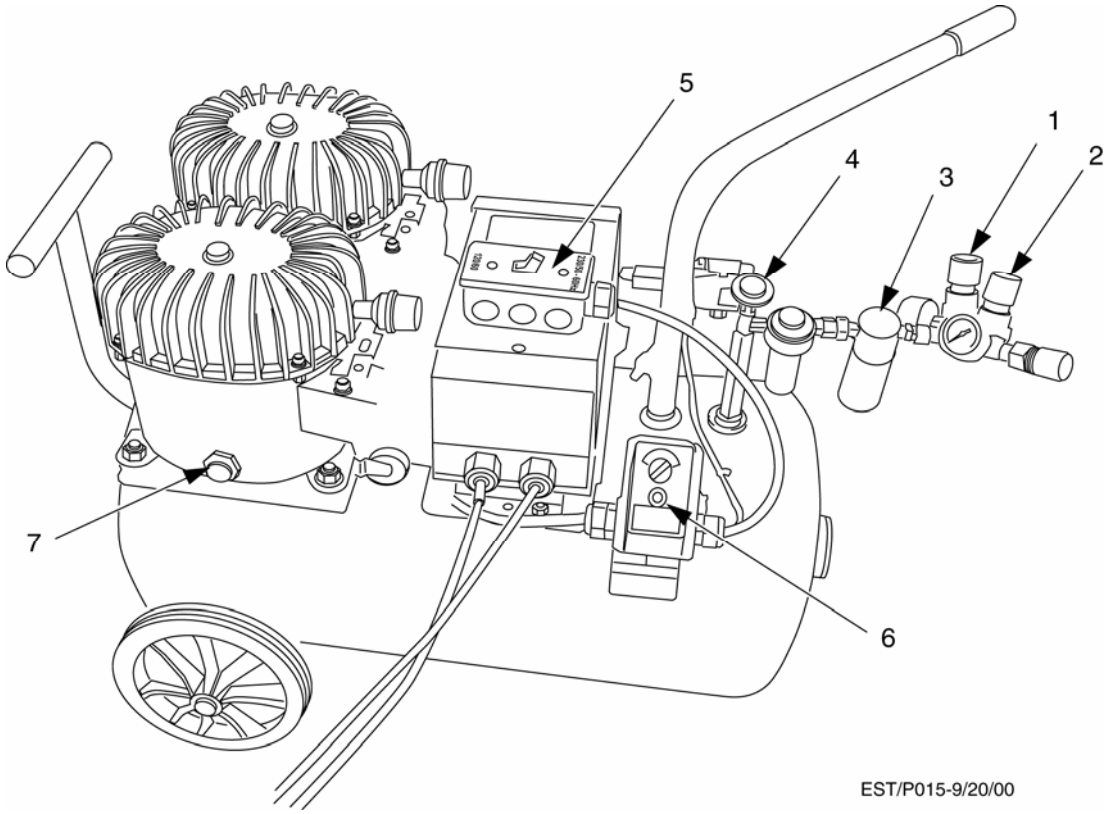
Item	Control/Indicator	Function
11.	Remote Control	Remote input device.
11.1	RC operating indicator	Lights up when a button on the remote control is pressed. This is a visual indicator to check the operation of the remote control.
11.2	PIP ADJUST	Used to select a PiP window and change its configuration on screen.
11.3	BACK	Used to leave the selected menu or item (go upwards to the previous menu).
11.4	ENTER	Used to start up the adjustment mode or to confirm an adjustment or selection in the adjustment mode.
11.5	FREEZE	Used to freeze the projected image.
11.6	PIP	Used to activate the PICTURE IN PICTURE mode.
11.7	DIGI ZOOM	Allows a digital zoom of a part of the image.
11.8	Picture controls	Phase, tint, color, brightness, and contrast controls. Used to obtain the desired picture analog level.
11.9	Lens Controls	Used to obtain the desired ZOOM, SHIFT, FOCUS.
11.10	Digit Buttons	Used for direct input selection.
11.11	AUTOIMAGE	Used to center the image on the active LCD surface.
11.12	Mute	No function in this projector.
11.13	LOGO key	Used to recall the stored Logo (not in PiP mode).
11.14	STBY	Used to initiate remote power up operation or stop projection without main power off. When the projector is running, press for 2 seconds to switch to Standby mode.
11.15	PAUSE	Used to stop projection for a short time. The image disappears but full power is retained for immediate restarting.
11.16	Address key	Used to enter the address of the projector (between 0 and 9). Press the recessed address key with a pencil, followed by one digital button between 0 and 9.
11.17	Cursor keys	Used to make menu selections or access the toolbar.
11.18	ADJ	Used to enter or exit the adjustment mode.
11.19	EFFECTS	No function in this projector.
11.20	Function Keys	Programmable keys with functions for direct access.

Figure 3-31. Projection System (Sheet 2 of 2)



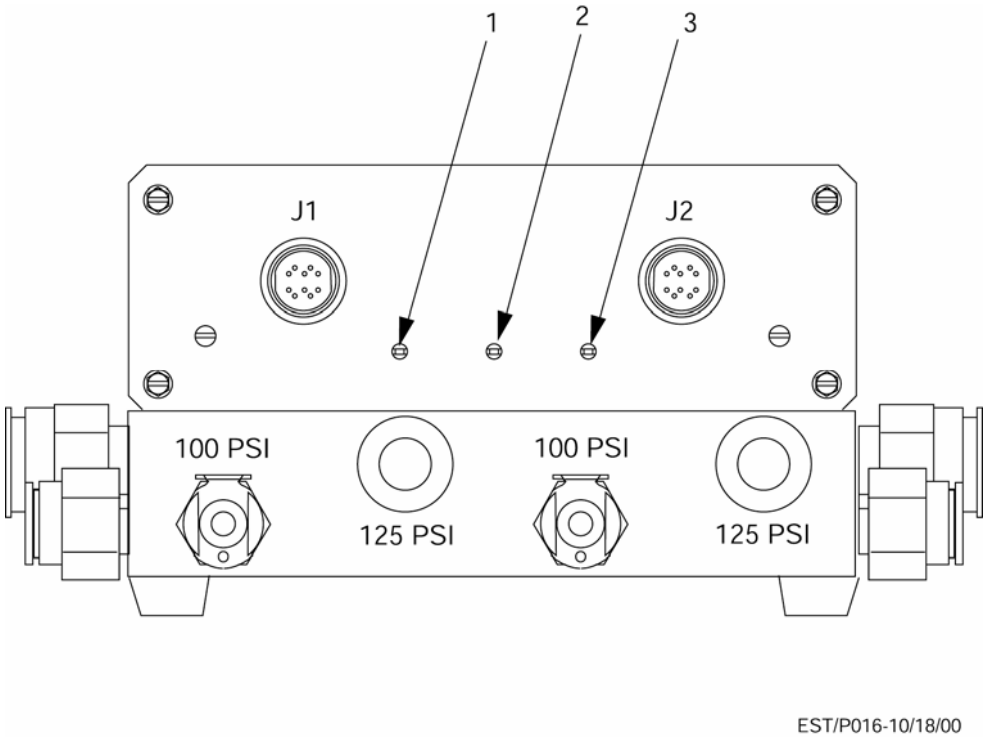
Item	Control/Indicator	Function
1.	Volume control	Set the level of the built-in power amplifiers.
2.	Battery VU meter	N/A
3.	AC input	Connect the supplied heavy-gauge 3-pin IEC power cable here.
4.	Voltage selector	2-position switch used to select correct voltage for country used in.
5.	AC output	AC power outlet
6.	Power switch	2-position switch
7.	Input connector	Connector used to route line-level signal into the speaker.
8.	Output connector	Connector used to carry the line-level output signal from the speaker.
9.	Limiter Switch	2-position switch used to turn the built-in limiter circuitry on or off.
10.	Output VU meter	Three-segment bar meter that shows output level.

Figure 3-32. Speaker



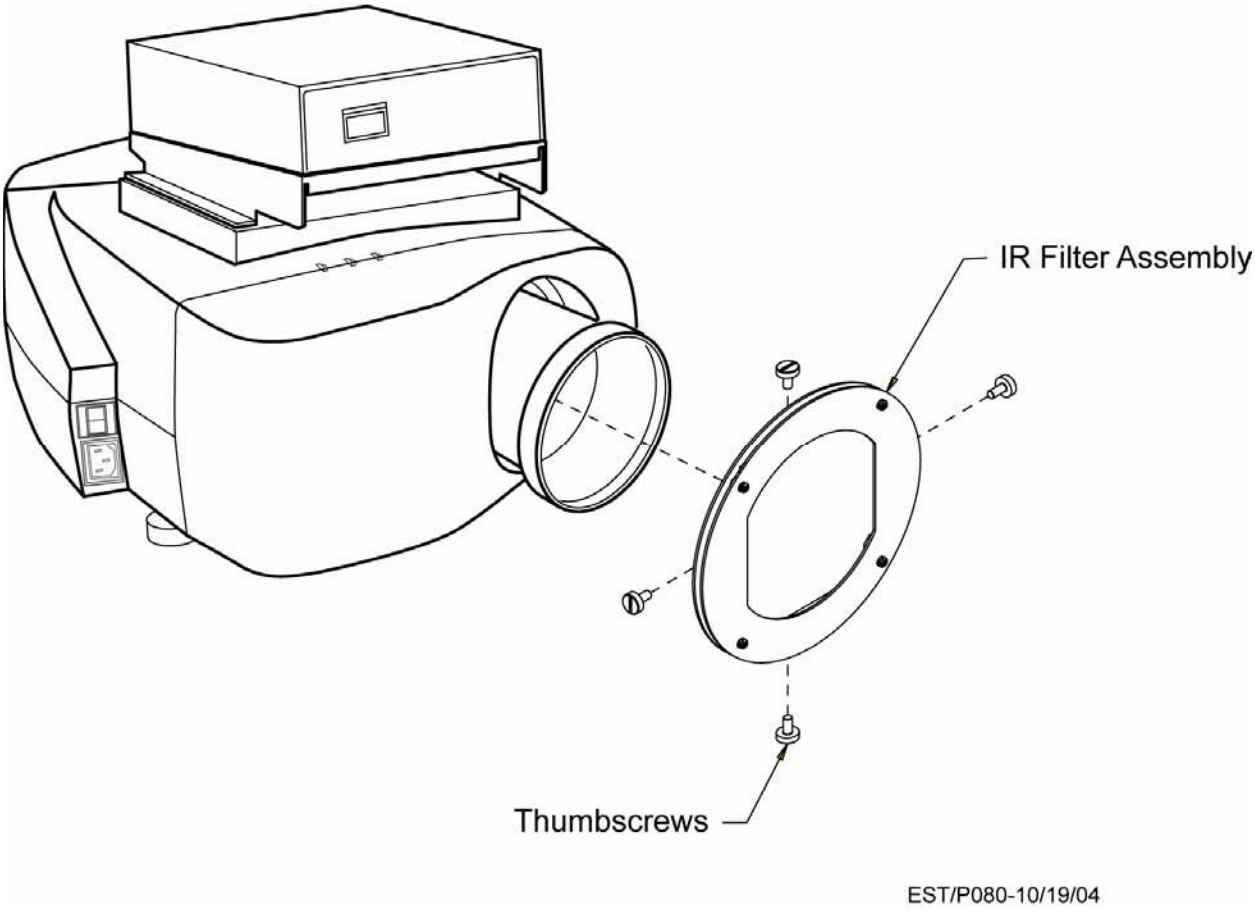
Item	Control/Indicator	Function
1.	Pressure Regulator	Used to set 100 psi.
2.	Pressure Regulator	Used to set 125 psi.
3.	Filter Assembly	Used to trap oil and condensation.
4.	Main Air Valve	Controls air to system.
5.	Voltage Selector Switch	Used to select 110 or 220 volts.
6.	Master Power Switch	Used to control power to unit.
7.	Oil-Sight Level (2)	Indicates oil level.

Figure 3-33. Air Compressor



Item	Control/Indicator	Function
1.	J1 Indicator Light	Solid green light – Port enabled, ready for weapon connection. Flashing green light – Data transfer from weapon to host. Solid orange light – Port disabled, not ready for weapon connection. Flashing orange light – Data error from weapon to host. Check weapon.
2.	Status Indicator Light	Orange flashing light – Data transfer to host.
3.	J2 Indicator Light	Solid green light – Port enabled, ready for weapon connection. Flashing green light – Data transfer from weapon to host. Solid orange light – Port disabled, not ready for weapon connection. Flashing orange light – Data error from weapon to host. Check weapon.

Figure 3-34. Floor Box



*The thumbscrews are shown exploded for clarity.

Figure 3-35. IR Filter Assembly

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

3.3. OPERATOR INSTRUCTIONS

The following subparagraphs provide instructions on the operation of the EST 2000. Appendix B provides step by step procedures for setting up, performing, and evaluating a sample EST 2000 exercise. Appendix C provides an operating procedure overview for use as a refresher for Instructor/Operator personnel already familiar with EST 2000 operation.

3.3.1. Weapon Safety

Each simulated weapon has the same appearance as a fully functioning weapon, with the exception of the trainer peculiar umbilical cable. Under certain circumstances, especially in the subdued light of a training room, it is possible to mistake a "live" firearm for a simulated weapon. This situation could create the potential for personal injury or damage to property. To avoid confusion, neither live nor blank ammunition, nor any live weapons, should be allowed in the training room.

Simulated weapons will not accept live or blank ammunition. Any attempt, accidental or otherwise, to chamber a live or blank round may damage the simulated weapon and create an unsafe situation.

The following general safety precautions should be adhered to:

- Fire simulated weapons only if they are pointed downrange
- Post WARNING signs at all entry doors
- Do not allow personnel to stand downrange from the firing line
- Instruct weapons handlers never to look directly into a barrel
- Take the weapon off-line for testing and service at the first indication of malfunction and refer to troubleshooting procedures.

3.3.2. Laser safety

WARNING

Laser light is used in the operation of this equipment. Injury may result if personnel fail to observe safety precautions. Never stare into the laser beam, look down the barrel of the simulated weapon, or directly view the laser beam with optical instruments. Avoid direct eye exposure. No one should be allowed beyond the firing line. The Instructor/Operator and NCOIC should ensure that all persons entering the training room are aware that laser radiation is present.

The lasers used in the simulated weapons meet ANSI Standard Z136.1-1993 Class I Standards for single laser pulse power. This classification is commonly referred to by the industry rating of "eye-safe". However, even eye-safe lasers may be dangerous under extraordinary circumstances. To ensure personnel safety, weapons handlers should not stare directly down a simulated weapon barrel. Serious eye injury could result if a laser malfunctioned while a user was staring into the weapon's muzzle (into the laser beam).

3.4. TRAINING SYSTEM OPERATION

To enter into the EST 2000 training environment, follow the instructions listed below:

3.4.1. Preparation for Training

Perform the following operations in the sequence presented to bring the EST 2000 to a powered-on, ready for training condition.

a. Prior to scheduled training, coordinate with the incoming unit to obtain the information listed below, and input this information according to the instructions contained in paragraphs 3.5.1.2.1., 3.5.2.3.1., and 3.5.3.2.1.
   - The name, ID, rank, squad, platoon, company, and battalion of each firer; and the type of practice or training desired (i.e., Marksmanship, M16 Battlesight Zero).

   Note: The Firer ID DOES NOT have to be a Social Security Number. The Firer ID can be any combination of numbers and/or letters that uniquely identifies the individual.

b. Conduct Pre-training Equipment Checks

   Air Compressor:
   Ensure the oil-sight level reads within minimum and maximum levels.
   Power up the Air Compressor.
   Open the main air valve.
   Ensure air pressure gauges register between 130 psi and 160 psi for the Air Compressor main gauge, 100 psi for the small line, and 125 psi for the large line.
   Press the spring-loaded manual drain to remove moisture.

   Note: Air Compressor main gauge (tank) pressure is factory set. The Air Compressor will start if tank pressure drops below 130 psi and will stop when pressure reaches 160 psi. The two line regulators may be adjusted if line pressure is incorrect. Pull up on the regulator “cap”, turn clockwise to increase pressure, or counterclockwise to decrease pressure. When desired pressure is reached push “cap” down, locking it place.

   Projector and IR Camera:
   Remove and store projector lens cover.
   Ensure power and data connections are secure.

   Floor Boxes:
   Check air-supply lines.
   Check data cable connections

   Weapons:
   Verify weapons air hoses and data cables are free of kinks and frays.
   Ensure weapons are lightly lubricated. Refer to appropriate attachment (Simulated Weapons attachments 1 – 16) for guidance.

   Note: In addition to the electrical line connector, there is one of two (2) different types of air line connections on the weapons, one is brass (125 psi) and the other is silver (100 psi) in color. In connecting these to the Floor Box, remember to connect brass to brass (125 psi connector) and silver to silver (100 psi connector). Figure 3-34 shows the location of these connections on the Floor box. On the electrical line connector, there is a dimpled node on the end of the connector that must be on top (12o’clock position) when making the connection.

   Instructor/Operator Station (IOS):
   Ensure all connections on the RDU and ACPDU are secure.

3.4.2. Training Operation Procedures

The following provides the EST 2000 power-on procedures as well as procedures for navigating through the various EST 2000 screens/menus.

Note: At the EST Login Screen selecting the “Training” menu option allows the Instructor/Operator to proceed directly to the practice training modes (paragraph 3.5. and Figure 3-47). Selecting the “Menu” option presents the EST Main Menu Screen (Figure 3-81) where the Instructor/Operator’s options are:

- “Engagement Skills”
  - ✓ This selection presents two additional choices
    1. “Training" - training modes (paragraph 3.5. and Figure 3-47)
    2. “Roster and Training History" - class rosters and courses completed (paragraph 3.6).
- “Maintenance” - presents the EST Maintenance Menu (paragraph 3.7. and Figure 3-92)
- “Scenario Editor” - Accesses editor program (appendix D)
- “Integrated Courseware” – Accesses training program (paragraph 3.8.).
- “Help” – Accesses the embedded documentation on the EST 2000 System (paragraph 3.9).
- “Exit” (paragraph 3.10.)

For a block diagram of these options, refer to Figure 3-36.

3.4.2.1. Start-up Procedures

a. At the IOS, power-up the system. The switch is located at the rear of the IOS on the ACPDU.

   Note: When the projector assembly is turned on, it goes into “standby” mode. The projector assembly requires a 5-minute warm-up period before it can be used. The projector must be taken out of “standby” mode for the warm-up period to begin. The EST system will automatically take the projector assembly out of the “stand-by” mode during the “boot-up” sequence.

b. When the computer has completed system “boot-up”, the EST Login Screen will be displayed on the IOS monitor. Figure 3-37.
c. Wait five minutes for the projector assembly to complete the warm-up period before continuing.
d. Enter the Password “EST” and click on "1. Training". Figure 3-38.
e. Click "OK" to begin training.
f. Select "Marksmanship", "Collective", or "Shoot-Don't Shoot" from the Practice Type Screen. Figure 3-39.
g. See paragraph 3.5. for the procedures to run each training type.

   Note: Occasionally system generated messages (i.e., “Illegal Operation” and “This machine has been configured...”) are projected on the large Projection Screen, if the Projector is in “standby” mode, the operator won’t know there’s a message requiring a response. The system is “dead” until the message is acknowledged. If the computer hangs up/freezes at any time, the operator should take the Projector out of “standby” to check for system generated messages. If there are no system generated messages, reboot the system by turning off the power for at least 60 seconds and then turning the power back on. If the system still hangs or freezes after rebooting, refer to the Troubleshooting Procedures located in Chapter 4.

.

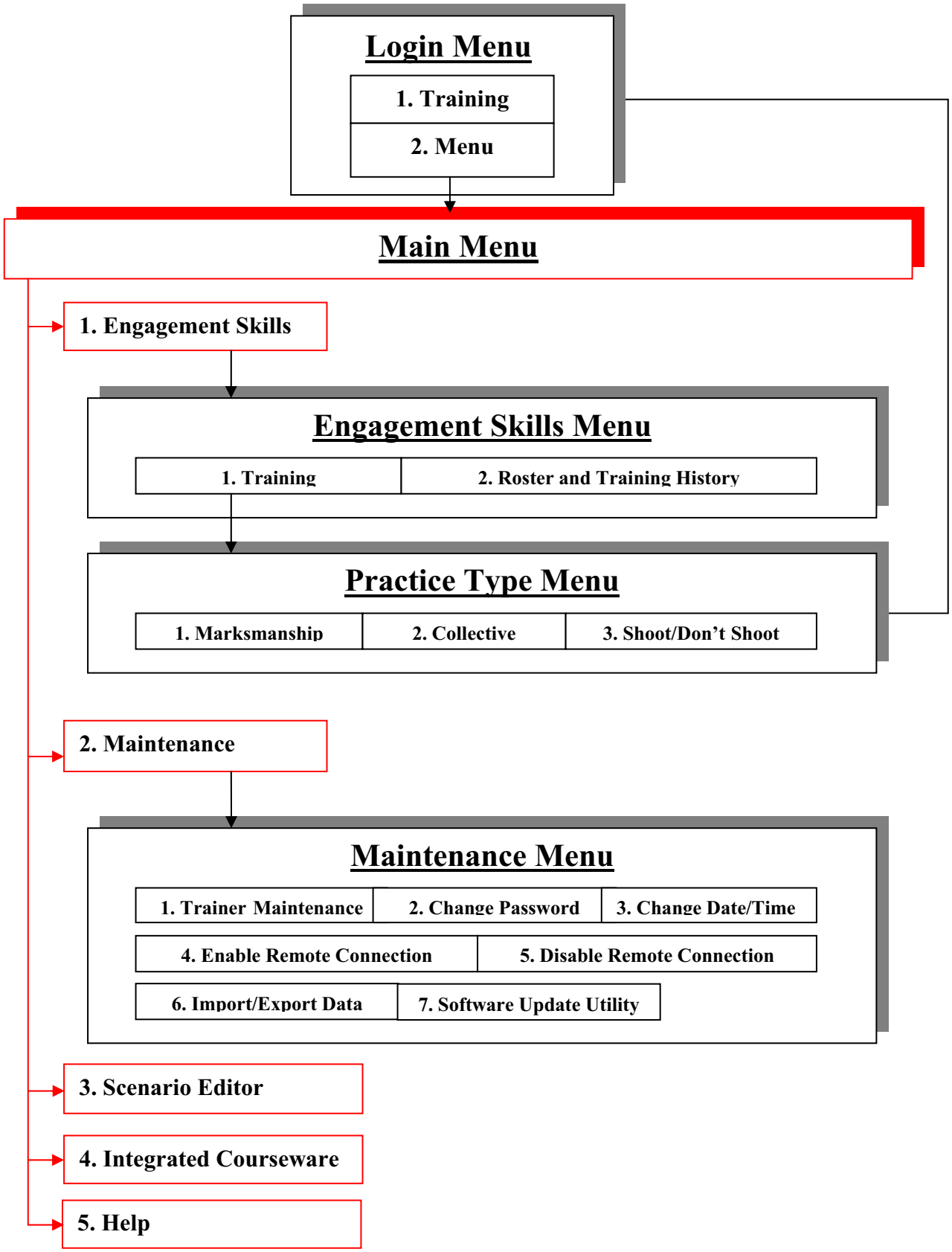


Figure 3-36. System Navigation Block Diagram

Figure 3-37. Login Screen (Menu Selected)

Figure 3-38. Login Screen (Training Selected)

3.5. PRACTICE TYPES

The desired practice type is selected from the Practice Type Screen as shown in Figure 3-39. The Practice Type Screen allows the Instructor/Operator to choose training practices in one of three training types (Marksmanship, Collective, or Shoot /Don't-Shoot). See the following subparagraphs for operating the differing training modes:

- Marksmanship Paragraph 3.5.1.
- Collective Paragraph 3.5.2
- Shoot/Don't Shoot Paragraph 3.5.3

3.5.1. Marksmanship Mode

Marksmanship training provides basic range firing and qualification training and is accomplished in either 5, 10, or 15-lane configurations. Each firer is restricted to one firing lane. The Marksmanship core scenario descriptions are listed in Table 3-1.

Note: The EST 2000 subsystem contains three floor boxes for each five lanes of training. When setup, the third floor box only supports one lane of training (except in collective mode for tandem weapon capabilities).

a. To begin Marksmanship training, select "1. Training" from the Engagement Skills Trainer Login Screen (Figure 3-38).
b. On the Practice Type Screen, select "1. Marksmanship", then click on "OK" (Figure 3-39).
c. The Subsystem Allocation Screen (Figure 3-40) appears. Select the desired lane configuration by clicking on Station 1, 2, or 3 for 5-lane operation; 1 and 2, or 2 and 3 for 10-lane operation; or 1, 2, and 3 for 15-lane operation, then click on "OK".

   Note: The Instructor/Operator's options may be limited, based upon individual site configurations. The station marked with an asterisk indicates the IOS in which the Instructor/Operator is physically operating from.

d. The system will automatically initialize at this point (Figure 3-41).
e. After Autotracker calibration has been completed, the Instructor/Operator will see the Engagement Skills Trainer Assign Firers Screen (Figure 3-42) on the IOS Monitor. If Autotracker Calibration is unsuccessful, the Instructor/Operator will see an Autotracker Calibration Failure Message on the IOS Monitor.

   Note: If Autotracker Calibration has failed, the Instructor/Operator should refer to Table 4-8 in the Troubleshooting Section of this manual.

f. From EST Assign Firers Screen (Figure 3-42) select "Hardware" on tool bar (paragraph 3.5.1.1.) at top left (Figure 3-43) and check the Sight Aim Point (SAP) on each connected weapon. (paragraph 3.5.1.1.2.2. Check Weapon Laser Alignment)

3.5.1.1. EST Tool Bar

The tool bar at the top left of the screen (Figure 3-43) provides drop down menus under IOS and HARDWARE. The paragraphs below describe the drop down menus.

3.5.1.1.1. IOS drop down menu

Selecting "IOS" will present a drop down menu containing "Preferences" and "Return to Main Menu" (Figure 3-43).

3.5.1.1.1.1. Preferences

Select "Preferences" and the Preference Screen (Figure 3-44) will appear allowing the Instructor/Operator to set the following options:

- Auto Calibrate after Nth course load – Automatically calibrates the laser tracking system after the entered number of courses run, i.e. if N=1, everytime a course of fire is loaded, the system will calibrate the laser tracking system.
- Set Auto-Save ON by default – enable the AutoSave option on the run practice tab.
- Trainee results hidden – if selected, the trainee results will not be displayed on the projection screen at the end of each table.
- Dispersion OFF in Zeroing courses – any scenario that uses the method of zeroing will have simulated dispersion disabled.
- Use alternate 25m target – provides a higher contrast 25m target.
- IET Marksmanship Location – allows the instructor to select from a variety of backdrops.

3.5.1.1.1.2. Return to Main Menu

Select "Return to Main Menu" and a pop-up query box is displayed asking the Instructor/Operator to confirm the selection.

3.5.1.1.2. Hardware drop down menu

Selecting "HARDWARE" will present a drop down menu containing Calibrate Autotracker, Check Weapon Laser Alignment, Toggle Screens, and Microphone On. The paragraphs below describe each of the drop down menu options under the Hardware drop down menu.

3.5.1.1.2.1. Calibrate Autotracker

Used to recalibrate the Autotracker without leaving the selected mode of training. Select "Calibrate Autotracker", a pop-up window will appear allowing the Instructor/Operator to recalibrate the system's ATTR from within the currently selected training mode.

3.5.1.1.2.2. Check Weapon Laser Alignment

To check the Sight Aim Point (SAP), select "Check Weapon Laser Alignment". A pop-up window will appear allowing the Instructor/Operator to turn on the SAP for each weapon connected to the system. Select "Initiate" on this pop-up window. The projection screen will go dark and a green sight aim point with a lane number alongside will be visible from each connected weapon as the weapon is aimed at the screen (Figure 3-45).

After checking each weapon, select "Terminate" and then "Dismiss" to return the system to the training selected.

Note: The Check Weapon Laser Alignment feature should be used as a daily pre-training check to ensure correct weapon laser to weapon sight alignment. A properly aligned weapon will show the laser's SAP aligned with the weapon's sights as the weapon is aimed anywhere on the screen.

3.5.1.1.2.3. Toggle Screens

A feature that will allow the "swapping" of views on the IOS Monitor and the Projection Screen. Select "Toggle Screens", the view from the IOS monitor will appear on the projection screen and the view from the projection screen will appear on the IOS monitor. This is especially useful during Train-The-Trainer sessions for newly assigned Instructor/Operators.

Select "Toggle Screens" (IOS view on the projection screen) to return views to normal operation.

3.5.1.1.2.4. Microphone On
Turn the microphone On or Off by selecting or deselecting this option.

3.5.1.2. Training Control Menus
Training control menus incorporate user-friendly softkeys, display windows, and pulldown selection menus to help the Instructor/Operator quickly and efficiently initiate and monitor training on the desired simulation. Training control menus available from the training mode of operation include Assign Firers, Load Practice, Setup, and Run Practice. These training control menus are defined in the following paragraphs.

3.5.1.2.1. Assign Firers
The Assign Firers Screen is used to manage rosters, firers, and lane assignments. The Instructor/Operator is able to add, edit, delete, and review firer information using the softkeys available on the Assign Firers Screen. The Instructor/Operator can also export and import firer data and/or rosters via a 3½" floppy disk drive or a CDRW drive (paragraphs 3.6.2.4, 3.6.2.5, and 3.6.2.2).

Note: Activate the microphone by clicking the microphone button on the Assign Firers Screen. Adjust the volume of the system speakers by sliding the indicator to the right to increase and to the left to decrease the volume. The microphone button is displayed throughout the practice.

a. Before assigning a firer, connect a weapon to the floor box to activate the lane.

Note: If a weapon is new to the system, then it needs to be added to the subsystem's weapon database. Refer to Appendix E (paragraph E-1.2.1.4) for the procedure to add new weapons to the subsystem's weapon database.

b. Add a firer by clicking the softkey displayed in lower left of Assign Firers Screen (Figure 3-42). The Instructor/Operator will be prompted to add a new or existing firer (Figure 3-46). Select the appropriate choice and the Firer Data screen will appear (Figure 3-47). Required data fields are: Last Name; First Name; and Firer ID.

Note: The minimum information required when adding firers using this method is Last Name and Firer ID.

Note: The Firer ID DOES NOT have to be a Social Security Number. The Firer ID can be any combination of numbers and/or letters that uniquely identifies the individual.

The Instructor/Operator can also add multiple firers at once by clicking on the Generate Roster softkey. The Generate Roster screen (Figure 3-48) will appear with a default value for Number of Shooters and Groups. Enter the required data and click on "OK". The system will generate a roster for use in training.

c. To edit or delete a firer's data, click on the softkeys and change the information as required.

Note: When deleting a firer from the entire system, a message box will appear (Figure 3-49) asking the Instructor/Operator to verify this action before proceeding.

3.5.1.2.2. Select Roster

A roster identifies a specific group of individuals.

a. Create a roster by clicking on Select Roster on the Assign Firers Screen (Figure 3-42). Using the softkeys, the Instructor/Operator can Add, Edit, Delete, Print, Store, Retrieve, or Generate a roster.
b. Add firers to a specific roster by clicking on the Add Firer softkey.
c. Generate an automatic roster by clicking on the Generate Roster softkey.

Note: To Store or Retrieve a roster see paragraphs 3.6.2.1 and 3.6.2.2.

Note: Roster option tabs can be used in conjunction with the Selected Roster pulldown menu. For example, to view details of a previously saved roster, first click the down arrow next to the Selected Roster window and highlight the desired roster from the pulldown menu. Click on Edit Roster to display detailed information on the selected roster. Other roster options include Add Roster, Delete Roster, Print Roster, Store Roster, Retrieve Roster, and Generate Roster.

3.5.1.2.3. Load Practice

a. Click on the Load Practice tab to access the Load Practice Screen. The Load Practice Screen (Figure 3-50) provides for the selection of individual tables/tasks or courses of fire based upon the weapon selected in the weapon Category field.
b. Begin by selecting either Courses of Fire or Individual Tables/Tasks (Table 3-1).
c. Click on the down arrow in the Category field to display a list of weapon types. Following the selection of a weapon, a list of available tables/tasks or courses of fire is displayed.
d. Click on the View Practice Description box (lower left side of screen), a description of the highlighted practice appears in the practice description window on the right side of the screen.
e. The desired practice is loaded by first highlighting it in the Practice menu and then clicking on the Load This Practice key. A momentary message, “Loading Practice Defaults”, appears following the selection of the Load This Practice key.

3.5.1.2.4. Setup

a. Click on the Setup tab to access the Setup Screen (Figure 3-51). The Setup Screen allows the Instructor/Operator to specify conditions for the selected scenario.
b. The Current Conditions display (Figure 3-52) allows the Instructor/Operator to modify weather conditions if required. Modifiable conditions include visibility, wind, diffuse lighting (ambient lighting is not available) and bullet options.

Note: Bullet splash on and dispersion on are the default bullet option setting.

c. Modify weapon settings using the Change Settings softkey located on the Settings display. Weapon types and lane assignments are displayed in the Weapon Parameter window. The Weapon Settings display (Figure 3-53) on the Setup Screen provides weapon-specific data such as magazine and ammo quantities for a weapon highlighted in the Weapon Parameter.

3.5.1.2.5. Run Practice

a. To begin training, click on the Run Practice tab to access the Run Practice Screen.
b. Click the Run Practice (▸) button. An “Initializing Weapons - Please Wait” message box appears followed by an instruction to “lock and load weapons now” (Figure 3-54).
c. Instruct the firers to “lock and load” their weapons when the message box appears.

Note: If the firer locks and loads a weapon before the Instructor/Operator gives the command, the ammo settings for the weapon may be improper. Likewise, if the Instructor/Operator clicks on "OK" prior to all firers successfully locking and loading their weapons, the scenario may not run properly.

d. When the status of all lanes changes from NOT READY (Figure 3-55) to READY (Figure 3-56) click "OK" to proceed.

Note: The Run Practice default screen is multi-lane status (Figure 3-57). The multi-lane targets view is shown in Figure 3-58. The Run Practice Screen allows the Instructor/Operator to monitor single or multiple lanes via the Monitor Lane(s) selection area. The Run Practice single lane details view is shown in Figure 3-59. Control of the training scenario is provided through the Run Practice, Pause, Stop, and Replay softkeys.

e. After each table or task is completed, a chart will appear on the projection screen indicating the lane number of each firer and the target distances. The number of hits (H), misses (M), late fires (L), no fires (NF), for each lane will be indicated. If a firer shoots too soon, a no target (NT) will appear on the chart.
f. If running a Courses of Fire category, after each table is completed, a message box appears on the IOS monitor indicating the table or task is over. Click "OK" to proceed. After all the tables or tasks in the Course of Fire category are completed, a message will appear indicating the Course of Fire is over. Click "OK" to proceed.
g. If running an Individual Tables and Tasks category, after each table or task is completed, a message will appear indicating the table or task is completed (Figure 3-60). Click "OK" to proceed.

3.5.1.2.6. Practice replay

a. To replay a practice, first indicate in the Replay pulldown menu the method of the replay. Replay selections for Marksmanship Mode include: shot by shot, target by target, burst by burst.
b. Click the replay box. Each shot, target and lane number appears on the screen as the practice is replayed (Figure 3-61).
c. To advance to the next shot, target, or burst, click the Run Practice (▸) button. When the replay is complete, a message will appear indicating the replay is over, click "OK".

3.5.1.2.7. Performance table window

A lane-by-lane summary of shot performance including detailed firer/lane data is accessible by the Instructor/Operator via the selection tabs located on the left side of a single lane details screen (Figure 3-59). Data selections include shot, grouping, performance, sensors, profile, and weapon.

a. Select the Shot tab (Figure 3-62 and Figure 3-63) to view details including shot type, reaction time, result, time of shot, weapon, ammo, offsets, and score.
b. Select the Grouping tab (Figure 3-64 and Figure 3-65) to access data on the number of shots, group width and height, and horizontal and vertical zeroing offsets.
c. Select the Performance tab (Figure 3-66) to provide the following data: practice designation, start time, duration, shots fired, score, last shot type, and an overall performance rating of the firer.
d. Select the Sensors tab (Figure 3-67) to display a graphical representation of the trigger pressure and weapon cant angle corresponding to the shot. Press shot number display window up arrow to see the shot position and sensor data corresponding to the second shot. The down arrow returns to display the previous shot performance data.
e. Select the Profile tab (Figure 3-68) to view the name, rank, serial number, platoon, and company of the firer. Any practice specific comments concerning the firer are also presented.
f. Select the Weapon tab (Figure 3-69) to view detailed information on the current weapon being used during the practice.

3.5.1.2.8. Saving a completed practice

In order for results tables and scorecards to be generated, the completed practice must be saved.

a. The Instructor/Operator can either manually save following completion of the practice or select the Auto Save On option (3.5.1.1.1.0.) prior to beginning a practice.

3.5.1.2.9. Results Table and Scorecards

a. The results table (Figure 3-70) shows summary information on all lanes. From the results table, click to highlight the desired lane, and select the Show Scorecard for Selected Lane softkey.

   Note: Scorecards are only available in Marksmanship training mode.

b. Scorecards are available for all completed and saved Marksmanship courses of fire. To access a scorecard, double click on a completed course of fire listed in the View Saved Practices course list). A sample scorecard is provided in Figure 3-71. A description of the practice or course is also available from the View Saved Practices Screen (Figure 3-72).

3.5.1.2.10. Printing - Marksmanship mode

a. Select the Print icon to print the results table, shot charts, or scorecards. (Run Practice tab, Single Lane Details selected, lower right corner of screen, Figure 3-62 through Figure 3-69)
b. Select Print Results Table softkey (upper right of Results Table Screen, Figure 3-70) to print a copy of the Results Table.
c. Select Print softkey (upper left corner of score card, Figure 3-71) to print a copy of an individual scorecard.

3.5.1.3. Switching between Training Modes

The Instructor/Operator can switch to another training mode (Collective or Shoot/Don't Shoot) by selecting "Return to Main Menu" on the IOS pulldown menu (Figure 3-73). A screen will appear stating "Exit IOS, Return to Main Menu (Figure 3-74). Click "YES". After a few moments, the EST Login Screen (Figure 3-38) will appear. Follow the procedures outlined in paragraph 0. or paragraph 3.5.3.

Table 3-1. Marksmanship Core Scenarios

No	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	TARGET	IO FDBK	SOLDIER FDBK	TIMED	AAR
A002	Shot Grouping	M16A2/M4	27	Unspec/Day/Clear	25m	Sngl/Stat	Y	T	N	Y
A003	Battlesight Zero	M16A2/M4	18	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	N	Y
A004	Downrange Feedback I	M16A2/M4	6	Unspec/Day/Clear	175m	Sngl/Stat	Y	Y	N	Y
A005	Downrange Feedback II	M16A2/M4	10	Unspec/Day/Clear	75m	Sngl/Stat	Y	Y	N	Y
A006	Downrange Feedback III	M16A2/M4	20	Unspec/Day/Clear	175m	Sngl/Stat	Y	Y	N	Y
A007	Downrange Feedback IV	M16A2/M4	10	Unspec/Day/Clear	300m	Sngl/Stat	Y	Y	N	Y
A008	Field Fire I	M16A2/M4	36	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
A009	Field Fire II	M16A2/M4	54	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
A010	Practice Record Fire (Sim)	M16A2/M4	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
A011	Record Fire (Sim)	M16A2/M4	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
A012	Burst Firing	M16A2/M4	21	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
A013	Protective Mask Firing	M16A2/M4	20	Unspec/Day/Clear	25m	Mult/Stat	Y	Y	Y	Y
A014	Night Fire I	M16A2/M4	35	Unspec/Night/Clear	Multiple	Mult/Stat	Y	Y	N	Y
A015	Night Fire II	M16A2/M4	35	Unspec/Night	Multiple	Mult/Stat	Y	Y	N	Y
A016	Advanced Marksmanship I	M16A2/M4	10	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
A017	Advanced Marksmanship II	M16A2/M4	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
A018	Advanced Marksmanship-Qual (Sim)	M16A2/M4	50	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
A019	Quick Fire	M16A2/M4	20	Unspec/Day/Clear	25/50m	Mult/Stat	Y	Y	Y	Y
A020	NBC Fire	M16A2/M4	30	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
A021	Night Fire I	M16A2/M4	30	Unspec/Night	75/175m	Sngl/Stat	Y	Y	Y	Y
A022	Night Fire II (w AN/PVS-4)	M16A2/M4	30	Unspec/Night	Multiple	Sngl/Stat	Y	Y	Y	Y
A023	KD Range I (Zero)	M16A2/M4	12	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	N	Y
A024	KD Range II	M16A2/M4	46	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
A025	Rapid Fire	M16A2/M4	10	Unspec/Day/Clear	25M	Sngl/Stat	Y	Y	Y	Y
A026	Rapid Fire II	M16A2/M4	10	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
A027	AR Firing	M16A2/M4	35	Unspec/Day/Clear	25M	Sngl/Stat	Y	Y	N	Y
	BRM Quick Zero	M16A2/M4	3	Unspec/Day/Clear	25M	Sngl/Stat	Y	Y	N	Y
	IET Shot Group	M16A2/M4	18	Unspec/Day/Clear	25M	Sngl/Stat	Y	Y	N	Y
	Brm Battlesight Zero	M16A2/M4	18	Unspec/Day/Clear	25M	Sngl/Stat	Y	Y	N	Y
	BRM Shot Grouping	M16A2/M4	18	Unspec/Day/Clear	25M	Sngl/Stat	Y	Y	N	Y
B007	Simulated Qualification - Table I	M9	7	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
B008	Simulated Qualification -Table II	M9	8	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
B009	Simulated Qualification - Table III	M9	7	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
B010	Simulated Qualification - Table IV	M9	5	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
B011	Simulated Qualification - Table V	M9	13	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
B012	Simulated Night Qualification - Table I	M9	7	Unspec/Night	Multiple	Mult/Stat	Y	Y	Y	Y
B013	Simulated Night Qualification - Table II	M9	8	Unspec/Night	Multiple	Mult/Stat	Y	Y	Y	Y
B014	Simulated Night Qualification - Table III	M9	7	Unspec/Night	Multiple	Mult/Stat	Y	Y	Y	Y
B015	Simulated Night Qualification - Table IV	M9	5	Unspec/Night	Multiple	Mult/Stat	Y	Y	Y	Y
B016	Simulated Night Qualification - Table V	M9	13	Unspec/Night	Multiple	Mult/Stat	Y	Y	Y	Y
B017	Simulated NBC Qualification - Table I	M9	7	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
B018	Simulated NBC Qualification - Table II	M9	8	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y

Table 3-1. Marksmanship Core Scenarios - Continued

No	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	TARGET	IO FDBK	SOLDIER FDBK	TIMED	AAR
B019	Simulated NBC Qualification - Table III	M9	7	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
B020	Simulated NBC Qualification - Table IV	M9	5	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
B021	Simulated NBC Qualification - Table V	M9	13	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
B022	Alt Sim Qualification - Table I	M9	7	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
B023	Alt Sim Qualification - Table II	M9	13	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
B024	Alt Sim Qualification - Table III	M9	10	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
B025	Alt Sim Qualification - Table IV	M9	10	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
B026	Alt Sim Night Qualification	M9	30	Unspec/Night	25m	Sngl/Stat	Y	Y	Y	Y
B027	Alt Sim NBC Qualification	M9	20	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
B028	Military Police Firearms Qualification	M9	10	Unspec/Day/Clear	35m	Sngl/Stat	Y	Y	N	Y
B029	Military Police Firearms Qualification	M9	10	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	N	Y
B030	Military Police Firearms Qualification	M9	10	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
B031	Military Police Firearms Qualification	M9	5	Unspec/Day/Clear	15m	Sngl/Stat	Y	Y	Y	Y
B032	Military Police Firearms Qualification	M9	10	Unspec/Day/Clear	15m	Sngl/Stat	Y	Y	Y	Y
B033	Military Police Firearms Qualification	M9	5	Unspec/Day/Clear	7m	Sngl/Stat	Y	Y	Y	Y
C001	10 Meter Zeroing	M249	12	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
C002	10 m Controlled Burst Firing	M249	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
C003	10 m NBC Traverse & Search I	M249	15	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
C004	10 m Traverse & Search I	M249	24	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
C008	Transition Firing I (Fld Zero)	M249	12	Unspec/Day/Clear	300 m	Sngl/Stat	Y	Y	N	Y
C009	Transition Firing II	M249	6	Unspec/Day/Clear	200 m	Sngl/Stat	Y	Y	Y	Y
C010	Transition Firing III (Sim Qual)	M249	6	Unspec/Day/Clear	400 m	Sngl/Stat	Y	Y	Y	Y
C011	Transition Firing IV (Sim Qual)	M249	6	Unspec/Day/Clear	100 m	Sngl/Stat	Y	Y	Y	Y
C012	Transition Firing V (Sim Qual)	M249	6	Unspec/Day/Clear	300 m	Sngl/Stat	Y	Y	Y	Y
C013	Transition Firing VI (Sim Qual)	M249	12	Unspec/Day/Clear	100/300m	Sngl/Stat	Y	Y	Y	Y
C014	Transition Firing VII (Sim Qual)	M249	12	Unspec/Day/Clear	200/400m	Mult/Stat	Y	Y	Y	Y
C015	Transition Firing VIII (Sim Qual)	M249	18	Unspec/Day/Clear	100/200/400m	Mult/Stat	Y	Y	Y	Y
C016	Night Firing I (Zeroing AN/PVS-4)	M249	12	Unspec/Night	25 m	Sngl/Stat	Y	Y	N	Y
C017	Night Firing II	M249	6	Unspec/Night	200 m	Sngl/Stat	Y	Y	N	Y
C018	Night Firing III	M249	6	Unspec/Night	400 m	Mult/Stat	Y	Y	N	Y
C019	Night Firing IV	M249	6	Unspec/Night	100 m	Sngl/Stat	Y	Y	N	Y
C020	Night Firing V	M249	6	Unspec/Night	300 m	Sngl/Stat	Y	Y	N	Y
C021	Night Firing VI	M249	6	Unspec/Night	100 m	Sngl/Stat	Y	Y	N	Y
C022	Field Firing I (Zeroing)	M249	12	Unspec/Day/Clear	300 m	Sngl/Stat	Y	Y	N	Y
C023	Field Firing II	M249	30	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	N	Y
C024	Field Firing III	M249	46	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
C025	Field Firing IV	M249	60	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
C026	Alternate Field Firing II	M249	6	Unspec/Day/Clear	25m	Sngl/Stat	Y	Y	Y	Y
C027	Alternate Field Firing III	M249	12	Unspec/Day/Clear	50/25 m	Sngl/Stat	Y	Y	Y	Y
C028	Alternate Field Firing IV	M249	18	Unspec/Day/Clear	25/50/75 m	Sngl/Stat	Y	Y	Y	Y
D001	10 Meter Bipod Firing I (Zeroing)	MG	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y

Table 3-1. Marksmanship Core Scenarios - Continued

No	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	TARGET	IO FDBK	SOLDIER FDBK	TIMED	AAR
D002	10m Bipod Firing II	MG	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D003	10 m Bipod Firing III	MG	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
W04	10m Bipod Firing IV	MG	6	Unspec/Day/Clear	10m	Sngl/Stat	Y	Y	N	Y
D005	10 m Bipod Firing V	MG	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D006	10m Bipod Firing VI	MG	6	Unspec/Day/Clear	10m	Sngl/Stat	Y	Y	N	Y
D007	10m Bipod Firing VII	MG	6	Unspec/Day/Clear	10m	Sngl/Stat	Y	Y	N	Y
D008	10m Tripod Firing Practice I (Zero)	MG	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D009	10 m Tripod Firing Practice 11	MG	24	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D010	10 m Tripod Firing Practice 111	MG	48	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D011	10m Tripod Firing Practice IV	MG	30	Unspec/Day/Clear	10m	Sngl/Stat	Y	Y	N	Y
D012	10 m Tri Firing Record Practice I	MG	48	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D013	10 m Tri Firing Record Practice 11	MG	30	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D014	10 m Tripod Firing, Sim Record I	MG	6	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D015	10 m Tripod Firing, Sim Record 11	MG	24	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
D016	10 m Tripod Firing, Sim Record m	MG	48	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	Y	Y
D017	10m Tripod Firing, Record IV	MG	30	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	Y	Y
D018	Transition Firing I	MG	20	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	N	Y
D019	Transition Firing II	MG	120	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	Y	Y
D020	Day Defensive Firing I (Zeroing)	MG	20	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	N	Y
D021	Day Defensive Firing II	MG	100	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D022	Day Defensive Firing III	MG	80	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D023	Predetermined Fire I	MG	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D024	Predetermined Fire II	MG	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D025	Predetermined Fire III	MC	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D026	Predetermined Fire IV	MG	20	Unspec/Night	Multiple	Mult/Stat	Y	Y	N	Y
D027	Predetermined Fire V	MG	20	Unspec/Night	Multiple	Mult/Stat	Y	Y	N	Y
D028	Predetermined Fire VI	MG	20	Unspec/Night	Multiple	Mult/Stat	Y	Y	N	Y
D029	Assault Firing I	MG	30	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D030	Assault Firing 11	MG	40	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D031	Assault Firing 111	MG	30	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
D032	Conduct Or Stationary Firing I	MG	25	Unspec/Day/Clear	300 m	Mult/Stat	Y	Y	N	Y
D033	Conduct Or Stationary Firing II	MG	25	Unspec/Day/Clear	800 m	Multi/Stat	Y	Y	N	Y
D034	Conduct Or Stationary Firing III	MG	25	Unspec/Day/Clear	1100 m	Mult/Stat	Y	Y	N	Y
D035	Conduct or Stationary Firing IV	MG	25	Unspec/Day/Clear	500 m	Mult/Stat	Y	Y	N	Y
D036	Conduct Or Moving Firing I	MG	25	Unspec/Day/Clear	300 m	Mult/Stat	Y	Y	N	Y
D037	Conduct Or Moving Firing II	MG	25	Unspec/Day/Clear	300 m	Mult/Stat	Y	Y	N	Y
D038	Conduct Or Moving Firing III	MG	25	Unspec/Day/Clear	300 m	Mult/Stat	Y	Y	N	Y
D040	Conduct Or Moving Firing IV	MG	25	Unspec/Day/Clear	300 m	Mult/Stat	Y	Y	N	Y
E001	10 Meter Firing I (Zero)	M2	12	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
E002	10 m Firing II	M2	14	Unspec/Day/Clear	10m	Sngl/Stat	Y	Y	N	Y
E003	10 m Firing III	M2	35	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
E004	10m Firing IV	M2	56	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
E005	10 m Simulated Qual Firing V	M2	28	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
E006	10 m Sim Qual Firing VI	M2	56	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y

Table 3-1. Marksmanship Core Scenarios - Continued

No	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	TARGET	IO FDBK	SOLDIER FDBK	TIMED	AAR
E007	10 m Sim Qual Firing VII	M2	35	Unspec/Day/Clear	10 m	Sngl/Stat	Y	Y	N	Y
E008	Transition Firing I (Sim Qual)	M2	28	Unspec/Day/Clear	550m	Sngl/Stat	Y	Y	N	Y
E009	Transition Firing II (Sim Qual)	M2	14	Unspec/Day/Clear	800 m	Sngl/Stat	Y	Y	Y	Y
E010	Transition Firing III (Sim Qual)	M2	14	Unspec/Day/Clear	400m	Sngl/Stat	Y	Y	Y	Y
E011	Transition Firing IV (Sim Qual)	M2	14	Unspec/Day/Clear	700 m	Sngl/Stat	Y	Y	Y	Y
E012	Transition Firing V (Sim Qual)	M2	14	Unspec/Day/Clear	1000 m	Sngl/Stat	Y	Y	Y	Y
E013	Transition Firing VI (Sim Qual)	M2	28	Unspec/Day/Clear	400/700 m	Sngl/Stat	Y	Y	Y	Y
E014	Transition Firing VII (Sim Qual)	M2	28	Unspec/Day/Clear	550/800m	Sngl/Stat	Y	Y	Y	Y
E015	Transition Firing VIII (Sim Qual)	M2	42	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
E016	NBC Firing I (Sim Qual)	M2	28	Unspec/Day/Clear	550m	Sngl/Stat	Y	Y	N	Y
E017	NBC Firing II (Sim Qual)	M2	14	Unspec/Day/Clear	800m	Sngl/Stat	Y	Y	Y	Y
E018	NBC Firing III (Sim Qual)	M2	14	Unspec/Day/Clear	400 m	Sngl/Stat	Y	Y	Y	Y
E019	NBC Firing IV (Sim Qual)	M2	14	Unspec/Day/Clear	700 m	Sngl/Stat	Y	Y	Y	Y
E020	NBC Firing V (Sim Qual)	M2	14	Unspec/Day/Clear	1000m	Sngl/Stat	Y	Y	Y	Y
E021	NBC Firing VI (Sim Qual)	M2	28	Unspec/Day/Clear	400/700m	Multi/Stat	Y	y	Y	Y
E022	NBC Firing VII (Sim Qual)	M2	28	Unspec/Day/Clear	550/800m	Multi/Stat	Y	Y	Y	Y
E023	NBC Firing VIII (Sim Qual)	M2	42	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
E024	Night Firing Sim Qual (Zero AN/TVS-5)	M2	26	Unspec/Night	50m	Sngl/Stat	Y	Y	N	Y
E025	Night Firing Sim Qual II	M2	14	Unspec/Night	800m	Sngl/Stat	Y	Y	Y	Y
E026	Night Firing Sim Qual III	M2	14	Unspec/Night	400m	Sngl/Stat	Y	Y	Y	Y
E027	Night Firing Sim Qual IV	M2	14	Unspec/Night	700m	Sngl/Stat	Y	Y	Y	Y
E028	Night Firing Sim Qual V	M2	14	Unspec/Night	1000m	Sngl/Stat	Y	Y	Y	Y
E029	Night Firing Sim Qual VI	M2	28	Unspec/Night	400/700m	Multi/Stat	Y	Y	Y	Y
E030	Night Firing Sim Qual VII	M2	28	Unspec/Night	550/800m	Multi/Stat	Y	Y	Y	Y
E031	Night Firing Sim Qual VIII	M2	42	Unspec/Night	Multiple	Multi/Stat	Y	Y	Y	Y
E032	Mounted Firing Exercise I	M2	7	Unspec/Day/Clear	450m	Sngl/Stat	Y	Y	N	Y
E033	Mounted Firing Exercise II	M2	14	Unspec/Day/Clear	450m	Sngl/Stat	Y	Y	N	Y
E034	Mounted Firing Exercise III	M2	14	Unspec/Day/Clear	850m	Sngl/Stat	Y	Y	N	Y
E035	Mounted Firing Exercise IV	M2	28	Unspec/Day/Clear	Multiple	Multi/Multi	Y	Y	N	Y
E036	Mounted Firing Exercise V	M2	28	Unspec/Day/Clear	Multiple	Mult/Stat	Y	Y	N	Y
E037	Mounted Firing Exercise VI	M2	28	Unspec/Day/Clear	Multiple	Multi/Mov	Y	Y	N	Y
E039	Mounted Firing Exercise VIII	M2	14	Unspec/Day/Clear	500 m	Sngl/Stat	Y	Y	N	Y
E040	Mounted Firing Exercise IX	M2	28	Unspec/Day/Clear	Multiple	Multi/Multi	Y	Y	N	Y
E041	Mounted Firing Exercise X	M2	42	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E042	Predetermined Firing I	M2		0 Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E043	Predetermined Firing II	M2	28	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E044	Predetermined Firing III	M2	56	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E045	Predetermined Firing IV	M2	28	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E046	Predetermined Firing V	M2	28	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E047	Predetermined Firing VI	M2	14	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
E048	Predetermined Firing VII	M2	14	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	N	Y
F003	Instructional Fire III	MK19	4	Unspec/Day/Clear	400 m	Sngl/Stat	Y	Y	N	Y

Table 3-1. Marksmanship Core Scenarios - Continued

No	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	TARGET	IO FDBK	SOLDIER FDBK	TIMED	AAR
F004	Instructional Fire IV	MK19	8	Unspec/Day/Clear	1100 m	Sngl/Stat	Y	Y	N	Y
F005	Instructional Fire V	MK19	8	Unspec/Day/Clear	1500 m	Sngl/Stat	Y	Y	N	Y
F006	Instructional Fire VI	MK19	6	Unspec/Day/Clear	600 m	Multi/Stat	Y	Y	N	Y
F010	Dismounted Range Card III	MK19	4	Unspec/Day/Clear	400m	Sngl/Stat	Y	Y	N	Y
F011	Dismounted Range Card IV	MK19	4	Unspec/Day/Clear	600 m	Sngl/Stat	Y	Y	Y	Y
F012	Dismounted Range Card V	MK19	8	Unspec/Day/Clear	1100m	Sngl/Stat	Y	Y	Y	Y
F013	Dismounted Range Card VI	MK19	6	Unspec/Day/Clear	600 m	Multi/Stat	Y	Y	Y	Y
F014	Dismounted Range Card VII	MK19	8	Unspec/Day/Clear	1500 m	Sngl/Stat	Y	Y	Y	Y
F015	Dismounted Range Card VIII	MK19	12	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
F018	Mounted Combat II	MK19	4	Unspec/Day/Clear	400 m	Sngl/Stat	Y	Y	Y	Y
F019	Mounted Combat III	MK19	8	Unspec/Day/Clear	800 m	Sngl/Stat	Y	Y	Y	Y
F020	Mounted Combat IV	MK19	6	Unspec/Day/Clear	600m	Multi/Stat	Y	Y	Y	Y
F021	Mounted Combat V	MK19	8	Unspec/Day/Clear	1000 m	Sngl/Stat	Y	Y	Y	Y
F024	Night Fire II	MK19	6	Unspec/Night	400m	Sngl/Stat	Y	Y	Y	Y
F025	Night Fire III	MK19	8	Unspec/Night	600m	Sngl/Stat	Y	Y	Y	Y
F026	Night Fire IV	MK19	8	Unspec/Night	800m	Sngl/Stat	Y	Y	Y	Y
G001	Zero I (Leaf Sight)	M203	3	Unspec/Day/Clear	200 m	Sngl/Stat	Y	Y	N	Y
G002	Zero II (Quadrant Sight)	M203	3	Unspec/Day/Clear	200 m	Sngl/Stat	Y	Y	N	Y
G003	Simulated Record Fire I	M203	3	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
G004	Simulated Record Fire II	M203	3	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
G005	Simulated Record Fire III	M203	3	Unspec/Day/Clear	Multiple	Multi/Stat	Y	Y	Y	Y
G006	Simulated Record Fire IV	M203	3	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
G007	Simulated Record Fire V	M203	3	Unspec/Day/Clear	Multiple	Sngl/Stat	Y	Y	Y	Y
G008	Zeroing the AN/PVS-4	M16/M203	10/10	Unspec/Day/Clear	10/25 m	Sngl/Stat	Y	Y	N	Y
G009	Night Firing	M203	3	Unspec/Night	Multiple	Sngl/Stat	Y	Y	N	Y
H001	Instructional Fire	AT4	12	Unspec/Day/Clear	Multiple	Multi/Multi	Y	Y	N	Y
H002	Instructional Night Fire	AT4	12	Unspec/Night	Multiple	Multi/Multi	Y	Y	N	Y
H003	Qualification Fire(Sim)	AT4	8	Unspec/Day/Clear	Multiple	Multi/Multi	Y	Y	N	Y
H004	Night Qual Fire (Sim)	AT4	6	Unspec/Night	Multiple	Multi/Multi	Y	Y	N	Y
H005	Advanced Instructional Fire	AT4	6	Unspec/Day/Clear	Multiple	Multi/Multi	Y	Y	N	Y
I001	M1200	SHOTGUN 25 M QUALIFICATION (TABLE 1)								
I002	M1200	SHOTGUN 25 M QUALIFICATION (TABLE 2)								
I003	M1200	SHOTGUN 25 M QUALIFICATION (TABLE 3)								

Figure 3-39. Select Practice Screen (Marksmanship Selected)

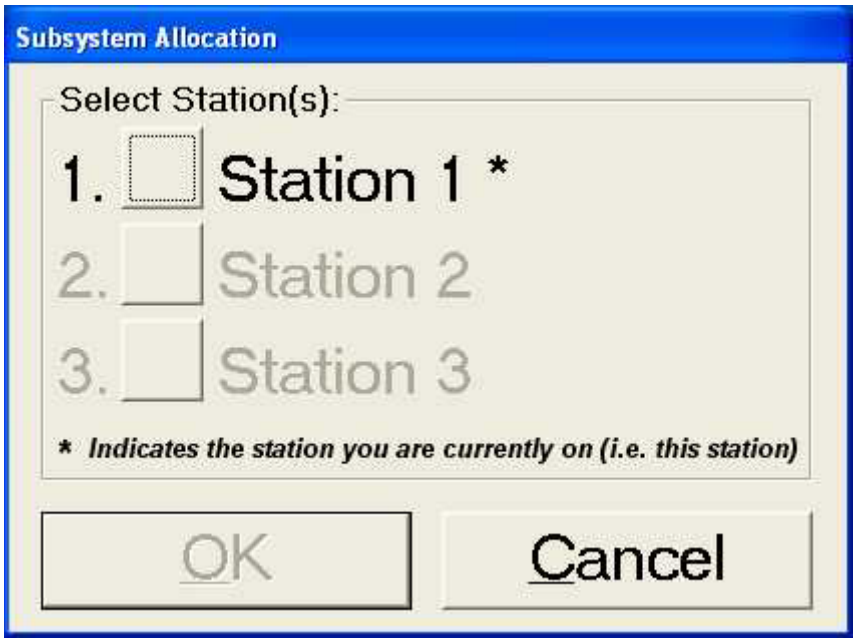


Figure 3-40. Subsystem Allocation Screen

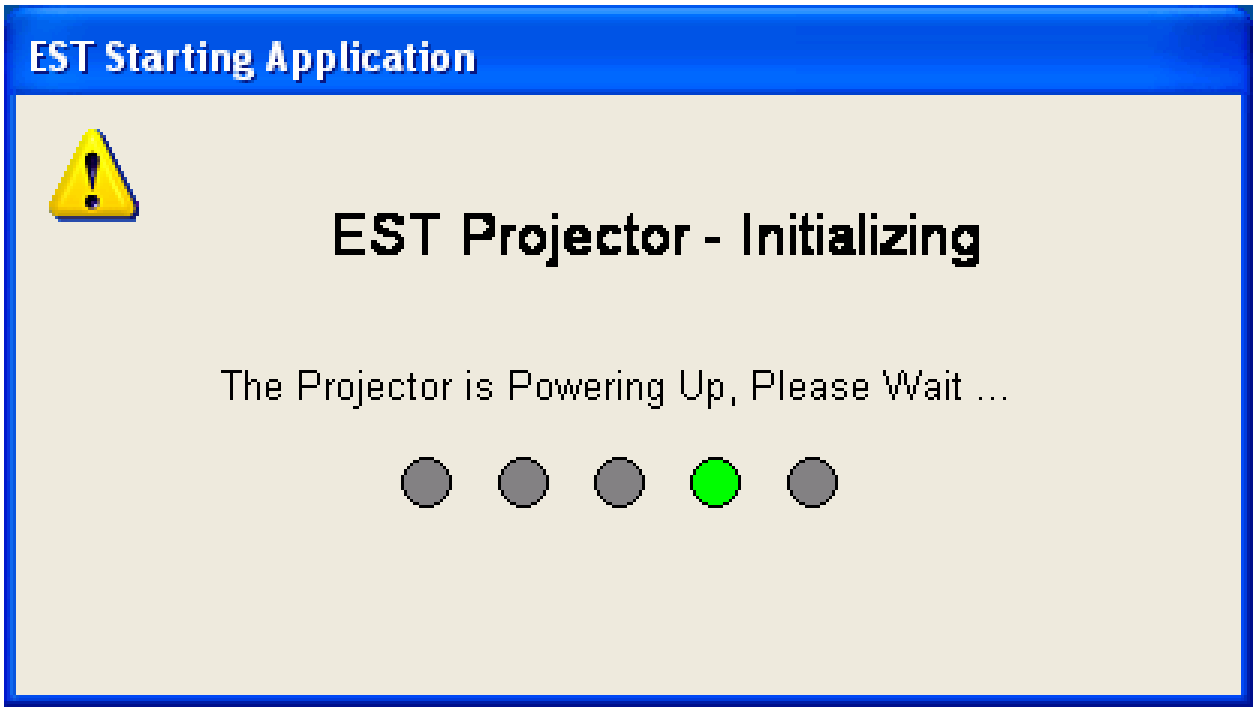


Figure 3-41. EST Projector – Initializing Screen

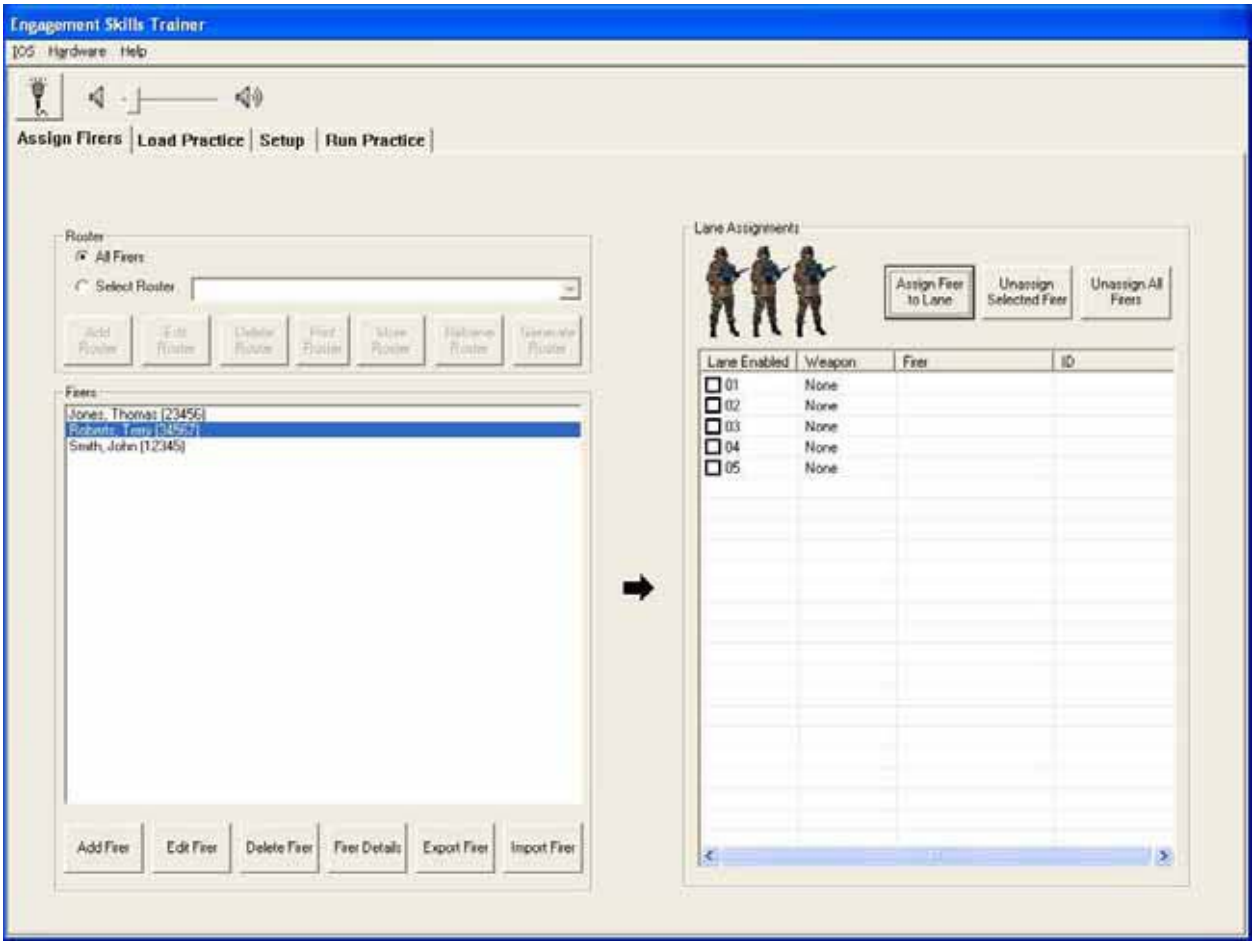


Figure 3-42. Assign Firers Screen (typical)

TD-07-6910-702-10

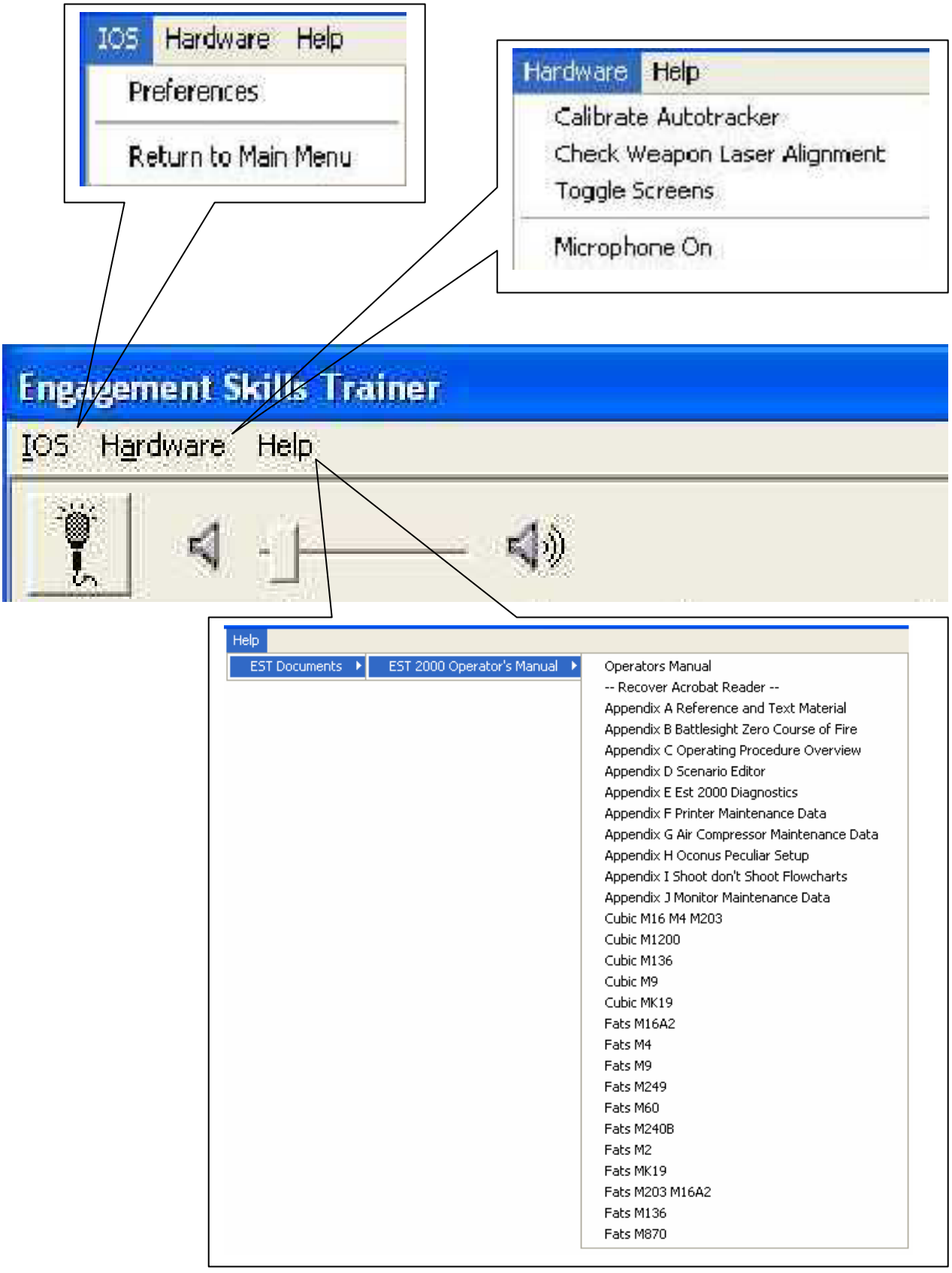


Figure 3-43. EST Main Toolbar

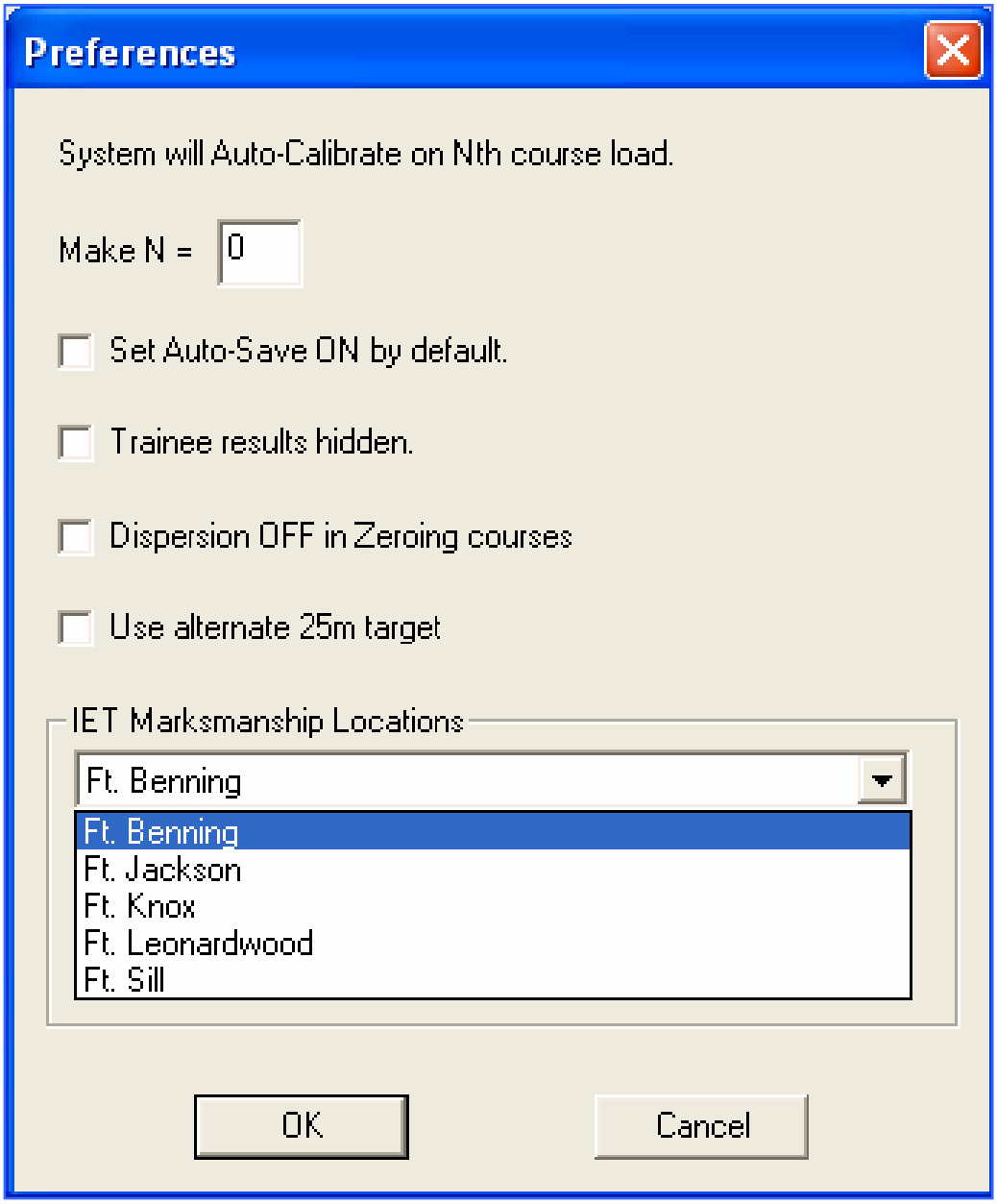


Figure 3-44. IOS Preferences Screen

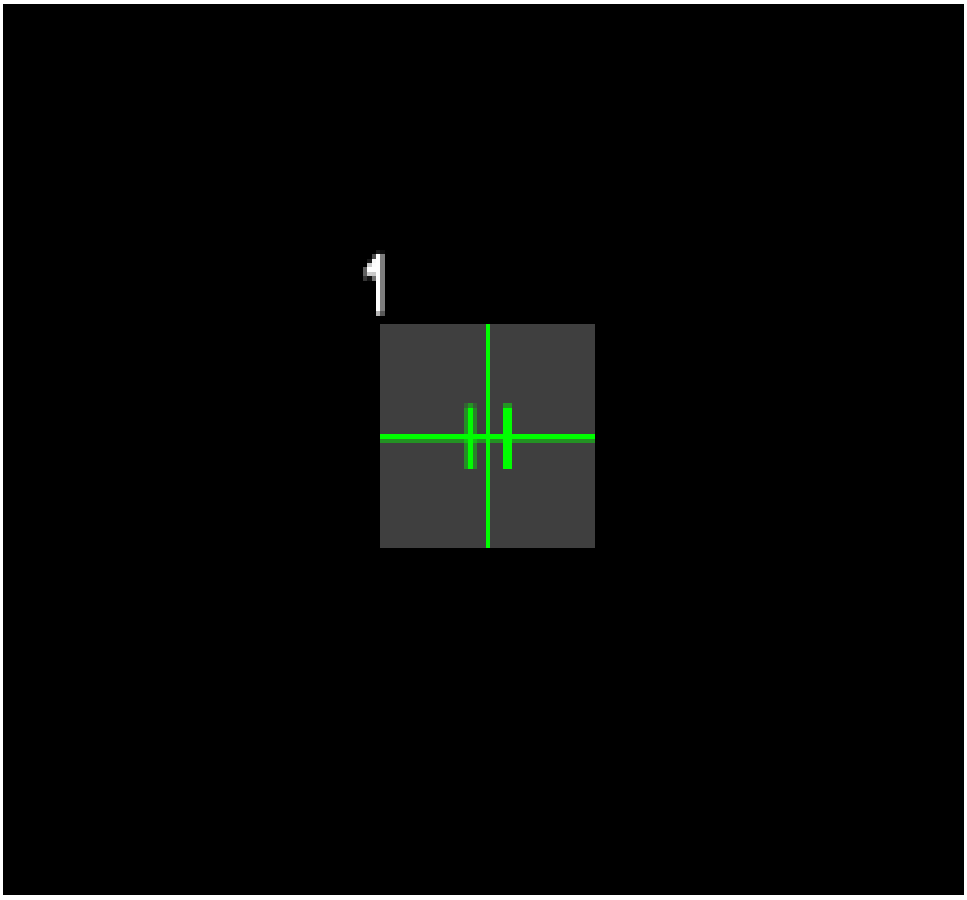


Figure 3-45. Sight Aim Point

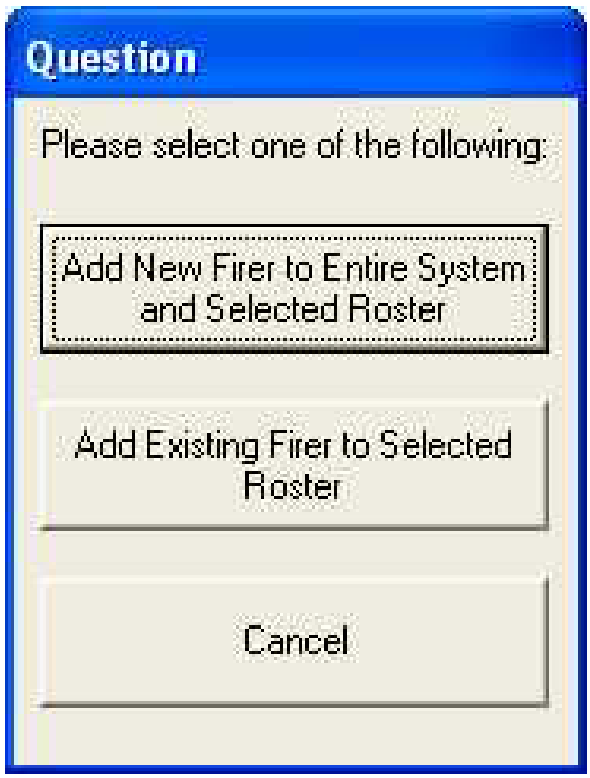


Figure 3-46. Add Firer

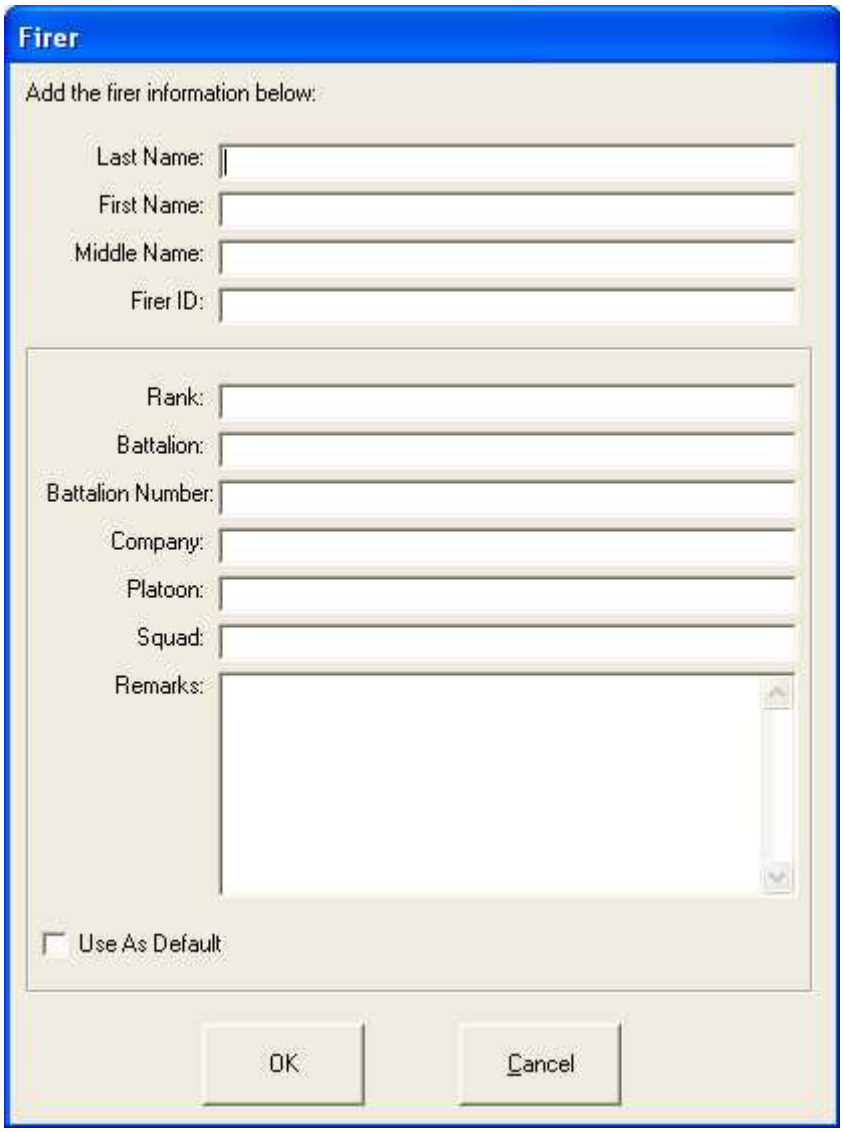


Figure 3-47. Firer Data

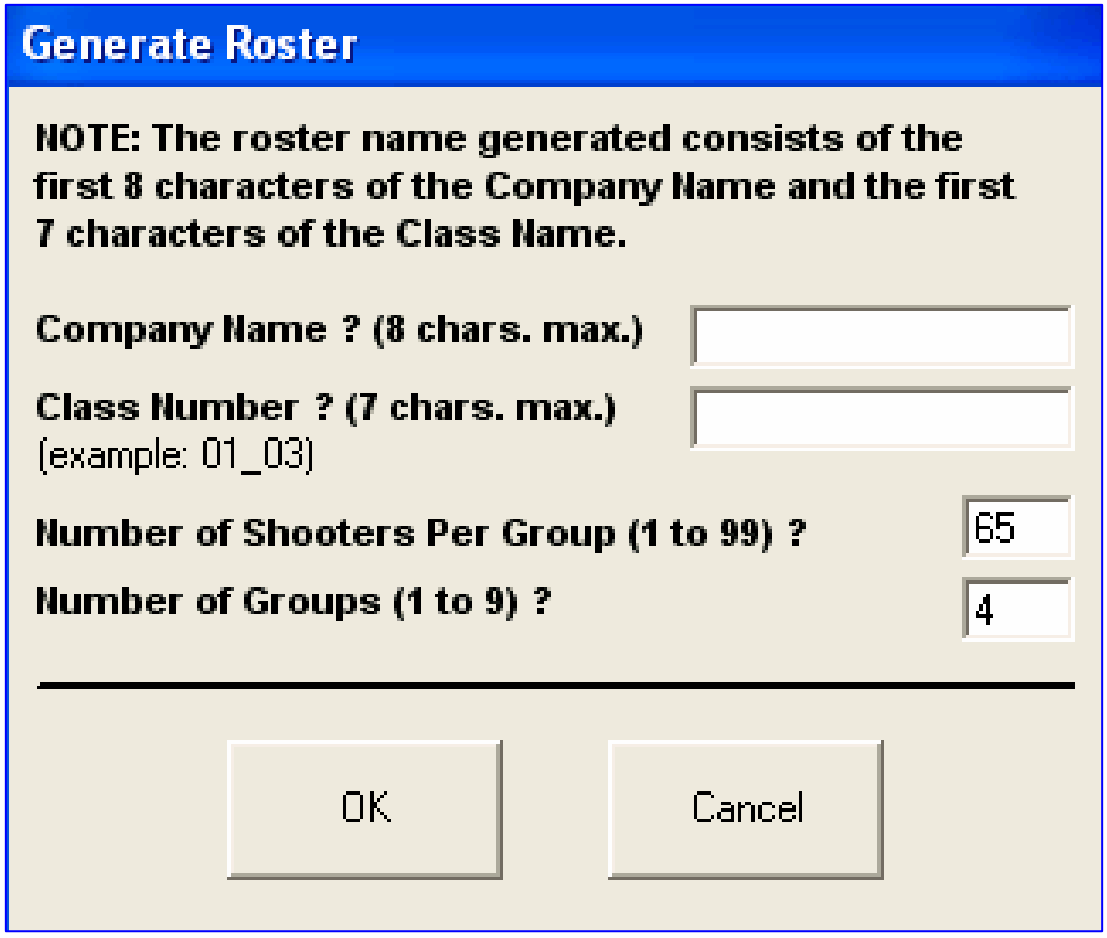


Figure 3-48. Generate Roster Screen

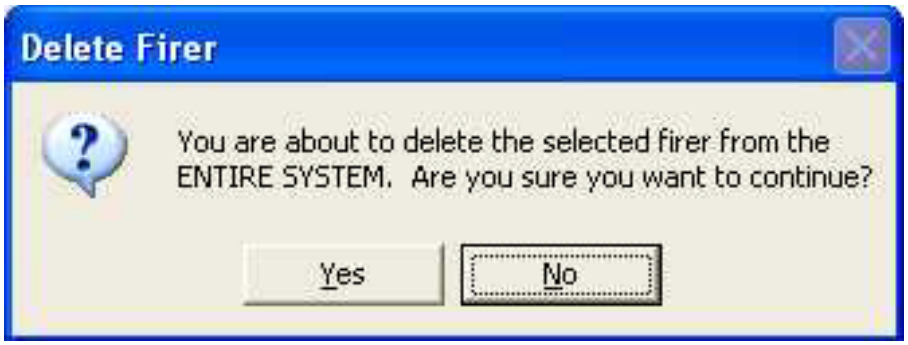


Figure 3-49. Delete Firer from Entire System

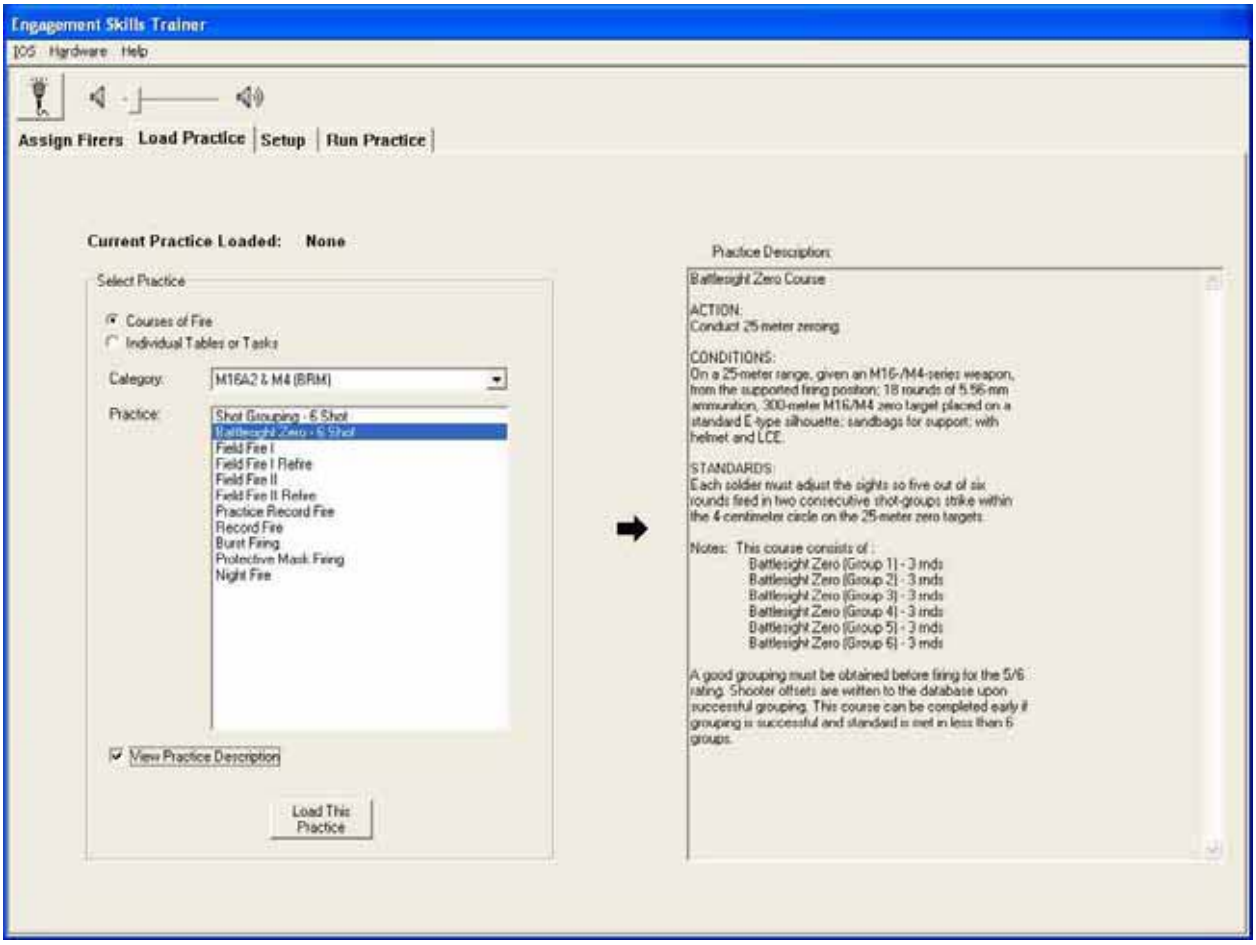


Figure 3-50. Load Practice Screen (Marksmanship Mode)

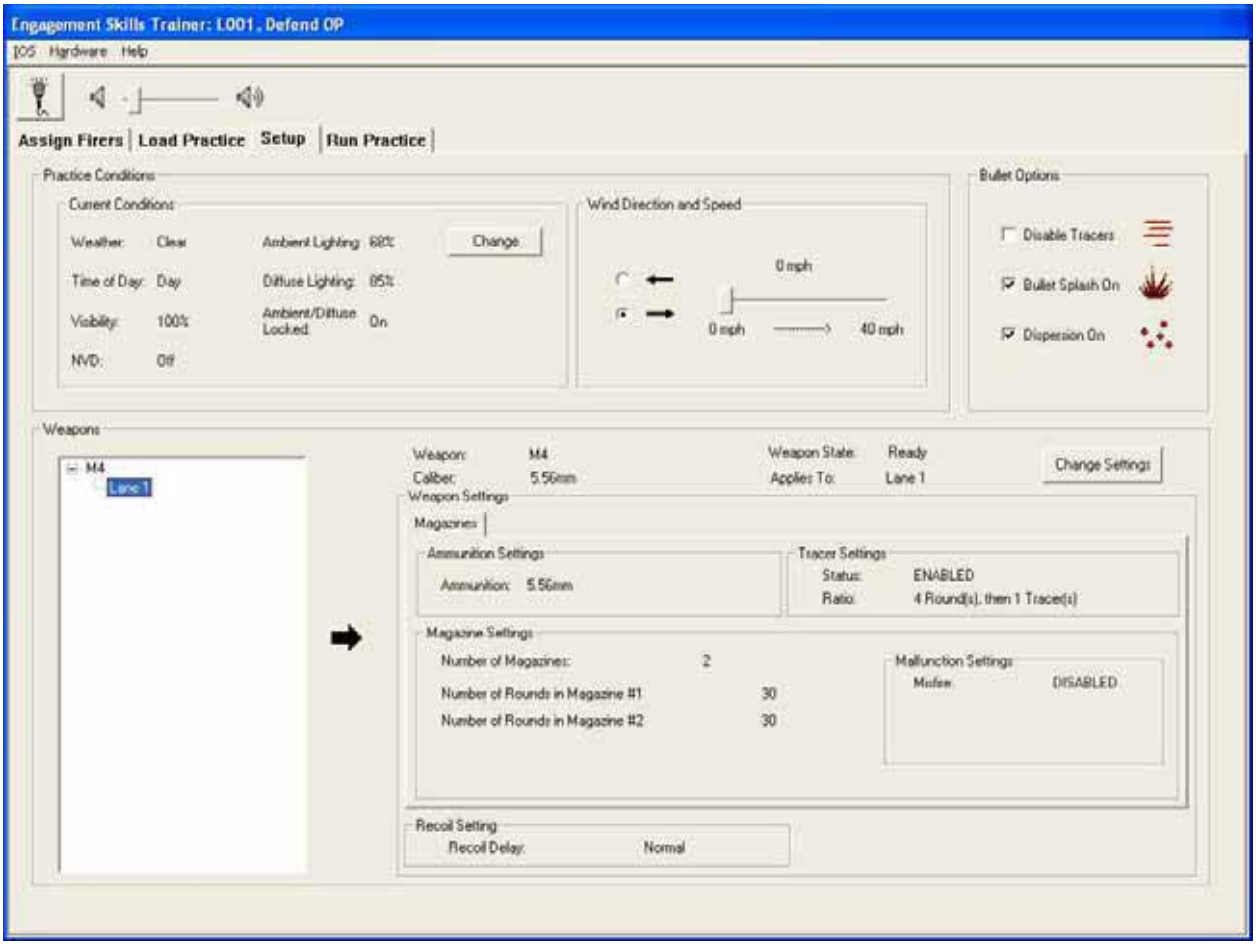


Figure 3-51. Setup Screen

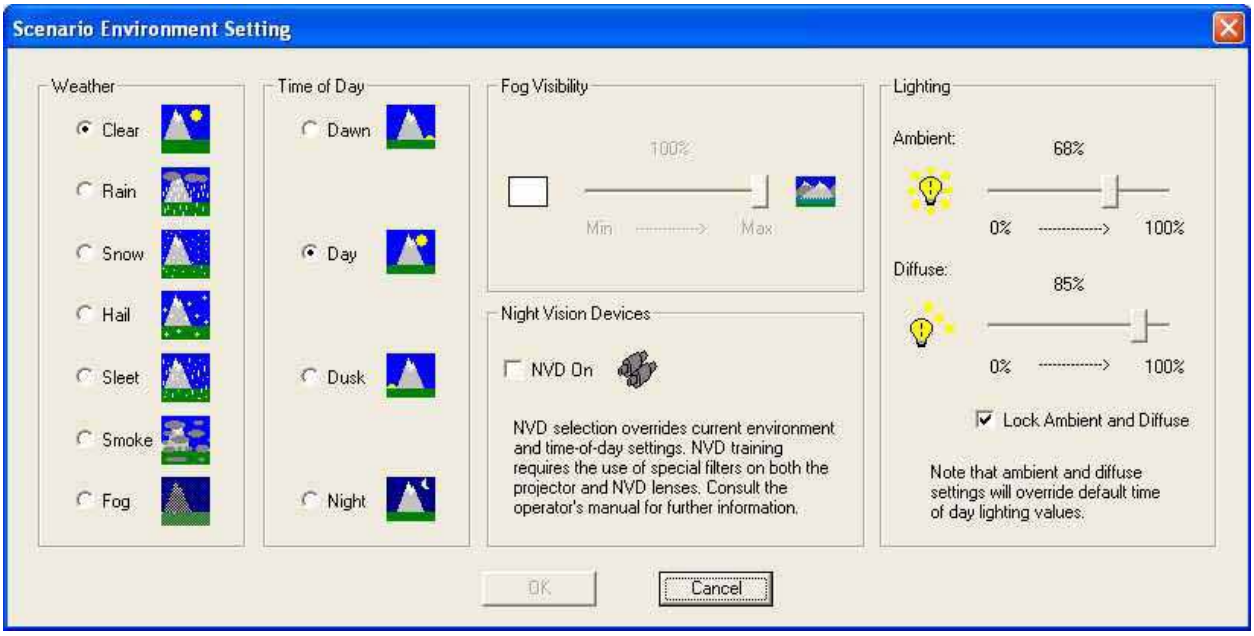


Figure 3-52. Current Conditions Screen

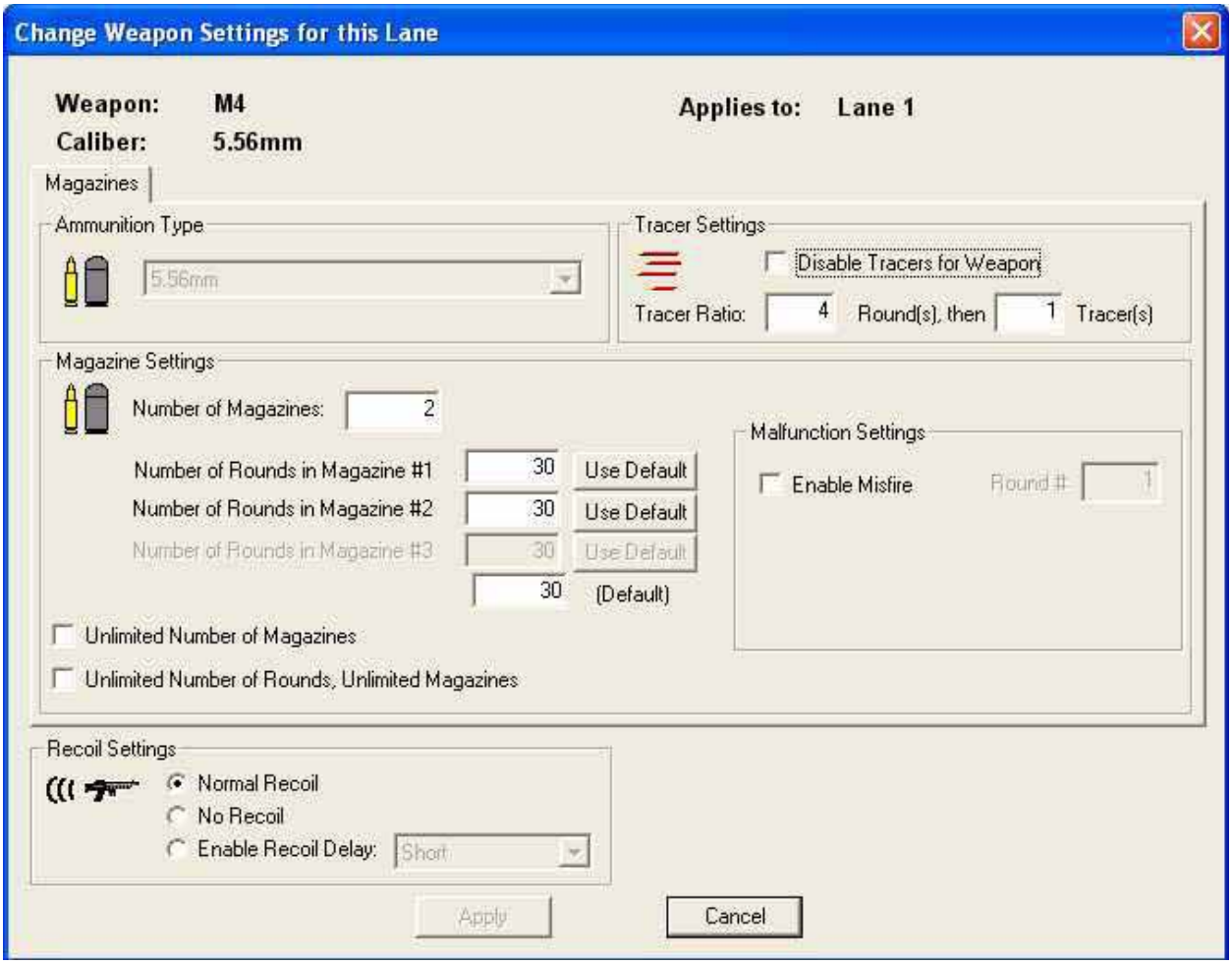


Figure 3-53. Weapon Settings Screen

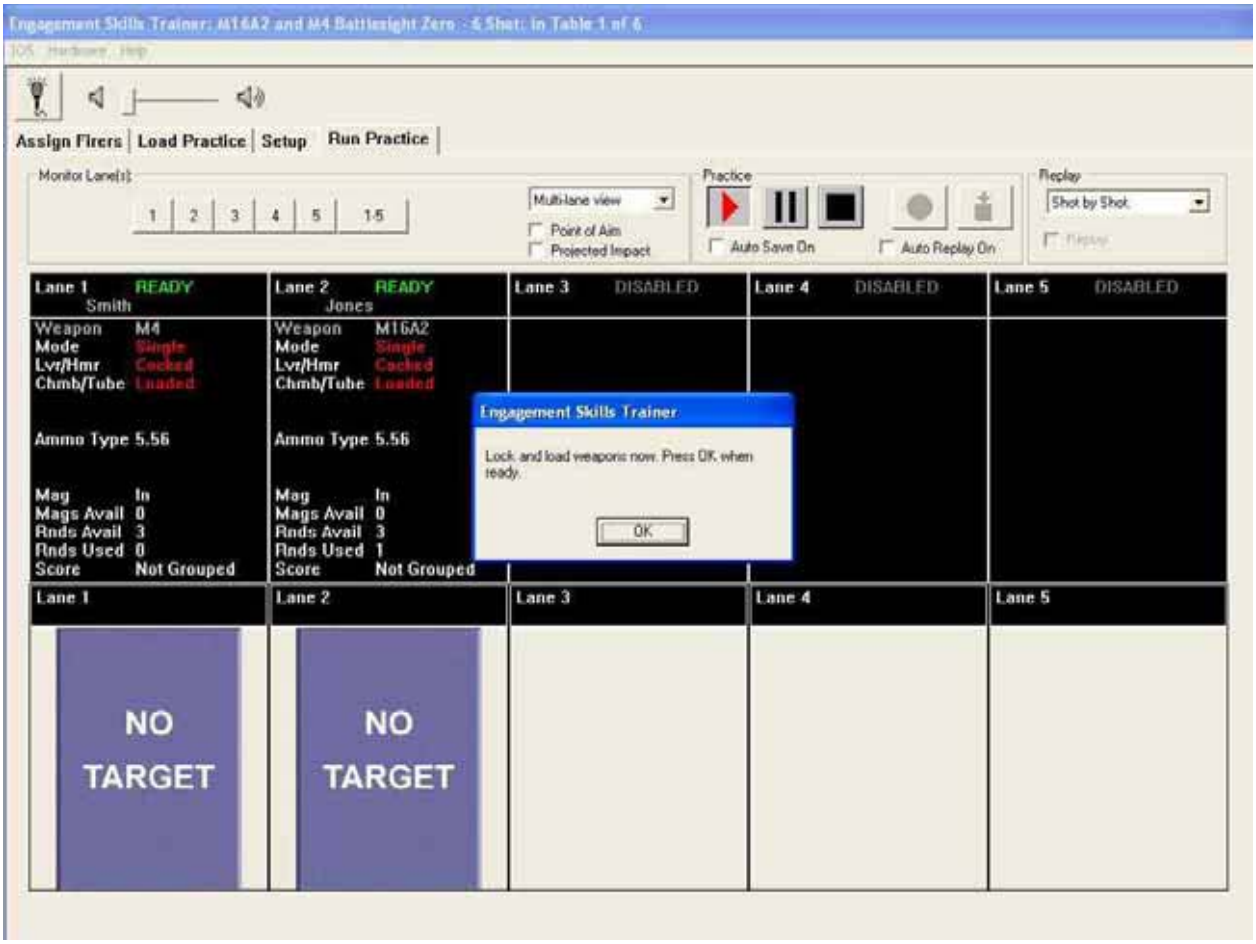


Figure 3-54. Lock and Load Screen

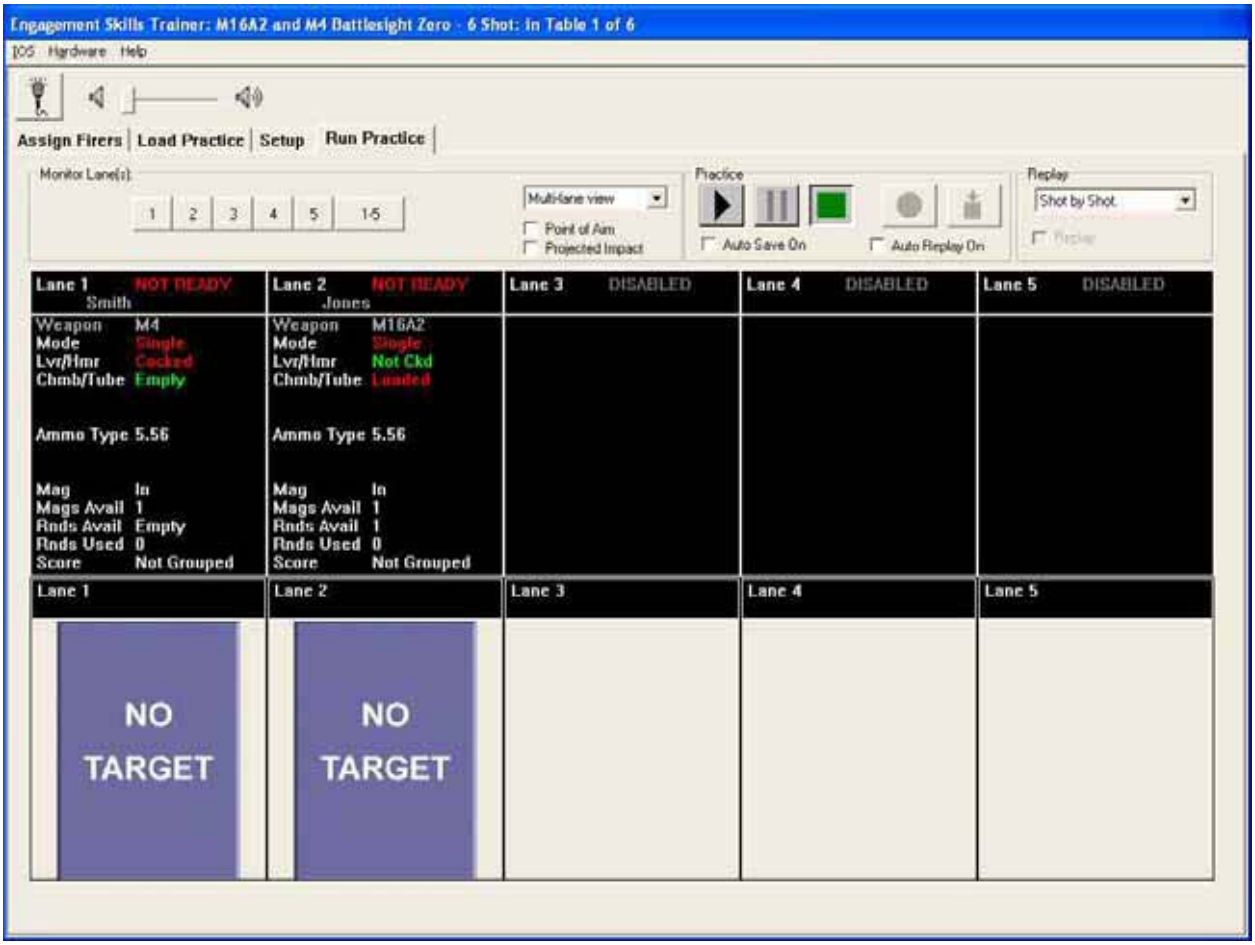


Figure 3-55. NOT READY Screen

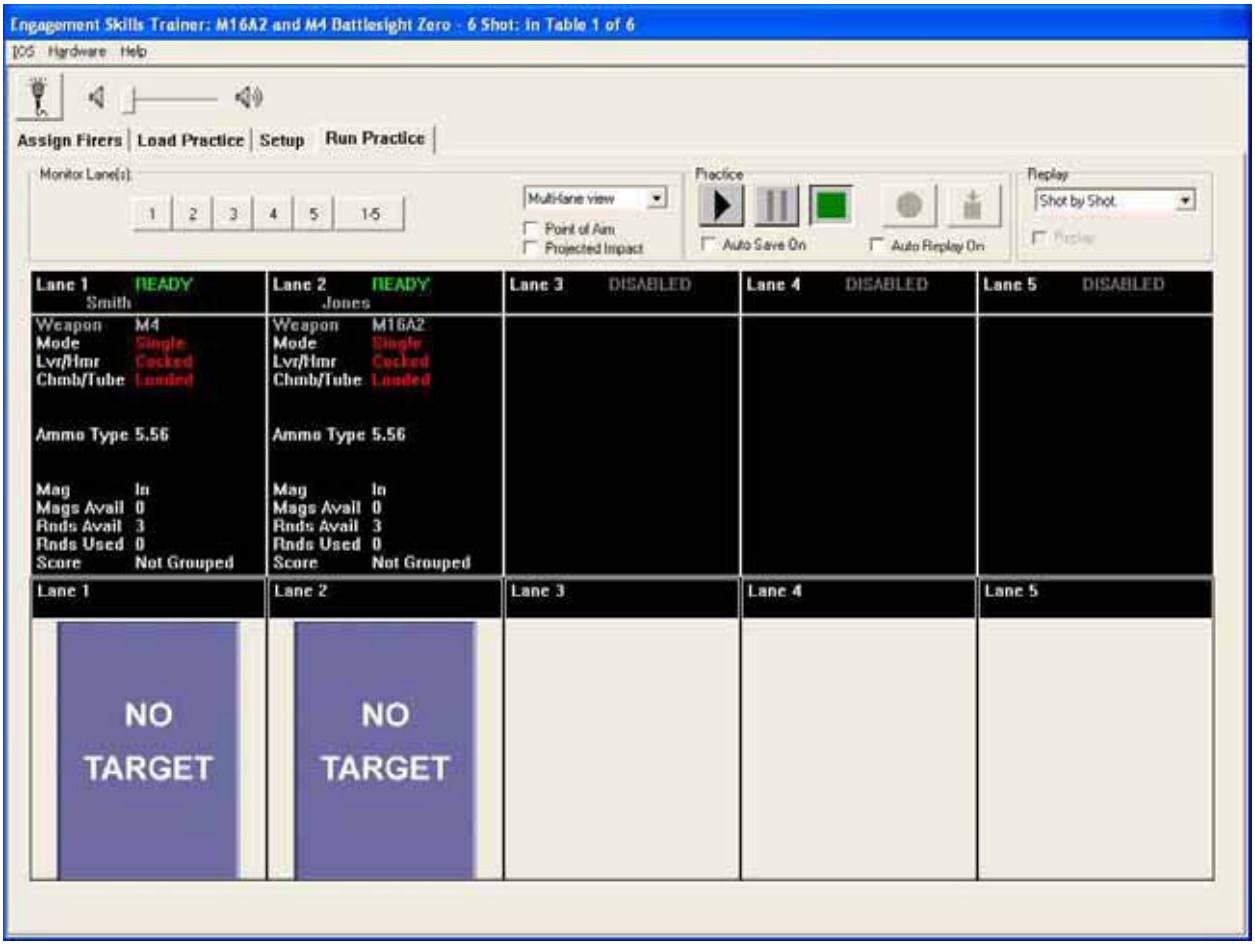


Figure 3-56. READY Screen

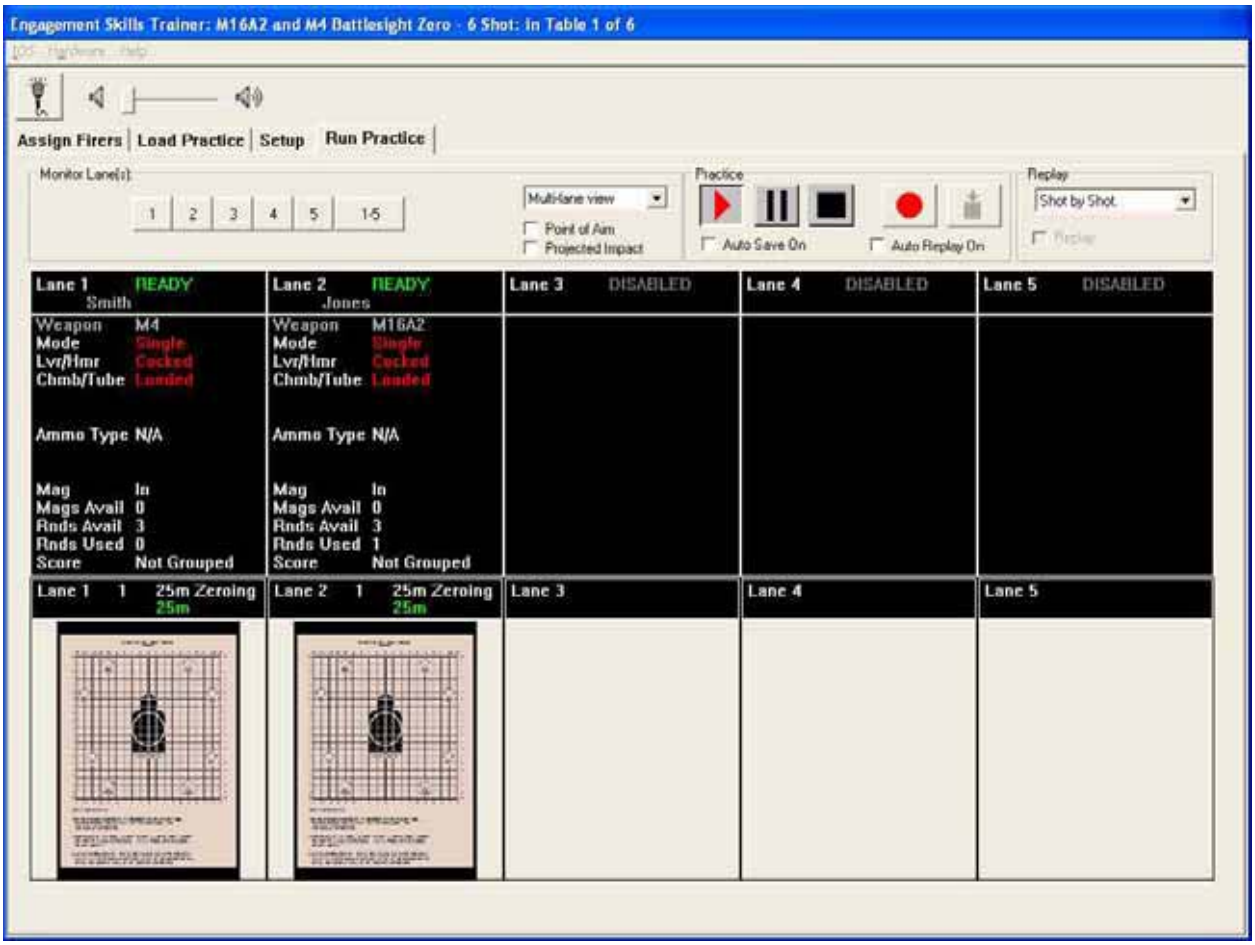


Figure 3-57. Run Practice Screen (Multi-lane Status)

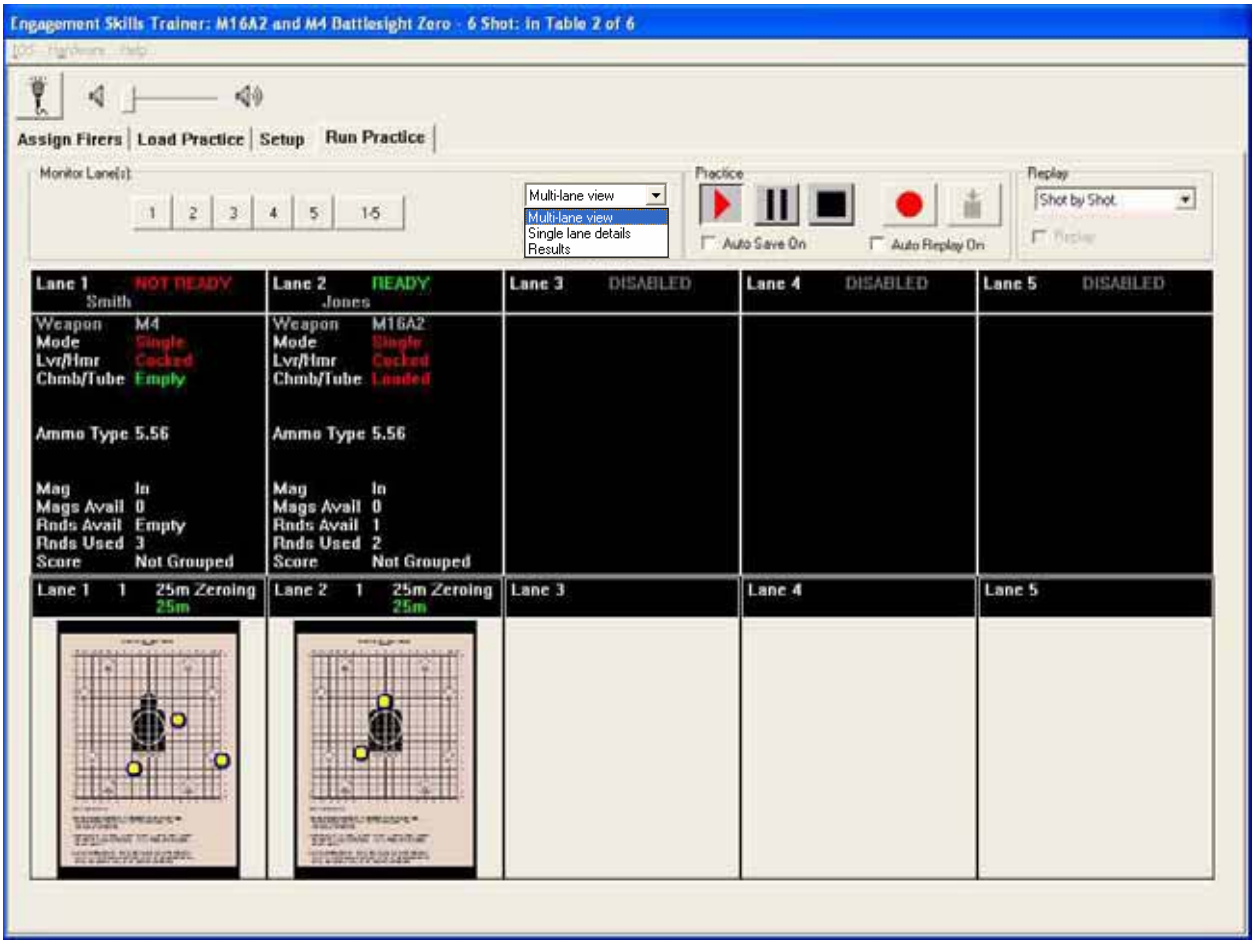


Figure 3-58. Run Practice Screen (Multi-lane Targets)

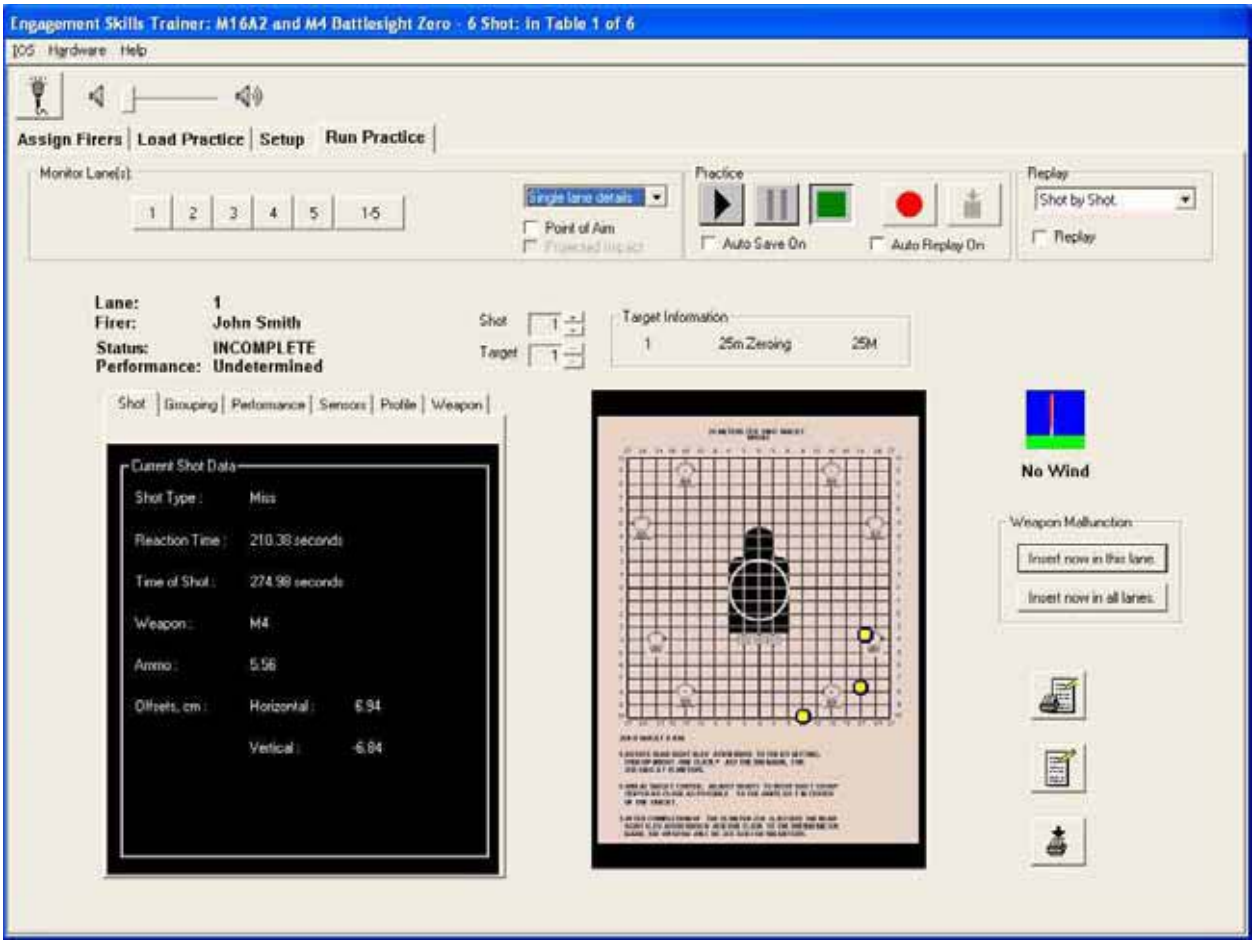


Figure 3-59. Run Practice Screen (Single Lane Details)

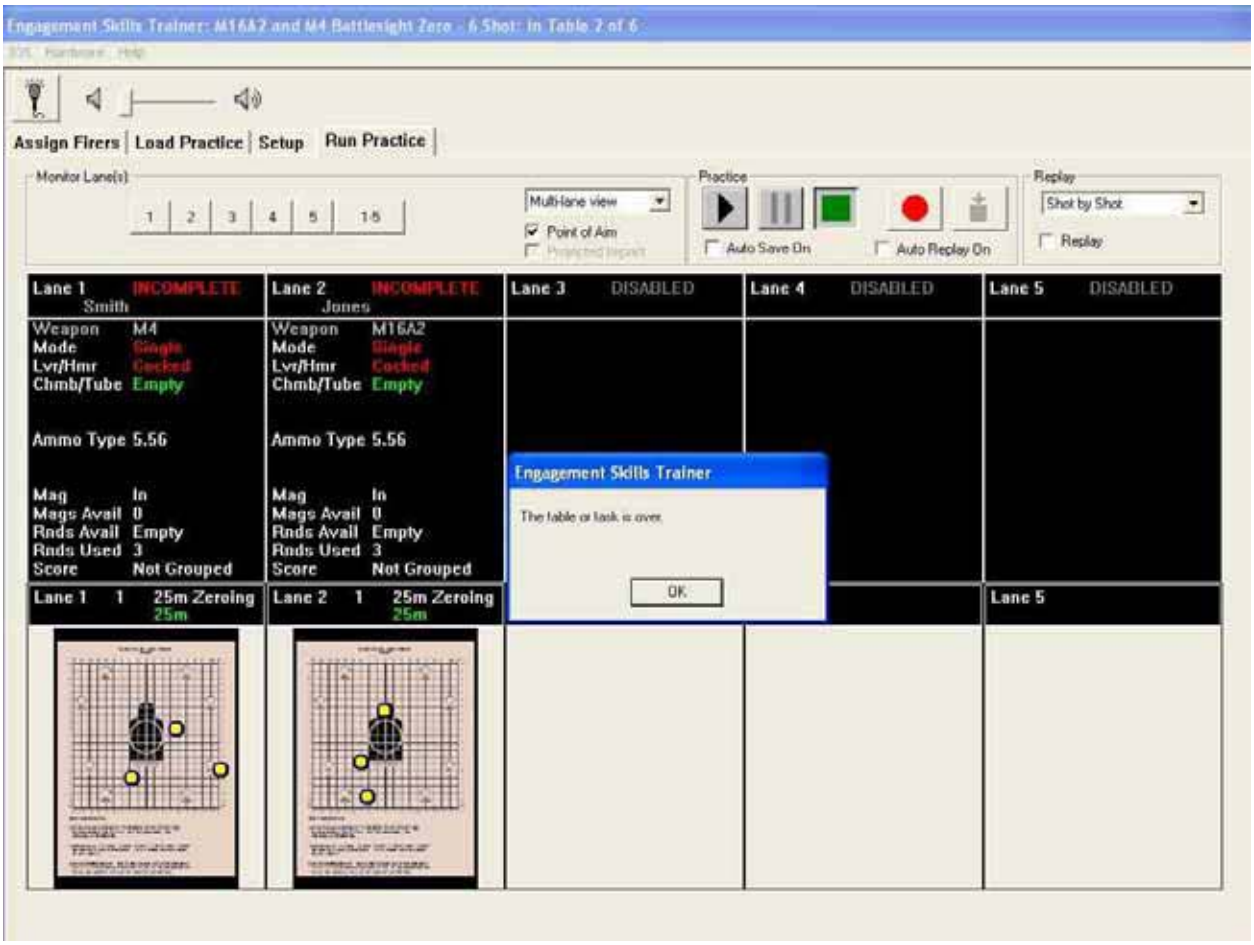


Figure 3-60. Table or Task Complete Screen

Figure 3-61. Range Target – Projection Screen Display

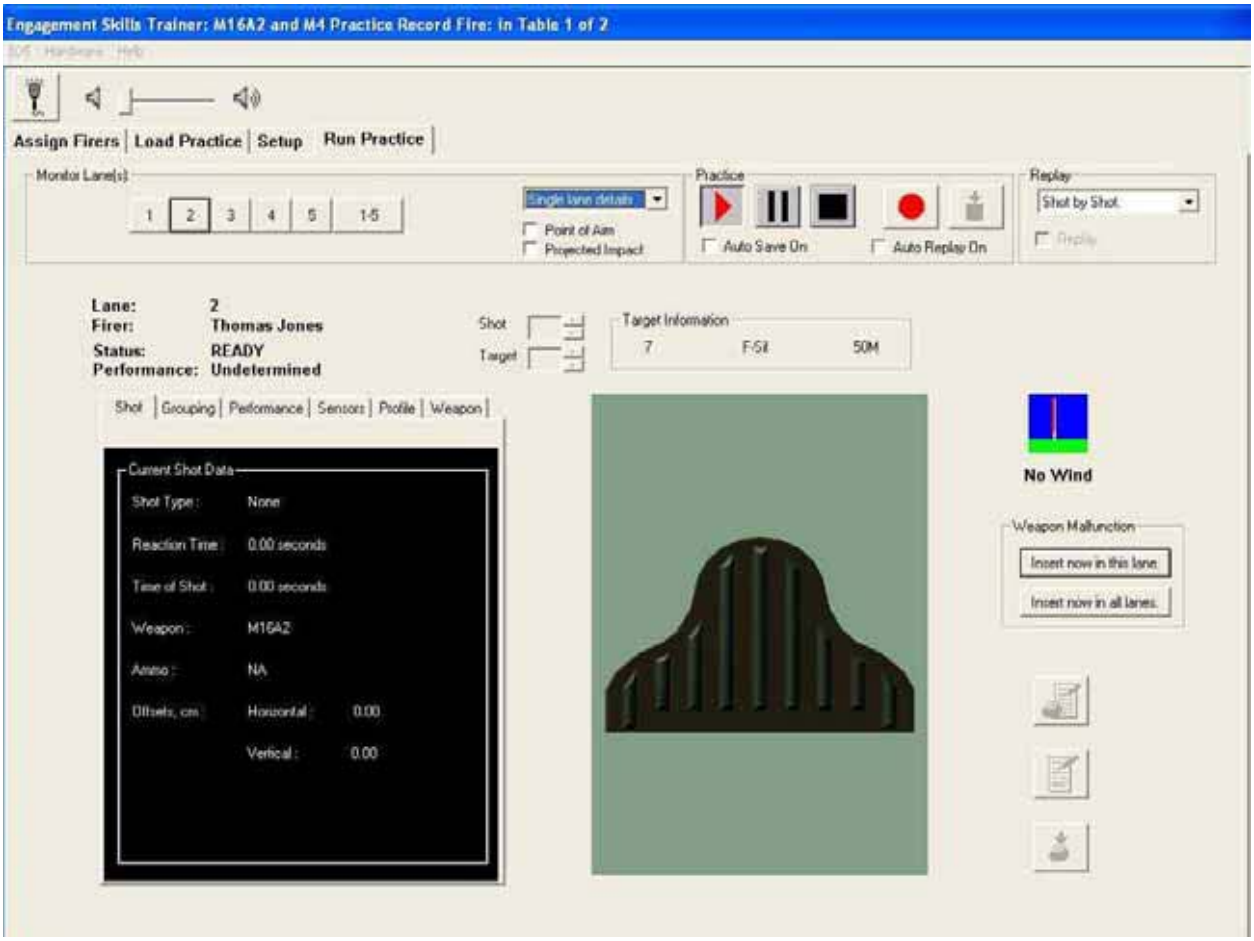


Figure 3-62. Range Target – IOS Display - Single Lane Details

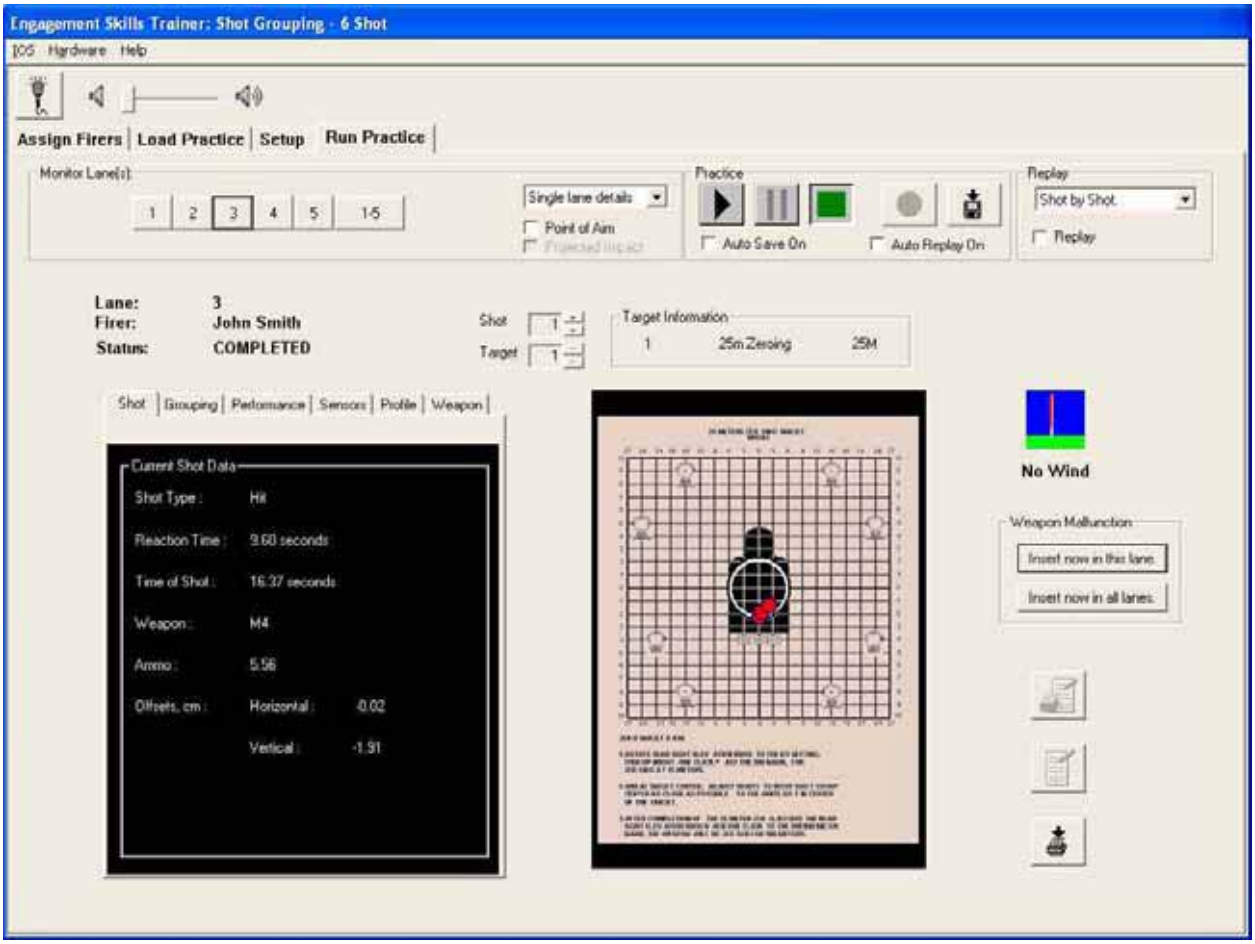


Figure 3-63. Single Lane Details - Shot Chart

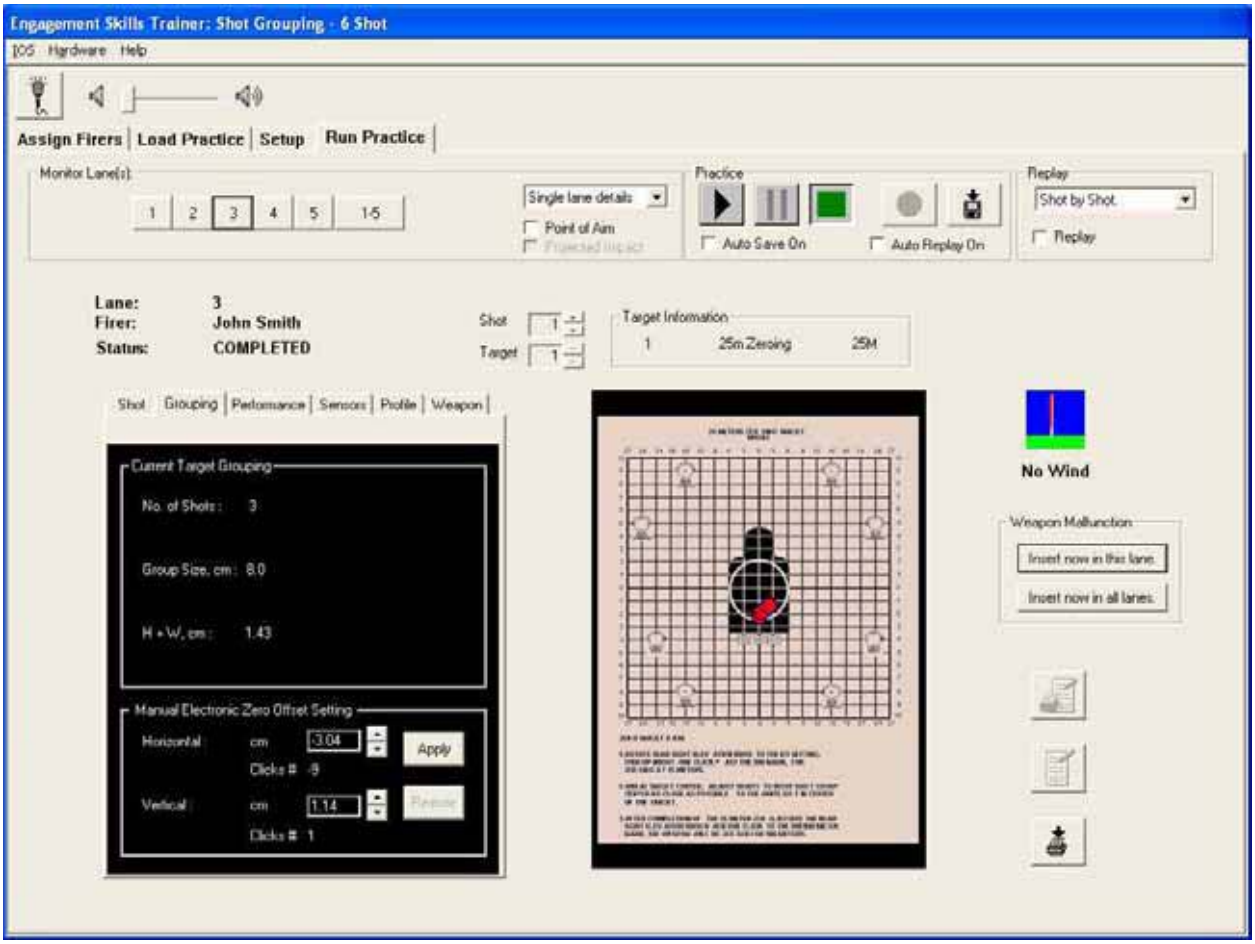


Figure 3-64. Grouping Circle – IOS Single Lane Display

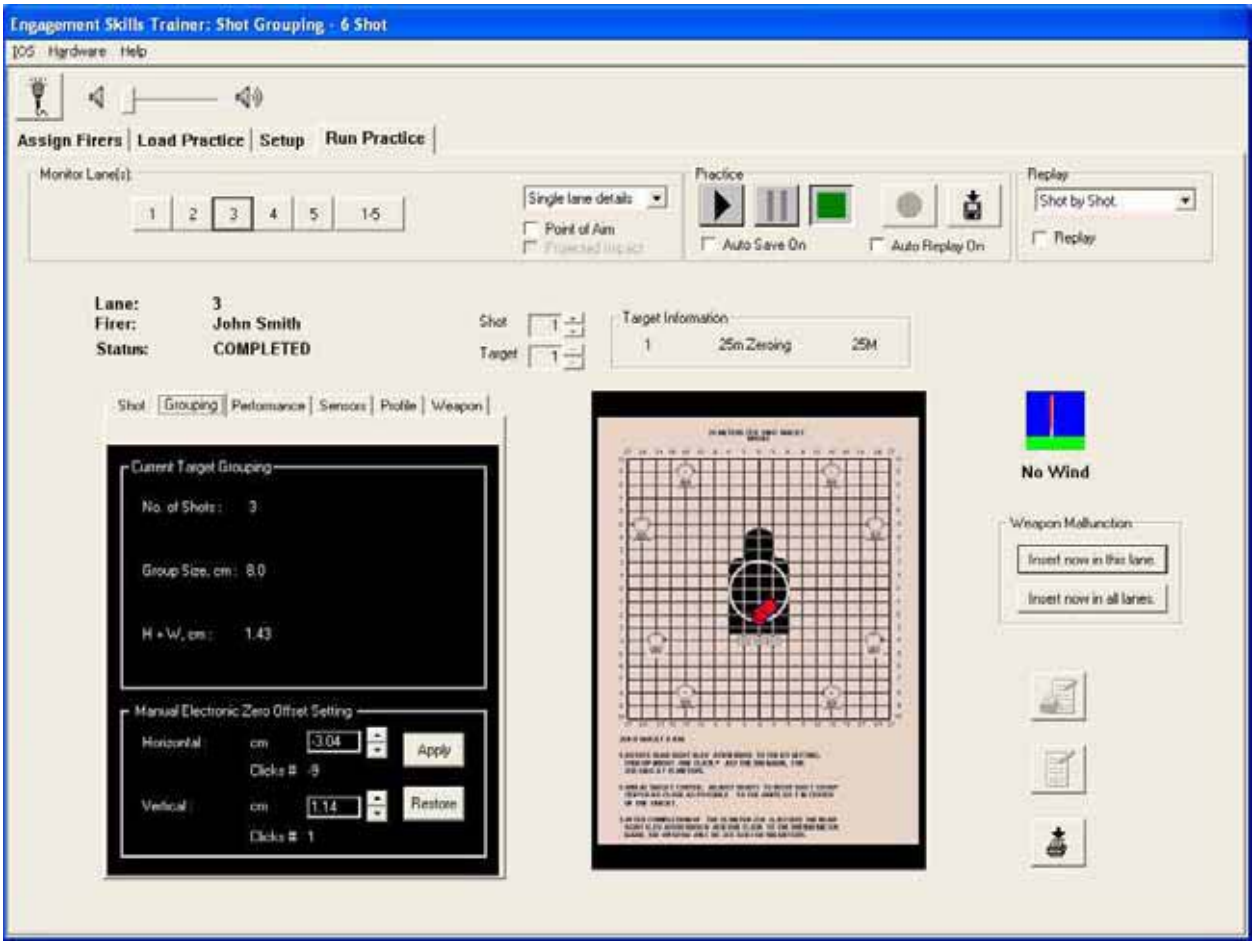


Figure 3-65. Single Lane Details - Grouping Chart

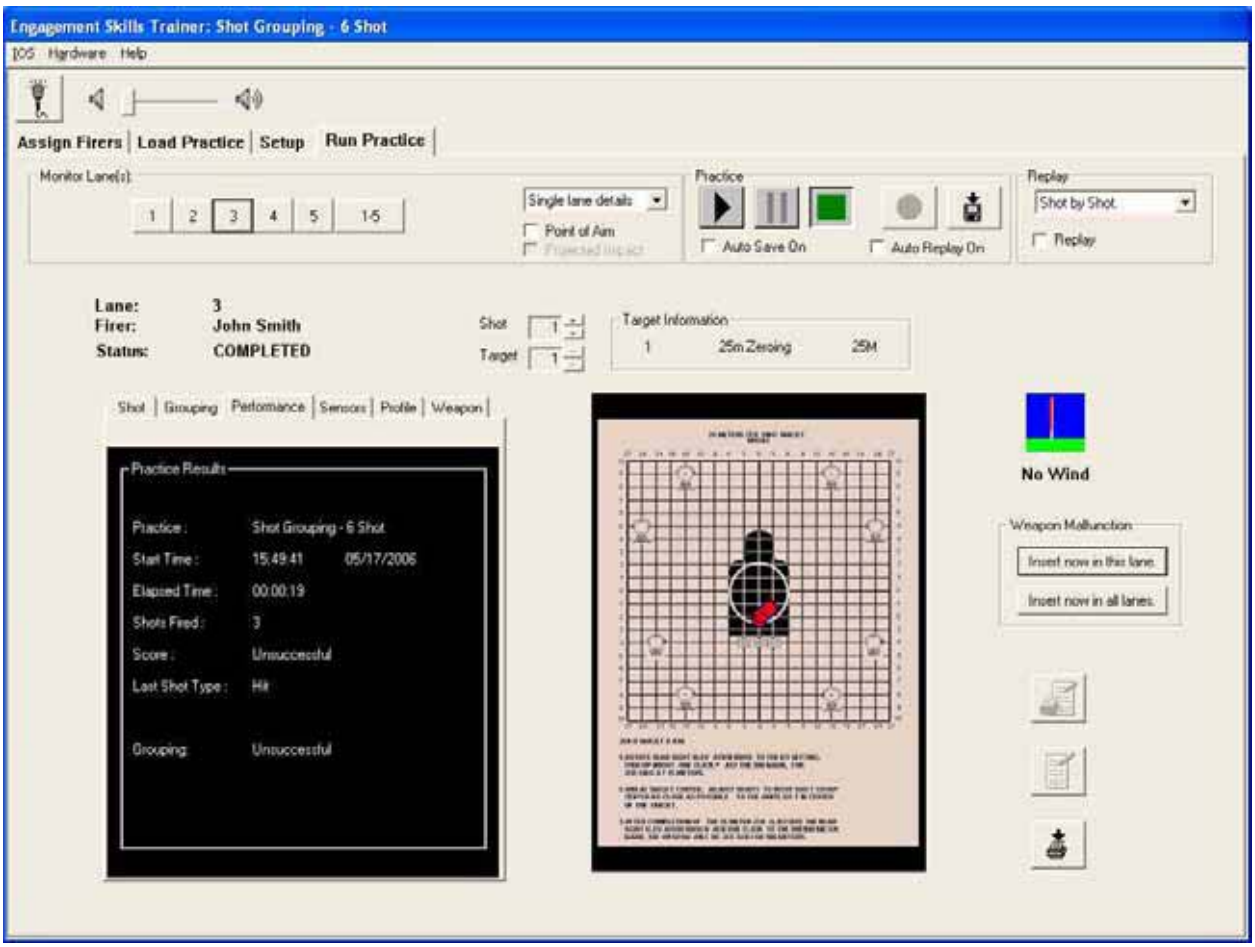


Figure 3-66. Single Lane Details - Performance Chart

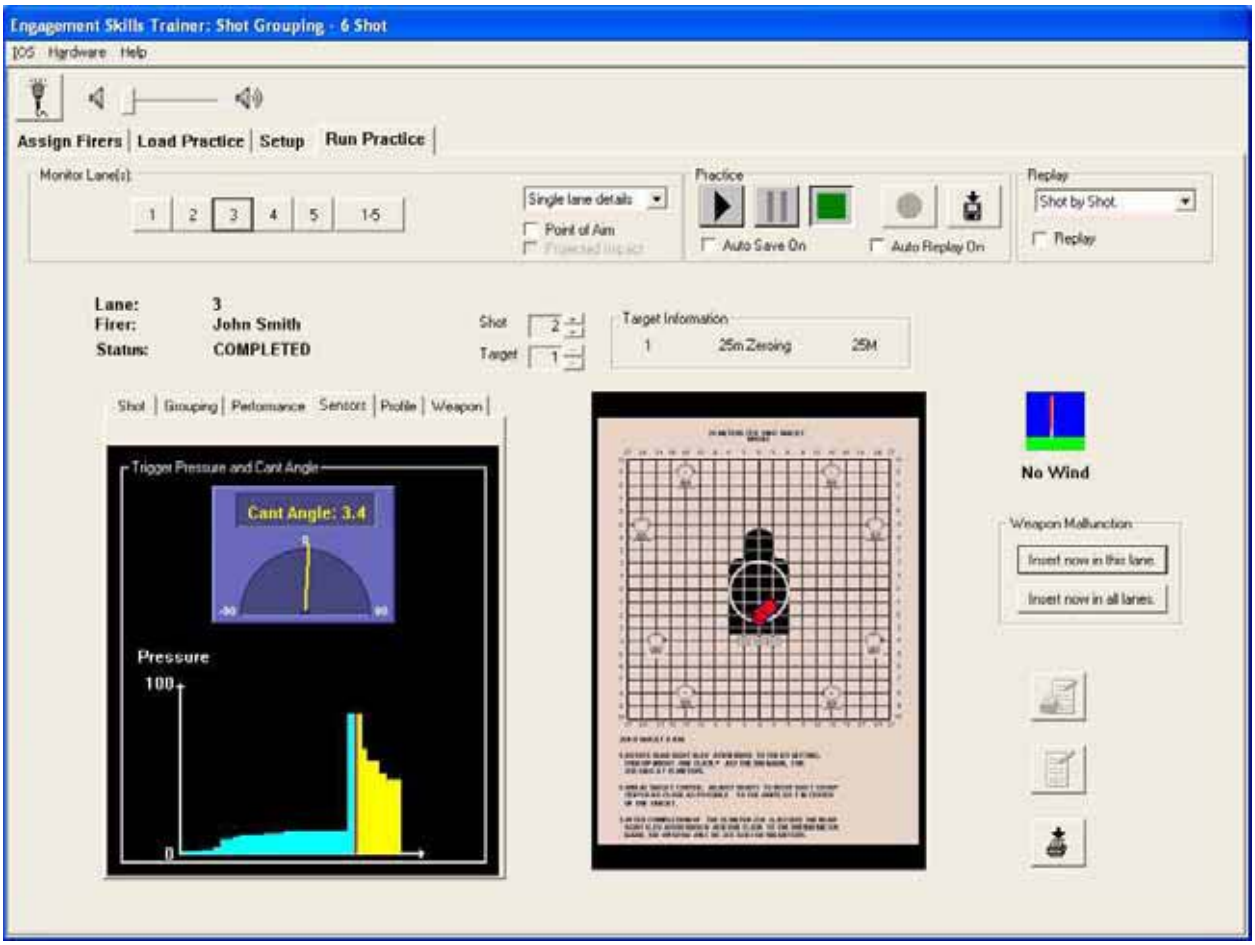


Figure 3-67. Single Lane Details - Sensors Chart

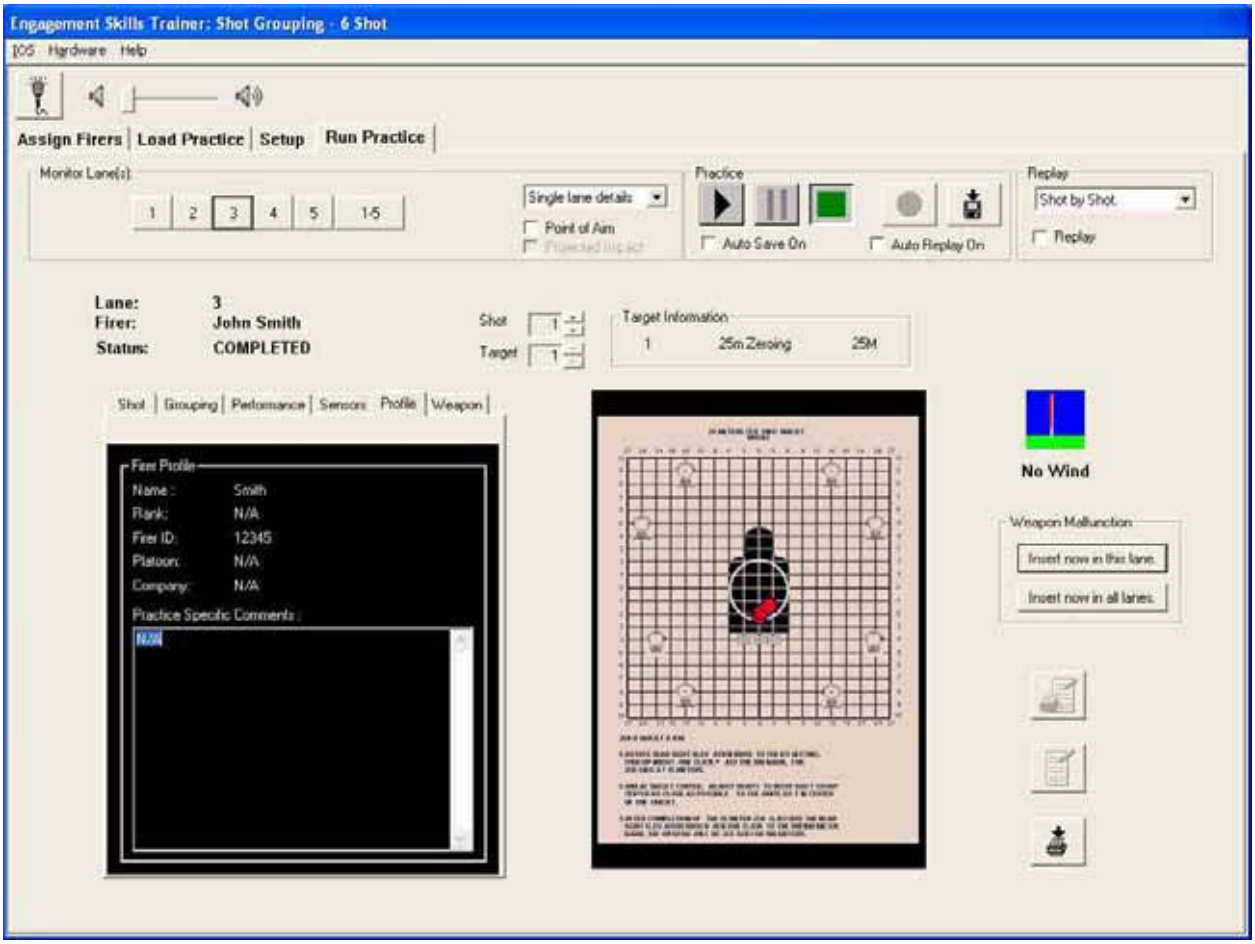


Figure 3-68. Single Lane Details - Profile Chart

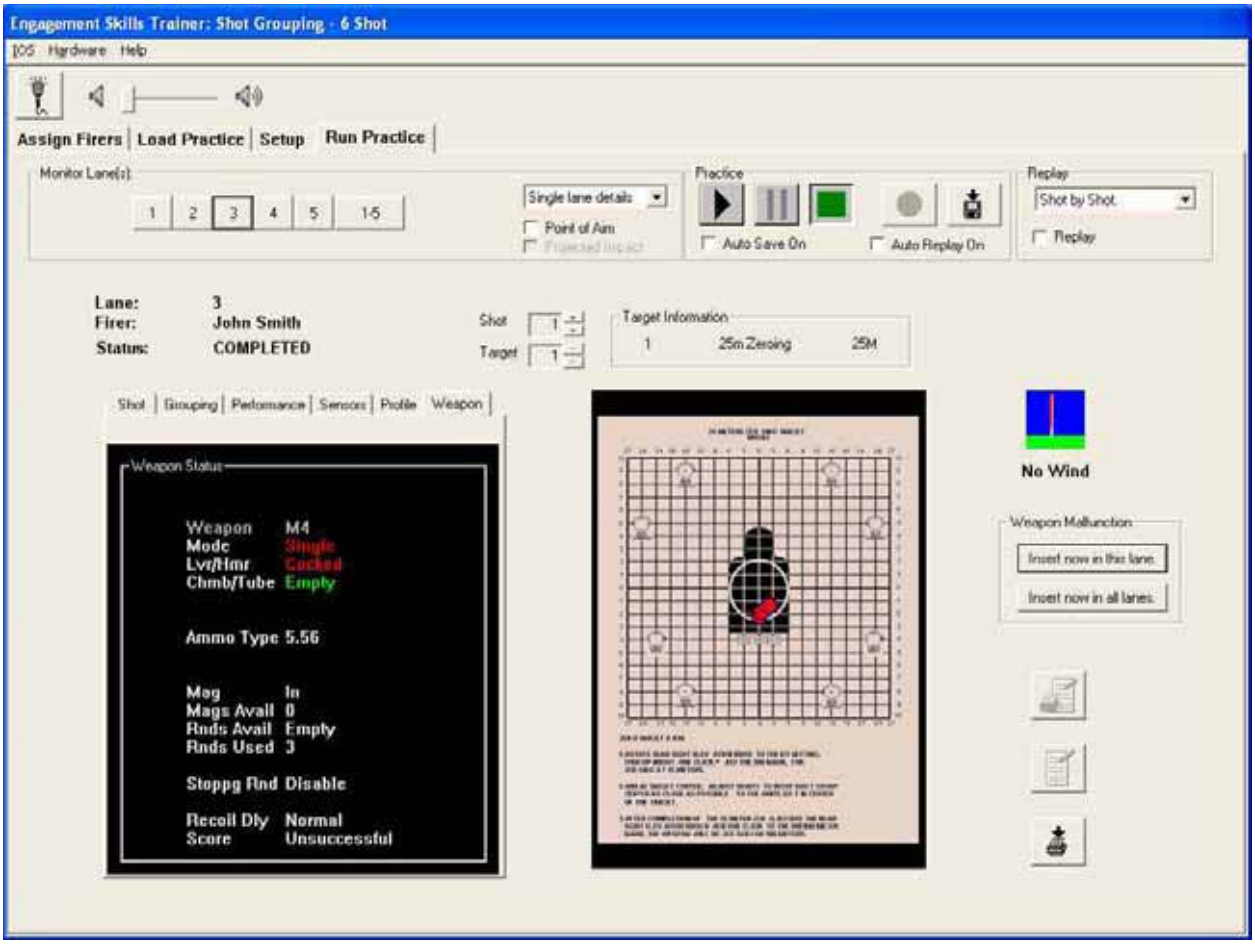


Figure 3-69. Single Lane Details - Weapon Chart

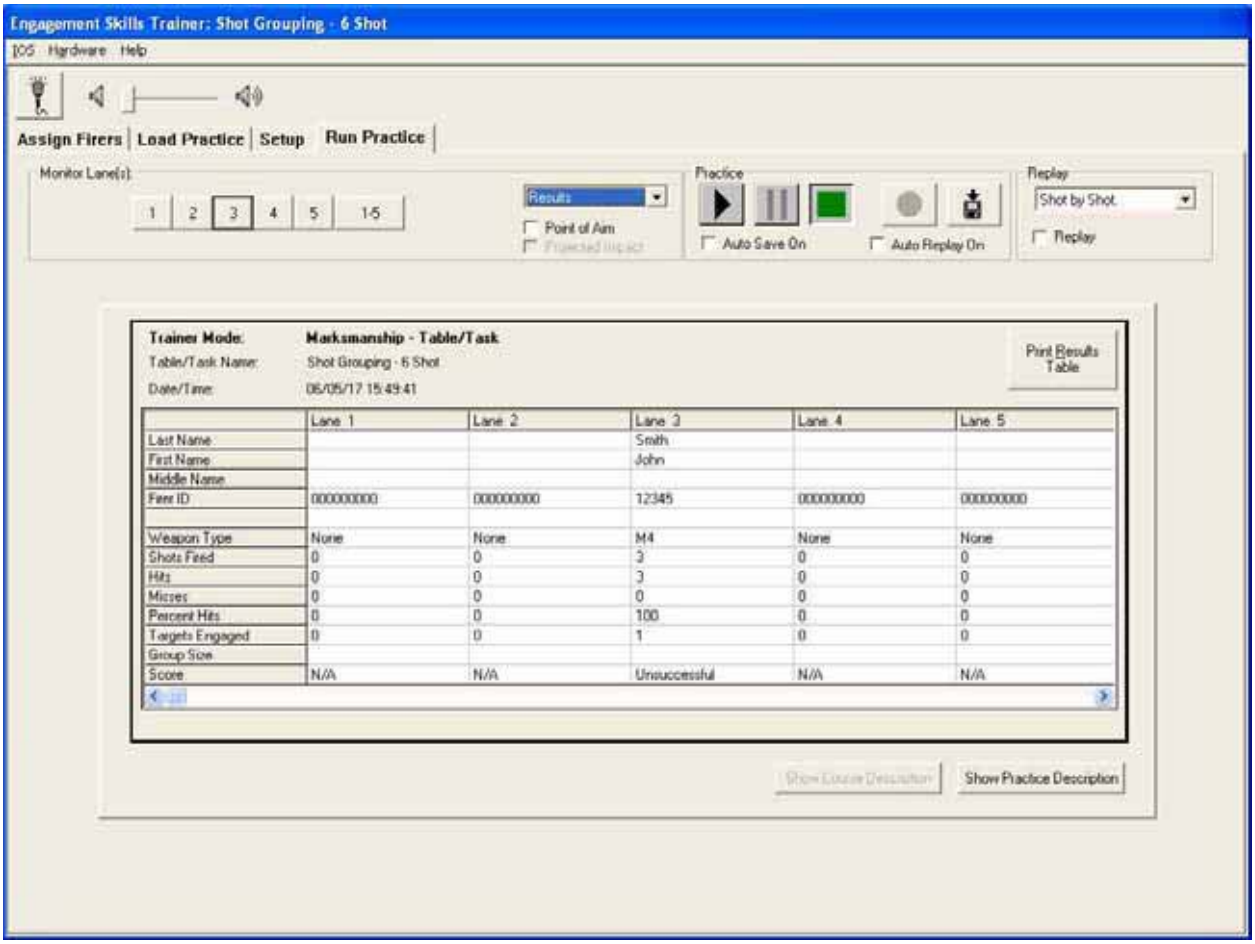


Figure 3-70. Sample Results Table

TD-07-6910-702-10

DA FORM 3595-R

Print

RECORD FIRE SCORECARD

For use of this form, see FM 23-9; the proponent agency is TRADOC

Exit

DATA REQUIRED BY PRIVACY ACT OF 1974

AUTHORITY: 10 USC 3012(g); Executive Order 9397. PRINCIPAL PURPOSE(S): Facilitates individual's training on multiple weapon target engagement of varying ranges. ROUTINE USE(S): To advise individual supervisory NCOs/squad leaders/platoon sergeants/unit commanders. MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION: Voluntary. Individuals not providing information cannot be rated; scored on a reset basis.

1. NAME (LAST, FIRST, MIDDLE INITIAL)	2. SSN	3. GRADE	4. UNIT	5. ROSTER NO.
John Smith	12345			

6. TABLE 1 - SUPPORTED FIGHTING POSITION

RD	RANGE (M)	TIME (SEC)	HIT	MISS	NO FIRE	RD	RANGE (M)	TIME (SEC)	HIT	MISS	NO FIRE
1	50	3	X			11	100	8		X	
2	200	6	X			12	200		X		
3	100	4		X		13	150	10		X	
4	150	5		X		14	300				X
5	300	8		X		15	100	9			X
6	250	7		X		16	250				X
7	50	3	X			17	300	6			X
8	200	6		X		18	150	5			X
9	150	5		X		19	50	6			X
10	250	7		X		20	100				X
	TOTAL		3	7	0		TOTAL		1	2	7

7. TABLE 2 - PRONE UNSUPPORTED POSITION

RD	RANGE (M)	TIME (SEC)	HIT	MISS	NO FIRE	RD	RANGE (M)	TIME (SEC)	HIT	MISS	NO FIRE	RD	RANGE (M)	TIME (SEC)	HIT	MISS	NO FIRE
1	100	5				11	150	8									
2	250	8				12	300	9									
3	150	6				13	400	10									
4	50	4				14	200										
5	200	8				15	150	12									
6	150	7				16	350										
7	200	8				17	100	8									
8	50	5				18	150										
9	150	6				19	200	9									
10	100	8				20	100										
	TOTAL		0	0	0		TOTAL		0	0	0		TOTAL		0	0	0

8. SCORE

TABLE	HIT	MISS	NO FIRE
1	4	9	7
2	0	0	0
TOTAL	4	5	7

9. QUALIFICATION SCORES. RATING (CHECK ONE)

- ☐ 36-40 EXPERT
- ☐ 30-35 SHARPSHOOTER
- ☐ 23-29 MARKSMAN
- ☒ 22 BELOW UNQUALIFIED

10. FIRER'S QUALIFICATION SCORE: Unqualified

11. REMARKS

NIGHT FIRE EXERCISE

DATE	HIT	MISS	GO	NO GO

NBC FIRE EXERCISE

DATE	HIT	MISS	GO	NO GO

12. DATE SIGNED

13. SCORER'S SIGNATURE

14. DATE SIGNED

15. OFFICER'S SIGNATURE

DA FORM 3595-R, JUN 89

Figure 3-71. Sample Scorecard

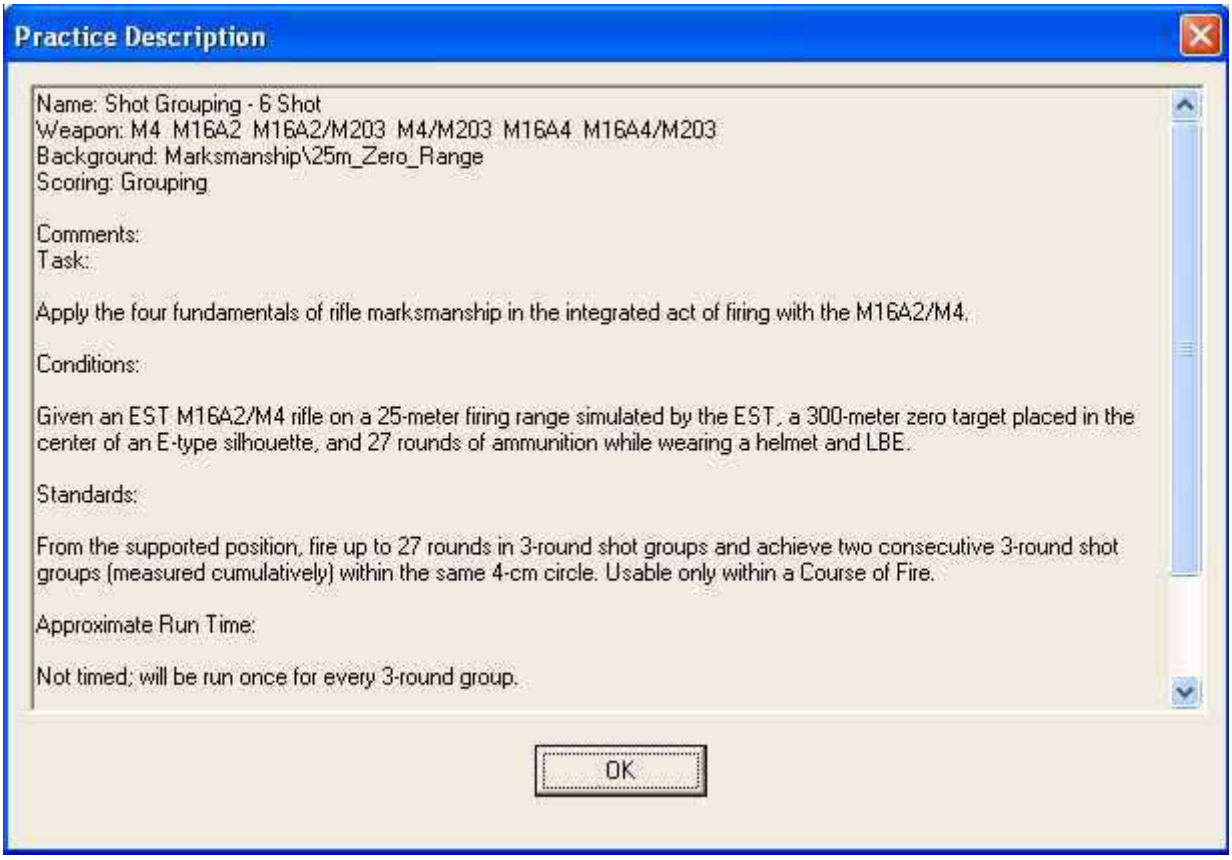


Figure 3-72. Course/Practice Description

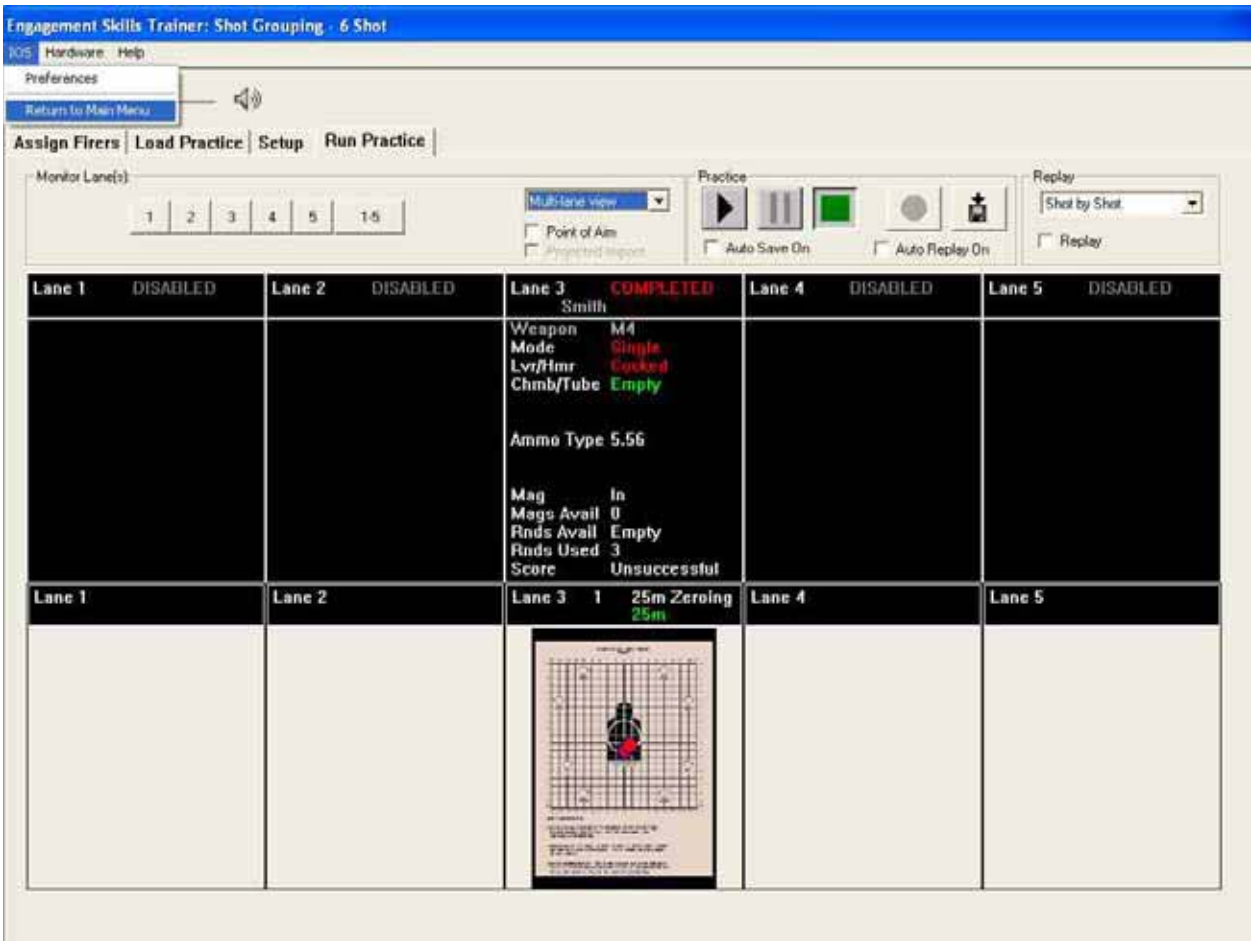


Figure 3-73. Return to Main Menu Screen

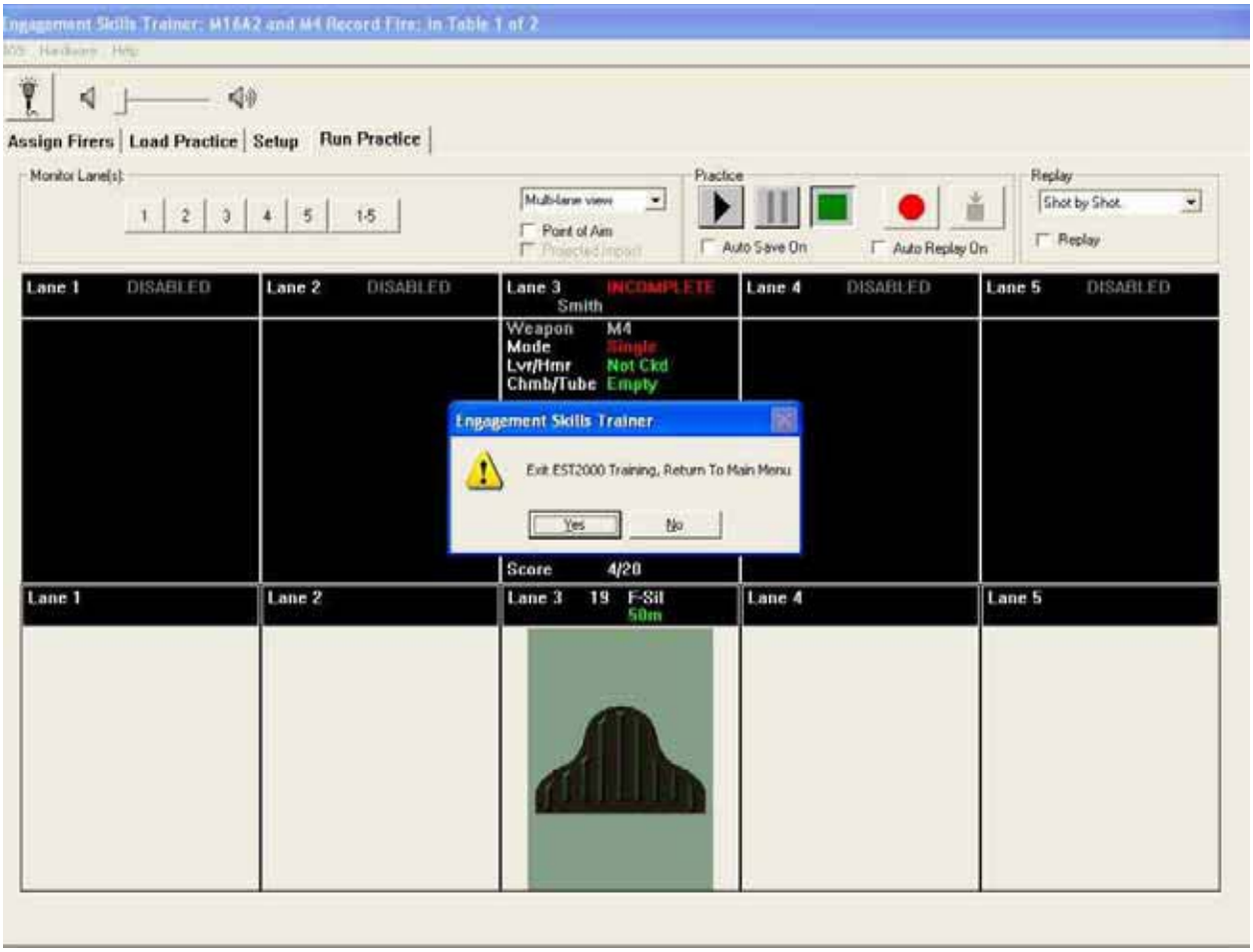


Figure 3-74. Exit Screen

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

3.5.2. Collective mode

Collective training is conducted on one 5-lane or two networked 5-lane subsystems (See paragraph 3.1.3.1. regarding networking systems). The Collective core scenario descriptions are listed in Table 3-2. Two networked 5-lane subsystems support up to eleven weapons (including tandem weapons) for the following types of training:

Collective training for an Infantry Squad of nine soldiers.
Collective training for a Scout Squad of five soldiers.
Collective training for a Combat Engineer Squad of nine soldiers.
Collective training for a Military Police Squad of ten soldiers.
Collective training for a Combat Support/Combat Service Support element of up to ten soldiers.

a. To begin Collective training, select "1. Training" from the Engagement Skills Trainer Login Screen (Figure 3-38).
b. On the Practice Type Screen, select "2. Collective" (Figure 3-75) then click on "OK".
c. The Subsystem Allocation Screen (Figure 3-40) appears. Select the desired lane configuration by clicking on Station 1 and 2, or 2 and 3 (for 10-lane operation) then click on "OK".

   Note: The Instructor/Operator's options may be limited, based upon individual site configurations. The station marked with an asterisk indicates the IOS in which the Instructor/ Operator is physically operating from.

   Note: In a 3-subsystem configured site (15-lanes), you cannot select Station 1 and 3 for a 10-lane Collective training event. The two subsystems must be adjacent (1 and 2, or 2 and 3).

d. After clicking "OK" the system will proceed with Autotracker Calibration.
e. After Autotracker Calibration has been completed, the Instructor/Operator will see the Engagement Skills Trainer Assign Firers Screen (Figure 3-42) on the IOS Monitor. If Autotracker Calibration is unsuccessful, the Instructor/Operator will see an Autotracker Calibration Failure Message on the IOS Monitor.

   Note: If calibration has failed, the Instructor/Operator should refer to Table 4-8 in the Troubleshooting Section of this manual.

f. From EST Assign Firers Screen (Figure 3-42) select "Hardware" on EST tool bar (paragraph 3.5.2.2.) at top left (Figure 3-44) and check the Sight Aim Point (SAP) on each connected weapon. (paragraph 3.5.2.2.2.2. Check Weapon Laser Alignment)

3.5.2.1. Tandem Weapon Capabilities

The tandem weapon capabilities are available in Collective training mode only. This capability allows for the use of an extra weapon connected to Port 6 (3rd/Right Floor Box, Right Port) allowing a firer to manage two weapons.

Note: Tandem weapon capabilities does not support using two of the same type weapons, or an M203 weapon connection.

3.5.2.2. EST Tool Bar

The tool bar at the top left of the screen (Figure 3-43) provides drop down menus under IOS and HARDWARE. The paragraphs below describe the drop down menus.

3.5.2.2.1. IOS drop down menu

Selecting "IOS" will present a drop down menu containing "Preferences" and "Return to Main Menu" (Figure 3-43).

3.5.2.2.1.1. Preferences

Select "Preferences" and the Preference Screen (Figure 3-44) will appear allowing the Instructor/Operator to set the following options:

- Auto Calibrate after Nth course load – not used in Collective training.
- Set Auto-Save ON by default – enable the AutoSave option on the run practice tab.
- Trainee results hidden – not used in Collective training.
- Dispersion OFF in Zeroing courses – not used in Collective training.
- Use alternate 25m target – not used in Collective training.
- IET Marksmanship Location – not used in Collective training.

3.5.2.2.1.2. Return to Main Menu

Select "Return to Main Menu" and a pop-up query box is displayed asking the Instructor/Operator to confirm the selection.

3.5.2.2.2. Hardware drop down menu

Selecting "HARDWARE" will present a drop down menu containing Calibrate Autotracker, Check Weapon Laser Alignment, Toggle Screens, and Microphone On. The paragraphs below describe each of the drop down menu options under the Hardware drop down menu.

3.5.2.2.2.1. Calibrate Autotracker

Used to recalibrate the ATTR without leaving the selected mode of training. Select "Calibrate Autotracker", a pop-up window will appear allowing the Instructor/Operator to recalibrate the system's ATTR from within the currently selected training mode.

3.5.2.2.2.2. Check Weapon Laser Alignment

To check the Sight Aim Point (SAP), select "Check Weapon Laser Alignment". A pop-up window will appear allowing the Instructor/Operator to turn on the SAP for each weapon connected to the system. Select "Initiate" on this pop-up window. The projection screen will go dark and a green sight aim point with a lane number alongside will be visible from each connected weapon as the weapon is aimed at the screen.

After checking each weapon, select "Terminate" and then "Dismiss" to return the system to the training selected.

Note: The Check Weapon Laser Alignment feature should be used as a daily, pre-training check to ensure correct weapon laser to weapon sight alignment. A properly aligned weapon will show the laser's SAP aligned with the weapon's sights as the weapon is aimed anywhere on the screen.

3.5.2.2.3. Toggle Screens

A feature that will allow the "swapping" of views on the IOS Monitor and the Projection Screen. Select "Toggle Screens", the view from the IOS monitor will appear on the projection screen and the view from the projection screen will appear on the IOS monitor. This is especially useful during Train-The-Trainer sessions for newly assigned Instructor/Operators.

Select "Toggle Screens" (IOS view on the projection screen) to return views to normal operation.

3.5.2.2.3.1. Microphone On

Turn the microphone On or Off by selecting or deselecting this option.

3.5.2.3. Training Control Menus

Training control menus incorporate user-friendly softkeys, display windows, and pulldown selection menus to help the Instructor/Operator quickly and efficiently initiate and monitor training on the desired simulation. Training control menus available from the training mode of operation include Assign Firers, Load Practice, Setup, and Run Practice. These training control menus are defined in the following paragraphs.

3.5.2.3.1. Assign Firers

The Assign Firers Screen is used to manage rosters, firers, and lane assignments. The Instructor/Operator is able to add, edit, delete, and review firer information using the softkeys available on the Assign Firers Screen. The Instructor/Operator can also export and import firer data via a 3½" floppy disk drive or a CDRW drive (paragraphs 3.6.2.4 and 3.6.2.5.).

a. Before assigning a firer, connect a weapon to the floor box to activate the lane.

   Note: If a weapon is new to the system, then it needs to be added to the subsystem's weapon database. Refer to Appendix E (paragraph E-1.2.1.4) for the procedure to add new weapons to the subsystem's weapon database.

b. Add a firer by clicking the softkey displayed in lower left of Assign Firers Screen (Figure 3-42). The Instructor/Operator will be prompted to add a new or existing firer (Figure 3-46). Select the appropriate choice and the Firer Data screen will appear (Figure 3-47). Required data fields are: Last Name; First Name; and Firer ID.

   Note: The minimum information required when adding firers using this method is Last Name and Firer ID.

   Note: The Firer ID DOES NOT have to be a Social Security Number. The Firer ID can be any combination of numbers and/or letters that uniquely identifies the individual.

   The Instructor/Operator can also add multiple fires at once by clicking on the Generate Roster softkey. The Generate Roster screen (Figure 3-48) will appear with a default value for Number of Shooters and Groups. Enter the required data and click on "OK". The system will generate a roster for use in training.

c. To edit or delete a firer's data, click on the softkeys and change the information as required.

   Note: When deleting a firer from the entire system, a message box will appear (Figure 3-49) asking the Instructor/Operator to verify this action before proceeding.

3.5.2.3.2. Select Roster

A roster identifies a specific group of individuals.

a. Create a roster by clicking on Select Roster on the Assign Firers Screen (Figure 3-42). Using the softkeys, the Instructor/Operator can Add, Edit, Delete, Print, Store, Retrieve, or Generate a roster.
b. Add firers to a specific roster by clicking on the Add Firer softkey.
c. Generate an automatic roster by clicking on the Generate Roster softkey.

Note: To Store or Retrieve a roster see paragraphs 3.6.2.1 and 3.6.2.2.

Note: Roster option tabs can be used in conjunction with the Selected Roster pulldown menu. For example, to view details of a previously saved roster, first click the down arrow next to the Selected Roster window and highlight the desired roster from the pulldown menu. Click on Edit Roster to display detailed information on the selected roster. Other roster options include Add Roster, Delete Roster, Print Roster, Store Roster, Retrieve Roster, and Generate Roster.

3.5.2.3.3. Load Practice

a. Click on the Load Practice tab to access the Load Practice Screen. The Load Practice Screen (Figure 3-76) provides for the selection of training scenarios based upon the Category selected (i.e. Infantry, Engineer, MP).
b. Begin by selecting a Category.
c. Click on the down arrow in the Category field to display a list of Categories of training. Following the selection of a Category, a list of available scenarios (Table 3-2) for that Category is displayed.
d. Select a scenario by highlighting the scenario in the “practice” box.
e. Click on the View Practice Description box (lower left side of screen), a description of the highlighted practice appears in the practice description window on the right side of the screen.
f. The desired practice is loaded by clicking on the Load This Practice key. A momentary message, “Loading Practice Defaults”, appears following the selection of the Load This Practice key.

3.5.2.3.4. Setup

a. Click on the Setup tab to access the Setup Screen. The Setup Screen (Figure 3-51) allows the Instructor/Operator to specify conditions for the selected scenario.
b. Modify conditions if required. Modifiable conditions include visibility, wind, and bullet options.
c. Modify weapon settings using the Change Settings softkey located on the Settings display. Weapon types and lane assignments are displayed in the Weapon Parameter window. The Weapon Settings display on the Setup Screen provides weapon-specific data such as magazine and ammo quantities for a weapon highlighted in the Weapon Parameter window.

3.5.2.3.5. Run Practice

a. To begin training, click on the Run Practice tab to access the Run Practice Screen.
b. Click the Run Practice (▸) button. An “Initializing Weapons - Please Wait” message box appears followed by an instruction to “lock and load weapons now” (Figure 3-54).
c. Instruct the firers to “lock and load” their weapons when the message box appears.

Note: If the firer locks and loads a weapon before the Instructor/Operator gives the command, the ammo settings for the ammo may be improper. Likewise, if the Instructor/Operator clicks on “OK” prior to all firers successfully locking and loading their weapons, the scenario may not run properly.

d. When the status of all lanes changes from NOT READY (Figure 3-55) to READY (Figure 3-56) click “OK” to proceed.

Note: For tandem weapon capabilities, both weapons will indicate status in lane 5 for the firer assigned to the lane.

Note: The Run Practice default screen is multi-lane status (Figure 3-57). The Run Practice Screen allows the Instructor/Operator to monitor single or multiple lanes via the Monitor Lane(s) selection area. The Run Practice single lane details view is shown in Figure 3-59. Control of the training scenario is provided through the Run Practice, Pause, Stop, and Replay softkeys.

e. After the practice is complete, a screen indicating the table or task is over appears (Figure 3-60), click "OK" to proceed.

3.5.2.3.6. Practice replay

After a practice is complete, the Instructor/Operator can replay the entire practice on the projection screen.

a. To replay a practice, first indicate in the Replay pulldown menu the method of the replay. Replay selections for Collective Mode include Run to Completion, Pause on next shot, and Pause on next hit. (Figure 3-77)
b. Click the replay box. Each shot appears in either green (miss) or red (hit) on the projection screen as the practice is replayed. The lane number of the firer is displayed along with the shot to allow the Instructor/Operator to easily identify each firer's performance (Figure 3-78).
c. To advance to the next shot, or next hit, click the Run Practice (▸) button. When the replay is complete, a message will appear indicating the replay is over, click on "OK" to proceed.

Note: For tandem weapon capabilities, both weapons will indicate practice replay status in lane 5 for the firer assigned to the lane.

3.5.2.3.7. Performance table window

A lane-by-lane summary of shot performance including detailed firer/lane data is accessible by the Instructor/Operator via the selection tabs located on the left side of a single lane details screen (Figure 3-59). Data selections include shot, grouping, performance, sensors, profile, and weapon.

a. Select the Shot tab (Figure 3-62 and Figure 3-63) to view details including shot type, reaction time, result, time of shot, weapon, ammo, offsets, and score.
b. Select the Grouping tab (Figure 3-64 and Figure 3-65) to access data on the number of shots, group width and height, and horizontal and vertical zeroing offsets.
c. Select the Performance tab (Figure 3-66) to provide the following data: practice designation, start time, duration, shots fired, score, last shot type, and an overall performance rating of the firer.
d. Select the Sensors tab (Figure 3-67) to display a graphical representation of the trigger pressure and weapon cant angle corresponding to the shot. Press shot number display window up arrow to see the shot position and sensor data corresponding to the second shot. The down arrow returns to display the previous shot performance data.
e. Select the Profile tab (Figure 3-68) to view the name, rank, serial number, platoon, and company of the firer. Any practice specific comments concerning the firer are also presented.
f. Select the Weapon tab (Figure 3-69) to view detailed information on the current weapon being used during the practice.

3.5.2.3.8. Saving a completed practice

In order for results tables and scorecards to be generated, the completed practice must be saved.

a. The Instructor/Operator can either manually save following completion of the practice or select the Auto Save On option prior to beginning a practice. The summary of data saved to disk is saved in MS Access. Table 3-4 summarizes the data when a student record is stored.

3.5.2.3.9. Results Table

Results tables can be viewed by double clicking on any course or practice listed on the View Saved Practices Screen course and practice lists. In collective training the results table (Figure 3-70) shows a unit summary in the first column in addition to information on all lanes. A description of the practice or course is also available from the View Saved Practices Screen (Figure 3-72).

3.5.2.3.10. Printing - Collective mode

a. Select the Print icon to print the results table, and shot charts.
b. Click on Print Direct and either Print Results Table or Print Target Graphics, then press the Print All Lanes button or, for a shot chart, select a lane and then press Print Selected.

3.5.2.4. Switching between Training Modes

The Instructor/Operator can switch to another training mode (Marksmanship or Shoot/Don't Shoot) by selecting "Return to Main Menu" on the IOS pulldown menu (Figure 3-75). A screen will appear stating "Exit IOS, Return to Main Menu (Figure 3-74). Click "YES". After a few moments, the EST Login Screen (Figure 3-38) will appear. Follow the procedures outlined in paragraph 3.5.1. or paragraph 3.5.3.

Table 3-2. Collective Core Scenarios

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
K001	Defend	M16s/Atch. MG - All Small Arms supported	Basic Load	Desert/day/clear	450m	18 man dismounted patrol-80 total personal targets	Y	Y	N	Y
K002	Defend	M16s/4AT4/Atch.- MG All Small Arms supported	Basic Load	Desert/day/cloudy	400m	2 BTR w/Squads Preceded by 9 dismounts- 80 total personal targets	Y	Y	N	Y
K003	Defend	M16s/Atch. MG - All Small Arms supported	Basic Load	Forest/day/cloudy	300m	18 man dismounted patrol-80 total personal targets	Y	Y	N	Y
K004	Defend	M16s/2AT4/Atch. MG - All Small Arms supported	Basic Load	Forest/night/clear	250m	1 BTR Preceded by 10 dismounts – 80 total personal targets	Y	Y	N	Y
K005	Defend	M16s/2AT4/Atch. MG - All Small Arms supported	Basic Load	Desert/night/clear	300m	2 BTR w/Squads Preceded by 9 dismounts- 80 total personal targets	Y	Y	N	Y
K006	Defend	M16s/Atch. MG - All Small Arms supported	Basic Load	Urban/day/clear	100m	18 man dismounted patrol-80 total personal targets	Y	Y	N	Y
K007	Defend	M16s/2AT4/Atch. MG - All Small Arms supported	Basic Load	Woodland/dusk/haze	250m	1 BTR Preceded by 18 dismounts – 80 total personal targets	Y	Y	N	Y
K008	Defend	M16s/Atch. MG - All Small Arms supported	Basic Load	Woodland/day/cloudy	400m	18 man dismounted patrol-80 total personal targets	Y	Y	N	Y
K009	Overwatch	M16s/Atch. MG/PVS-7 - All Small Arms supported	Basic Load	Forest/night/clear	100m	1 sqd in defense posture w/AK 74s	Y	Y	N	Y
K010	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Urban/day/clear	150m	1 sqd size Patrol w/ AK 74s	Y	Y	N	Y
K011	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Forest/day/cloudy	200m	10 men Patrol, w/ AK 74s	Y	Y	N	Y
K012	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Jungle/day/clear	75m	9 man dismounted patrol	Y	Y	N	Y
K013	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Mountains/day/rain	200m	1 sqd size element in defense posture	Y	Y	N	Y
K014	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Desert/day/sunrise	175m	9 man dismounted patrol	Y	Y	N	Y
K015	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Woodland/day/clear	100-150m	9 man dismounted patrol	Y	Y	N	Y
K016	Overwatch	M16s w/Atch. MG - All Small Arms supported	Basic Load	Woodland/dusk/clear	150m	1 Bunker w/ MG team w/ RPK 74s	Y	Y	N	Y
K017	Armor Ambush	M16s/4AT4/Atch. MG - All Small Arms supported	Basic Load	Forest/day/clear	275m	2 BTR w/ mounted squads	Y	Y	N	Y
K018	Armor Ambush	M16s/4AT4/Atch. MG - All Small Arms supported	Basic Load	Woodland/dusk/clear	275m	2 BTR w/ mounted squads	Y	Y	N	Y
K019	Armor Ambush	M16s/4AT4/Atch.MG - All Small Arms supported	Basic Load	Urban/day/clear	175m	2 BTR w/ mounted squads	Y	Y	N	Y
K020	Armor Ambush	M16s/2AT4/Atch. MG - All Small Arms supported	Basic Load	Forest/night/clear	200m	1 BTR 9 man dismounted squad	Y	Y	N	Y
K021	Armor Ambush	M16s/4AT4/Atch. M - All Small Arms supported	Basic Load	Mountains/dusk/clear	275m	2 BTR w/ mounted squads	Y	Y	N	Y

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
K022	Armor Ambush	M16s/4AT4/Atch. MG - All Small Arms supported	Basic Load	Woodland/day/fog	250m	2 BTR w/ mounted squads	Y	Y	N	Y
K023	Armor Ambush	M16s/4AT4/Atch. MG - All Small Arms supported	Basic Load	Valley(Open terrain)/night/clear	275m	2 BTR w/ mounted squads	Y	Y	N	Y
K024	Armor Ambush	M16s/2AT4/Atch. MG - All Small Arms supported	Basic Load	Desert/day/clear	275m	1 BTR w/ mounted squad	Y	Y	N	Y
K025	Knock/bunker	M16s w/Atth. MG - All Small Arms supported	Basic Load	Woods-Lt veg/day/haze	300m	2 bunker MG team w/ RPK 74	Y	Y	N	Y
K026	Knock/bunker	M16s w/Atth. MG - All Small Arms supported	Basic Load	Forest/night/clear	250m	1 bunker 1 MG team W/ RPK74	Y	Y	N	Y
K027	Knock/bunker	M16s w/Atth. MG - All Small Arms supported	Basic Load	Desert/day/cloudy	300m	2 bunker manned by two men w/ RPK 74s	Y	Y	N	Y
K028	Knock/bunker	M16s w/Atth. MG - All Small Arms supported	Basic Load	Woodland/night/smoke	350m	1 bunker 1 MG team W/ RPK 74	Y	Y	N	Y
K029	Knock/bunker	M16s, 2AT4s, w/Atth. MG - All Small Arms supported	Basic Load	Forest/dusk/clear	250m	2 bunker MG team w/ RPK 74	Y	Y	N	Y
K030	Knock/bunker	M16s, 2AT4s, w/Atth. MG - All Small Arms supported	Basic Load	Mountains/day/rain	200m	2 bunker MG team w/ RPK 74	Y	Y	N	Y
K031	Knock/bunker	M16s w/MG Tm - All Small Arms supported	Basic Load	Jungle/day/clear	75m	1 bunker 1 MG team W/ RPK 74	Y	Y	N	Y
K032	Knock/bunker	M16s w/MG Tm - All Small Arms supported	Basic Load	Woodland/dusk/hazy	350m	2 bunker MG team w/ RPK 74	Y	Y	N	Y
K033R1	Support by Fire	All small arms supported	Basic Load	Woodland/day/clear	600m	8-man support element + 7-man assault team w/ AK-74s and RPK-74s	Y	Y	N	Y
K034R1	Passage of Lines	All small arms supported	Basic Load	Woodland/dusk/clear	450m	10 man dismounted patrol w/ 8 AK-74s and 2 RPK-74s	Y	Y	N	Y
K035R1	Delay	All small arms supported	Basic Load	Woodland/day fog	450m	10 man dismounted patrol w/ 8 AK-74s and 2 RPK-74s	Y	Y	N	Y
K036R1	Support by Fire	All small arms supported	Basic Load	Desert/day clear	500m	8man support element+7man assault team w/ AK-74s and RPK-74S	Y	Y	N	Y
K037R1	Defend (FPL)	All small arms supported	Basic Load	Woodland/day/clear	300m	20man element x 2 w/ AK-74s	Y	Y	N	Y
K038R1	Passage of Lines	All small arms supported	Basic Load	Korean village/dusk/clear	300m	10 man dismounted patrol w/ 8 AK-74s and 2 RPK-74s	Y	Y	N	Y
K039R1	Delay	All small arms supported	Basic Load	Desert/day/smoke	300m	10 man dismounted patrol w/ 8 AK-74s and 2 RPK-74s	Y	Y	N	Y
K040R1	Support by Fire	All small arms supported	Basic Load	Woodland/day/clear	400m	8 man dismounted patrol w/6AK-74s and 2 RPK-74s	Y	Y	N	Y
K041	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Mountains/day/rain	350m	16 man dismounted patrol	Y	Y	N	Y
K042	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Woodland/day/fog	250m	16 man dismounted patrol	Y	Y	N	Y

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
K043	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Valley(Open terr)/night/clear	200m	16 man dismounted patrol	Y	Y	N	Y
K044	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Jungle/day/clear	75m	16 man dismounted patrol	Y	Y	N	Y
K045	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Forest/night/clear	75m	16 man dismounted patrol	Y	Y	N	Y
K046	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Woodland/dusk/smoke	100m	16 man dismounted patrol	Y	Y	N	Y
K047	Point Ambush	M16s w/Attch. MG - All small arms supported	Basic Load	Valley(Open terr)/night/clear	100m	16 man dismounted patrol	Y	Y	N	Y
K048	Point Ambush	M16s/2AT4/Atch. MG - All small arms supported	Basic Load	Forest/dusk/clear	200m	1 BTR 16 man dismounted squad	Y	Y	N	Y
K049	Point Ambush	M16s/4AT4/Attch. MG - All small arms supported	Basic Load	Mountains/day/haze	250m	2 BTRs, 14 dismount on contact	Y	Y	N	Y
K050R1	Fire FPL	All small arms supported	Basic Load	Mout/day/clear	300m	20 man element x 2 w/ AK-74s=40 total	Y	Y	N	Y
K051R1	Fire FPL	All small arms supported	Basic Load	Korea/day/clear	300m	20 man element x 2 w/ AK-74s=40 total	Y	Y	N	Y
K052R1	Call for Fire	All small arms supported	Basic Load	Woodland/day/clear	300m	20 man element x 2 w/ AK-74s=40 total	Y	Y	N	Y
K053R1	Call for Fire	All small arms supported	Basic Load	Woodland/day/clear	300m	6 BRDM w/Possible 16 men w/ AK-74s	Y	Y	N	Y
K054R1	Call for Fire	All small arms supported	Basic Load	Woodland/day/clear	300m	6 BRDM w/Possible 48 men w/ AK-74s	Y	Y	N	Y
K055R1	Passage of Lines	All small arms supported	Basic Load	Desert/day/clear	450m	10 man dismounted patrol w/AK-74s	Y	Y	N	Y
K056R1	FPL on Bridge	All small arms supported	Basic Load	Bridge/day/clear	300m	20 man element x 2 w/ AK-74s=40 total	Y	Y	N	Y
K057R1	FPL on Bridge	All small arms supported	Basic Load	Bridge/day/clear	300m	3 thin skinned vehicles w/ 14.5mm MG w/4 dismounts and AK-74s	Y	Y	N	Y
K058	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Bosnia/urban core/day/clear	100m	2 BTRs w/ mounted squads +9 dismounts - 26 total personnel targets	Y	Y	N	Y
K059	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Korea/village/day/haze	150m	2 BTRs w/ mounted squads + 9 dismounts - 35 total personnel targets	Y	Y	N	Y
K060	Defend MOUT	M16/4AT4/Attch MG - All Small Arms supported	Basic Load	Korea/residential/day/clear	250m	2 BTRs w/ mounted squads + 10 dismounts - 38 total personnel targets	Y	Y	N	Y
K061	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Outlying industrial/day/rain	200m	18 dismounts + 2 snipers = 54 total personnel targets	Y	Y	N	Y
K062	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Bosnia/commercial/night/clear	100m	18 dismounts - 50 total personnel targets	Y	Y	N	Y
K063	Defend MOUT	M16s/2AT4/Attch MG - All Small Arms supported	Basic Load	Bosnia/urban core/day/smoke	175m	9 dismounts - 36 total personnel targets	Y	Y	N	Y

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
K064	Defend MOUT	M16/2AT4/Attch MG/PVS7 - All Small Arms supported	Basic Load	Korea/residential/night/clear	75m	1 BTR w/mounted squad + 9 dismounts - 42 total personnel targets	Y	Y	N	Y
K065	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Sub-Sahara Africa/shanty town/dusk	300m	2 BTRs w/ mounted squads + 9 dismounts - 35 total personnel targets	Y	Y	N	Y
K066	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Korea/village/day/haze	350m	2 BTRs w/ mounted squads + 9 dismounts - 27 total personnel targets	Y	Y	N	Y
K067	Defend MOUT	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Far East/urban/day/clear	350m	3 BTR + 15 dismounts - 15 total personnel targets	Y	Y	N	Y
K068	Point Ambush	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Bosnia/urban core/dusk/clear	75m	2 BTRs, 7 dismount on contact = 14 total personnel targets	Y	Y	N	Y
K069	Point Ambush	M16s/2AT4/Attch MG - All Small Arms supported	Basic Load	Bosnia/urban core/dusk/clear	100m	1 BTR + 16 dismounts	Y	Y	N	Y
K070	Armor Ambush	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Korea/village/day/haze	200m	2 BTRs,9 dismount on contact = 18 total personnel targets	Y	Y	N	Y
K071R1	Delay	All small arms supported	Basic Load	Desert/day/clear	300m	4 BRDMs w/10 dismounts and AK-74s	Y	Y	N	Y
K072	Defend	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Bosnia/urban core/dusk/clear	150m	2 BTRs w/ mounted squads + 9 dismounts - 41 total personnel targets	Y	Y	N	Y
K073	Defend	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Far East/urban/day/rain	150-m	2 BTRs w/ mounted squads + 9 dismounts - 32 total personnel targets	Y	Y	N	Y
K074	Point Ambush	M16/2AT4/Attch MG/PVS7 - All Small Arms supported	Basic Load	Korea/outlying area/night/clear	200m	1 BTR, 18 man dismounted squad	Y	Y	N	Y
K075	Point Ambush	M16s/4AT4/Attch MG - All Small Arms supported	Basic Load	Far East/urban/day/clear	150m	2 BTRs, 7 dismount on contact = 14 total personnel targets	Y	Y	N	Y
J010	2-man Guard Post	M16/M9	3 Mags/Ea	Korea/Ammo Pt/Night/Snow	10-100m	Civ trk and clothes, weapons	Y	Y	N	Y
J017	2-man Guard Post	M16/M9	3 Mags/Ea	Africa/village/Red Cross sup pt/Day/Clear	150m	Receiving sniper fire	Y	Y	N	Y
J019	2-man Guard Post	M16/M9	3 Mags/Ea	Bosnia/MOUT/IFOR ckpt/Day/Clear	10-100m	Receiving sniper fire	Y	Y	N	Y
J025	2-man Guard Post	M16/M9	3 Mags/Ea	Africa/village/Fd wrhse/Night/F Moon	10-100m	Receiving sniper fire	Y	Y	N	Y
J027	Patrol Base-Inf Sqd	M16/M249/M203	Basic Load	Forest/Day/Clear	200m	Enemy patrol firing	Y	Y	N	Y
J028	Patrol Base-Inf Sqd	M16/M249/M203	Basic Load	Forest/Day/Smoke	100m	Enemy patrol, not firing	Y	Y	N	Y
J029	Patrol Base-Inf Sqd	M16/M249/M203	Basic Load	Jungle/Sunset/Clear	10m	Civilian, unarmed	Y	Y	N	Y

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
J030	Patrol Base-Inf Sqd	M16/M249/M203	Basic Load	Jungle/Sunrise/Fog	50-100m	Enemy patrol, not firing	Y	Y	N	Y
J031	Patrol Base-Inf Sqd	Same+PVS4&7	Basic Load	Forest/Night/Clear/Full Moon	100m	Enemy patrol, not firing	Y	Y	N	Y
J032	Patrol Base-Inf Sqd	Same+PVS4&7	Basic Load	Forest/Night/Smoke	25-50m	Friendly patrol	Y	Y	N	Y
J033	Patrol Base-Inf Sqd	Same+PVS4&7	Basic Load	Jungle/Night/Clear	25-50m	Civilian, armed	Y	Y	N	Y
J034	Patrol Base-Inf Sqd	Same+PVS4&7	Basic Load	Jungle/Night/Smoke	25-50m	Friendly patrol firing at you	Y	Y	N	Y
J015	2-man Guard Post	M16/M9	3 Mags/Ea	Bosnia/MOUT/IFOR ckpt/Day/Clear	10-100m	Delivery veh, proper I.D.	Y	Y	N	Y
J016	2-man Guard Post	M16/M9	3 Mags/Ea	Bosnia/MOUT/IFOR ckpt/Day/Snow	10-100m	Delivery veh, no I.D.	Y	Y	N	Y
J021	2-man Guard Post	M16/M9	3 Mags/Ea	Africa/MOUT/Food wrhse/Night/F Moon	10-100m	Mil veh, no I.D.	Y	Y	N	Y
J022	2-man Guard Post	M16/M9	3 Mags/Ea	Africa/MOUT/Fd wrhse/Night/Cloudy	10-100m	Mil veh, use of duress codeword	Y	Y	N	Y
SCOUT SQUAD - EST 2000 COLLECTIVE SIMULATION EXERCISES										
L001	Defend an observation Post	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Day/Clear	300-1000m	Inf Sqd				
L002	Defend an observation Post	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Desert/Day/Fog	300-1000m	Inf Sqd				
L003	Defend an observation Post	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Night	300-1000m	Inf Sqd				
L004	Support a Hasty attack dismounted	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Day/Clear	300-1000m	BDRM				
L005	Support a Hasty attack dismounted	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Night	300-1000m	BDRM				
L006	Support a Hasty attack dismounted	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Desert/Night	300-1000m	BDRM				
L007	Conduct a screen	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Day/Clear	300-1000m	2 BDRM				
L008	Conduct a screen	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Desert/Night	300-1000m	2 BDRM				
L009	Border Defense (Screen)	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Day/Clear	300-1000m	Inf Sqd				

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
L010	Border Defense (Screen)	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Night	300-1000m	Inf Sqd				
L011	Delay	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Forest/Day/Clear	300-1000m	2 BDRM				
L012	Guard Flank	M16/M4,M203,M240B,M2 ,AT4,Mk 19	Basic Load	Desert/Day/Fog	300-1000m	2 BDRM				
ENGINEER SQUAD - EST 2000 COLLECTIVE SIMULATION EXERCISES										
M001	Defend	M16s/2AT4/MG Tm	Basic Load	Desert/day/clear	500m	10 man dismounted patrol	Y	Y	N	Y
M002	Defend	M16s/2AT4/MG Tm	Basic Load	Urban/day/clear	100m	10 man dismounted patrol	Y	Y	N	Y
M003	Defend	M16s/2AT4/MG Tm	Basic Load	Desert/day/cloudy	400m	9 man dismounted patrol	Y	Y	N	Y
M004	Defend MOUT	M16s/2AT4/MG Tm	Basic Load	Bosnia/urban core/dusk/clear	100m	3 BTRs w/ mounted squads	Y	Y	N	Y
M005	Defend MOUT	M16/2AT4/MG Tm/PVS7	Basic Load	Korea/residential/night/haze	250m	2 BTRs w/ mounted squads	Y	Y	N	Y
M006	Defend MOUT	M16s/2AT4/MG Tm	Basic Load	Bosnia/commercial/night/clear	100m	2 BTRs,9 dismount on contact	Y	Y	N	Y
M007	Defend MOUT	M16/2AT4/MG Tm/PVS7	Basic Load	Korea/residential/night/clear	75m	1 BTR 4 man dismounted on contact	Y	Y	N	Y
M008	Defend MOUT	M16s/2AT4/MG Tm	Basic Load	Korea/village/day/haze	350m	2 BTRs,9 dismount on contact	Y	Y	N	Y
M009	Point Ambush	M16s/2AT4/MG Tm	Basic Load	Bosnia/urban core/dusk/clear	50m	2 BTRs, 9 dismount on contact	Y	Y	N	Y
M010	Defend	M16s/2AT4/MG Tm	Basic Load	Bosnia/urban core/dusk/clear	100m	3 BTRs w/ mounted squads	Y	Y	N	Y
MILITARY POLICE SQUAD COLLECTIVE SIMULATION EXERCISES										
N001	Convoy Security Operations	All EST 2000 weapons	Basic Load	Desert, Day, Clear	500m	10 man dismounted squad	Y	Y	N	Y
N002	Convoy Security Operations	All EST 2000 weapons	Basic Load	Desert, Day, Cloudy	300-1000m	2BTRs, sqd dismount on contact	Y	Y	N	Y
N003	Secure and defend position	All EST 2000 weapons	Basic Load	Forest Day, Rain	300m	10 man dismounted patrol	Y	Y	N	Y
N004	Secure and defend position	All EST 2000 weapons	Basic Load	Desert, Day, Smoke	200-1000m	1BTR, dismounted squad	Y	Y	N	Y
N005	Conduct Delay	All EST 2000 weapons	Basic Load	Forest, Night, Clear	600m	2BTR, sqd dismount on contact	Y	Y	N	Y
N006	Conduct Delay	All EST 2000 weapons	Basic Load	Urban, Day, Clear	600m	2BTR, sqd dismount on contact	Y	Y	N	Y
N010	Point Ambush	All EST 2000 weapons	Basic Load	Forest, day, clear	300m	10 man dismounted patrol	Y	Y	N	Y
N011	Point Ambush	All EST 2000 weapons	Basic Load	Jungle, day, rain	3oom	8 man dismounted patrol	Y	Y	N	Y
N012	Point Ambush	All EST 2000 weapons	Basic Load	Mountains, dusk clear	200m	8 man dismounted patrol with 4 non-combatants	Y	Y	N	Y
N013	Point Ambush	All EST 2000 weapons	Basic Load	Urban, day, clear	150m	10 man dismounted w/AK74s	Y	Y	N	Y
N014	Point Ambush	All EST 2000 weapons	Basic Load	Urban, day, snow	150m	10 man dismounted patrol with 8 non-combatants	Y	Y	N	Y
N015	LP/OP	All EST 2000 weapons	Basic Load	Desert, dusk, clear	500m	2 BTR, Squad dismounts	Y	Y	N	Y
N016	LP/OP	All EST 2000 weapons	Basic Load	Mountain, dusk, clear	800m	3 BTRs	Y	Y	N	Y
N017	LP/OP	All EST 2000 weapons	Basic Load	forest, dusk, rain	800m	3 BTRs	Y	Y	N	Y

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
MILITARY POLICE TEAM COLLECTIVE SIMULATION EXERCISES										
N018	3 Man TCP	All EST 2000 weapons	Basic Load	Urban, day, clear	100m	Drive by shooting	Y	Y	N	Y
N019	3 Man TCP	All EST 2000 weapons	Basic Load	Desert, dusk, clear	500m	1 BTR, squad dismounts on contact	Y	Y	N	Y
N020	3 Man TCP	All EST 2000 weapons	Basic Load	Village, day, snow	250m	1 BTR, squad dismounts on contact	Y	Y	N	Y
N021	3 Man TCP	All EST 2000 weapons	Basic Load	Urban, day, cloudy	150m	2 Snipers in bldg., Civ bystanders	Y	Y	N	Y
N022	LP/OP	All EST 2000 weapons	Basic Load	Forrest, day, clear	500m	3 BRDM, Squad dismounts	Y	Y	N	Y
N023	LP/OP	All EST 2000 weapons	Basic Load	Forrest, night, clear	500m	2 BRDM, Squad dismounts	Y	Y	N	Y
N024	LP/OP	All EST 2000 weapons	Basic Load	Urban, night, rain	500m	2 BRDM, Squad dismounts	Y	Y	N	Y
N025	LP/OP	All EST 2000 weapons	Basic Load	Urban, sunrise, fog	500m	Dismounted squad w/ mortar	Y	Y	N	Y
N026	Operate a Dismount Point	All EST 2000 weapons	Basic Load	Desert, dusk, clear	300m	Civ PU truck w/ MG	Y	Y	N	Y
N027	Operate a Dismount Point	All EST 2000 weapons	Basic Load	Forest, Day, clear	300m	3 man dismount w/MG	Y	Y	N	Y
N028	Operate a Dismount Point	All EST 2000 weapons	Basic Load	HQs, day, clear	300m	3 man dismount w/MG	Y	Y	N	Y
N029	Operate Roadblock	All EST 2000 weapons	Basic Load	Roadblock, Checkpoint	150m	4 Militia w/AK74s	Y	Y	N	Y
N030	Operate Roadblock	All EST 2000 weapons	Basic Load	Tent City, night	150m	6 dismounts w/AK74s	Y	Y	N	Y
N031	Perform Security Resettlement Camp	All EST 2000 weapons	Basic Load	Resettlement Camp, Day	50m	20 Hostiles w/rocks and bottles	Y	Y	N	Y
N032	Perform Security Resettlement Camp	All EST 2000 weapons	Basic Load	Resettlement Camp, night, rain	50m	20 Hostiles w/rocks and bottles	Y	Y	N	Y
COMBAT SUPPORT/COMBAT SERVICE SUPPORT ELEMENTS - EST 2000 COLLECTIVE SIMULATION EXERCISES										
P001	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Desert/day/clear/wpns free	500-Infinite	Mi-8 Hip hovering, firing	Y	Y	Y	Y
P002	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Desert/day/cloudy/wpns tight	1000 ft	An-2 crossing directly overhead	Y	Y	Y	Y
P003	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Desert/day/clear/wpns hold	500 ft	AH-64, crossing, not firing	Y	Y	Y	Y
P004	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Forest/day/clear/wpns free	500 ft	Su-25 crossing directly overhead	Y	Y	Y	Y
P005	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Forest/day/cloudy/wpns tight	100 ft	UH-60, crossing, not firing	Y	Y	Y	Y
P006	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Forest/day/clear/wpns hold	200 ft	Mi-8 Hip, crossing, not firing	Y	Y	Y	Y
P007	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Desert/night/clear/full moon/wpns free	2000 ft	An-2 Colt, crossing, paratroops exiting	Y	Y	Y	Y

Table 3-2. Collective Core Scenarios – Continued

NO	SCENARIO TASK	WPN	RDS	AREA/ CONDITIONS	RANGE	TARGET	I/O FDBK	SOLDIER FDBK	TIMED	AAR
P008	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Desert/night/cloudy/wpns tight	500 ft	Su-25 crossing overhead, not firing	Y	Y	Y	Y
P009	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Desert/night/clear/wpns hold	1500 ft	C130 crossing forward of position	Y	Y	Y	Y
P010	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Forest/night/clear/F moon/wpns free	1000 ft	C17 toward you	Y	Y	Y	Y
P011	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Forest/night/clear/wpns tight	200 ft	Su-25 toward you, firing	Y	Y	Y	Y
P012	Defend Against Air Atk	5-10 soldiers/M16s/1MG	Basic Load	Forest/night/cloudy/wpns hold	150 ft	AH-64 toward you, firing	Y	Y	Y	Y
P013	Defend	5-10 soldiers/M16s/1MG	Basic Load	Desert/day/clear	500 m	3 man friendly patrol, dismounted	Y	Y	Y	Y
P014	Defend	5-10 soldiers/M16s/1MG	Basic Load	Desert/day/smoke	350 m	5 man enemy patrol, dismounted	Y	Y	Y	Y
P015	Defend	5-10 soldiers/M16s/1MG	Basic Load	Desert/day/clear	1000 m	1 BRDM-2	Y	Y	Y	Y
P016	Defend	5-10 soldiers/M16s/1MG	Basic Load	Forest/day/clear	200 m	5 man enemy patrol, dismounted	Y	Y	Y	Y
P017	Defend	5-10 soldiers/M16s/1MG	Basic Load	Forest/day/rain	150 m	3 man friendly patrol, dismounted	Y	Y	Y	Y
P018	Defend	5-10 soldiers/M16s/1MG	Basic Load	Forest/day/smoke	200 m	10 man enemy patrol, dismounted	Y	Y	Y	Y
P019	Defend	5-10 soldiers/M16s/1MG	Basic Load	Desert/night/clear/full moon	300 m	3 man enemy patrol, dismounted	Y	Y	Y	Y
P020	Defend	5-10 soldiers/M16s/1MG	Basic Load	Desert/night/clear	250 m	5 man enemy patrol, dismounted	Y	Y	Y	Y
P021	Defend	5-10 soldiers/M16s/1MG	Basic Load	Desert/night/clear	800 m	1 BRDM-2	Y	Y	Y	Y
P022	Defend	5-10 soldiers/M16s/1MG	Basic Load	Forest/night/clear/full moon	100 m	10 man enemy patrol, dismounted	Y	Y	Y	Y
P023	Defend	5-10 soldiers/M16s/1MG	Basic Load	Forest/night/cloudy	100 m	3 man enemy patrol, dismounted	Y	Y	Y	Y
P024	Defend	5-10 soldiers/M16s/1MG	Basic Load	Forest/night/smoke	75 m	3 man friendly patrol, dismounted	Y	Y	Y	Y

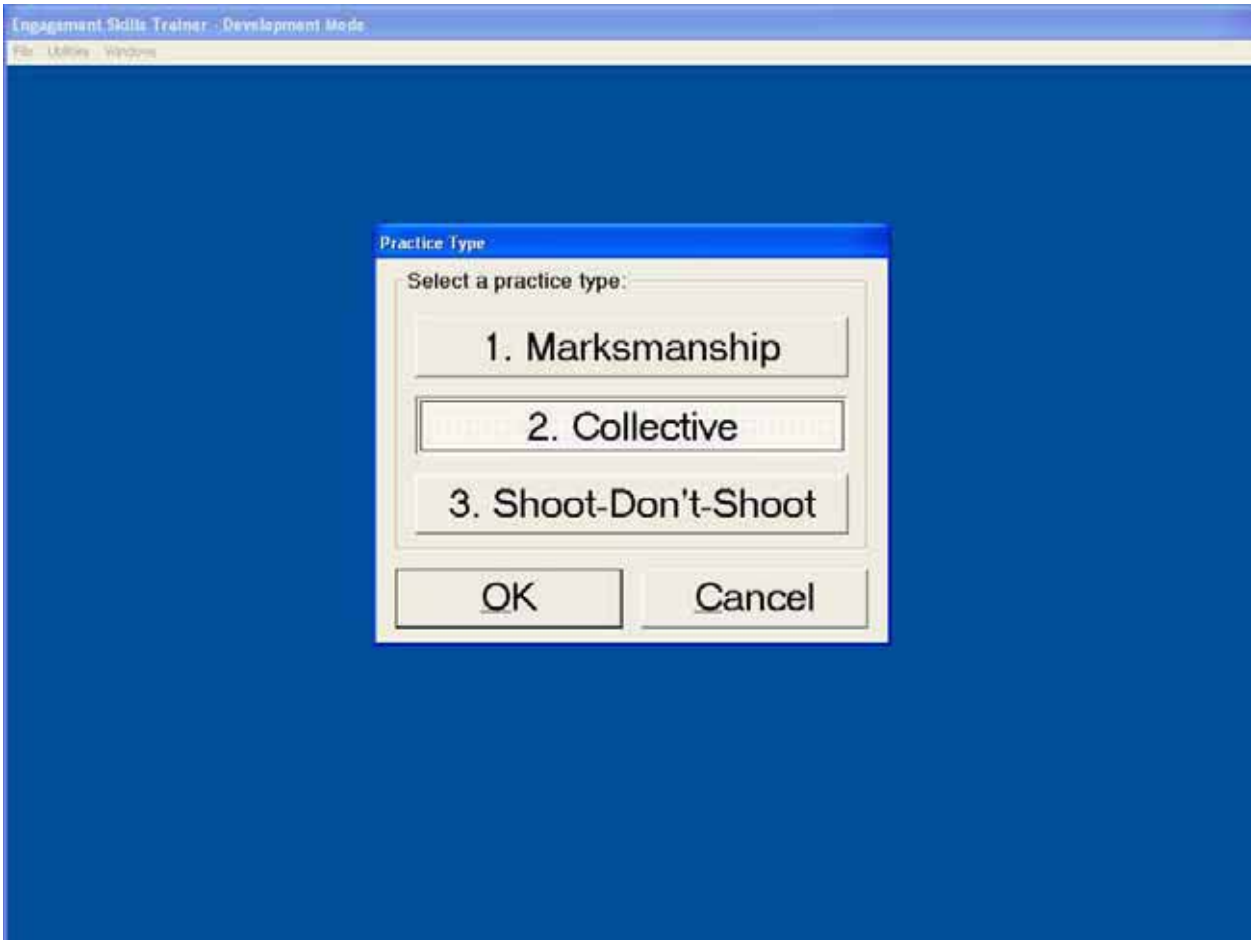


Figure 3-75. Select Practice Screen (Collective Selected)

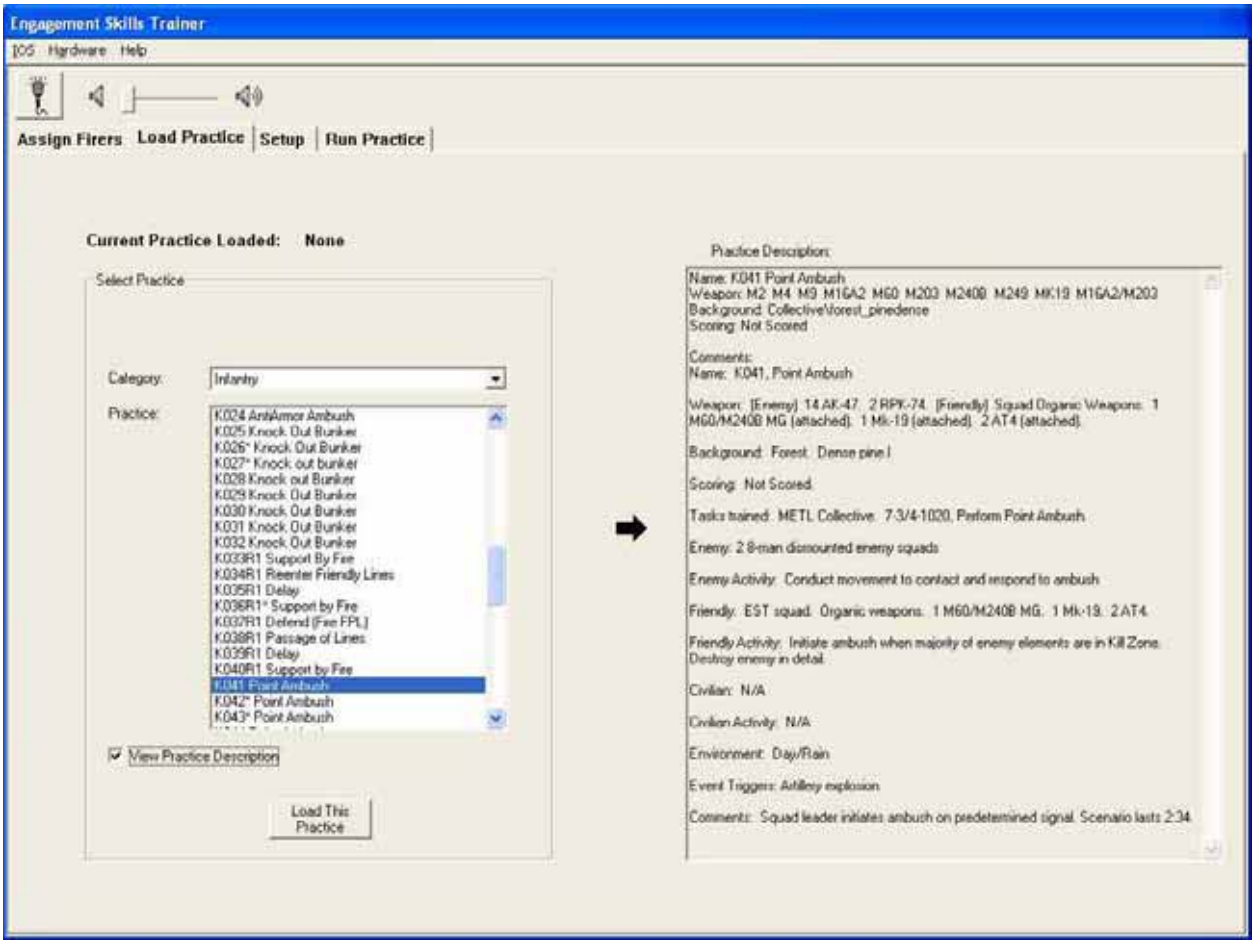


Figure 3-76. Load Practice Screen (Collective Mode)

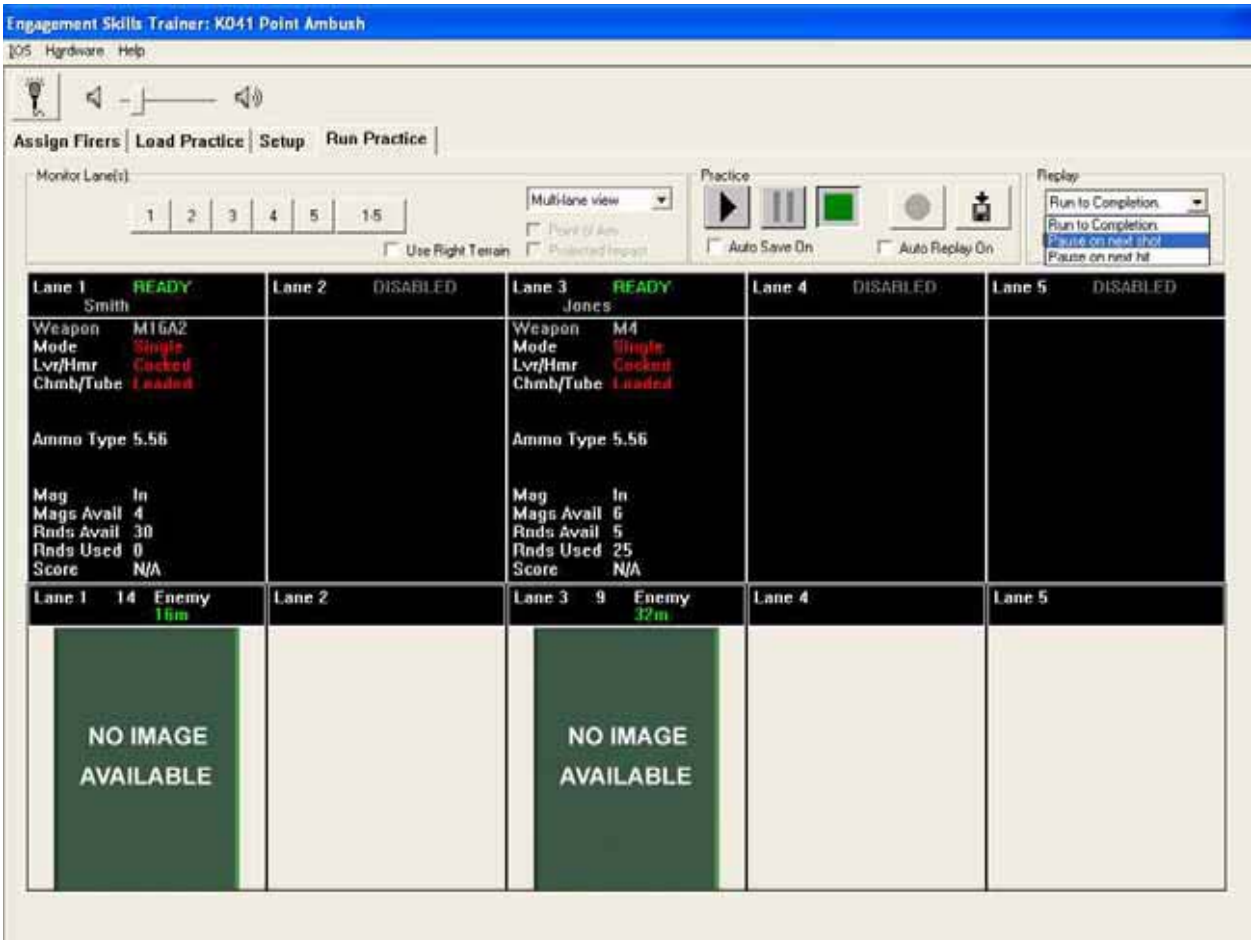


Figure 3-77. Practice Replay (Pulldown Menu)

Figure 3-78. Practice Replay Screen (Collective Mode)

3.5.3. Shoot/Don't Shoot mode

Shoot/Don't Shoot training is conducted on a 5-lane subsystem. The training practices provide sufficient detail so that the firer can see important cues such as facial expressions and body language. The Shoot/Don't Shoot core scenario descriptions are listed in Table 3-3.

Note: The EST 2000 subsystem contains three floor boxes for each five lanes of training. When setup, the third floor box only supports one lane of training (except in collective mode for tandem weapon capabilities).

a. To begin Shoot/Don't Shoot training mode, select "1. Training" from the Engagement Skills Trainer Login Screen (Figure 3-38).
b. On the Practice Type Screen, select "3. Shoot/Don't Shoot", then click on "OK" (Figure 3-79).
c. The Subsystem Allocation Screen (Figure 3-40) appears. Select the desired lane configuration by clicking on Station 1, 2, or 3 (for 5-lane operation), then click on "OK".

   Note: The Instructor/Operator's options may be limited, based upon individual site configurations. The station marked with an asterisk indicates the IOS in which the Instructor/Operator is physically operating from.

d. The system will automatically initialize at this point (Figure 3-41).
e. After Autotracker Calibration has been completed, the Instructor/Operator will see the Engagement Skills Trainer Assign Firers Screen (Figure 3-42) on the IOS Monitor. If Autotracker Calibration is unsuccessful, the Instructor/Operator will see an Autotracker Calibration Failure Message on the IOS Monitor.

   Note: If calibration has failed, the Instructor/Operator should refer to Table 4-8 in the Troubleshooting Section of this manual.

3.5.3.1. EST Tool Bar

The tool bar at the top left of the screen (Figure 3-44) provides drop down menus under IOS and HARDWARE. The paragraphs below describe the drop down menus.

3.5.3.1.1. IOS drop down menu

Selecting "IOS" will present a drop down menu containing the option "Return to Main Menu".

3.5.3.1.1.1. Return to Main Menu

Select "Return to Main Menu" and a pop-up query box is displayed asking the Instructor/Operator to confirm the selection.

3.5.3.1.2. Hardware drop down menu

Selecting "HARDWARE" will present a drop down menu containing Calibrate Autotracker, Check Weapon Laser Alignment, Toggle Screens, and Microphone On. The paragraphs below describe each of the drop down menu options under the Hardware drop down menu.

3.5.3.1.2.1. Calibrate Autotracker

Used to recalibrate the ATTR without leaving the selected mode of training. Select "Calibrate Autotracker", a pop-up window will appear allowing the Instructor/Operator to recalibrate the system's ATTR from within the currently selected training mode.

3.5.3.1.2.2. Toggle Screens
A feature that will allow the "swapping" of views on the IOS Monitor and the Projection Screen. Select "Toggle Screens", the view from the IOS monitor will appear on the projection screen and the view from the projection screen will appear on the IOS monitor. This is especially useful during Train-The-Trainer sessions for newly assigned Instructor/Operators.

Select "Toggle Screens" (IOS view on the projection screen) to return views to normal operation.

3.5.3.1.2.3. Microphone On
Turn the microphone On or Off by selecting or deselecting this option.

3.5.3.2. Training Control Menus
Training control menus incorporate user-friendly softkeys, display windows, and pulldown selection menus to help the Instructor/Operator quickly and efficiently initiate and monitor training on the desired simulation. Training control menus available from the training mode of operation include Assign Firers, Load Practice, Setup, and Run Practice. These training control menus are defined in the following paragraphs.

3.5.3.2.1. Assign Firers
The Assign Firers Screen is used to manage rosters, firers, and lane assignments. The Instructor/ Operator is able to add, edit, delete, and review firer information using the softkeys available on the Assign Firers Screen. The Instructor/Operator can also export and import firer data via a 3½" floppy disk drive or a CDRW drive (paragraphs 3.6.2.4 and 3.6.2.5.).

Note: Activate the microphone by clicking the microphone button on the Assign Firers Screen. Adjust the volume of the system speakers by sliding the indicator to the right to increase and to the left to decrease the volume. The microphone button is displayed throughout the practice.

a. Before assigning a firer, connect a weapon to the floor box to activate the lane.

Note: If a weapon is new to the system, then it needs to be added to the subsystem's weapon database. Refer to Appendix E (paragraph E-1.2.1.4) for the procedure to add new weapons to the subsystem's weapon database.

b. Add a firer by clicking the softkey displayed in lower left of Assign Firers Screen (Figure 3-42). The Instructor/Operator will be prompted to add a new or existing firer (Figure 3-46). Select the appropriate choice and the Firer Data screen will appear (Figure 3-47). Required data fields are: Last Name; First Name; and Firer ID.

Note: The minimum information required is Last Name and Firer ID.

Note: The Firer ID DOES NOT have to be a Social Security Number. The Firer ID can be any combination of numbers and/or letters that uniquely identifies the individual.

The Instructor/Operator can also add multiple fires at once by clicking on the Generate Roster softkey. The Generate Roster screen (Figure 3-48) will appear with a default value for Number of Shooters and Groups. Enter the required data and click on "OK". The system will generate a roster for use in training.

c. To edit or delete a firer's data, click on the softkeys and change the information as required.

Note: When deleting a firer from the entire system, a message box (Figure 3-49) will appear asking the Instructor/Operator to verify this action before proceeding.

3.5.3.2.2. Select Roster

A roster identifies a specific group of individuals.

a. Create a roster by clicking on Select Roster on the Assign Firers Screen (Figure 3-42). Using the softkeys, the Instructor/Operator can Add, Edit, Delete, Print, Store or Retrieve a roster.
b. Add firers to a specific roster by clicking on the Add firer softkey.
c. Generate an automatic roster by clicking on the Generate Roster softkey.

Note: To Store or Retrieve a roster see paragraphs 3.6.2.1 and 3.6.2.2.

Note: Roster option tabs can be used in conjunction with the Selected Roster pulldown menu. For example, to view details of a previously saved roster, first click the down arrow next to the Selected Roster window and highlight the desired roster from the pulldown menu. Click on Edit Roster to display detailed information on the selected roster. Other roster options include Add Roster, Delete Roster, Print Roster, Store Roster, Retrieve Roster, and Generate Roster.

3.5.3.2.3. Load Practice

a. Click on the Load Practice tab to access the Load Practice Screen.
b. Select a practice (Table 3-3).
c. Click on the View Practice Description box (lower left side of screen), a description of the highlighted practice appears in the practice description window on the right side of the screen.
d. The desired practice is loaded by first highlighting it in the Practice menu and then clicking on the Load This Practice key. A “Loading Practice Defaults” momentary message appears following the selection of the Load This Practice key.

3.5.3.2.4. Setup

a. Click on the Setup tab to access the Setup Screen. The Setup Screen (Figure 3-51) allows the Instructor/Operator to specify conditions for the selected scenario.
b. Modify conditions if required. Only “Bullet Options“ can be modified in Shoot/Don’t Shoot mode.
c. Modify weapon settings using the Change Settings softkey located on the Settings display. Weapon types and lane assignments are displayed in the Weapon Parameter window. The Weapon Settings display on the Setup Screen (Figure 3-53) provides weapon-specific data such as magazine and ammo quantities for a weapon highlighted in the Weapon Parameter window.

3.5.3.2.5. Run Practice

a. To begin training, click on the Run Practice tab to access the Run Practice Screen.
b. Click the Run Practice (▸) button. An "Initializing Weapons - Please Wait" message box appears followed by an instruction to “lock and load the weapon now” (Figure 3-54).
c. Instruct the firers to “lock and load” their weapons when the message box appears.

Note: If the firer locks and loads a weapon before the Instructor/Operator gives the command, the ammo setting for the weapon may be improper. Likewise, if the Instructor/Operator clicks on “OK” prior to all firers successfully locking and loading their weapons, the scenario may not run properly.

d. When the status of all lanes changes from NOT READY (Figure 3-55) to READY (Figure 3-56) click “OK” to proceed.

Note: Message(s) will appear during the practice prompting the Instructor/Operator to either “ESCALATE” or “DE-ESCALATE” the simulated situation. Flowcharts detailing the outcome of the escalate/de-escalate situations can be found in Appendix I. The Instructor/Operator should choose "Escalate" or "De-escalate" based on the performance of the student.

e. If the student fires when there is no apparent threat a message box reading “Defend Your Actions” appears on the projection screen and the practice pauses. The Instructor/Operator and/or the Unit Training NCO should conduct a brief counseling session to determine why the student fired. The Instructor/Operator then selects the Run Practice (▸) button to continue the practice.
f. Upon completion of the practice, a chart is displayed on the projection screen indicating the number of shots fired, lethal hits, non-lethal hits, and misses (Figure 3-80).

3.5.3.2.6. Practice replay

After a practice is complete, the Instructor/Operator can replay the entire practice on the projection screen.

a. To replay a practice, first indicate in the Replay pulldown menu the method of the replay (Figure 3-77). Replay selections for Shoot-Don't Shoot Mode include Run to Completion, Pause on next shot, and Pause on next hit. Replays can be presented in either slow, normal, or fast speeds.
b. Click the replay box. The lane number of the firer appears with each shot on the projection screen as the practice is replayed. Lethal hits appear in red, Non-lethal hits appear in yellow, and missed shots appear in green.
c. If pause on next shot or pause on next hit was selected for the replay, click the Run Practice (▸) button to advance to the next shot, or next hit. When the replay is complete, a message will appear indicating the replay is over, press “OK” to proceed.

3.5.3.2.7. Saving a completed practice

Shoot-Don’t-Shoot scenarios, practices, can not be saved or printed. Maximum use must be made of the Replay capabilities (paragraph 3.5.3.2.6. Practice Replay) and the “scoring chart” (Figure 3-80).

3.5.3.2.8. Results Table

The Results Table for Shoot-Don’t-Shoot scenarios is limited to the scoring screen shown in Figure 3-80. This “scoring chart” can not be saved or printed.

3.5.3.3. Switching between Training Modes

The Instructor/Operator can switch to another training mode (Marksmanship or Collective) by selecting “Return to Main Menu” on the IOS pulldown menu (Figure 3-73). A screen will appear stating “Exit IOS, Return to Main Menu (Figure 3-74). Click “YES”. After a few moments, the EST Login Screen (Figure 3-38) will appear. Follow procedures outlined in paragraph 3.5.1. or paragraph 0.

Table 3-3. Shoot/Don't Shoot Core Scenarios

NO	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	THREAT and OTHER PERSONNEL
N007	Gate Operations	M9	2 Mags	Woodline, Guard post/Outside/Day	10-15m	Civilian in car
N008	Domestic Disturbance	M9	2 Mags	Outside home, Outside/Day	10-15m	Couple argues
N009	Suspicious Person at Closed Club	M9	2 Mags	Closed Club's loading dock, low light/night	10m	2 armed men
N033	Domestic disturbance	M9	2 Mags	Residential interior/lamp lights	10m	1 armed man
N035	Respond to alarm	M9	2 Mags	Unit arms room/low light/night	10m	3 Men one is armed
N036	Felony Traffic Stop	M9	2 Mags	Vehicle/Outside/Day	10-15m	3 Civilians in van
N037	Felony Traffic Stop	M9	2 Mags	Vehicle/Outside/Day	10-15m	3 civilians with hostage
N038	Commissary Hostage rescue/Robbery	M9	2 Mags	Commissary interior/overhead lighting	10-20m	2 armed men, 5 hostages/bystanders
N039	Armed Forces Bank Robbery	M9	2 Mags	Bank interior/overhead lighting	10m	2 Armed men, 2 tellers
N040	Shoppette Robbery	M9	2 Mags	Shoppette interior/overhead lighting	10m	1 armed man, 1 Hostage
N041	Electronics Store Robbery (Shoplifting)	M9	2 Mags	Electronics Store interior/low overhead lighting	10m	1 armed man, 1 hostage/manager
N042	Felony Traffic Stop	M9	2 Mags	Vehicle/Outside/day	8-12m	2 civilians, hostage
N043	Drug buy	M9	2 Mags	Night, outside	10m	1 armed man, 1 undercover agent
N044	Drug Buy Gone Bad	M9	2 Mags	Night Outside	10m	1 armed man, 1 undercover agent
N045	Weapons buy	M9	2 Mags	Night, outside	10m	2 armed men, 2 undercover agents
J001	Vehicle Inspection	M16A2	2 Mags	Day, outside	10m	1 armed man
J002	Vehicle Search	M16A2	2 Mags	Day, outside	10m	2 armed men
J003	Two Civilians with Ordnance	M16A2	2 Mags	Day, outside	10m	Armed man and woman, soldier
J004	Reentry of Lines	M16A2	2 Mags	Night, outside	20m	Group of civilians, 2 armed men
J005	Observation Listening post	M16A2	2 Mags	Day, outside	20-50m	4 armed irregulars
J006	Crowd approaches	M16A2	2 Mags	Day, outside	10m	Small crowd, 2 armed men
J007	Check point	M16A2	2 Mags	Day, outside	10m	Armed man and woman
J008	Check point, vehicle with three Occupants	M16A2	2 Mags	Day, outside	10m	Armed woman and 2 men
J009	Check point, van with three Occupants	M16A2	2 Mags	Day, outside	10m	3 armed men, soldier
J010	Checkpoint, Pick-up detainee	M16A2	2 Mags	Day, outside	10m	2 armed men
J011	Personnel Holding area and drive-bys	M16A2	2 Mags	Day, outside	10m	2-3 armed men, bystanders

NO	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	THREAT and OTHER PERSONNEL
J012	Guard post in a building	M16A2	2 Mags	Interior	10m	2 armed men, 2 soldiers
J013	Confiscate contraband	M16A2	2 Mags	Interior	10m	Armed man, unarmed man, soldier
J014	Escort news crew	M16A2	2 Mags	Day, outside	10-30m	Small crowd, several soldiers
J015	Vehicle accident	M16A2	2 Mags	Day, outside	10-30m	2 armed men, several soldiers
J016	Motor Pool Guard Duty	M16A2	2 Mags	Night, outside	10-30m	1 armed man
J017	Break-in (building)	M16A2	2 Mags	Night, outside	10-20m	2 armed men
J018	Break-in (motor pool)	M16A2	2 Mags	Night, outside	10-20m	3 armed men
J019	Force Protection-Critical Facility	M16A2	2 Mags	Exterior Building/Outside/Day	15-25 m	Civilians
J020	Force Protection-Dismounted Patrol	M16A2	2 Mags	Cluttered Interior Room/Natural light/Day	10 m	Several civilians
J021	Force Protection-Intermediate Staging Base	M16A2	2 Mags	Exterior Building w/pick-up truck/outside/day	15-20 m	Small crowd rushes truck
J022	Force Protection-Dignitary Gathering	M16A2	2 Mags	Moving vehicle, outside day	20-40 m	Small crowd greets VIP
J023	Force Protection-Mounted Perimeter Patrol	M16A2	2 Mags	Moving vehicle, outside day	10-20 m	Civilians seeking assistance
J024	Force Protection-Dismounted Patrol-Critical Facilities	M16A2	2 Mags	Cluttered Interior Room/Smoky/Natural light/day	10-15 m	Civilians
J025	Installation Security – IP Station	M16A2	2 Mags	Foreign desert/Outside/Day	20-40 m	Insurgents attack
J026	Vehicle Checkpoint	M16A2	2 Mags	Foreign rocky terrain/outside/day	20-40 m	Vehicles with armed occupants
J027	Vehicle Checkpoint - Overwatch	M16A2	2 Mags	Foreign rocky terrain/outside/day	20-30 m	Vehicles with armed occupants
J028	Cordon Search Room Clearing	M16A2	2 Mags	Foreign Interior room/Overhead lighting	8-15 m	Civilians in room
J029	Blocking Cordon Search	M16A2	2 Mags	Foreign desert/outside/day	10-20 m	Small crowd
J030	Blocking Cordon Search	M16A2	2 Mags	Moving vehicle/outside day	15-25 m	Civilians around woman laying on road
J031	Crowd Control Operation	M16A2	2 Mags	Foreign desert/Outside/Day	8-50 m	Civilians and Insurgents
J032	Crowd Control Opteration React to Contact	M16A2	2 Mags	Foreign desert/Outside/Day	8-50 m	Civilians and Insurgents
J033	Traffic Control Point	M16A2	2 Mags	Foreign desert/Outside/Day	8-50 m	Civilians
J034	Blocking Position	M16A2	2 Mags	Foreign desert/Outside/Day	8-50 m	Civilians and Insurgents
J035	VCP – Overwatch IP Search	M16A2	2 Mags	Foreign desert/Outside/Day	8-250m	Civilians and Insurgents

NO	SCENARIO TASK	WPN	RDS	AREA/CONDITIONS	RANGE	THREAT and OTHER PERSONNEL
T001	LSV Interior Security	M16A2	2 Mags	Ship interior	8-15 m	Unauthorized personnel in passageway and engine room
T002	Port Security	M16A2	2 Mags	Day/outside	15-30 m	Unauthorized civilians
T003	Underway Force Protection	50 cal M16A2	2 Mags	Day/outside	25-300 m	Small boat with civilians

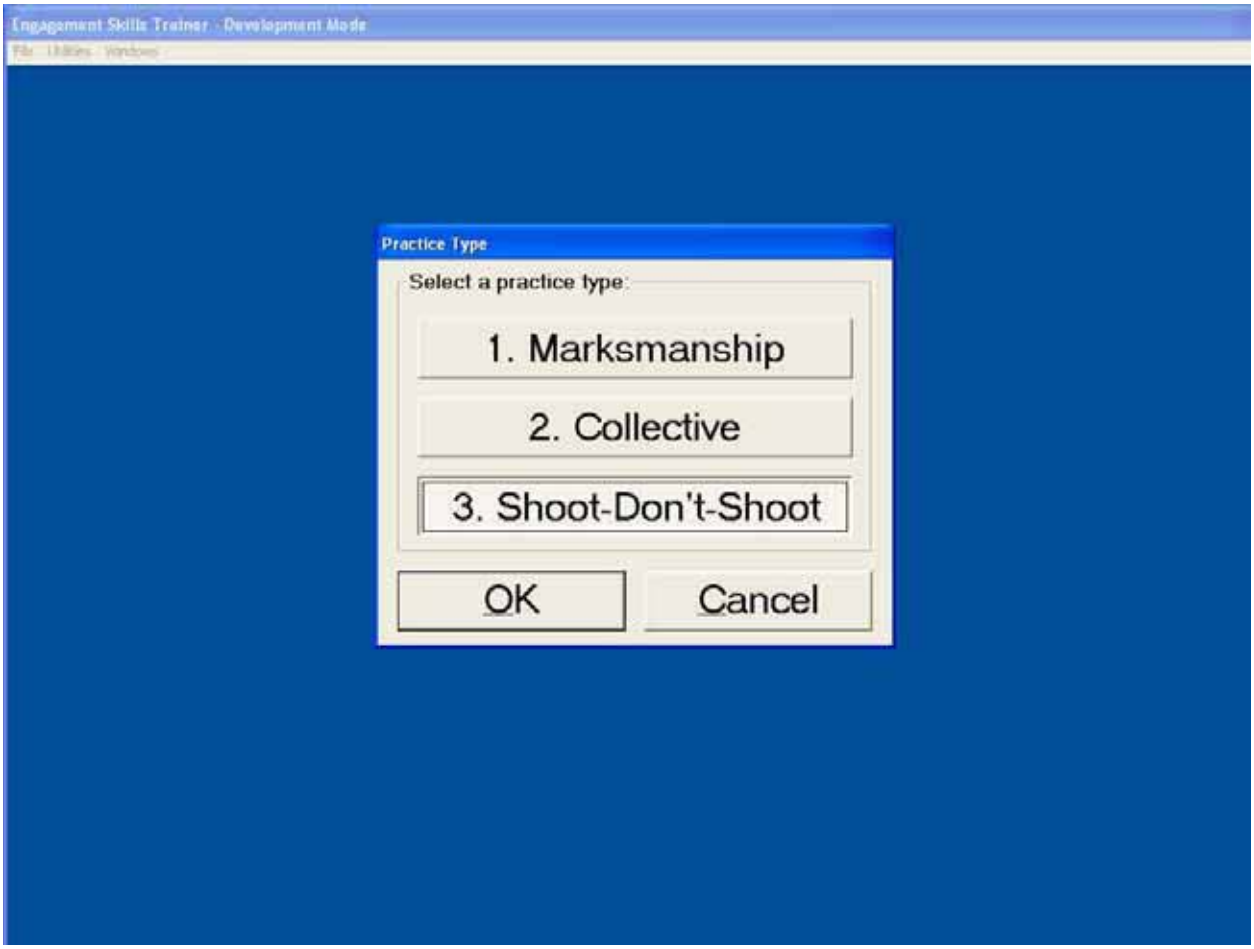


Figure 3-79. Select Practice Screen (Shoot/Don't Shoot Selected)

Figure 3-80. Shoot/Don't Shoot Scoring (Projector) Screen

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

3.6. ROSTER AND TRAINING HISTORY

Roster and Training History allows the Instructor/Operator to manage the roster and review training history before and after training sessions. To enter the Roster and Training History tool, perform the following steps:

a. Select “2. Menu” from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The system will automatically initialize at this point (Figure 3-41).
c. On the Engagement Skills Trainer Main Menu (Figure 3-81), select “1. Engagement Skills”.
d. On the Engagement Skills Training pop-up menu (Figure 3-82), select “2. Roster and Training History”.
e. The Roster and Training History Screen (Figure 3-83) is displayed containing two menu tabs, “Manage Rosters” and “View Saved Practices”.

3.6.1. Roster and Training History Tool Bar

The toolbar menus under Roster and Training History provide two drop down menus: “File” and "Tools" (Figure 3-84).

3.6.1.1. File drop down menu

Selecting the “File” drop down menu will present a drop down menu (Figure 3-84) containing the “Open”, “Save as”, “Empty Main EST Database”, and “Exit”.

3.6.1.1.1. Open

Used to open a saved/archived database.

3.6.1.1.2. Save as

Used to save/archive the current database under a new name.

3.6.1.1.3. Empty Main EST Datebase

Used to delete all data, (i.e. all rosters and firer data), in the main database.

3.6.1.1.4. Exit

Used to return the Instructor/Operator to the Main Menu.

3.6.1.2. Tools drop down menu

Selecting the “Tools” drop down menu will present a drop down menu (Figure 3-84) containing “Compact Database” and “Repair database”, two database management tools:

3.6.1.2.1. Compact Database

The “Compact Database” option compacts the database after deleting records. This conserves file space on the EST 2000 computer.

3.6.1.2.2. Repair Database

The “Repair Database” option repairs the database when the system shuts down suddenly, as a result of a power outage, for example.

3.6.2. Manage Rosters

The Manage Rosters tab (Figure 3-83) allows the Instructor/Operator to perform the following functions:

- Add, Edit, Delete, View, Export, and Import Firer Information
- Add, Edit, Delete, Print, Store, Retrieve, and Generate Roster Information

3.6.2.1. Store Roster

a. Select the Manage Roster tab (Figure 3-83).
b. Select the Roster to be stored.
c. Click on Store Roster.
d. On the "Select the Store Roster type" pop-up box (Figure 3-85), select the roster Version type to save, and select "OK".
   - The "Short Version" stores only the firer attributes and weapon zero offsets for each firer in the roster.
   - The "Long Version" stores firer attributes, weapon zero offsets, scenarios, courses, targets, and shots for each firer in the roster.
e. Use the drop down menu on the Store Roster pop-up box (Figure 3-86) to select CD or 3½ Floppy to store the roster on.
f. Type in a file name and click "Save".

Note: The files imported and exported are saved as Access files (.mdb) on a CD using Adaptec DirectCD (or similar program).

3.6.2.2. Import/Retrieve Roster

To import/retrieve a stored roster, insert the CD or 3½ Floppy where the file is stored.

a. Select the Manage Roster tab (Figure 3-83).
b. Select Retrieve Roster.
c. Use the pulldown menu on the Retrieve Roster pop-up box (Figure 3-87) to locate the roster file.
d. Select the file and click "Open". The roster is now stored on the EST 2000 subsystem.

Note: If importing a duplicate roster name to a subsystem, the Instructor/Operator will be directed to rename or merge the data.

3.6.2.3. Add, Edit, Delete, Print, Generate Roster

Click on the Add or Edit Roster softkey to add rosters or edit the roster information. Click on the Delete softkey to delete a selected roster. Click on the Print softkey to print a selected roster. Associated pop-up boxes are shown in Figure 3-88.

Refer to Paragraphs 3.5.1.2.1.b and 3.5.1.2.2 and Figure 3-48 for information on Generating Rosters.

3.6.2.4. Export Shooter data

Each time a practice is saved, the shooter data is stored on the EST 2000 system in an Access (.mdb) file located at C:\EST\Databases\EST_db.mdb. Table 3-4 provides a summary of the exported shooter data. To export this file, follow the steps below:

a. Select the Manage Roster tab.
b. Select a firer from a Roster or the All Firers list.
c. Select Export Firer.
d. Use the drop down menu on the Export Shooter pop-up box (Figure 3-89) to select CD or 3½ Floppy to store the firer's data on.
e. Type in a file name and click "Save".

Note: Repeat steps to save each firer records.

3.6.2.5. Import Shooter data

a. Select the Manage Roster tab.
b. Click on Import Firer.
c. Use the drop down menu on the Import Shooter pop-up box (Figure 3-90) to locate the file on the CD or 3½ Floppy.
d. Click the filename and press Open. The file will be saved in the C:\EST\Databases directory.

Note: If importing a duplicate firer's shooter data to a subsystem, the Instructor/Operator will be directed to rename or merge the data.

3.6.2.6. Add, Edit, Delete, and Firer Details

Refer to Paragraph 3.5.1.2.1 for information on Add, Edit, Delete, and Firer Details functions (Figure 3-42, Figure 3-44, Figure 3-46, Figure 3-47, and Figure 3-49).

3.6.3. View Saved Practices

The View Saved Practices tab (Figure 3-91) allows the Instructor/Operator to view student performance records on any completed course or practice that was saved to the database. Courses and practices can be displayed by firer, roster, squad, or date. Additional options in this section allow the Instructor/Operator to Sort, Delete, and Print records. Double click on the desired selection in the Course or Practice List to view the Results Table (Figure 3-70), Scorecard (Figure 3-71), and/or the Course/Practice Description (Figure 3-72) for the item selected.

3.6.4. Standalone Roster Tool

The standalone Roster management tool is contained on a CD and capable of running on a standalone PC or laptop and used to manage rosters or create new ones before or after training. It runs the same as the Roster Management tool on the IOS.

Note: Test the roster generation tool with a few items before creating an extensive roster to verify the standalone CD created will work on the system.

Figure 3-81. EST Main Menu

Figure 3-82. Selecting Roster and Training History

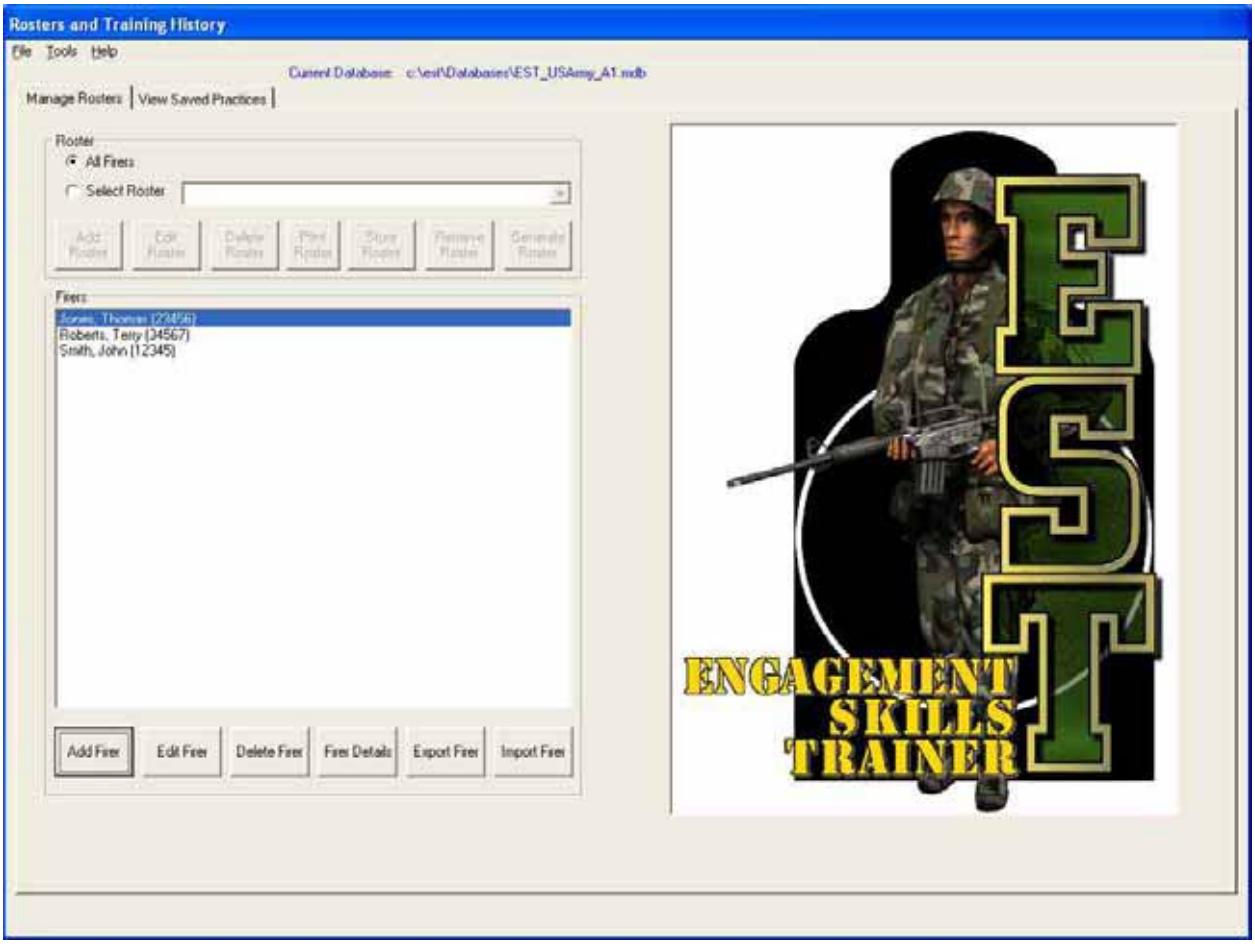


Figure 3-83. Roster Management Screen

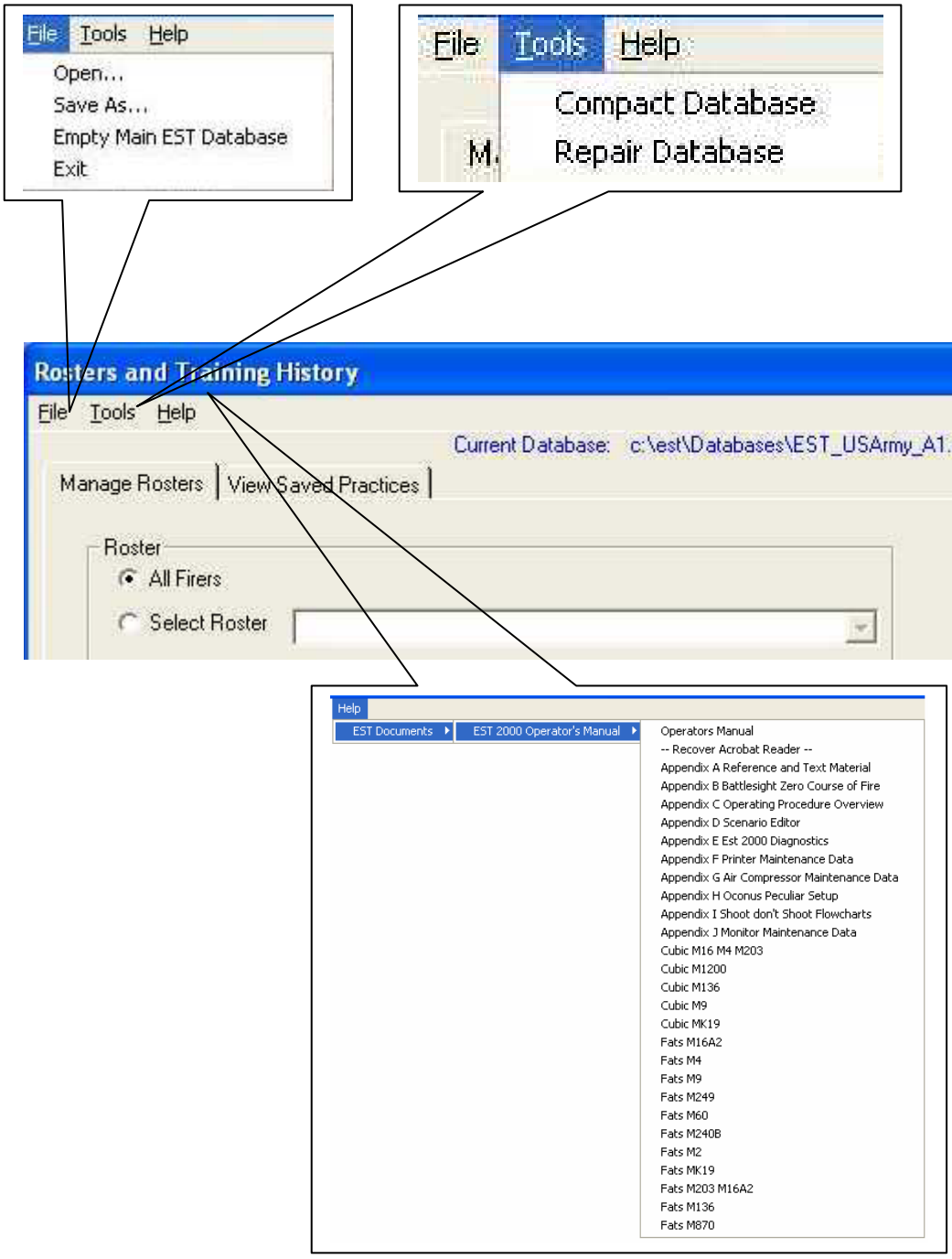


Figure 3-84. Roster and Training History Tool Bar

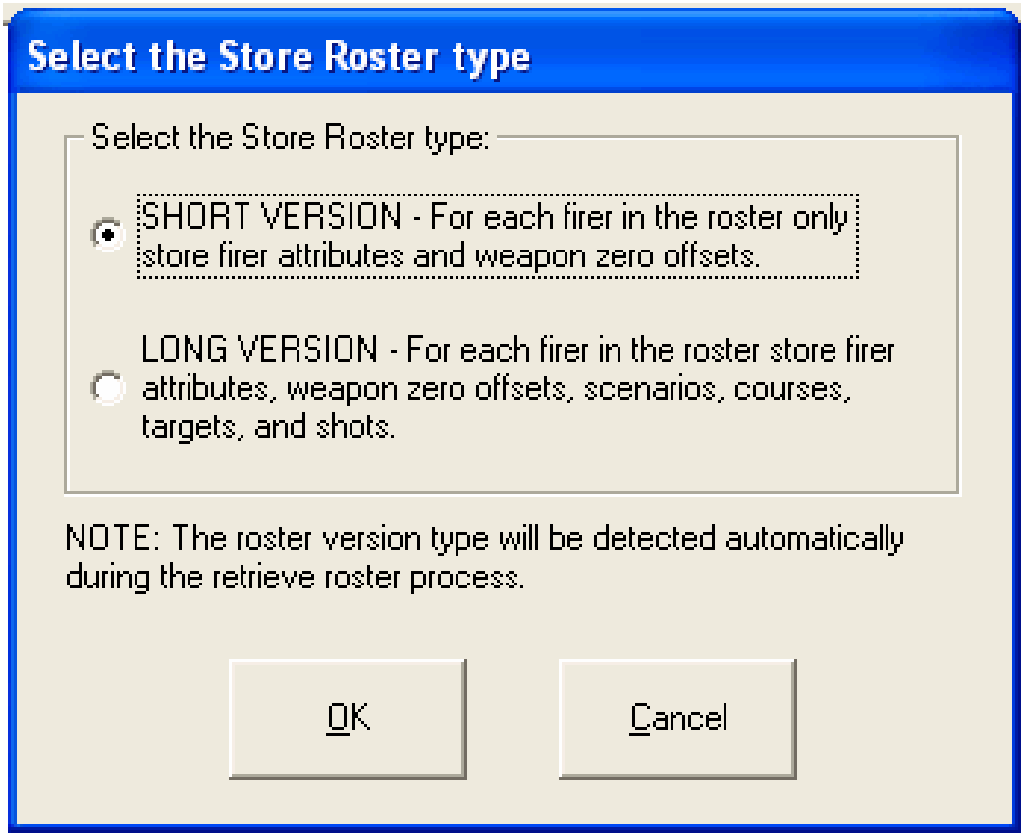


Figure 3-85. Store Roster Type Screen

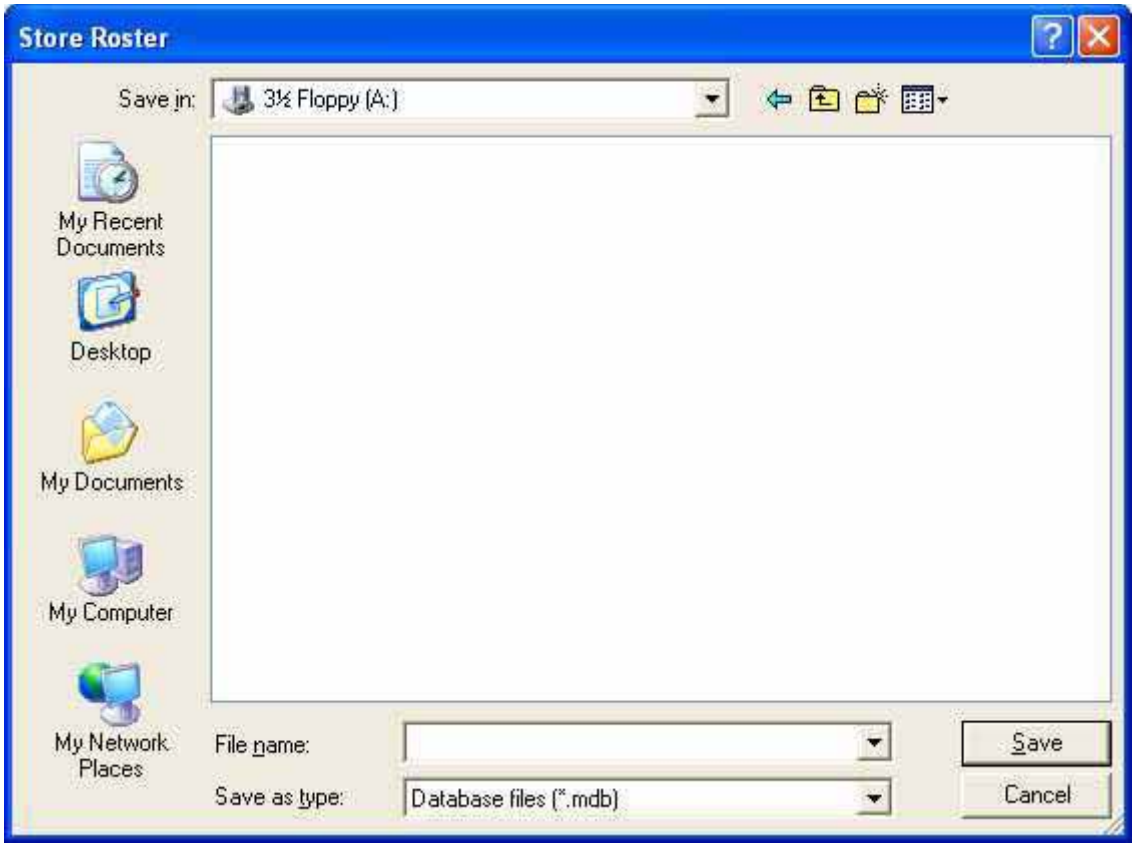


Figure 3-86. Store Roster

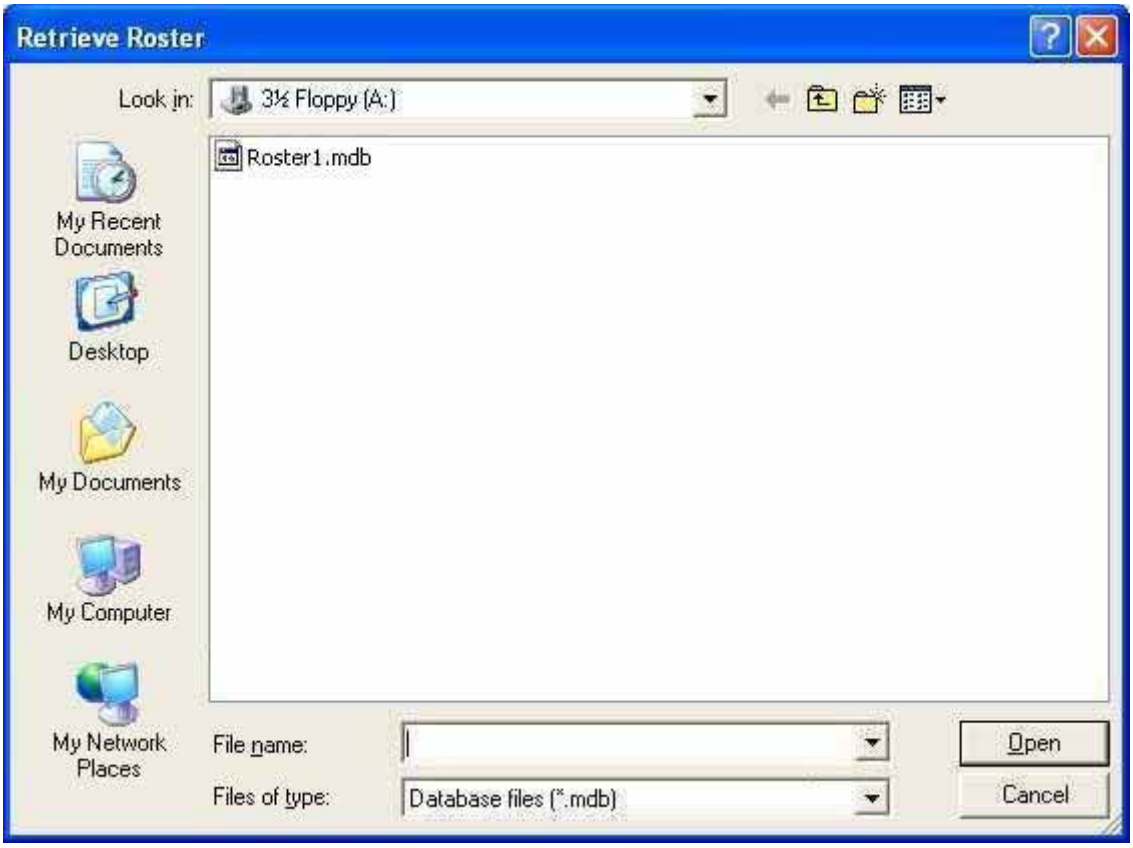


Figure 3-87. Retrieve Roster

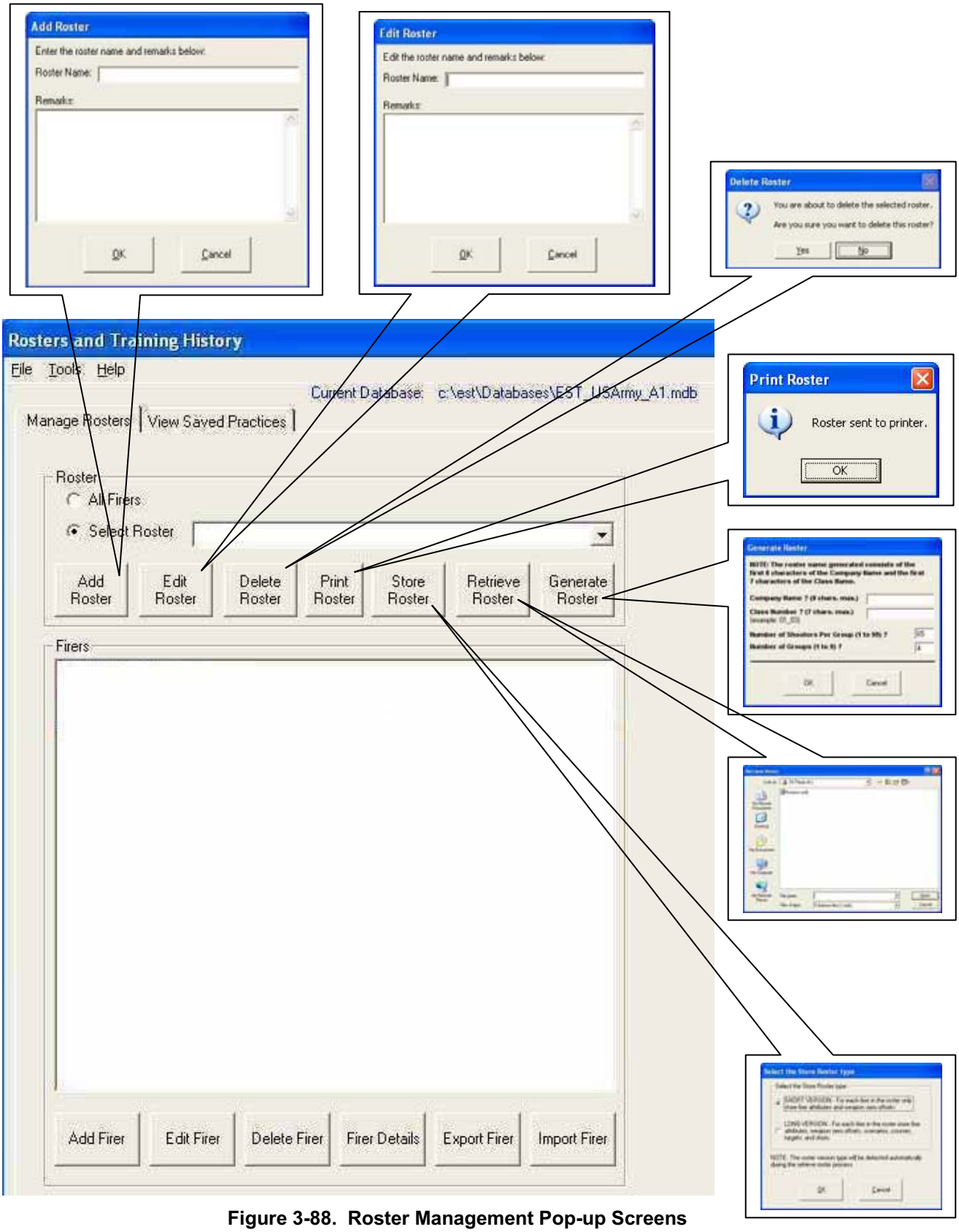


Figure 3-88. Roster Management Pop-up Screens

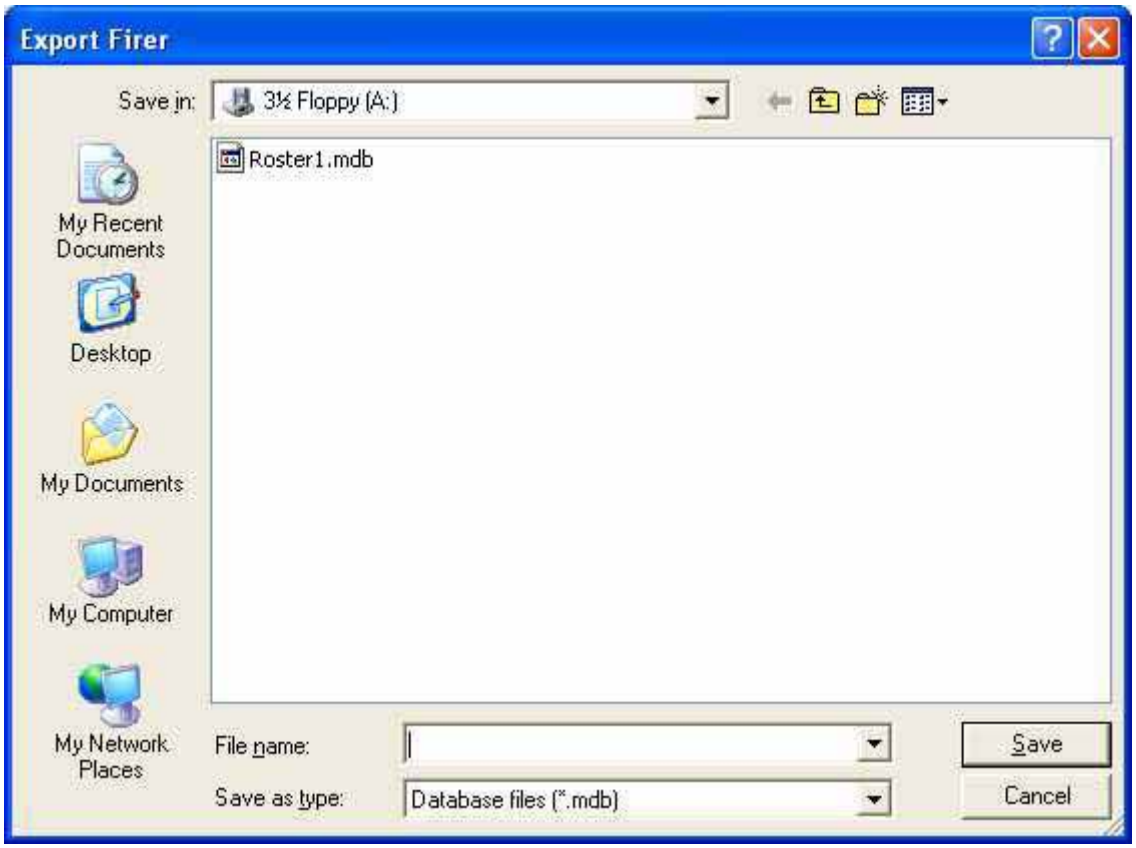


Figure 3-89. Export Firer

Table 3-4. Summary of Exported Shooter Data

Course	Stores the summary information of the courses shot by the shooter, which includes course ID (CourseID), course name(CourseName), course date(CourseDate), course time(CourseTime), Score Card ID (CardType), and description of the course (Description).
CourseScenario	This table acts as a link between the courses the shooter shot and the scenarios that belong to the courses. It includes course ID (CourseID), scenario name (ScenarioName).
Roster	Stores the roster information which the shooter belongs to, left empty if the shooter does not belong to any roster. It includes roster name (RosterName), remarks of the roster (Remarks).
Scenario	Stores the summary information of the scenarios the shooter shot, including the scenarios that are in the courses the shooter fired. The table includes name of the scenario (ScenarioName), time of the scenario start (ScenarioTime), date of the scenario (ScenarioDate), scenario duration in seconds (ScenarioDuration), cross wind (CrossWind), visibility (Visibility, ranged 1 to 100), dispersion on/off (Dispersion), tracers on/off (Tracers), bullet splash on/off (BulletSplash), description of the scenario (Description), scenario file name (ScenarioFileName), number of entities in the scenario (NumEntities).
ScenarioFile	Store the scenario file information of the scenarios the shooter practiced, including scenario file name (ScenarioFileName), path to the scenario file (Path), title of the scenario file (Title), replay option ID (ReplayOptionID, pause on shot/hit, run without pause, etc.), the intended weapon for the scenario (Category), scoring method ID (ScoringMethod), description of the scenario file (Description).
Shooter	Stores the shooter information, includes shooter ID (ShooterID), last name (LName), first name (FName), middle name (MName), rank, battalion, battalion number, company, platoon, squad, remarks.
ShooterCourse	Stores the summary information of the courses the shooter fired, including shooter ID (ShooterID), course ID (CourseID), average shot group size for the course (AvgGroupSize, only used in zeroing and grouping courses), course rating (Rating), score card data (CardData, for internal use only).
ShooterScenario	Stores the summary information of the scenarios the shooter fired, including shooter ID (ShooterID), scenario name (ScenarioName), the lane shooter fired from (Lane), weapon the shooter used for the exercise (WeaponTypeID), number of targets engaged (NumTargetsEngaged), number of rounds fired (NumRounds), number of friendly hits (NumFriendlyHits, only used in collective mode), number of hits (NumHits), number of mobility kills (NumMobilityKills, only used in collective mode), number of kills (NumKills, only used in collective mode), shot group size for the scenario (GroupSize, only used in grouping and zeroing scenarios), score (interpreted differently for different scoring method, could be hits/shots, points of the subtargets hit, number of targets hit, etc.), remarks, number of fire power kills (NumFirePwrKills, only used in collective scenarios), roster name the shooter fired from (RosterName).
ShooterWeaponType	Stores the zeroing offsets for the shooter on a particular type of weapon, including shooter ID (ShooterID), weapon type ID (WeaponTypeID), X offset, and Y offset.
Shot	Stores the information about the shots the shooter fired in practices, including shot ID (ShotID), X location of the shot (X), Y location of the shot (Y), round type of the shot (RoundType), hit type of the shot (HitType), target ID the shot belongs to (TargetID).
Target	Stores the information about the targets/entities that are presented in the practices the shooter fired, including target ID (TargetID), target type ID (TargetTypeID), target sequence number (TargetSequence, the order the target appeared), range of the target (Range), lane of the target (Lane), score on the target (score), scenario the target was presented in (ScenarioName), shooter ID (ShooterID).

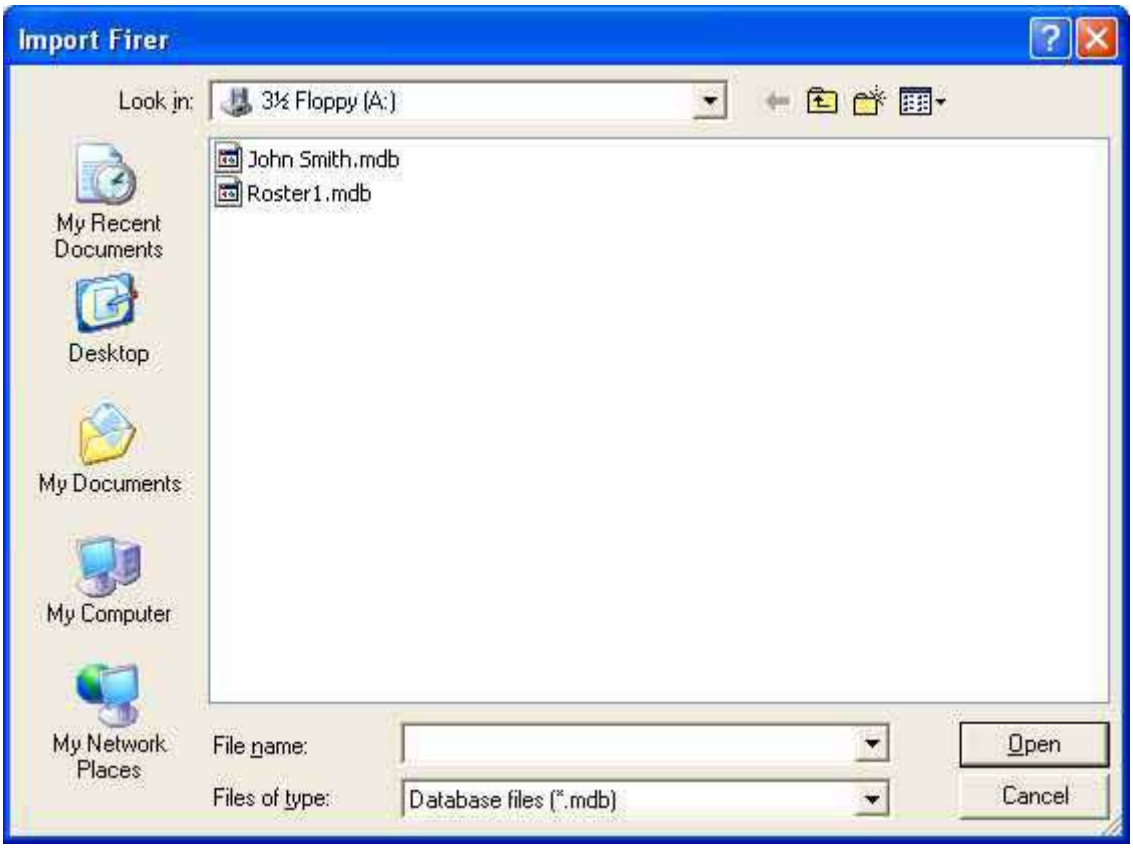


Figure 3-90. Import Firer

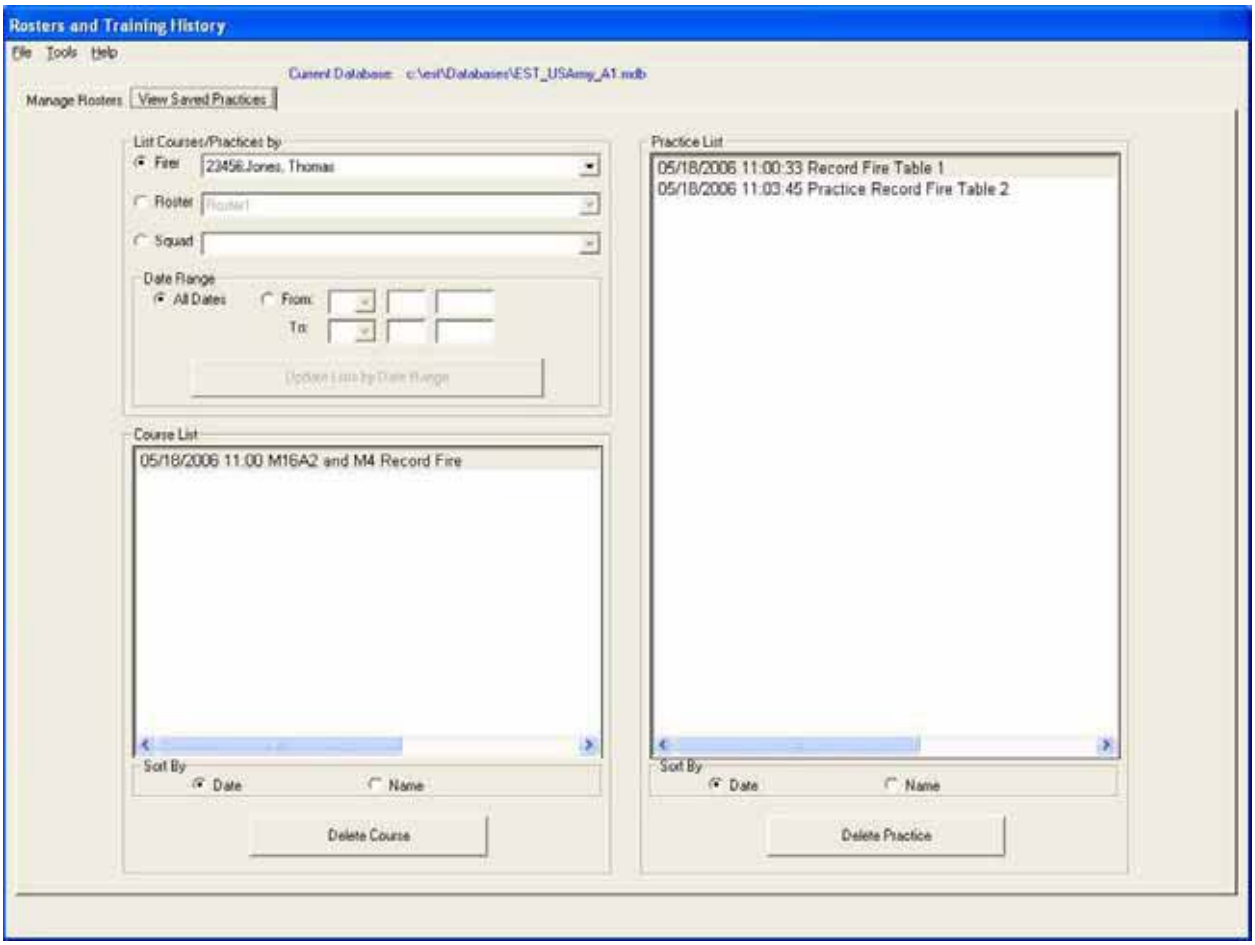


Figure 3-91. View Saved Practices Screen

3.7. EST MAINTENANCE MENU

The EST Maintenance Menu is shown in Figure 3-92. From this menu, the Instructor/Operator can access the following:

- Trainer Maintenance
- Change Password
- Change Date/Time
- Enable Remote Diagnostics
- Disable Remote Diagnostics
- Import/Export Data
- Software Update Utility

3.7.1. Trainer Maintenance

a. To enter the Trainer Maintenance section, select “2. Menu” from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The Engagement Skills Trainer Main Menu is displayed (Figure 3-81). Select “2. Maintenance”.
c. The EST Maintenance Menu is displayed (Figure 3-92). Select “1. Trainer Maintenance”.
d. An Operational Readiness Test (ORT) is automatically initiated at this point. A message indicating “ORT in Progress” appears (Figure 3-93, top).
e. At the conclusion of the ORT, a message will appear indicating an ORT Pass or Failure. If the ORT failed, the message will indicate which component(s) failed (Figure 3-93, bottom). In this event, the Instructor/Operator should refer to Appendix E (EST Diagnostics).

Note: If no telephone line is connected to the Modem the system will report the Modem has failed the ORT testing. This is normal and will not interfere with operation. Click “Yes” to proceed.

3.7.2. Change Password

a. To change the system password, select “2. Menu” from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The Engagement Skills Trainer Main Menu is displayed (Figure 3-81). Select “2. Maintenance”.
c. The EST Maintenance Menu is displayed (Figure 3-92). Select “2. Change Password”.
d. To change the trainer password, first enter the old password in the Old Password field (Figure 3-94).
e. Move the cursor and click on the New Password field and enter the new password.
f. Move the cursor and click on the Confirm New Password field and retype the new password.
g. Select “OK” to complete the password change or “Cancel” to return to the old password.

3.7.3. Change Date/Time

a. To change the system Date or Time, select “2. Menu” from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The Engagement Skills Trainer Main Menu is displayed (Figure 3-81). Select “2. Maintenance”.
c. The EST Maintenance Menu is displayed (Figure 3-92). Select “3. Change Date/Time”.
d. Highlight the desired field, and enter the correct date and/or time (Figure 3-95).
e. Select “OK” to complete the change or “Cancel” to return to the old date/time.

Note: EST 2000 subsystems are generally shipped with EST/EDT. System time should be checked to ensure it matches your time zone.

3.7.4. Enable Remote Connection

The remote connection provides the means for a technician at the Help Desk to perform diagnostics on your system. The telephone line connected to your Modem must be capable of receiving incoming calls.

Because the Remote Diagnostics looks from left to right, in multiple subsystem installations, 10-lane and 15-lane, the telephone line must be connected to the Modem in the left IOS (lanes 1 – 5).

a. To enable the remote connection, select "2. Menu" from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The Engagement Skills Trainer Main Menu is displayed (Figure 3-81). Select "2. Maintenance".
c. The EST Maintenance Menu is displayed (Figure 3-92). Select "4. Enable Remote Connection".
d. After selecting "4. Enable Remote Connection", the title "grays-out" indicating the trainer Modem is enabled and ready for a remote connection.

   Note: If the Modem was successfully enabled, the Monitor Screen will automatically shift to the Engagement Skills Trainer Login Screen.

e. Provide the Help Desk technician with the number for the telephone line connected to your system.

3.7.5. Disable Remote Connection

a. To disable the remote connection, select "2. Menu" from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The Engagement Skills Trainer Main Menu is displayed (Figure 3-81). Select "2. Maintenance".
c. The EST Maintenance Menu is displayed (Figure 3-92). Select "5. Disable Remote Connection".
d. After selecting "5. Disable Remote Connection", the title "grays-out" indicating the trainer Modem is now disabled.

3.7.6. Import/Export Data

Each subsystem has a weapon database. As newly received weapons are added to a subsystem their information is only in the database of the subsystem where the action was accomplished. In multiple subsystem installations, 10-lane and 15-lane, this feature will allow the Instructor/Operator to perform the procedures for adding new weapons to the database on one subsystem. After completing the procedures, instead of taking the weapon(s) to the other subsystems in the installation, the Instructor/Operator may export that data to the other subsystems in the installation choosing to merge databases or overwrite the other databases. If merge is chosen, the system will not overwrite existing files, for example, if the database being exported contains a M9, serial number 007, and this weapon is in the database of the receiving subsystem the export function will keep the newest file for this weapon.

a. To enter the Import/Export Data section, select "2. Menu" from the Engagement Skills Trainer Login Screen (Figure 3-37).
b. The Engagement Skills Trainer Main Menu is displayed (Figure 3-81). Select "2. Maintenance".
c. The EST Maintenance Menu is displayed (Figure 3-92). Select "6. Import/Export Data".
d. The Instructor/Operator may now import or export Weapon Database Files between the subsystems of the installation by following on-screen instructions.

3.7.7. Software Update Utility

This utility will allow the user to update the system software via CD-ROM.

3.8. INTEGRATED COURSEWARE (ICW)

Selecting Integrated Courseware will launch refresher training courseware. The time to complete the Engagement Skills Trainer 2000 training will be a function of the speed with which the student learns.

This training program contains a test that may be used as a diagnostic or as a post-test.

- As a diagnostic, the test will assist to determine your training strengths and weaknesses. Based on this assessment, you can establish individual training goals.

TD-07-6910-702-10

- As a post-test, it will assess your EST 2000 proficiency.

If you are using this program for your initial EST 2000 training you are advised to complete each lesson in the order shown before taking the test. In addition, you should review the EST 2000 Operator's Manual and New Equipment Training Instructor's Guide. Before you take the test, you will log in with a nine digit identification number. The program will automatically record your test score.

The training program will guide you through the lessons. However, at any time you may return to the Main Menu to enter another lesson. From the Main Menu, you may also access the course outline. The course outline provides more lesson detail than is available in the Main Menu. From the course outline, you may move quickly to another outline section.

Throughout this training, you will be required to respond to prompts. When the lesson requires you to take an action, the cursor will change to a "hand" and a "cross hair" will illuminate in the lower left corner of the screen. You will periodically receive guidance to select or activate words, buttons, or pictures.

- To select an item, you place the cursor over that item. Its appearance will change.
- To activate an item, you click on it after selecting it.

Definitions of abbreviations and acronyms can be found in the glossary. You access the glossary through the Main Menu.

Figure 3-92. EST Maintenance Menu

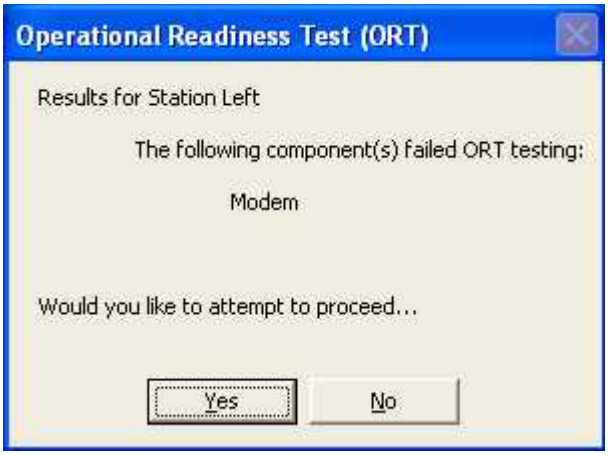


Figure 3-93. Operational Readiness Test

Figure 3-94. Password Maintenance Screen

Figure 3-95. Date/Time Maintenance Screen

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

3.9. HELP

Selecting Help from the Main Menu brings up the list of embedded documents available in the EST 2000 system. Embedded documets included are the EST 2000 Operator's Manual and the Operator's Manuals for all the simulated weapons.

3.10. EXIT

Selecting Exit from the Main Menu brings the Instructor/Operator back to the EST 2000 Login Screen. The Instructor/Operator can then choose to resume training or shutdown the trainer.

3.11. MONITORING PROCEDURES

Malfunction indications include error messages presented on the IOS monitor and I/O device operational failures. Refer to paragraph 3.11.1 for Instructor/Operator level recovery procedures.

3.11.1. Recovery Procedures

a. In the event of temporary computer failure or power interruptions resulting in error messages or input device malfunction, remove power from the system by setting the power switch on the ACPDU to the "OFF" position (refer to item 1, Figure 3-28).
b. Wait approximately 60 seconds and reapply power by setting the ACPDU power switch to either the 125V position or 250V position depending upon available facility power.
c. Following a successful reboot, the EST 2000 Login Screen appears.
d. Log on and resume training.
e. If the system fails to successfully boot up or if operational problems persist, shutdown the system and notify Help Desk technicians.

3.12. EMERGENCY OPERATIONS

Immediately upon recognizing a possible emergency situation, shut down power at the trainer and disconnect the trainer from the facility power source. Provide first aid assistance to injured personnel. For artificial respiration, refer to FM 21-11.

3.13. SYSTEM SHUTDOWN

a. For non-emergency shutdown situations, using the remote control, place the projector assembly in the "stand-by" state.
b. Select "Return to Main Menu" from the IOS drop down menu on the upper left corner of the EST tool bar (Figure 3-43).
c. The Login In screen (Figure 3-37) will appear, click on the SHUTDOWN softkey.
d. The Shutdown Screen will appear (Figure 3-96).
e. From the Shutdown Screen, shutdown the single EST 2000 subsystem or, in the case of multiple networked EST 2000 subsystems, shutdown all EST 2000 subsystems.
f. If the projector assembly has not already automatically shut itself off at this point, a cool down period will be initiated and the cool down screen will appear (Figure 3-97).
g. Following automatic shutdown, position the switch on the ACPDU to "OFF".
h. On the Air Compressor, close the main air valve and drain moisture from the air-supply lines. Turn the power switch to off.
i. Replace the lens covers on the projector.
j. Disconnect weapon umbilical from the floor boxes by firmly grasping the weapon air-pressure line with one hand and use the other hand to slide the collar or press the release button

CAUTION

Do not wrap umbilical cable around the simulated weapon. Damage may occur.

k. Store simulated weapons in the designated storage area.

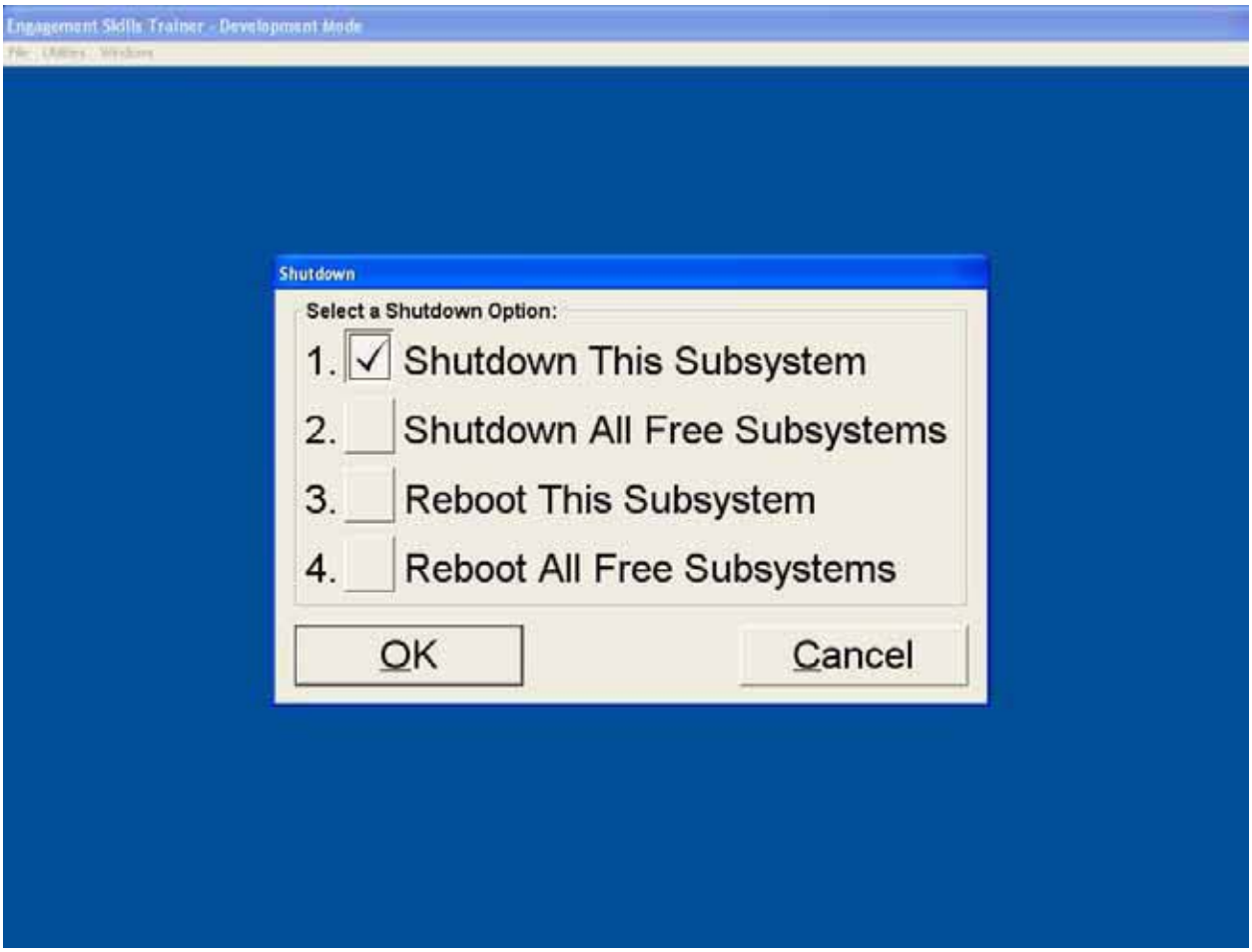


Figure 3-96. Shutdown Screen

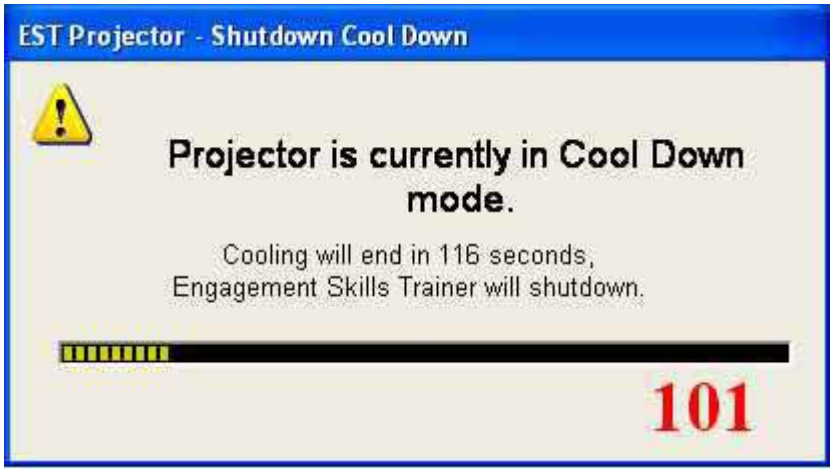


Figure 3-97. Shutdown Cool Down Screen

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 4. MAINTENANCE INSTRUCTIONS.

4. MAINTENANCE INSTRUCTIONS

The following paragraphs describe Instructor/Operator level maintenance procedures for the EST 2000.

4.1. PREVENTIVE MAINTENANCE

Preventive Maintenance Checks and Services (PMCS) means systematic caring, inspection, and servicing of equipment to keep it in good working condition and to prevent breakdowns. The maintainer of the equipment has the responsibility to:

a. Be sure to perform the PMCS each time the equipment is operated. Always do the PMCS in the same order, so it becomes a habit. After some practice, problems will be identified quickly.
b. Do the DAILY PMCS just prior to operating the equipment. This is to be performed prior to each daily class. Pay attention to all **WARNING**s, **CAUTION**s, and **Note**s.
c. Do your weekly PMCS once a week.
d. Do your monthly PMCS once a month.
e. Record any faults you find and document that PMCS procedures have been performed in the daily logs provided with the trainer.

4.1.1. PMCS Procedures and Table

PMCS, Table 4-1, lists inspections and care required to keep the equipment in good operating condition. The column headings for the PMCS table are explained below:

a. The "INTERVAL" column specifies when to perform a certain check or service.
b. The "ITEM TO BE INSPECTED Procedure" column lists the name(s) of the item and the PMCS procedures.
c. The "WORK TIME" column specifies the length of time the PMCS procedure should take.

4.2. LIST OF CONSUMABLE MATERIALS AND SUPPLIES

Consumable items required for maintaining the EST 2000 are listed below:

Part Number	Item Name	CAGE Code	Unit of Measure
SJ-27	Synthetic Oil, Air Compressor	*	Quart
HP 51645A Series or HP No. 45	Black InkJet Print Cartridge	28480	EA
HP C6578 Series or HP No. 78	Tri-Color InkJet Print Cartridge	28480	EA
Any	100% Rubbing Alcohol	Any	Any
Any	Lint Free Cloth	Any	Any
Any	100% Rubbing Alcohol	Any	Any
Any	Cotton Swab	Any	Any
Any	Liquid Detergent, Mild	Any	Any
DPSJMB	Dustoff	02670	EA
TBD	CLP lightweight gun oil		
*JUN-AIR USA Inc., 1350 Abbot Court, Buffalo Grove, IL 60089 (Telephone: 847/215-9444)			

4.3. REMOTE ACCESS PROCEDURES

In order for the Help Desk Technician to access the EST system via the modem, the Instructor/Operator must follow the procedures listed below.

a. Access the EST Main Menu.
b. Click on Maintenance.

c. Click on Enable Remote Connection (Figure 3-92). The Help Desk Technician will now be able to troubleshoot any failures via the modem.

4.4. CORRECTIVE MAINTENANCE

The daily readiness test performed automatically upon power-up will identify system failures prior to beginning training routines. If failures are noted during the daily readiness test or during normal training, the Instructor/Operator should refer to the troubleshooting procedures in paragraph 4.4.1. Paragraph 4.4.2 provides Instructor/Operator level remove and replace procedures. This manual does not include all malfunctions that may occur, nor all test, inspections, and corrective actions. If a malfunction cannot be corrected, or is not included in this manual or is beyond the scope of Instructor/Operator maintenance, contact the EST Help Desk for further troubleshooting guidance and assistance. Before calling the EST Help Desk, note the Product Configuration Id as shown in Figure 4-1. To access the Product Configuration Id Screen, click on “About” located on the Login Screen (Figure 3-37 and/or Figure 3-38).

4.4.1. Troubleshooting Procedures

Refer to Table 4-2 for general troubleshooting categories. Table 4-3 through Table 4-9 provide system specific troubleshooting procedures.

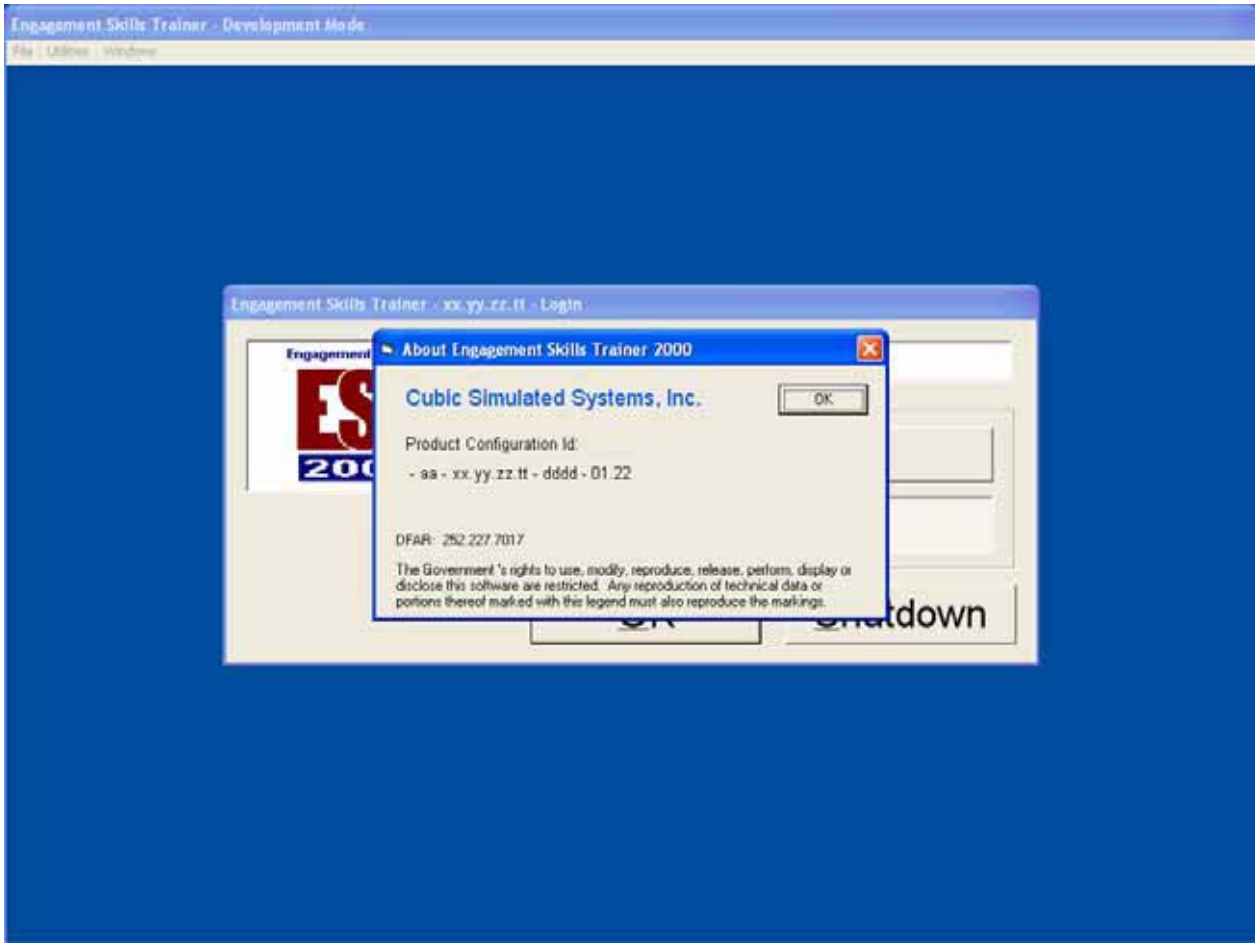


Figure 4-1. Product Configuration Id Screen

Table 4-1. Preventive Maintenance Checks and Services.

AR – As Required
D – Daily
W – Weekly
M – Monthly
S – Semi-annually

Interval					ITEM TO BE INSPECTED Procedure	Work Time (Hours)
AR	D	W	M	S		
		X			**General Cleanliness Of Equipment** 1. Inspect outside of all assemblies. Outer surfaces should be clean and free of dust, dirt, and grease. **WARNING** **Do not use wax/grease remover or lens cleaner near spark or open flame. Use only in well-ventilated area. Avoid contact with eyes or skin. Wash affected area with warm water if contact occurs.** **CAUTION** **Do not use substitutes for the recommended cleaning agents to clean exterior surfaces. Some agents will dissolve the plastic surfaces.** 2. Wipe outer surfaces outer surfaces with a clean lint-free cloth. **CAUTION** **Do not use spray cleaner directly on system components. Liquids may run into internal components, causing damage.** 3. To remove grease smudges and other oil-based foreign matter, use general purpose cleaner and a clean, lint-free cloth. Follow by washing with mild soap and a damp lint-free cloth, rinsing with clean damp lint-free cloth, and wiping dry with a clean, lint-free cloth.	0.1 0.2 0.2
		X			**Keyboard** Using Dustoff®, remove loose dust and dirt from keyboard.	0.1
					Mouse 1. Remove trackball from mouse. 2. Using Dustoff®, clean trackball compartment in mouse. 3. Using a clean lint-free cloth, wipe dust from mouse trackball. Excessive dirt build-up may be cleaned with a clean, lint-free cloth and a household window cleaner.	0.1

Table 4-1. Preventive Maintenance Checks and Services – Continued

AR – As Required
D – Daily
W – Weekly
M – Monthly
S – Semi-annually

Interval					ITEM TO BE INSPECTED Procedure	Work Time (Hours)
AR	D	W	M	S		
			X		**IOS Monitor** 1. Wipe screen with soft, clean, lint-free cloth. **CAUTION** **Some detergents contain significant amounts of alcohol-based solvent, which can damage (color change) or crack the monitor case. The antiglare/anti-static surface coating on the CDT may also be affected.** 2. If IOS monitor screen requires more than dusting, slightly moisten a soft, clean, lint free cloth with water diluted mild detergent to clean the monitor screen. Dilute the detergent (1:10) with water before using.	0.1
					Air Compressor	
		X			1. Check oil level. During standstill the correct level is between the maximum and minimum indications. Use only SJ-27 synthetic oil.	0.1
		X			2. Drain condensation from air tank (at a pressure of max. 2bar/30 psi).	0.2
		X			3. Check and empty outlet filter of water by pressing the black button in the bottom. If fitted with auto drain, this will take place automatically.	0.2
			X		4. Check Air Compressor air lines and equipment for leaks and check the pumping time.	0.1
			X		5. Inspect and clean or replace air intake filter.	0.2
			X		6. Clean the Air Compressor with a soft, damp cloth. Dust and dirt build-up will prevent cooling.	0.2
X*					7. *Check the O-ring in the non-return valve and replace if necessary. **Note:** Empty receiver of air before dismounting.	0.2
X*					8. *Check filter and filter elements for optimum efficiency.	0.1
X*					9. *Test the safety valve by gently pulling the ring with pressure in the receiver.	0.1
					* AR - Recommend Annually.	

Table 4-1. Preventive Maintenance Checks and Services – Continued

AR – As Required
D – Daily
W – Weekly
M – Monthly
S – Semi-annually

Interval					ITEM TO BE INSPECTED Procedure	Work Time (Hours)
AR	D	W	M	S		
					Projector/Camera Assembly	
	X				1. Check the Projector/Camera Assembly window and clean when necessary.	0.1
					CAUTION **Do not touch the projector lens, oils in fingerprints can damage the lens.**	
					CAUTION **Do not use water, detergent, lens tissue, or commercial lens cleaner on the projector's lens. Use of such material will damage the lens.**	
		X			2. Dust with Dustoff® once a week to remove accumulated dust from projector lenses and camera assembly window. Keep lens cover in place when not in use.	0.1
X					If a finger smudge occurs on a projector lens, remove loose dust with Dustoff® and wipe the finger smudge with a soft, clean, lint-free cloth. Be gentle, do not rub, and always wipe in one direction. Some visible smudge may remain.	0.1
					Note: If remaining smudge degrades quality of projected images contact the EST Help Desk for further troubleshooting guidance and assistance.	
		X			3. Remove the Projector Assembly dust filters once a week to remove accumulated dust. Clean the dust filters with a clean dry cloth. Re-install the dust filters in the Projector Assembly.	0.2
					Printer	
		X			1. Use a soft cloth moistened with water to wipe off dust, smudges, and stains on exterior of printer.	0.1
			X		2. As required, align, clean and/or replace ink cartridges. Refer to HP DeskJet 6120 series users guide.	0.2
					IOS Computer	
		X			1. Remove the IOS Chassis fan dust filters once a week to remove accumulated dust. Clean the dust filters by running under water to until clean. Remove moisture by rolling in a clean dry cloth. Re-install the dust filters in the IOS Chassis.	0.2

Table 4-1. Preventive Maintenance Checks and Services – Continued

AR – As Required
D – Daily
W – Weekly
M – Monthly
S – Semi-annually

Interval					ITEM TO BE INSPECTED Procedure	Work Time (Hours)
AR	D	W	M	S		
					Cables	
					WARNING **Disconnect power cable from wall receptacle before checking cables. Electricity from damaged cable can cause serious injury or death to personnel.**	
			X		Inspect any visible damage to cables or connectors.	0.1
					Weapons	
					WARNING **Avoid cleaning or performing maintenance on a simulated weapon that is connected to the electrical or pneumatic umbilical cables. Severe injury may result.**	
					Daily maintenance consists of pre-training maintenance and post-training maintenance.	
					To do pre-training maintenance, perform these steps:	
	X				1. Wipe the simulated weapon down with a dry, clean cloth.	0.1
	X				2. Visually inspect the simulated weapon for any damage or missing components.	0.1
	X				3. Plug the weapon simulator into the system.	0.1
	X				4. Initialize the weapon simulator on the system.	0.1
					Note: If the laser fails to operate, check for oil on the laser lens. If oil is on the laser lens, clean the lens by using a cotton swab with 100% pure rubbing alcohol.	
	X				5. Perform functional tests (operation of all the mechanical parts such as safety, trigger, slide, etc.).	0.2
					Note: The FATS simulated weapons operating psi are: • M136 – 100psi M2 – 100psi • M240 – 100psi M249 – 100psi • M9 – 125psi MK19 – 100psi • M16 – 100psi M203 – 100psi • M4 – 125psi **Note:** The CUBIC simulated weapons operating psi is 125psi	

Table 4-1. Preventive Maintenance Checks and Services – Continued

AR – As Required
D – Daily
W – Weekly
M – Monthly
S – Semi-annually

Interval					ITEM TO BE INSPECTED Procedure	Work Time (Hours)
AR	D	W	M	S		
					To do post training maintenance, perform these steps:	
	X				6. Wipe the simulated weapon down with a dry, clean cloth.	0.1
					WARNING **Never use oil that contains any type of solvent as it may damage the electronic components.**	
	X				7. Apply a light coat of CLP lightweight gun oil over the entire weapon avoiding the muzzle end where the laser is mounted. Do not get oil on the laser lens.	0.1
	X				8. Visually inspect the simulated weapon for any damage.	0.1
					To do weekly maintenance, perform these steps:	
		X			9. Clean the laser lens with a dry cotton swab to remove any dust or particulate matter. Refer to step 4 in the pre-operation training maintenance section if oil is present on the laser lens.	0.1
		X			10. Visually inspect the simulated weapon for any damage or missing components. Do not attempt to use a weapon that is visually damaged or missing components.	0.1
					To do quarterly maintenance, perform these steps:	
X*					11. *Oil the following internal components: • Slide rails on hand guns. • Bolt through the ejection port on rifles. • Bolt and receiver by lifting the cover on machine guns.	0.5
X*					12. *Inspect and replace the O-ring on the pneumatic cable if necessary.	0.2
					* AR - Recommend Quarterly.	
	X				**Sight Aim Point** Check Weapon Laser Alignment. The Check Weapon Laser Alignment feature is used as a daily pre-training check to ensure correct weapon laser calibration. A properly calibrated weapon will show the SAP aligned with the weapon's sights as the weapon is pointed anywhere on the screen. (paragraph 3.5.1.1.2.2. or 3.5.2.2.2.2.)	0.1

Table 4-2. Troubleshooting Failure Table.

Malfunction Category	Specific Malfunction	Corrective Action
AC Power Faults	No power to System and/or components.	Go to Table 4-3.
Initialization Fault	1. No power to IOS (indicator lights on display controller computer, ATTR, etc. are not lit)	Go to Table 4-3.
	2. Data file error displayed on host terminal.	Software data files are corrupted. A software download is needed to correct problem. Contact the EST Help Desk for further troubleshooting guidance and assistance.
	3. Program error.	Program software files are corrupted. A software download is needed to fix problem. Contact the EST Help Desk for further troubleshooting guidance and assistance.
Display Controller Computer Fault	1. While booting, an error message is displayed on the IOS monitor.	If unable to isolate and resolve malfunction contact the EST Help Desk for further troubleshooting guidance and assistance.
	2. Computer fails system diagnostic test(s) while booting.	If unable to isolate and resolve malfunction contact the EST Help Desk for further troubleshooting guidance and assistance.
	3. Computer does not power up.	Go to Table 4-3.
Keyboard/Mouse Fault	Keyboard/Mouse inoperative.	Contact the EST Help Desk for further troubleshooting guidance and assistance.
Mouse Fault	Erratic cursor movement when using the mouse.	Clean mouse components in accordance with Table 4-1.
IOS Monitor Failure	No display on monitor.	Check IOS Monitor's power switch. If switch is "ON" and IOS Monitor power light is not lit go to Table 4-3. Check video cable connections between IOS monitor and RDU. Correct any bad connections found. If no bad connections found, replace the IOS monitor in accordance with paragraph 4.4.2.5. If IOS monitor still does not work contact the EST Help Desk for further troubleshooting guidance and assistance.
Pneumatics Fault	No weapon recoil	Go to Table 4-4.
Scenario Fault	Scenario does not load/run	If unable to isolate and resolve malfunction contact the EST Help Desk for further troubleshooting guidance and assistance.
Audio System Fault	No sound	Go to Table 4-5.
Video System Fault	No display on projection screen.	Go to Table 4-6.
Targeting Fault	System does not track laser	Go to Table 4-7.
Autotracker Calibration Fault	System fails Autotracker Calibration	Go to Table 4-8.
Weapons Faults		Go to Table 4-9.

Table 4-3. Troubleshooting AC Power Problems

Step	Corrective Action
Step 1	Check connections between component and source of power in accordance with the following: Component — Power Source **IOS** — Facility **Air Compressor** — Facility If connections are properly seated go to Step 2. **Speaker** — ACPDU If connections are properly seated go to Step 4. **Projector** — ACPDU If connections are properly seated go to Step 8. **IOS monitor** — ACPDU If connections are properly seated go to Step 11. **IR Camera** — RDU If connections are properly seated go to Step 14. **Floor box** — RDU If connections are properly seated go to Step 18. **Weapon** — Floor Box If connections are properly seated go to Step 21.
Step 2	Air Compressor, check voltage selection switch and master power switch. IOS, check master power switch. Are switches set correctly? YES: Go to Step 3. NO: Set switch(es) correctly, test and return to normal operation.
Step 3	Check Facility Circuit Breaker. Is Circuit Breaker “ON”? YES: Contact Facility Engineer. NO: Turn Circuit Breaker to “ON”, test and return to normal operation.
Step 4	Check power switch on affected speaker(s). Is switch “ON”? YES: Go to Step 5. NO: Turn power switch to “ON”, test and return to normal operation.
Step 5	Does the problem affect both speakers? YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 6.
Step 6	At the IOS, turn master power switch to “OFF”. On the ACPDU, switch speaker power cables (J2 and J3, Figure 3-12). Turn master power switch to “ON”. Did the problem switch? Affected speaker now has power, and other speaker now has none? YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 7.
Step 7	At the IOS, turn master power switch to “OFF”. On the ACPDU, switch speaker power cables (J2 and J3, Figure 3-12) to original position. At the speakers switch speaker power cables. Turn master power switch to “ON”. Did the problem switch? Affected speaker now has power, and other speaker now has none? YES: Replace affected speaker’s power cable, test and return to normal operation. NO: Replace affected speaker, test and return to normal operation.

Table 4-3. Troubleshooting AC Power Problems

Step	Corrective Action
Step 8	Check projector power switch. Is switch “ON”? YES: Go to Step 9. NO: Turn power switch “ON”, test and return to normal operation.
Step 9	At the IOS, turn master power switch to “OFF”. On the ACPDU switch projector power (J4 – Figure 3-12) with a known working component (i.e. IOS monitor, J5). Turn master power switch to “ON”. Did the problem switch? Projector now has power and IOS monitor does not. YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 10.
Step 10	At the IOS, turn master power switch to “OFF”, switch power cables to original position, replace projector power cable. Turn IOS master power switch to “ON”. Does projector have power? YES: Test and return to normal operation. NO: Replace projector, test and return to normal operation.
Step 11	Check IOS monitor power switch. Is switch “ON”? YES: Go to Step 12. NO: Turn power switch “ON”, test and return to normal operation.
Step 12	At the IOS, turn master power switch to “OFF”. On the ACPDU switch IOS monitor power (J5 – Figure 3-12) with a known working component (i.e. projector, J4). Turn master power switch to “ON”. Did the problem switch? IOS monitor now has power and projector does not. YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 13.
Step 13	At the IOS, turn master power switch to “OFF”, switch power cables to original position, replace IOS monitor power cable. Turn IOS master power switch to “ON”. Does IOS monitor have power? YES: Test and return to normal operation. NO: Replace IOS monitor, test and return to normal operation.
Step 14	If your EST 2000 consists of two or more 5-lane subsystems go to Step 15. If your EST 2000 consists of a single 5-lane subsystem, at the IOS turn master power switch to “OFF” and go to Step 17.
Step 15	At all IOSs, turn master power switch to “OFF”. On the RDUs, switch IR camera Data cables (J2 – Figure 3-13). Turn master power switches to “ON”. Did the problem switch? Affected IR camera now has power, and other IR camera now has none? YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 16.
Step 16	At all IOSs, turn master power switch to “OFF”. At the IR cameras, switch the Data cables. Turn master power switches to “ON”. Did the problem switch? Affected IR camera now has power, and other IR camera now has none? YES: Go to Step 17. NO: Contact EST Help Desk for further troubleshooting guidance and assistance.
Step 17	Replace affected IR camera’s Data cable. Turn master power switches to “ON”. Does IR camera have power? YES: Test and return to normal operation. NO: Contact EST Help Desk for further troubleshooting guidance and assistance.

Table 4-3. Troubleshooting AC Power Problems

Step	Corrective Action
Step 18	Is problem associated with all three floor boxes? YES: Contact EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 19.
Step 19	At the IOS, turn master power switch to “OFF”. On the RDU switch affected floor box cable with an unaffected floor box (Figure 3-13, J3, J4, and J5). Turn IOS master power switch to “ON”. Did the problem switch? Affected floor box now has power, and other floor box now has none? YES: Contact EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 20.
Step 20	At the IOS, turn master power switch to “OFF”. On the RDU, switch floor box cables to original position. At the floor boxes switch affected floor box cable with an unaffected floor box. Turn master power switch to “ON”. Did the problem switch? Affected floor box now has power, and other floor box now has none? YES: Replace affected floor box cable, test, and return to normal operation. NO: Replace affected floor box, test and return to normal operation.
Step 21	Does floor box have power? YES: Go to Step 22. NO: Go to Step 18.
Step 22	Replace affected weapon with a known functional weapon. Is replacement weapon activated? YES: Replace original weapon, test and return to normal operation. NO: Replace floor box, test and return to normal operation.

Table 4-4. Troubleshooting the Pneumatics System

Step	Corrective Action
Step 1	Check exercise “setup” at the IOS to ensure recoil is not set for “delay” or turned “OFF”. Is recoil set properly? YES: Go to Step 2. NO: Reset recoil, test and return to normal operations.
Step 2	Does the Air Compressor have power? YES: Go to Step 3. NO: Go to Table 4-3.
Step 3	Is the problem associated only with weapon(s) connected to an individual floor box? YES: Go to Step 7. NO: Go to Step 4.
Step 4	Check Air Compressor set up (Figure 3-3). Is the Air Compressor “ON” with the main gauge reading 130 psi – 160 psi (**Note:** If main gauge reads above 130 psi the compressor will not be running), main air valve open with air line gauges reading 100 psi and 125 psi? YES: Go to Step 6. NO: Go to Step 5.
Step 5	Make the necessary changes to the Air Compressor set up (paragraph 3.4.1.). Is problem corrected? YES: Test and return to normal operation. NO: Go to Step 6.
Step 6	Check system air lines for kinks, listen for sounds of venting air. Are system air lines free of kinks and venting air? YES: Replace Air Compressor, test and return to normal operation. NO: Repair or replace air line, test and return to normal operation.
Step 7	Does floor box have power? YES: Go to Step 8. NO: Go to Table 4-3.
Step 8	Check weapon air lines for kinks and proper connection at floor box. Are air lines free of kinks and weapon(s) connected properly? YES: Replace affected weapon(s) with a known functional weapon and go to Step 9. NO: Connect weapon air line, test and return to normal operation.
Step 9	Does recoil on replacement weapon function? YES: Replace affected weapon, test, and return to normal operation. NO: Replace floor box, test and return to normal operation.

Table 4-5. Troubleshooting the Audio System

Step	Corrective Action
Step 1	Is problem associated with both speakers in the subsystem? YES: Go to Step 2. NO: Go to Step 6.
Step 2	Check system volume setting at IOS. Is volume set properly? YES: Go to Step 3. NO: Reset volume, test and return to normal operation.
Step 3	Check voltage selection switch, power switch, and volume control at each speaker. Are switches set correctly? YES: Go to Step 4. NO: Reset switches, test and return to normal operation.
Step 4	Do speakers have power? YES: Go to Step 5. NO: Go to Table 4-3.
Step 5	Check connections between speakers and RDU. Are connections secured? YES: Contact EST Help Desk for further troubleshooting guidance and assistance. NO: Secure connections, test and return to normal operation.
Step 6	Check voltage selection switch, power switch, and volume control at affected speaker. Are switches set correctly? YES: Go to Step 7. NO: Reset switches, test and return to normal operation.
Step 7	Does affected speaker have power? YES: Go to Step 8. NO: Go to Table 4-3.
Step 8	At the IOS, turn master power switch to “OFF”. On the RDU switch speaker audio cables. (J6 and J7 – Figure 3-13). Turn IOS master power switch to “ON”. Did the problem switch? Affected speaker now has sound, and the other speaker does not? YES: Contact EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 9.
Step 9	At the IOS, turn master power switch to “OFF”. On the RDU, switch speaker cables to original position. At the speakers switch audio cables. Turn master power switch to “ON”. Did the problem switch? Affected speaker now has sound, and the other speaker does not? YES: Replace affected speaker’s audio cable, test and return to normal operation. NO: Replace affected speaker, test and return to normal operation.

Table 4-6. Troubleshooting the Video System

Step	Corrective Action
Step 1	Check system projector. Is projector power switch “ON” and lens covers removed? YES: Go to Step 2. NO: Turn projector power switch “ON”, test and return to normal operation.
Step 2	Does projector have power? YES: Go to Step 3. NO: Go to Table 4-3.
Step 3	Have lens covers been removed? YES: Go to Step 4. NO: Remove lens covers, test and return to normal operation.
Step 4	Is the projector in standby mode? **Note:** If projector is in standby mode there will be a single red light visible at the bottom center on the front of the projector. YES: Go to Step 5. NO: Go to Step 6.
Step 5	Open the access door on top of the projector (Figure 3-31) and push the standby button or, push the standby button on the remote control device (Figure 3-31). Test and return to normal operation.
Step 6	Check connections between RDU and projector. Are connections secured? YES: Go to Step 7. NO: Secure connections, test and return to normal operation.
Step 7	If your EST 2000 consists of two or more 5-lane subsystems go to Step 9. If your EST 2000 consists of a single 5-lane subsystem at the IOS turn master power switch to “OFF” and go to Step 8.
Step 8	Replace projector signal cable, turn IOS master power switch to “ON”. Is problem corrected? YES: Test and return to normal operation. NO: Contact EST Help Desk for further troubleshooting guidance and assistance.
Step 9	At all IOSs, turn master power switch to “OFF”. On the RDUs, switch projector signal cables (J1 – Figure 3-13). Turn master power switches to “ON”. Did the problem switch? Affected projector is now working, and the other is not? YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 10.
Step 10	At all IOSs, turn master power switch to “OFF”. On the RDUs, return projector signal cables to their original connections. At the projectors, switch the projector signal cables. Turn master power switches to “ON”. Did the problem switch? Affected IR camera now has power, and other IR camera now has none? YES: Replace the affected projector’s signal cable, test, and return to normal operation. NO: Contact EST Help Desk for further troubleshooting guidance and assistance.

Table 4-7. Troubleshooting the Targeting System

Step	Corrective Action
Step 1	Does IR camera have power? YES: Go to Step 2. NO: Go to Table 4-3.
Step 2	Check video connections between camera and RDU. Are connections secured? YES: Go to Step 3. NO: Secure connections, test and return to normal operation.
Step 3	Does system calibrate properly? YES: Go to Step 4. NO: Go to Table 4-8.
Step 4	Is problem associated with all weapons in subsystem? YES: Go to Step 5. NO: Go to Step 9.
Step 5	If your EST 2000 consists of two or more 5-lane subsystems go to Step 7. If your EST 2000 consists of a single 5-lane subsystem, at the IOS turn master power switch to “OFF” and go to Step 6.
Step 6	Replace IR camera’s video cable, at the IOS turn master power switch to “ON”. Is problem corrected? YES: Test and return to normal operation. NO: Contact EST Help Desk for further troubleshooting guidance and assistance.
Step 7	At all IOSs, turn master power switch to “OFF”. On the RDUs switch IR camera video cables (J11 – Figure 3-13). Turn master power switches to “ON”. Did the problem switch? Affected IR camera is now tracking, and the other is not? YES: Contact the EST Help Desk for further troubleshooting guidance and assistance. NO: Go to Step 8.
Step 8	At all IOSs, turn master power switch to “OFF”. On the RDUs return IR video cables to their original connections. At the IR cameras, switch the video cables. Turn master power switches to “ON”. Did the problem switch? Affected IR camera is now tracking, and the other is not? YES: Replace the affected IR camera’s video cable, test and return to normal operation. NO: Contact EST Help Desk for further troubleshooting guidance and assistance.
Step 9	Does affected floor box have power? YES: Go to Step 10. NO: Go to Table 4-3.
Step 10	Replace affected weapon with a known functional weapon. Is replacement weapon functional? YES: Replace original weapon, test and return to normal operation. NO: Replace floor box, test and return to normal operation.

Table 4-8. Troubleshooting an Autotracker Calibration Failure

Step	Corrective Action
Step 1	Did the system pass the calibration stage with no errors and proceed to the operational mode? YES: Proceed to step 16. NO: Proceed to step 2.
Step 2	Was the Autotracker calibration reported as "**Video Too Bright**"? YES: Go to step 11. NO: Go to step 3.
Step 3	Was the Was the Autotracker calibration reported as " **Video Too Dim**"? YES: Go to step 8. NO: Go to step 4.
Step 4	Was the Autotracker calibration reported as "**Unknown Tracker Error**"? YES: Go to step 8. NO: Go to step 5.
Step 5	Was the Autotracker calibration reported as "**Sync Time Bad**"? YES: Go to step 9. NO: Go to step 6.
Step 6	Were the green calibration brackets displayed in each of the four corners? YES: Go to step 7. NO: Go to step 2.
Step 7	Were the green calibration dots displayed on the Projection Screen during the calibration process? YES: Go to step 1. NO: Go to step 8.
Step 8	Does the IR Camera Filter open during the calibration process? YES: Go to step 9. **WARNING** **Damage to personnel or equipment may occur if the data cable is removed or inserted with power applied.** NO: See below. Check to ensure that filter is clear and free to retract when activated. Check to ensure that the cables are properly connected. Go to step 1.
Step 9	If the system is configure in 10 or 15-lanes of operation the use of a Sync cable if required. Ensure that the cable is installed as required. YES: Go to step 15. NO: Go to step 1.
Step 10	At the Projector, check the following; Ensure that the lens covers are removed. Ensure that the power switch is turned to the "On" position. Ensure that the Projector is not in the "pause" or "standby" mode. Ensure the proper "Selected Source" is selected on the projector (press "1" on the RCU). Ensure that the cables are all properly connected. Go to step 1.
Step 11	Ensure that the room lighting is not causing interference. Was this the source of the problem? YES: Go to step 1. NO: Go to step 15.

Table 4-8. Troubleshooting an Autotracker Calibration Failure

Step	Corrective Action
Step 12	At the Autotracker computer? Ensure that the green power on indicator located on the front of the Autotracker is on. YES: Go to step 13. NO: Proceed to step 14.
Step 13	Connect a monitor, keyboard, and mouse to the Autotracker computer. Ensure that the Win Tracker (Autotracker software GUI) is displayed? YES: Proceed to step 1. NO: Use the mouse to double click on the Tracker.exe icon displayed on the Windows Desktop. After the program starts proceed to Step 1.
Step 14	Depress the main power switch on the front panel of the Autotracker. Did the Autotracker power up successfully? YES: Proceed to step 1. NO: Ensure that the power cable in the rear of the Autotracker is properly seated in both the Autotracker and the power strip. Depress the main power switch again. If this did not correct the problem proceed to step 15.
Step 15	If a calibration message is received, other than those messages listed in Steps 2 through 5, contact the EST Help Desk for further troubleshooting guidance and assistance.
Step 16	System is functioning normally.

Table 4-9. Troubleshooting a Simulated Weapon Failure

TROUBLE	CAUSE	SOLUTION
Weapon does not initialize on the system	Weapon trainer is not connected to the EST2000 system.	Connect the weapon's electrical umbilical to the EST2000 system.
Weapon does not fire.	Weapon trainer is not connected to EST2000 system.	Connect the umbilical plugs to EST2000 system.
	Safety switch is selected.	Turn safety switch to FIRE.
	Weapon not loaded per simulated loading procedures.	Drop magazine and reinsert. Pull slide to the rear and release.
	Weapon is not registered.	Register weapon on the system.
	Ammo belt not seated in the tray correctly.	Reseat ammo belt or replace belt if damaged.
	System is not aligned.	Align the system in the designated setup menu.
Weapon shots are inaccurate.	System is not calibrated.	Calibrate the system in the Main menu selection.
	Weapon is not calibrated.	Calibrate the weapon in the Main menu.
	Weapon is not boresighted.	Boresight the weapon.
	Weapon is not connected to the system.	Connect the weapon to the gun port on the system.
Hit not recorded on screen.	Weapon is not initialized.	Initialize the weapon from the Setup menu.
	IR camera inoperative.	Check the camera and system alignment.
	Laser path to projected screen obstructed.	Remove the obstruction.
	Laser inoperative.	Contact the CRA.
	Weapon is not zeroed.	Zero the weapon.
Cannot hit targets.	Excessive ambient light.	Eliminate outside light and use only fluorescent lighting.
False hits are recorded on the screen.	Bent or worn magazine.	Replace the magazine.
The magazine will not lock into weapon	Damaged ammo belt or damage first and second rounds.	Replace the ammo belt.
The ammo belt will not seat in tray.	Weapon is not connected to a floor box.	Connect the weapon's air umbilical hose to the floor box.
Weapon produces no recoil.	Low AIR pressure.	Adjust the regulator to recommended pressure.
	Weapon not registered on system	Register weapon on system
	Low AIR pressure.	Adjust the regulator to recommended pressure.
Weapon functions slowly.	Weapon dirty or rusty	Clean and lubricate weapon simulator
	Over pressurized hose fitting.	Ensure the correct operating pressure is set at the AIR source.
	Low AIR pressure.	Adjust the regulator to recommended pressure.

Table 4-9. Troubleshooting a Simulated Weapon Failure – Continued

TROUBLE	CAUSE	SOLUTION
Audible AIR leak inside weapon.	Faulty valve or seat.	Exchange the weapon.
	Weapon not selected in scenario	Select the weapon in check box next to the lane.
	Weapon not supported in scenario	Select proper scenario for the weapon.

TD-07-6910-702-10

THIS PAGE INTENTIONALLY LEFT BLANK

4.4.2. Remove and Replace Procedures

Refer to Chapter 3 for additional guidance when removing/replacing trainer components.

WARNING

Trainer is powered by HIGH VOLTAGE. Failure to disconnect power prior to maintenance procedures may result in serious injury or death to personnel and/or damage to equipment .

4.4.2.1. Remove and replace Air Compressor assembly

4.4.2.1.1. Remove Air Compressor assembly

(a) Turn Air Compressor assembly master power switch to the OFF position.
(b) Turn Air Compressor assembly power selection switch to the OFF position.
(c) Disconnect Air Compressor assembly power cable from facility power source.
(d) Release air pressure from air lines.

Note: All air pressure must be removed from the air lines before you will be able to disconnect them. To disconnect push in on the collar of the fitting and pull straight out on the air line.

(e) Disconnect air lines from 100 psi and 125 psi pressure regulators.
(f) Remove the Air Compressor assembly.

4.4.2.1.2. Replace Air Compressor assembly

(a) To replace Air Compressor assembly, refer to Chapter 3, paragraph 3.1.2.5 for instructions.

4.4.2.2. Remove and replace floor box

4.4.2.2.1. Remove floor box

(a) Turn master power switch on the IOS to OFF.
(b) Disconnect IOS power cable from facility power source.
(c) Disconnect any weapons from the floor box.
(d) Disconnect cable assembly from the floor box.
(e) Release air pressure from air lines.

Note: All air pressure must be removed from the air lines before you will be able to disconnect them. To disconnect push in on the collar of the fitting and pull straight out on the air line.

(f) Disconnect the 100 psi and 125 psi air lines from the floor box.
(g) Remove termination plugs if applicable.
(h) Remove floor box.

4.4.2.2.2. Replace floor box

(a) Place floor box in correct position at firing line.
(b) Connect the 100 psi and 125 psi air lines to the floor box.
(c) Install termination plugs if applicable.
(d) Connect cable assembly to the floor box.
(e) Ensure master power switch on the IOS is OFF.
(f) Connect IOS power cable to facility power source.

4.4.2.3. Remove and replace IR camera assembly

4.4.2.3.1. Remove IR camera assembly

(a) Turn master power switch on IOS to OFF.
(b) Disconnect IOS power cable from facility power source.
(c) Disconnect cables from the IR camera assembly.
(d) Remove the four screws securing the IR camera assembly cover.
(e) Remove the IR Camera assembly cover.
(f) Remove the three push rivets securing the IR camera assembly to the projector assembly adapter bracket; set the push rivets in a safe place for reuse.
(g) Remove the IR camera assembly from the projector assembly.
(h) Reinstall the IR camera assembly cover and secure with the four screws.

4.4.2.3.2. Replace IR camera assembly

(a) Remove the four screws securing the IR camera assembly cover on the replacement IR camera assembly.
(b) Remove the IR Camera assembly cover.
(c) Align the IR camera assembly on the projector assembly adapter bracket.
(d) Install the three push rivets securing the IR camera assembly to the projector assembly adapter bracket.
(e) Reinstall the IR camera assembly cover and secure with the four screws.
(f) Connect cable assemblies to the IR camera assembly.
(g) Ensure master power switch on the IOS is OFF.
(h) Connect IOS power cable to facility power source.

4.4.2.4. Remove and replace projector assembly

4.4.2.4.1. Remove projector assembly

(a) Turn master power switch on IOS to OFF.
(b) Disconnect IOS power cable from facility power source.
(c) Remove the Projector Assembly cable cover.
(d) Disconnect cables from the projector and IR camera assemblies.
(e) Loosen four screws securing the IR camera assembly to the projector assembly.
(f) Remove the four screws securing the IR camera assembly cover.
(g) Remove the IR Camera assembly cover.
(h) Remove the three push rivets securing the IR camera assembly to the projector assembly adapter bracket; set the push rivets in a safe place for reuse.
(i) Remove the IR camera assembly from the projector assembly.
(j) Remove the projector assembly.

CAUTION

When shipping the Projector Assembly for repair, the Projector Assembly Lens must be removed from the Projector Assembly prior to packing. Pack the Projector Assembly Lens in its own box before placing it in the Projector Assembly Shipping Case. Failure to remove the Projector Assembly Lens from the Projector Assembly prior to shipping will result in damage to the Projector Assembly Lens and/or Projector Assembly.

4.4.2.4.2. Replace projector assembly

(a) As required, refer to paragraph 3.1.2.8
(b) Align the IR camera assembly on the projector assembly adapter bracket.
(c) Install the three push rivets securing the IR camera assembly to the projector assembly adapter bracket.
(d) Reinstall the IR camera assembly cover and secure with the four screws.
(e) Position projector assembly in correct location.
(f) Remove the projector assembly cable cover.
(g) Connect cables to the projector and IR camera assemblies.
(h) Install the projector assembly cable cover.
(i) Ensure projector assembly power switch is OFF.
(j) Ensure master power switch on the IOS is OFF.
(k) Connect IOS power cable to facility power source.

4.4.2.5. Remove and replace IOS monitor

4.4.2.5.1. Remove IOS monitor assembly

(a) Turn master power switch on IOS to OFF.
(b) Disconnect IOS power cable from facility power source.
(c) Disconnect the IOS monitor assembly power cable from the IOS monitor assembly.
(d) Disconnect the IOS monitor assembly signal cable from the RDU assembly.
(e) Remove the IOS monitor assembly.

4.4.2.5.2. Replace IOS monitor assembly

(a) Set the IOS monitor assembly on the IOS.
(b) Connect the IOS monitor assembly power cable to the IOS monitor assembly.
(c) Connect the IOS monitor signal cable to the RDU assembly.
(d) Ensure IOS monitor assembly power switch is ON.
(e) Ensure master power switch on the IOS is OFF.
(f) Connect IOS power cable to facility power source.

4.4.2.6. Remove and replace printer assembly

4.4.2.6.1. Remove printer assembly

(a) Turn master power switch on IOS to OFF.
(b) Disconnect IOS power cable from facility power source.
(c) Disconnect the printer assembly power cable from the printer assembly.
(d) Disconnect the printer assembly signal cable from the printer assembly.
(e) Remove the printer assembly.

4.4.2.6.2. Replace printer assembly

(a) Set printer assembly near IOS.
(b) Connect the printer assembly power cable to the printer assembly.
(c) Connect the printer assembly signal cable to the printer assembly.
(d) Ensure printer assembly power switch is ON.
(e) Ensure master power switch on the IOS is OFF.
(f) Connect IOS power cable to facility power source.

4.4.2.7. Remove and replace screen assembly

4.4.2.7.1. Remove screen assembly

(a) As required, remove the two wing bolts and u-clamps joining the screens together.
(b) Remove the screen.

4.4.2.7.2. Replace screen assembly

(a) Refer to Chapter 3, paragraphs 3.1.2.6 for screen assembly instructions.
(b) As required, install the two wing bolts and u-clamps joining the screens together (Figure 3-18).

4.4.2.8. Remove and replace speaker

4.4.2.8.1. Remove speaker

(a) Turn master power switch on IOS to OFF.
(b) Disconnect IOS power cable from facility power source.
(c) Disconnect the speaker power and audio cable assemblies from the speaker.
(d) Remove the speaker.

4.4.2.8.2. Replace speaker

(a) Place the speaker in correct location.
(b) Ensure speaker voltage selection switch is in appropriate 110VAC or 220VAC position.
(c) Connect the speaker power and audio cable assemblies.
(d) Ensure speaker power switch is ON.
(e) Ensure master power switch on the IOS is OFF.
(f) Connect IOS power cable to facility power source.

INDEX

THIS PAGE INTENTIONALLY LEFT BLANK

2

24V Power Supply....3-42

A

AC Power Distribution Unit (ACPDU). 3-42
ACPDU....3-42
Air Compressor 3-43
Air supply line connections....3-17
ATTR....3-42
Audio System 3-43
Autotracker....3-42

B

Boxes, Floor 3-43

C

Cable bundle connections....3-16
Camera and Projector connections....3-18
camera assembly, Remove and replace....4-24
camera, IR detection 3-43
Camera/projector assembly position....3-12
CAPABILITIES, PURPOSE OF 2-2
CAUTION ....xi, xii, 2-3, **3-1**, 3-6, 3-7, 3-12, 3-16, 3-18, 3-165, 4-4, 4-5, 4-6, 4-24
CHARACTERISTICS, TECHNICAL....2-2
CLASSIFICATION, SECURITY 2-1
Collective Core Scenarios (Table) 3-119
Collective mode....3-113
component locations 3-4
Component removal....3-5
compressor assembly, Remove and replace....4-23
Compressor setup....3-5
Compressor, Air 3-43
Computer, Display controller....3-41
CONDITIONS, ENVIRONMENTAL 2-3
CONFIGURATION, TRAINER 3-30
Configurations 3-29
Configure New Subsystems....3-30
connection and placement, Monitor 3-13
connection and placement, Printer 3-13
Connection, Disable Remote 3-157
Connection, Enable Remote 3-156
connection, Facility power source....3-18
connections, Air supply line....3-17
connections, Cable bundle....3-16
connections, Floor box....3-17
connections, projector and IR Camera 3-18
connections, Speaker....3-16
CONSUMABLES....4-1
CONTROLS AND INDICATORS, OPERATOR....3-41
COURSEWARE, INTEGRATED....3-157

D

Date/Time, Change 3-156
Display controller computer....3-41

E

EMERGENCY OPERATIONS 3-165
ENVIRONMENTAL CONDITIONS 2-3
EQUIPMENT REQUIRED BUT NOT SUPPLIED 2-2
Equipment Specifications (Table) 2-4
EQUIPMENT SUPPLIED 2-2
EXIT 3-165
Export Shooter data 3-142
Export/Import Data 3-157
Exported Shooter Data, Summary (Table) 3-153

F

Facility power source connection 3-18
FACILITY REQUIREMENTS 2-2, 2-3
Firers, Assign 3-67, 3-115, 3-132
floor box assembly, Remove and replace 4-23
Floor box connections 3-17
Floor box positioning 3-12
Floor Boxes 3-43
FUNCTIONAL DESCRIPTION, SUBSYSTEM 2-4

H

HELP 3-165
HISTORY, ROSTER AND TRAINING 3-141

I

ICW 3-157
Import Roster 3-142
Import Shooter data 3-143
Import/Export Data 3-157
Installation 3-1
INSTRUCTIONS, MAINTENANCE CHAPTER 4 4-1
INSTRUCTIONS, OPERATING CHAPTER 3 ..... **3-1**
INSTRUCTIONS, Operator 3-59
Instructor Operator Station (IOS). 3-41
INTEGRATED COURSEWARE 3-157
INTRODUCTION, CHAPTER 1 1-1
IOS 3-41
IOS positioning 3-13

K

keyboard 3-42

L

Laser safety 3-59

M

MAINTENANCE 3-156
MAINTENANCE, CORRECTIVE 4-3
MAINTENANCE, PREVENTIVE 4-1
Maintenance, Trainer 3-156
Marksmanship Core Scenarios (Table) 3-71

Marksmanship mode....3-65
Mode, Collective....3-113
mode, Marksmanship....3-65
mode, Shoot/Don't Shoot....3-131
Modem....3-42
Monitor....3-42
Monitor placement and connection....3-13
monitor, IOS, Remove and replace....4-25
Monitor, keyboard, and mouse....3-42
mouse....3-42
Multi-subsystem Configurations....3-29

N

Networking subsystems....3-29
Night Vision Devices....3-44

O

OPERATION....3-60
OPERATION, PREPARATION FOR....3-1
OPERATION, TRAINING SYSTEM....3-60
OPERATOR CONTROLS AND INDICATORS....3-41
OPERATOR INSTRUCTIONS....3-59
Optical Devices....3-44
ORGANIZATION....1-1

P

Password, Change....3-156
PMCS Procedures and Table....4-1
Power Requirements....3-1
Power Supply, 24V....3-42
Practice Types....3-65
Preparation for Training....3-60
Preventive Maintenance Checks and Services (Table)....4-4
printer assembly, Remove and replace....4-25
Printer placement and connection....3-13
Printer....3-42
PROCEDURES, MONITORING....3-165
Procedures, Recovery....3-165
Projection System....3-42
Projector....3-43
Projector and IR Camera connections....3-18
projector assembly, Remove and replace....4-24
Projector/camera assembly positioning....3-12

R

Rack Distribution Unit (RDU)....3-42
RDU, Rack Distribution Unit....3-42
Reconfigure Subsystems....3-31
Remote Connection, Disable....3-157
Remote Connection, Enable....3-156
Remove and Replace Procedures....4-23
Roster and Training History....3-141
Roster Tool, Standalone....3-143
Roster, Import....3-142
Roster, Store....3-142

S

SAFETY SUMMARY ..... ix, x, xi, xii
safety, Laser 3-59
Safety, Weapon 3-59
Scenarios, Collective Core (Table) 3-119
Scenarios, Marksmanship Core (Table) 3-71
Scenarios, Shoot/Don't Shoot (Table) 3-135
Screen assembly and positioning, Projection 3-6
screen assembly, Remove and replace 4-26
Screen, Projector 3-43
screens, multiple 3-31
Shipping configuration 3-1
Shoot/Don't Shoot Core Scenarios (Table) 3-135
Shoot/Don't Shoot mode 3-131
Shooter data, Export 3-142
Shooter data, Import 3-143
SHUTDOWN, SYSTEM 3-165
Software Update Utility 3-157
Speaker connections 3-16
Speaker positioning 3-7
speaker, Remove and replace 4-26
Standalone Roster Tool 3-143
Start-up Procedures 3-61
Store Roster 3-142
Subsystem Configurations 3-29
Subsystems, networking 3-29
SYSTEM DESCRIPTION, CHAPTER 2 1-1

T

Tandem Weapon Capabilities 3-113
Time/Date, Change 3-156
Tool Bar, EST 3-65, 3-113, 3-131
Tools required for assembly 3-4
Trainer Maintenance 3-156
TRAINER, DESCRIPTION **2-1**
TRAINING SYSTEM OPERATION 3-60
TRAINING, LEVEL OF 1-1
Troubleshooting a Simulated Weapon Failure (Table) 4-19
Troubleshooting an Autotracker Calibration Failure (Table) 4-17
Troubleshooting Failure (Table) 4-9
Troubleshooting Peripheral Power (Table) 4-10
Troubleshooting Procedures 4-3
Troubleshooting the Audio System (Table) 4-14
Troubleshooting the Pneumatics System (Table) 4-13
Troubleshooting the Targeting System (Table) 4-16
Troubleshooting the Video System (Table) 4-15

U

Utility ,Software Update 3-157

W

WARNING ..... ix, x, xi, 3-1, 3-5, 3-7, 3-19, 3-59, 4-4, 4-7, 4-8, 4-17, 4-23
Weapon Safety 3-59
Weapon, simulated 3-44

SECTION 15954

PROGRAMMABLE LOGIC CONTROL FOR HVAC (FORT SAM HOUSTON)
01/2003

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500 (1989) Test Methods for Louvers, Dampers and Shutters

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1(1988) Code for Electricity Metering

ANSI X3.64(1979; R 1990) Additional Controls for Use with American National Standard Code for Information Interchange

ANSI X3.154 (1988) Office Machines and Supplies - Alphanumeric Machines-Keyboard Arrangement

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 269(1994a) Seamless and Welded Austenitic Stainless Steel Tubing for General Service

ASTM B 88(1993a) Seamless Copper Water Tube

ASTM D 635(1991) Rate of Burning and/or Extent and Time of Burning ofSelf-Supporting Plastics in a Horizontal Position

ASTM D 1693(1970; R 1988) Environmental Stress-Cracking of Ethylene Plastics

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE-03(1993; Errata) Handbook, Fundamentals I-P Edition

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPV VIII Div I(1992; Addenda Dec 1992, Dec 1993) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

ASME B16.34(1988) Valves - Flanged, Threaded, and Welding End

ASME B40.1(1991) Gauges - Pressure Indicating Dial Type - Elastic Element

CODE OF FEDERAL REGULATIONS (CFR)

47 CFR 15Radio Frequency Devices

47 CFR 68Connection of Terminal Equipment to the Telephone Network

INTERNATIONAL ELECTRICAL COMMISSION (IEC)

IEC 1131-3(1993) Programmable Controllers - Part 3: Programmable Languages

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41(1991) Surge Voltages in Low-Voltage AC Power Circuits

INSTRUMENT SOCIETY OF AMERICA (ISA)

ISA S7.3(1975; R 1981) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250(1993) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ICS 1(1993) Industrial Control and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70(1996) National Electrical Code

NFPA 90A(1993) Installation of Air Conditioning and Ventilating Systems

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION
(SMACNA)
SMACNA-07(1993) HVAC Systems - Testing, Adjusting and Balancing

UNDERWRITERS LABORATORIES (UL)

UL 94(1991; Rev thru May 1994) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 268A(1993; Rev Apr 1994) Smoke Detectors for Duct Applications

UL 508(1993) Industrial Control Equipment

UL 555S (1993; Rev Sep 1994) Leakage Rated Dampers for Use in Smoke-Control Systems

UL 916 (1994; Rev Apr 1994) Energy Management Equipment

1.2 GENERAL REQUIREMENTS

The heating, ventilating and air-conditioning (HVAC)control system shall be a Programmable Logic Control (PLC) system. The PLC system shall be a complete system suitable and intended for (HVAC) system control. All PLC's shall be locally networked. The system shall me compatible with and capable of being monitored and controlled by the Fort Sam Houston basewide UMCS system. The basewide UMCS system uses front end software RS View, Version 4.0 by Rockwell.

1.2.1 Nameplates, Lens Caps, and Tags

Nameplates and lens caps bearing legends as shown and tags bearing device-unique identifiers as shown shall have engraved or stamped characters. A plastic or metal tag shall be mechanically attached directly to each device or attached by a metal chain or wire. Each airflow measurement station shall have a tag showing flow rate range for signal output range, duct size, and identifier as shown.

1.2.2 Verification of Dimensions

The Contractor shall become familiar with all details of the work, shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.2.3 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

1.2.4 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.2.5 Surge Protection for Transmitter and Control Wiring

DDC-PLC system control-panel equipment shall be protected against surges induced on control and transmitter wiring installed outside and as shown. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

a. A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.

b. An 8-microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

1.2.7 System Overall Reliability Requirement

The system shall be configured and installed to yield a mean time between failure (MTBF) of at least 40,000 hours. Each DDC-PLC-PLC panel shall be designed, configured, installed and programmed to provide for stand alone operation with minimal performance degradation on failure of other system components to which it is connected or with which it communicates.

1.2.8 Multiple DDC-PLC Panel Requirement

Where the system to be controlled by the DDC-PLC-PLC system is located in multiple mechanical rooms, each mechanical room shall have at least one DDC--PLC panel. DDC-PLC panels shall be located in the same room as the equipment being controlled or in an adjacent space which has direct access to the equipment room. DDC-PLC panels shall not control equipment located in a different mechanical room.

1.2.9 System Accuracy and Display

The system shall maintain an end-to-end accuracy for 1 year from sensor to operator's console display for the applications specified and shall display the value as specified. Each temperature shall be displayed and printed to nearest 0.1 degree F.

1.2.9.1 Space Temperature

Space temperature with a range of 50 to 85 degrees F plus or minus 0.75 degree F for conditioned space; 30 to 130 degrees F plus or minus 1 degree F for unconditioned space.

1.2.9.2 Duct Temperature

Duct temperature with a range of 40 to 140 degrees F plus or minus 2 degrees F.

1.2.9.3 Outside Air Temperature

Outside air (OA) temperature with a range of minus 30 to plus 130 degrees F plus or minus 2 degrees F; with a subrange of 30 to 100 degrees F plus or minus 1 degree F.

1.2.9.4 Water Temperature

Water temperature with a range of 30 to 100 degrees F plus or minus 0.75 degree F; the range of 100 to 250 degrees F plus or minus 2 degrees F; and water temperatures for the purpose of performing Btu calculations using differential temperatures to plus or minus 0.5 degree F using matched sensors.

1.2.9.5 High Temperature

High temperature with a range of 200 to 500 degrees F plus or minus 2.0 degrees F.

1.2.9.6 Relative Humidity

Relative humidity with a range of 20 to 80 percent plus or minus 6.0 percent of range (display and print to nearest 1.0 percent).

1.2.9.7 Pressure

Pressure with a range for the specific application plus or minus 2.0 percent of range (display and print to nearest psi.

1.2.9.8 Flow

Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of thermal calculations to plus or minus 2.0 percent of actual flow (display and print to nearest unit, such as gallons per minute).

1.2.9.9 KWh and kW Demand

KWh and kW demand with a range for the specific application plus or minus 1.0 percent of reading (display and print to nearest kWh or kW).

1.2.9.10 Analog Value Input

An analog value input to the system's equipment via an AI with a maximum error of 0.50 percent of range, not including the sensor or transmitter error. This accuracy shall be maintained over the specified environmental conditions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

HVAC Control System;

Drawings shall be on full-size (34-inch by 22-inch) sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control-system element on a drawing shall have a unique identifier as shown. All HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations shall be approved by the Contracting Officer. Drawings shall be submitted along with Submittal Description SD-03 Product Data.

HVAC Control System Drawings shall include the following:

Sheet One: Drawing Index, HVAC Control System Legend
Sheet Two: Valve Schedule, Damper Schedule
Sheet Three: Compressed Air Station Schematic
Sheet Four: Control System Schematic and Equipment Schedule
Sheet Five: Sequence of Operation and Data Terminal Strip Layout
Sheet Six: Control Loop Wiring Diagrams
Sheet Seven: Motor Starter and Relay Wiring Diagram
Sheet Eight: Communication Network and Block Diagram
Sheet Nine: DDC-PLC-PLC Panel Installation and Block Diagram

Repeat Sheets Four through Seven for each AHU System

The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list all HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used.

The HVAC Control System Legend shall show generic symbols and the name of all devices shown on the HVAC Control System Drawings.

The Valve Schedule shall include each valve's unique identifier, size, flow coefficient (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

The Damper Schedule shall contain each damper's and each actuator's identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the maximum leakage rate at the operating static-pressure differential. The Damper Schedule shall contain actuator selection data supported by calculations of the torque required to move and seal the dampers, access and clearance requirements. Damper schedules may be submitted in advance but shall be included in the complete submittal.

The Compressed-Air Station Schematic Diagram (if used) shall show all equipment, including: compressor with motor horsepower and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air Compressor and air dryer data shall include calculations of the air consumption of all current-to-pneumatic transducers and of any other control system devices to be connected to the compressed air station, and the compressed air supply dewpoint temperature at 20 psig. Compressed-Air Station Schematic drawings shall be submitted for each compressed air station.

The HVAC Control System Schematics shall be in the form shown, and shall show all control and mechanical devices associated with the HVAC system. A System Schematic drawing shall be submitted for each HVAC system.

The HVAC Control System Equipment Schedule shall be in the form shown. All devices shown on the drawings having unique identifiers shall be referenced in the Equipment Schedule. Information to be included in the Equipment Schedule shall be the Control Loop, Device Unique Identifier, Device Function, Setpoint, Input Range, and additional important parameters (i.e. output range). An Equipment Schedule shall be submitted for each HVAC system.

The HVAC Control System Sequence of Operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of Operation shall be submitted for each HVAC Control System including each type of terminal-unit control system.

The HVAC Control System Wiring Diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show all necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. All sources of power required for HVAC control systems and for packaged-equipment control systems shall be identified back to the panel-board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not

integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring Diagrams shall be submitted for each HVAC control system.

Commissioning Procedures;

Six copies of the HVAC Control System Commissioning Procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning Procedures shall be provided for each HVAC control system, and for each type of terminal-unit control system. The Commissioning Procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The Commissioning Procedures shall be specific for each HVAC system, and shall give detailed step-by-step procedures for commissioning of the system.

The Commissioning Procedures shall include detailed, product-specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product-specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the HVAC Control System Commissioning Procedures to the manuals.

An HVAC Control System Commissioning Procedures Equipment List shall be included that lists the equipment to be used to accomplish commissioning. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Performance Verification Test Procedures;

Six copies of the HVAC Control System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The Performance Verification Test Procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the HVAC control system performs in accordance with the sequences of operation, and other contract documents.

An HVAC Control System Performance Verification Test Equipment List shall be included that lists the equipment to be used during Performance Verification Testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

SD-03 Product Data

General Equipment Requirements;
Electrical and Electronic Equipment;
Tubing;
Wiring;
Actuators;

Automatic Control Valves;
Dampers;
Smoke Detectors;
Instrumentation;
Thermostats;
Pressure Switches and Solenoid Valves;
Indicating Devices;
Control Devices and Accessories;
Compressed Air Stations;
Field Equipment Panel Hardware;
Field Equipment Panel Software;
Central Operator Workstation Human Machine Interface (HMI);
LAN Equipment;
Equipment Compliance Booklet;

The HVAC Control System Equipment Compliance Booklet (ECB) shall be in booklet form and indexed, with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a Bill of Materials for each HVAC Control System. The Bill of Materials shall function as the Table of Contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB. The ECB shall be submitted along with Submittal Description SD-02 Shop Drawings.

SD-06 Test Reports

Commissioning Report;

Six copies of the HVAC Control System Commissioning Report, in booklet form and indexed, within 30 days after completion of the system commissioning. The Commissioning Report shall include data collected during the HVAC Control System Commissioning Procedures and shall follow the format of the Commissioning Procedures. The Commissioning Report shall include all Configuration Checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, results of adjustments, and results of testing.

Performance Verification Test;

Six copies of the HVAC Control System Performance Verification Test Report, in booklet form and indexed, within 30 days after completion of the test. The HVAC Control System Performance Verification Test Report shall include data collected during the HVAC Control System Performance Verification Test. The original copies of all data

gathered during the Performance Verification Test shall be turned over to the Government after Government approval of the test results.

SD-07 Certificates

Air-Storage Tank;

Provide an ASME Air-Storage Tank Certificate for each air storage tank.

SD-10 Operation and Maintenance Data

Operation Manual;
Six copies of the HVAC Control System Operation Manual for each HVAC control system, in booklet form and indexed, 30 days before the date scheduled for the Training Course. The Operation Manual shall include the HVAC Control System Sequence of Operation, and Procedures for the HVAC System Start-up, Operation and Shut-down. The Operation Manual shall include all As-Built HVAC Control System Detail Drawings. The Operation Manual shall include the As-Built Configuration Checksheets, the Procedures for Changing HVAC Control System Setpoints, and the Procedures for Placing HVAC System Controllers in the Manual Control Mode.

The Procedures for Changing HVAC Control System Setpoints shall describe the step-by-step procedures required to change: the process variable setpoints, the alarm setpoints, the bias settings, and setpoint reset schedules.

The Procedures for Placing HVAC System Controllers in the Manual Control Mode shall describe step-by-step procedures required to obtain manual control of each controlled device and to manually adjust their positions.

Maintenance and Repair Manual;

Six copies of the HVAC Control System Maintenance and Repair Manual for each HVAC control system, in booklet form and indexed in hardback binders, 30 days before the date scheduled for the Training Course. The Maintenance and Repair Manual shall include the Routine Maintenance Checklist, a Recommended Repair Methods List, a List of Recommended Maintenance and Repair Tools, the Qualified Service Organization List, the As-Built Commissioning Procedures and Report, the As-Built Performance Verification Test Procedures and Report, and the As-Built Equipment Data Booklet. The Routine Maintenance Checklist shall be arranged in a columnar format. The first column shall list all devices listed in the Equipment Compliance Booklet, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

The Recommended Repair Methods List shall be arranged in a columnar format and shall list all devices in the Equipment Data Compliance Booklet and state the guidance on

recommended repair methods, either field repair, factory repair, or whole-item replacement.

The As-Built Equipment Data Booklet shall include the Equipment Compliance Booklet and all manufacturer supplied user manuals and information.

If the Operation Manual and the Maintenance and Repair Manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

SD-11 Closeout Submittals

Training;

An outline for the HVAC Control System Training Course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 30 days prior to the start of the training.

Six copies of HVAC Control System Training Course material 30 days prior to the scheduled start of the training course. The Training Course material shall include the Operation Manual, Maintenance and Repair Manual, and paper copies of overheads used in the course.

Service Personnel;

Six copies of a list of service organizations and personnel qualified to service the HVAC control system. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Posted and Panel Instructions;

Furnish posted and panel instructions in accordance with Part 3 paragraph BALANCING, COMMISSIONING, AND TESTING, subparagraph Posted and Panel Instructions.

1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage-condition limits published by the equipment manufacturer. Dampers shall be stored so that seal integrity, blade alignment and frame alignment are maintained.

1.5 FACTORY TESTING

1.5.1 General

The Contractor shall assemble the factory test DDC-PLC-PLC system as specified and perform test to demonstrate that the performance of the system satisfies the requirements of this specification. Model numbers of equipment tested shall be identical to those to be delivered to the site. Original copies of all data produced, including results of each test procedure during factory testing shall be delivered to the Government at the conclusion of testing, prior to Government approval of the test. The test results documentation shall be arranged so that all commands, responses, and data acquired are correlated in a manner which will allow for logical interpretation of the data.

1.5.2 Factory Test Setup

The factory test setup shall include the following:

a. Command Entry Device with Keyboard.

b. Printer.

c. Disk Storage.

d. PLC Panel.

e. PLC Panel Test Set.

f. PLC Panel Portable Tester.

g. VAV Box Controller.

h. VAV Box Communication and Programming Device.

i. Communication links of each type and speed including MODEMs.

j. Dial-up MODEM.

k. Software.

1.6 TRAINING

1.6.1 Training-Course Requirements

A training course shall be conducted for 3 operating staff members designated by the Contracting Officer in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of 16 hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and 6 sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15-minute

breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

1.6.2 Training-Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each system-control device external to the panels, the location of the compressed-air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of HVAC control-system performance by which to measure operation and maintenance effectiveness.

1.7 MAINTENANCE AND SERVICE

1.7.1 General Requirements

Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of 1 year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

1.7.2 Description of Work

The adjustment and repair of the system shall include the manufacturer's required adjustments of computer equipment, software updates, transmission equipment and instrumentation and control devices.

1.7.3 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

1.7.4 Scheduled Inspections

Two inspections shall be performed at 6-month intervals (or less if required by the manufacturer), and all work required shall be performed. Inspections shall be scheduled in June and December. These inspections shall include:

a. Visual checks and operational tests of all equipment.

b. Fan checks and filter changes for all control system equipment.

c. Clean all control system equipment including interior and exterior surfaces.

d. Check and calibrate each field device. Check and calibrate 50 percent of the total analog points during the first inspection. Check and calibrate the remaining 50 percent of the analog points during the second major inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Randomly check at least 25 percent of all digital points for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital points during the second inspection.

e. Run all system software diagnostics and correct all diagnosed problems.

f. Resolve any previous outstanding problems.

1.7.5 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding legal holidays.

1.7.6 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 24 hours after receiving a request for service. The control system shall be restored to proper operating condition within 3 calendar days after receiving a request for service.

1.7.7 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

1.7.8 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain all initial analog span and zero calibration values and all digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

1.7.9 Work Requests

Each service call request shall be recorded as received and shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

1.7.10 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

1.7.11 Software

Updates to the software shall be provided for system, operating and application software, and operation in the system shall be verified. Updates shall be incorporated into operations and maintenance manuals, and software documentation. There shall be at least one scheduled update near the end of the first year's warranty period, at which time the latest released version of the Contractor's software shall be installed and validated.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in a satisfactory commercial or industrial use for 2 years prior to use on this project. The 2 years' use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years' experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6,000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Automatic temperature controls shall be direct digital controls that will provide the required sequence of operation. No pneumatics will be allowed except for valve or damper actuators.

2.1.1 Electrical and Electronic Devices

Electrical, electronic, and electropneumatic devices not located within an DDC-PLC panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown.

2.1.2 Standard Signals

Except for air distribution terminal unit control equipment, the output of all analog transmitters and the analog input and output of all DDC-PLC panels shall be 4-to-20 mAdc or 0-to 10 vdc signals.

2.1.3 Ambient Temperature Limits

DDC-PLC panels shall have ambient condition ratings of 35 to 120 degrees F and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 35 to plus 150 degrees F. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

2.3 WIRING

2.3.1 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.3.2 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

2.3.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 600-volt service.

2.3.4 Instrumentation Cable

Instrumentation cable shall be 18 AWG, stranded copper, single- or multiple-twisted, minimum 2 inch lay of twist, 100 percent shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.3.5 Transformers

Step down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80 percent of the rated capacity or less. Transformers shall conform to UL 508 and NEMA ST 1.

2.4 ACTUATORS

2.4.1 General Requirements

Actuators shall be electronic of the bi-directional type, capable of delivering 150% of torque required. Actuator shall be provided with mounting and connecting hardware. Actuators shall be supplied with field selectable rotation direction collar design that allows for easy field adjustment of rotation angle and position indicator, manual override, electronic stall detection and output position feedback. All actuators shall be controlled with analog modulation using 0-10 VDC, 2-10VDC or 4-20 mA for control and feedback. Discrete, floating or pulse width modulation actuator control is not allowed.

Actuators shall fail to their spring return positions on signal or power failure. (Note: We normally do not use spring return actuators.) The actuator stroke shall be limited in the direction of power stroke by an adjustable stop. Actuators shall have a visible position indicator, readable from 20 feet. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 60 seconds or less. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric actuators used in a sequencing application shall have zero and span adjustments.

2.4.2 Damper Actuators

Damper actuators shall be provided with mounting and connecting hardware. Actuators shall smoothly operate the devices to which they are applied. Actuators shall fully open and close the devices to which they are applied and shall have a full stroke response time of 60 seconds or less. The actuator stroke shall be limited by an adjustable stop in the direction of power stroke.

2.4.2 Valve Actuators

Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

2.4.2 VAV Box Actuators

VAV boxes shall be supplied with a calibrated air volume sensing device, damper, combination controller/actuator, and accessory relays. Controller/actuator shall consist of a programmable PLC and electrical actuator mounted together on a single common base. PLC shall be supplied with a Modbus link enabling the main EMCS PLC to read and write data for both monitoring and remote control, and to include changing set points from the post UMCS Front End. Electrical actuator shall stroke the box damper from the full open position to the full closed position in less than 60 seconds.

2.5 AUTOMATIC CONTROL VALVES

Valves shall have stainless-steel stems and stuffing boxes with extended have globe style bodies. Valve bodies shall be designed for not less than 125 psig working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv. Unless otherwise specified, bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends; bodies for 2 inch valves shall have threaded ends; and bodies for valves 2 inches to 3 inches shall be of brass, bronze or iron. Bodies for valves 2-1/2 inches and larger shall be provided with flanged-end connections. Valve Cv shall be within 100 to 125 percent of the Cv shown.

2.5.1 Butterfly-Valve Assembly

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from minus 20 to plus 250 degrees F. Valves shall have a manual means of operation independent of the actuator. The rated Cv for butterfly valves shall be the valve Cv at 70% open (60 degrees open).

2.5.2 Two-Way Valves

Two-way modulating valves shall have equal-percentage characteristics.

2.5.3 Three-Way Valves

Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.

2.5.4 Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for terminal-unit coils. Flare nuts shall be furnished for each flare-type end valve.

2.5.5 Valves for Chilled-Water Service

Internal valve trim shall be bronze except that valve stems may be type 316 stainless steel. Valve Cv shall be within 100 percent to 125 percent of the Cv shown. Valves 4 inches and larger shall be butterfly.

2.5.6 Valves for Hot-Water Service

For hot water service below 250 degrees F service, internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than 210 degrees F shall be Type 316 stainless steel. Internal trim for valves controlling water 210 degrees F or less shall be brass or bronze. Nonmetallic parts of hot-water control valves shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher. Valves 4 inches and larger shall be butterfly valves.

2.6 DAMPERS

2.6.1 Damper Assembly

A single damper section shall have blades no longer than 48 inches and shall be no higher than 72 inches. Maximum damper blade width shall be 8 inches. Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 0.5 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 0.04 inch water gauge at 1,000 feet per minute in the wide-open position. Frames shall not be less than 2 inches in width. Dampers shall be tested in accordance with AMCA 500.

2.6.2 Operating Links

Operating links external to dampers, such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least twice the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

2.6.3 Damper Types

Dampers shall be parallel-blade type.

2.6.3.1 Outside Air, Return Air, and Relief Air Dampers

Outside air, return air and relief air dampers shall be provided where shown. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Dampers shall not leak in excess of 20 cfm per square foot 4 inches water gauge static pressure when closed. Seals shall be suitable for an operating temperature range of minus 40 to plus 200 degrees F. Dampers shall be rated at not less than 2,000 feet per minute air velocity.

2.6.3.2 Mechanical and Electrical Space Ventilation Dampers

Mechanical and electrical spare ventilation dampers shall be as shown. Dampers shall not leak in excess of 80 cfm square foot at 4 inches water gauge static pressure when closed. Dampers shall be rated at not less than 1,500 feet per minute air velocity.

2.6.3.3 Smoke Dampers

Smoke-damper and actuator assembly required per NFPA 90A shall meet the Class II leakage requirements of UL 555S. Dampers shall be rated at not less than 2000 fpm air velocity.

2.6.4 Damper End Switches

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.7 SMOKE DETECTORS

Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A. Duct smoke detectors shall conform to the requirements of UL 268A. Duct smoke detectors shall have perforated sampling tubes extended into the air duct. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. Detectors shall have manual reset. Detectors shall be rated for air velocities that include air flows between 500 and 4000 fpm. Detectors shall be powered from the HVAC control panel. Detectors shall have two sets of normally open alarm contacts and two sets of normally closed alarm contacts. Detectors shall be connected to the building fire alarm panel for alarm initiation. A remote annunciation lamp and accessible remote reset switch shall be provided for duct detectors that are mounted 8 feet or more above the finished floor and for detectors that are not readily visible. Remote lamps and switches as well as the affected fan unit(s) shall be properly identified in etched rigid plastic placards.

2.8 INSTRUMENTATION

2.8.1 Measurements

Transmitters shall be calibrated to provide the following measurements, over the indicated ranges, for an output of 4 to 20 mAdc or 0 to 10 vdc:

a. Conditioned space temperature, from 50 to 85 degrees F.

b. Duct temperature, from 40 to 140 degrees F except that return-air temperature for economizer operation shall be minus 30 to plus 130 degrees F.

c. Not used.

d. Chilled-water temperature, from 30 to 100 degrees F.

e. Not used.

f. Heating hot-water temperature, from 100 to 250 degrees F.

g. Not used.

h. Outside-air temperature, from minus 30 to 130 degrees F.

i. Relative humidity, 0 to 100 percent for space and duct high-limit applications.

j. Differential pressure for VAV supply-duct static pressure from 0 to 2.5 inches water gauge.

k. Pitot-tube air-flow measurement station and transmitter, from 0 to 0.1 inch water gauge for flow velocities of 700 to 1200 fpm, 0 to 0.25 inch water gauge for velocities of 700 to 1800 fpm, or 0 to 0.5 inch water gauge for velocities of 700 to 2500 fpm.

l. Electronic air-flow measurement station and transmitter, from 125 to 2500 fpm.

2.8.2 Temperature Instruments

2.8.2.1 Resistance Temperature Detectors (RTD)

Temperature sensors shall be 100 ohms 3- or 4-wire RTD. Each RTD shall be platinum with a tolerance of plus or minus 0.1 percent at 32 degrees F, and shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper. Each RTD shall be furnished with an RTD transmitter as specified, integrally mounted unless otherwise shown.

2.8.2.2 Continuous Averaging RTD

Continuous averaging RTDs shall have a tolerance of plus or minus 1.0 degree F at the reference temperature, and shall be of sufficient length to ensure that the resistance represents an average over the cross section in which it is installed. The sensing element

shall have a bendable copper sheath. Each averaging RTD shall be furnished with an RTD transmitter to match the resistance range of the averaging RTD.

2.8.2.3 RTD Transmitter

The RTD transmitter shall match the resistance range of the RTD. The transmitter shall be a 2-wire, loop powered device. The transmitter shall produce a linear 4-to-20 mAdc or 0 to 10 vdc output corresponding to the required temperature measurement. The output error shall not exceed 0.1 percent of the calibrated measurement.

2.8.3 Relative Humidity Instruments

A relative-humidity instrument for indoor application shall have a measurement range from 0 to 100 percent relative-humidity and be rated for operation at ambient air temperatures within the range of 25 to 130 degrees F. It shall be capable of being exposed to a condensing air stream (100 percent RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The instrument shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Instruments used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted instruments shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The instrument (sensing element and transmitter) shall be a two-wire, loop-powered device and shall have an accuracy of plus or minus 3 percent of full scale within the range of 20 to 80 percent relative humidity. The instrument shall have a typical long-term stability of 1 percent or less drift per year. The transmitter shall convert the sensing element's output to a linear 4-to-20 mAdc or 0-to-10 Vdc output signal in proportion to the measured relative-humidity value. The transmitter shall include offset and span adjustments.

2.8.5 Pitot Tube Airflow Measurement Stations and Transmitters

2.8.5.1 Stations

Each station shall contain an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 0.08 inch water gauge at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflows of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus 3 percent over a range of 500 to 2,500 fpm. This device will not be used if the required velocity measurement is below 700 fpm or for outside airflow measurements.

2.8.5.2 Transmitters

Each transmitter shall produce a linear 4-to-20 mAdc or 0-to10Vdc output corresponding to the required velocity pressure measurement. Each transmitter shall have a low range differential pressure sensing element. The transmitter shall be a 2-wire, loop powered device. Sensing element accuracy shall be plus or minus 1 percent of full scale, and overall transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement.

2.8.6 Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus 2 percent of full scale. The transmitter shall be a two-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc or 0-to-10 Vdc output corresponding to the required pressure measurement.

2.8.7 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 2 inch lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

2.8.8 Sunshields

Sunshields for outside air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshields shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The top of each sunshield shall have a galvanized metal rainshield projecting over the face of the sunshield. The sunshields shall be painted white.

2.9 THERMOSTATS AND MULTIFUNCTION DEVICES

2.9.1 General

Thermostat ranges shall be selected so that the setpoint is adjustable between plus or minus 10 degrees F of the setpoint shown. Thermostats shall be electronic or electric. Multifunction devices are products that combine the functions of sensor and user input or output devices into a single product.

2.9.2 Nonmodulating Room Thermostats

Contacts shall be single-pole double-throw (SPDT), hermetically sealed, and wired to identified terminals. Maximum differential shall be 5 degrees F. Room thermostats shall be enclosed with separate locking covers (guards).

2.9.3 Microprocessor Based Room Thermostats

Microprocessor based thermostats shall have built-in keypads for scheduling of day and night temperature settings. Access to the scheduling mode shall be by a password control code. When out of the scheduling mode, thermostats shall have continuous display of time, with AM and PM indicator, continuous display of day of week, and either continuous display of room temperature with display of temperature setpoint on demand, or continuous display of temperature setpoint with display of room temperature on demand. In the programmable mode, the display shall be used for interrogating time program ON-OFF setpoints for all 7 days of the week. The time program shall allow two separate temperature setback intervals per day. The thermostats shall have a means for temporary and manual override of the program schedule, with automatic program restoration on the following day. Thermostats shall have a replaceable battery to maintain the timing and maintain the schedule in memory for 1 year in the event of a power outage. Maximum differential shall be 2 degrees F. When used for heat pump applications, the thermostat shall have an emergency heat switch.

2.9.4 VAV Terminal Unit Space Sensor & User Interface

Each VAV Terminal unit shall have a multifunction device located within the controlled space as indicated. Each multifunction device (indicate by the symbol "T" on the drawings) shall have a space temperature sensor and a user interface set point adjust mechanism. The set point adjust may be a rotating knob, slide bar, or increase decrease buttons. The multifunction device shall also have an LED or LCD display indicating current space temperature and shall change to display current setpoint when user makes an input to the setpoint adjust mechanism. Where indicated, the device shall be enclosed with separate locking cover (guard).

2.9.5 Nonmodulating Capillary Thermostats and Aquastats

Each thermostat shall have a capillary length of at least 5 feet, shall have adjustable direct-reading scales for both setpoint and differential, and shall have a differential adjustable from 6 to 16 degrees F. Aquastats shall be of the strap on type, with 10 degrees F fixed differential.

2.9.6 Freezestats

Freezestats shall be manual reset, low temperature safety thermostats, with NO and NC contacts and a 20 foot element which shall respond to the coldest 18 inch segment.

2.10 PRESSURE SWITCHES AND SOLENOID VALVES

2.10.1 Pressure Switches

Each switch shall have an adjustable setpoint with visible setpoint scale. Range shall be as shown. Differential adjustment shall span 20 to 40 percent of the range of the device.

2.10.2 Differential-Pressure Switches

Each switch shall be an adjustable diaphragm-operated device with two SPDT contacts, with taps for sensing lines to be connected to duct pressure fittings designed to sense air pressure. These fittings shall be of the angled-tip type with tips pointing into the air stream. The setpoint shall not be in the upper or lower quarters of the range and the range shall not be more than three times the setpoint. Differential shall be a maximum of 0.15 inch water gauge at the low end of the range and 0.35 inch water gauge at the high end of the range.

2.11 INDICATING DEVICES

2.11.1 Thermometers

2.11.1.1 Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9-inch scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern.

2.11.1.2 Piping System Thermometer Stems

Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.11.1.3 Nonaveraging Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.11.1.4 Averaging Air-Duct Thermometers

Averaging thermometers shall have a 3-1/2 inch (nominal) dial, with black legend on white background, and pointer traveling through a 270-degree arc.

2.11.1.5 Accuracy

Thermometers shall have an accuracy of plus or minus 1 percent of scale range. Thermometers shall have a range suitable for the application.

2.11.2 Pressure Gauges

Gauges shall be 2 inch (nominal) size, back connected, suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Accuracy shall be plus or minus 3 percent of scale range. Gauges shall meet requirements of ASME B40.1.

2.11.2.3 Hydronic-System Gauges

Gauges for hydronic-system applications shall have ranges and graduations as shown.

2.11.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauges shall have ranges and graduations as shown. Accuracy shall be plus or minus 2 percent of scale range.

2.12 CONTROL DEVICES AND ACCESSORIES

2.12.1 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts (two normally open, two normally closed) enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage. Time delay relays shall be 2PDT with 8-pin connectors, dust cover, and a matching rail-mounted socket. Adjustable timing range shall be 0 to 5 minutes. Power consumption shall not be greater than 3 watts.

2.11.2 Occupancy Sensors

Occupancy sensors shall have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes. Occupancy sensors shall be rated for operation in ambient air temperatures ranging from 50 degreesF to 104 degreesF or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches shall have an auto-off switch. Wall switch sensors shall be decorator style and shall fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs shall be UL listed.

In addition to any outputs required for lighting control, the occupancy sensor shall provide a contact output rated at 1A at 24 Vac or a SNVT output.

2.11.2.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors shall have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 6 meters (20 feet) unless otherwise shown or specified. PIR Sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors shall be immune to false triggering from RFI and EMI.

2.11.6 Current Sensing Relays

Current sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

2.12.3 Watthour Meters

Watthour meters shall be in accordance with ANSI C12.1 and shall have pulse initiators for remote monitoring of watthour consumption. Pulse initiators shall consist of contacts (one normally open, one normally closed) with a current rating not to exceed 2 amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Pulse initiator contacts shall be connected to a terminal strip external to the meter enclosure. Meter sockets shall be in accordance with ANSI C12.1.

2.12.4 Watthour Transducers

Watthour transducers shall have an accuracy of plus or minus 0.25 percent of full scale for kW and kWh outputs from full lag to full lead power factor. Input ranges for kW and kWh transducers shall be selectable without requiring the changing of current or potential transformers. The output shall be 4 to 20 mAdc.

2.12.5 Power-Line Conditioners

Power line conditioners shall be furnished for each DDC-PLC panel. The Power line conditioners shall provide both voltage regulation and noise rejection. The Power line conditioner shall be of the ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power-line side. The power line conditioners shall be sized for 125 percent of the actual connected kVA load. Characteristics of the PLC shall be as follows:

a. At 85 percent load, the output voltage shall not deviate by more than plus or minus 1 percent of nominal when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

b. During load changes of zero to full load, the output voltage shall not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances shall be accomplished within 5 cycles, and 95 percent correction shall be accomplished within 2 cycles of the onset of the disturbance.

c. Total harmonic distortion shall not exceed 3-1/2 percent at full load.

2.14 FIELD EQUIPMENT PANEL HARDWARE

2.14.1 General

All Field Equipment Panels shall be based upon Programmable Logic Controllers (PLCs). PLCs shall be commercially available, off-the-shelf offerings of multiple vendors. Acceptable PLC offerings shall have a family of PLC processors to cover the requirements from very large applications (eg, Central Plant, major equipment room, etc.) to very small applications (eg, a single VAV box). The PLCs shall be compatible with the IEC 1131-3 programming standard. All functions, constraints, database information, operator developed programs and any other data shall be downloadable from a central work station/tester through the primary network to Field Equipment Panels. The PLC family must be such that the top end PLCs share features with the low end PLCs. Similar features shall include common language features, similar programming look/feel, common coprocessor language, coprocessor programming support, communications protocols, common operator interface and common I/O circuits.

2.14.1 Operator Interfaces

Control panels shall be provided with operator interfaces mounted on front of control panel. Each building shall have a central control panel that will have as a minimum a 10.5" Ethernet Capable Color touchscreen. This screen will have a program that allows monitoring and control of all EMCS devices located in the building. All AHU panels shall have as a minimum a 5" Ethernet Capable Monochrome touchscreen. The AHU interface will have a program that will allow monitoring and control of the local AHU and all associated zones. Small devices such as Water Source Heat Pumps and VAV boxes do not require individual operator interfaces.

2.13.3 Large Memory Modular Controller Hardware

Large memory modular controllers shall be used in applications with high I/O counts and/or large buildings where the HVAC system is spread over a large area. Large memory modular controllers shall consist of a local or remote backplane upon which shall be mounted the processor, power supply, and I/O cards. All communication between the PLC and local I/O cards takes place over a communication bus integral to the backplane. Remote backplanes will talk to the PLC over a remote I/O network.

2.13.4 2.12.3 Small Memory Controller Hardware

Small memory controller hardware shall be used on applications with small I/O counts that are clustered in a local area. Examples are indivual AHU control and VAV boxes. I/O shall be "brick" type with capability to expand via a remote network. I/O supplied at device shall be enough to do designed control plus 25% spares.

2.13.4.1 VAV Controller Hardware

A small memory controller will be used in VAV control applications. A PLC will be dedicated to each VAV controller. Pressure transmitter will be used to calculate velocity pressure which PLC will use to calculate flow. PLC will calculate required CFM based on space needs. PLC will adjust VAV damper to maintain CFM setpoint. A temperature sensor will monitor discharge air of VAV.

2.13.5 Modular Controller I/O Types

Modular I/O cards shall support the following I/O types:

Discrete:
110 VAC Inputs
24 VDC Inputs
24 VAC Inputs
110 VAC Triac Outputs
24 VDC Outputs
24 VAC Outputs
Relayed Outputs

Analog:
100 Ohm Platinum RTD Inputs
0-10 VDC Input
2-10 VDC Input
4-20 mA Input
0-10 VDC Output
2-10VDC Output
4-20 mA Output

Analog I/O shall have 12 bit resolution as a minimum. Large memory modular controller shall have a real time clock and calendar integral to the controller. The large memory modular controller shall support the use of floating point math and PID control.

2.13.6 Modular Controller Programming Software

Large and Small controller programming software must be capable of programming all controllers. A separate programming package for Large and Small controllers is not allowed. Programming software shall allow for discrete I/O to be disabled and forced to a

ON or OFF state. Programming software must be able to display and write to analog registers in integer, long integer, floating point and ASCII formats. Programming software must allow for on-line programming and documentation of logic elements. Software shall allow printing of logic, comments, logic elements used and element use cross reference. Large memory modular controllers shall fully support IEC 1131.3 programming software. This shall include as a minimum the following modules of IEC 1131.3:

Ladder Diagram
Function Block Diagram
Structured Text
Instruction List
Sequential Function Charts

#.1 Modular Controller Communications

Modular PLC controller shall have a minimum of two communication ports integral to the processor. These ports shall facilitate a serial link between the PLC and other parts of the building HVAC control system. At least one of the ports shall be capable of supporting the Modbus serial and/or Modbus/TCP Ethernet protocol.

#.1 Modular Controller I/O Expandability

The controller shall be expandable from its basic configuration to handle additional I/O points. This may be accomplished by adding additional backplanes. The controller shall also support I/O expansion by use of remote I/O drops.

#.1 Connection to Base EMCS

The PLC shall directly connect to an Ethernet TCP/IP network. This shall allow the PLC to be connected to a postwide fiber-optic system. Controller connection to Base EMCS will support Modbus/TCP protocol.

#.1 Control Panel Items

All control panels shall contain the following:

-Isolation circuit breaker to kill all panel and field devices
-Duplex receptacle
-TSS (Transient Surge Suppression)
- Uninterruptible Power Supply (UPS) for Main Panel Only
-Individual fusing on all discrete outputs and/or interposing relays
-Fuse holders that allow individual disconnect of all discrete outputs
-Wiring management system (conduit, wire trays, etc.)
-PLC and terminal blocks DIN rail mounted

#.1 Control Panel Terminals

All discrete and analog I/O shall be wired from PLC to terminal blocks located in the panel. Field I/O shall be landed on these terminal blocks during installation.

#.1 Control Panel Wiring

Discrete wire color in the control panel shall follow these guidelines:

-Black = 110 VAC Hot
-White = 110 VAC Neutral
-Red = 110 VAC Control
-Dark Blue = 24 VDC+
-Gray = 24 VDC-
-Light Blue = 24 VDC Control
-Orange = 24 VAC Hot
-Yellow = 24 VAC Neutral

All analog wiring (in panel and field) shall be shielded, twisted pair. All analog I/O shall have shields grounded at the terminal blocks of the control panel. When available in field devices, analog control signals shall be 4-20 mA. If 4-20 mA is not available, then use 0-10 VDC.

#.1 Modular Controller Programming

Modular controller programming shall follow current logic and alarming guidelines as supplied by the contracting officer. The purpose of these guidelines are to provide a uniform method of programming and alarming among vendors and contractors. These guidelines are periodically reviewed and updated as new HVAC hardware and methods are implemented.

#.1 I/O Functions

General

Field Equipment Panel I/O functions shall be defined as functionally part of the PLC, and communicate over a dedicated communication circuit. When remotely located, I/O functions shall be subject to the same requirements as for the PLC. The controller CPU and Input/Output system shall both be of a modular design using plug-in assemblies. The PLC offering shall have at least two different sized mounting racks available for each type of FIELD EQUIPMENT PANEL. In order to minimize spare parts stocking requirements, the controller family shall have a high degree of interchangeability. The

system design shall accommodate the replacement of I/O modules without having to disconnect field wiring.

#.1 The Analog Input (AI) function

The AI function shall monitor each analog input, perform A to D conversion, and hold the digital value in a buffer for interrogation. The A to D conversion shall have a minimum resolution of 12 bits. All Analog Inputs shall be individually calibrated for zero and full scale. Conversion to engineering units will be accomplished by PLC logic. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms. Input signals shall be within the range of 4-20 mA or 0-10 VDC.

#.1 The Analog Output (AO) function

The AO function shall accept digital data, perform D to A conversion, and output a signal within the range of 4-20 mA or 0-10VDC. D to A conversion shall have a minimum resolution of 12 bits. All Analog Outputs shall be individually calibrated for zero and full scale. Short circuit protection on voltage outputs and open circuit protection on current outputs shall be provided.

#.1 The Digital Input (DI) Function

The DI function shall accept on off, open close, or other change of state (two state data) indications. Isolation and protection against an applied steady state voltage up to 180 VAC peak shall be provided.

#.1 The Digital Output (DO) function

The DO function shall provide contact closures for momentary and maintained operation of output devices. Closures shall have a minimum duration of 0.1 second. DO relays shall have a breakdown voltage between contacts and coil of at least 500 volt peak. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to non-damaging levels. Protection against an applied steady state voltage up to 180 VAC peak shall be provided. Minimum contact rating shall be 1 ampere at 24 VAC. HOA switches shall be provided for manual override of each digital output. Feedback shall be provided to the system as to the status of the override switch.

#.1 The Pulse Accumulator (PA) Function

The PA function shall have the same characteristic as the DI, except that a buffer shall be provided to totalize pulses and allow for interrogation by the system. The PA shall accept rates up to 20 pulses per second. The accumulator points shall totalize pulses received from dry contacts. A sensing voltage shall be supplied from the Field

Equipment Panel. Accumulator points shall accept Form C contacts (both the "Y" and "Z" contacts kilowatt-hour meter KYZ contacts shall be monitored) and Form "A" or "B" contact inputs. Each PA shall totalize a count of up to 65,536, and shall be able to be read at any time without loss of input data. When each PA reaches its maximum value, it shall automatically reset to zero, and begin counting pulses again. The totalized value shall be reset to zero upon operator's command.

#.1 The Binary Coded Decimal (BCD) Function

The BCD function shall have the same characteristic as the DI, except that, in addition, the Basic Process Controller shall provide a buffer to totalize inputs and allow for interrogation. The BCD function shall have 16-channel optically isolated buffered inputs to read four digit numbers. The BCD function shall accumulate inputs at rates up to 20 inputs per second.

#.1 Failure Mode

Upon failure of the I/O function, including data transmission failure, logic power supply failure, FIELD EQUIPMENT PANEL processor malfunction, software failure, interposing relay power failure, or any other failure which prevents stand alone operation of any FIELD EQUIPMENT PANEL normally capable of stand alone operation, connected outputs shall be forced to the failure mode shown.

#.1 Central Workstation/Tester

A central workstation/tester shall be provided and shall be able to communicate with any network control panel via the primary network. The central workstation/tester shall consist of a central computer with a nominal 14 inch VGA color display, capable of displaying up to 256 colors at a minimum resolution of 640 X 480 pixels, 64 bit data bus and 32 bit architecture microprocessor operating at a minimum of 100 MHz. The central workstation/tester shall have, as a minimum, a 2100 MB hard drive, 32 megabytes of memory, integral pointing device, serial and parallel ports, color VGA video port for an external color monitor, 3.5 inch floppy disk drive, modem, PCMCIA Type 3 slot, rechargeable battery, battery charger and 120 VAC power supply and network adapter (Ethernet IEEE 802.3). A printer shall be provided for the central workstation/tester. The central workstation/tester shall:

a) Run Field Equipment Panel diagnostics.
b) Load all Field Equipment Panel memory resident programs and information, including parameters and constraints.
c) Display any AI, DI, or PA input in engineering units.
d) Control any AO or DO.
e) Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object oriented graphical user interface.
f) Display database parameters.

g) Modify database parameters.

h) Accept Field Equipment Panel software from a 3.5 inch floppy disk and information via an EIA 232 E port at the Central Station computers provided, for subsequent loading into a specific Field Equipment Panel. Provide all necessary software and hardware required to support this function.
i) Disable/enable each Field Equipment Panel.
j) Perform all workstation functions as specified.

#.1 Printer

A printer shall be provided for use with the central workstation/tester. The printer shall have a minimum 96 character standard ASCII character set. It shall have adjustable sprockets for paper width up to 241 mm (9.5 inches) and a friction feed for paper width up to 216 mm (8.5 inches), and shall print at least 80 columns per line. The printer shall have a minimum speed of 150 characters per second in utility mode (draft quality) and 32 characters per second in near letter quality mode. Print mode shall be switch or software selectable. The minimum character spacing shall be 10 characters per inch and 3 to 8 lines per inch. The printer shall utilize standard form size, sprocket fed fanfold paper. The unit shall have programmable control of top of form and variable line skip capability.

#.1 Wire and Labeling

#.1 Wire and Cable

Wire and cable jacket material shall be flame retardant PVC, or floropolymer as required for the application per NFPA 70. Multi-conductor cable shall have an outer jacket. Wire and cable not indicated as GFE shall be provided.

#.1 Control Wiring

a) Digital Functions: Control wiring for digital functions shall be 18 AWG minimum with 600 volt insulation.

b) Analog Functions: Control wiring for analog functions shall be 18 AWG minimum with 600 volt insulation, twisted and each pair shielded, 2, 3, or 4 wire to match analog function hardware.

#.1 Sensor Wiring

Sensor wiring shall be 20 AWG minimum twisted and shielded, 2, 3, or 4 wire to match analog function hardware.

#.1 Terminal Blocks

Terminal blocks shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

#.1 Transformer

Step-down transformer shall be utilized where control equipment operates at lower than line circuit voltage. Transformer, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformer shall be sized so that the connected load is 80 % of the rated capacity or less.

#.1 Non-conducting Wiring Duct

Non-conducting wiring duct in control panels shall have slotted sides, snap-on duct covers, fittings for connecting ducts, mounting clips for securing ducts, and wire-retaining clips.

2.15 FIELD EQUIPMENT PANEL SOFTWARE

Field Equipment Panel software shall consist of inherent, PLC application software, and Field Equipment Panel resident application programs.

2.15.1 Inherent Software

The Contractor shall provide inherent software for all Field Equipment Panel to perform the following functions.

2.15.1.1 Operating System

Each Field Equipment Panel shall contain an operating system that controls and schedules that Field Equipment Panel's activities in real time. The Field Equipment Panel shall maintain a point database in its memory that includes all parameters, constraints, and the latest value or status of all points connected to that Field Equipment Panel. The execution of Field Equipment Panel application programs shall utilize the data in memory resident files. The operating system shall include a real time clock function that maintains the seconds, minutes, hours, date and month, including day of the week. Each Field Equipment Panel with a real time clock shall be automatically synchronized with the system's real time clock at least once per day to plus or minus 10 seconds. The time synchronization shall be accomplished without operator intervention and without requiring system shutdown. The operating system shall allow both local and remote (from the primary network) loading of software and data files from the Portable Tester/Workstation or central station HMI. It shall also support data entry and diagnostics.

2.15.1.2 Startup

The Field Equipment Panel shall have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A Field Equipment Panel restart program based on detection of power failure at the Field Equipment Panel shall be included in the Field Equipment Panel software. Upon restoration of power to the Field Equipment Panel, the program shall restart equipment and restore loads to the state at time of power failure, or to the state as commanded by time programs or other overriding programs. The restart program shall include start time delays between successive commands to prevent demand surges or overload trips. The startup software shall initiate operation of self-test diagnostic routines. Upon failure of the Field Equipment Panel, if the database and application software are no longer resident or if the clock cannot be read, the Field Equipment Panel shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made. If the database and application programs are resident, the Field Equipment Panel shall resume operation after an adjustable time delay of from 0 to 600 seconds. The startup sequence for each Field Equipment Panel shall include a unique time delay setting for each control output when system operation is initiated.

2.15.1.3 Operating Mode

Each Field Equipment Panel shall control and monitor functions as specified, independent of communications with the Primary Network. This software shall perform all Field Equipment Panel functions and Field Equipment Panel resident application programs as specified using data obtained from I/O functions and based upon the Field Equipment Panel real time clock function. When communications circuits between the Field Equipment Panel and the Primary Network are operable, the Field Equipment Panel shall obtain real time clock updates and any required global data values transmitted from the Primary Network. The Field Equipment Panel software shall execute commands after performing constraints checks in the Field Equipment Panel. Status and analog values, including alarms and other data shall be transmitted to the Central Station/tester via the Primary Network when communications circuits are operable. If communications are not available, each Field Equipment Panel shall function in stand-alone mode and operational data, including the latest status and value of each point and results of calculations, normally transmitted to the Master HMI shall be stored for later transmission to the central station/tester. Storage for the latest 1024 values shall be provided at each PLC. Each Field Equipment Panel shall accept software downloaded from a Central Station/tester.

2.15.1.4 Failure Mode

Upon failure for any reason, each Field Equipment Panel shall perform an orderly shutdown and force all Field Equipment Panel outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device.

2.15.2 Resident Application Programs

The Contractor shall provide all software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within each PLC. The Contractor shall adhere to IEC 1131-3 compliant programming enviroment.

2.15.2.1 General Functions

a. List of General Functions

(1) Scanning of inputs.

(2) Control of outputs.

(3) Reporting of analog changes outside a selectable differential.

(4) Reporting of unauthorized digital status.

(5) Reporting of alarms automatically to Central Station.

(6) Reporting of I/O status to Central Station upon request.

(7) Maintenance of real time, updated by the Central Station at least once a day.

(8) Communication with Central Station/tester via primary network, secondary network, and serial ports.

(9) Execution of Field Equipment Panel resident application programs.

(10) Averaging or filtering of all AIs.

(11) Constraints checks (prior to command issuance).

(12) Diagnostics.

(13) Reset of PA by operator based on time and value.

(14) PI Control: This function shall provide proportional control and proportional plus integral control.

(15) Two Position Control: This function shall provide control for a two state device by comparing a set point against a process variable and an established deadband.

(16) Floating Point Control: This function shall exercise control when an error signal exceeds a selected deadband, and shall maintain control until the error is within the deadband limits.

(17) Signal Selection: This function shall allow the selection of the highest or lowest analog value from a group of analog values as the basis of control. The function shall include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two
outputs.

(18) Signal Averaging: This function shall allow the mathematical calculation of the average analog value from a group of analog values as the basis of control. The function shall include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control.

(19) Reset Function: This function shall develop an AO based on up to two AIs and one operator specified reset schedule.

(20) Ventilation Delay Mode shall occur one hour prior to the start of the Occupied Mode.

(21) Unoccupied Mode shall take place between the Occupied Mode and the Ventilation Delay Mode.

a. Analog Monitoring

The system shall measure and transmit all analog values including calculated analog points. An analog change in value is defined as a change 1% of scale. The record transmitted for each analog value shall include a readily identifiable flag which indicates the abnormal status of the value when it deviates from operator selectable upper and lower analog limits. Analog values shall be expressed in proper engineering units with sign. Engineering units conversions shall be provided for each measurement. Each engineering units conversion set shall include range, span, and conversion equation. A vocabulary of engineering unit descriptors shall be provided, using at least three alphanumeric characters to identify information in the system.

b. Logic (Virtual) Points

Logic (virtual) points shall be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points shall be analog or digital points created by calculation from any combination of digital and analog points, or other data having all the properties of real points, including alarms, without the associated hardware. Logic (virtual) points shall be defined or calculated and entered into the database by the Contractor. The calculated analog point shall have point identification in the same format as any other analog point. The calculated point shall be used in any program where the real value is not obtainable directly. Constants used in calculations shall be changeable on-line by the operator. Calculated point values shall be current for use by the system within 10 seconds of the time of any input changes.

c. State Variables

Analog variables, real or virtual, which represent more than two (up to 8) specific states, each state shall have an assignable name for each state.

d. Alarm Processing

Each Field Equipment Panel shall have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that Field Equipment Panel.

e. Digital Alarms Definition

Digital alarms are those abnormal conditions indicated by DIs as specified and shown.

f. Analog Alarms Definition

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings shall be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits shall be assigned to each analog point in the system. Each analog alarm limit shall have an associated unique limit differential specifying the amount by which a variable must return into the proper operating range before being enunciated as a return-to-normal-state. All limits and differentials shall be entered online by the operator in units of the measured variable, without interruption or loss of monitoring of the point concerned. The program shall automatically change the high or low limits or both, of any analog point, based on sensed values, schedules, or mode of operation, allowing for a time interval before the alarm limit becomes effective.

g. Not Used

h. Constraints

All control devices connected to the system shall have the Field Equipment Panel memory resident constraints checked before each command is issued to insure that no equipment damage will result from improper operation. Each command shall be executed by the Field Equipment Panel only after all constraints checks have been passed. Each command point shall have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value shall be assigned to each AI. Values outside the reasonableness limits shall be rejected and an alarm message sent to the Central Station. Status changes and analog point values shall be reported to the workstation upon operator request, such as for reports, alphanumeric displays, graphic displays, and application programs. Each individual point shall be capable of being selectively disabled by the operator from the workstation. Disabling a point shall prohibit alarming of that point. Each control point in the database shall have Field Equipment Panel resident constraints defined and entered by the Contractor, including as applicable:

(1) Maximum starts (cycles) per hour.

(2) Minimum off time.

(3) Minimum on time.

(4) High limit (value in engineering units).

(5) Low limit (value in engineering units).

i. Diagnostics

Each Field Equipment Panel shall have self-test diagnostic routines implemented in firmware. The tests shall include routines that exercise memory. Diagnostic software shall be usable in conjunction with the portable tester/workstation. The software shall display messages in English to inform the tester's operator of diagnosed problems.

2.15.2.2 Control Sequences and Control Loops

The Contractor shall provide resident applications programs developed in accordance with IEC 1131-3 to achieve the sequences of operation, parameters, constraints, and interlocks shown. Application software shall be resident in the Field Equipment Panel in addition to any other required software.

Specific functions to be implemented are defined in individual system control sequences and database tables shown in the drawings, and shall include, as applicable, the following:

a. Economizer Program

The software shall reduce the HVAC system cooling requirements when the OA dry bulb temperature is less than the return air temperature and the system is in cooling mode. When the OA dry bulb temperature is above the return air temperature or changeover setpoint, the OA dampers, return air dampers, and relief air dampers shall be positioned to provide minimum required OA. When the OA dry bulb temperature is below a changeover setpoint temperature (Return air temperature minus deadband) and the air handler is in cooling mode, the OA dampers, return air dampers, and exhaust air dampers shall be modulated by the PID algorithm to maintain the required mixed air temperature. A deadband shall be incorporated to prevent cycling of the economizer.

(1) Program Input

(a) Changeover conditions.
(b) OA dry bulb temperature.
(c) Return air dry bulb temperature.

(d) Mixed air dry bulb temperature.
(e) Maximum allowable OA air dry bulb temperature.
(f) Equipment constraints.

(2) Program Output: Damper actuator/cooling control signal.

b. Ventilation-Recirculation Program

The software shall provide the ability to reduce the HVAC system thermal load during both warm-up and cool-down cycles prior to occupancy of the building and during day/night setback operations.

(1) Ventilation mode: In this mode, the system shall use 100% outside air to cool (heat) the space prior to building occupancy and during day/night setback operations. When the outside air temperature is lower (higher) than the space temperature, the outside air damper and exhaust air damper shall open to their maximum positions and the return air damper shall close to its minimum position. The outside air damper and the exhaust (relief) air damper shall be closed at all other times during unoccupied periods.

(2) Recirculation mode: In this mode, the system shall cool (heat) the space prior to building occupancy and during day/night setback operations. When the outside air temperature is higher (lower) than the space temperature, the outside air damper and the exhaust air damper shall close to their minimum positions and the return air damper shall open to its maximum position. The outside air damper and the exhaust air damper shall be closed at all other times during unoccupied periods.

(3) Not Used.

(4) Program Inputs

(a) Day of week.
(b) Time of day.
(c) Outside air temperature.
(d) Equipment status.
(e) Cooling or heating mode operation.
(f) Cooling or heating occupancy schedule (fixed or calculated).
(g) Space temperature.
(h) Equipment constraints.

(5) Program Output

(a) Damper actuator control signal.
(b) Heating valve actuator control signal.
(c) Cooling valve actuator control signal.

c. Day-Night Setback Program

The Day-Night Setback program shall limit the drop of space temperature during unoccupied hours. Whenever the space temperature below the operator assigned temperature limit, the system shall be turned on until the temperature is within the assigned temperature limit. The outside air damper and the exhaust air damper shall remain closed.

(1) Program Inputs:

(a) Day of week.

(b) Time of day.

(c) Cooling or heating mode of operation.

(d) Cooling and heating occupancy schedules.

(e) Equipment status.

(f) Space temperature (or specified fluid temperature).

(g) Minimum space temperature (or specified fluid temperature) during unoccupied periods.

(h) Maximum space temperature (or specified fluid temperature) during unoccupied periods.

(i) Equipment constraints.

(2) Program Outputs: Start/stop signal.

(3) Command Priority: The Night Setback program shall override all command priorities except operator initiated. Night Setback shall function at all times that the system is determined to be in Unoccupied Mode.

d. Operator Initiated Start/Stop

The resident application shall perform a start stop command when it is requested from an authorized logon at an HMI. This shall have the highest (Level 1) priority.

2.15.2.3 Language Support

The software development environment shall Sequential Function Chart programing according to IEC 1131-3.

2.15.2.4 Program Inputs and Outputs

The Contractor shall use program inputs listed for each application program to calculate the required program outputs. All program inputs shall be provided and entered by the contractor. Program outputs shall be real analog or digital outputs or logic (virtual) points as required to provide the specified functions. The Contractor shall select the appropriate input and output signals to satisfy the requirements for control of all systems as shown.

2.15.3 PLC Interface Software

2.15.3.1 Database Definition

Data throughout the network will be available to all Operator Stations. The PLC shall provide a data management function relative to a system-wide data base. Windows-based standards will be utilized to provide data transfers in a client-server architecture. The contractor shall initially configure the database at the PLC level. A standard forms approach will be applied using an off-the-shelf program such as Microsoft Excel. The same form will then be used by the process software to configure the system data base at that level. The definition shall include all physical parameters associated with each point. Each point shall be defined and entered into the database by the Contractor, including as applicable:

a. Name.

b. Device or sensor type (i.e., sensor, control relay, motors).

c. Point identification number.

d. Unit.

e. Building number.

f. Area.

g. Installation.

h. Field Equipment Panel number and channel address.

i. Sensor range.

j. Controller range.

k. Sensor span.

l. Controller span.

m. Engineering units conversion (scale factor).

n. Setpoint (analog).

o. High reasonableness value (analog).

p. Low reasonableness value (analog).

q. High alarm limit (differential return to normal).

r. Low alarm limit differential (return to normal).

s. High alarm limit (analog).

t. Low alarm limit (analog).

u. Alarm disable time period upon startup or change of setpoint.

v. Analog change differential (for reporting).

w. Alarm class and associated primary message test.

x. High accumulator limit (pulse).

y. Status description.

z. Run time target.

aa. Failure mode as specified and shown.

bb. Constraints as specified.

2.15.3.2 Command Priorities

A scheme of priority levels shall be provided to prevent interaction of a command of low priority with a command of higher priority. The system shall require the latest highest priority command addressed to a single point to be stored for a period of time longer than the longest time constraint in the on and off states, insuring that the correct command shall be issued when the time constraint is no longer in effect or report the rejected command. The default priorities of the various modes associated with resident application software shall be from the highest to lowest as follows.

PRIORITY 1 - Operator initiated
PRIORITY 2 - Day Night Setback

PRIORITY 3 - Special Events
PRIORITY 4 - Holiday Schedule
PRIORITY 5 - Scheduled Start-Stop

2.16 CENTRAL OPERATOR WORKSTATION HUMAN MACHINE INTERFACE (HMI)

2.16.1 Hardware

2.16.2 Software

Using the Government provided Human Machine Interface (HMI) graphical interface software templates, the Contractor shall provide all software necessary to accomplish the following functions, as appropriate, fully implemented and operational, within the Central Operator Workstations. The Contractor shall adhere to the non-disclosure requirements of the current basewide UMCS Systems Integration contract.

2.16.2.1 Scheduled, Holiday, and Special Events Start Stop Program

The Scheduled, Holiday, and Special Events Start Stop Program shall start and stop equipment based on a Daily Default Schedule, a Holiday Schedule, and a Special Events Schedule. To eliminate power surges, an operator adjustable time delay shall be provided between consecutive start commands. This program shall coordinated the Daily Default Schedule, the Holiday Schedule, and a Special Events Schedule. Each shall have inputs, outputs, and a graphic display as described. All shall have a System Database to save scheduled information.

a. Scheduled Start Stop (Daily Default) Schedule

The Daily Default Start-Stop Schedule function shall allow for assignment of specific HVAC systems to unique start-stop schedules. The system shall default to these schedules whenever they do not conflict with either a Holiday Schedule or Special Event Schedule. It shall interface with the temperature control programs to determine whether each of the subordinate HVAC systems should be in Ventilation Delay, Occupied or Unoccupied Mode. The values for program inputs 1,2, and 3 (enabling of the specified day, start time, and duration) shall initially be entered at the Operator Stations and shall then be transferred to the Basic Process PLC for each HVAC system independently. The Basic Process PLC shall use these values to determine the current mode of a specific HVAC system. It shall then send a command, via the Secondary Network, to the subordinate Application Specific PLC or Micro PLC informing the specific HVAC system to enter into an Occupied Mode, Ventilation-Delay Mode, or Unoccupied Mode based upon the current time of day.

(1) Program Inputs:

(a) Enable/Disable Default Schedule

(b) Cooling and heating start schedules
(c) Cooling and Heating Duration
(d) Current Day of week
(e) Time of day
(f) Cooling or heating mode of operation
(h) Equipment status
(i) Equipment constraints
(j) Consecutive start time delay
(k) Current Month
(l) Current date of month

(2) Program Outputs:

(a) Start/stop signal.
(b) Calculated Stop time based upon the Start time and its duration.

(3) Constraints

Changes to the Start Time, Duration or Enable while a HVAC system is in Occupied Mode shall not effect the system until after it has exited the Occupied Mode.

(4) Graphical Interface

The operator shall configure the following schedule parameters used to interact with the application programs through the Central Station HMI.

(a) Enable or Disable the Occupied Mode for a specific day of the week.

(b) Time in which the Occupied Mode shall start for each specific day of the week.

(c) Duration in hours for the Occupied Mode for each specific day of the week.

b. Holiday Schedule

The Holiday Schedule function shall override equipment start stop times on days that are defined as holidays. The Holiday Schedule shall have a capacity for at least fifteen (15) base wide holidays. The Base Wide Holiday Schedule or shall be accessed through the Start/Stop Schedule of individual HVAC system graphics. Further, each holiday shall be individually enabled or disabled for each specific HVAC system, thereby allowing a complete configuration of each HVAC system as needed based upon the holiday schedule of the occupants. The Basic Process PLC shall determine when a holiday month and date matches the current month and date. If this occurs, the selected holiday schedule shall override the existing daily schedule. The Basic Process PLC shall then determine the current mode a specific HVAC system should be in. It shall then send a command, via the Secondary Network, to the subordinate PLC informing the specific HVAC system to

enter into an Occupied Mode, Ventilation-Delay Mode, or Unoccupied Mode based upon the current time of day.

(1) Configurable Inputs For Each Specific Holiday

(a) Enable/Disable
(b) Date
(c) Start
(d) Duration

(2) Constraints

(a) The base wide Holidays must be entered in chronological order for the program to execute properly.

(b) If changes to the base wide holiday schedule are not made by January 15 of a new year, the system shall inform the operator to set the holiday schedule for the new year.

c. Special Events

The Special Events program shall allow for unique start-stop schedules for special occurrences throughout the year. Up to fifteen (15) special events shall be entered for a specific HVAC system via its special events graphical interface. These special events shall only affect their associated HVAC system. The operator interface shall allow the configuration of special event start times and durations for each individual HVAC system. Additionally, a comment shall be enterable allowing the operator to enter a description of the special event.

(1) Program Inputs

(a) Date
(b) Month
(c) Year
(d) Start Time
(e) Duration
(f) Comment

(2) Configurable Values

All program inputs shall be configurable via the special events graphic.

(3) Constraints

The system shall automatically sort the special events in chronological order whenever a new event is added or an existing event is edited or deleted. Any special events that have already occurred shall automatically be removed from the special events list. Once these

special events have been configured, the next scheduled special event is transferred to the Basic Process PLC. When the Basic Process PLC determines that this special event month and date matches the current month and date, the special event start time and duration shall override scheduled Start stop and Holiday Schedules.

(4) Graphic Interface

The operator shall configure the following schedule parameters used to interact with the application programs through the portable work station or thecentral station HMI.

(a) Add a new special event and configure its start time and duration. Also a description may be entered that is associated with the new special event.

(b) Edit the configuration parameters of an existing special event (i.e. start time, duration, description).

(c) Delete an existing special event.

(d) View the special events list in chronological order. This includes an operator entered start time, duration, and description. Also, the calculated stop time may be seen.

d. Graphic Display Windows

Scheduled, Holiday, and Special Events Start Stop program shall have the following graphic display windows associated with it:

(1) DEFAULT START/STOP
(2) SCHEDULED START/STOP HELP
(3) SPECIAL EVENTS
(4) BASE WIDE HOLIDAY SCHEDULE

2.17 LAN EQUIPMENT

All local PLCs shall be networked together with necessary cables and accessories as specified. All LAN equipment shall fully comply with IEEE 802.3 (10 BASE 2 or 10 BASE T) Ethernet networks.

2.17.1 Coaxial Cables and Connectors

Cable shall be type RG-58/U coaxial cable specifically designed for Ethernet applications or RG-62 coaxial cable specifically designed for ARCNET application compatible with the LAN and shall have a tinned copper conductor with polyethylene insulation, tinned copper braid shield, PVC jacket and minimum shield coverage of 95 %. Connections to the LAN shall be made using BNC Female-Male-Female T-connectors utilizing a radiation suppressing sleeve supporting the sheath. LAN terminations shall be made using 50 or 93 ohm resistors as required by the LAN.

2.17.2 10 BASE T Cable and Accessories

a. Cable shall meet the requirements of EIA TSB36 for Category 3 cable. Cable shall be label verified. Cable jacket shall be factory marked at regular intervals indicating the verifying organization and its performance level. Conductors shall be solid untinned copper 24 AWG. Cable shall be rated for plenum application per NFPA 70.

b. Outlets shall be 8-position modular jacks that meet the requirements of EIA TSB40-A for Category 3 connecting hardware. Outlet wire terminations shall be insulation displacement type. Jack pin/pair configuration shall be T568A per EIA 568. Outlets shall be unkeyed. Faceplates shall be provided and shall be ivory in color, impact resistant plastic, single gang. Mounting plates shall be provided for system furniture and shall match the furniture system in color.

c. Patch panels shall consist of 8-position jacks arranged in rows or columns on wall mounted frames. Cable terminations shall be insulation displacement type. Patch panel components shall meet or exceed the requirements of EIA TSB40-A for Category 3 connecting hardware. Jack pin/pair configuration shall be T568A per EIA 568. Jacks shall be unkeyed.

d. Patch cords shall be cable assemblies consisting of flexible, twisted pair stranded wire with 8-position plugs at each end. Patch cords shall meet the requirements of EIA TSB36 and TSB40-A for Category 3. Cable shall be label-verified. Cable jacket shall be factory marked at regular intervals indicating the verifying organization and performance level. Patch cords shall be wired straight through such that pin numbers are identical at each end and shall be paired to match T568A patch panel jack wiring per EIA 568. Patch cords shall be unkeyed. Patch cords shall be factory assembled.

2.17.3 Network Interface Card

Network interface cards shall be provided for LAN management functions and for serving devices as shown on the drawings. The network interface card shall use a 16 bit interface to the data bus. It shall be supplied with an on-board BNC RJ45 connector and transceiver for direct connection to the LAN. It shall also have an auxiliary unit input port for performing diagnostics. On-board buffer memory of at least 16K bytes shall be included to prevent loss of data packets.

2.17.4 Bridges

Bridges shall provide communication between local area networks segments as shown. Bridges shall support protocols utilized in the local area networks. The bridge shall include interface equipment to support data rates shown, but no less than 14,400 bps. Bridges with multiple communication lines shall be modular, expandable to a minimum of 16 ports. Each port shall have LED indicators for monitoring network status. The bridge shall be self-configuring and protocol transparent.

2.17.5 Hubs

Network hubs shall provide communication between network devices using 10 BASE T cables. Network hubs shall support protocol utilized in the LAN. Network hubs shall be modular and expandable from a minimum of 16 ports up to 48 ports. Each port shall have LED indicator for network monitoring status. Network hubs shall permit online network changes without disturbing network devices. Malfunctioning network devices shall be automatically removed from service without shutting down the network.

2.17.6 Communications Network Interface

The Central Station shall include modems, data connecting units, and other line terminations as required for each communications circuit connected to the communication network shown.

2.17.7 Network Security Callback Modem

The network security callback modem shall be a stand-alone modem with a security feature to call back the originating number after receiving a call. The modem shall be programmable to set callback telephone numbers. It shall operate at 14,400 bps full duplex on circuits in the asynchronous mode. The modem shall have error detection, auto answer/auto dial, call progress detection, and the appropriate security safeguards, including passwording, to allow for call back of predefined numbers associated with each password, after receiving a call. Modem shall meet the requirements of CCITT for V.32 bis modems. Modem shall be suitable for operating on unconditioned voice grade telephone lines.

2.17.8 Central Station Consoles and Accessories

The Contractor shall provide color coordinated consoles and equipment cabinets. One locking cabinet approximately 6 feet high, 3 feet wide, 18 to 36 inches deep with three adjustable shelves, and four storage racks for storage of disks, tapes, printouts, printer paper, ribbons, manuals, and other documentation shall be provided. Equipment cabinets shall have front and back plexiglass doors, thermostatic controlled bottom-mounted fan, and metal fitted and louvered tops.

2.17.9 Uninterruptible Power Supply (UPS)

A self contained UPS suitable for installation and operation at the Central Station, shall be provided sized to provide a minimum of 30 minutes of operation of the Central Station Equipment. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS. UPS shall be complete with all necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of low battery power. The UPS shall be as

specified in SECTION 16285 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM ABOVE 15 KVA CAPACITY.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION CRITERIA

3.1.1 HVAC Control System

The HVAC control system shall be completely installed and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.2 Software Installation

Software shall be loaded for an operational system, including databases for all points, operational parameters, and system, command, and application software. The Contractor shall provide original and backup copies of source, excluding the general purpose operating systems and utility programs furnished by computer manufacturers and the non-job-specific proprietary code furnished by the system manufacturer, and object modules for all software on each type of media utilized, within 30 days of formal Government acceptance. In addition, a copy of individual floppy disks of all software for each DDC-PLC panel shall be provided.

3.1.3 Device-Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with all required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

3.1.4 Wiring Criteria

Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. Wiring shall be installed without splices between control devices and DDC-PLC panels. Instrumentation grounding shall be installed as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system.

Ground rods installed by the contractor shall be tested as specified in IEEE Std 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings, in accordance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR. Other electrical work shall be as specified in Section 16415 ELECTRICAL WORK, INTERIOR and as shown.

3.2 CONTROL-SYSTEM INSTALLATION

3.2.1 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.2 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible receiver gauge installed in the tubing lines at the actuator as shown.

3.2.3 Room-Instrument Mounting

Room instruments shall be mounted so that their sensing elements are 5 feet above the finished floor unless otherwise shown. Temperature setpoint device shall be recess mounted.

3.2.4 Freezestats

For each 20 square feet of coil-face area, or fraction thereof, a freezestat shall be provided to sense the temperature at the location shown. Manual reset freezestats shall be installed in approved, accessible locations where they can be reset easily. The freezestat sensing element shall be installed in a serpentine pattern.

3.2.5 Averaging-Temperature Sensing Elements

Sensing elements shall have a total element minimum length equal to 1 linear foot per square foot of duct cross-sectional area.

3.2.8 Duct Static-Pressure Sensing Elements and Transmitters

The duct static-pressure sensing element and transmitter sensing point shall be located at 75% to 100% of the distance between the first and last air terminal units.

3.2.9 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.3 CONTROL SEQUENCES OF OPERATION

3.3.1 General Requirements - HVAC Systems

These requirements shall apply to all primary HVAC systems unless modified herein. The sequences describe the actions of the control system for one direction of change in the HVAC process analog variable, such as temperature, humidity or pressure. The reverse sequence shall occur when the direction of change is reversed. Sequence of Control shall be as described on the control drawings.

3.4 COMMISSIONING PROCEDURES

3.4.1 Evaluations

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, set the time schedule, and make any necessary control-system corrections to ensure that the systems function as described in the sequence of operation.

3.4.1.1 Item Check

Signal levels shall be recorded for the extreme positions of each controlled device. An item-by-item check of the sequence of operation requirement shall be performed using Steps 1 through 4 in the specified control system commissioning procedures. Steps 1, 2, and 3 shall be performed with the HVAC system shut down; Step 4 shall be performed after the HVAC systems have been started. External input signals to the DDC-PLC panel (such as starter auxiliary contacts, and external systems) may be simulated in steps 1, 2, and 3. With each operational-mode signal change, DDC-PLC panel output relay contacts shall be observed to ensure that they function.

3.4.1.2 Weather-Dependent Test Procedures

Weather-dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be verified in the appropriate season.

3.4.1.3 Two-Point Accuracy Check

A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the DDC-PLC panel readout to

the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC-PLC panel readout accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC-PLC panel readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

3.4.1.4 Insertion and Immersion Temperatures

Insertion temperature and immersion temperature sensing elements and transmitter-to-DDC-PLC panel readout calibration accuracy shall be checked at one physical location along the axis of the sensing element.

3.4.1.5 Averaging Temperature

Averaging-temperature sensing element and transmitter-to-DDC-PLC panel readout calibration accuracy shall be checked every 2 feet along the axis of the sensing element in the proximity of the sensing element, for a maximum of 10 readings. These readings shall then be averaged.

3.4.3 Unit Heater and Cabinet Unit Heater

The "OFF/AUTO" switch shall be placed in the "OFF" position. Each space-thermostat temperature setting shall be turned up so that it makes contact and turns on the unit heater fans. The unit heater fans shall not start. The "OFF/AUTO" switch shall be placed in the "AUTO" position. It shall be ensured that the unit-heater fans start. Each space thermostat temperature setting shall be turned down, and the unit-heater fans shall stop. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.4.5 All-Air Small Packaged Unitary

The schedules shall be manually entered for day temperature and night temperature setpoints as shown. The fan "AUTO/ON" switch shall be set to "ON." The time shall be manually entered as "DAY." The heating-cooling switch shall be raised to "HEATING" and it shall be ensured that cooling is off. The temperature setpoint shall be raised and it shall be ensured that heating starts. The heating/cooling switch shall be set to "COOLING" and it shall be ensured that heat is off. The temperature setpoint shall be lowered and it shall be ensured that cooling starts. The fan "AUTO/ON" switch shall be set to "AUTO" and the foregoing procedure repeated. The fan shall start and stop automatically with the starting and stopping of heating and cooling. The time shall be

manually entered as "NIGHT." The foregoing procedures shall be repeated. When the system is verified as operational, the correct "DAY" and "NIGHT" temperature settings shall be restored and the correct time restored. The power to the thermostat shall be shut off and it shall be verified that the thermostat clock keeps time. The results of testing of one of each type of unit shall be logged.

3.4.8 Single Building Hydronic Heating with Hot Water Boiler

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature-sensing element location. Each temperature shall be read at the DDC-PLC panel, and the thermometer and DDC-PLC panel readings logged. The calibration accuracy of the sensing element-to-DDC-PLC panel readout for outside air temperature and system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC-PLC panel. The proper operation of the actuators and positioners for all valves shall be verified visually. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) The two-point calibration sensing element-to-DDC-PLC panel readout accuracy check for the outside-air temperature shall be performed. Any necessary software adjustments to setpoints or parameters shall be made to achieve the outside-air temperature schedule.

(2) The outside air temperature shall be simulated through an operator entered value to be above the setpoint and the airhandler schedule shall be set for unoccupied. It shall be verified that pumps HP-1 and boiler B-1 stop. A value shall be entered to simulate that the outside-air temperature is below the setpoint as shown. It shall be verified that pumps HP-1 start and boiler B-1 operates.

(3) The 2-point calibration accuracy check of the sensing element-to-DDC-PLC panel readout for the system-supply temperature shall be performed. The system-supply temperature setpoint shall be set for the temperature schedule as shown. Signals of 8 ma and 16 ma shall be sent to the DDC-PLC panel from the UMCS control point adjust, to verify that the system-supply temperature setpoint changes to the appropriate values.

(4) The system shall be placed in the occupied mode. The calibration accuracy check of sensing element-to-DDC-PLC panel readout shall be performed for each space temperature sensor and the values logged. Each space temperature setpoint shall be set as shown. The system shall be placed in the unoccupied mode, and it shall be verified that each space temperature setpoint changes to the unoccupied mode setting.

3.4.17 Variable Air Volume Control System - Without Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside-air and relief-air dampers are closed, the return-air damper is open, and the cooling coil valves are closed.

b. Step 2 - Calibration Accuracy Check with HVAC System in Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC-PLC panel, and the thermometer and DDC-PLC panel display readings logged. The calibration accuracy of the sensing element-to-DDC-PLC panel readout for outside-air, return-air, mixed-air, and the cooling-coil discharge air temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC-PLC panel. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control-System Commissioning:

(1) With the fan ready to start, the system shall be placed in the ventilation delay mode and in the occupied mode through operator entered values. It shall be verified that supply fan starts. It shall be verified that the outside-air damper and relief-damper (and relief-air exhaust fans EF-1, and EF-6, where applicable) are closed / off, the return-air damper is open, and the cooling coil valve and supply fan speed are under control, by simulating a change in the air handler discharge temperature. The system shall be placed out of the ventilation delay mode, and it shall be verified that the outside-air, return-air, and relief-air dampers (and fans) come under control, by simulating a change in the mixed air temperature.

(2) The occupied outside air mode signal shall be applied, and it shall be verified that the outside-air damper opens and modulates to maintain the required outside-air as

scheduled and as measured by the outside-air flow measurement station and the relief air exhaust fans start.

(3) With supply fan running, a high static-pressure input signal shall be simulated at the device, by pressure input to the differential pressure switch sensing device. HVAC system shutdown shall be verified, it shall be verified that the high-static-pressure alarm is initiated. The differential pressure switch shall be set at the setpoint. The HVAC system shall be restarted by manual reset, and it shall be verified that the high static-pressure alarm returns to normal.

(4) The 2-point calibration accuracy check for sensing element-to-DDC-PLC panel readout for the static pressure in the supply duct shall be performed.

(5) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the outside-air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC-PLC panel readout for outside-air, return-air, and mixed-air temperatures shall be performed. The temperature setpoint shall be set as shownNot used.

(6) The 2-point calibration accuracy check of sensing element-to-DDC-PLC panel readout for the fan discharge temperature shall be performed. The setpoint for the fan discharge temperature shall be set as shown. A change shall be simulated in the discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(7) The system shall be placed in the unoccupied-mode and it shall be verified that the occupied-mode light turns off, the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint as shown.

(8) With the HVAC system running, a filter differential-pressure-switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint.

(9) With the HVAC system running, a freezestat trip input signal shall be simulated, at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(10) With the HVAC system running, a smoke-detector trip input signal shall be simulated at each detector, and control-device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

(11) Velocity setpoints shall be set for minimum and maximum flow and temperature setpoints for the heating/cooling dead band, for each VAV terminal unit. The actions of the controller, the operation of the damper, and the operation of heating shall be verified. It shall be verified that space temperature is maintained.

3.5 BALANCING, COMMISSIONING, AND TESTING

3.5.1 Coordination with HVAC System Balancing

Commissioning of the control system, except for tuning of controllers, shall be performed prior to or simultaneous with HVAC system balancing. The contractor shall tune the HVAC control system after all air-system and hydronic-system balancing has been completed, minimum damper positions set and a report has been issued.

3.5.2 Control System Calibration, Adjustments, and Commissioning

Control system commissioning shall be performed for each HVAC system, using test plans and procedures previously approved by the Government. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform commissioning and testing of the HVAC control system. All instrumentation and controls shall be calibrated and the specified accuracy shall be verified using test equipment with calibration traceable to NIST standards. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Mechanical control devices shall be adjusted to operate as specified. HVAC control panels shall be pretested off-site as a functioning assembly ready for field connections, calibration, adjustment, and commissioning of the operational HVAC control system. Control parameters and logic (virtual) points including control loop setpoints, gain constants, and integral constraints, shall be adjusted before the system is placed on line. Communications requirements shall be as indicated. Written notification of any planned commissioning or testing of the HVAC Control systems shall be given to the Government at least 14 calendar days in advance.

3.5.3 Performance Verification Test

The Contractor shall demonstrate compliance of the HVAC control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test procedures shall show, step-by-step, the

actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Commissioning Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off-periods of base heating and cooling systems.

3.5.4 Endurance Test

The endurance test shall be used to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall not be started until the Government notifies the Contractor in writing that the performance verification test is satisfactorily completed. The Government may terminate the testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

a. Phase I (Testing)

The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

b. Phase II (Assessment)

After the conclusion of Phase I, the Contractor shall identify failures, determine causes of failures, repair failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the jobsite to present the results and recommendations to the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and test review meeting, the Government may require that the Phase I test be totally or partially rerun. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

3.5.5 Posted and Panel Instructions

Posted and Panel Instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of laminated half-size drawings and shall include the control system schematic, equipment schedule, sequence of

operation, wiring diagram, communication network diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a Routine Maintenance Checklist and as-built configuration check sheets. Panel instructions and one copy of the Operation and Maintenance Manuals, previously described herein, shall be placed inside each control panel or permanently affixed, by mechanical means, to a wall near the panel.

3.6 OPERATION AND MAINTENANCE DATA

Furnish the Operation Manual and Maintenance and Repair Manual in accordance with Part 1 paragraph SUBMITTALS.

OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

JAN 19 2010

MEMORANDUM FOR ACTING ASSISTANT SECRETARY OF THE ARMY
(INSTALLATIONS AND ENVIRONMENT)
ACTING ASSISTANT SECRETARY OF THE NAVY
(INSTALLATIONS AND ENVIRONMENT)
ACTING ASSISTANT SECRETARY OF THE AIR
FORCE (INSTALLATIONS, LOGISTICS, AND
ENVIRONMENT)

SUBJECT: DoD Implementation of Storm Water Requirements under Section 438 of the Energy Independence and Security Act (EISA)

Reducing the impacts of storm water runoff associated with new construction helps to sustain our water resources. In October 2004, DoD issued Unified Facilities Criteria on Low Impact Development (LID) (UFC 3-210-10), a storm water management strategy designed to maintain the hydrologic functions of a site and mitigate the adverse impacts of storm water runoff from DoD construction projects. Using LID techniques on DoD facility projects can also assist in fulfilling environmental regulatory requirements under the Clean Water Act. Since 2004, DoD has implemented LID techniques for controlling storm water runoff on a number of projects.

EISA Section 438 (Title 42, US Code, Section 17094) establishes into law new storm water design requirements for Federal development and redevelopment projects. Under these requirements, Federal facility projects over 5,000 square feet must "maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow." Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (October 5, 2009), directed the U.S. Environmental Protection Agency (EPA) to issue EISA Section 438 guidance. DoD shall implement EISA Section 438 and the EPA *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*, using LID techniques in accordance with the policy outlined in the attachment.

EISA Section 438 requirements are independent of storm water requirements under the Clean Water Act and should not be included in permits for storm water unless a State (or EPA) has promulgated regulations for certain EISA Section 438

requirements (i.e., temperature/heat criteria) that are applicable to all regulated entities under its Clean Water Act authority.

The attached policy will be incorporated into applicable DoD Unified Facilities Criteria within six months. My points of contact are Thadd Buzan at (703) 571-9079 and Ed Miller at (703) 604-1765.

Dorothy Robyn
Deputy Under Secretary of Defense
(Installations and Environment)

Attachment:
As stated

DoD Policy on Implementing Section 438 of the Energy Independence and Security Act (EISA)

1. EISA Section 438 requirements apply to projects that construct facilities with a footprint greater than 5,000 gross square feet, or expand the footprint of existing facilities by more than 5,000 gross square feet. The project footprint consists of all horizontal hard surfaces and disturbed areas associated with the project development, including both building area and pavements (such as roads, parking, and sidewalks). These requirements do not apply to internal renovations, maintenance, or resurfacing of existing pavements.

2. The overall design objective for each project is to maintain predevelopment hydrology and prevent any net increase in storm water runoff. DoD defines "predevelopment hydrology" as the pre-project hydrologic conditions of temperature, rate, volume, and duration of storm water flow from the project site. The analysis of the predevelopment hydrology must include site-specific factors (such as soil type, ground cover, and ground slope) and use modeling or other recognized tools to establish the design objective for the water volume to be managed from the project site.

3. Project site design options shall be evaluated to achieve the design objective to the maximum extent technically feasible. The "maximum extent technically feasible" criterion requires full employment of accepted and reasonable storm water retention and reuse technologies (e.g., bio-retention areas, permeable pavements, cisterns/recycling, and green roofs), subject to site and applicable regulatory constraints (e.g., site size, soil types, vegetation, demand for recycled water, existing structural limitations, state or local prohibitions on water collection). All site-specific technical constraints that limit the full attainment of the design objective shall be documented. If the design objective cannot be met within the project footprint, LID measures may be applied at nearby locations on DoD property (e.g., downstream from the project) within available resources.

4. Prior to finalizing the design for a redevelopment project, DoD Components shall also consider whether natural hydrological conditions of the property can be restored, to the extent practical.

5. Estimated design and construction costs for implementing EISA Section 438 shall be documented in the project cost estimate as a separate line item. Final implementation costs will be documented as part of the project historical file. Post-construction analysis shall also be conducted to validate the effectiveness of as-built storm water features.

The following flowchart illustrates the DoD implementation process for EISA Section 438, consistent with the U.S. Environmental Protection Agency's *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act* (December 2009) (http://www.epa.gov/owow/nps/lid/section438/.

Flowchart for EISA §438 Implementation

1. Determine applicability

Requirement: apply to all Federal projects with a footprint greater than 5,000 square feet

2. Establish design objective

Requirement: maintain or restore predevelopment hydrology

OPTIONS

1
Total volume of rainfall from 95th percentile storm is to be managed on-site.

2
Determine predevelopment hydrology based on site-specific conditions and local meteorology by using continuous simulation modeling techniques, published data, studies, or other established tools. Determine water volume to be managed onsite.

Design water volume
(to be retained)

3. Evaluate design options

Design water volume
(to be retained)

Requirement: meet design objective to maximum extent technically feasible (METF)

TYPICAL ON-SITE DESIGN OPTIONS

- **Bio-retention areas**
- **Permeable pavements**
- **Cisterns / recycling**
- **Green roofs**

Use any combination of on-site options to achieve the design objective to the METF. Document site-specific constraints.

TECHNICAL CONSTRAINT EXAMPLES

- Retaining storm water on site would adversely impact receiving water flows
- Site has shallow bedrock, contaminated soils, high groundwater, underground facilities or utilities
- Soil infiltration capacity is limited
- Site is too small to infiltrate significant volume
- Non-potable water demand (for irrigation, toilets, wash-water, etc.) is too small to warrant water harvesting and reuse systems
- Structural, plumbing, or other modifications to existing buildings to manage storm water are infeasible
- State or local requirements restrict water harvesting
- State or local requirements restrict the use of green infrastructure/LID

remaining water volume?

Selected on-site design options

OFF-SITE OPTIONS
(optional)

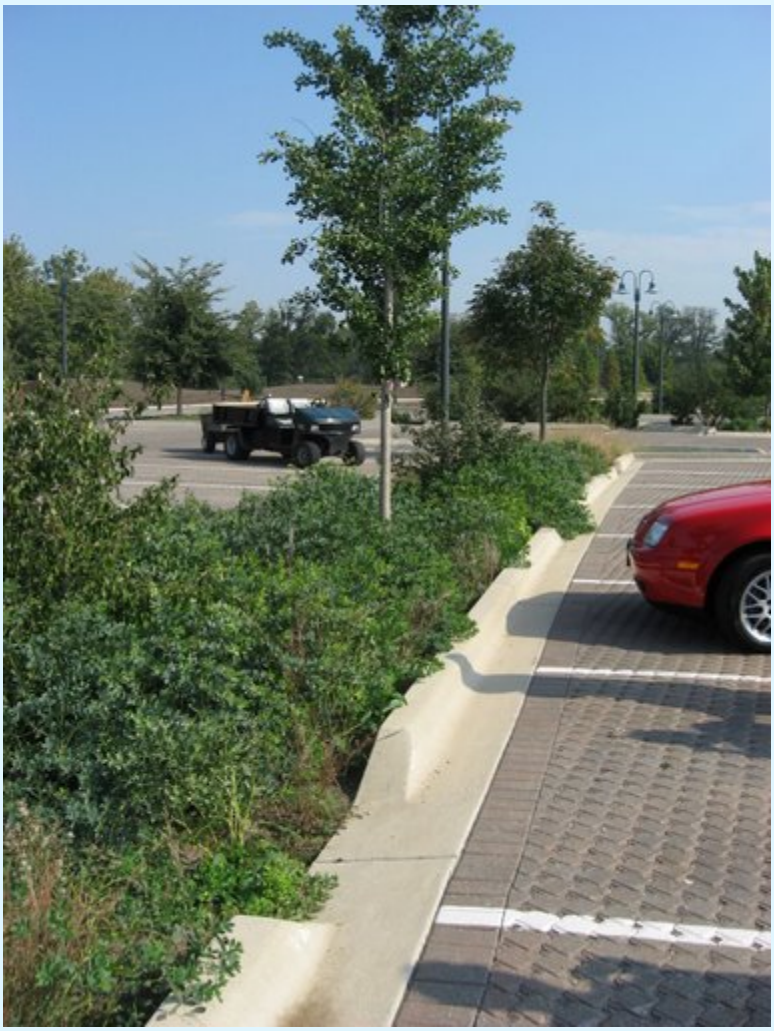
Selected off-site design options

Thursday, October 28, 20

4. Finalize design and estimate cost

United States Environmental Protection Agency | Office of Water (4503T) Washington, DC 20460 | EPA 841-B-09-001 December 2009 www.epa.gov/owow/nps/lid/section438

Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act



Foreword

Stormwater runoff in urban and developing areas is one of the leading sources of water pollution in the United States. In recognition of this issue, Congress enacted Section 438 of the Energy Independence and Security Act of 2007 (EISA) to require federal agencies to reduce stormwater runoff from federal development projects to protect water resources. More recently, the President signed Executive Order 13514 on "Federal Leadership in Environmental, Energy, and Economic Performance" calling upon all federal agencies to "lead by example" to address a wide range of environmental issues, including stormwater runoff. The Executive Order required the U.S. Environmental Protection Agency (EPA), in coordination with other federal agencies, to publish this Technical Guidance.

EPA worked closely with many federal agencies to develop this Technical Guidance to help federal agencies in implementing EISA Section 438. The guidance provides a step-by-step framework that will help federal agencies maintain pre-development site hydrology by retaining rainfall on-site through infiltration, evaporation/transpiration, and re-use to the same extent as occurred prior to development. The Technical Guidance provides background information, key definitions, case studies, and guidance on meeting the new requirements.

Federal agencies can comply with Section 438 by using a variety of stormwater management practices often referred to as "green infrastructure" or "low impact development" practices, including, for example, reducing impervious surfaces, using vegetative practices, porous pavements, cisterns and green roofs.

One of the most exciting new trends in water quality management today is the movement by many cities, counties, states, and private sector developers toward the increased use of this next generation stormwater management practices to help protect and restore water quality. Many federal agencies, including EPA, are already using a full spectrum of stormwater management practices to reduce the impact of federal facilities on local watersheds. These projects have produced results such as reductions in site runoff volumes and increased stormwater quality, which ultimately lead to more sustainable facilities.

EPA enjoyed the opportunity to work with a number of federal agencies to develop this state-of-the art, technical guidance and appreciate all their input. We look forward to continuing the dialogue as we all work to implement this guidance.

Peter S. Silva
Assistant Administrator
Office of Water
U.S. Environmental Protection Agency

Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act

INTRODUCTION

In December 2007, Congress enacted the Energy Independence and Security Act of 2007. Section 438 of that legislation establishes strict stormwater runoff requirements for federal development and redevelopment projects. The provision reads as follows:

> **"Storm water runoff requirements for federal development projects.** The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow."

The intent of Section 438 of the Energy Independence and Security Act of 2007 (EISA) is to require federal agencies to develop and redevelop applicable facilities in a manner that maintains or restores stormwater runoff to the maximum extent technically feasible. Until recently, stormwater programs established to address water quality objectives have been designed to control traditional pollutants that are commonly associated with municipal and industrial discharges, e.g., nutrients, sediment, and metals. Increases in runoff volume and peak discharge rates have been regulated through state and local flood control programs. Although these programs have merit, knowledge accumulated during the past 20 years has led stormwater experts to the conclusion that conventional approaches to control runoff are not fully adequate to protect the nation's water resources (National Research Council, 2008).

Implementation of Section 438 of the EISA can be achieved through the use of the green infrastructure/low impact development (GI/LID) infrastructure tools described in this guidance. The intention of the statute is to maintain or restore the pre-development site hydrology during the development or redevelopment process. To be more specific, this requirement is intended to ensure that receiving waters are not negatively impacted by changes in runoff temperature, volumes, durations and rates resulting from federal projects. It should also be noted that a performance-based approach was selected in lieu of a prescriptive requirement in order to provide site designers maximum flexibility in selecting control practices appropriate for the site.

Section 14 of the Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance

On October 5, 2009, President Barack Obama signed Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance." Section 14 of the Executive Order provides:

> Stormwater Guidance for Federal Facilities. Within 60 days of the date of this order, the Environmental Protection Agency, in coordination with other Federal agencies as

> appropriate, shall issue guidance on the implementation of section 438 of the Energy Independence and Security Act of 2007 (42 U.S.C. 17094).

This provision contains two significant elements. First, for the first time, EPA is formally assigned the responsibility to write and issue the Section 438 guidance, in coordination with other federal agencies. Second, it establishes a deadline for EPA to do so by December 5, 2009.

Purpose and Organization of this Guidance

The purpose of this document is to provide technical guidance and background information to assist federal agencies in implementing EISA Section 438. Each agency or department is responsible for ensuring compliance with EISA Section 438. The document contains guidance on how compliance with Section 438 can be achieved, measured and evaluated. In addition, information detailing the rationale for the stormwater management approach contained herein has been included.

This document is intended solely as guidance. This document is not a regulation nor does it substitute for statutory provisions or regulations. This guidance does not impose any legally binding requirements on federal agencies and does not confer any legal rights or impose legal obligations upon any member of the public. This document does not create a cause of action against the EPA, other federal agencies, or the United States.

The following information is presented within this document:

Part I: Implementation Framework

A. Background
B. Benefits and outcomes of the new stormwater performance requirements
C. Applicability and definitions
D. Tools to implement the requirements of Section 438
E. Calculating the 95th percentile rainfall event

Part II: Case Studies on Capturing the 95th Percentile Storm Using Onsite Management Practices

Case studies representing typical federal installations have been included. The case studies were selected to demonstrate the feasibility of providing adequate stormwater control for a range of site conditions and building designs. To the maximum extent technically feasible, each case study includes a description of a method that can be used to determine the design objectives of the project based on retaining the 95th percentile storm. Examples of onsite technologies and practices have also been provided. The case studies are intended to provide examples of modeling procedures that can be used to quantify treatment system performance and processes for assessing sites and determining appropriate control techniques to the maximum extent technically feasible.

Part I: Implementation Framework

A. BACKGROUND

This section contains background on the causes and consequences of stormwater discharges, solutions that can be used to address the causes and consequences of stormwater discharges and how to implement those solutions to comply with Section 438 of EISA.

Alterations to Natural Hydrology and the Impact on Stormwater Runoff
In the natural, undisturbed environment rain that falls is quickly absorbed by trees, other vegetation, and the ground. Most rainfall that is not intercepted by leaves infiltrates into the ground or is returned to the atmosphere by the process of evapotranspiration. Very little rainfall becomes stormwater runoff in permeable soil, and runoff generally only occurs with larger precipitation events. Traditional development practices cover large areas of the ground with impervious surfaces such as roads, driveways, sidewalks, and buildings. Under developed conditions runoff occurs even during small precipitation events that would normally be absorbed by the soil and vegetation. The collective force of the increased runoff scours streambeds, erodes stream banks, and causes large quantities of sediment and other entrained pollutants to enter the water body each time it rains (Shaver, et al., 2007; Booth testimony, 2008).

As watersheds are developed and impervious surfaces increase in area, the hydrology of the watersheds fundamentally changes over time which results in degraded aquatic ecosystems. In recognition of these problems, stormwater managers employed extended detention approaches to mitigate the impacts of increased peak runoff rates. However, wet ponds and similar practices are not fully adequate to protect downstream hydrology because of the following inherent limitations of these conventional practices (National Research Council, 2008; Shaver, et al., 2007):

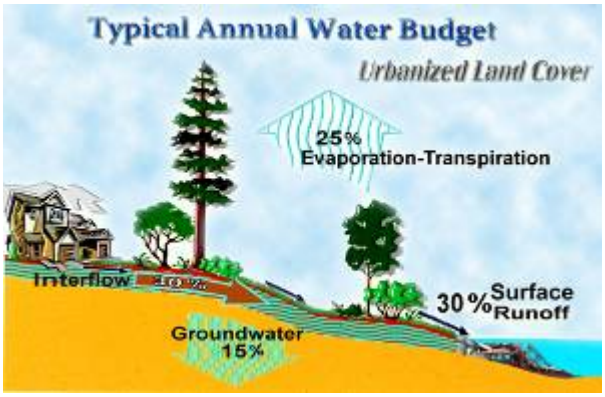
- Poor peak control for small, frequently-occurring storms;
- Negligible volume reduction; and
- Increased duration of peak flow.

Detention storage targets relatively large, infrequent storms, such as the two and 10-year/24-hour storms for peak flow rate control. As a result of this design limitation, flow rates from smaller, frequently-occurring storms typically exceed those that existed onsite before land development occurred and these increases in runoff volumes and velocities typically result in flows erosive to stream channel stability (Shaver, et al., 2007). Section 438 is intended to address the inadequacies of the historical detention approach to managing stormwater and promote more sustainable practices that have been selected to maintain or restore predevelopment site hydrology.

A 2008 National Research Council report on urban stormwater confirmed that current stormwater control efforts are not fully adequate. Three of the report's findings on stormwater management approaches are particularly relevant (National Research Council, 2008).

1. Individual controls on stormwater discharges are inadequate as the sole solution to stormwater in urban watersheds;
2. Stormwater control measures such as product substitution, better site design, downspout disconnection, conservation of natural areas, and watershed and land-use planning can dramatically reduce the volume of runoff and pollutant load from new development; and
3. Stormwater control measures that harvest, infiltrate, and evapotranspire stormwater are critical to reducing the volume and pollutant loading of small storms.

Pre-development Hydrology. *Courtesy of C. May, University of Washington.*



Post-Development Hydrology. *Courtesy of C. May, University of Washington.*

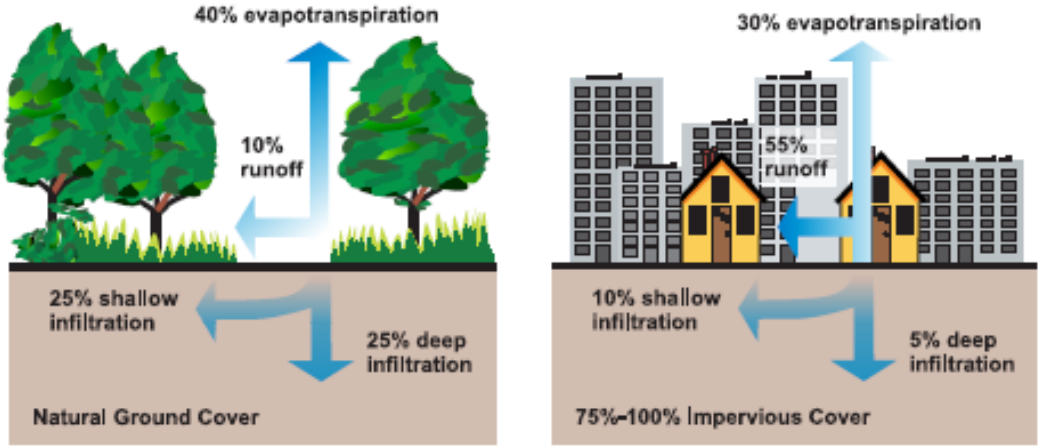


Figure 1. Pre-Development and Post-Development Hydrology. (USDA).

Figure 1 contains two sets of diagrams depicting the water balances at undeveloped and developed sites. Runoff patterns will vary based on factors such as geographic location, local meteorological conditions, vegetative cover and soils. The first set of figures represents conditions in the Pacific Northwest where storms have a long duration and low intensity, i.e., the volume of rain in an individual storm is small. The second set of figures from the U.S. Department of Agriculture represents a more generalized set of conditions, but was included to illustrate that heavily urbanized areas typically cause large increases in runoff.

Land cover changes that result from site development include increased imperviousness, soil compaction, loss of vegetation, and loss of natural drainage patterns, which result in increased runoff volumes and peak runoff rates. The cumulative impacts of the land cover changes result in alterations of the natural hydrology of a site, which disrupts the natural water balance and changes water flow paths. The consequences of these impacts include:

1. *Increased volume of runoff*. With decreased area for infiltration and evapotranspiration due to development, a greater amount of rainfall is converted to overland runoff which results in larger stormwater discharges.
2. *Increased peak flow of runoff*. Increased impervious surface area and higher connectivity of impervious surfaces and stormwater conveyance systems increase the flow rate of stormwater discharges and increase the energy and velocity of discharges into the stream channel.
3. *Increased duration of discharge*. Detention systems generate greater flow volumes and rates. These prolonged higher discharge rates can undermine the stability of the stream channel and induce erosion, channel incision and bank cutting.
4. *Increased pollutant loadings*. Impervious areas are a collection site for pollutants. When rainfall occurs these pollutants are mobilized and transported directly to stormwater conveyances and receiving streams via these impervious surfaces.
5. *Increased temperature of runoff*. Impervious surfaces absorb and store heat and transfer it to stormwater runoff. Higher runoff temperatures may have deleterious effects on receiving streams. Detention basins magnify this problem by trapping and discharging runoff that is heated by solar radiation (Galli, 1991; Schueler and Helfrich, 1988).

The resulting increases in volume, peak flow, and duration are illustrated in the hydrograph in Figure 2, which is a representation of a site's stormwater discharge with respect to time. The hydrograph illustrates the impacts of development on runoff volume and timing of the runoff. Individual points on the curve represent the rate of stormwater discharge at a given time. The graph illustrates that development and corresponding changes in land cover result in greater discharge rates, greater volumes, and shorter discharge periods. In a natural condition, runoff rates are slower than those on developed sites and the discharges occur over a longer time period. The predevelopment peak discharge rate is also much lower than the post-development peak discharge rate due to attenuation and absorption by soils and vegetation. In the post-development condition there is generally a much shorter time before runoff begins because of increased impervious surface area, a higher degree of connectivity of these areas and the loss of soils and vegetative cover that slow or reduce runoff.

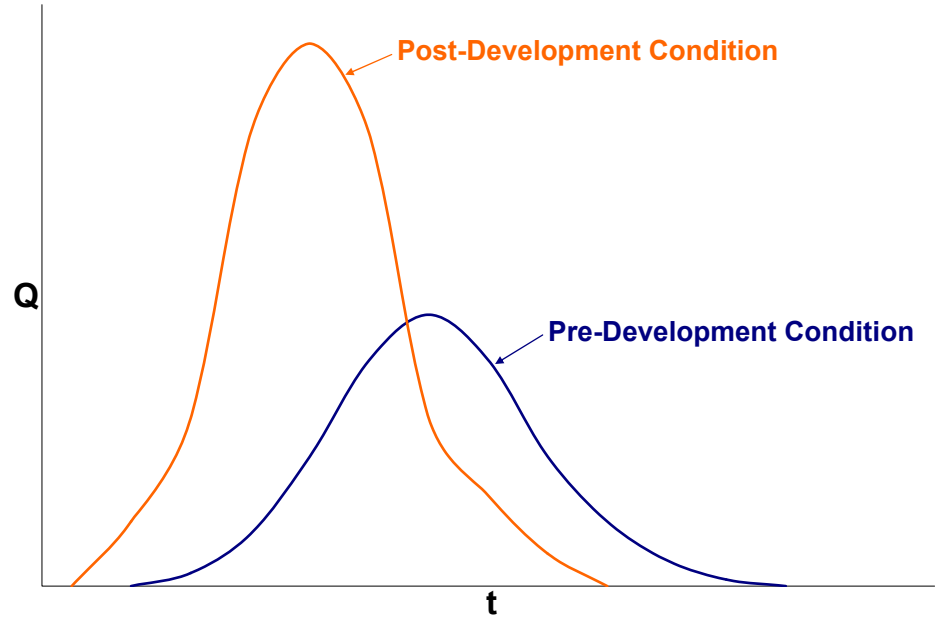


Figure 2. Post-Development Hydrograph.
(Q = volumetric flow rate; t = time)

Figure 3. Stream Displaying the Effects of Stormwater Runoff and Channel Downcutting.

The Solution: Preserving and Restoring Hydrology

A new approach has evolved in recent years to eliminate or reduce the amount of water and pollutants that run off a site and ultimately are discharged into adjacent water bodies.

The fundamental principle is to employ systems and practices that use or mimic natural processes to: 1) infiltrate and recharge, 2) evapotranspire, and/or 3) harvest and use precipitation near to where it falls to earth.

GI/LID practices include a wide variety of practices that utilize these mechanisms. These practices can be used at the site, neighborhood and watershed/regional scales. In this document the focus is on site-level practices, which is most consistent with the terms used in Section 438: "project," "facility," and "property." Although these performance requirements apply at the project site-level, flexibility exists to utilize nearby areas or areas directly adjacent to the facility to manage the runoff, i.e., evapotranspirate, infiltrate or harvest and use. Where justifiable, it also may be appropriate to evapotranspirate, infiltrate or harvest and use an equivalent or greater amount of runoff offsite as long as the runoff is discharged or used in the same receiving subwatershed or watershed.

The purpose of EISA Section 438 is to replicate the pre-development hydrology to protect and preserve both the water resources onsite and those downstream. For example, if prior to development, twenty five (25) percent of the annual rainfall runs directly into the stream and the remainder infiltrates into the ground or is evapotranspired into the air, then the post-development goal should be to limit runoff to twenty five (25) percent of the annual precipitation while maintaining the correct aquifer recharge rate. This has the benefit, in most cases, of delivering water to the stream at approximately the same rate, volume, duration and temperature as the stream had naturally evolved to receive prior to development. The result will be to eliminate or minimize the erosion of streambeds and streambanks, significantly reduce the delivery of many pollutants to water bodies, and retain historical instream temperatures.

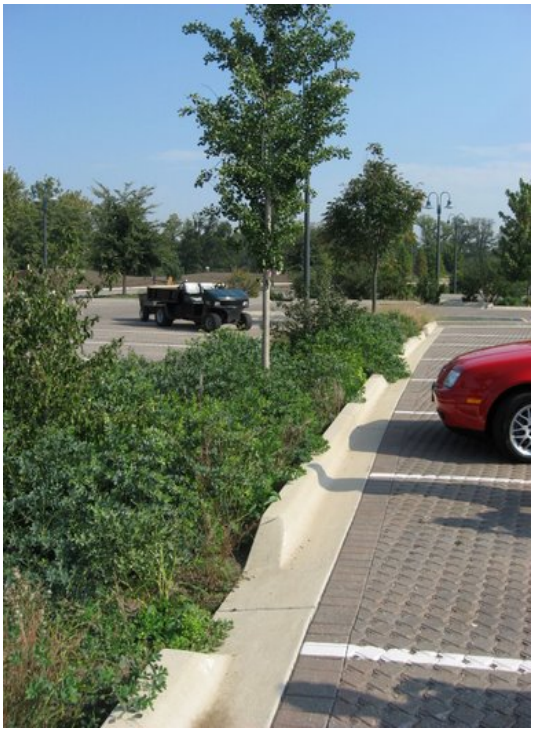


Figure 4. Parking lot bioswale and permeable pavers in Chicago.

Restoring or maintaining pre-development hydrology has emerged as a control approach for several reasons. Most importantly, this approach is intended to directly address the root cause of impairment. Current control approaches have been selected in an attempt to control the symptoms (peak flow, and excess pollutants), but this strategy is not fully adequate because of the scale of the problem, the cumulative impacts of multiple developments and the need to manage both site and watershed level impacts. With current approaches, it is also difficult to adequately protect and improve water quality because the measures employed are not addressing the main problem which is a hydrologic imbalance.

Designing facilities based on the goal of maintaining or restoring pre-development hydrology provides a site specific basis and an objective methodology with which to determine appropriate practices to protect the receiving environment.

Using pre-development hydrology as the guiding control principal also allows the designer to consider climatic and geologic variability and tailor the solutions to the project location. Thus the need for a one size fits all approach is rendered unnecessary since the design objective is dictated by the pre-development site conditions and other technicalities of the project site and facility. Instead of prescribed approaches dictating discharge volumes or flow rates, site assessments of historical infiltration and runoff rates will inform the designer and provide the basis for a suitable design. The use of this approach will minimize compliance complications that may arise from prescriptive design approaches which do not account for the variability of precipitation frequencies, rainfall intensities and pre-development land cover and soil conditions that influence infiltration and runoff.

B. Benefits and Outcomes of the New Stormwater Performance Requirements

Implementation of these new stormwater performance requirements in EISA Section 438 provides numerous environmental and economic benefits in addition to reducing the volume of stormwater runoff:

Benefits to Water Resources:

- *Cleaner Water.* The use of plants, soils and water harvesting and use practices can reduce stormwater runoff volumes and pollutant loadings and the frequency and magnitude of combined sewer overflows (volume and pollutant loading reductions). These practices are part of a larger set of practices called green infrastructure/low impact development.
- *Clean and Adequate Water Supplies.* GI/LID approaches using soil based vegetated infiltration systems can be used to recharge ground water and maintain stream base flow. By recharging ground water aquifers, aquatic ecosystem health is maintained and base flows are increased which helps ensure more constant flows for drinking water withdrawals. Harvesting and reusing rainwater also reduces the need to use potable water for all uses and can reduce both the infrastructure and energy needed to treat and transport both drinking water and stormwater.
- *Source Water Protection.* GI/LID practices provide pollutant removal benefits, thereby providing some protection for both ground water and surface water sources of drinking water. In addition, GI/LID provides ground water recharge benefits.

GI/LID approaches are a set of management approaches and technologies that utilize and/or mimic the natural hydrologic cycle processes of infiltration, evapotranspiration and use. GI/LID practices include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, porous and permeable pavements, vegetated median strips, reforestation and revegetation and protection of riparian buffers and floodplains. These practices can be used almost anywhere soil and vegetation can be worked into the urban or suburban landscape. They include decentralized harvesting approaches such as rain barrels and cisterns that can be used to capture and re-use rainfall for watering plants or flushing toilets.

Other Social and Environmental Benefits:

- *Cleaner Air.* Trees and vegetation improve air quality by filtering many airborne pollutants and can help reduce the amount of respiratory illness (Vingarzan and Taylor, 2003).
- *Reduced Urban Temperatures.* Summer city temperatures can average 10ºF higher than nearby suburban temperatures (Casey Trees, 2007). High temperatures are also linked to higher ground level ozone concentrations. Vegetation creates shade, reduces the amount of heat absorbing materials and emits water vapor – all of which cool hot air (Grant, et al., 2003). Reductions in impervious surface and the use of light colored pervious surfaces (e.g., permeable concrete) also can mitigate urban temperatures.
- *Moderate the Impacts of Climate Change.* Climate change impacts and effects vary regionally, but GI/LID techniques can provide adaptation benefits for a wide array of circumstances. They can be used to conserve, harvest and use water, to recharge ground waters and to reduce surface water discharges that could contribute to flooding. In addition, there are mitigation benefits such as reduced energy demand and carbon sequestration by vegetation.
- *Increased Energy Efficiency.* Green space helps lower ambient temperatures and, when incorporated on and around buildings, helps shade and insulate buildings from wide temperature swings, decreasing the energy needed for heating and cooling. Diverting stormwater from wastewater collection, conveyance and treatment systems can reduce the amount of energy needed to pump and treat the water. Energy efficiency not only reduces costs, but also reduces generation of greenhouse gases.
- *Community Benefits.* Trees and plants improve urban aesthetics and community livability by providing recreational and wildlife areas. Studies show that property values are higher when trees and other vegetation are present. Increased green space also has public health benefits and has been shown to reduce crime and the associated stresses of urban living.

Figure 5. Rain water cistern.

C. APPLICABILITY AND DEFINITIONS

Applicability

1. Who is a "**Sponsor**" of a project?

Section 438 applies to the "**sponsor** of any development or redevelopment project involving a Federal facility . . ." Section 438 requires that the "sponsor . . . shall use . . . strategies for the property to maintain or restore . . . the predevelopment hydrology. . ." The "sponsor" should

generally be regarded as the federal department or agency that owns, operates, occupies or is the primary user of the facility and has initiated the development or redevelopment project. If the federal agency hires another entity to perform activities such as site construction or maintenance, the agency should nonetheless be regarded as the sponsor and be responsible to assure compliance with the requirements of Section 438. The agency sponsor is free to contract out various duties and responsibilities that are associated with achieving compliance.

2. What is a "**Federal facility**"?

Section 438 provides that its requirements apply to the "sponsor of any development or redevelopment project involving a **Federal facility** . . ." Section 401(8) of EISA states: "The term `Federal facility' means any building that is constructed, renovated, leased, or purchased in part or in whole for use by the Federal Government."

3. What is a **"footprint**"?

Section 438 applies to a federal facility "with a **footprint** that exceeds 5,000 square feet." For the purposes of this guidance, any project involving a federal facility that disturbs 5,000 square feet or more of ground area is covered by this guidance. Existing facilities that have an overall **footprint** of 5,000 square feet or greater that disturb less than 5,000 square feet of land area as part of any single development or redevelopment project are not subject to Section 438 requirements. Consistent with the purpose of Section 438 to preserve or restore pre-development hydrology, the term "footprint" includes all land areas that are disturbed as part of the project.

4. What is "**the property**"?

Section 438 provides that the project sponsor "shall use site planning, design, construction, and maintenance strategies for the **property** to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the **property."** This clause has been interpreted to mean that the land surrounding the project site is available to implement the appropriate GI/LID practices where optimal.

Although the performance requirements of EISA Section 438 apply only to the project footprint, the flexibility exists to utilize the entire federal property in implementing the stormwater strategies for the project.

Definitions

95th percentile rainfall event. The 95th percentile rainfall event represents a precipitation amount which 95 percent of all rainfall events for the period of record do not exceed. In more technical terms, the 95th percentile rainfall event is defined as the measured precipitation depth accumulated over a 24-hour period for the period of record that ranks as the 95th percentile rainfall depth based on the range of all daily event occurrences during this period.

The 24-hour period is typically defined as 12:00:00 am to 11:59:59 pm. In general, at least a 20-30 year period of rainfall record is recommended for such an analysis. This raw data is readily

available and collected by most airports across the county. Small rainfall events that are 0.1 of an inch or less are excluded from the percentile analysis because this rainfall generally does not result in any measureable runoff due to absorption, interception and evaporation by permeable, impermeable and vegetated surfaces. Many stormwater modelers and hydrologists typically exclude rainfall events that are 0.1 inch or less from calculations of rainfall events of any storm from their modeling analyses of rainfall event frequencies. See, for example, the Center for Watershed Protection's Urban Subwatershed Restoration Manual 3 (available at www.cwp.org).

Federal facility. The term "federal facility" means any buildings that are constructed, renovated, leased, or purchased in part or in whole for use by the federal government as defined in section 401(8) of the Energy Independence and Security Act.

Development or re-development. For the purposes of this provision this term applies to any action that results in the alteration of the landscape during construction of buildings or other infrastructure such as parking lots, roads, etc, (e.g., grading, removal of vegetation, soil compaction, etc.) such that the changes affect runoff volumes, rates, temperature, and duration of flow. Examples of projects that would fall under "re-development" include structures or other infrastructure that are being reconstructed or replaced and the landscape is altered. Typical patching or resurfacing of parking lots or other travel areas would not fall under this requirement.

D. TOOLS TO IMPLEMENT THE REQUIREMENTS OF SECTION 438

Section 438 of the Energy Independence and Security Act of 2007 reads as follows:

> **Section 438. Storm water runoff requirements for federal development projects.** The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.

The intention of EISA Section 438 is to preserve or restore the hydrology of the site during the development or redevelopment process. To be more specific, this requirement is intended to ensure that aquatic biota, stream channel stability, and historical aquifer recharge rates of receiving waters are not negatively impacted by changes in runoff temperature, volumes, durations and rates resulting from federal projects. A performance based approach was selected in lieu of a prescriptive requirement in order to provide site designers maximum flexibility in selecting control practices appropriate for the site.

To meet these performance objectives, technically feasible stormwater control practices that are effective in reducing the volume of stormwater discharge should be used. To implement EISA Section 438, this guidance recommends that the federal facility use all known, available and reasonable methods of stormwater retention and/or use to the maximum extent technically feasible (METF). Tools to implement the requirements of Section 438 are described below and illustrated in Figure 8.

Establishing Section 438 Performance Design Objectives

Described below are options site designers can use to comply with Section 438. There may be situations where Option 1 (retaining the 95th percentile rainfall event) is not protective enough to maintain or restore the predevelopment hydrology of the project (for example, in some headwater streams). In these cases, Option 2 (site-specific hydrologic analysis) could be used to determine the types of stormwater practices necessary to preserve predevelopment runoff conditions. Option 2 could also be used if predevelopment runoff conditions can be maintained by retaining less than the 95th percentile rainfall event. Because a performance based approach was selected in lieu of a prescriptive requirement in order to provide site designers maximum flexibility in selecting control practices appropriate for the site, Option 2 was provided in recognition that there are established methodologies that can be utilized to estimate the volume of infiltration and evapotranspiration based on site-specific hydrology and thus establish the predevelopment hydrology performance design objectives.

Option 1: Retain the 95th Percentile Rainfall Event

One approach to establishing the performance design objectives is to design, construct, and maintain stormwater management practices that manage rainfall onsite, and prevent the off-site discharge of the precipitation from all rainfall events less than or equal to the 95th percentile rainfall event to the maximum extent technically feasible (METF). This objective should be accomplished by the use of practices that infiltrate, evapotranspire and/or harvest and use rainwater. The 95th percentile rainfall event is the event whose precipitation total is greater than or equal to 95 percent of all storm events over a given period of record. For example, to determine what the 95th percentile storm event is in a specific location, all 24 hour storms that have recorded values over a 30 year period would be tabulated and a 95th percentile storm would be determined from this record, i.e., 5% of the storms would be greater than the number determined to be the 95th percentile storm. Thus the 95th percentile storm would be represented by a number such as 1.5 inches, and this would be the design storm (example 95th percentile storm events for selected cities are presented in Table 1). The designer would then select a system of practices, to the METF, that infiltrate, evapotranspire or harvest and use this volume multiplied by the total area of the facility/project footprint. Methods and data used to estimate the 95th percentile event are discussed in Part II of this document.

For the purposes of this guidance, retaining all storms up to and including the 95th percentile storm event is analogous to maintaining or restoring the pre-development hydrology with respect to the volume, flow rate, duration and temperature of the runoff for most sites. This 95th percentile approach was identified and recommended because this storm size represents the volume that appears to best represent the volume that is fully infiltrated in a natural condition and thus should be managed onsite to restore and maintain this pre-development hydrology for duration, rate and volume of stormwater flows. In general, only large storms generate significant runoff. In addition, this approach was identified because it employs natural treatment and flow attenuation methods that are presumed to have existed on the site before construction of infrastructure (e.g., building, roads, parking lots, driveways,) and is intended to infiltrate or evapotranspirate the full volume of the 95th percentile storm. Because this approach necessitates the use of practices that generally preclude extended detention, it will also typically address the

issue of maintaining predevelopment temperatures. However, in cases where there are discharges to cool water streams or other sensitive receiving waters, additional strategies may be needed to ensure that stormwater discharges do not result in greater thermal impacts than would occur in pre-development conditions (Schueler and Helfrich, 1988).

Where technically feasible, the goal of Option 1 is that one hundred percent (100%) of the volume of water from storms less than or equal to the 95th percentile event over the footprint of the project should not be discharged to surface waters. In some cases, runoff can be harvested and used and ultimately may be discharged to surface waters or a sanitary treatment system; such direct or indirect discharges must be authorized or allowed by the regulatory authority. For example, if runoff is captured for nonpotable uses such as toilet flushing or other uses that are not irrigation related, these waters potentially could be discharged into the sanitary sewer system. Preferred mechanisms for retaining discharges from storms greater than the 95th percentile event are through overflow or diversion for the volume that exceeds the 95th percentile amount. Because standard underdrains typically discharge from smaller storms as well, underdrain designs, if employed, should ensure adequate retention capacity for the 95th percentile event volume. For structures such as roofs and paved surfaces that can increase the temperature of stormwater runoff, materials that minimize temperature increases (e.g., concrete vs. asphalt; vegetated roofs) should be considered and used as appropriate.

Retaining 100 percent of all rainfall events equal to or less than the 95th percentile rainfall event was identified as Option 1 because small, frequently-occurring storms account for a large proportion of the annual precipitation volume, and the runoff from those storm events also significantly alters the discharge frequency, rate and temperature of the runoff.

Figure 6. Bioretention facility in Oregon.

The runoff produced by these small storms and the initial portion of larger storms has a strong negative cumulative impact on receiving water hydrology and water quality. In areas that have been developed, runoff is generated from almost all storms, both small and large, due to the impervious surfaces associated with development and the loss of soils and vegetation. In contrast, natural or undeveloped areas discharge little or no runoff from small storms because the rain is absorbed by the landscape and vegetation. Studies have shown that increases in runoff event frequency, volume and rate can be diminished or eliminated through the use of GI/LID designs and practices, which infiltrate, evapotranspire and capture and use stormwater.

Option 1 was identified because it is a simplified approach to meet the intent of Section 438 in contrast to Option 2 which requires the designer to conduct a hydrologic analysis of the site based on site-specific conditions.

Table 1. Example 95th Percentile Storm Events for Select U.S. Cities (adapted from Hirschman and Kosco, 2008).

City	95th Percentile Event Rainfall Total (in)	City	95th Percentile Event Rainfall Total (in)
Atlanta, GA	1.8	Kansas City, MO	1.7
Baltimore, MD	1.6	Knoxville, TN	1.5
Boston, MA	1.5	Louisville, KY	1.5
Buffalo, NY	1.1	Minneapolis, MN	1.4
Burlington, VT	1.1	New York, NY	1.7
Charleston, WV	1.2	Salt Lake City, UT	0.8
Coeur D'Alene, ID	0.7	Phoenix, AZ	1.0
Cincinnati, OH	1.5	Portland, OR	1.0
Columbus, OH	1.3	Seattle, WA	1.6
Concord, NH	1.3	Washington, DC	1.7
Denver, CO	1.1		

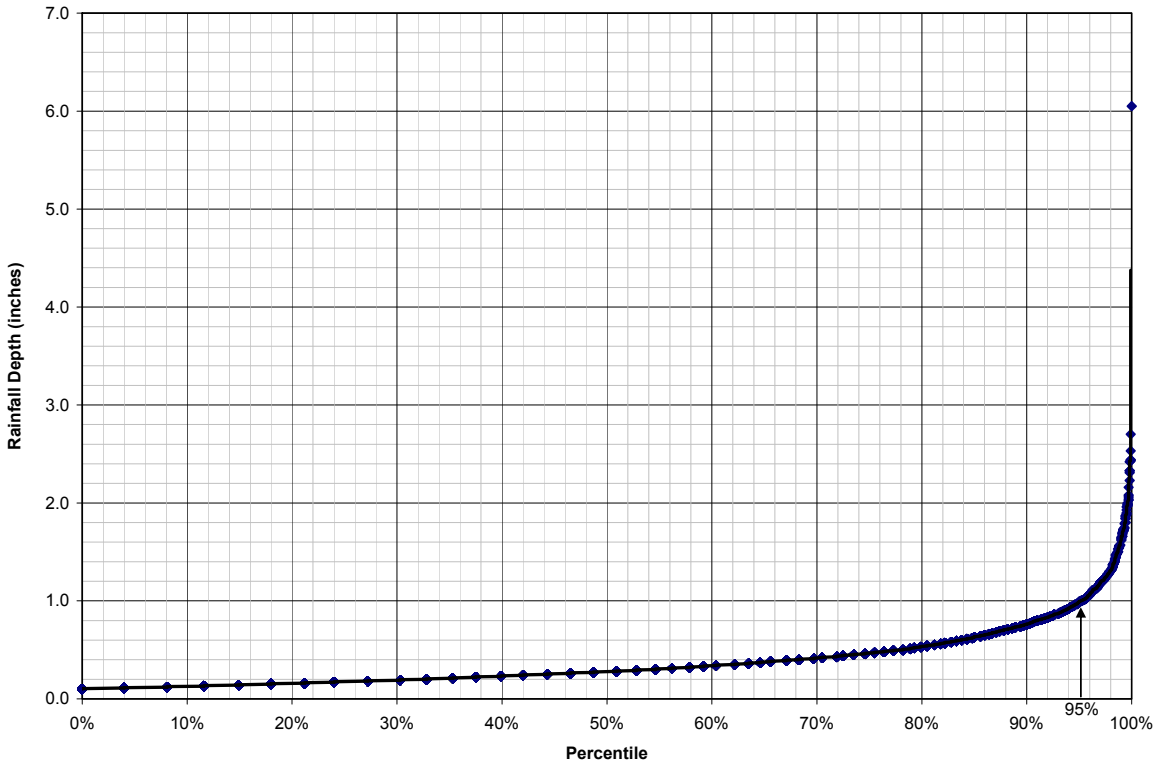


Figure 7. Rainfall Frequency Spectrum showing the 95th percentile rainfall event for Portland, OR (~1.0 inches)

Calculating the 95th Percentile Rainfall Event

Section E of this guidance contains information on how to calculate the 95th percentile rainfall event for a specific area. A long-term record of daily rainfall amounts (ideally, at least 30 years) is needed to calculate the 95th percentile rainfall.

Designers opting to use Option 1 need to do the following:

1) calculate or verify the precipitation amount from the 95th percentile storm event (this number would be typically expressed in inches, e.g., 1.5", and

2) employ onsite stormwater management controls to the METF that infiltrate, evapotranspire or harvest and use the appropriate design volume.

The 95th percentile event can be calculated by using the following procedures below (summarized from Hirschman and Kosco, 2008, *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program*, Center for Watershed Protection):

- Obtain a long-term rainfall record from a nearby weather station (daily precipitation is fine, but try to obtain at least 30 years of daily record). Long-term rainfall records can be obtained from many sources, including NOAA at http://cdo.ncdc.noaa.gov/pls/plclimprod/poemain.accessrouter?datasetabbv=SOD&countryabbv=&georegionabbv=.
- Remove data for small rainfall events that are 0.1 inch or less and snowfall events that do not immediately melt from the data set. These events should be deleted since they do not typically cause runoff and could potentially cause the analyses of the 95th percentile storm runoff volume to be inaccurate.
- Using a spreadsheet or simple statistical package, sort the rainfall events from highest to lowest. In the next column, calculate the percentage of rainfall events that are less than each ranked event (event number/total number of events). For example, if there were 1,000 rainfall events and the highest rainfall event was a 4" event, then 999 events (or a percentile of 999/1000, or 99.9%) are less than the 4" rainfall event.
- Use the rainfall event at 95% as the 95th percentile storm event.

Option 2: Site-Specific Hydrologic Analysis

Another approach to establishing the performance design objective is to design, construct, and maintain stormwater management practices that preserve the pre-development runoff conditions following construction. Option 2 allows the designer to conduct a site-specific hydrologic analysis to determine the pre-development runoff conditions instead of using the estimated volume approach of Option 1. Under Option 2, the pre-development hydrology would be determined based on site-specific conditions and local meteorology by using continuous simulation modeling techniques, published data, studies, or other established tools. If the designer elects to use Option 2, the designer would then identify the pre-development condition of the site and quantify the post-development runoff volume and peak flow discharges that are equivalent to pre-development conditions. The post-construction rate, volume, duration and

temperature of runoff should not exceed the pre-development rates and the predevelopment hydrology should be replicated through site design and other appropriate practices to the maximum extent technically feasible. These goals should be accomplished through the use of infiltration, evapotranspiration, and/or rainwater harvesting and use. Defensible and consistent hydrological assessment tools should be used and documented. Additional discussions of appropriate methodologies to use in assessing site hydrology have been included in the technical sections of this document. See, for example, the discussion of spreadsheet versions or curve numbers based on the Natural Resource Conservation Service Technical Release 55 (TR-55) Method in Appendix A of this document.

Development
The pre-development hydrologic condition of the site is the combination of runoff, infiltration and evapotranspiration rates and volumes that typically existed on the facility site before "development" on a greenfields site (meaning any construction of infrastructure on undeveloped land such as meadows or forests). In practice, determining the pre-development hydrology of a given site can be difficult if there is no suitable reference site. As a result, reference conditions for typical land cover types in the locality often are used to approximate what fraction of the precipitation ran off, soaked into the ground or was evaporated from the landscape. The use of reference conditions can be problematic if suitable data are not available or unique site conditions exist that do not fit within a typical land use cover type for the area, e.g., meadow or forest. In cases where suitable data from comparable conditions cannot be found or is otherwise inadequate to be used in conducting an Option 2 analysis for the specific area being considered for development or redevelopment, the project sponsor should use the Option 1 analytical framework.

Re-development
For re-development sites, existing site conditions and uses of the site can influence the amount of runoff that can be managed on site through infiltration, evapotransporation and harvest and use and thus the performance design objective. In these cases the design process in Figure 8 and Scenario 9 illustrate the decision processes that can be used.

In the context of some re-development projects, fully restoring predevelopment hydrology can be difficult to achieve and Congress recognized this potential difficulty by including the METF language in the statute. In these cases, Congressional intent can be best carried out by using a systematic METF analysis to determine what practices can be implemented at the site to maintain or store the hydrologic condition of the site. Scenarios 1-8 provide examples of METF analyses that demonstrate that pre-development hydrology can be achieved. Scenario 9 provides an example of an METF analysis that demonstrates that pre-development hydrology cannot be fully achieved and illustrates the extent to which pre-development hydrology can be restored.

Note: *It should also be emphasized that the performance based approach in Option 1 is intended to be a surrogate for determining the pre-development reference condition and this standard is intended to be used in cases where it is more practical, cost effective, and/or expeditious than Option 1, or where it is difficult or infeasible to identify the relevant reference conditions for the site.*

Determination of Maximum Extent Technically Feasible

Compliance with Section 438 requires that stormwater management measures are implemented to the maximum extent technically feasible (METF) to maintain or restore the pre-development hydrology conditions specifically with respect to temperature, rate, volume, and duration of flow.

Performance or design goals based on the pre-development hydrology can be established by using options such as the following: Retention of the 95th percentile rainfall event (Option 1), or through a site-specific hydrologic analysis that estimates the volume of infiltration, evapotranspiration or onsite stormwater harvesting and use based on site-specific hydrologic conditions (Option 2).

Technical Infeasibility

For projects where technical infeasibility exists, the federal agency or department sponsoring the project should document and quantify that stormwater strategies, such as infiltration, evapotranspiration, and harvesting and use have been used to the METF, and that full employment of these types of controls are infeasible due to site constraints. Some western states place restrictions on harvesting and use due to water rights, however, these requirements do not necessarily preclude the sponsor of the project from implementing strategies such as infiltration and evapotranspiration. Documentation of technical infeasibility should include, but may not be limited to, engineering calculations, geologic reports, hydrologic analyses, and site maps. A determination that the performance design goals cannot be met on site should include analyses that rule out the use of an adequate combination of infiltration, evapotranspiration, and use measures. Examples of where site conditions may prevent the full employment of appropriate management techniques to the METF include a combination of:

- The conditions on the site preclude the use of infiltration practices due to the presence of shallow bedrock, contaminated soils, near surface ground water or other factors such as underground facilities or utilities.
- The design of the site precludes the use of soil amendments, plantings of vegetation or other designs that can be used to infiltrate and evapotranspirate runoff.
- Water harvesting and use are not practical or possible because the volume of water used for irrigation, toilet flushing, industrial make-up water, wash-waters, etc. is not significant enough to warrant the design and use of water harvesting and use systems.
- Modifications to an existing building to manage stormwater are not feasible due to structural or plumbing constraints or other factors as identified by the facility owner/operator.
- Small project sites where the lot is too small to accommodate infiltration practices adequately sized to infiltrate the volume of runoff from impervious surfaces,
- Soils that cannot be sufficiently amended to provide for the requisite infiltration rates,
- Situations where site use is inconsistent with the capture and use of stormwater or other physical conditions on site that preclude the use of plants for evapotranspiration or bioinfiltration.
- Retention and/or use of stormwater onsite or discharge of stormwater onsite via infiltration has a significant adverse effect on the site or the down gradient water balance of surface waters, ground waters or receiving watershed ecological processes.

- State and local requirements or permit requirements that prohibit water collection or make it technically infeasible to use certain GI/LID techniques.
- Compliance with the Section 438 requirements would result in the retention and/or use of stormwater on the site such that an adverse water balance impact may occur to the receiving surface waterbody or ground water.

Please note that a single one of these characteristics is very unlikely to preclude meeting the performance standard, but a combination of factors may.

In cases where the facility has a defensible showing of technical infeasibility and can provide adequate documentation of site conditions or other factors that preclude full implementation of the performance design goal, the facility should still install stormwater practices to infiltrate, evapotranspire and/or harvest and use onsite the maximum amount of stormwater technically feasible. Note: Facilities must still comply with all other applicable federal, state and local requirements.

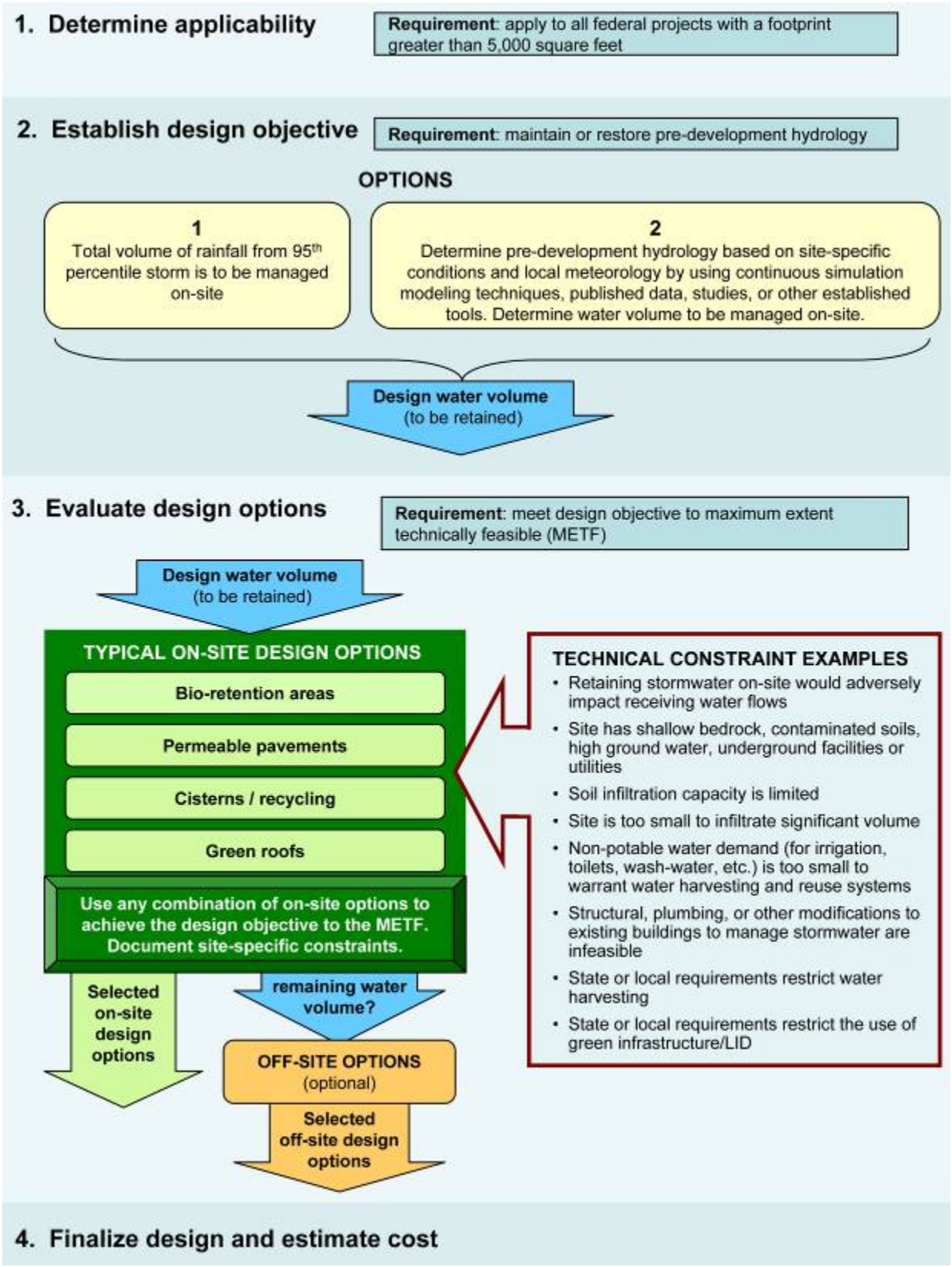


Figure 8. Section 438 Implementation Process

Documenting EISA Section 438 Implementation
Each agency or department is responsible for ensuring compliance with Section 438. It is recommended that: 1) the final design and as-built drawings of each facility shall be reviewed by a registered professional engineer and 2) the agency or department develop and maintain documentation of the following design criteria for each project subject to Section 438:

- Site evaluation and soils analysis
- Calculations for the 95th percentile rainfall event or the pre-development runoff volumes and rates to identify the volume of stormwater requiring management
- Documentation of modifications to the performance design objective based on technical constraints (site-specific METF determination)
- The site design and stormwater management practices employed on the site
- Design calculations for each stormwater management practice employed
- The respective volume of stormwater managed by each practice and the system as a whole
- Operations and maintenance protocols for the stormwater management system

The information should provide the necessary documentation and detail to demonstrate compliance and operation of stormwater management practices for the entire site.

Common Green Infrastructure/Low Impact Development Tools to Implement Section 438
Although Congress did not prescribe specific practices to be used to implement Section 438 it can be inferred that one of the goals of the Act was to promote the use of innovative stormwater management approaches, designs and practices that better protect receiving water quality, flow regimes and provide other important environmental benefits. GI/LID are preferred practices, to be supplemented with or replaced with conventional controls when site specific conditions dictate.

The GI/LID management approaches and technologies that federal agencies would typically use enhance and/or mimic the natural hydrologic cycle processes of infiltration, evapotranspiration, and use. Federal agencies can also use footprint reduction practices (e.g., building up instead of out) to reduce their stormwater impact. GI/LID approaches include biological systems and engineered systems. These include but are not necessarily limited to:

- Rain gardens, bioretention, and infiltration planters
- Porous pavements
- Vegetated swales and bioswales
- Green roofs
- Trees and tree boxes
- Pocket wetlands
- Reforestation/revegetation using native plants
- Protection and enhancement of riparian buffers and floodplains
- Rainwater harvesting for use (e.g., irrigation, HVAC make-up, non-potable indoor uses).

GI/LID practices are recommended to implement EISA Section 438 for the following reasons:
- cost savings in many cases

- overall environmental performance
- pollutant loading reduction capability
- pollution prevention focus
- effectiveness in managing runoff volumes and rates
- energy efficient and energy conservative
- appropriate in a wide range of site condition and locations
- appropriate for new development and redevelopment projects
- appropriate at multiple scales of development, e.g., site, neighborhood, region

For more information on specific GI/LID practices and how they function, visit: www.epa.gov/greeninfrastructure and www.epa.gov/nps/lid.

Figure 9. Disconnected downspout discharging to planter box.

Cost of Compliance

The cost of complying with Section 438 may require the use of approaches and techniques that initially may be more costly to design and implement. It is anticipated that as the expertise of the implementing agency or department increases and the demand for GI/LID materials and equipment increases that the overall costs of the projects will be lower or equivalent to the costs of constructing conventional stormwater practices. Initial studies conducted by EPA and others suggest that the use of GI/LID practices can be cost competitive. Recent evaluations of GI/LID projects have identified opportunities for cost savings because of reduced infrastructure and site preparation demands. In addition, longer term studies have indicated that GI/LID practices are continuing to gain cost efficiency as they are adopted more widely and with greater frequency thus reducing overall implementation costs.

In *Reducing Stormwater Costs through LID Strategies and Practices* (EPA 841-F-07-006, December 2007 - available for download at www.epa.gov/nps/lid), EPA examined 17 case studies in which conventional development costs were compared to GI/LID costs. In the great majority of cases, the GI/LID approach was between 15 and 80 percent less expensive than conventional control measures because implementation of GI/LID practices can offset costs of conventional construction and stormwater management approaches. Significant cost savings that were identified in the report include:

- Elimination or reduction of detention ponds
- Elimination or reductions of stormwater and CSO treatment and conveyance systems such as pipes, storage structures, stormwater treatment devices, and other related stormwater infrastructure
- Narrower streets with reduced material demands

- Fewer square yards of sidewalks
- Reduced land purchases for stormwater control structures

In addition, other benefits were achieved through the use of GI/LID such as more beneficial uses of land previously dedicated to stormwater devices, increased livability and higher property values.

There are many different combinations of practices that can be employed at particular sites to achieve pre-development hydrology. In selecting the appropriate set of practices to be used at the site, project sponsors should consider a broad range of factors, including cost-effectiveness of particular combinations of practices as applied to the site, as well as the potential for ancillary cost savings or community benefits (e.g., elimination or reduction of infrastructure costs, or the creation of attractive green spaces). EPA encourages project sponsors to include these factors in the planning and design phases of their projects so as to maximize triple bottom-line (economic, environmental, and social) results.

E. Calculating the 95TH Percentile Rainfall Event

A long period of precipitation records, i.e., a minimum of 10 years of data, is needed to determine the 95th percentile rainfall event for a location. Thirty years or more of monitoring data are desirable to conduct an unbiased statistical analysis. The National Climatic Data Center (NCDC) provides long-term precipitation data for many locations of the United States. You can download climate data from their Web site (www.ncdc.noaa.gov) or by ordering compact discs (NOTE: The NCDC charges a fee for access to their precipitation data). Local airports, universities, water treatment plants, or other facilities might also maintain long-term precipitation records. Data reporting formats can vary based on the data sources. In general, each record should include the following basic information:

- Location (monitoring station)
- Recording time (usually the starting time of a time-step)
- Total precipitation depth during the time-step

In addition to the above information, a status flag is sometimes included to indicate data monitoring errors or anomalies. Typical NCDC flags include A (end accumulation), M (missing data), D (deleted data), or I (incomplete data). If there are no flags, the record has passed the quality control as prescribed by the NCDC and has been determined to be a valid data point.

There are several data processing steps to determine the 95th percentile rainfall event using a spreadsheet. These steps are summarized below:

1. Obtain a long-term 24-hr precipitation data set for a location of interest (i.e., from the NCDC website).

2. Import the data into a spreadsheet. In MS Excel [Data / Import External Data / Import Data]

3. Rearrange all of the daily precipitation records into one column if the original data set has multiple columns of daily precipitation records.

	A	B	C	D
1	Date	Prcp		
2	1/2/1921	0.05		
3	1/3/1921	0		
4	1/4/1921	0		
5	1/5/1921	0.33		
6	1/6/1921	0.08		
7	1/7/1921	0.08		
8	1/8/1921	0.19		
9	1/9/1921	0		

4. Review the records to identify if there are early periods with a large number of flagged data points (e.g., erroneous data points). Select a long period of good recording data that represents, ideally, 30 years or more of data. Remove all of the extra data (if not using the entire dataset).

5. Remove all flagged data points (i.e., erroneous data points) from the selected data set for further analysis.

6. Remove small rainfall events (typically less than 0.1 inches), which may not contribute to rainfall runoff. These small events are categorized as depressional storage, which, in general, does not produce runoff from most sites.

	A	B	C	D
1	Date	Prcp		
2	1/5/1921	0.33		
3	1/8/1921	0.19		
4	1/14/1921	1.04		
5	2/6/1921	0.12		
6	2/11/1921	0.63		
7	2/20/1921	1.33		
8	2/28/1921	0.43		
9	3/3/1921	0.13		

Note: Steps 4 through 6 can be processed by applying data sort, delete and re-sort spreadsheet functions. In MS Excel [Data / Sort]

7. Calculate the 95th percentile rainfall amount by applying the PERCENTILE spreadsheet function at a cell. In MS Excel [=PERCENTILE(precipitation data range,95%)]

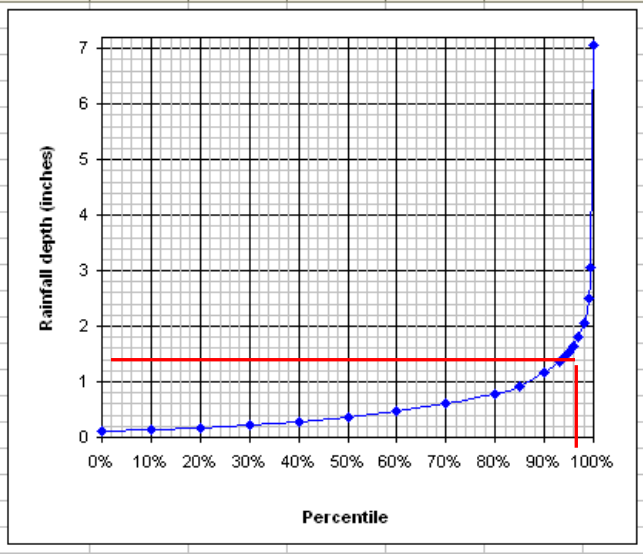
	A	B	C	D	E	F
1	Date	Prcp				
2	1/5/1921	0.33		=PERCENTILE(B:B,95%)		
3	1/8/1921	0.19		1.52		
4	1/14/1921	1.04				
5	2/6/1921	0.12				
6	2/11/1921	0.63				
7	2/20/1921	1.33				
8	2/28/1921	0.43				

Note: The PERCENTILE function returns the nth percentile of value in the entire precipitation data range. This function can be used to determine the 95th percentile storm event that captures all but the largest 5% of storms.

8. The 95th percentile was calculated in the previous step. However, if the user would like to see this information represented graphically and get a relative sense of where individual storm percentiles fall in terms of rainfall depths, the following methodology can be used. Derive a table showing percentile versus rainfall depth to draw a curve as shown below. The PERCENTILE spreadsheet function can be used for each selected percent. It is recommended to include at least 6 points between 0% and 100% (several points should be between 80% and 100% to draw an accurate curve).

	A	B	C	D	E	F	G
1	Date	Prcp		Percentile	Rainfall		
2	1/5/1921	0.33		0%	=PERCENTILE(B:B,D2)		
3	1/8/1921	0.19		10%	=PERCENTILE(B:B,D3)		
4	1/14/1921	1.04		20%	=PERCENTILE(B:B,D4)		
5	2/6/1921	0.12		30%	=PERCENTILE(B:B,D5)		
6	2/11/1921	0.63		40%	=PERCENTILE(B:B,D6)		

	A	B	C	D	E
1	Date	Prcp		Percentile	Rainfall
2	1/5/1921	0.33		0%	0.1
3	1/8/1921	0.19		10%	0.13
4	1/14/1921	1.04		20%	0.17
5	2/6/1921	0.12		30%	0.22
6	2/11/1921	0.63		40%	0.28
7	2/20/1921	1.33		50%	0.36
8	2/28/1921	0.43		60%	0.46
9	3/3/1921	0.13		70%	0.6
10	3/9/1921	0.31		80%	0.79
11	3/13/1921	0.46		85%	0.93
12	3/25/1921	0.47		90%	1.16
13	3/28/1921	0.12		93%	1.35
14	4/1/1921	0.36		94%	1.44
15	4/9/1921	0.69		95%	1.52
16	4/15/1921	0.24		96%	1.65
17	4/17/1921	0.32		97%	1.82
18	4/18/1921	0.55		98%	2.068
19	4/23/1921	0.69		99%	2.508
20	4/24/1921	0.19		99.5%	3.049
21	4/30/1921	1.44		100%	7.06



Use the spreadsheet software to create of plot of rainfall depth versus percentile, as shown above. The 95th percentile storm event should correlate to the rainfall depth calculated in step 7, however the graph can be used to calculate rainfall depths at other percentiles (e.g., 50%, 90%).

Part II: Case Studies on Capturing the 95th Percentile Storm Using Onsite Management Practices

INTRODUCTION

This section contains nine case studies that are intended to be representative of the range of projects that are subject to the requirements legislated in Section 438 of the Energy Independence and Security Act. The facility examples in the case studies were selected to illustrate project scenarios for differing geographic locations, site conditions, and project sizes and types. As noted in Part I, all projects with a footprint greater than 5,000 square feet must comply with the provisions of Section 438. What this means is that both new development and redevelopment projects should be designed to infiltrate, evapotranspirate, and/or harvest and use runoff to the maximum extent technically feasible (METF) to maintain or restore the pre-development hydrology of the site. Scenarios 1-8 are examples of sites where it was technically feasible to design the stormwater management system to retain the 95th percentile storm onsite. Scenario 9, however, was provided as an example of an METF analysis where site constraints allowed the designers to retain only 75% of the 95th percentile storm.

Given the site-specific nature of individual projects, the case study scenarios described herein do not include site specific design features such as runoff routing, specific site infiltration rates, the structural loading capacity of buildings, etc. in terms of stormwater practice selection.

It should be noted that an example of Option 2, which requires a site-specific hydrologic analysis, has not been provided in this document because of the complexity of factors and the lack of general applicability such an analysis would have.

Background

Numerous approaches exist for determining the volume of runoff to be treated through stormwater management. Retaining stormwater runoff from all events up to and including the 95th percentile rainfall event was identified as Option 1 because small, frequently-occurring storms account for a large proportion of the annual precipitation volume. Using GI/LID practices to retain both the runoff produced by small storms and the first part of larger storms can reduce the cumulative impacts of altered flow regimes on receiving water hydrology, e.g., channel degradation and diminished baseflow. For the purposes of this guidance, retaining all storms up to and including the 95th percentile storm event is analogous to maintaining or restoring the pre-development hydrology with respect to the volume, flow rate, duration and temperature of the runoff for most sites.

Determination of the 95th Percentile Rainfall Event

The 95th percentile rainfall rainfall event was determined using the long-term daily precipitation records from the National Climate Data Center (NCDC, 2007). By analyzing the frequency and rainfall depths from daily rainfall records over 24-hour periods, the 95th percentile storm event can be determined. From a frequency analysis viewpoint, the 95th percentile event is the storm event that is greater than or equal to 95% of all storms that occur within a given period of time. Regional climate conditions and precipitation vary across the U.S. Because of local values, it is essential that the implementing agency or department establish the 95th percentile storm event for

the project site since the control volume may vary depending on local weather patterns and conditions.

Onsite Stormwater Management Practice Determinations

For the purposes of the case study scenarios, the following four categories of practices were selected as the most appropriate practices for implementing Section 438 requirements: bioretention, permeable pavements and pavers, cisterns, and green roofs. These practices were selected based on known performance data and cost. For each case study, the same hierarchy of selection criteria was used, i.e., the most cost effective practices were considered before other practices were considered. Bioretention practices were considered first because these systems generally have the lowest cost per unit of stormwater treated (Hathaway and Hunt, 2007). Thus, if the bioretention system could not be designed to adequately capture the desired runoff volume, permeable pavement and pavers, cisterns, and green roofs were considered in that order based on relative cost. In most cases a combination of practices was selected as part of an integrated treatment system. It should be noted that all treatment systems were designed to accomplish the goal of capturing the 95th percentile rainfall event onsite. Examples of onsite stormwater management practices selected for each site are presented in the results section. For the Boston, MA site, it was assumed that bioretention was not feasible in order to simulate a situation where space was severely limited; as a result, interlocking modular pavers were selected as the most cost-effective stormwater management to capture the requisite design volume. To further illustrate the range of site conditions designers may encounter, and how site conditions impact the selection of appropriate control options, Scenario #3 (Cincinnati, OH) was re-analyzed as Scenario #8. In Scenario #8, it was assumed that the site had clay soils and low infiltrative capacity. Given these site conditions, the range of potential control options was more limited and a combination of modular paving blocks, a green roof, and cisterns was ultimately selected based on cost and site suitability factors.

For purposes of these modeling exercises, a number of assumptions were associated with each category of practice. These assumptions are not necessarily an endorsement of a particular design paradigm, but rather were used to keep a somewhat conservative cap on the scenarios in order to demonstrate the feasibility of the approach. For example, bioretention retrofits can and should often be located in prior impervious locations; however, in all modeled scenarios bioretention was restricted to currently landscaped areas. The assumptions were:

- **Bioretention areas**: On-lot retention of stormwater through the use of vegetation, soils, and microbes to capture, treat and infiltrate runoff.

  It is assumed bioretention practices would be installed within currently landscaped pervious areas or that pervious areas would be created for bioretention cells. While termed bioretention, these systems are designed to provide infiltration as well as temporary storage. Bioretention areas would be designed to accept up to a depth of 10 inches of water across the surface of the bioretention cell (see Appendix A). The conceptual design of this storage depth would occur within the media and/or could be included as ponded storage. Further design storage beyond the 10 inches would be acceptable (and encouraged) above the media on a site-by-site basis with ponded depth generally not to exceed 12 inches.

Uniform infiltration was assumed across the entire base of the bioretention cell. No additional media underneath the amended soils were included in the designs with infiltration rates in this layer governed by the *in situ* soils. Underdrains were not modeled directly but could be applied at the point of storage overflow such that no overflow occurs until the design depth of 10 inches is saturated. This approach was selected to maximize the storage and infiltration benefits of these systems. Designs utilizing underdrains at the base of the bioretention cell do not store the requisite volumes because the media is permeable and the underdrain conveys the runoff offsite through the underdrain before it can be infiltrated. Because standard underdrains typically discharge from smaller storms as well, underdrain designs, if employed, should ensure adequate retention capacity for the 95th percentile event volume.

The bioretention footprint for modeling purposes was calculated as one uniform area that did not include side slopes. There is an expectation that actual bioretention cell construction would be distributed throughout the site with targeted locations based on hydrology (natural flow paths) and soils with greater infiltrative capacity. Side slopes may increase the surface excavation area required to accommodate the footprint and freeboard of these systems depending on the design or the bioretention system.

- **Porous/permeable pavement**: Transportation surfaces constructed of asphalt, concrete or permeable pavers that are designed to infiltrate runoff.

  Infiltration was modeled for the entire porous pavement area with drainage pipes used only as overflow outlets. This design was chosen to maximize infiltration capabilities of the system. While many types of porous pavement systems can be used, modular block type pavers were generally applied in this design category under the assumption that they typically include sufficient volumetric storage in the media layer. [Note: Other types of porous pavement applications are available that support heavy loads and can be designed to temporarily store and infiltrate runoff beneath the surface of the pavement.]

  For these systems, an equivalent of 2 inches of design storage depth was assumed. This design depth could be achieved by specifying 10 inches of media depth that had 20% void space. Similarly, this could be achieved by designing six inches of media depth above the bottom surface, with specified media containing 33% void space. This alternative would have the overflow outlet at the 6 inch depth providing an equivalent water storage depth of 2 inches.

  The soils under the paver blocks may require or be subjected to some compaction for engineering stability. As a result, infiltration into underlying soils was modeled conservatively by applying the minimum infiltration rate for each soil type (see Appendix A).

  Generally, porous pavement is not recommended for high traffic areas or loading bays Because of this the scenarios assumed that only a percentage of total parking and road areas on a site can be converted to porous pavement. The assumed maximum percentage

applied in the scenarios was set at 60% of the total paved area. Guidance on porous pavements is available at: http://cfpub.epa.gov/npdes/greeninfrastructure/technology.cfm#permpavements

- **Cistern**: Containers or vessels that are used to store runoff for future use.

  Cisterns were modeled in cases where green roofs were not feasible or where it was necessary to include additional storage volume to meet the goal of onsite rainfall runoff capture. The sizes of cisterns would be calculated based on site-specific rainfall, site-specific spatial and structural conditions, use opportunities and rates, and consideration of cost per volume of storage. For simplicity, cistern volume was reported as a total volume. This total volume could be subdivided into any number of cisterns to provide the total necessary storage but should be based on the impervious area and runoff quantities which will flow to the cistern. The most efficient cost per volume storage would need to be considered on a site-by-site basis (see Appendix A).

- **Green roof**: Roof designed with light weight soil media and planted with vegetation.

  Frequently, green rooftop area is limited by structural capacity. In addition, other rooftop equipment may need to be accommodated in this space including HVAC systems and air handlers. For this reason, and to provide a somewhat conservative rate of application, it was assumed for these modeling analyses that up to 30% of a roof's impervious area could be converted into a green roof. Green roof area was assumed to have 1 inch of total effective stormwater storage, i.e., a 2.5 inch media depth with 40% void space (see Appendix A).

General Approach

Using site aerial photos, spatial analysis should be conducted to estimate the land cover types and areas for each site. The surface conditions of each site can be digitized using geographic information systems (GIS) techniques. Alternatively, computer-aided design (CAD) drawings can be used to estimate the surface area of each land cover type. The schematic in Figure 10 illustrates the processes used for selecting and determining the overall size of stormwater management practices for each site.

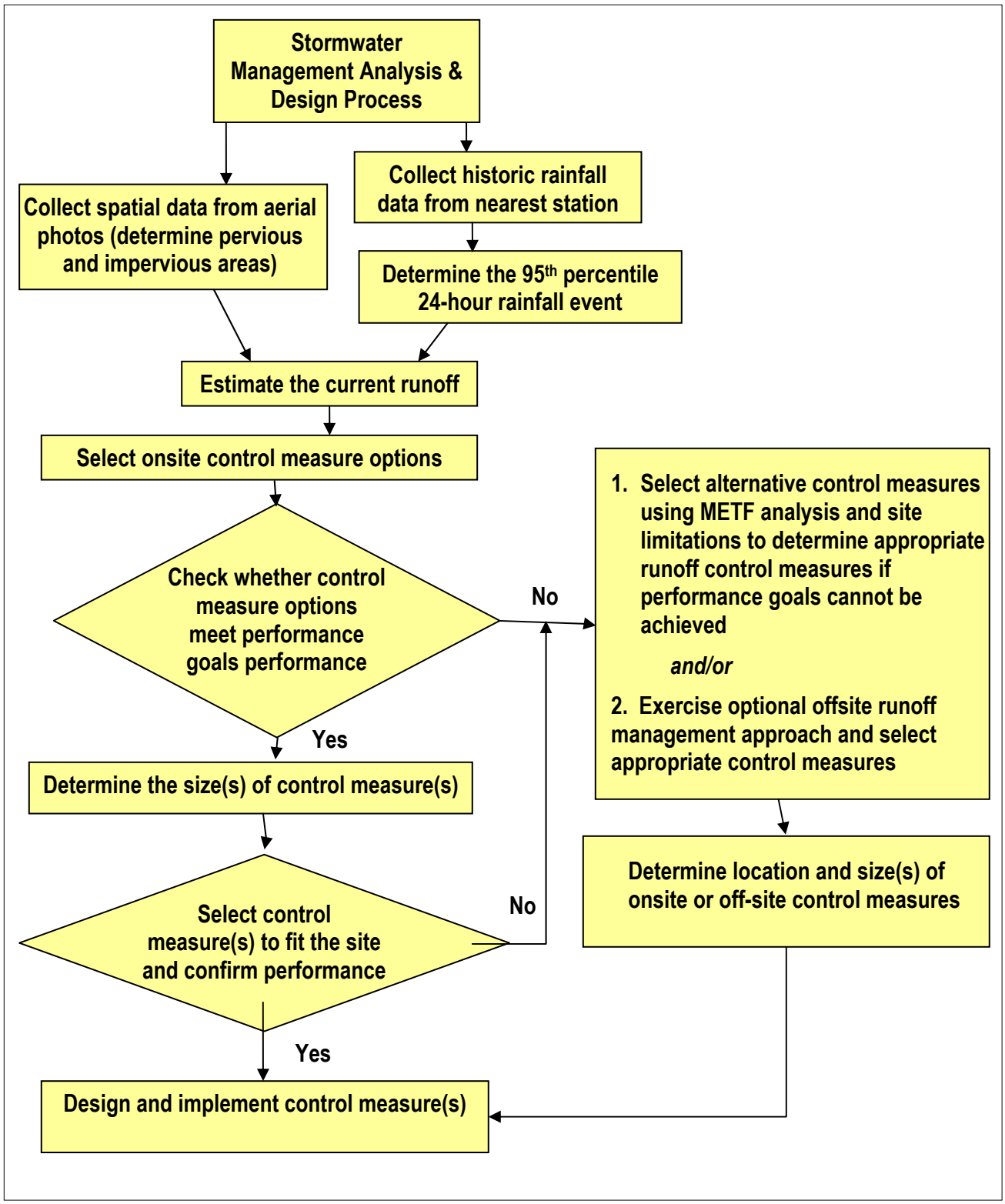


Figure 10. Flow chart depicting the process for determining control measures using the 95th percentile, 24-hour, annual rainfall event.

The following steps provide more detailed information on acquiring and calculating the necessary data to complete the processes indicated in Figure 10. This methodology was used in the scenario analyses that follow.

Collecting spatial data for a site

1. Collect an aerial orthophotograph for the desired site.
2. Digitize land use/land cover conditions using GIS techniques. If CAD drawings of the site exist, they can be used to estimate land cover area (pervious, impervious).
3. Categorize the digitized or planned land use/land cover based on surface hydrologic conditions, e.g., rooftop, pavement, and pervious/landscaped area.
4. Estimate the size of each land use/land cover category (by polygon).

Determining the 95th percentile, 24-hr rainfall event

1. Obtain a long-term 24-hr precipitation data set for the location of interest (i.e., from the NCDC Web site or other source).
2. Import the data into a spreadsheet. *In MS Excel* [Data / Import External Data / Import Data]
3. Rearrange all of the daily precipitation records into one column if the original data set has multiple columns of daily precipitation records.
4. Remove all flagged data points (i.e., erroneous data points) from the selected data set for further analysis.
5. Remove small rainfall events (typically less than 0.1 inches) that may not contribute to rainfall runoff. These small storms often produce little if any appreciable runoff from most sites and for modeling purposes are typically considered as volume captured in surface depression storage.
6. Calculate the 95th percentile rainfall volume by applying the PERCENTILE spreadsheet function to a range of data cells. The PERCENTILE function returns the nth percentile value in the specified precipitation data range. This function can be used to determine the 95th percentile storm event that captures all but the largest 5% of storms. *In MS Excel* [PERCENTILE(precipitation data range,95%)]

Estimating Current Runoff and Placing onsite control measures to capture the 95th percentile rainfall event

1. Collect spatial data for a site, e.g., rooftop, pavement, and pervious areas as above.
2. Check soil type (USDA mapping, borings, or onsite testing) for the site to determine infiltration parameters. For this modeling, many of the assumptions that pertain to generalized soils groups and their infiltration properties come from the EPA Stormwater Management Model (SWMM 4.x) manual (see Appendix A).
3. Determine the current runoff volume that would occur during a 24 hour period by applying the 95th percentile rainfall to the existing site conditions (land use and soil properties) as above using a hydrologic model (such as TR-55 or SWMM). For this analysis, it is assumed that the rainfall amount is distributed over a 24 hour period. Actual rainfall event duration (and intensity) was not considered for determining rainfall runoff (however, timing was considered when modeling infiltration).
4. Determine flow paths so that management practice placements are in locations where flows can be intercepted and routed to practices. Because this is a site specific effort and may require detailed topographic information or further surveys this would be a task to be

completed onsite and therefore is not included as a part of the modeling scenario exercise.

5. Select onsite control practices to capture the current 95th percentile runoff event; base the selection of appropriate options on site conditions, areas available for treatment options, and other factors such as site use and other constraints.

Note: The steps above have been generalized for the purposes of this guidance. It is recommended that a qualified professional engineer determine or verify that stormwater management practices are sized, placed, and designed correctly. It should also be noted that the methodology to determine rainfall amount used a 24 hour time period based on daily records. Actual rainfall events may have occurred over shorter or longer time periods. Similarly, for modeling purposes, the 24 hour rainfall amount was distributed to pervious and impervious areas (and management practices) as a uniform event occurring during a 24-hour period. A large dataset (greater than 50 years) was used to reasonably represent rainfall depth on a daily bases. It stands to reason that more frequent, shorter duration precipitation events are better represented than less frequent, longer duration precipitation events.

Scenarios

Eight locations were selected for the 9 case studies as shown in Figure 11 and Table 2. Case study numbers 3 and 8 were both developed based on the Cincinnati, Ohio facility, although the site parameters were altered to represent differing site conditions and design constraints. Annual average rainfall depths for these locations range from 7.5 inches to 48.9 inches. Analyses of the 95th percentile rainfall events for these locations produced rainfall depths that range from 1.00 inch to 1.77 inches (Table 2).

Figure 11. Locations for Analyzing Onsite Control Measures.

The government facilities in the 8 case study locations were selected because they represent generic sites from the major climatic regions of the U.S. These facilities also were selected because the sites have a range of site characteristics that can be used to illustrate different site designs and stormwater management options, e.g., pervious, roof, and pavement areas (Table 3). Site sizes ranged from 0.7 to 27 acres with percent site imperviousness area ranging from 47% to 95% of the site. Aerial photos of the sites are included along with site specific rainfall runoff and soil results.

Table 2. Summary of Rainfall Data for the Seven Locations.

No	Location	NCDC Daily Precipitation Data		Rainfall Depth (inches)	
		Period of record	Coverage	Annual average	95th percentile rainfall event
1	Charleston, WV	1/1/1948 - 12/31/2006 (59 yrs)	99%	43.0	1.23
2	Denver, CO	1/1/1948 - 12/31/2006 (59 yrs)	96%	15.2	1.07
3	Cincinnati, OH	1/1/1948 - 12/31/2006 (59 yrs)	96%	36.5	1.45
4	Portland, OR	1/1/1941 - 12/31/2006 (66 yrs)	98%	35.8	1.00
5	Phoenix, AZ	1/1/1948 - 12/31/2006 (59 yrs)	99%	7.5	1.00
6	Boston, MA	1/1/1920 - 12/31/2006 (87 yrs)	99%	41.9	1.52
7	Atlanta, GA	1/1/1930 - 12/31/2006 (77 yrs)	100%	48.9	1.77
8	Norfolk, VA	1/1/1957 - 12/31/2006 (50 yrs)	99%	45.4	1.68

The results of the spatial analyses were summarized and divided into three land cover categories; rooftop, pavement, and pervious area, as shown in Table 3.

Table 3. Summary of Land-use Determinations of the Study Sites.

No	Location	Facility Spatial Info (acres)				Site Imperviousness
		Rooftop	Pavement	Pervious	Total	
1	Charleston, WV	0.1	0.4	0.2	0.7	73%
2	Denver, CO	0.5	1.9	2.0	4.5	55%
3	Cincinnati, OH	1.6	8.0	9.4	19	51%
4	Portland, OR	8.8	16.9	1.3	27	95%
5	Phoenix, AZ	0.2	0.7	1.1	2	47%
6	Boston, MA	0.9	1.5	1.1	3.5	69%
7	Atlanta, GA	3.9	10.8	6.2	21	70%
8	Norfolk, VA	0.9	0.55	0.15	1.6	91%

Methods for Determining Runoff Volume

Direct Determination of Runoff Volume

Runoff from each land cover was estimated using a simplified volumetric approach based on the following equation:

$$Runoff = Rainfall - Depression\ Storage - Infiltration\ Loss$$

Again, this methodology does not consider routing of runoff; therefore slope is not considered when calculating on a volumetric basis.

Infiltration loss is calculated only in pervious areas (e.g., there is no infiltration in impervious areas). In this analysis, infiltration was estimated using Horton's equation:

$$F_t = f_{min} + (f_{max} - f_{min})\, e^{-k\,t}$$

where, F_t= infiltration rate at time t (in/hr)
f_{min} = minimum or saturated infiltration rate (in/hr)
f_{max} = maximum or initial infiltration rate (in/hr)
k = infiltration rate decay factor (/hr) and
t = time (hr) measured from time runoff first discharged into infiltration area

Infiltration loss for the 24-hr rainfall duration was estimated by the following equation with assumptions of a half hour Δt and uniform rainfall distribution in time:

$$Infiltration\ Loss = \sum (f \cdot \Delta t)$$

To more accurately describe the dynamic process of infiltration associated with Horton's equation, infiltration loss was integrated over a 24-hour period using a half hour time step while applying the maximum and minimum infiltration rates (in/hr) with time using the appropriate soil decay factor. The results of this process are further illustrated in Appendix A.

Once runoff from each land cover was estimated, the total runoff from a site can be obtained using an area-weighted calculation as shown below:

$$Runoff_{site} = \{(Runoff_{roof} \times A_{roof}) + (Runoff_{pavement} \times A_{pavement}) + (Runoff_{pervious} \times A_{pervious})\} / A_{site}$$

Where $Runoff_{site}$ = total runoff from the site (inches); A_{site} = site area (acres); $Runoff_{roof}$ = runoff from rooftop (inches); A_{roof} = rooftop area (acres); $Runoff_{pavement}$ = runoff from pavement area (inches); $A_{pavement}$ = pavement area (acres); $Runoff_{pervious}$ = runoff from pervious area (inches); and $A_{pervious}$ = pervious area (acres).

An example demonstrating how to calculate runoff by applying the Direct Determination method is presented below using the Charleston, WV (Scenario #1) site condition presented in Tables 2 and 3.

$Runoff_{roof}$ = 95th *Rainfall – Depression Storage*
= 1.23 – 0.1 = 1.13 inches

$Runoff_{pavement}$ = 95th *Rainfall – Depression Storage*
= 1.23 – 0.1 = 1.13 inches

$Runoff_{pervious}$ = 95th *Rainfall – Depression Storage – Infiltration Loss*
= 1.23 – 0.1 – 9.73 = 0 inches (i.e., no runoff because the result is a negative number)

$$Runoff_{site} = \{(Runoff_{roof} \times A_{roof}) + (Runoff_{pavement} \times A_{pavement}) + (Runoff_{pervious} \times A_{pervious})\} / A_{site}$$
$$= \{(1.13 \times 0.10) + (1.13 \times 0.41) + (0 \times 0.19)\} / 0.7 = 0.82 \text{ inches}$$

Infiltration loss was estimated based on soil type B by applying the Horton equation as described above. Because the volume removed from surface runoff through infiltration was substantial, no runoff occurred from the pervious area.

In cases where sites had limited physical space available for stormwater management, a series of practices was used (e.g., treatment train) to simulate the runoff and infiltrative behavior of the system. For example, if there was inadequate area and infiltrative capacity to infiltrate 100 percent of the 95th percentile storm event within a bioretention system another onsite management practice was selected to manage the runoff that could provide the necessary capacity. In this manner, excess runoff was routed to another management practice in the series of treatment cells where possible.

Two types of soils were considered for every site: hydrologic soil group B and C (except for scenario 8 in which hydrologic soil group D was used). Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and either loamy sand or sandy loam textures with some loam, silt loam, silt, or sandy clay loam soil textures placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam soil textures with some clay, silty clay, or sandy clay textures placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments (USDA-NRCS, 2007). The application of these hydrologic soil groups was intended to give reasonable and somewhat conservative estimates of infiltration capacity.

General hydrologic parameters in this analysis were assumed as follows (see Appendix A for citations of assumptions):

- Depression storage (or initial abstraction)
    - Rooftop: 0.1 inches
    - Pavement: 0.1 inches
    - Pervious area: 0.2 inches

- Horton Infiltration parameters
    - Hydrologic Soil Group B
        - Maximum infiltration rate: 5 in/hr
        - Minimum infiltration rate: 0.3 in/hr
        - Decay factor: 2 /hr
    - Hydrologic Soil Group C
        - Maximum infiltration rate: 3 in/hr
        - Minimum infiltration rate: 0.1 in/hr
        - Decay factor: 3.5 /hr

- Design storage assumptions of control measures
    - Bioretention: up to 10 inches (but variable based on balancing necessary storage volume, media depth for plant survivorship, and surface area limitations)
    - Green roof: 1 inch (2.5 inches deep media with 40% void space)
    - Porous pavement: 4 inches (10 inches deep media with 40% void space)

Other Methods for Estimating Runoff Volume

Runoff from a site after applying the 95th percentile storm can be estimated by using a number of empirical, statistical, or mathematical methods. Several methods were considered in this analysis. The Rational Method can be used to estimate peak discharge rates and the Modified Rational Method can be used to develop a runoff hydrograph. The NRCS TR-55 model can be used to predict runoff volume and peak discharge. TR-55 can also be used to develop a runoff hydrograph. The EPA Stormwater Management Model (SWMM) can be used to simulate rainfall-runoff, pollutant build-up and wash-off, transport-storage-treatment of stormwater flow and pollutants, backwater effects, etc. for a wide range of temporal and spatial scales. The SWMM model can be fit to model a small site with a distributed system. Hydrologic Simulation Program – Fortran (HSPF, USDA) is a watershed and land use based lumped model that can be used to compute the movement of water and pollutants when evaluating the effects of land use change, reservoir operations, water quality control options, flow diversions, etc. In general, regionally calibrated modeling parameters are incorporated into HSPF. QUALHYMO is a complete hydrologic and water quality model, which can be used to factor in snowmelt or soil moisture conditions or to simulate system behavior based on infiltration and ET, ground water storage tracking, baseflow and deep volumetric losses, and other variables.

Many of the existing tools for analyzing distributed systems use some part or all of the principles or formulae of the modeling approaches highlighted above. For example, the Emoryville spreadsheet control measure model (Emoryville, CA) uses a runoff coefficient (i.e., Rational Method) for analyzing lot-level to neighborhood-scale control measure sizing. The Green Calculator (Center for Neighborhood Technologies) estimates the benefit of onsite GI/LID options on a neighborhood-scale by applying the curve numbers (i.e., TR-55) and the Modified Rational Method. The Northern Kentucky Spreadsheet Tool uses a TR-55 based approach for control measure sizing on neighborhood or site level spatial scales. The WWHM (Western Washington Hydrology Model) is a regionally calibrated HSPF model intended for use in sizing stormwater detention and water quality facilities to meet the Washington State Department of Ecology standards. WBM-QUALHYMO is a Canadian model used in conjunction with the Water Balance Model (WBM). This model can be used to continuously simulate stormwater storage routing, stream erosion, drainage area flow routing, and snowmelt runoff (and ultimately freeze-thaw). Table 4 contains a summary of these different methods based on generic modeling features.

Table 4. Potential Methods for Analyzing Control Measures.

Model Considerations		Rational Method	TR-55	SWMM	Direct Determination	HSPF	QUALHYMO
Temporal scale	Single Event	Yes	Yes	Yes	Yes	Yes	Yes
	Continuous Simulation	No	No	Yes	Possible	Yes	Yes
Spatial scale	Lot-level	Yes	Yes[b]	Yes	Yes	No	No
	Neighborhood	Yes	Yes	Yes	Yes	Possible	Possible
	Regional	Yes	Yes[c]	Yes	No	Yes	Yes
Outputs	Peak Discharge	Yes	Yes	Yes	No	Yes	Yes
	Runoff Volume	Yes	Yes	Yes	Yes	Yes	Yes
	Hydrograph	Yes[a]	Yes	Yes	No	Yes	Yes
	Water Quality	No	No	Yes	Possible	Yes	Yes

[a] Modified Rational Method

[b] No less than 1 acre.

[c] No more than 25 square miles (up to 10 subareas).

From the viewpoint of modeling both lot-level and neighborhood scale projects, the Rational Method, NRCS TR-55, SWMM, and Direct Determination approaches were selected for use in scenario analyses. Strength and weakness of these methods are presented below:

Table 5. Comparison of approaches for determining runoff volume.

Method	Strengths	Weaknesses
Direct Determination	• Methodology for runoff determination is same as SWMM • Models basic hydrologic processes directly (explicit) • Simple spreadsheet can be used	• Direct application of Horton's method may estimate higher infiltration loss, especially at the beginning of a storm • Does not consider flow routing
Rational Method	• Method is widely used • Simple to use and understand	• Cannot directly model storage-oriented onsite control measures
TR-55	• Method is widely used • Simple to use and understand	• May not be appropriate for estimating runoff from small storm events because depression storage is not well accounted for
SWMM	• Method is widely used • Can provide complete hydrologic and water quality process dynamics in stormwater analysis	• Needs a number of site-specific modeling parameters • Generally requires more extensive experience and modeling skills

Each method requires specific parameters for estimating runoff from a site. Runoff coefficients for the Rational Method are assumed to be 0.9 for rooftop and pavement areas, and 0.1 and 0.135 for Group B and C soil pervious areas, respectively (Caltrans, 2003). The slope of the pervious area was assumed to be an average of 2%. Applying these runoff coefficients for each surface, the overall area-weighted runoff coefficient can be determined.

When applying the NRCS TR-55 method, Curve Numbers (CNs) should be determined for each drainage area. For rooftop and pavement areas the CN was assumed to be 98, and pervious area CN was determined on the basis of the hydrologic soil group and the status of grass cover condition. Curve numbers for pervious areas were assumed to be 61 and 74 for Group B and C soils, respectively, with an assumption of over 75% grass cover. The overall CN can be estimated by using an area-weighted calculation (USDA-SCS, 1986).

In SWMM modeling, infiltration was modeled using Horton's equation. The same infiltration parameters and depression storage values used in the direct determination method of runoff treatment volume described earlier were applied to the SWMM analyses. The average slope of the pervious area was again assumed to be 2%. The same uniform rainfall distribution and time step was applied for the SWMM model runs.

Runoff Methodology Results

Stormwater management practice sizes (and depth) were determined using the Direct Determination approach to capture the volume of runoff generated in a 95th percentile rainfall event at each location. Total acreage, impervious area, the 95th percentile rainfall event, the current expected runoff for the 95th percentile rainfall event, and the future runoff with stormwater management controls were reported for each site. Results were summarized for the two soil types (three soil types for scenarios #3 and #8 in Cincinnati). The spatial location of onsite control measures was also illustrated in the site aerial photo figures. Note that site practices were placed only on undeveloped or landscaped areas without regard for true flow paths or technical feasibility. It may be preferred to place practices in existing impervious areas, if possible. For the purposes of this modeling exercise, the least cost and most practical solutions were used, i.e., locating bioretention systems on undeveloped or landscaped areas. On an actual site, flow paths would be determined and berms and swales might be used to route runoff to areas that are most suitable for infiltration. In other cases, areas that are currently impervious could be modified to accept runoff, e.g., impermeable pavements removed and replaced by permeable, sidewalks could be redesigned to include sidewalk bioretention cells and streets could be designed with flow through or infiltration curb bumpouts/raingardens.

To compare other approaches of runoff estimation, alternate methodologies were also employed for three scenarios. TR-55 was used for Scenario #1 (Atlanta), the Rational Method was applied to Scenario #2 (Denver), and the SWMM was run for Scenario #7 (Charleston).

Although flood control is not the focus of this guidance, most localities have flood control requirements that will need to be considered in designing control measures to comply with Section 438. For flood control purposes, TR-55 was used to model the 10 year frequency design storm for each site under the assumption that all stormwater management practices were in place. The 10-year design storms were selected from the NRCS TR-55 Manual (USDA, 1986) for both the Eastern U.S. and the Western U.S. Precipitation Frequency Maps (www.wrcc.dri.edu/pcpnfreq.html). The 10-year frequency design storm was selected because it represents a common design standard used by state and local governments in order to manage peak rates of runoff and prevent flooding.

COST ESTIMATES FOR SELECTED SCENARIOS

Scenarios #2 and 7 include cost estimates comparing the capital costs for a design to comply with Section 438 (retention of the 95th percentile rainfall event) and capital costs for a traditional stormwater management design (e.g., typical curb and gutter, off-site pond for stormwater management). These costs are based on average unit costs to construct both traditional and GI/LID controls.

Scenario #1 - Charleston, WV

A 0.7-acre site with 73% impervious area was selected from Charleston, West Virginia (Figure 12). If the 95th percentile rainfall event (1.23 inches) occurred on the existing site (i.e., with no control measures), 0.82 inches of runoff using the Direct Determination method would be generated and require management. The runoff from the 95th percentile rainfall event could be retained by the installation of bioretention systems totaling 0.03 acres if hydrologic soil group B is present, or 0.06 acres if hydrologic soil group C (Table 6) is the predominant soil type on the site. Assuming that bioretention practices are placed in areas that are currently pervious or landscaped, a total of 0.2 acres of pervious area would be available for the placement of bioretention systems. The effective design storage depth within the designated bioretention area was 8 inches.

Figure 12. Actual Site and Onsite Control Measures (Charleston, WV)

Table 6. Estimated Sizes of Onsite Control Measures for Scenario #1 (Charleston, WV)

Total Area (acres)		0.7	
Estimated Imperviousness (%)		73%	
95th Percentile Rainfall Event (inches)		1.23	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		0.82	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Bioretention estimated by Direct Determination method (acres)		0.03	0.06
Bioretention estimated by SWMM (acres)		0.03	0.05
Off-site storage necessary to control the 10-yr event of 3.9 inches (acre-ft)	With onsite controls	0.10	0.12
	Without onsite controls	0.16	0.17

Note: The two hydrologic methods used (direct determination and SWMM) estimated similar bioretention sizes.

Scenario #2 - Denver, CO

A 4.5-acre site with 55% impervious area was selected from Denver, Colorado (Figure 13). If the 95th percentile rainfall event (1.07 inches) occurred on the existing site (i.e., with no control measures), 0.53 inches of runoff from the site would be generated and require management. The runoff from the 95th percentile rainfall event could be retained by the installation of bioretention systems totaling 0.16 acres if the hydrologic soil group B is present or 0.3 acres if hydrologic soil group C (Table 7) is the predominant soil type on the site. Assuming that bioretention practices are only placed in areas that are currently pervious or landscaped, a total of 2 acres of pervious area is available for the placement of bioretention systems. The design storage depth of media within the designated bioretention area was 6 inches.

Figure 13. Actual Site and Onsite Control Measures (Denver, CO)

Table 7. Estimated Sizes of Onsite Control Measures for Scenario #2 (Denver, CO)

Total Area (acres)		4.5	
Estimated Imperviousness (%)		55%	
95th Percentile Rainfall Event (inches)		1.07	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		0.53	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Bioretention estimated by the Direct Determination method (acres)		0.16	0.3
Bioretention estimated by Rational Method (acres)		0.16	0.28
Off-site storage necessary to control the 10-yr event of 3.2 inches (acre-ft)	With onsite controls	0.35	0.52
	Without onsite controls	0.64	0.64

Cost estimates were also developed for this scenario (Table 8) to compare the costs of installing onsite control measures to retain the 95th percentile rainfall event versus the costs to install traditional stormwater management controls (e.g., curbs and gutters combined with off-site retention such as extended detention wet ponds). In a GI/LID scenario, the bioretention cell would occupy a specified area. This same area in a traditional design would be covered in turf since the pond would typically be offsite and not occupy the area planted in turf. Table 8 includes this cost under the traditional column. Note: typical land development practices involve mass clearing and grading so little or no pre-existing vegetation is typically retained. It is also assumed that the use of GI/LID practices would require less underground infrastructure because the traditional design typically routes stormwater underground to an off-site pond via pipes or culverts while GI/LID practices are designed to manage runoff onsite and as close to its source as possible. They are also dispersed across the site and routing occurs through surface drainage via bioswales and overland flow. As a result GI/LID practices do not require as much or any hard or grey infrastructure. The cost estimates were developed for Hydrologic Soil Group B.

Table 8. Estimated Costs for Scenario #2 (Denver, CO)

Sizes of Onsite Control Practices			
		Controls for 95th Percentile Event	Traditional Stormwater Controls
Rainfall depth (in)		1.07	
Bioretention (acres)		0.1	
Paver blocks (acres)		0	
Green roof (acres)		0	
Off-site Pond	WQV (ac-ft)	-	0.18
	10-Yr Fld Cntr (ac-ft)	0.15	0.14
Total Off-Site Requirement (ac-ft)		0.15	0.32
Land Area (assumes avg 3 ft depth)		0.05	0.11
% of the site		2.8%	
Costs of Onsite Control Practices			
Biorention/alternative		$32,495	$4,187
Off-site Pond	WQV (ac-ft)		$14,833
	10-Yr Fld Cntr (ac-ft)	$10,073	$9,527
Infrastructure	Pipe	$8.990	$16,982
	Inlet	$9.920	$14,880
Land Area (assumes $300K/acre)		$14,500	$31,500
Sum		**$75,978**	**$91,909**
% difference from Traditional		**-17.3%**	

Scenario #3 - Cincinnati, OH

A 19-acre site with 51% impervious area was selected in Cincinnati, Ohio (Figure 14). If the 95th percentile rainfall event (1.45 inches) occurred on the existing site (i.e., no control measures were in place), 0.68 inches of runoff from the site would be generated and require management. The runoff from the 95th percentile rainfall event could be retained by the installation of bioretention systems totaling 0.8 acres if the hydrologic soil group B is present or 1.3 acres if hydrologic soil group C (Table 9) is the predominant soil type on the site. Assuming that bioretention practices are only placed in areas that are currently pervious or landscaped, a total of 9.4 acres of pervious area is available for the placement of bioretention systems. The design storage depth of media within the designated bioretention area was 8 inches.

Figure 14. Actual Site and Onsite Control Measures (Cincinnati, OH)

Table 9. Estimated Sizes of Onsite Control Measures for Scenario #3 (Cincinnati, OH)

Total Area (acres)		19	
Estimated Imperviousness (%)		51%	
95th Percentile Rainfall Event (inches)		1.45	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		0.68	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Bioretention estimated by the Direct Determination (acres)		0.8	1.3
Off-site storage necessary to control the 10-yr event of 4.2 inches (acre-ft)	With onsite controls	2.42	3.24
	Without onsite controls	3.29	3.73

Scenario #4 - Portland, OR

A 27-acre site with 95% impervious area was selected in Portland, Oregon (Figure 15). If the 95th percentile rainfall event (1.0 inches) occurred on the existing site (i.e., no control measures), 0.86 inches of runoff would be generated and require management. This site has the greatest imperviousness among the 7 sites.

Given these site conditions, there is not enough pervious area to manage the entire runoff volume discharged by the 95th percentile rainfall event with bioretention. As a result, other practices were evaluated and selected. The practices integrated into the design included a green roof, cisterns, and porous pavement. Based on the technical considerations of constructing and maintaining control measures at the site, it was assumed that approximately 30% of the available pervious area could be converted into bioretention cells; 20% of total rooftop area could be converted into green roofs; 40% of paved area could be converted into paver blocks; and 50,000 gallons of total volume could be captured in cisterns for use on this urbanized site. Using this system of four different practices, all runoff for the 95th percentile rainfall event would be retained (Table 10).

Figure 15. Actual Site and Onsite Control Measures (Portland, OR)

Table 10. Estimated Sizes of Onsite Control Measures for Scenario #4 (Portland, OR)

Total Area (acres)		27	
Estimated Imperviousness (%)		95%	
95th percentile Rainfall Event (inches)		1.00	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		0.86	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Paver block area estimated by Direct Determination (acres)		1.4	3.5*
Bioretention estimated by Direct Determination (acres)		0.4	
Green Roof estimated by Direct Determination (acres)		1.7	
Cistern volume estimated by Direct Determination (gallons)		50,000	
Off-site storage necessary to control the 10-yr event of 3.7 inches (acre-ft)	With onsite controls	5.37	5.62
	Without onsite controls	7.70	7.71

*The size of porous pavement area was increased because the other control options were maximized based on the site-specific design assumptions.

A total of 1.3 acres of the site is pervious area or landscaped of which, 0.4 acres (30% of the pervious area) could be converted to bioretention cells that have a storage depth of 10 inches. Of the 8.8 acres of current rooftop area, 1.7 acres (20% of the rooftop area) could be retrofitted into green roof areas. Of the 16.9 acres of paved area, 1.4 acres (8% of the paved area) for hydrologic soil group B, or 3.5 acres (20% of the paved area) for hydrologic soil group C, of paver block systems could be implemented. One or more cisterns (as indicated in Figure 15) could be used to capture up to 50,000 gallons of runoff from rooftop areas. Note: The high percentage of imperviousness of the site (95%) requires that all infiltration designs be based on resident soil type and design volumes, or with adequate sub-bases or amended soils.

Scenario #5 – Near Phoenix, AZ

A 2-acre site with 47% impervious area was selected near Phoenix, Arizona (Figure 16). If the 95th percentile rainfall event (1.0 inches) occurred on the existing site (i.e., with no control measures), 0.42 inches of runoff would be generated and require management. The runoff from the 95th percentile rainfall event could be retained by installing bioretention systems totaling 0.06 acres if the hydrologic soil group B is present or 0.1 acres if hydrologic soil group C (Table 11) is the predominant soil type on the site. Assuming that bioretention practices are only placed in areas that are currently pervious or landscaped, a total of 1.1 acres of pervious area is available for the placement of these practices. The design storage depth of media within the designated bioretention area was 6 inches. Note: If the design storage depth were increased to 10 inches, the off-site storage necessary for the 10-year event could be reduced to 0.03 acre-ft for type B soils and 0.08 acre-ft for type C soils.

Figure 16. Actual Site and Onsite Control Measures (Phoenix, AZ)

Table 11. Estimated Sizes of Onsite Control Measures for Scenario #5 (Phoenix, AZ)

Total Area (acres)		2	
Estimated Imperviousness (%)		47%	
95th Percentile Rainfall Event (inches)		1.00	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		0.42	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Bioretention estimated by the Direct Determination (acres)		0.06	0.1
Off-site storage necessary to control the 10-yr event of 2.4 inches (acre-ft)	With onsite controls	0.05	0.12
	Without onsite controls	0.18	0.18

Scenario #6 - Boston, MA

A 3.5-acre site with 69% impervious area was selected in Boston, Massachusetts (Figure 17). If the 95th percentile rainfall event (1.52 inches) occurred on the existing site (i.e., with no control measures), 0.98 inches of runoff would be generated and require management. Given these site characteristics, there is adequate area to place appropriately sized bioretention cells to capture the 95th percentile storm event. However, for the purposes of this analysis, unspecified conditions preclude the use of bioretention. As a result, a paver block system was selected as the best onsite control measure and the system was designed such that the necessary design parameters could be achieved by storing some of the volume in the paver media and by infiltrating the remainder of the volume. The runoff from the 95th percentile rainfall event could be retained by installing a paver block area totaling 0.4 and 0.8 acres assuming soil types B and C, respectively (Table 12). For the purposes of this case study, a total of 1.5 acres of parking lot was made available to accommodate the paver block system. The area retrofitted with paver blocks would primarily be dedicated for use as parking stalls.

Figure 17. Actual Site and Onsite Control Measures (Boston, MA)

Table 12. Estimated Sizes of Onsite Control Measures for Scenario #6 (Boston, MA)

Total Area (acres)		3.5	
Estimated Imperviousness (%)		69%	
95th Percentile Rainfall Event (inches)		1.52	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		0.98	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Paver block area estimated by Direct Determination (acres)		0.4	0.8
Off-site storage necessary to control 10-yr event of 4.5 inches (acre-ft)	With onsite controls	0.59	0.71
	Without onsite controls	0.89	0.96

Scenario #7 - Atlanta, GA

A 21-acre site with 70% impervious area was selected in Atlanta, Georgia (Figure 18). If the 95th percentile rainfall event (1.77 inches) occurred on the existing site (i.e., with no control measures), 1.17 inches of runoff would be generated and require management. The runoff from the 95th percentile rainfall event could not be adequately retained solely with bioretention systems. Based on the technical considerations of constructing and maintaining control measures at the site, it was assumed that up to 15% of the pervious area could be converted into bioretention cells and up to 40% of paved area could be converted into a paver block system. If the stormwater management techniques used on the site includes both bioretention and paver blocks as presented in Table 13, then all runoff for the 95th percentile rainfall event would be controlled.

Figure 18. Actual Site and Onsite Control Measures (Atlanta, GA)

Table 13. Estimated Sizes of Onsite Control Measures for Scenario #7 (Atlanta, GA)

Total Area (acres)		21	
Estimated Imperviousness (%)		70%	
95th Percentile Rainfall Event (inches)		1.77	
Expected Runoff for the 95th Percentile Rainfall Event (inches)		1.17	
Stormwater Management Area Required		Hydrologic Soil Group	
		B	C
Bioretention estimated by the Direct Determination (acres)		0.9	
Paver block area estimated by the Direct Determination (acres)		0.9	3.2*
Bioretention estimated by TR-55		0.8**	0.9
Paver block area estimated by TR-55		0**	1.84
Off-site storage necessary to control 10-yr event of 6.0 inches (acre-ft)	With onsite controls	5.85	6.62
	Without onsite controls	7.25	8.49

*The size of porous pavement was increased because the bioretention already reached its maximum size based on the site-specific design assumptions.

**Because TR-55 estimated smaller runoff in this scenario, bioretention can retain all of the 95th percentile runoff if the site has soil group B.

For the example site in Atlanta, GA, areas of 1.8 acres for hydrologic soil group B, and 4.1 acres for hydrologic soil group C, would be required to manage the runoff discharged from a 95th percentile rainfall event. Assuming that bioretention practices are only placed in areas that are currently pervious or landscaped, a total of 6.2 acres of pervious area is available for the placement of bioretention systems. The design storage depth of media within the designated bioretention area was 10 inches. Permeable pavement systems could be used to treat the remaining volume on the 10.8 acres of existing paved area.

In applying the TR-55 model, the overall curve numbers for the site were 87 and 91 for Group B and C soils, respectively. TR-55 was used to estimate 0.73 inches of runoff for soil group B and 0.97 inches for soil group C, which are smaller numbers than the 1.17 inches of runoff estimated by the Direct Determination method. As a result, the sizes of the onsite control measures designed using the TR-55 model were smaller than those designed using the Direct Determination method. Note: It is recommended that caution be exercised when using TR-55 to model storms less than 0.5 inches per event. See application of TR-55 in Table 5.

Cost estimates were also developed for this scenario (Table 14) to compare the costs to install onsite control measures to retain the 95th percentile rainfall event, and costs to install traditional stormwater management controls (e.g., primarily curb and gutter with off-site retention). The cost estimates were developed for Hydrologic Soil Group B.

Table 14. Estimated Costs for Scenario #7 (Atlanta, GA)

Sizes of Onsite Control Practices			
		Controls for 95th Percentile Event	Traditional Stormwater Controls
Rainfall depth (in)		1.77	
Bioretention (acres)		0.94	
Paver blocks (acres)		0.86	
Off-site Pond	WQV (ac-ft)	-	1.75
	10-Yr Fld Cntr (ac-ft)	0.84	0.0
Total Off-Site Requirement (ac-ft)		0.84	1.75
Land Area (assumes avg 3 ft depth)		0.28	0.58
% of the site		8.5%	
Costs of Onsite Control Practices			
Biorention/alternative		$232,923	$30,617
Paver block/alternative		$236,878	$88,409
Off-site Pond	WQV (ac-ft)	$0	$72,888
	10-Yr Fld Cntr (ac-ft)	$39,648	$0
Infrastructure	Pipe	$54,827	$191,095
	Inlet	$52,080	$79,360
Land Area (assumes $300K/acre)		$84,000	$175,000
Sum		**$700,356**	**$637,368**
% difference from Traditional		**9.9%**	

Scenario #8 - Cincinnati, OH

A 19-acre site with 51% impervious area was selected in Cincinnati, Ohio (Figure 19). If the 95th percentile rainfall event (1.45 inches) occurred on the existing site (i.e., with no control measures), 0.68 inches of runoff would be generated and require management. The runoff from the 95th percentile rainfall event could be retained by the installation of bioretention systems totaling 0.8 acres if the hydrologic soil group B is present or 1.3 acres if hydrologic soil group C (Table 9) is the predominant soil type on the site. Assuming that bioretention practices are only placed in areas that are currently pervious or landscaped, a total of 9.4 acres of pervious area is available for the placement of bioretention systems. The design storage depth of media within the designated bioretention area was 8 inches.

Scenario #8 represents an alternative to the Cincinnati, scenario in #3 (Figure 14). In this case, hydrologic soil group D was selected to represent the soil characteristics present for the entire site. Alternatively, simulations could have been run under the assumption that the use of infiltration practices were precluded by contaminated soils or high ground water tables. Under these site conditions, bioretention options are severely limited and cannot be used to adequately capture the entire 95th percentile storm event. As a result, options such as cisterns and green roofs were considered. In the absence of management practices, the 95th percentile rainfall event discharges 1.45 inches of stormwater and 0.53 inches of this runoff is captured by onsite depression storage. The difference, 0.92 inches of runoff, would then require capture and management. Based on the technical considerations of constructing and maintaining controls at the site, it was assumed that up to 20% of pervious area can be converted into bioretention areas; up to 30% of paved area can be converted into porous pavement; and up to 30% of the rooftop area can be converted into green roofs. Cisterns can be added to the system if additional storage volume is required. It should be noted that green roofs were selected lowest in the hierarchy of practices evaluated because of cost and potential structural issues associated with design and placement on existing buildings. By using the four onsite control options as presented in Table 15, all runoff for the 95th percentile rainfall event would be retained. From a management perspective, it was assumed that the design storage depth within the designated bioretention area was 6 inches because of the low infiltration rates adopted for this scenario.

Figure 19. Actual Site and Onsite Control Measures (Cincinnati, OH)

Table 15. Estimated Sizes of Onsite Control Measures for Scenario #8 (Cincinnati, OH)

Total Area (acres)	19
Estimated Imperviousness (%)	51%
95th Percentile Rainfall Event (inches)	1.45
Expected Runoff for the 95th Percentile Rainfall Event (inches)	0.92
Stormwater Management Applied	Hydrologic Soil Group D
Bioretention estimated by Direct Determination (acres)	1.9
Paver block area estimated by Direct Determination (acres)	2.4
Green Roof estimated by Direct Determination (acres)	0.5
Cisterns estimated by Direct Determination (gallons)	13,000

This site contains a total of 9.4 acres of pervious area, 8.0 acres of paved area, and 1.6 acres of rooftop area. If 1.9 acres (20%) of the pervious area were converted to bioretention cells; 2.4 acres (30%) of parking lot converted to paver blocks; and 0.5 acres (30%) of rooftop area were retrofitted to green roof areas for this site, then 97% of stormwater runoff from the 95th percentile storm would be captured on site. By also adding one or more cisterns (as indicated in Figure 19), an additional 13,000 gallons could be captured, thus illustrating that 100% of the rainfall from the 95th percentile event can be managed onsite with GI/LID practices.

Scenario #9 – Norfolk, VA

A 1.6 acre site with 91% impervious area was selected from Norfolk, Virginia. Table 16 contains the land use categories for the site. Figure 20 depicts the site and associated facilities. Site specific factors based on an METF analysis allow management of 75 % of the 95th percentile storm onsite (1.27 inches). The remaining portion of the 95th percentile rainfall event (0.41 inches would be discharged off of the site.

Table 16. Land Use Determination After Redevelopment

Land Use	Acres	Site Coverage Percent
Building	0.90	56.3
Parking	0.35	21.9
Streets/Sidewalks	0.20	12.5
Undeveloped	0.15	9.3
Total	**1.60**	**100%**

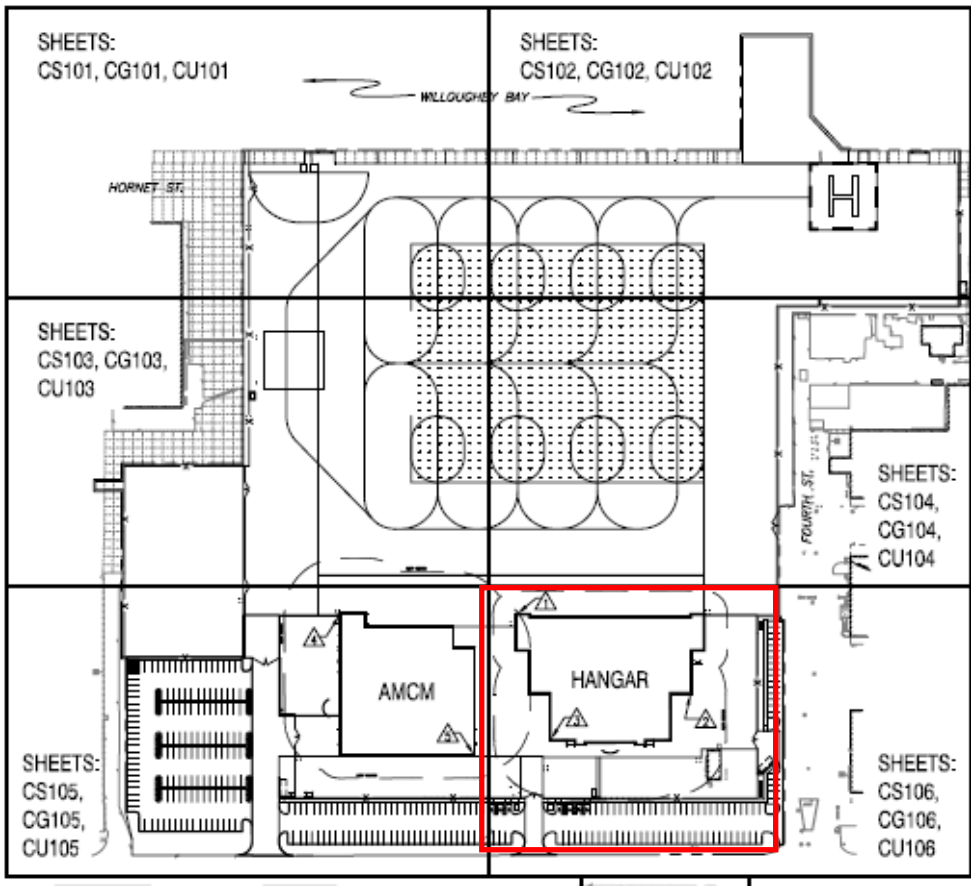


Figure 20. Proposed Redevelopment Scenario

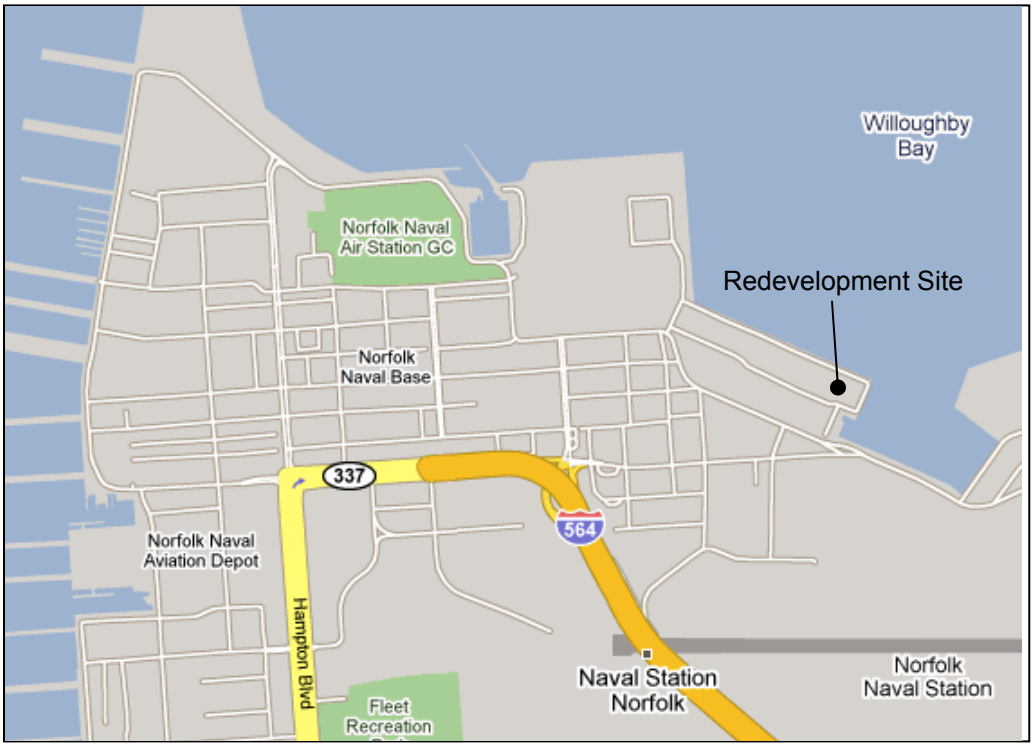


Figure 21. Location of Facility (Norfolk, VA)

Site conditions and intended uses limited the number of practices that were technically feasible to use onsite to manage runoff. For example, the use of a green roof was not feasible because the project includes the construction of an airplane hanger which lacks the structural strength to support a green roof. Cisterns were also not included in the set of suitable practices based on the analysis, which considered the number of people and amount of daily water use at the site, i.e., 40 people x 3.5 toilet flushes per day would use only 280 gallons of runoff per day or 2,000 gallons per week. Stormwater use for HVAC make-up would also be negligible based on the typical cooling system design. To put things in perspective, if the hanger rooftop covers the entire building footprint, 41,000 gallons of runoff would be generated from a 1.68 inch rainfall. Assuming a drawdown of 2,000 gallons per week based on toilet flushing, the users would only use 5% of the 95th percentile event. Because of the relatively large volume of water that would need to be collected and used, cisterns were not considered a feasible option to manage a significant volume of runoff at the site.

However, site conditions did allow for the use of both permeable pavement and bioretention practices. Approximately 0.15 acres (6,500 sf) of the proposed site is undeveloped and available for bioretention. Based on Department of Defense facility requirements, ten percent of the parking area is designed with landscaping, usually around the perimeter and in landscaped islands. If this ten percent were designed as bioretention cells, then 0.035 acres of bioretention would be achieved. If bioretention cells were also placed in about 30% of the undeveloped area of the project, then an additional 0.045 acres of bioretention could be implemented. Note: not all undeveloped land was assumed to be available for bioretention because of conflicts with site

utilities, security and anti-terrorism requirements and slopes that limited the use of infiltration practices directly adjacent to the hanger.

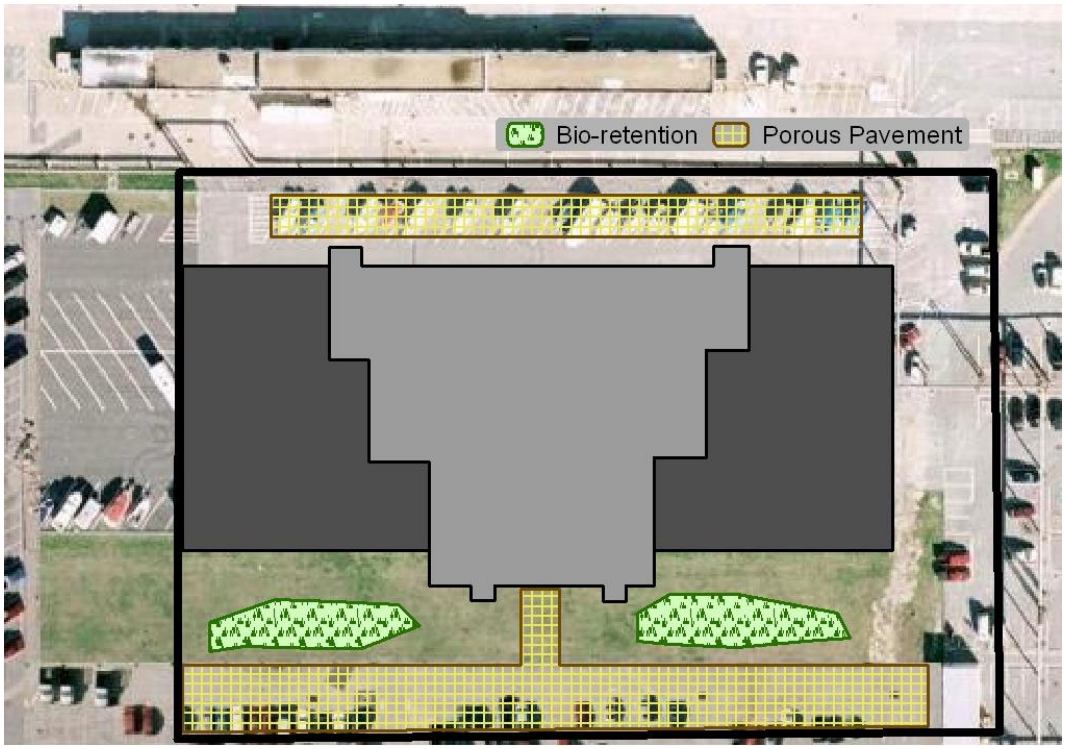


Figure 22. Actual Site and Onsite Control Measures (Norfolk, VA)

Table 17. Estimated Sizes of Onsite Control Measures for Scenario #9 (Norfolk, VA)

Total Area (acres)	1.6
Estimated Imperviousness (%)	91%
95th Percentile Rainfall Event (inches)	1.68
Expected Runoff for the 95th Percentile Rainfall Event (inches)	1.50
Stormwater Management Area Required	Hydrologic Soil Group D
Porous Pavement estimated by Direct Determination method (acres)	0.21
Bioretention estimated by Direct Determination method (acres)	0.08

The bioretention cells were designed with an effective storage depth of 10 inches, which included a depth from media surface to outlet of 10 inches. In this case study, state regulations precluded the project from taking credit for the storage potential provided by the void space within the bioretention cell media. Similarly, approximately 0.55 acres of the proposed site is impervious due to parking lots, streets, and sidewalks. Due to manufacturer's recommendations that permeable pavement materials not be used in applications subject to heavy loads and potential pollutant exposure the access roads and parking lot access isles were assumed to be constructed from conventional impervious concrete or asphalt. Thus 60% of the parking area (primarily parking stalls and sidewalks), which is about 38% of the entire paved area, is assumed to be suitable for paver blocks. A high water table at the site limited the modeled net storage depth under paver blocks placed in the parking areas and sidewalks to four inches. This storage was calculated using the assumption that the pavement sub-base of 12 inches would have a minimum void space of approximately 30%.

COMPARISON OF THE RUNOFF ESTIMATION METHODS

As illustrated in each of the case studies above, runoff of the 95th percentile storm was estimated in order to size onsite control measures. These estimates were produced by applying four different methods: the Direct Determination method, the Rational Method, the NRCS TR-55, and the EPA SWMM. The results comparing each of these methods for scenarios 1-7 are presented in Table 18.

Table 18. Comparison of the estimated runoff (unit: inches)

Method		Direct Determination		Rational Method		TR-55		SWMM	
Soil Groups		B	C	B	C	B	C	B	C
1	Charleston, WV	0.82	0.82	0.83	0.84	0.36	0.53	0.82	0.83
2	Denver, CO	0.53	0.53	0.57	0.59	0.12	0.26	0.53	0.53
3	Cincinnati, OH	0.68	0.68	0.73	0.76	0.26	0.46		
4	Portland, OR	0.86	0.86	0.86	0.86	0.63	0.71		
5	Phoenix, AZ	0.42	0.42	0.46	0.48	0.06	0.17		
6	Boston, MA	0.98	0.98	0.99	1.00	0.51	0.70		
7	Atlanta, GA	1.17	1.17	1.17	1.19	0.73	0.97	1.19	1.23

As shown in the above table, the estimated runoff results from direct determination, the Rational Method, and SWMM are relatively similar. Runoff volumes using TR-55 are lower than the other estimates. SWMM modeling results using NRCS 24-hour rainfall distributions were nearly identical to the results based on uniform distribution.

Table 19. Applicability of the methods for analyzing onsite control measures

Purpose	Direct Determination	Rational Method	TR-55*	SWMM
Planning Tool	Applicable	Applicable	Applicable	Applicable
Preliminary Design	Applicable	Applicable	Applicable	Applicable
Detailed Design	Not applicable	Not applicable	Not applicable	Applicable
Actual Assessment (Long-term)	Not applicable	Not applicable	Not applicable	Applicable
Water Quality	Not applicable	Not applicable	Not applicable	Applicable

*Use with caution when applying this method for small storms

CONCLUSIONS

Although sites varied in terms of climate and soil conditions, in most of the scenarios selected, the 95th percentile storm event could be managed onsite with GI/LID systems. There are other infiltration, evapotranspiration and capture and use stormwater management options available than those used in these analyses. These options provide site managers additional flexibility to choose appropriate systems and practices to manage site runoff.

REFERENCES

Booth, Derek Direct Testimony. 2008. *Pollution Control Hearings Board for the State of Washington*, Puget Soundkeeper Alliance and People for Puget Sound; Pierce County Public Works and Utilities Department; City of Tacoma; The Port of Seattle; Snohomish County; Clark County; and Pacificorp and Puget Sound Energy, Appellants, vs. Department of Ecology, Respondent, and King County; City of Seattle; Port of Tacoma, and Washington State Department of Transportation, Intervenors, August 2008.

California Department of Transportation (Caltrans). 2003. *Caltrans Storm Water Quality Handbooks*. California Department of Transportation.

Casey Trees. 2007. *The Case for Trees – Relief from Summer Heat*, www.caseytrees.org/resources/casefortrees.html.

Galli, John. 1991. *Thermal Impacts Associated with Urbanization and Stormwater Best Management Practices in Maryland*, Anacostia Restoration Team for the Maryland Department of the Environment, Washington, DC.

Grant, Gary, Luke Engleback and Barry Nicholson. 2003. Green Roofs: Their Existing Status and Potential for Conserving Biodiversity in Urban Areas, Report Number 498, English Nature Research Reports.

Hathaway, J., and W.F. Hunt. 2007. *Stormwater BMP Costs*. North Carolina Department of Environment and Natural Resources. www.bae.ncsu.edu/stormwater/PublicationFiles/DSWC.BMPcosts.2007.pdf.

Hirschman, David and John Kosco. 2008. *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program*, Center for Watershed Protection, www.cwp.org/postconstruction.

Holz, Thomas Written Direct Testimony. 2008. *Pollution Control Hearings Board for the State of Washington*, Puget Soundkeeper Alliance and People for Puget Sound; Pierce County Public Works and Utilities Department; City of Tacoma; The Port of Seattle; Snohomish County; Clark County; and Pacificorp and Puget Sound Energy, Appellants, vs. Department of Ecology, Respondent, and King County; City of Seattle; Port of Tacoma, and Washington State Department of Transportation, Intervenors, August 2008.

Horner, Richard Direct Testimony. 2008. *Pollution Control Hearings Board for the State of Washington*, Puget Soundkeeper Alliance and People for Puget Sound; Pierce County Public Works and Utilities Department; City of Tacoma; The Port of Seattle; Snohomish County; Clark County; and Pacificorp and Puget Sound Energy, Appellants, vs. Department of Ecology, Respondent, and King County; City of Seattle; Port of Tacoma, and Washington State Department of Transportation, Intervenors, August 2008.

National Climatic Data Center (NCDC). 2007. NCDC precipitation data, CD-ROM, National Climatic Data Center.

National Research Council. 2008. *Urban Stormwater Management in the United States*, The National Academies Press, Washington, DC.

Shaver, E., R. Horner, J. Skupien, C. May, and G. Ridley. 2007. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues – 2nd Edition*, North American Lake Management Society, Madison, WI.

Schueler, T. and M. Helfrich. 1988. "Design of Wet Extended Detention Pond Systems," *Design of Urban Runoff Controls*, L. Roesner and B. Urbonas eds., American Society of Civil Engineers, New York, NY.

Schueler, T and H. Holland. 2000. The Practice of Watershed Protection: Techniques for Protecting our Nation's Streams, Lakes, Rivers, and Estuaries. Center for Watershed Protection, Ellicott City, MD.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2007. *National Engineering Handbook*, title 210–VI. Part 630, chapter 7. Washington, DC. http://directives.sc.egov.usda.gov/.

U.S. Department of Agriculture, Soil Conservation Service. 1986. *Urban Hydrology for Small Watersheds*. Technical Release No. 55. Second Edition. Washington, D.C.

U.S. Environmental Protection Agency, *Managing Wet Weather with Green Infrastructure*, www.epa.gov/greeninfrastructure.

Vingarzan and Taylor. 2003. Trend Analysis of Ground Level Ozone in the Greater Vancouver/ Fraser Valley Area of British Columbia, Environment Canada – Aquatic and Atmospheric Sciences Division.

Wisconsin DNR. 2008. *Impact of Redevelopment on TSS Loads, Runoff Management*, available at http://www.dnr.state.wi.us/runoff/pdf/rules/nr151/Impact_of_RedevTSSLoads_021308.pdf.

APPENDIX A: Runoff Methodology Parameter Assumptions

Runoff from each land cover was estimated by the following equation:

$$Runoff = Rainfall - Depression\ Storage - Infiltration\ Loss \quad (1)$$

Depression Storage

Reference depression storage (inches)

Reference	Impervious	Pervious
1	0.05 - 0.1	0.1 - 0.3
2	0.01 - 0.11	0.02 - 0.6
3	0.1	0.2

1. ASCE, (1992). *Design & Construction of Urban Stormwater Management Systems*. New York, NY.
2. Marsaleck, J., Jimenez-Cisreros, B., Karamouz, M., Malmquist, P-R., Goldenfum, J., and Chocat, B. (2007). *Urban Water Cycle Processes and Interactions. Urban Water Series*, UNESCO-IHP, Tyler & Francis.
3. Walesh, S. G. (1989).*Urban Surface Water Management*. John Wiley & Sons, Inc.

Based on the above reference data, depression storage (or initial abstraction, the rainfall required for the initiation of runoff) to the direct determination method was assumed as follows:

- Rooftop: 0.1 inches
- Pavement: 0.1 inches
- Pervious area: 0.2 inches

Infiltration

Infiltration loss occurs only in pervious areas. In this analysis, infiltration was estimated by Horton's equation:

$$F_t = f_{min} + (f_{max} - f_{min})\, e^{-k\,t} \quad (2)$$

where, F_t = infiltration rate at time t (in/hr),
f_{min} = minimum or saturated infiltration rate (in/hr),
f_{max} = maximum or initial infiltration rate (in/hr),
k = infiltration rate decay factor (/hr), and
t = time (hr) measured from time runoff first discharged into infiltration area

Reference infiltration parameters

Maximum infiltration rate (in.hr), f_{max}

Infiltration (in/hr)	Partially dried out with		Dry soils with	
	No vegetation	Dense vegetation	No vegetation	Dense vegetation
Sandy	2.5	5	5	10
Loam	1.5	3	3	6
Clay	0.5	1	1	2

Reference: Huber, W. C. and Dickinson, R. (1988). *Storm Water Management Model User's Manual, Version 4*. EPA/600/3-88/001a (NTIS PB88-236641/AS), U.S. Environmental Protection Agency, Athens, GA.

Minimum infiltration rate (in/hr), f_{min}

Hydrologic Soil Group	Infiltration (in/hr)
A	0.45 - 0.30
B	0.30 - 0.15
C	0.15 - 0.05
D	0.05 - 0

A: well drained sandy; D: poorly drained clay
Reference: Huber, W. C. and Dickinson, R. (1988). *Storm Water Management Model User's Manual, Version 4*. EPA/600/3-88/001a (NTIS PB88-236641/AS), U.S. Environmental Protection Agency, Athens, GA.

Decay coefficient, k

Soils	k (sec^{-1})	k (hr^{-1})
Sandy	0.00056	2
⇕	0.00083	3
	0.00115	4
Clay	0.00139	5

Reference: Huber, W. C. and Dickinson, R. (1988). *Storm Water Management Model User's Manual, Version 4*. EPA/600/3-88/001a (NTIS PB88-236641/AS), U.S. Environmental Protection Agency, Athens, GA.

Based on the above reference data, infiltration parameters to the direct determination method were assumed as follows:

- Hydrologic Soil Group B
  - Maximum infiltration rate: 5 in/hr
  - Minimum infiltration rate: 0.3 in/hr
  - Decay factor: 2 /hr
- Hydrologic Soil Group C
  - Maximum infiltration rate: 3 in/hr
  - Minimum infiltration rate: 0.1 in/hr
  - Decay factor: 3.5 /hr
- Hydrologic Soil Group D
  - Maximum infiltration rate: 1 in/hr
  - Minimum infiltration rate: 0.02 in/hr
  - Decay factor: 5 /hr

Infiltration loss for the 24-hr rainfall duration was estimated by the following equations with assumptions of a half hour Δt:

$$\textit{Infiltration Loss at the } n^{\text{th}} \textit{ time-step} = (f \cdot \Delta t) = \{(f_{n-1} + f_n)/2) \cdot \Delta t\} \quad (3)$$

$$\textit{Integrated Infiltration Loss for 24 hours} = \sum (f \cdot \Delta t) \quad (4)$$

Integrating infiltration loss during 24 hours with a half hour Δt

time-step	t (hr)	Infiltration rate (in/hr) [a]			Infiltration volume (inches) [b]		
		Soil B	Soil C	Soil D	Soil B	Soil C	Soil D
0	0	5	3	1	0	0	0
1	0.5	2.03	0.60	0.100	1.757	0.901	0.275
2	1	0.94	0.19	0.027	0.741	0.198	0.032
3	1.5	0.53	0.12	0.021	0.368	0.076	0.012
4	2	0.39	0.10	0.02	0.230	0.054	0.01
5	2.5	0.33	0.1	0.02	0.179	0.05	0.01
6	3	0.31	0.1	0.02	0.161	0.05	0.01
7	3.5	0.30	0.1	0.02	0.154	0.05	0.01
8	4	0.3	0.1	0.02	0.15	0.05	0.01
9	4.5	0.3	0.1	0.02	0.15	0.05	0.01
10	5	0.3	0.1	0.02	0.15	0.05	0.01
11	5.5	0.3	0.1	0.02	0.15	0.05	0.01
12	6	0.3	0.1	0.02	0.15	0.05	0.01
13	6.5	0.3	0.1	0.02	0.15	0.05	0.01
14	7	0.3	0.1	0.02	0.15	0.05	0.01
15	7.5	0.3	0.1	0.02	0.15	0.05	0.01
16	8	0.3	0.1	0.02	0.15	0.05	0.01
17	8.5	0.3	0.1	0.02	0.15	0.05	0.01
18	9	0.3	0.1	0.02	0.15	0.05	0.01
19	9.5	0.3	0.1	0.02	0.15	0.05	0.01
20	10	0.3	0.1	0.02	0.15	0.05	0.01
21	10.5	0.3	0.1	0.02	0.15	0.05	0.01
22	11	0.3	0.1	0.02	0.15	0.05	0.01
23	11.5	0.3	0.1	0.02	0.15	0.05	0.01
24	12	0.3	0.1	0.02	0.15	0.05	0.01
25	12.5	0.3	0.1	0.02	0.15	0.05	0.01
26	13	0.3	0.1	0.02	0.15	0.05	0.01
27	13.5	0.3	0.1	0.02	0.15	0.05	0.01
28	14	0.3	0.1	0.02	0.15	0.05	0.01
29	14.5	0.3	0.1	0.02	0.15	0.05	0.01
30	15	0.3	0.1	0.02	0.15	0.05	0.01
31	15.5	0.3	0.1	0.02	0.15	0.05	0.01
32	16	0.3	0.1	0.02	0.15	0.05	0.01
33	16.5	0.3	0.1	0.02	0.15	0.05	0.01
34	17	0.3	0.1	0.02	0.15	0.05	0.01
35	17.5	0.3	0.1	0.02	0.15	0.05	0.01
36	18	0.3	0.1	0.02	0.15	0.05	0.01
37	18.5	0.3	0.1	0.02	0.15	0.05	0.01
38	19	0.3	0.1	0.02	0.15	0.05	0.01
39	19.5	0.3	0.1	0.02	0.15	0.05	0.01
40	20	0.3	0.1	0.02	0.15	0.05	0.01
41	20.5	0.3	0.1	0.02	0.15	0.05	0.01
42	21	0.3	0.1	0.02	0.15	0.05	0.01
43	21.5	0.3	0.1	0.02	0.15	0.05	0.01
44	22	0.3	0.1	0.02	0.15	0.05	0.01

45	22.5	0.3	0.1	0.02	0.15	0.05	0.01
46	23	0.3	0.1	0.02	0.15	0.05	0.01
47	23.5	0.3	0.1	0.02	0.15	0.05	0.01
48	24	0.3	0.1	0.02	0.15	0.05	0.01
Sum: Infiltration loss during 24 hours [c]					9.743	3.430	0.769

[a] Calculated infiltration rate at each time by Equation (2)
[b] Calculated infiltration volume from the previous time to the current time by Equation (3)
[c] Integrated infiltration volume for 24 hours with a half hour Δt by Equation (4)

Based on the above calculation, 24-hr infiltration losses for pervious areas and bioretention areas were modeled as follows:

- Soil Group B: 9.743 inches
- Soil Group C: 4.430 inches
- Soil Group D: 0.769 inches

Infiltrations of underlying soils at paver blocks were modeled conservatively by applying the minimum infiltration rate for each soil type (Infiltration loss = f_{min} · 24) because the soils under the paver blocks may require or be subjected to some compaction for engineering stability. The estimated infiltration losses for each soil are presented below:

- Soil Group B: (0.3 in/hr) · (24 hrs) = 7.2 inches
- Soil Group C: (0.1 in/hr) · (24 hrs) = 2.4 inches
- Soil Group D: (0.02 in/hr) · (24 hrs) = 0.48 inches

Design Storage of Management Practices

Bioretention

Reference	Ponding (inches)[1]	Mulch (inches)	Soil media (ft)	Soil Media Porosity	Underdrain
1	up to 12	2 - 4 (optional)	1 - 1.5	about 40%	bioretention systems utilize infiltration rather than an underdrain
2	6 - 12	2 - 3	2.5 - 4	about 40%	recommended, especially if initial testing infiltration rate < 0.52 in/hr
3	6 - 12		2 - 4		
4		2 - 3	1.5 - 4		if necessary
5	up to 6		1.5 - 2	30 - 40%	Optional
6	6 - 18	as needed	2 - 4		if necessary

1. State of New Jersey. (2004). *New Jersey Stormwater Best Management Practices Manual* www.nj.gov/dep/stormwater/tier_A/pdf/NJ_SWBMP_9.1 print.pdf.
2. Maryland Department of the Environment (MDE), (2000). *2000 Maryland Stormwater Design Manual, Volumes I & II*, prepared by the Center for Watershed Protection and the Maryland Department of the Environment, Water Management Administration, Baltimore, MD. www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp.

[1] Ponding is a measure of retention capacity

3. Clar, M. L. and R. Green, (1993). *Design Manual for Use of Bioretention in Storm Water Management*, prepared for the Department of Environmental Resources, Watershed Protection Branch, Prince George's County, MD, prepared by Engineering Technologies Associates, Inc. Ellicott City, MD, and Biohabitats, Inc., Towson, MD.
4. U.S. Environmental Protection Agency. (1999). *Storm Water Technology Fact Sheet: Bioretention*. EPA 832-F-99-012. Office of Water. US Environmental Protection Agency. Washington, D.C. www.epa.gov/owm/mtb/biortn.pdf.
5. Prince George's County. *Bioretention Design Specifications and Criteria*. Prince George's County, Maryland. www.co.pg.md.us/Government/AgencyIndex/DER/ESG/Bioretention/pdf/bioretention_design_manual.pdf.
6. City of Indianapolis. (2008). *Indianapolis Stormwater Design Manual*. www.sustainindy.org/assets/uploads/4_05_Bioretention.pdf.

Paver Blocks

Reference	Media (inches)	Void Space
1	12 or more	40%
2	9 or more	40%
3	12 - 36	40%

1. Univ. of California at Davis. (2008). Low Impact Development Techniques: Pervious Pavement. http://extension.ucdavis.edu/unit/center_for_water_and_land_use/pervious_pavement.asp.
2. AMEC Earth and Environmental, Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, and Atlanta Regional Commission. (2001). Georgia Stormwater Management Manual Volume 2: Technical Handbook www.georgiastormwater.com/.
3. Subsurface Infiltration Bed. www.tredyffrin.org/pdf/publicworks/CH2 - BMP4 Infiltration Bed.pdf.

Green Roofs

Reference	Media (inches)
1	3 - 4
2	1 - 6
3	2 - 6

1. Charlie Miller. (2008). Extensive Green Roofs. Whole Building Design Guide (WBDG). www.wbdg.org/resources/greenroofs.php.
2. Great Lakes WATER Institute. Green Roof Project: Green Roof Installation. www.glwi.uwm.edu/research/genomics/ecoli/greenroof/roofinstall.php.
3. Paladino & Company. (2004). Green Roof Feasibility Review. King County Office Project. http://your.kingcounty.gov/solidwaste/greenbuilding/documents/KCGreenRoofStudy_Final.pdf.

Based on the above reference data, design storages to the direct determination method were assumed as follows:

- Bioretention: up to 10 inches (depending on practice used, site conditions, etc.)
- Green roof: 1 inch (2.5 inches deep media with 40% void space)
- Porous pavement: 4 inches (10 inches deep media with 40% void space)

Factors that influence total storage available include, ponding depth, available media void space, and supplemental storage if the system is designed with gravel or open pipes underneath the media.

UFC 3-210-10
25 October 2004
including Change 2, 6 April 2010

UNIFIED FACILITIES CRITERIA (UFC)

LOW IMPACT DEVELOPMENT MANUAL

DISTRIBUTION STATEMENT A: Approved for Public Release;
Distribution is unlimited.

UFC 3-210-10
25 October 2004
including Change 2, 6 April 2010

UNIFIED FACILITIES CRITERIA (UFC)

DESIGN: LOW IMPACT DEVELOPMENT MANUAL

Any copyrighted material included in this UFC is identified at its point of use. Use of copyrighted material apart from this UFC must have the permission of the copyright holder.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing ACTIVITY)

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

RECORD OF CHANGES (changes are indicated by **1**\…./**1**/)

Change No.	**Date**	**Location**
1	DEC 2005	Forward
2	6 APR 2010	2-2 Compliance and Applicability

UFC 3-210-10
25 October 2004
including Change 2, 6 April 2010

FOREWORD

\1\ The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD-3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Support Agency (AFCESA) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site: http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

AUTHORIZED BY:

DONALD L. BASHAM, P.E.
Chief, Engineering and Construction

D
Naval Facilities Engineering Command

KATHLEEN I. FERGUSON, P.E.
The Deputy Civil Engineer
DCS/Installations & Logistics
Department of the Air Force

D P.E.
Director, Installations Requirements and Management
Office of the Deputy Under Secretary of Defense (Installations and Environment)

TABLE OF CONTENTS

Page

CHAPTER 1 INTRODUCTION TO LID AND MANUAL OVERVIEW

Paragraph 1-1 DEFINITION OF LID 1
1-2 BACKGROUND ON THE USE OF LID 2
1-3 INTRODUCTION TO UFC 2
1-4 LID SITE DESIGN STRATEGIES 3
1-4.1 LID Devices 4
1-5 BASIC LIST OF IMPs 4

CHAPTER 2 INSTITUTIONAL ISSUES

Paragraph 2-1 INTRODUCTION 6
2-2 COMPLIANCE WITH DOD CRITERIA 6
2-2.1 Compliance with DoD Design Criteria 6
2-2.2 Cost-Effectiveness 6
2-2.3 Antiterrorism/Force Protection 6
2-3 FEDERAL, STATE AND LOCAL GOVERNMENT ACCEPTANCE 6
2-4 BUILDING CODES 6

CHAPTER 3 WATER RESOURCE PROBLEMS, ISSUES, AND CHALLENGES

Paragraph 3-1 INTRODUCTION 8
3-2 COASTAL ZONE ISSUES 8
3-3 REGULATORY COMPLIANCE 8
3-3.1 Clean Water Act 8
3-3.2 Safe Drinking Water Act Wellhead Protection Program 10
3-3.3 Coastal Zone Management Act 10
3-3.4 Energy Policy Act of 1992 11
3-3.5 Estuaries and Clean Waters Act of 2000 11
3-3.6 National Environmental Policy Act of 1969 11
3-3.7 Sikes Act 12
3-4 DIRECTIVES 12
3-4.1 EO 13148 12
3-4.2 LEED Green Building Rating System™ 12
3-5 VOLUNTARY PROGRAMS AND AGREEMENTS 12
3-6 COSTS 12
3-7 RETROFITS 13

CHAPTER 4 STORMWATER MANAGEMENT USING THE HYDROLOGIC CYCLE APPROACH

Paragraph 4-1 INTRODUCTION 14
4-2 DESIGN INPUTS 14

4-3 PRECIPITATION DATA 16
4-3.1 LID Precipitation Analysis 16
4-3.2 Conventional Precipitation Analysis 17
4-4 STORAGE 17
4-4.1 LID Storage Concepts 17
4-4.2 Conventional Storage Concepts 18
4-5 INFILTRATION 19
4-5.1 LID Infiltration Concepts 20
4-5.2 Conventional Infiltration Concepts 21
4-6 EVAPOTRANSPIRATION 21
4-6.1 LID Evapotranspiration Concepts 21
4-6.2 Conventional Evaporation Concepts 21

CHAPTER 5 LID DESIGN GOALS AND OBJECTIVES

Paragraph 5-1 INTRODUCTION 22
5-2 REGULATORY AND NATURAL RESOURCE DESIGN ISSUES 22
5-3 FUNDAMENTAL SITE PLANNING CONCEPTS 23
5-3.1 Hydrology is the Integrating Framework for the Design 23
5-3.2 Distribute Controls Through Micromanagement 23
5-3.3 Stormwater is Controlled at the Source 23
5-3.4 Incorporate Non-Structural Systems 24
5-3.5 Utilize Multifunctional Landscape, Buildings and Infrastructures 24
5-4 LID MANAGEMENT AND DESIGN STRATEGIES 25
5-4.1 LID Site Planning Components 25
5-4.2 LID Design Approach 26
5-4.3 Minimization of Development Impacts 27
5-4.4 Control of Watershed Timing and Runoff Patterns 27
5-4.5 Use of Integrated Management Practices (IMPs) 28
5-4.6 Pollution Prevention 29
5-5 DESIGN GUIDANCE AND STANDARDS 29
5-5.1 Methods to Determine Effectiveness 29
5-5.2 Monitoring Strategies 31

CHAPTER 6 DISTRIBUTED MICRO-SCALE SYSTEMS

Paragraph 6-1 INTRODUCTION 34
6-2 REPRESENTATIVE LID PRACTICES 34
6-2.1 Nutrient Processing 35
6-2.2 Treatment Train Approach for Water Quality 36
6-2.3 Energy Processing 37
6-2.4 Multifunctional Infrastructure and Buildings 37
6-2.5 Ancillary Benefits 37

CHAPTER 7 COMPARISON OF LID TO CONVENTIONAL PRACTICES

Paragraph 7-1 INTRODUCTION 38
7-2 COMPLIANCE VS. WATER RESOURCE OBJECTIVES 38
7-3 WATER QUALITY CONTROL 38
7-4 CONSTRUCTION COSTS 38
7-5 OPERATION AND MAINTENANCE 39
7-6 RETROFIT POTENTIAL 39

CHAPTER 8 INTEGRATED MANAGEMENT PRACTICES

Paragraph 8-1 INTRODUCTION 40
8-1.1 Most Appropriate Uses 40
8-1.2 Cost Data 40
8-1.3 Maintenance Issues 40
8-1.4 Corrective Actions 40
8-2 SOIL AMENDMENTS 40
8-2.1 Most Appropriate Uses 41
8-2.2 Cost Data 41
8-2.3 Maintenance Issues 41
8-2.4 Corrective Actions 42
8-3 BIORETENTION 42
8-3.1 Most Appropriate Uses 42
8-3.2 Cost Data 43
8-3.3 Maintenance Issues 43
8-3.4 Corrective Actions 43
8-4 DRY WELLS 43
8-4.1 Most Appropriate Uses 44
8-4.2 Cost Data 44
8-4.3 Maintenance Issues 44
8-4.4 Corrective Actions 44
8-5 FILTER STRIPS 44
8-5.1 Most Appropriate Uses 44
8-5.2 Cost Data 45
8-5.3 Maintenance Issues 45
8-5.4 Corrective Actions 45
8-6 VEGETATED BUFFERS 45
8-6.1 Most Appropriate Uses 46
8-6.2 Cost Data 46
8-6.3 Maintenance Issues 46
8-6.4 Corrective Actions 46
8-7 GRASSED SWALES 46
8-7.1 Most Appropriate Uses 47
8-7.2 Cost Data 47
8-7.3 Maintenance Issues 47
8-7.4 Corrective Actions 48
8-8 INFILTRATION TRENCHES 48
8-8.1 Most Appropriate Uses 48

8-8.2 Cost Data 48
8-8.3 Maintenance Issues 49
8-8.4 Corrective Actions 49
8-9 INLET DEVICES 49
8-9.1 Most Appropriate Uses 49
8-9.2 Cost Data 50
8-9.3 Maintenance Issues 50
8-9.4 Corrective Actions 50
8-10 RAIN BARRELS 50
8-10.1 Most Appropriate Uses 51
8-10.2 Cost Data 51
8-10.3 Maintenance Issues 52
8-10.4 Corrective Actions 52
8-11 TREE BOX FILTERS 52
8-11.1 Most Appropriate Uses 53
8-11.2 Cost Data 53
8-11.3 Maintenance Issues 53
8-11.4 Corrective Actions 53
8-12 VEGETATED ROOFS 53
8-12.1 Most Appropriate Uses 54
8-12.2 Cost Data 54
8-12.3 Maintenance Issues 55
8-12.4 Corrective Actions 55
8-13 PERMEABLE PAVERS 55
8-13.1 Most Appropriate Uses 56
8-13.2 Cost Data 56
8-13.3 Maintenance Issues 57
8-13.4 Corrective Actions 57
8-14 PERMEABLE PAVEMENT 57
8-14.1 Most Appropriate Uses 57
8-14.2 Cost Data 58
8-14.3 Maintenance Issues 58
8-14.4 Corrective Actions 58
8-15 TECHNICAL CONSULTATION 59
8-16 DEVELOPMENT AND EVALUATION OF ADDITIONAL PRACTICES 59

CHAPTER 9 LID SITE PLANNING PROCESS

Paragraph 9-1 INTRODUCTION 60
9-2 MODEL PLANNING PROCESS 60

CHAPTER 10 DESIGN EXAMPLES

Paragraph 10-1 OFFICE COMPLEX RETROFIT 65
10-1.1 PROJECT OBJECTIVES 65
10-1.2 RANK AND PRIORITIZE OPPORTUNITIES 66

10-1.3 SITE CONDITIONS 66
10-1.4 LID DESIGN 67
10-2 NEW HOUSING DESIGN 70
10-2.1 Curve Number Calculations for Existing Site Condition 70
10-2.2 Post Development Curve Number Calculations 71
10-2.3 Runoff Volume for Existing and Proposed Conditions 73
10-2.4 LID Site Planning Strategies 74
10-2.5 Time of Concentration for Existing and Proposed Conditions 75
10-2.6 Storage Volume Comparison 76
10-2.7 Distributed Detention and Retention Storage Requirements 77
10-2.8 Selection of Appropriate IMPs 77
10-2.9 Water Quality Calculations 85
10-2.10 Conclusion 85

APPENDIX A REFERENCES 86
APPENDIX B GLOSSARY 93
APPENDIX C SUPPORTING CALCULATIONS FOR SECTION 10-2 94
APPENDIX D LID DESIGN CHARTS 98

FIGURES

Figure	Title	Page
1-1	Key LID Elements	1
4-1	Natural Hydrologic Cycle	15
4-2	Hydrologic Cycle of a Developed Environment	15
4-3	Frequency of Small Storms	17
4-4	Greenwall	18
4-5	Mechanism of Groundwater Recharge	20
5-1	Removal Effectiveness of Various BMPs	22
5-2	Biological and Chemical Processes that Occur in a Bioretention Cell	24
5-3	LID Design Process	26
6-1	Treatment Train Process for Phosphorous Removal	37
8-1	Southern Maryland Wood Treating Site (Soil Amendments)	41
8-2	Bioretention Area	42
8-3	Dry Well Schematic	43
8-4	Filter Strip	44
8-5	Riparian Buffer Management	46
8-6	Grassed Swale Schematic	47
8-7	Infiltration Trench Schematic	48
8-8	Inlet Device Schematic	49
8-9	Rain Barrel	51
8-10	Cistern	51
8-11	Manufactured Tree Box Filter	52

8-12 Vegetated Roof Cross-Section 54
8-13 Permeable Paver 56
8-14 Permeable Pavement Cross-Section 59
8-15 Drainage in Both Types of Pavement 59
10-1 Landscaped Area and Parking Area 65
10-2 Drainage Inlet 66
10-3 Drainage Areas of Proposed Practices 67
10-4 Office Complex Retrofit 68
10-5 Map of Existing Conditions 71
10-6 Proposed Housing 72
10-7 Map of Proposed Conditions (Conventional Design) 73
10-8 Map of Proposed Conditions (LID Design) 75
10-9 Street Island Modifications 79
10-10 Street Alterations 80
10-11 Trash Rack 81
10-12 Tree Box Filter 82
10-13 Bioretention (Rain Garden) 83
10-14 Reforestation 84

TABLES

Table Title
5-1 Standard Pollutants in Urban Runoff 32
6-1 Functions of LID Features 35
8-1 Costs Associated with Soil Amending 41
10-1 Projected Load Reduction After LID Retrofit 70
10-2 Composite Curve Number Calculation for Existing Condition 71
10-3 Composite Curve Number Calculation for Proposed Condition 72
10-4 Runoff Depth for Existing and Proposed Conditions (5-inch Rainfall) 74
10-5 Composite CN Calculation for Proposed Condition Using LID 75
10-6 Summary of Graphical Peak Discharge Results 76
10-7 Post-Development Storage Volumes 76

EQUATIONS

Equation
10-1 69
10-2 69
10-3 70
10-4 73
10-5 73
10-6 73
10-7 77
10-8 78

CHAPTER 1

INTRODUCTION TO LID AND MANUAL OVERVIEW

1-1 **DEFINITION OF LID.** Low Impact Development (LID) is a stormwater management strategy concerned with maintaining or restoring the natural hydrologic functions of a site to achieve natural resource protection objectives and fulfill environmental regulatory requirements. LID employs a variety of natural and built features that reduce the rate of runoff, filter out its pollutants, and facilitate the infiltration of water into the ground. By reducing water pollution and increasing groundwater recharge, LID helps to improve the quality of receiving surface waters and stabilize the flow rates of nearby streams.

LID incorporates a set of overall site design strategies as well as highly localized, small-scale, decentralized source control techniques known as Integrated Management Practices (IMPs). IMPs may be integrated into buildings, infrastructure, or landscape design. Rather than collecting runoff in piped or channelized networks and controlling the flow downstream in a large stormwater management facility, LID takes a decentralized approach that disperses flows and manages runoff closer to where it originates. Because LID embraces a variety of useful techniques for controlling runoff, designs can be customized according to local regulatory and resource protection requirements, as well as site constraints. New projects, redevelopment projects, and capital improvement projects can all be viewed as candidates for implementation of LID.

Figure 1-1. Key LID Elements

1-2 **BACKGROUND ON THE USE OF LID.** The use of LID was pioneered in the 1990s by the Prince George's County, Maryland Department of Environmental Resources (PGDER). Prince George's County has a population of over 800,000, and land uses within the County are very diverse, ranging from sparsely populated natural and agricultural areas to densely populated urban centers. The LID effort in Prince George's County began with the development and use of bioretention cells. A bioretention cell is created by replacing existing soil with a highly porous soil mixture, grading the area to form a shallow depression, and replanting the area with specially selected vegetation. The vegetation must be able to tolerate temporarily saturated soil conditions as well as the pollutants contained in the local runoff. When it rains, bioretention areas collect the runoff and then filter out the pollutants as the water passes down through the soil.

The County's initial experience with bioretention led to a full-scale effort to incorporate LID into the County's resource protection program. In 1998, the County produced the first municipal LID manual. This was later expanded into a nationally distributed LID manual published in 2000.[1] A feasibility study was prepared by the Low Impact Development Center in 2002 that provided guidance on how LID could be used to retrofit urban areas.[2] Numerous municipalities, including Portland, Oregon,[3] are incorporating LID techniques into their urban resource protection programs. Although LID concepts and techniques are new to many planners in the United States, many of these techniques have been successfully used in Europe and Asia for many years.[4]

Several successful pilot projects have been constructed by the Navy and other Department of Defense (DoD) agencies during the last several years. The effectiveness of these projects in managing runoff, reducing construction and maintenance costs, and creating ancillary benefits such as community involvement has created significant interest in LID. The challenge is to adapt these approaches and techniques to the unique requirements of DoD facilities on a wider scale.

1-3 **INTRODUCTION TO UFC.** This UFC provides guidelines for integrating LID planning and design into a facility's regulatory and resource protection programs. It will be useful to engineers, planners, maintenance personnel, regulatory compliance staff, and community outreach staff who want a basic understanding of the technical and administrative concepts associated with the design, construction, and maintenance of LID features. The UFC answers the following questions:

- What is LID and what value does it have for DoD facilities?
- What are the basic planning, design, construction, and maintenance considerations?

[1] PGDER, 2000a.
[2] LID Center, 2002.
[3] BES, 2000.
[4] Ibid.

- How can this approach be incorporated into facility operations?
- Where are successful examples of LID DoD facilities and programs?
- What does a typical LID design look like?
- Where can additional guidance be obtained?

This UFC is divided into ten chapters, including this introductory chapter. Chapter 2 provides a brief summary of issues related to compliance and the review process for any DoD project. Chapter 3 discusses regulations that apply to water resource and sustainability concerns for DoD projects, and how implementation of LID will affect compliance. Chapter 4 compares the ways that LID and conventional stormwater management approaches utilize hydrologic data and concepts in the design process. Chapter 5 discusses the goals of an LID design and the principles and strategies to meet them. Chapter 6 provides an overview of LID devices and the objectives they are designed to meet. Chapter 7 discusses the relative benefits of LID and conventional stormwater management practices. Chapter 8 details the appropriate use, cost, and maintenance issues for the LID devices introduced in Chapter 6. Chapter 9 provides a detailed outline of the LID planning process. Finally, Chapter 10 offers two examples of LID techniques put into practice, with accompanying calculations.

1.4 **LID SITE DESIGN STRATEGIES.** The goal of LID site design is to reduce the hydrologic impact of development and to incorporate techniques that maintain or restore the site's hydrologic and hydraulic functions. The optimal LID site design minimizes runoff volume and preserves existing flow paths. This minimizes infrastructural requirements. By contrast, in conventional site design, runoff volume and energy may increase, which results in concentrated flows that require larger and more extensive stormwater infrastructure.

Generally, site design strategies for any project will address the arrangement of buildings, roads, parking areas, and other features, and the conveyance of runoff across the site. LID site design strategies achieve all of the basic objectives of site design while also minimizing the generation of runoff. Some examples of LID site design strategies discussed in this UFC include:

- Grade to encourage sheet flow and lengthen flow paths.
- Maintain natural drainage divides to keep flow paths dispersed.
- Disconnect impervious areas such as pavement and roofs from the storm drain network, allowing runoff to be conveyed over pervious areas instead.
- Preserve the naturally vegetated areas and soil types that slow runoff, filter out pollutants, and facilitate infiltration.

- Direct runoff into or across vegetated areas to help filter runoff and encourage recharge.
- Provide small-scale distributed features and devices that help meet regulatory and resource objectives.
- Treat pollutant loads where they are generated, or prevent their generation.

1-4.1 **LID Devices.** Reevaluate the site design once all of the appropriate site design strategies are considered and proposed to determine whether the stormwater management objectives have been met. Stormwater management controls, if required, should be located as close as possible to the sources of potential impacts. The management of water quality from pavement runoff, for example, should utilize devices that are installed at the edge of the pavement. These types of controls are generally small-scale (because the site planning strategies have created small-scale drainage areas and runoff volumes) and can be designed to address very specific management issues. The objective is to consider the potential of every part of the landscape, building(s), and infrastructure to contribute to the site stormwater management goals. When selecting LID devices, preference should be given to those that use natural systems, processes, and materials. The following list briefly defines the LID devices (or IMPs) described in this UFC.

1-5 **BASIC LIST OF IMPs.** Here is a basic list of IMPs that are available. More detailed descriptions are presented in Chapter 8. Appendix B contains a list of acronyms and abbreviations cited in the UFC.

Bioretention: Vegetated depressions that collect runoff and facilitate its infiltration into the ground.

Dry Wells: Gravel- or stone-filled pits that are located to catch water from roof downspouts or paved areas.

Filter Strips: Bands of dense vegetation planted immediately downstream of a runoff source designed to filter runoff before entering a receiving structure or water body.

Grassed Swales: Shallow channels lined with grass and used to convey and store runoff.

Infiltration Trenches: Trenches filled with porous media such as bioretention material, sand, or aggregate that collect runoff and exfiltrate it into the ground.

Inlet Pollution Removal Devices: Small stormwater treatment systems that are installed below grade at the edge of paved areas and trap or filter pollutants in runoff before it enters the storm drain.

Permeable Pavement: Asphalt or concrete rendered porous by the aggregate structure.

Permeable Pavers: Manufactured paving stones containing spaces where water can penetrate into the porous media placed underneath.

Rain Barrels and Cisterns: Containers of various sizes that store the runoff delivered through building downspouts. Rain barrels are generally smaller structures, located above ground. Cisterns are larger, are often buried underground, and may be connected to the building's plumbing or irrigation system.

Soil amendments: Minerals and organic material added to soil to increase its capacity for absorbing moisture and sustaining vegetation.

Tree Box Filters: Curbside containers placed below grade, covered with a grate, filled with filter media and planted with a tree in the center.

Vegetated Buffers: Natural or man-made vegetated areas adjacent to a water body, providing erosion control, filtering capability, and habitat.

Vegetated Roofs: Impermeable roof membranes overlaid with a lightweight planting mix with a high infiltration rate and vegetated with plants tolerant of heat, drought, and periodic inundation.

CHAPTER 2

INSTITUTIONAL ISSUES

2-1 **INTRODUCTION.** As with other types of construction projects, LID designs must meet DoD criteria and specifications before they can be approved. In addition, state and local zoning requirements and building codes may apply. This section provides an overview of these institutional issues and how they can be addressed effectively.

2-2 \2**COMPLIANCE AND APPLICABILITY.** Currently this UFC is under revision to comply with new legislation and policies. Comply with Energy and Independence Security Act (EISA) Section 438 and Executive Order 13514. In addition for Navy and Marine Corps facilities comply with Interim Technical Guidance (ITG) FY10-02 LOW IMPACT DEVELOPMENT (UFC 3-210-10N)/2/

2-2.1 **Compliance with DoD Design Criteria.** LID techniques will comply with DoD design criteria. This UFC has the approval of Naval Facilities Engineering Command for compliance with Navy and DoD criteria and is written with the express purpose of assisting site engineers with satisfying DoD design criteria.

2-2.2 **Cost-Effectiveness.** The cost-effectiveness of LID-based projects may affect DoD approval. LID projects that incorporate newer technology may involve higher design and construction costs and may take more time to receive approval as a result. Whether or not this is the case for a particular site will depend on the level of experience that the project managers, engineers, and contractors have with LID techniques, and on the receptiveness of permitting authorities to LID practices. As with any new approach, the cost of implementing LID will decrease as institutional experience increases and the benefits of using LID are realized in practice.

2-2.3 **Antiterrorism/Force Protection.** All DoD facilities must comply with UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*. If any conflict occurs between this UFC and UFC 4-010-01, the requirements of UFC 4-010-01 take precedence.

2-3 **FEDERAL, STATE, AND LOCAL GOVERNMENT ACCEPTANCE.** Every new construction or retrofit project must meet applicable federal, state, and local regulatory requirements pertaining to construction materials, elevation and drainage, stormwater management, historic features, and wetlands protection. Because LID may be a new concept in some areas, DoD personnel may have to plan for additional reviews to gain support for LID as an effective alternative to traditional stormwater management control.

2-4 **BUILDING CODES.** For some DoD facilities, all projects, including LID designs, must meet UFC 1-200-01, *General Building Requirements*. As with any project, the project manager or contractor must ensure that the project meets all

applicable zoning, land use, or development regulations and must identify any special waivers, modifications, or processes that may be needed to gain approval. The design details should be evaluated for conformance with standard building codes to address access, safety and health issues.

CHAPTER 3

WATER RESOURCE PROBLEMS, ISSUES, AND CHALLENGES

3-1 **INTRODUCTION.** Stormwater management efforts at DoD facilities will have a higher value when the design objectives involve not only the control of runoff at the drainage area outlet but also on-site water conservation, strategic conveyance of runoff, pollution prevention, stormwater treatment, and habitat preservation. DoD facility staff, however, currently face several significant challenges when pursuing these objectives because they must simultaneously consider mission, environmental, facility and budgetary goals. In many instances, LID can benefit several of these goals at the same time. For instance, LID can help to reduce expenditures on piped or channelized conveyance systems and large retention basins, because a fundamental LID technique is to provide storage and treatment on-site before runoff builds up in significant quantities. The following sections present the key issues and challenges associated with implementing LID on DoD facilities.

3-2 **COASTAL ZONE ISSUES.** Coastal zone issues are of particular concern for the DoD. DoD facilities located on the coast or along major water bodies often receive increased public and regulatory scrutiny. The primary stormwater management challenge facing DoD facility managers is minimizing uncontrolled runoff from industrial operations (e.g., ship maintenance operations and fueling areas) and from impervious areas (e.g., cantonment areas, docks, parking lots). Retrofitting a site using strategically placed LID components will enable DoD to conduct operations on a landscape that is less detrimental to water quality.

3-3 **REGULATORY COMPLIANCE.** This section lists the major federal laws concerning stormwater management and natural resource conservation at DoD facilities, and how implementing LID can help reduce the burdens associated with complying with these regulations.

3-3.1 **Clean Water Act.** The Clean Water Act (CWA) is the primary Federal law concerned with protecting the quality of the nation's waters. The major CWA programs pertaining to stormwater management are:

3-3.1.1 **Section 303. Total Maximum Daily Loads.** Section 303 of the CWA requires states, territories, and authorized tribes to develop lists of impaired waters and establish total maximum daily loads (TMDLs) allowable for these waters. States use the TMDL process to allocate pollutant loadings among pollution sources in a watershed and to provide a basis for establishing controls to reduce both point and non-point source pollutant loadings. LID can be used to help states meet TMDL targets in designated watersheds.

3-3.1.2 **Section 311. Spill Prevention, Control and Countermeasure Requirements.** Section 311 addresses pollution from oil and hazardous substance releases, providing EPA and the U.S. Coast Guard with the authority to establish a

program for preventing, preparing for, and responding to oil spills that occur in navigable waters of the United States. EPA requires that certain facilities develop and implement oil spill prevention, control, and countermeasures (SPCC) plans. The goal of an SPCC plan is to ensure that facilities install containment and other countermeasures to prevent oil spills from reaching navigable waters.

3-3.1.3 **Section 319. State Non-Point Source Management Program.** This section delegates the regulation of non-point source pollution to the states and establishes the Non-Point Source Management Program. Although Section 319 of the CWA includes no enforcement mechanism to ensure that states actually develop and implement programs, CWA Section 303 requires that states identify all the activities that are causing a water body to be impaired, including non-point source pollutants, and develop mitigation plans.

3-3.1.4 **Section 401. Certification and Wetlands.** Section 401 of the CWA gives states, territories and authorized tribes the authority to review and approve, deny or condition all Federal permits or licenses that might result in a discharge to State or Tribal waters, including wetlands. State wetland water quality standards will limit the degradation of its waters and wetlands resulting from Federal activity. (In states without such standards, Federal water quality standards apply.) In order to obtain state certification, a development project may be required to prevent potential degradation of receiving waters caused by the discharge of stormwater runoff. LID can be used to reduce pollutant concentrations in stormwater runoff. Because of their small footprint and their manner of operation (i.e. filtering and dewatering devices rather than wet systems) LID devices themselves will not be subject to regulation as wetlands.

3-3.1.5 **Section 402. National Pollutant Discharge Elimination System (NPDES) Program.** The CWA prohibits the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized by a NPDES permit. Facilities that discharge stormwater from certain activities (including industrial activities, construction activities, and municipal stormwater collection systems) require NPDES permits. These facilities must implement commonly-accepted stormwater discharge management controls, often referred to as best management practices (BMPs), to effectively reduce or prevent the discharge of pollutants into receiving waters. Using LID to eliminate the volumes of effluent discharges of permit–requiring activities can help reduce the need for NPDES permits.

For many DoD facilities, the CWA Stormwater Phase II rule will expand their NPDES permitting requirements. Under the CWA Stormwater Phase II rule, EPA (or a state given CWA enforcement authority) can require a facility with a stormwater system to obtain a permit, even if it is not automatically regulated, if the facility's stormwater system discharges via a point source to an impaired water (the CWA 303d list), or to sensitive waters. Facilities that fall under the Phase II rule must develop and implement various BMPs including expanded stormwater management. LID techniques can help a facility to meet stormwater control requirements in a manner that minimizes impacts to

the facility and natural environment and reduces the amount of infrastructure to be constructed and maintained.

Stormwater management solutions must qualify as state and local government-approved BMPs and meet technical performance criteria. For example, an infiltration trench must provide a minimum level of pollutant removal as well as meet other performance requirements. A number of regulators are specifically encouraging the use of LID techniques and other innovative stormwater management solutions that reduce pollution associated with runoff. Many already encourage the use of bioretention, dry wells (where permitted), filter strips, vegetated buffers, grassed swales, and infiltration trenches. In some cases, stormwater credits may be given for using LID approaches.

3-3.1.6 **Section 404. Regulation of Dredged or Fill Material.** Section 404 of the CWA establishes programs to regulate the discharge of dredged or fill material into U.S. waters, including wetlands. The U.S. Army Corps of Engineers and the EPA jointly administer Section 404. According to these regulations,[5] no discharge of dredged or fill material can be permitted if a practicable alternative exists that is less damaging to the aquatic environment, or if the nation's waters would be significantly degraded. In other words, a permit applicant must demonstrate that they have:

- taken steps to avoid wetland impacts where practicable;
- minimized potential impacts to wetlands; and
- provided compensation for any remaining, unavoidable impacts through activities to restore or create wetlands.

LID features can reduce potential impacts to wetlands in several ways. First, filtering out pollutants from runoff helps to preserve the quality of water reaching the wetlands. Additionally, enhancing infiltration in the vicinity of the wetlands helps to sustain the supply of groundwater that feeds them. Finally, by reducing runoff energy, LID devices help prevent downstream erosion, reducing the volume of material that must ultimately be dredged from a channel or reservoir.

3-3.2 **Safe Drinking Water Act Wellhead Protection Program.** The Wellhead Protection Program protects the recharge areas of public water system wells from all sources of contamination. Groundwater recharge often results from LID techniques that increase rates of infiltration. Care should be taken, however, to ensure that any pollutants contained in runoff are adequately filtered out before the stormwater percolates down to aquifers in wellhead protection zones.

3-3.3 **Coastal Zone Management Act.** The Coastal Zone Management Act requires DoD facilities located in coastal states with approved coastal zone

[5] http://www.epa.gov/owow/wetlands/facts/fact10.html

management programs to conform to the state program. As part of their programs, states must develop and implement coastal non-point source pollution control programs. States may object to permits for activities that are inconsistent with the state's coastal zone management plan. LID techniques can comprise a constructive response to state implementation of a non-point source pollution control program.

3-3.4 **Energy Policy Act of 1992.** The Energy Policy Act of 1992 created conservation and energy-efficiency requirements for the federal government and consumers. The Act requires federal agencies to install, by January 1, 2005, energy and water conservation measures that will achieve acceptable payback periods. (A payback period is the time required to recoup the initial investment in a product or service.) LID techniques such as vegetated roofs and landscape shading can help a facility treat stormwater runoff, meet energy reduction goals, and possibly extend the life of infrastructure such as roofs. Water collected from rain barrels and cisterns for landscaping can be used to reduce a facility's water consumption, again helping to meet the Act's goals.

3-3.5 **Estuaries and Clean Waters Act of 2000.** The Estuaries and Clean Waters Act of 2000 established a program to utilize federal, state and private funding to support locally proposed watershed restoration projects. Under the Act, all Chesapeake Bay agreements are now codified, meaning that all agreements that DoD has signed are now law. Under the Act, federal agencies that own or operate a facility within the Chesapeake Bay watershed must participate in regional and sub-watershed planning and restoration programs. Additionally, the Act states that:

> "The head of each Federal agency that owns or occupies real property in the Chesapeake Bay watershed shall ensure that the property, and actions taken by the agency with respect to the property, complies with the Chesapeake Bay Agreement, the Federal Agencies Chesapeake Bay Unified Plan, and any subsequent agreements and plans."

Lastly, by 2010, the Chesapeake Bay watershed must be off the impaired waters list or it will be subject to TMDL requirements. Stricter discharge limits may result. Wherever discharge limits are imposed, LID techniques can be used to control the discharge of pollutants in stormwater.

3-3.6 **National Environmental Policy Act of 1969.** The National Environmental Policy Act of 1969 requires facilities to conduct and document environmental analyses and seek advice, participation, or comment from appropriate governmental agencies, and inform interested public and private organizations. The analyses include many aspects covering land use, air and water quality, wildlife and their habitats, socioeconomic factors, human health and safety, and natural and historical resources. By incorporating LID into site design, facilities can minimize adverse affects of new development on the environment (e.g., topography, stormwater, vegetation).

3-3.7 **Sikes Act.** The Sikes Act requires facilities to manage natural resources via an approved Integrated Natural Resource Management Plan. This plan serves as the facility plan for managing its ecosystems, including watersheds and wetlands. Consistent with the goals of the Sikes Act, the use of LID techniques will help maintain the natural landscape and its hydrology.

3-4 **DIRECTIVES.** DoD facilities also must meet various Presidential Executive Orders (EOs) or directives in addition to meeting federal laws. This section lists the major directives that relate to stormwater management and conservation and indicates how implementing LID designs can help reduce compliance burdens.

3-4.1 **EO 13148, Greening the Government through Leadership in Environmental Management.** Each agency must strive to promote the sustainable management of federal facility lands through the implementation of cost-effective, environmentally sound landscaping practices and programs designed to reduce adverse impacts on the natural environment. Sustainable environmental management can be implemented directly and visibly through the use of LID.

3-4.2 **LEED Green Building Rating System™.** The U.S. Green Building Council has developed the LEED Green Building Rating System™, a national standard for developing high-performance, sustainable buildings. Projects can earn LEED™ certification for sustainability based on the number of sustainable practices incorporated into the project. DoD facilities that implement LID techniques can receive LEED™ points for limiting the disruption of natural water flows by minimizing stormwater runoff, increasing on-site infiltration, and reducing contaminants. Currently, Navy and Air Force policies encourage the use of the LEED checklist, which the Army soon plans to adopt as well. Other DoD criteria such as the Army's Sustainable Project Rating Tool (SPiRiT), which is adapted from the LEED checklist, may also apply.

3-5 **VOLUNTARY PROGRAMS AND AGREEMENTS.** Partnerships between federal, state, local, and private entities have developed voluntary, watershed-wide guidelines aimed at preserving and restoring water quality in water bodies such as the Potomac River or Chesapeake Bay. One such partnership is the Chesapeake Bay Program, of which DoD is a partner. The Chesapeake Bay Program offers specific guidelines such as providing riparian buffers and implementing new stormwater management technologies in targeted watersheds. (Riparian land is adjacent to a stream or river and has an elevated level of biological activity because of that proximity.[6]) The use of LID as a design approach will help to fulfill the aims of these facilities agreements and partnerships.

3-6 **COSTS.** LID practices offer opportunities to reduce the life cycle cost of a site's stormwater infrastructure. It is impractical to make broad generalizations about costs for stormwater facilities because of the inherent variability between sites and the complexity of management issues. Although initial construction costs for LID practices

[6] Lee, 1998.

may be higher than initial costs for conventional stormwater practices, this initial expense is often offset by cost savings in operations and maintenance. This savings is possible because the maintenance of LID features can generally be incorporated into regular landscaping maintenance activities and does not require expensive training or hiring of a separate contractor for maintenance. Details for specific LID practices are presented in Chapter 8.

3-7 **RETROFITS.** Older DoD facilities were developed either with traditional approaches or with no stormwater management at all. Eventually, stormwater management components will have to be installed, replaced or retrofitted – a costly task. DoD will inevitably need to replace pipes and dredge stormwater ponds. LID techniques, particularly non-structural techniques such as disconnecting impervious areas, can significantly reduce the cost of retrofitting or providing stormwater management.

CHAPTER 4

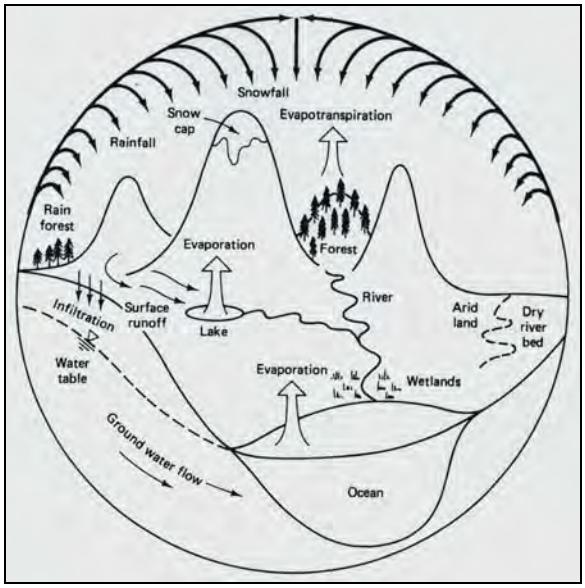
STORMWATER MANAGEMENT USING THE HYDROLOGIC CYCLE APPROACH

4-1 **INTRODUCTION.** Development affects the natural hydrologic cycle as shown in Figures 4-1 and 4-2. The hydrologic cycle consists of the following processes: convection, precipitation, runoff, storage, infiltration, evaporation, transpiration, and subsurface flow.

A hydrologic budget describes the amounts of water flowing into and out of an area along different paths over some discrete unit of time (daily, monthly, annually). Grading, the construction of buildings, and the laying of pavement typically affect the hydrologic budget by decreasing rates of infiltration, evaporation, transpiration and subsurface flow, reducing the availability of natural storage, and increasing runoff. In a natural condition such as a forest, it may take 25 to 50 mm (one to two inches) of rainfall to generate runoff. In the developed condition, even very small amounts of rainfall can generate runoff because of soil compaction and connected impervious areas. The result is a general increase in the volume and velocity of runoff. This, in turn, increases the amount of pollution that is carried into receiving waters and amplifies the generation of sediment and suspended solids resulting from bank erosion.

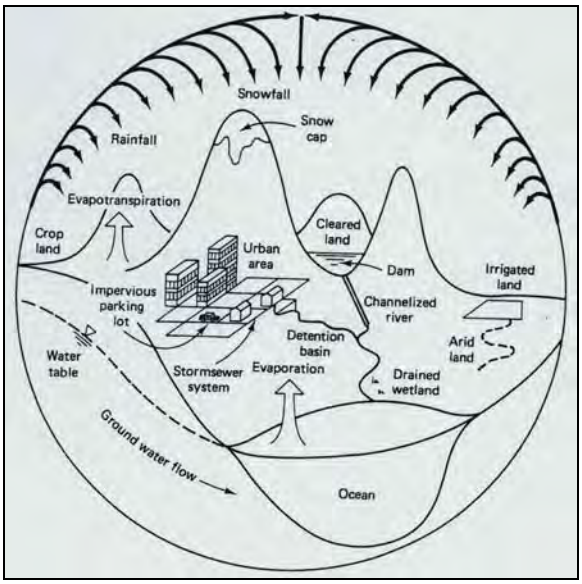
4-2 **DESIGN INPUTS.** Both LID and conventional stormwater management techniques attempt to control rates of runoff using accepted methods of hydrologic and hydraulic analysis. The particular site characteristics that are considered will depend on the nature of the project. Land use, soil type, slope, vegetative cover, size of drainage area and available storage are typical site characteristics that affect the generation of runoff. The roughness, slope and geometry of stream channels are key characteristics that affect their ability to convey water.

Figure 4-1. Natural Hydrologic Cycle



Source: McCuen, 1998.

Figure 4-2. Hydrologic Cycle of a Developed Environment



Source: McCuen, 1998.

While conventional approaches to stormwater management design typically include only the hydrologic components of precipitation, runoff conveyance and storage capacity within their scopes, LID design recognizes the significance of other components of the hydrologic cycle as well. How these other components are actually taken into account will depend on the information available and purpose of the design. One LID design objective, for example, may be to maintain a natural groundwater recharge rate for a given site. Determining the appropriate number, size, and location of infiltration devices can require an extensive atmospheric data set (temperature and

precipitation) to calculate evapotranspiration rates, along with measures of soil hydraulic conductivity.

The following section describes how LID design can make use of precipitation, storage, infiltration, evaporation, and transpiration data. The discussion includes a brief description of each of these types of data, and compares the use of these data from LID and conventional stormwater management perspectives.

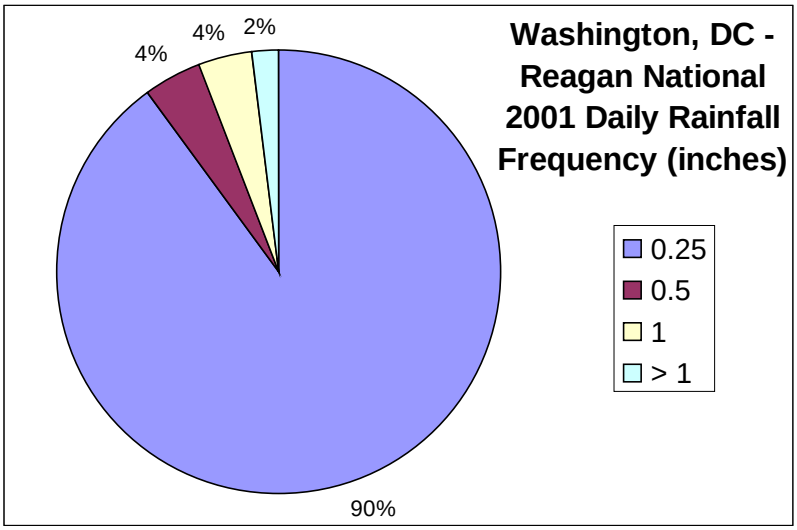
4-3 **PRECIPITATION DATA.** Precipitation data is often analyzed in terms of the frequency at which storm events of different magnitudes and durations occur at a given location. Stormwater management designs may take into account the total annual depths or the volume generated by a storm of a specific frequency and duration (e.g. 2-year 24-hour storm event). Hydrologic models may use precipitation data to develop a synthetic design storm that reflects the pattern and intensity of precipitation for the project location region or use actual gage data from a given storm event.

The level of detail and accuracy of data used is dependent on the requirements of the hydrologic model. For example, to develop a simple water balance for on-site irrigation only a few years of annual rainfall totals may be required. Some advanced urban hydraulic models, on the other hand, may require the collection of rainfall data in 2-minute intervals over several years to determine the appropriate system design.

4-3.1 **LID Precipitation Analysis.** An important approach to analyzing the effectiveness of an LID design is to consider the number of storm events for which the design will provide enough storage and infiltration capacity to capture all of the precipitation on-site. This is useful because maintaining the hydrologic integrity or water balance of a site is better accomplished by managing the frequent smaller events rather than the occasional large events.

For example, in the Washington, D.C. region there are approximately 80 storm events per year that collectively generate approximately 1000 mm (40 in) of precipitation. Approximately 75 of these storm events generate 13 mm (0.5 in) or less of precipitation. Figure 4-3 illustrates this concept.

Figure 4-3. Frequency of Small Storms



Source: NOAA.

This kind of analysis allows the designer to determine the overall storage and infiltration capacity required to control the desired number of storm events within any given year or period. The analysis can also be undertaken in terms of the precipitation depth associated with discrete storm events such as the 1-year 24-hour storm.

4-3.2 **Conventional Precipitation Analysis.** Conventional practices, as well as many state and local regulations, often require site engineers to control only specific events such as the 2-year 24-hour storm events. In the Washington, D.C. area, this would mean reducing the peak runoff to predevelopment rates for only those events in which 76 mm (3 in) of rainfall. Events that occur more or less frequently would be less effectively controlled.

4-4 **STORAGE.** Precipitation may be temporarily detained within site depressions or held in the soil. When the capacity of a depression is exceeded, the water is released as runoff that may be captured further downstream. Water that is not released as runoff will be infiltrated into the soil, taken up by plants, or evaporated back into the atmosphere. Natural land cover often provides depression storage in small undulations in the topography. Greater storage capacity is provided in ponds or lakes.

4-4.1 **LID Storage Concepts.** LID employs site planning and grading techniques to direct or maintain the flow of runoff to naturally occurring storage areas such as wetlands. Keeping the storage area volume stable helps to maintain the existing hydrologic and biological function of the storage area.

An LID design may also include small-scale retention components (retention is defined as the volume of runoff that never reaches the drainage area outlet). Retention can be provided in a variety of ways that not only support the management of runoff, but also supply water for on-site use. For example, a cistern may be used to

store and release water for peak flow control as well as to store water for domestic purposes. Additionally, some industrial buildings can provide roof storage and release water for use in cooling systems. Another example, shown in Figure 4-4, is a green wall within a building. The green wall is used to modify temperature and improve air quality by having stored roof water flow across the vegetation.

Capturing runoff in small volumes helps to prevent erosion, because the runoff is less likely to reach damaging flow rates. The distribution of storage components also tends to result in a more robust stormwater management system, because the failure of one component will not cause the entire system to fail. Care must be taken when ponding or storing water to make sure there is adequate flow, infiltration, evaporation, or discharge, and that unwanted carriers of disease such as mosquitoes are adequately controlled.

Figure 4-4. Greenwall

Source: Greenland International Consulting, Inc., Ontario, Canada.

4-4.2 **Conventional Storage Concepts.** Conventional stormwater strategies often include the storage of water in large centralized end-of-pipe facilities. Site designs direct and convey most runoff as quickly as possible to these facilities and then discharge through an outlet structure at a limited release rate (e.g., 2-year 24-hour pre-development runoff rate). Conventional runoff management techniques can dramatically reduce the flow of runoff into natural storage areas such as wetlands, depriving a variety of organisms of the level of moisture they need.

Conventional approaches can have other negative impacts. By removing opportunities for storage onsite, rates of ground water recharge will be reduced. In

addition, the concentrated flow conveyed to large-scale facilities accumulates pollutants and increases the erosive force of the water, which must be slowed down and treated to maintain the natural energy and chemical balance of the ecosystem. An increase in temperature as the water is pooled may also be detrimental to the ecological integrity of the receiving water.

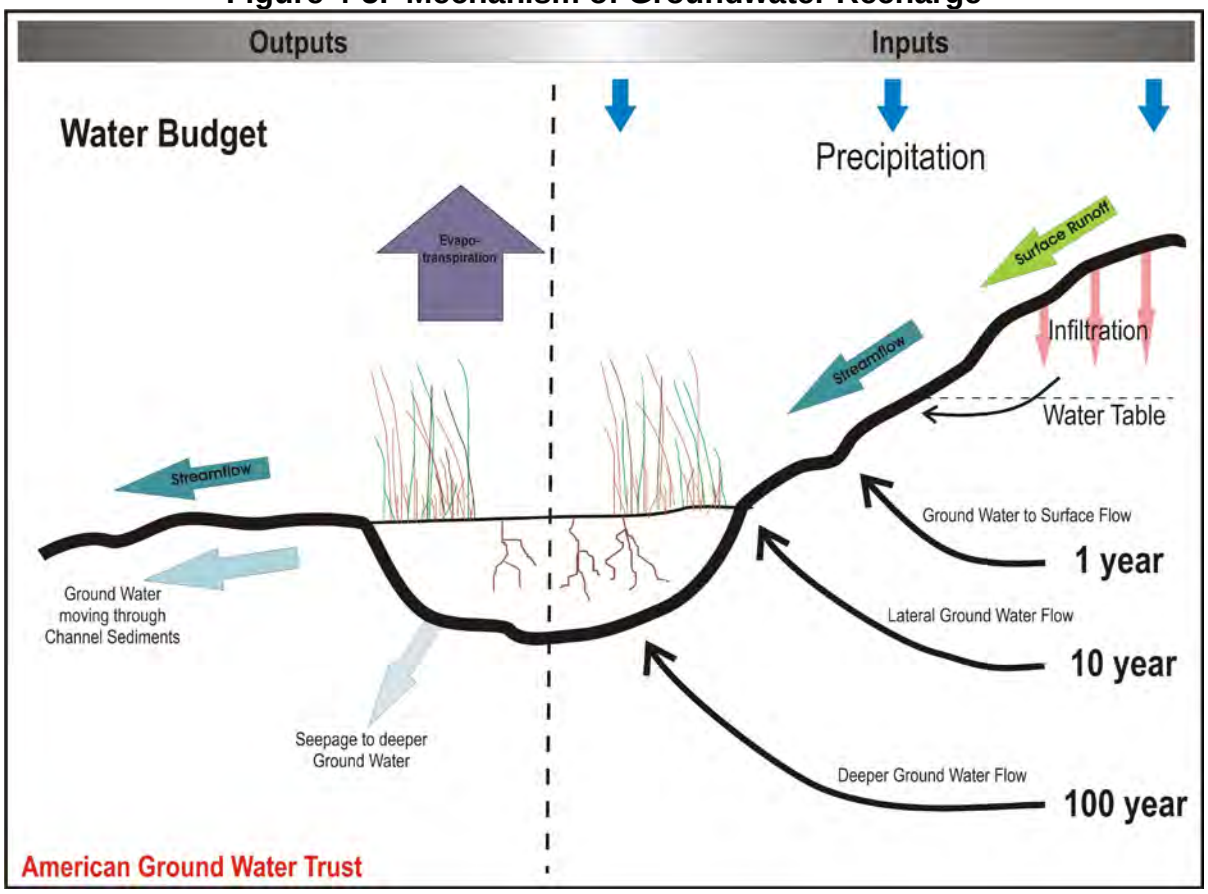
4-5 **INFILTRATION.** Water stored in depressions will infiltrate into the soil at different rates, depending on the soil type and the amount of moisture already in the soil. Some of the water that infiltrates into the ground may then percolate further downward into an aquifer, or travel horizontally and reappear as surface flow in a stream. A portion of the water will be held in the soil and extracted by vegetation.

The capacity of the soil to absorb and infiltrate water is dependent on a variety of factors such as soil structure (e.g., pore spaces and particle size), classification (percentage of sand, silt, and clay) and biological activity (e.g., roots, worms). Water is filtered by the soil system by various mechanisms such as adsorption and chemical and biological reactions. Under natural conditions, a significant portion of the annual precipitation may infiltrate into the ground. As land is developed, however, many natural depressions that would otherwise collect water are eliminated, the soil is compacted, and impervious area is added in the form of buildings and pavement. Consequently, levels of infiltration typically decrease when a site is developed. The additional runoff generated often results in degradation of the watercourse because of bank erosion, increased flooding, and alteration of habitat characteristics.[7]

The infiltration flow patterns and processes are extremely important to maintain the water balance in wetlands and the base flow in stream channels. Figure 4-5 illustrates how groundwater feeds an aquatic system.

[7] Gordon et al., 1992.

Figure 4-5. Mechanism of Groundwater Recharge



4-5.1 **LID Infiltration Concepts.** Maintaining natural infiltration rates is an important aspect of LID design. Accomplishing this requires an accurate understanding of the existing soils and groundcover conditions. For example, a clay soil on a pre-development site may have very little infiltration capacity or a sandy soil, which is compacted, may have reduced capacity. The design should take care not to overload the hydraulic conductivity of existing soils.

Soil maps by themselves are not sufficient to determine the capacity of the soils to absorb and filter water; additional field testing is required. Dispersing flows, maintaining natural flow patterns, and directing flows towards soils with high capacities for infiltration will help maintain ground water levels. Amending soils by adding organic materials, reducing compaction by aeration, maintaining leaf or “duff” layers in natural areas, and reducing compaction requirements for non-load bearing areas will also enhance and maintain infiltration rates and patterns.

Although soils and natural areas have a high capacity to filter and treat pollutants, careful planning must take place to ensure that potential pollutants such as nitrates, oils, or other urban runoff contaminants are adequately treated before entering any potential water supply. Infiltration areas should not be located near areas that have potential for hazardous waste spills or contamination. It is important to ensure that

runoff is adequately filtered before it is allowed to infiltrate, especially if local aquifers are particularly shallow. In cases where the water table is very high, it is often advisable to avoid infiltration altogether.

4-5.2 **Conventional Infiltration Concepts.** Conventional approaches concentrate on the infiltration capacity of a single end-of-pipe management facility such as a pond. Infiltration potential elsewhere on the site is often discounted or only analyzed for its effect on the flow of runoff into the facility. The conventional infiltration objective is to concentrate flows in one area and then utilize the infiltration capacity of the natural soil or conduits such as gravel. Natural groundwater flow patterns and recharge are often not considered. Conventional approaches may result in the elimination of critical volumes of flows to sensitive areas such as wetlands. Additionally, in many urban areas, the high loads of fine sediments to centralized facilities and the impacts of construction compaction can severely limit the infiltration capacity of the facility.

4-6 **EVAPOTRANSPIRATION.** Evapotranspiration is the loss of water from the ground by evaporation and transpiration. Evaporation is the return of moisture to the atmosphere from depressions, pond areas, or other surfaces. Transpiration is the return of water to the atmosphere through plants; moisture is absorbed by the roots and released through the leaves. The rate of evapotranspiration is dependent on air temperature, humidity, wind speed, sunlight intensity, vegetation type, and soil conditions.

4-6.1 **LID Evapotranspiration Concepts.** LID designs use open areas and vegetation to promote evapotranspiration. Larger areas used for evaporation, such as ponds, should have a flow regime that controls mosquito breeding. LID designs should not pond water for more than 72 hours as it may provide an opportunity for mosquitoes to breed. By keeping surface areas small and shallow, water can quickly evaporate and pollutants volatilize through plant uptake or evaporation.

LID designs also employ the capacity of vegetated areas to absorb, process, volatilize, and treat non-point source pollution as well as atmospheric pollution. Interception by leaves can significantly reduce the requirement for storage and infiltration. A mature canopy can intercept a significant number of small-volume, frequently occurring storms, absorbing precipitation into the plant leaves or evaporating precipitation from the leaf surface.[8] Additionally, uptake of soil moisture by plants helps to maintain the soil's capacity to absorb rainfall.

4-6.2 **Conventional Evaporation Concepts.** Conventional stormwater approaches are based on peak flow control over a short duration (usually 24 hours or less). For these single event designs, the evaporation process is often discounted or not considered.

[8] Sanders, 1986.

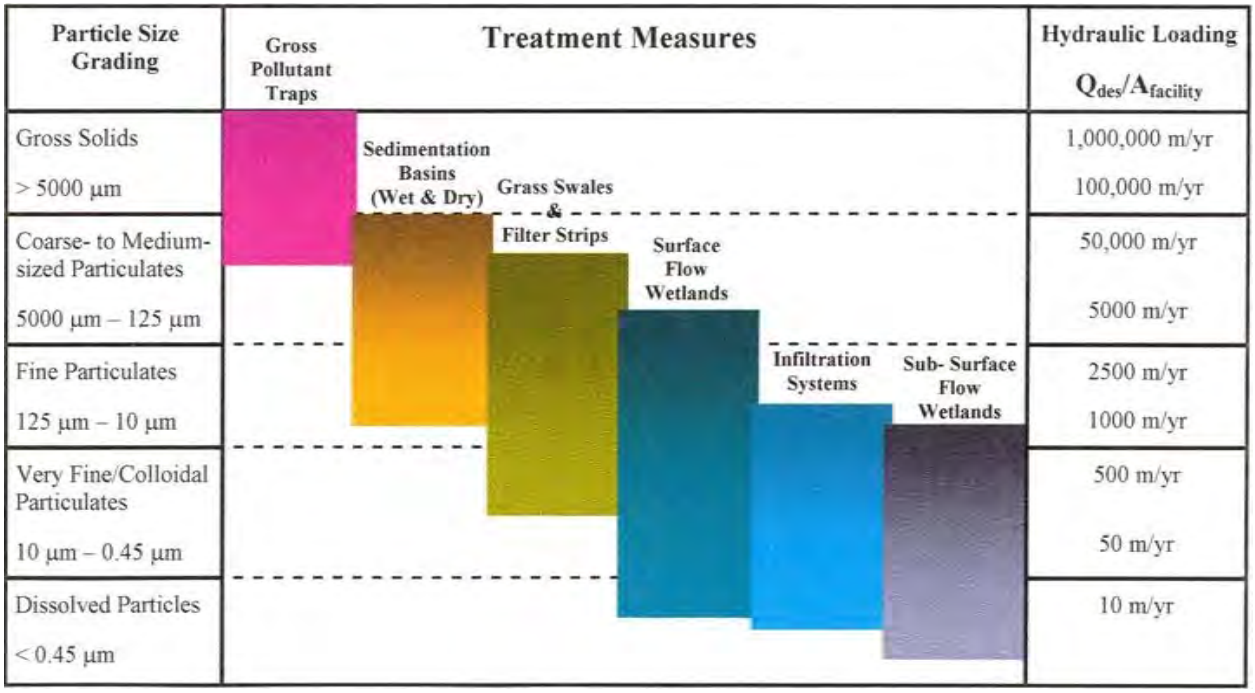
CHAPTER 5

LID DESIGN GOALS AND OBJECTIVES

5-1 **INTRODUCTION.** DoD facilities are faced with the responsibility of managing and protecting the natural resources of often large parcels of land reserved for many different functions. Uses can be intensive and can pose a variety of stormwater challenges. For example, a truck maintenance facility or post-exchange may generate stormwater pollutants and alter the downstream hydrology. Alternatively, a vehicle training range may pose a high risk for pollution (e.g., high TSS) but on an infrequent basis. There is no single management practice that can be universally applied to all drainage areas.

Figure 5-1 illustrates the removal effectiveness of various BMPs for a variety of pollutants. The graph illustrates the complexity of stormwater management; there is no single BMP or technique that can be used to effectively address all of the potential watershed issues.

Figure 5-1. Removal Effectiveness of Various BMPs



Source: Wong.

5-2 **REGULATORY AND NATURAL RESOURCE DESIGN ISSUES.** Many regulatory compliance or flood control (peak rate design) schemes for construction are designed to achieve only one objective (e.g., pre-development control for the 2-year 24-hour storm event). Regulations often fail to consider overall natural resource management, hydrologic objectives, and stewardship responsibilities of facilities.

Budget constraints often limit construction funding to that necessary for conveyance or flood control requirements. The limited framework may create situations where regulatory requirements are met but the design results in degradation of the natural resources. LID principles use hydrology as the integrating framework of design, and protect the overall ecology of the watershed. LID allows facilities to meet the regulatory requirement for flood control (by storing and infiltrating a sufficient volume) while sufficiently filtering targeted pollutants through natural and man-made systems.

5-3 **FUNDAMENTAL SITE PLANNING CONCEPTS.** The goal of LID site planning is to allow for full development and function of the intended site activity while maintaining the site's essential natural or existing hydrologic function. The LID site design process is sequential and iterative, and embraces the following five concepts:[9]

- Hydrology is the Integrating Framework for the Design
- Distribute Controls through Micromanagement
- Stormwater is Controlled at the Source
- Utilize Non-structural Systems Where Possible
- Create Multifunctional Landscape, Buildings and Infrastructures

5-3.1 **Hydrology is the Integrating Framework for the Design.** LID designs have the goal of mimicking the natural site drainage processes and functions. Techniques are used to modify hydrologic processes, such as infiltration or storage, to meet the specific water quality, water quantity, and natural resource objectives. LID designs create an effective drainage process for stormwater on the site. A stormwater management system will come closest to mimicking natural flow patterns when storage and infiltration components are distributed across the site.

5-3.2 **Distribute Controls Through Micromanagement.** In order to emulate natural processes, it is imperative to view the site as a series of interconnected small-scale design controls. Such a structure creates opportunities for redundancy in treatment and control, the development of a "treatment train" for water quality control, and the opportunity to strategically locate LID components.

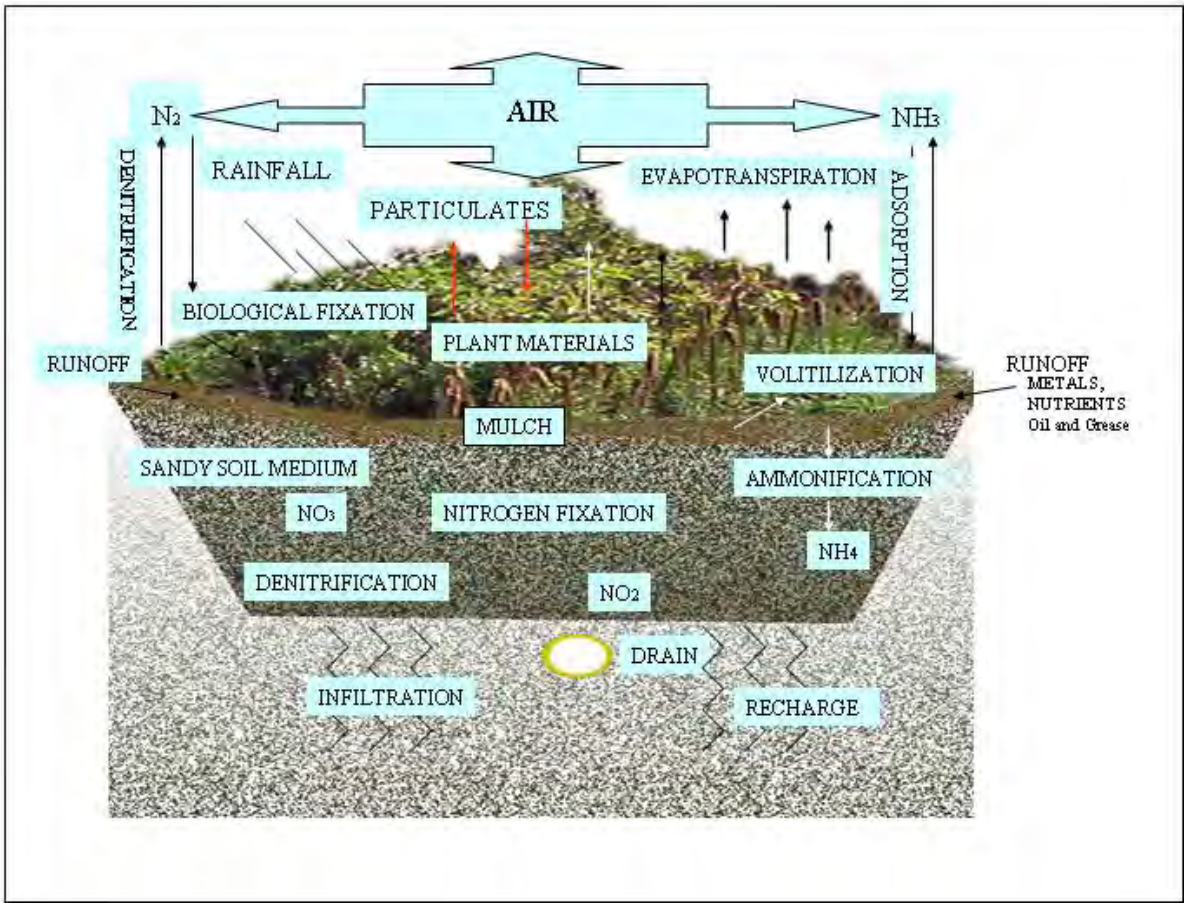
5-3.3 **Stormwater is Controlled at the Source.** Controlling and treating runoff as it is being generated reduces or eliminates the risks associated with transporting pollutants further downstream through pipes and channels. Management of stormwater at the source is especially valuable if remediation is required, such as in the case of an accidental spill of pollutants, because the problem can be easily isolated or the treatment system adjusted.

[9] PGDER, 2000a.

5-3.4 **Incorporate Non-Structural Systems.** LID designs recognize the potential of natural systems to intercept and filter pollutants. Phytoremediation techniques that take advantage of the biological and chemical processes of the plant soil complex have shown tremendous potential in stormwater management. These natural systems are easy to design, construct, and maintain, even though the naturally occurring filtering and treatment processes may be quite complex and multidimensional. Benefits of using these small-scale and simplified systems (such as soil amendments, landscaping, or re-vegetation) include the reduced need for costly large-scale construction projects (such as underground concrete vaults or proprietary filters).

Figure 5-2 illustrates the range of biological and chemical processes that have been documented to occur in a bioretention cell. The bioretention cell is a landscape area constructed of specialized soil and plants that can effectively absorb and treat urban runoff.

Figure 5-2. Biological and Chemical Processes that Occur in a Bioretention Cell



Source: Prince George's County, Maryland Department of Environmental Resources (PGDER), 2000.

5-3.5 **Utilize Multifunctional Landscape, Buildings and Infrastructures.** There are a wide variety of LID practices available. The primary criterion in selecting LID

practices is that the design of the component contributes to satisfying the design and regulatory objectives. Design features are often multifunctional and satisfy multiple objectives. The development of vegetated roofs is a good example. A vegetated roof can reduce the effects of atmospheric pollution, reduce runoff volume and frequency, reduce energy costs, create an attractive environment, and have reduced replacement and maintenance, and longer life cycle costs. There are many types of vegetated roofs that can be developed including pre-made grids, or cells, or whole systems.

5-4 **LID MANAGEMENT AND DESIGN STRATEGIES.** LID design is an iterative process that requires a thorough understanding of the management objectives, a detailed understanding of the physical and natural resources of the site, a conceptual site design that can be refined to achieve the goal of a hydrologically functional landscape, and a long-term maintenance plan.

5-4.1 **LID Site Planning Components.** This section presents the aims of LID site planning and, in light of existing site development requirements, describes how LID site design can be best approached to manage runoff.

5-4.1.1 **Hydrologic and Hydraulic Objectives.** The purpose of LID site planning is to significantly maintain the predevelopment runoff volume and flow rate. Ideally, and where site conditions allow, this will be achieved in a way that replicates the site's predevelopment hydrologic functions. Sites that are characterized before development by porous soils, substantial vegetative ground cover, and ungraded topography naturally perform several important hydrologic functions:

- Facilitate infiltration, evapotranspiration, retention and detention of runoff
- Limit runoff flow rates because of ground surface roughness
- Help control water quality through surface and subsurface filtering of pollutants and sediments

On a developed site, these hydrologic functions can continue to be provided by the preservation of natural features or construction of a variety of man-made features (as described in Chapter 9). Taken together, the utilization of these features comprises a distributed source control strategy that is designed to not only meet regulatory requirements but also to provide superior natural resource protection.

Maintaining areas with high soil porosity, vegetative ground cover, and shallow ponding will help meet the following objectives:

- Flood control. Facilitating the infiltration of runoff and decreasing overland flow rates reduces the risk of flooding in receiving waters. To meet design objectives and regulatory requirements completely, supplemental controls may still be required.

- Volume Control. The overall volume of runoff that leaves a site is kept as close as possible to predevelopment levels.

- Peak Control. The peak runoff rate does not increase above predevelopment levels, and the entire runoff hydrograph emulates the predevelopment hydrograph.

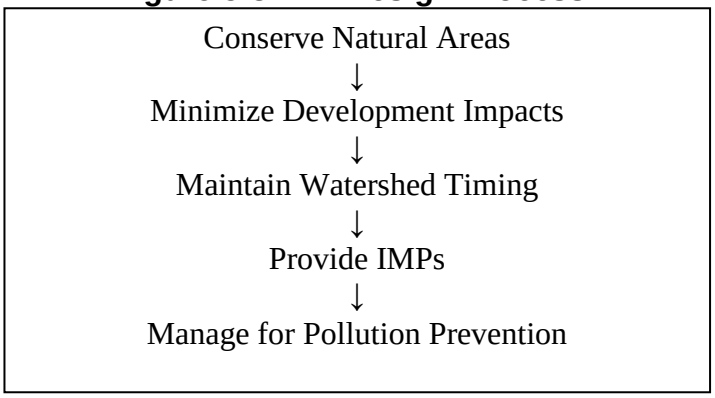
- Filtering and Treatment of Pollutants. Runoff is directed across vegetated areas and through porous media to provide significant reductions in the concentration of sediments and pollutants in the water.

- Groundwater Recharge. Infiltration is expedited to enhance groundwater recharge rates and help sustain base flows in nearby streams.

5-4.2 **LID Design Approach.** The LID approach to site design seeks to maintain or restore the hydrologic impacts of site development using a combination of runoff management strategies, site design techniques, and distributed source controls (IMPs). LID design requires that site plans address the overall natural resource and compliance issues within the watershed. The long-term success of this approach requires an understanding of the maintenance requirements and life-cycle effectiveness of the LID practices and the development of an appropriate maintenance and pollution prevention plan for the facility.

While the influence of each of the components of the design process varies from site to site, a general process has been developed to ensure that all of these components are considered. Although the preference in LID design is to reduce the hydrologic impacts on the site and to retain naturally effective hydrologic features, it is recognized that significant impacts may occur because of the nature of DoD activities. When compensating features are required, LID emphasizes the use of integrated site features that control runoff as close as possible to the source, rather than transporting pollutants and attempting to mitigate for lost functions elsewhere. Figure 5-3 illustrates the general flow of the design process.

Figure 5-3. LID Design Process



Source: PGDER.

This approach is often an iterative process that requires several attempts to balance all of the design components in the most economical and environmentally effective way. Described below are the individual design components.

5-4.2.1 **Conservation of Natural Areas.** LID is a stormwater management strategy that addresses the overall regulatory and resource protection goals of a site in a watershed context. Because development typically occurs incrementally, this approach will allow for adjustments or modifications to site design strategies and techniques to reflect dynamic resource protection and regulatory issues. Communities and bases often have extensive watershed management and natural resources conservation goals; master plans identify sensitive environmental areas and preservation areas such as wetlands, mature woods, and habitats. The LID site design should address any potential impacts to these areas and encourage conservation of these areas within the site. Examples of conservation include:

- Preserving a forest corridor that connects with an existing stream valley
- Maintaining flow volume and discharge rates to offsite wetlands
- Incorporating buffers around sensitive habitat areas

5-4.3 **Minimization of Development Impacts.** Within the portion of the site selected for the placement of roads, buildings, and other development activities, minimal disturbance techniques (site fingerprinting) can be used to avoid soil compaction, retain mature trees, and limit the environmental impact of staging areas. Examples of minimal disturbance techniques include:

- Delineating and flagging the smallest site disturbance area possible
- Minimizing the size of construction impacts or offsite easements and property acquisition
- Minimizing the size of material storage areas during and after construction
- Maintaining flow patterns

5-4.4 **Control of Watershed Timing and Runoff Patterns.** Maintaining the site's natural runoff control areas and restricting building over the site's more pervious soils will help keep the infiltration capacity of the site close to predevelopment levels. Maintaining the watershed timing of a site is also important. The cumulative effects of decreasing the post-development watershed times of concentration of several sites can have a significant impact on downstream habitat. It is also desirable to maintain natural vegetation in steeply sloped areas and to retain natural drainage divides. This will encourage dispersed flow paths and, consequently, help reduce the development of channels that lead to erosion and flooding problems.

Adequate drainage from buildings, walkways, and roads must be provided. Traditional designs often create a drainage system that has the effect of increasing the rate at which runoff moves into receiving waters during storm events. In turn, this produces a higher volume of runoff, a higher peak rate of flow, and an earlier runoff event than would occur under less developed conditions. The opportunity for groundwater recharge is eliminated, because infiltration into swales and grassed areas cannot effectively occur if runoff passes through quickly.

The overall grading objective for LID is to provide a surface landform that will distribute flows in a shallow and slow moving pattern toward areas where the infiltration capacity is highest. Examples of LID techniques to control rates of runoff and watershed timing include:

- Use flatter rather than steeper grades, provided that adequate drainage for buildings and traffic is maintained
- Reduce the height of slopes, to prevent runoff from gaining speed as it moves downhill
- Where flow begins to accumulate, increase the length of flow paths, diverting and redirecting the flow, preferably with vegetated features
- Minimize use of curb and gutter systems and piped drainage systems in favor of grassed swales
- Minimize the amount of impervious area used for pavement
- Disconnect impervious areas by directing runoff from buildings and pavements onto lawns or other vegetated areas, keeping flow velocities at a level that will not cause erosion
- Preserve naturally vegetated areas and existing topography in places where these help slow runoff and encourage infiltration
- Use weirs and check dams in swales

5-4.5 **Use of Integrated Management Practices (IMPs).** Once all of the design strategies and techniques have been implemented, IMPs are selected to achieve the site water quality and quantity objectives. IMPs are distributed, multifunctional, small-scale controls, selected based on their ability to achieve the site design water quality and quantity objectives in a cost effective manner. IMPs are not a “one-size-fits-all” approach. For example, using amended soils to filter and store runoff may be appropriate for a rural road section with high traffic but inappropriate next to a parking area that may be subjected to compaction from overflow parking or vehicle movement. More details on IMPs and their selection are found in Chapter 8.

5-4.6 **Pollution Prevention.** The goal of pollution prevention is to reduce, reuse and recycle a variety of pollutants before they become environmental problems. The final step of the LID design approach is to incorporate programs that keep pollution out of runoff in the first place and, consequently, to increase the longevity of the IMPs. Reduction of fertilizer, pesticide and herbicide use and the implementation of regular street sweeping are some common pollution prevention activities.

NAVY: Pollution Prevention (P2) is one of the four pillars of the Navy's Environmental Quality Initiative (EQI). EQI aims to use P2 to attain environmental compliance, while minimizing life cycle costs. Rather than promoting pollution prevention because it is desirable from an environmental standpoint, EQI uses pollution prevention to minimize the cost of environmental compliance. For example, building a bioretention cell to treat runoff from a parking lot before discharge into a stream is a much more efficient and cost effective alternative to discharging directly into the stream and paying for stream restoration later.

AIR FORCE: Air Force Instruction (AFI) 32-7080 lays the framework for P2 implementation. Compliance by all Air Force installations is required. Air and water pollutant reduction is one of the six P2 program elements. P2 is mandated at the Major Command (MAJCOM) level, and the Air Force Center for Environmental Excellence is the primary provider of P2 technical support services. Installations must implement P2 management plans and conduct regular P2 opportunity assessments, which should be based on existing waste stream management plans when they exist.[10]

ARMY: P2 is a required element in the Army's Sustainable Project Rating Tool (SPiRiT); compliance with SPiRiT is now mandatory for MILCON construction projects. P2 plans for Army installations are developed from opportunity assessments of existing waste stream data and are designed to maximize environmental compliance. The U.S. Army Environmental Center provides P2-related technical and policy assistance.

5-5 DESIGN GUIDANCE AND STANDARDS

5-5.1 **Methods to Determine Effectiveness.** Stormwater projects are typically designed with a particular objective in mind, such as flood control or water quality improvement. Such projects typically require that the designer evaluate the effectiveness of the proposed treatments at meeting the stated objectives.

A number of hydrologic models have been developed to model surface runoff from a given drainage area. Because conventional models are primarily concerned with computing flow rates or flood hydrographs at a point of interest, this approach to hydrologic analysis must be modified in cases where not all of the runoff from a given site converges to a single point. Typical watershed models take into account general land cover and stream channel characteristics. To account for LID features and runoff

[10] Air Force, 1994.

management devices, refinement of the analysis may be desirable. A variety of tools are freely available from public agencies:

5-5.1.1 **Natural Resources Conservation Service (NRCS).** The NRCS, formerly called the Soil Conservation Service, has been developing runoff models for decades. The NRCS models TR-20 and TR-55 account for variations in land cover and the velocity of water movement across a watershed. Of particular interest are the determination of a drainage area's curve number (CN) and time of concentration (T_c). The value of CN reflects the degree to which land surface conditions will generate runoff, while the value of T_c indicates how quickly the runoff will converge at a particular point downstream. TR-20 and TR-55 are popular for watershed modeling but are generally not recommended for predicting runoff from small storms.

5-5.1.2 **Federal Highway Administration (FHWA).** The FHWA has developed a variety of software packages, primarily concerned with channel and pipe hydraulics. These programs are most useful in those areas where detailed analysis of flow behavior based on predetermined flow rates is required.

5-5.1.3 **Hydrologic Engineering Center of the U.S. Army Corps of Engineers (HEC).** The Hydrologic Engineering Center of the U.S. Army Corps of Engineers actively maintains a suite of tools for modeling surface water hydrology and hydraulics.

5-5.1.4 **EPA.** The EPA maintains the Storm Water Management Model (SWMM) that performs simulations of both water quantity and quality for urban runoff events.[11] In late 2002, EPA extensively revised SWMM to include more detailed analysis of small-scale stormwater management devices. The SWMM algorithm is able to explicitly simulate storage and, therefore, is particularly appropriate for simulating discrete LID systems. Obtaining reasonable estimates of storage parameters needed in SWMM is of critical importance. Creative adaptations of SWMM may be necessary because the model does not directly model runoff from an impervious surface onto a pervious one.

5-5.1.5 **Prince George's County, Maryland.** The Prince George's County Department of Environmental Resources – Programs and Planning Division, working with Tetra Tech, Inc., has developed a BMP evaluation module to assist in assessing the effectiveness of LID technology. This module uses simplified process-based algorithms to simulate BMP control of modeled flow and water quality time series generated from runoff models such as the Hydrologic Simulation Program, FORTRAN (HSPF). These simple algorithms include weir and orifice control structures, storm swale characteristics, flow and pollutant transport, flow routing and networking, infiltration and saturation, evapotranspiration, and a general loss/decay representation for pollutants. It offers the user the flexibility to design retention style or open-channel BMPs, define flow routing through a BMP or BMP network, simulate IMPs such as reduced or discontinuous impervious surfaces through flow networking, and compare BMP controls against a defined benchmark such as a simulated pre-development

[11] EPA, 1983.

condition. Because the underlying algorithms are based on physical processes, BMP effectiveness can be evaluated and estimated over a wide range of storm conditions, BMP designs, and flow routing configurations. Such a tool provides a quantitative medium for assessing and designing TMDL allocation scenarios and evaluating the effectiveness of a proposed management approach.

Five basic design aspects were used to develop the methodology for the module. They are: (1) the incorporation of input runoff data, (2) design and representation of a site plan, (3) configuration of BMPs of various sizes and functions, (4) schematic representation of flow routing through a network of BMPs, and (5) evaluation of the impact of a site design with BMPs. The module interface is the platform for an interactive linkage between each of the five design features of the module.

5-5.1.6 **Commercial Sources.** In addition to the freely available models, there are a variety of commercial models on the market. Information about these other tools can be found on the Internet.

5-5.2 **Monitoring Strategies.** A variety of techniques are available to monitor the effectiveness of LID features for managing water quantity and quality. A well-implemented monitoring program will be valuable not only for the purpose of local runoff management objectives, but can also provide useful information to the Engineering Service Center, which is developing a web-based expert system.

5-5.2.1 **Water Quantity Monitoring.** The effectiveness of LID in controlling runoff volume and peak flow rates can be monitored either at individual features on a site or at some selected point downstream where flow paths converge and a measurement device can be installed.

5-5.2.1.1 **Small Scale.** On a small scale, both manual and automatic sampling methods can be used to calculate flow rates upstream and downstream of an LID installation, based on the depth measured using a weir or a rate of flow measured using a conveyance device.

5-5.2.2 **Large Scale.** On a larger scale, where LID features are used as retrofits in developed areas, the effectiveness of the retrofits can be assessed by comparing pre-LID and post-LID flow rates downstream. Using these data and some straightforward hydrologic calculations, a characteristic hydrograph can be developed to evaluate the site's response to storm events resulting from the implementation of LID treatments. Data from stream gages should indicate that runoff from smaller storms has decreased after LID implementation. As more LID features are used for stormwater retrofits on a site, the decrease in runoff will become more significant.

5-5.2.3 **Water Quality Monitoring Parameters.** The effectiveness of a runoff management feature can be evaluated using the flow through the feature, the quality of

the receiving waters, or both. The Nationwide Urban Runoff Program (NURP) has identified the following "standard pollutants characterizing urban runoff:"[12]

Table 5-1. Standard Pollutants in Urban Runoff

Pollutant	Abbreviation
Suspended Solids Concentration	SSC
Biochemical Oxygen Demand	BOD
Chemical Oxygen Demand	COD
Copper	Cu
Zinc	Zn
Total Phosphorous	TP
Soluble Phosphorus	SP
Total Kjeldahl Nitrogen	TKN
Nitrate + Nitrite	$NO_2 + NO_3$

5-5.2.4 **Biological Monitoring.** Pollutants in stormwater runoff have a direct effect on the biological integrity of the receiving waters. The effectiveness of water quality controls can therefore be evaluated by assessing the biological health of the receiving waters in the vicinity of the stormwater outfall. The EPA has developed Rapid Bioassessment Protocols (RBP)[13] that can be used to characterize the existence and severity of impairments to streams, and help to identify sources and causes of impairment.

5-5.2.5 **Monitoring Program.** There are four phases to develop a monitoring program:[14]

1. Determine the objectives and scope of the monitoring program
2. Develop the monitoring plan in view of the objectives
3. Implement the monitoring plan
4. Evaluate and report the results

Monitoring programs are shaped by the site characteristics, the goals of the project, regulatory requirements, and available funds.

[12] Ibid.
[13] Barbour et al., 1999.
[14] DOT, 2000; EPA, 2002.

5-5.2.6 **Variability.** The high variability of stormwater flows and pollutant concentrations at any location makes it difficult to obtain useful monitoring results. Typically, facilities must collect a large number of samples to adequately characterize how a device is functioning under natural conditions. The monitoring approach used on any given site will depend on regulatory requirements, the pollutants of concern, the physical characteristics of the runoff management features, and the availability of funds and personnel for planning, sampling and analysis.

5-5.2.7 **State and Local Program Conformance.** Water quality monitoring programs should be undertaken to conform to state and local protocols. A detailed guidance manual for water quality data collection, management and interpretation is available from the Environmental Protection Agency[15] and the Department of Transportation.[16] The guidelines, which are primarily concerned with meeting the national stormwater BMP database requirements, can be easily adapted for use in a variety of monitoring activities.

5-5.2.8 **Sampling Locations.** An effective monitoring effort for decentralized runoff management requires a judicious selection of sampling locations as well as sampling times and techniques. The challenge is often to complete the monitoring effort effectively under budget constraints. If the site design includes many LID features, sampling only a few may provide a reasonable basis to estimate the effectiveness of the full suite of features.

5-5.2.9 **Sampling Protocols.** Monitoring protocols vary depending on the expected chemical composition of the runoff, the pollutant of concern, the desirability of monitoring the effectiveness of a device at a given location, and the importance of assessing water quality at points downstream. As sampling data is collected over time, trends in the water quality become apparent. Adjustments in the monitoring plan may be appropriate to ensure that across the site samples are not taken any more or less frequently than necessary to ensure that a desirable level of water quality is maintained.

[15] EPA, 2002.
[16] DOT, 2000.

CHAPTER 6

DISTRIBUTED MICRO-SCALE SYSTEMS

6-1 **INTRODUCTION.** In addition to land surface strategies, LID practices include incorporating small landscaped features and manufactured devices into a site. The management of runoff as it is generated reduces the need for management further downstream. Small distributed systems can perform several important runoff management functions:

- Increase rates of infiltration
- Slow down runoff, reducing flow rates from the site and increasing time for infiltration
- Add retention (the amount of water stored at the surface for the duration of the storm event)
- Add detention, which causes water to be restrained temporarily before it moves further downstream
- Improve water quality by filtering pollutants through media

6-2 **REPRESENTATIVE LID PRACTICES.** LID uses design components (IMPs) that can be selected and customized for specific stormwater management objectives. The selective use and customization of these components will involve a variety of standards and specifications for construction and maintenance. Described below is a collection of LID practices and their design, construction and maintenance characteristics.

Distributed micro-scale systems can include, but are not limited to:

- Soil amendments
- Bioretention
- Dry Wells
- Filter Strips
- Vegetated Buffers
- Grassed Swales
- Infiltration Trenches
- Inlet Pollution Removal Devices

- Rain Barrels and Cisterns
- Tree Box Filters
- Vegetated Roofs
- Permeable Pavers

Table 6-1 presents the variety of runoff management functions provided by these features. A more detailed description and design approach for these features is provided in Chapter 8.

Table 6-1. Functions of LID Features

Feature	Effect or Function				
	Slower Runoff	Infiltration	Retention	Detention	Water Quality Control
Soil Amendments		X			
Bioretention		X	X	X	X
Dry Wells		X	X		X
Filter Strips	X				X
Vegetated Buffers	X				X
Grassed Swales	X				X
Infiltration Trenches		X			X
Inlet Devices					X
Rain Barrels			X		
Cisterns			X		
Tree Box Filters					X
Vegetated Roofs	X			X	X
Permeable Pavers		X			X

6-2.1 **Nutrient Processing.** Surface water runoff in urban areas can include significant quantities of chemical nutrients, particularly nitrogen and phosphorous. When these nutrients reach local water bodies, they can contribute to eutrophication. (Eutrophication is a naturally occurring process in which nutrients accumulate in a body of water over time; the term is often used to signify acceleration of this process by

human activity.) Several of the LID components described in this UFC (see Chapter 8) filter out these nutrients to various degrees of effectiveness, depending on the design. LID approaches that utilize vegetation not only filter nitrogen and phosphorous out of the water and into the soil, but also make these nutrients available to the plants to form plant tissue.

6-2.2 **Treatment Train Approach to Water Quality.** Following a typical flow path beginning where runoff is generated from an impervious area, runoff water quality control can be implemented in the following steps:

1. Minimization. Design the site to treat pollutants effectively in small quantities, rather than allow larger quantities of runoff to accumulate before treatment.

2. Natural Filtration. Use the physical, chemical and biological processes of vegetation and soils to filter pollutants.

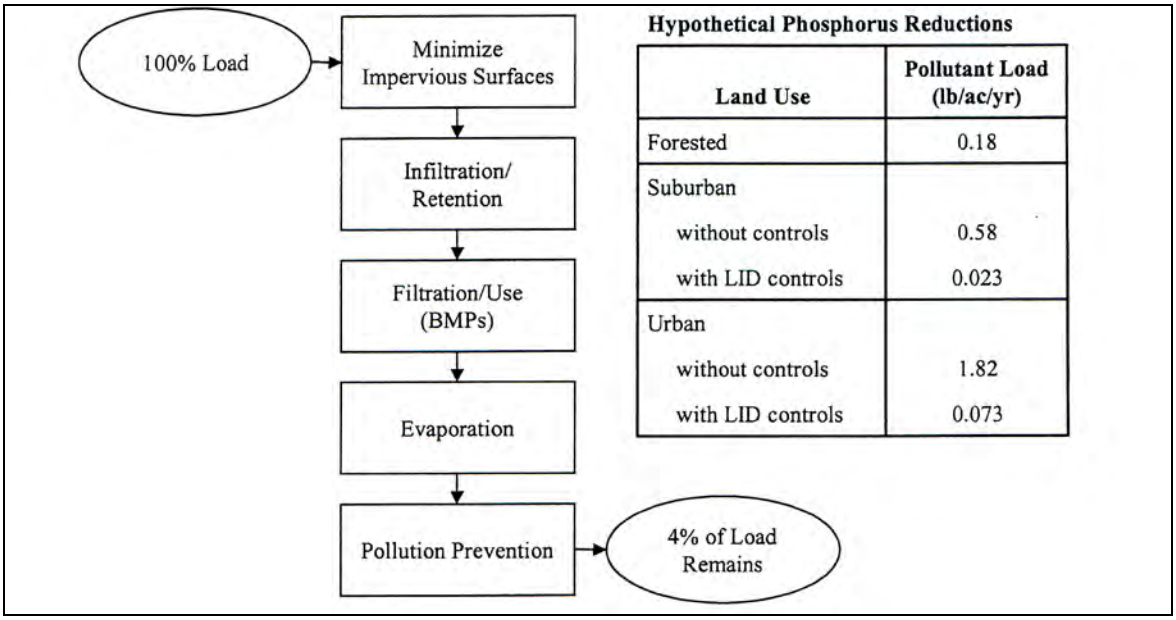
3. Constructed Filtration. Use the physical, chemical and biological processes of distributed micro-scale systems to filter pollutants.

4. Evaporation. Store and evaporate water in shallow depressions so that particulates can be removed.

5. Pollution prevention. Incorporate management practices such as restricted fertilizer use and diligent street sweeping to reduce pollutant loads. (Note that while the first four steps above pertain to site features, this final step pertains to post-construction maintenance).

Figure 6-1 shows a typical treatment train process for phosphorus removal.

Figure 6-1. Treatment Train Process for Phosphorus Removal



Hypothetical Phosphorus Reductions

Land Use	Pollutant Load (lb/ac/yr)
Forested	0.18
Suburban	
without controls	0.58
with LID controls	0.023
Urban	
without controls	1.82
with LID controls	0.073

Source: Adapted from PGDER.

6-2.3 **Energy Processing.** LID features that incorporate vegetation can help to moderate high ambient air temperatures. Even on a small scale, vegetation will have a local cooling effect. Vegetation can be selected and placed to improve shading, or to provide a buffer against winds. Using vegetated roofs can result in significant energy savings in the operation of a building's air conditioning system.

6-2.4 **Multifunctional Infrastructure and Buildings.** Some LID features can simultaneously provide a variety of hydrologic functions. A bioretention area, for example, can filter runoff for quality control, detain it, and infiltrate the stormwater into the ground. Similarly, vegetated roofs on buildings reduce runoff, reduce pollutants in both the water and the air, and moderate the internal building temperature.

6-2.5 **Ancillary Benefits.** This UFC describes LID primarily in terms of hydrologic impacts. LID runoff management strategies can also contribute to an aesthetically pleasing landscape, increasing the value of the property where these strategies are employed. In a variety of completed projects, micro-scale runoff management features have provided architectural interest in various forms, such as employing berms in otherwise open spaces, rainwater channels along pedestrian streets, fountains fed by intermittent stormwater, and bioretention areas that attractively subdivide large parking lots. The visibility of these features also provides opportunities for citizens and property owners to become more aware of the importance of stormwater in our urban environment.

CHAPTER 7

COMPARISON OF LID TO CONVENTIONAL PRACTICES

7-1 **INTRODUCTION.** Conventional stormwater management practices focus on providing an efficient site drainage system that rapidly conveys runoff away from buildings and off pavement, and then attenuates the peak runoff rate at a large stormwater management facility downstream. In contrast, LID provides runoff management as far upstream as possible – where it originates – and if necessary, also at multiple points along each flow path. LID and conventional practices can be further compared in a variety of ways:

7-2 **COMPLIANCE VS. WATER RESOURCE OBJECTIVES.** While conventional stormwater management is primarily concerned with attenuating the peak runoff rate from a developed site, the principal goal of LID is to ensure maximum protection of the ecological integrity of the receiving waters by maintaining the watershed's hydrologic regime.

7-3 **WATER QUANTITY CONTROL.** Conventional drainage practices effectively reduce peak runoff rates, but do not reduce runoff volume. Instead, conventional drainage practices increase runoff volume by not mitigating the effects of the increased impervious area. The LID features that facilitate infiltration, by comparison, help to reduce runoff volume directly. Runoff volume reductions using LID features can be significant when infiltration is increased over a sufficiently large area.

Conventional drainage reduces the amount of subsurface water available to the base flow in nearby streams. LID features that enhance infiltration can have the beneficial effect of helping to maintain those base flows. Other LID features allow the strategic use of stormwater on-site, while conventional drainage designs focus on moving the water rapidly off-site.

A conventional stormwater management facility has a limited ability to manage water quality because it is limited to removal by settlement of pollutants. An LID approach, by comparison, takes advantage of a variety of mechanisms that filter water either overland or via infiltration to the subsurface.

7-4 **CONSTRUCTION COSTS.** Construction costs for LID will vary depending on the characteristics of predevelopment site features, the density of development, the particular LID features selected, and their size and design. For example, the cost of bioretention areas will be a function of the depth of porous backfill and the degree to which underdrains are utilized. Case studies for commercial, townhouse, and detached home residential areas in Prince George's County, Maryland, have demonstrated that LID site design costs can compare favorably with conventional approaches.[17] Costs are not simple to generalize. The scale of the project, availability of materials, and skills

[17] Greenhorne and O'Mara, 1998.

and training of staff are all factors. IMPs involving landscaped areas are often simple to maintain because work can often be performed by landscaping crews or residents; hard structures, such as permeable paving systems with underdrains, may require more specialized maintenance.

7-5 **OPERATION AND MAINTENANCE.** Regular inspections of conventional stormwater management facilities are required to ensure that the storage volume has not been reduced by sediment, outlets are not clogged by debris, and structural features maintain their integrity. For a site designed using an LID approach, runoff management features will tend to be higher in number and several types of features (e.g., bioretention areas) need to be maintained by the property owner. The maintenance of these LID features is straightforward and can easily be performed as part of regular landscaping. Other LID features typically employed along public streets (such as tree filters) require more specialized maintenance to ensure that the filter media are not clogged and toxic materials such as heavy metals do not accumulate to a level at which they become a health hazard.

7-6 **RETROFIT POTENTIAL.** Retrofitting an already developed area with a conventional stormwater management system requires a considerable amount of space and is likely to involve extensive site disturbance. The LID micro-scale systems listed in the previous chapter require less site disturbance for each installment. LID retrofits may be much easier than conventional retrofits on sites where intensive development has already occurred. Locating sites for installing small devices is far easier than finding a large site for a stormwater management facility. LID retrofits can be customized to pollutant loads, allowing more complete control over pollutant removal.

CHAPTER 8

INTEGRATED MANAGEMENT PRACTICES

8-1 **INTRODUCTION.** This chapter gives an overview of several of the most common and well-researched integrated management practices (IMPs) currently in use. Information is given on appropriate use, typical cost, maintenance needs, and commonly required corrective actions. This information is meant to facilitate the selection of IMPs appropriate for individual situations. This chapter is not exhaustive: many other IMP types are in use or are under development. Evaluation of other practices is left to the facility and regulatory agencies.

8-1.1 **Most Appropriate Uses.** This section outlines how each of the IMPs should be incorporated into a site plan.

8-1.2 **Cost Data.** Cost data is given in 2003 U.S. dollars, except where noted. All costs are estimates, and are given in broad ranges. These represent only initial costs and do not account for life cycle costs such as maintenance. These cost estimates are to be used for general planning purposes, not to create accurate project budgets.

8-1.3 **Maintenance Issues.** This section highlights some of the maintenance requirements of the IMPs. It is meant to give a general sense of the maintenance intensity of each of the technologies.

8-1.4 **Corrective Actions.** This section highlights some of the common problems associated with each of the IMPs.

8-2 **SOIL AMENDMENTS.** Soil amendments, which include both soil conditioners and fertilizers, make the soil more suitable for the growth of plants and increase water retention capabilities. The use of soil amendments is conditional on their compatibility with existing vegetation, particularly native plants.

Figure 8-1. Southern Maryland Wood Treating Site: On-site Thermal Desorption of Contaminated Soils. Final Grading and LeafGro® Placement

Source: EPA.

8-2.1 **Most Appropriate Uses.** Soil amendments increase the soil's infiltration capacity and help reduce runoff from the site. They have the added benefit of changing physical, chemical and biological characteristics so that the soils become more effective at maintaining water quality.

8-2.2 **Cost Data.** Compared to the costs of traditional lawn preparation practices, enhancing native soil with soil amendments may have increased upfront costs. However, the cost of using amended soils can be at least partially offset by reductions in the required volume of stormwater ponds or other detention or retention practices. Tilled Compost-Amended Turf (TCT) practices, besides requiring greater site preparation, require larger volumes of material to be delivered to the site as well as methods to ensure that the amendments are well mixed with the existing soil.[18] The following cost estimates are based upon 1996 prices in the Seattle, Washington metropolitan area. Potential soils analysis costs are not included, but can cost as much as $125 per sample.

Table 8-1. Costs Associated with Soil Amending[19]

Component	Average Cost (1996 U.S. dollars)
Soil and Site Preparation	61¢ per square foot
Soil Amendments	$16 per cubic yard
Blower Application	5¢ to 10¢ per square foot

8-2.3 **Maintenance Issues.** In some jurisdictions across the country, soil amendments may be inspected as part of the sediment control plan for a site, usually

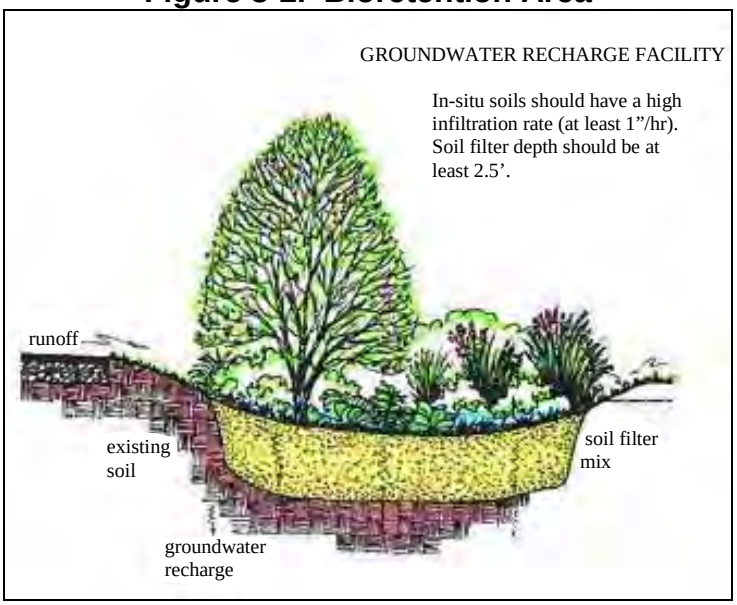
[18] Chollak and Rosenfeld, 1998.
[19] Ibid.

upon site completion. Routine inspection of amended soils should evaluate factors that may affect the soil's infiltration capacity, aeration and organic content. Typical post construction concerns include areas subject to compaction, hydric or waterlogged soils, poor cover conditions, increased development, and a decrease in organic content. In addition, a routine soil infiltration rate analysis of amended soils in potential problem areas is recommended.

8-2.4 **Corrective Actions.** Corrective actions for soil amendments involve restoring the infiltration capacity of the soil. Reductions in infiltration capacity typically result from compaction or extensive root matting of groundcovers, such as grasses. The first step of corrective action should be extensive mechanical aeration. If this does not restore the infiltration rate, organic amendments should be disked into the soil for a depth of several inches and the site restabilized.

8-3 **BIORETENTION.** Bioretention areas typically have porous backfill under the vegetated surface, and an underdrain that encourages infiltration and water quality filtering while avoiding extended ponding.

Figure 8-2. Bioretention Area



Source: PGDER.

8-3.1 **Most Appropriate Uses.** Bioretention features are used to treat stormwater that has run over impervious surfaces in commercial, residential, and industrial areas.[20] Use of bioretention for stormwater management is ideal for median strips, parking lot islands, and swales.

[20] EPA, 1999a.

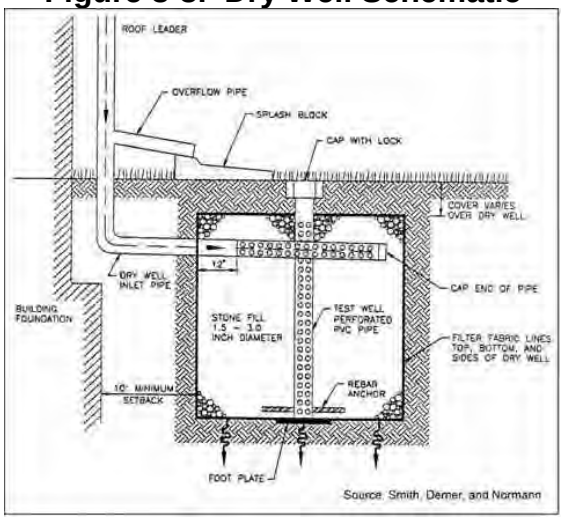
8-3.2 **Cost Data.** Construction cost estimates for a bioretention area are slightly greater than for required landscaping at a new development.[21] Commercial, industrial and institutional site costs range between $107 and $430 per square meter ($10 and $40 per square foot,) based on the need for control structures, curbing, storm drains and underdrains.

8-3.3 **Maintenance Issues.** Routine maintenance should include a biannual health evaluation of the trees and shrubs and subsequent removal of any dead or diseased vegetation.[22] This maintenance can be incorporated into regular maintenance of the site landscaping. If the bioretention feature is located in a housing development, the maintenance responsibility could be delegated to the residents. The use of native plant species in the bioretention cell will reduce fertilizer, pesticide, water, and overall maintenance requirements.

8-3.4 **Corrective Actions.** Treat diseased vegetation as needed using preventative and low-toxic measures. When levels of pollutants reach toxic levels that impair plant growth and the effectiveness of the BMP, soil replacement may be required.[23] Other potential tasks include replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging the underdrain, and repairing overflow structures. Depending on pollutant loads, soils may need to be replaced within 5-10 years of construction.[24]

8-4 **DRY WELLS.** A dry well typically consists of a pit filled with aggregate such as gravel or stone and is located to catch water from roof downspouts or paved areas.

Figure 8-3. Dry Well Schematic



Source: Stormwater Management for Maine, 1995.

[21] Ibid.
[22] Ibid.
[23] PGDER, 1993.
[24] LID Center, 2000.

8-4.1 **Most Appropriate Uses.** Dry wells are suitable for treating small impervious areas (as an alternative to infiltration trenches) and may be useful on steeper slopes where trenches or other facilities cannot be installed. Dry wells are particularly suited to treat runoff from residential driveways or rooftop downspouts. It is important to avoid installation in large areas with high sediment loads and in soils with limited permeability. Dry wells are not appropriate for treating runoff from large impervious surfaces such as parking lots.

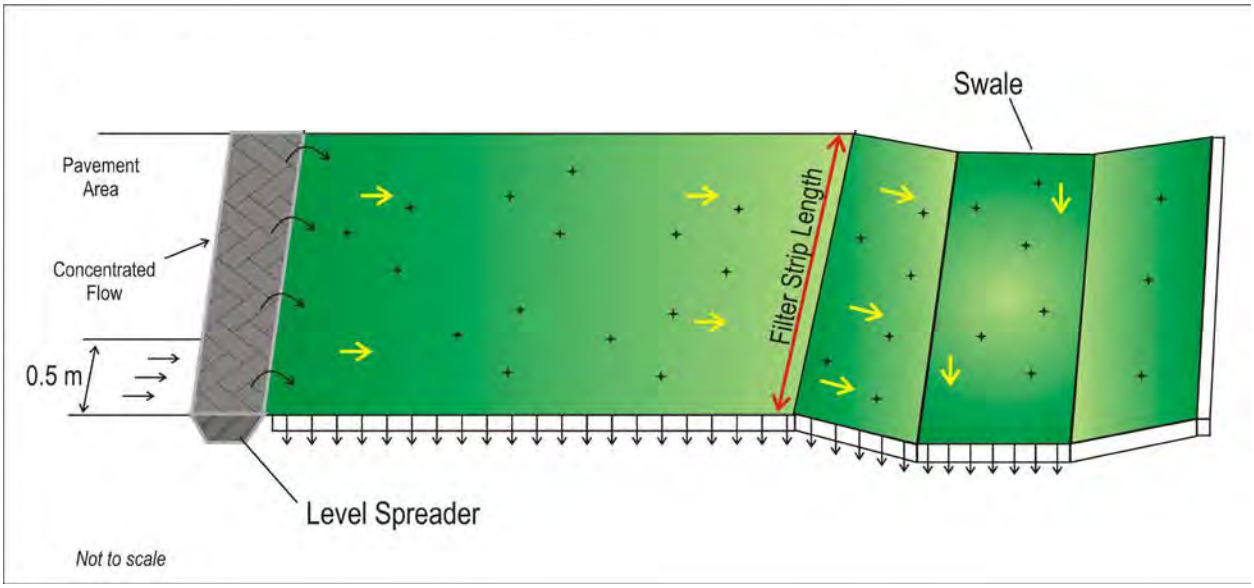
8-4.2 **Cost Data.** Costs for dry wells are site specific. Cost is determined by the cost of excavation and the price of gravel. This will depend on the well volume and the source of the gravel.

8-4.3 **Maintenance Issues.** Dry wells are typically employed in single-family homes; maintenance is usually the responsibility of the homeowner. Maintenance is minimal and includes clearing the rain gutters of debris that clogs the downspout.

8-4.4 **Corrective Actions.** Dry wells can clog over time if there is extensive loading of fine grained sediment. Clogging is evident if there is standing water after a rain event at the surface of the facility. The appropriate corrective action is to first dig out the gravel and then excavate to remove the sediment and uncover a layer of soils that has sufficient infiltration capacity.

8-5 **FILTER STRIPS** are bands of dense vegetation planted downstream of a runoff source.

Figure 8-4. Filter Strip



8-5.1 **Most Appropriate Uses.** The use of natural or engineered filter strips is limited to gently sloping areas where the vegetative cover is well-established and where

channelized flow is not likely to develop. Filter strips are well suited for treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. They are also ideal components for the fringe of a stream buffer, or as pretreatment for a structural practice.

8-5.2 **Cost Data.** A rough estimate of filter strip construction costs includes the cost of seed or sod, approximately 30¢ per square foot for seed or 70¢ per square foot for sod. This amounts to a cost of between $32,000 and $74,000 per hectare ($13,000 and $30,000 per acre) for filter strips. The cost of filter strip construction may be higher than other stormwater management practices, but the construction costs are offset by low maintenance costs, roughly $865 per hectare ($350 per acre) per year.[25] Additionally, maintenance costs might overlap with regular landscape maintenance costs.

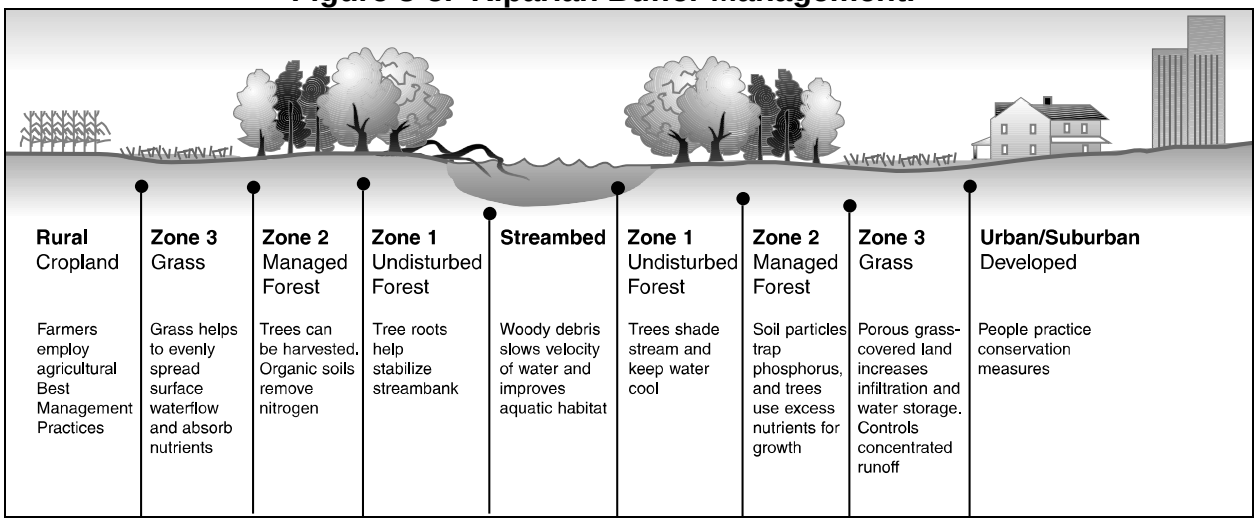
8-5.3 **Maintenance Issues.** Filter strips require standard vegetation management, such as mowing, irrigation, and weeding. Typical maintenance activities include inspection of filter strips at least twice annually for erosion or damage to vegetation and additional inspection after periods of heavy runoff. Recent research on biofiltration swales indicates that grass height and mowing frequency have little impact on pollutant removal rates.[26] Therefore, mowing may only be necessary once or twice a year for safety and aesthetics or to suppress weeds and woody vegetation.

8-5.4 **Corrective Actions.** Trash tends to accumulate in filter strip areas, particularly along highways. The need for litter removal should be determined through periodic inspection, but litter should always be removed prior to mowing.

8-6 **VEGETATED BUFFERS.** Vegetated buffers trap and filter sediments, nutrients, and chemicals from surface runoff and shallow groundwater.

[25] Adapted from SWRPC, 1991.
[26] Colwell et al., 2000.

Figure 8-5. Riparian Buffer Management.



Source: Maryland Cooperative Extension Fact Sheet 724.

8-6.1 **Most Appropriate Uses.** Maintaining a vegetated buffer along creeks, streams, and rivers provides an attractive landscape and can improve water quality by removing sediment and chemicals before they reach the waterway. In addition, buffers provide flood control, help recharge groundwater, prevent soil erosion, and preserve or improve certain types of wildlife habitat. Well-designed buffers can also stabilize the stream bank and help absorb stormwater runoff.

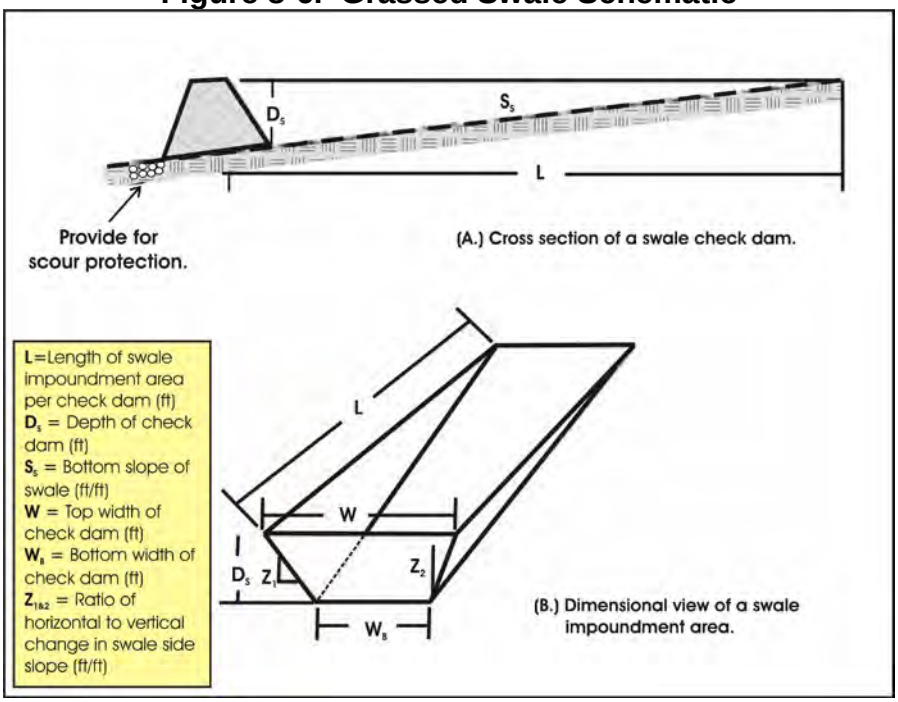
8-6.2 **Cost Data.** Forest buffer costs range between $540 and $1800 per hectare ($218 and $729 per acre) to plant and maintain. Planting costs depend on geographic location, number of acres planted, number of trees planted per acre, species of trees, and whether or not the trees are from bare root or container stock. Grass buffers tend to cost less than forest buffers to plant and maintain ($415 to $ 1000 per hectare [$168 to $400 per acre]).

8-6.3 **Maintenance Issues.** Buffers should be monitored and managed to maintain their maximum water quality benefits and, where desired, wildlife habitat benefits. They should be inspected at least once a year, and always within a few days after severe storms, for evidence of sediment deposition, erosion, or development of concentrated flow channels. Weed and invasive species control is essential for the survival and rapid growth of trees and shrubs. It is best to avoid working in the riparian area between April 15 and August 15, when a variety of animals are bearing their young.

8-6.4 **Corrective Actions.** If the buffer width is sufficient, vegetated buffers should be self-maintaining. Changes in hydrology, drought, over-grazing or natural disasters such as flooding or fire may require the replanting or reestablishment of the buffer.

8-7 **GRASSED SWALES** are shallow grass-covered hydraulic conveyances that help to slow runoff and facilitate infiltration.

Figure 8-6. Grassed Swale Schematic



Source: NVPDC, 1991. In EPA, 1999d.

8-7.1 **Most Appropriate Uses.** The suitability of grassed swales depends on land use, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the grassed swale system.[27] In general, grassed swales can be used to manage runoff from drainage areas that are less than 4 ha (10 acres) in size, with slopes no greater than 5 percent. Use of natural low-lying areas is encouraged and natural drainage courses should be preserved and utilized.[28]

8-7.2 **Cost Data.** Grassed swale construction costs are estimated at approximately $2.70 per square meter ($0.25 per square foot.)[29] These costs, however, do not include design costs, raising the total cost to approximately $5.40 per square meter ($0.50 per square foot.) Grassed swale costs compare favorably with other stormwater management practices.[30]

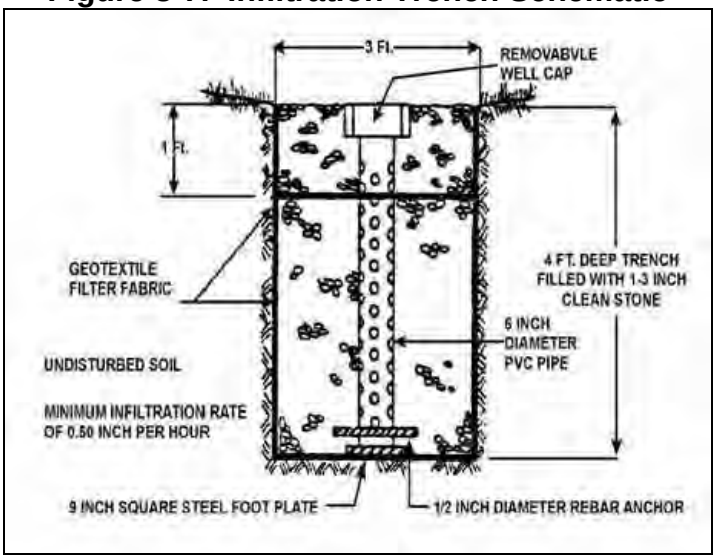
8-7.3 **Maintenance Issues.** The maintenance objectives include keeping up the hydraulic and removal efficiency of the channel and maintaining a dense, healthy grass cover. Maintenance activities should include periodic mowing (with grass never cut shorter than the design flow depth), weed control, watering during drought conditions, reseeding of bare areas, and clearing of debris and blockages.

[27] Schueler et. al., 1992.
[28] Young et al., 1996
[29] SEWRPC, 1991.
[30] Brown and Schueler, 1997.

8-7.4 **Corrective Actions.** Cuttings should be removed from the channel. Accumulated sediment should also be removed manually to avoid concentrated flows in the swale. Avoid applying fertilizers and pesticides. The grass cover should be thick and reseeded as necessary. Any standing water removed during the maintenance operation must be properly disposed of at an approved discharge location.

8-8 **INFILTRATION TRENCHES.** Infiltration trenches are trenches that have been back-filled with stone. These trenches collect runoff during a storm event and release it into the soil by infiltration**.**

Figure 8-7. Infiltration Trench Schematic



Source: SWRPC, 1991. In EPA, 1999c.

8-8.1 **Most Appropriate Uses.** Infiltration trenches may be used in conjunction with another stormwater management device, such as a detention pond, to provide both water quality control and peak flow attenuation.[31] Runoff that contains high levels of sediments or hydrocarbons (oil and grease) that may clog the trench are often pretreated with other devices such as grit chambers, water quality inlets, sediment traps, swales, and vegetated filter strips.[32]

8-8.2 **Cost Data.** Construction costs include clearing, excavation, placement of the filter fabric and stone, installation of the monitoring well and, where desired, establishment of a vegetated buffer strip. The 1993 construction cost for a large infiltration trench (1.8 m (6 ft) deep, 1.2 m (4 ft) wide, and with a 68 m^3 (2,400 ft^3) volume) ranges from $8,000 to $19,000. A smaller trench (0.9 m (3 ft) deep, 1.2 m (4 ft) wide, and with a 34 m^3 (1,200 ft^3) volume) is estimated to cost from $3,000 to $8,500.

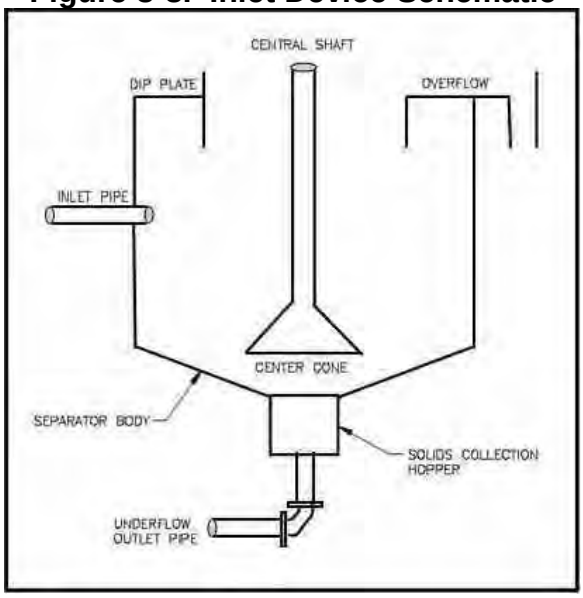
[31] Harrington, 1989.
[32] SEWRPC, 1991; Harrington, 1989.

8-8.3 **Maintenance Issues.** The principal maintenance objective is to prevent clogging, which may lead to trench failure. Infiltration trenches should be inspected after large storm events and any accumulated debris or material should be removed. A thorough annual inspection should include monitoring of the observation well to confirm that the trench is draining properly. Trenches with filter fabric should be inspected for sediment deposits by removing a small section of the top layer and examining the material in the trench itself. When vegetated buffer strips are used, they should be mowed regularly and inspected for erosion or other damage after each major storm event.

8-8.4 **Corrective Actions**. The corrective action for infiltration trench failure is to remove the stone and sediment that has clogged the system. The trench should be over excavated and scarified to ensure that the infiltration capacity of the soil is sufficient. The stone is washed to remove any sediment and then replaced. It is critical that any surrounding areas be stabilized to eliminate the potential for sediment clogging.

8-9 **INLET DEVICES** (a.k.a. hydrodynamic separators). Inlet devices are flow-through structures with a settling or separation unit to remove sediments and other stormwater pollutants.

Figure 8-8. Inlet Device Schematic



Source: Tyack & Fenner, 1997. In EPA, 1999b.

8-9.1 **Most Appropriate Uses.** This technology may be used by itself or in conjunction with other stormwater management devices as part of an overall stormwater control strategy. Hydrodynamic separators are ideal for areas with limited land availability. In addition, hydrodynamic separators can be placed in almost any location in a system, making them ideal for use in potential stormwater “hotspots” (areas where higher concentrations of pollutants are more likely to occur; e.g. gas stations).

Decreasing land availability for the installation of large stormwater management facilities is fueling the need for solutions such as hydrodynamic separators.

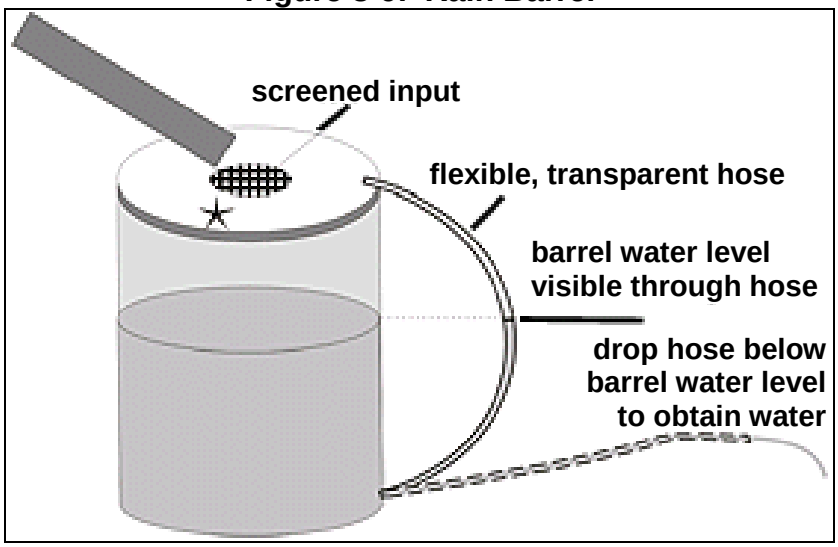
8-9.2 **Cost Data.** Costs are influenced by several factors including the amount of runoff to be treated, the amount of land available, and any other treatment technologies that are presently being used. Capital costs can range from $2,300 to $40,000 per pre-cast unit. Units that are site-specifically designed typically are more costly. Total costs for hydrodynamic separators often include pre-design costs, capital costs, and operation and maintenance costs.

8-9.3 **Maintenance Issues.** Proper maintenance of a hydrodynamic separator involves frequent inspections throughout the first year of installation to ensure that sediments are removed before the unit's sediment capacity is reached. Sediment depth can be measured using a "dip stick" or rod. Subsequently, sediment removal may be performed with a sump-vac or vacuum truck, depending on which type of separator is used. After the first year of installation, inspections can be scheduled according to observed rates of sediment accumulation. In general, hydrodynamic separators require a minimal amount of maintenance, but lack of attention will lower their overall pollutant removal efficiency.

8-9.4 **Corrective Actions.** Corrective action for structure or device failure typically requires removal and replacement of the device. Excessive bypass of sediments or pollutants may require additional devices or modification of the device.

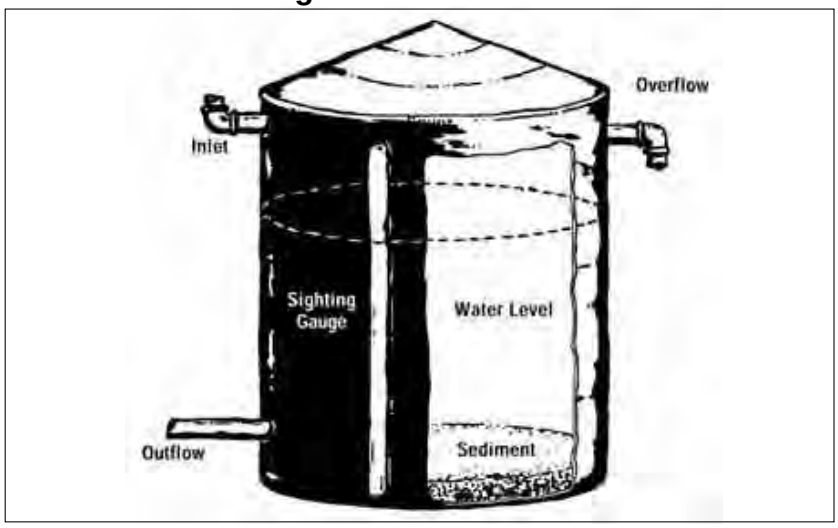
8-10 **RAIN BARRELS.** Rain barrels are placed outside of a building at roof downspouts to store rooftop runoff for later reuse in lawn and garden watering. **Cisterns** also collect rooftop runoff but store the water in significantly larger volumes in manufactured tanks or built underground storage areas. Both cisterns and rain barrels can be implemented without the use of pumping devices, instead relying on gravity flow.

Figure 8-9. Rain Barrel



Source: Maryland DNR Green Building Program.

Figure 8-10. Cistern



Source: Texas Guide to Rainwater Harvesting.

8-10.1 **Most Appropriate Uses.** Rain barrels and cisterns are low-cost water conservation devices that reduce runoff volume and, for very small storm events, delay and reduce the peak runoff flow rates. Both rain barrels and cisterns can provide a source of chemically untreated 'soft water' for gardens and compost, free of most sediment and dissolved salts.

8-10.2 **Cost Data.** The cost of a single rain barrel without any other attachments or accessories is typically around $120. The cost of constructing cisterns can vary greatly depending upon their size, material, location (above- or below-ground), and whether they are prefabricated. Pre-manufactured tanks utilized as cisterns can vary in price

from hundreds to tens of thousands of dollars. Sizes can vary from hundreds of gallons for residential use to tens of thousands of gallons for commercial and industrial uses.

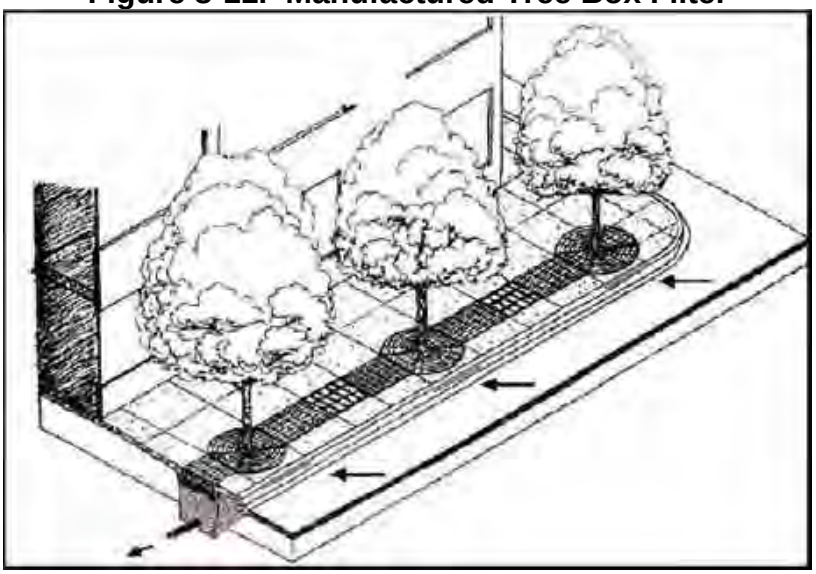
The use of water stored in rain barrels or cisterns for non-potable applications such as landscaping or toilets, or for potable applications if properly treated, may reduce potable water supply costs in areas where water costs are at a premium.

8-10.3 **Maintenance Issues.** Maintenance requirements for rain barrels are minimal and consist only of regular inspection of the unit as a whole and any of its constituent parts and accessories. All components should be inspected at least twice a year and repaired or replaced as needed. If cisterns are used to provide a supplemental supply of irrigation water, maintenance requirements for cisterns are often low. Cisterns designed for drinking water supply have much higher maintenance requirements, including biannual testing for water quality and filtering systems. Cisterns, along with all their components and accessories, should undergo regular inspection at least twice a year. Replacement or repair of the unit as a whole, and any of its constituent parts and accessories should be completed as necessary.

8-10.4 **Corrective Actions.** There are few mechanical parts on cisterns or rain barrels. Items such as screens or valves may fail, but are easily replaced. Large cisterns constructed out of materials such as metal or concrete may need repairs to walls by parging (for concrete) or welding (for metal).

8-11 **TREE BOX FILTERS.** Tree box filters are in-ground containers typically containing street trees in urban areas. These filters can be very effective at controlling runoff water quality, especially when numerous units are distributed throughout a site. Runoff is directed to the tree box, where it is filtered by vegetation and soil before entering a catch basin.

Figure 8-11. Manufactured Tree Box Filter



Source: Virginia DCR Stormwater Management Program.

8-11.1 **Most Appropriate Uses.** Tree box filters can help meet a variety of stormwater management goals, satisfy regulatory requirements for new development, protect and restore streams, control combined sewer overflows (CSOs), retrofit existing urban areas, and protect reservoir watersheds. The compact size of tree box filters allows volume and water quality control to be tailored to specific site characteristics. Tree box filters provide the added value of aesthetics while making efficient use of available land for stormwater management. Typical landscape plants (e.g., shrubs, ornamental grasses, trees and flowers) are an integral part of the bioretention system. Ideally, plants should be selected that can withstand alternating inundation and drought conditions, and that do not have invasive root systems which may reduce the soil's filtering capacity.

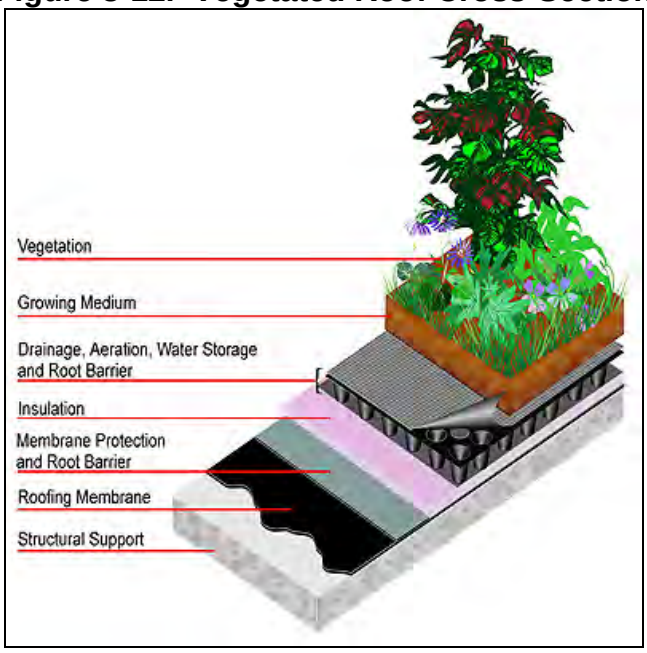
8-11.2 **Cost Data.** A single-unit tree box filter costs approximately $6,000 per unit per 0.1 ha (1/4 acre) of impervious surface (total cost = $24,000 per acre). This estimate includes two years of operating maintenance and filter material and plants. Additional costs include installation and annual maintenance. Installation varies with each site, but is approximately $1500 per unit. Annual maintenance is $500 per unit when performed by the manufacturer and $100 per unit when performed by the owner. (This sample cost estimate is based on a commercial tree box filter, the Filterra™ Stormwater Bioretention Filtration System.)

8-11.3 **Maintenance Issues.** Tree box filters require little maintenance. Maintenance includes annual routine inspection and the regular removal of trash and debris. The first two years of maintenance are typically included with the purchase of single and multiple-unit tree box filters. These would include removal of trash, debris and sediment, replenishment of the mulch, and care or replacement of plants. During extreme droughts, the plants may need to be watered in the same manner as any other landscape material.

8-11.4 **Corrective Actions.** Plants may have to be replaced because they have overgrown the filter, in which case their root structure may overwhelm the area of the soils, or because of environmental stress. The grates on top of the structure may become cracked and have to be replaced, although this should rarely occur because they are designed to be traffic bearing. The soil may become contaminated from a spill and have to be removed and properly disposed.

8-12 **VEGETATED ROOFS.** Vegetated roofs, also known as green roofs, eco-roofs or nature roofs, are structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing or detaining rainfall.

Figure 8-12. Vegetated Roof Cross-Section



Source: American Wick Drain Corp.

8-12.1 **Most Appropriate Uses.** Through a variety of physical, biological and chemical treatment processes that filter pollutants and reduce the volume of runoff, vegetated roofs reduce the amount of pollution delivered to the local drainage system and, ultimately, to receiving waters. One pollutant that vegetated roofs help control, for example, is nitrogen. While nitrogen gas occurs naturally as a major component of the atmosphere, nitrogen compounds from automobile exhaust, agricultural fertilizers and industrial activities can create a significant pollution problem. Airborne nitrogen compounds can fall to the ground in dust, raindrops, or simply by gravity. When these compounds are carried away with stormwater runoff, they contribute to eutrophication problems in surface water. Vegetated roofs can help control nitrogen pollution in stormwater runoff.

8-12.2 **Cost Data.** Costs for vegetated roofs in the United States are estimated to average between $161 and $215 per square meter ($15 and $20 per square foot) for all use types (i.e., high density residential, commercial, or industrial).[33] These costs include all aspects of vegetated roof installation, from the waterproofing membrane to soil substrate creation to planting. By far the highest costs associated with vegetated roof creation are the soil substrate and growth medium and the associated plant components. Vegetated roof retrofit projects may have increased cost associated with traffic and resource scheduling concerns as well as the on-site availability of equipment and materials. Planting costs are higher if plants are placed individually rather than pre-grown on vegetation mats.

[33] Scholz-Barth, 2001.

8-12.3 **Maintenance Issues.** Once a properly installed vegetated roof is well established, its maintenance requirements are usually minimal. There are two basic types of vegetated roofing systems: extensive and intensive.

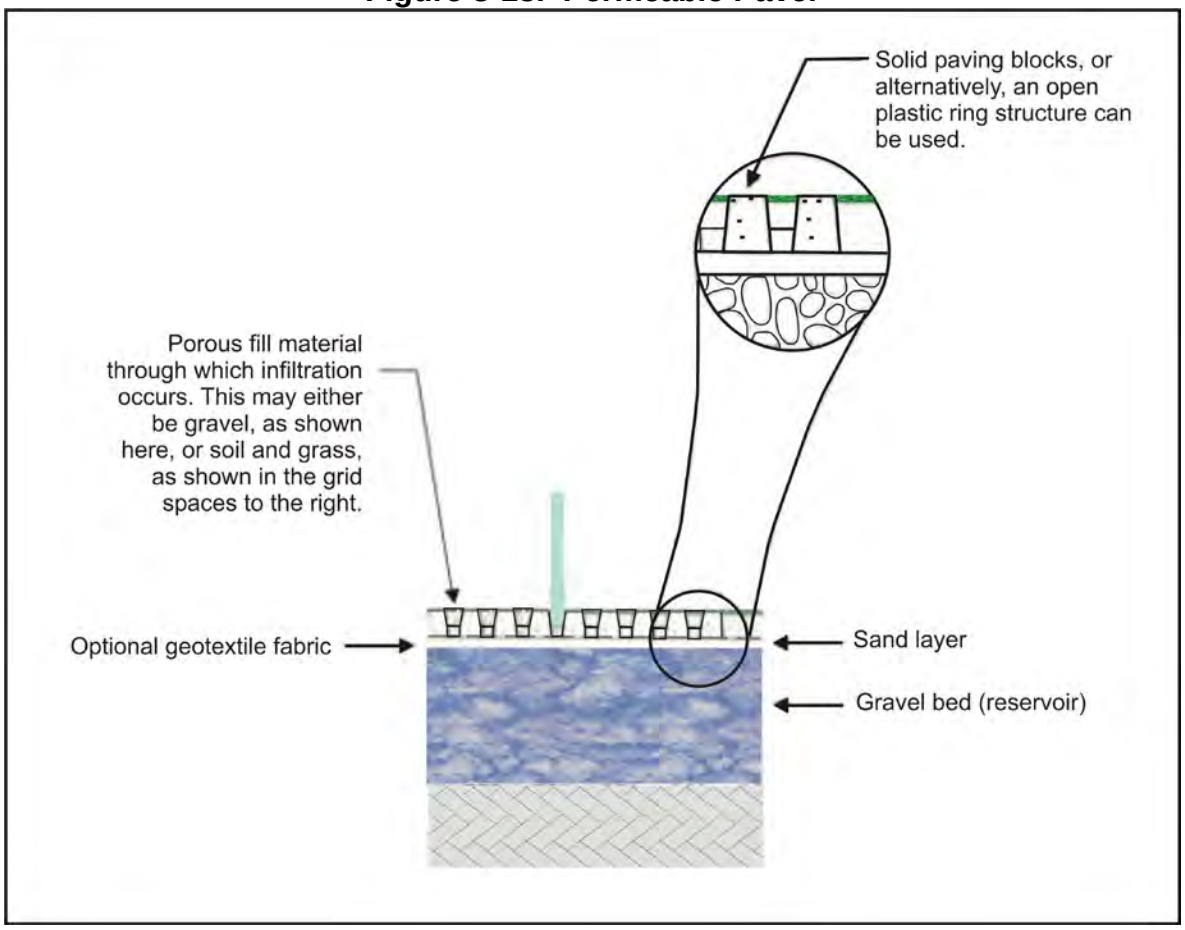
Extensive roofs form a thin vegetated sheath of self-sufficient mosses, sedums, and small shrubs. Their low profile allows them to be added to existing buildings, including those with sloping roofs.

By contrast, intensive roofs are integral to the roof structure, permitting the use of trees and walkways. A greater depth of media may be required to accommodate larger vegetation and surface features. Intensive roofs require more structural as well as horticultural maintenance, similar to a conventional garden, because plantings tend to be both heavier and more elaborate than on extensive roofs. For both types of roofs, maintenance requirements typically include inspection of the roof membrane, the most crucial element of a vegetated roof, as well as inspection and preventive maintenance of the drainage layer flow paths.

8-12.4 **Corrective Actions.** Corrective actions for vegetated roofs are generally to repair localized problems. More complex systems may have monitoring devices incorporated into the membrane. Leak detection systems can be brought to the site to locate breaches in the membrane. The soil media can be removed and the membrane repaired. Long periods of drought or loss of soil to high winds may require replacement of the media or replanting. If drought becomes an issue, corrective actions include installing an irrigation system or scheduling supplemental watering.

8-13 **PERMEABLE PAVERS.** Permeable pavers allow water to seep through regularly interspersed void areas in order to reduce runoff and associated pollutants**.**

Figure 8-13. Permeable Paver



Source: SCA Consulting Group, Lacey, WA.

8-13.1 **Most Appropriate Uses.** Runoff percolates through voids in permeable pavers and may be detained in the gravel bed, infiltrated into the underlying soil, or both. By reducing the volume of runoff, permeable pavers help to decrease downstream flooding, the frequency of combined sewer overflows, and the thermal pollution of sensitive waters. Permeable pavers can reduce or eliminate the requirement for underground sewer pipes and conventional stormwater retention and detention systems. Use of these materials can eliminate problems with standing water, provide for groundwater recharge, control erosion of streambeds and riverbanks, facilitate pollutant removal, and provide for a more aesthetically pleasing site. The drainage of paved areas and traffic surfaces by means of permeable systems is an important building block within an overall Low Impact Development scheme that seeks to achieve a stormwater management system that mimics natural conditions.

8-13.2 **Cost Data.** Initial expenses for alternative paving materials may be greater than conventional materials. However, the use of permeable pavers can often eliminate the requirement for underground storm drainpipes and conventional stormwater systems. Cost savings resulting from decreased investments in reservoirs, storm sewer

extensions, and the repair and maintenance of storm drain systems should be considered. Interlocking concrete paving blocks cost $54 to $108 per square meter ($5.00 to $10.00 per square foot.) In general, the multifunctional nature of permeable pavers reduces overall costs.

8-13.3 **Maintenance Issues.** After installation of a permeable paver system, maintenance is minimal but absolutely necessary to ensure the long lifetime of the system. Grass pavers will require the normal watering and mowing maintenance of any turf system. Porous concrete and interlocking concrete paving blocks require that the surface be kept clean of organic materials (leaves, for example). Periodic vacuuming and low-pressure washing should be used to clear out voids and extend the paver's functional life. Conventional street sweepers should be used with vacuums, brushes and water ideally four (4) times a year, but the actual required frequency will be determined by local conditions. With the interlocking system, additional aggregate fill material may be required after cleaning.

8-13.4 **Corrective Actions.** If there is an extensive buildup of a "scum" layer within the voids, the chip stone should be vacuumed, power-washed, cleaned and replaced. In case of localized settling, individual paver blocks can be removed, new gravel added, and the blocks replaced. In case of spills or contamination, the blocks and gravel layers can be removed and the area remediated.

8-14 **PERMEABLE PAVEMENT** can be either asphalt or concrete. As with permeable pavers, water is allowed to pass through voids and infiltrate into the underlying soil. Permeable pavement lacks most of the fine material found in conventional pavements, allowing water to flow through voids in the aggregate. (By contrast, paver blocks themselves are not necessarily permeable; infiltration occurs in the gaps between the blocks.) A layer of clean, uniformly graded gravel lies beneath the pavement, and geotextile separates this stone bed from the soil below. Runoff from the paved surface and adjacent impervious areas slowly passes through the gravel layer, which also may serve as a storage area. Permeable pavement has the same structural properties as conventional pavement. Environmental benefits are similar to other IMPs: reduction of runoff volume and rate, pollutant filtering, flow dispersion, and groundwater recharge. In addition, permeable pavements reduce the footprint of a site's impervious area.

8-14.1 **Most Appropriate Uses.** Permeable pavement may be substituted for conventional pavement in any application; however, it is most commonly and successfully used in parking lots and walkways. Permeable pavements simultaneously serve as hardscape and as stormwater infrastructure, and are therefore especially practicable where space constraints preclude the use of other IMPs such as bioretention. Cahill Associates reports that large permeable paved areas are still functioning after 20 years, outlasting conventional pavements in some cases. Permeable pavements reduce the likelihood of sinkhole formation because runoff is

dispersed over a large area (i.e., the entire paved surface), rather than concentrated in a small area such as a pond or catch basin.[34]

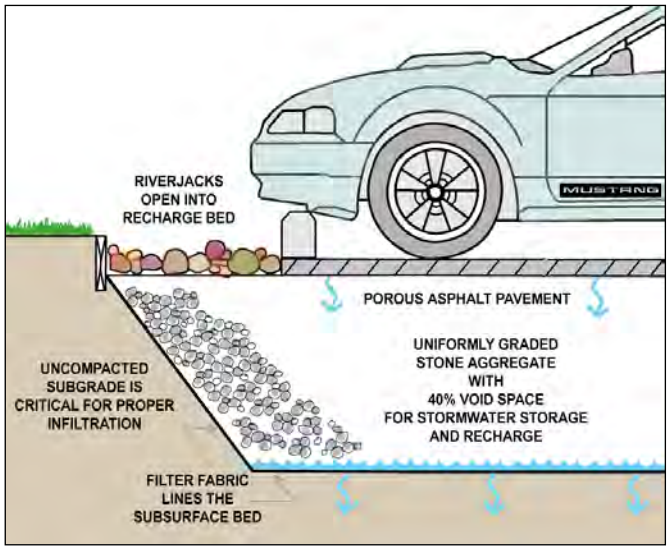
8-14.2 **Cost Data.** Permeable asphalt costs range from $5 t0 $11 per square meter ($0.50 to $1.00 per square foot,) while permeable concrete costs between $22 and $70 per square meter ($2.00 and $6.50 per square foot.) In addition, permeable pavements may reduce or eliminate the need for additional stormwater infrastructure, so a more accurate price comparison would involve the costs of the full stormwater management paving system. For example, a grass/gravel paver and porous concrete representative stated that when impervious paving costs for drains, reinforced concrete pipes, catch basins, outfalls and storm drain connections are included, an asphalt or conventional concrete stormwater management paving system costs between $102 and $125 per square meter ($9.50 and $11.50 per square foot,) compared to a permeable pavement stormwater management system at $50 to $70 per square meter ($4.50 to $6.50 per square foot.) The savings are considered to be even greater when permeable paving systems are calculated for their stormwater storage; if designed properly, they can eliminate retention pond requirements.[35]

8-14.3 **Maintenance Issues.** Maintenance requirements are similar to those for permeable pavers. To maintain its permeability, the pavement must be vacuumed or cleaned with a street sweeper twice a year. This removes sediments, organic matter, and atmospheric deposition that would otherwise clog the pavement over time.

8-14.4 **Corrective Actions.** With proper preventative maintenance, no additional actions should be necessary to maintain permeability. Pavements that have clogged as a result of neglect may require intensive vacuuming. As with conventional pavement, normal wear and tear may require repairs. For asphalt, however, care should be taken to *replace* the affected areas, because re-sealing would create an impervious surface. Contractors and maintenance staff should be acquainted with the differences between conventional and permeable pavement in order to prevent such a scenario.

[34] Cahill Associates, 2003.
[35] Peterson, 2002.

Figure 8-14. Permeable Pavement Cross-Section



Source: Cahill Associates.

Figure 8-15. Drainage in Both Types of Pavement

Source: Cahill Associates.

8-15 **TECHNICAL CONSULTATION.** With the possible exception of dry wells, infiltration trenches, and inlet devices, the vegetated IMPs described here are integral to a site's landscape design. Accordingly, they should be designed by, or under the direct supervision of, an appropriate licensed professional such as a landscape architect.

8-16 **DEVELOPMENT AND EVALUATION OF ADDITIONAL PRACTICES.** Additional practices not discussed in this UFC may also be appropriate for use as IMPs. The practice's applicability, effectiveness, cost and maintenance requirements must be considered in order to evaluate its potential use as an IMP.

CHAPTER 9

LID SITE PLANNING PROCESS

9-1 **INTRODUCTION.** This is a representative process for planning LID retrofits. Individual facilities will have unique needs and should adapt this process accordingly.

9-2 **MODEL PLANNING PROCESS.**

Step 1: Define project objectives and goals

1. Identify the LID objectives for the project. Consider these four fundamental aspects of stormwater control:[36]

   - Runoff volume
   - Peak runoff rate
   - Flow frequency and duration
   - Water quality

2. Evaluate existing stormwater infrastructure in terms of how well it functions with respect to each of these aspects.

3. Determine the goals and feasibility for control of runoff volume, flow frequency and duration, and water quality; as well as on-site use of stormwater (e.g. irrigation).

4. Prioritize and rank basic objectives.

5. Define hydrologic controls required to meet objectives (i.e. infiltration, filtration, discharge frequency, volume of discharges, groundwater recharge).

Step 2: Perform site evaluation and analysis

A site evaluation will facilitate LID design development by providing site details that will assist in the development of an LID program.

1. Conduct a detailed investigation of the site using available documents such as drainage maps, utilities information, soils maps, land use plans, and aerial photographs.

2. Perform an on-site evaluation highlighting opportunities, such as pollutant-generating areas, potential disconnects from combined sewer systems, and potential green corridors. Note potential LID practices and areas where water quality and quantity controls could be installed.

[36] PGDER, 2000b.

3. Evaluate site constraints such as available space, soil infiltration characteristics, water table, slope, drainage patterns, sunlight and shade, wind, critical habitat, circulation and underground utilities.

4. Identify protected areas, setbacks, easements, topographic features, subdrainage divides, and other site features that should be protected such as floodplains, steep slopes, and wetlands.

5. Delineate the watershed and microwatershed areas. Take into account previously modified drainage patterns, roads, and stormwater conveyance systems.

6. Locate baseline hydrologic and water quality data. In order of preference, try to locate:

   a) Local stream gage data and site water quality sampling data
   b) Data from a similar area within region
   c) Local averages
   d) Modeling results

7. Identify applicable local regulations or codes.

Step 3: Develop LID control strategies

Use hydrology as a design element. In order to minimize the runoff potential of the development, the hydrologic evaluation should be an ongoing part of the design process. An understanding of site drainage can suggest locations both for green areas and potential building sites. An open drainage system can help integrate the site with its natural features, creating a more aesthetically pleasing landscape.

1. Determine the design storm(s). Regulatory requirements for design storms may also be stipulated in local ordinances, and these may limit or constrain the use of LID techniques or necessitate that structural controls be employed in conjunction with LID techniques.

2. Define modeling technique(s) to be employed. Section 5-5.1 includes a detailed description several available hydrologic models. The model selected will depend on the type of watershed, complexity of the site planning goals, familiarity with the model, and level of detail desired.

3. Evaluate current conditions. Use the results of modeling to estimate baseline values for the four evaluation measures: runoff volume, peak runoff rate, flow frequency and duration, and water quality.

4. Implement non-structural site planning techniques:

a) Minimize total site impervious area.

- Use alternative roadway layouts that minimize imperviousness.
- Reduce road widths.
- Limit sidewalks to one side of roads.
- Reduce on-street parking.
- Use permeable paving materials.

b) Minimize directly connected impervious areas.

- Disconnect roof drains. Direct flows to vegetated areas.
- Direct flows from paved areas to stabilized vegetated areas.
- Break up flow directions from large paved surfaces.
- Encourage sheet flow through vegetated areas.
- Locate impervious areas so that they drain to permeable areas.

c) Modify drainage flow paths to increase time of concentration (T_c).

- Maximize overland sheet flow.
- Lengthen flow paths and increase the number of flow paths.
- Maximize use of open swale systems.
- Increase (or augment) the amount of vegetation on the site.

d) Define the development envelope.

- Use site fingerprinting. Restrict ground disturbance to the smallest possible area.
- Reduce paving.
- Reduce compaction of highly permeable soils.
- Minimize size of construction easements and material stockpiles.
- Place stockpiles within development envelope during construction.
- Avoid removal of existing trees.
- Disconnect as much impervious area as possible.
- Maintain existing topography and associated drainage divides to encourage dispersed flow paths.
- Locate new development in areas that have lower hydrologic function, such as barren clayey soils.

5. Evaluate site planning benefits and compare with baseline values. The modeling analysis is used to evaluate the cumulative hydrologic benefit of the site planning process in terms of the four evaluation measures.

6. Evaluate the need for Integrated Management Practices (IMPs). If site planning is not sufficient to meet the site's LID objectives, additional hydrologic control needs may be addressed through the use of IMPs

(described in Chapter 8). After IMPs are selected for the site, a second-level hydrologic evaluation can be conducted that combines the IMPs with the controls provided by the planning techniques. Results of this hydrologic evaluation are compared with the baseline conditions to verify that the site LID objectives have been achieved. If not, additional IMPs are located on the site to achieve the optimal condition.

7. Evaluate supplemental needs. If supplemental control for either volume or peak flow is still needed after the use of IMPs, selection and listing of additional management techniques should be considered. For example, where flood control or flooding problems are key design objectives, or where site conditions, such as poor soils or a high water table, limit the use of IMPs, additional conventional end-of-pipe methods, such as large detention ponds or constructed wetlands, should be considered. In some cases their capacity can be reduced significantly by the use of LID upstream. It may be helpful to evaluate several combinations of LID features and conventional stormwater facilities to determine which combination best meets the stated objectives. Use of hydrologic evaluations can assist in identifying the alternative solutions prior to detailed design and construction costs.

For residential areas, Prince George's County, Maryland, has developed a detailed illustration of an approach for conducting a hydrologic evaluation based on the NRCS TR-55 method. Where NRCS methods (TR-20, TR-55) are accepted for hydrologic evaluation, the effect of LID features should be reflected in the curve numbers and times of concentration selected for the analysis. A full description of this process is available from Prince George's County.[37]

Step 4: Design LID Site or Master Plan

1. Sketch a design concept that distributes the LID practices appropriately around the project site. Try to use all surface types (built, hardscape, and landscape). Keep in mind the multifunctional capability of LID technologies (i.e., parking lot with detention facility underground).

2. Develop a master plan that identifies all key control issues (water quality, water quantity, water conservation) and implementation areas. Specify specific LID technologies and any connections they have to stormwater overflow units and sub-surface detention facilities.

Step 5: Develop Operation and Maintenance Procedures

Develop operation and maintenance procedures for each of the LID practices implemented in the site plan. Different types of IMPs will have different maintenance requirements, but some general principles will apply:

[37] PGDER, 2000b.

- Keep IMPs and flow paths clear of debris.
- Water vegetation regularly during dry periods.
- Grassed areas should be mowed regularly.
- Plantings should be pruned as needed.

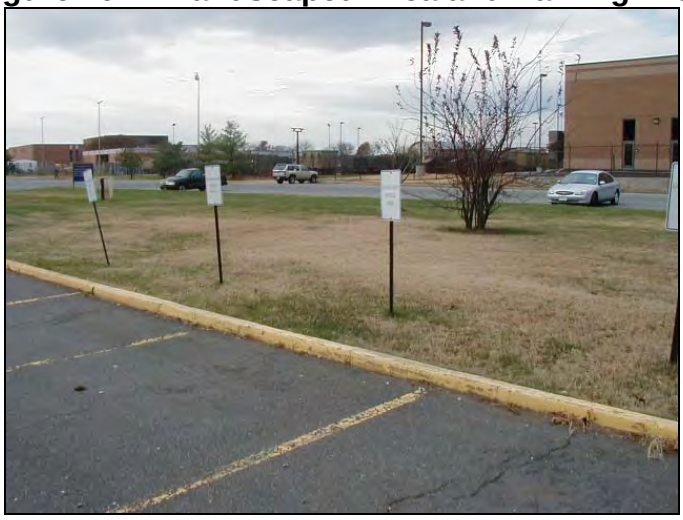
Specific maintenance requirements of the different IMPs are discussed in Chapter 8.

CHAPTER 10

DESIGN EXAMPLES

10-1 **OFFICE COMPLEX RETROFIT.** This example illustrates how an existing office building complex can be retrofit with LID components to improve water quality. This complex is located at the Anacostia Annex of the Washington Navy Yard in Washington, D.C. This area has extremely flat topography with clay soils. Because of its proximity to the Anacostia River, there is a high water table. No stormwater management quantity or quality controls are currently being used. The existing asphalt surface has been patched several times and is in poor condition. A full-depth replacement of the parking area is required. Many of the drainage inlets and old brick drainage structures are cracked or broken and need to be replaced. Much of the sidewalk surrounding the building is also cracked or heaving and the site pedestrian access does not comply with current Americans with Disabilities Act (ADA) Standards. Much of the existing vegetation around the building is overgrown and the lawn areas are in poor condition from compaction and poor management. This condition creates an opportunity to retrofit the parking area for immediate water quality improvements and make long-term recommendations for the entire area.

Figure 10-1. Landscaped Area and Parking Area



10-1.1 **PROJECT OBJECTIVES.** The objectives for this retrofit are to:

- Integrate water quality management practices into the repaving of parking areas
- Repair the sidewalks
- Re-landscape

Funding for LID retrofits has been approved as part of the paving and reconstruction so that the area will comply with local stormwater quality regulations.

Pollutants of concern for this watershed are oils and grease, total suspended solids, nitrogen, and phosphorus. All of these pollutants are generated by the land use. In this case, as with many retrofits, the goal is to improve stormwater quality generally rather than to meet a specific load reduction goal. Quantity control is not required because the site outfall is located near the outlet of the watershed of a major watercourse and the facility's storm drain network has adequate capacity.

10-1.2 **RANK AND PRIORITIZE OPPORTUNITES.** For this project, retrofit opportunities will be ranked and prioritized according to the following criteria:

- Greatest potential to reduce non-point source pollutant loads
- Minimal costs for new structures or materials
- Minimal disturbance and ability to integrate construction into storm drain repair
- Minimal maintenance cycles
- Minimal maintenance costs and training
- Ancillary benefits (landscaping, energy conservation, water conservation)

10-1.3 **SITE CONDITIONS.** The site has minimal topographic relief. The groundwater table is approximately 3 feet (0.91 m) below the surface elevation. The soils in the area are fill soils with poor infiltration rates. The site is fronted by a landscaped buffer along the access road. There is an existing drainage system below the buffer. The adjacent parking area has several mature trees and drains towards the landscape buffer area. Figure 10-1 is a picture of the landscaped area taken from the parking area. Several yard inlets are located in the parking areas and along the access road. Figure 10-2 is a picture of a drainage inlet that has a concrete pilot channel to help collect runoff from the parking areas.

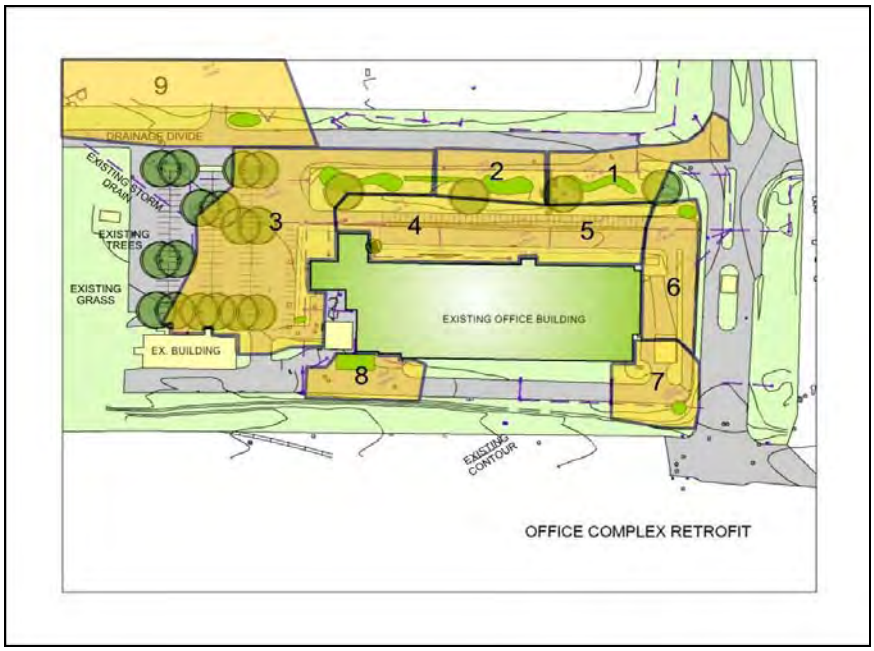
Figure 10-2. Drainage Inlet

Utility maps, topographic maps, and aerial photography were gathered and a site visit was conducted. Drainage patterns were verified during the site visit.

(Drainage areas and patterns found in the field often deviate from those shown on plans because of changing field conditions, new utilities, repairs, or inaccuracies in the data.)

10-1.4 **LID DESIGN.** Four types of LID components were selected: bioretention, permeable pavers, tree box filters, and a vegetated roof. Because of the poor infiltration capacity of the soil, these features will not be capable of infiltrating stormwater into the ground. Instead, they will be equipped with underdrains and used to control water quality and provide detention storage. Site drainage areas were delineated, and LID features were located in places both appropriate to the technology and to the runoff patterns and volumes. Figure 10-3 shows the site drainage patterns and Figure 10-4 shows the locations of the LID features.

Figure 10-3 Drainage Areas of Proposed Practices



The description of the practices and their locations is as follows:

- **Drainage Areas One through Three:** Several LID components will be installed in the large vegetated island behind the parking areas along the access road. The design includes three bioretention cells, a bioretention swale, and a footpath constructed using permeable pavers. Installation will require that the existing curb be removed and replaced with wheel stops. These LID components can then treat the sheet flow from the access road and adjacent parking area and the parking lot to the south. A slight regrading of the drive area around the access road to the building will be required in order to direct runoff from the parking lot to the bioretention cells.

- **Drainage Area Four:** A tree box filter is designated for this area. This structure is appropriate because of space limitations.

- **Drainage Area Five:** Permeable pavers will be constructed in the existing valley between the access road and the parking area. This will require reconstruction of the inlet tops and some regrading. The curb in the back of the parking area is also deteriorated and should be replaced. The width of the pavers will be based on their infiltration capacity. The depth to groundwater also needs to be determined to make sure that the gravel bed underneath the pavers can be properly constructed to store and drain stormwater.

- **Drainage Area Six:** A bioretention cell will be constructed within a vegetated island at the north end of this parking area.

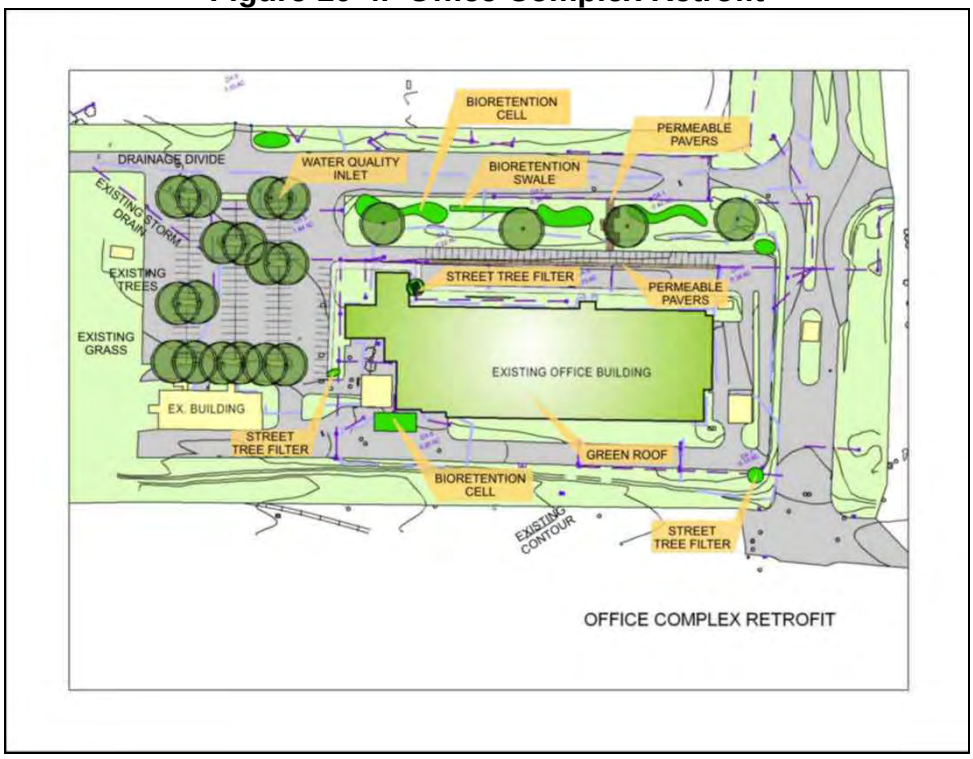
- **Drainage Area Seven:** An area of the pavement will be removed and replaced with a bioretention cell.

- **Drainage Area Eight:** This is near the loading dock area. Permeable pavers will be constructed. A sand layer may be incorporated into the system to increase efficiency.

- **Drainage Area Nine:** A bioretention cell will be located to the east of the access road, near the entrance to the storage lot to the south of building 399. This area will treat runoff from the access road and the storage area. The driveway apron will be reconstructed to direct runoff to the cell.

- **Rooftop:** A vegetated roof is proposed for building 168. This will filter pollutants from rain falling on the rooftop and will provide detention of rooftop runoff.

Figure 10-4. Office Complex Retrofit



Pollutant load calculations were developed for this project using a spreadsheet and a modification of the Simple Method[38] to determine the optimal areas in which to locate water quality improvement features. Although this method is more appropriate for larger watersheds and preliminary planning, the local jurisdiction uses it to evaluate water quality loading. Equation 10-1 is the water quality calculation.

$$L = 0.226 \times R \times C \times A$$ **Equation 10-1**

Where: L = Annual load (lbs)
R = Annual runoff (inches)
C = Pollutant concentration (mg/l)
A = Area (acres)
0.226 = Unit conversion factor
(Schueler, 1987)

Equation 10-2 is the projected load reduction.

$$D = L \times (1 - E)$$ **Equation 10-2**

Where: D = Annual load reduction (lbs)
L = Annual load (lbs)
E = Pollutant removal efficiency (fraction)

[38] Schueler, 1987.

For the purposes of this study, removal rates of 70 percent were used for bioretention and tree box filters, and a removal rate of 50 percent was used for permeable pavers. Calculations were performed for lead, copper, zinc, phosphorus and total nitrogen. The results show an overall reduction of almost 65 percent of the aggregate load for the areas directly controlled by the practices and 55 percent of the total annual load for the pollutants studied. Table 10-1 shows the projected load reduction for various pollutants.

Table 10-1. Projected Load Reduction After LID Retrofit

Pollutant	Annual Load kg (lbs) Existing Condition	Annual Load (lbs) After LID Retrofit
Zinc	7.94 (17.5)	2.8 (6.1)
Lead	7.76 (17.1)	2.7 (6.0)
Copper	2.1 (4.6)	0.73 (1.6)
Nitrogen (TKN)	43.4 (95.6)	15.1 (33.2)
Phosphorus	20.2 (44.5)	7.03 (15.5)

10-2 **NEW HOUSING DESIGN.** This example will demonstrate the differences between conventional and LID stormwater management approaches for a typical DoD housing community in a coastal area. The design objectives are to maintain the peak runoff rate for a Type II NRCS 2-year 24-hour storm event and provide water quality control for the development. Following the hydrologic analysis presented here, a series of pictures are presented to illustrate how selected LID components would look in a recently constructed housing development.

10-2.1 **Curve Number Calculations For Existing Site Condition.** The site being evaluated has a 2.6 ha (6.5 acre) drainage area. The land is relatively flat and drains to a small channel with wetlands at the outfall of the drainage area. The slopes are gentle, averaging 2 percent. The soils are classified as belonging to NRCS Hydrologic Soils Group (HSG) B. These soils have moderate infiltration rates and moderately fine to moderately coarse textures. They generally have a moderate rate of water transmission (0.15 to 0.30 in/hr), and the textures may be classified as a silt loam or loam.[39] Approximately 1.5 ha (3.6 acres) near the outfall is classified hydrologically as “Woods in Fair Condition”. The upper portion of the property is classified as “Brush in Poor Condition”. Figure 10-5 is a map of the existing condition.

The procedures from Worksheet 2, Figure 2-5 from TR-55[40] are used to calculate the composite curve number (CN) for the site. The resulting CN from Equation 10-3 is 63 for the 2.6 ha (6.5 acres.) Table 10-2 is a summary of those calculations.

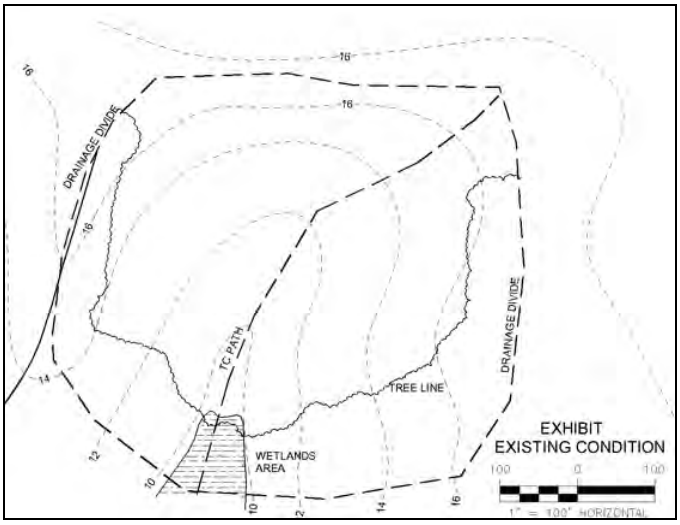
Weighted CN = Sum of Products ÷ Drainage Area **Equation 10-3**

[39] NRCS, 1986.
[40] Ibid.

Table 10-2. Composite Curve Number Calculation for Existing Condition

Hydrologic Soils Group	Cover Description	CN (Table 2-2 TR-55)	Area (Acres)	Product of CN x Area
B	Brush, Poor Condition	67	2.9	194.3
B	Woods, Fair	60	3.6	216.0
			Sum of Products	**410.3**
			÷ Drainage Area	6.5
			Weighted CN	**63**

Figure 10-5. Map of Existing Conditions



10-2.2 **Post Development Curve Number Calculations.** The conventional method for assigning a curve number to a residential development is to choose a single curve number for the entire site from a source such as Table 2-2a of TR-55.[41] Figure 10-6 is a picture of the proposed housing type, which can be classified as "Townhouse Residential District". For this land use, the CN from Table 2-2a of TR-55 is 85.

The LID method allows for the calculation of a "customized" CN that reflects the actual field conditions rather than a broad estimation. For this example, the amounts of impervious cover and other land covers were calculated directly from Figure 10-7. Table 10-3 is a summary of the proposed condition's "customized" CN using the LID calculation method.

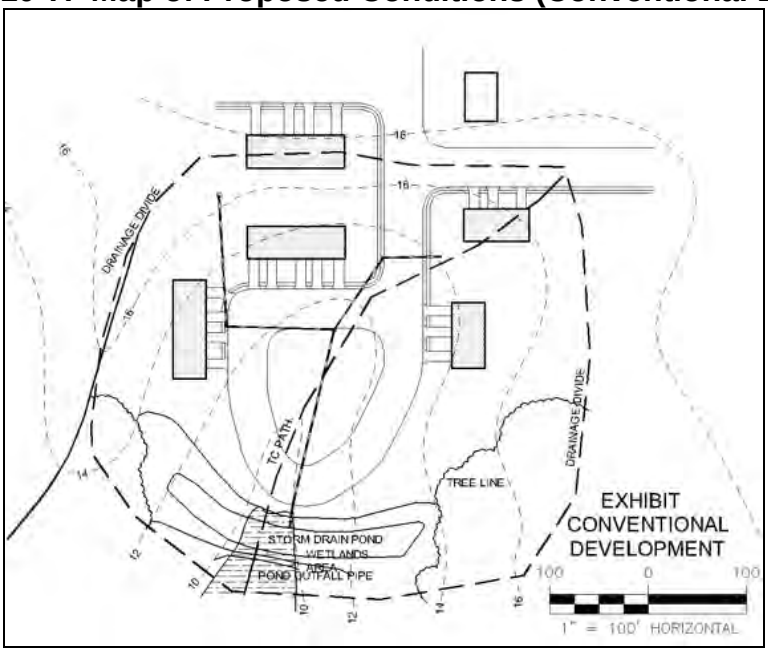
[41] Ibid.

Table 10-3. Composite Curve Number Calculation for Proposed Condition

Hydrologic Soils Group	Cover Description	CN (Table 2-2 TR-55)	Area (Acres)	Product of CN x Area
B	Lawn (fair condition)	69	3.2	220.8
B	Woods, Fair	60	0.7	42.0
B	Impervious	98	2.6	254.8
			Sum of Products	**517.6**
			÷ Drainage Area	6.5
			Weighted CN	**80**

Figure 10-6. Proposed Housing

Figure 10-7. Map of Proposed Conditions (Conventional Design)



10-2.3 **Runoff Volume For Existing And Proposed Conditions.** The difference in runoff volume between the existing and proposed conditions can be quite significant for both annual accumulations and peak events. A comparison of the volume (depth) of runoff from the pre- and post-development curve numbers for a 130 mm (5-in) rainfall using Equation 2-1 from TR-55[42] (Equation 10-4) is shown in Table 10-4.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$ **Equation 10-4**

Where: Q = runoff depth (in)
P = rainfall depth (in)
I_a = initial abstraction (in)

$$I_a = 0.2S$$ **Equation 10-5**

Where: S = potential maximum retention after runoff begins (in)

$$S = \frac{1000}{CN} - 10$$ **Equation 10-6**

[42] Ibid.

Table 10-4. Runoff Depth for Existing and Proposed Conditions (5-inch Rainfall)

Condition	Runoff (in)
Existing (CN = 63)	1.5
Proposed (CN = 80)	2.9

10-2.4 **LID Site Planning Strategies.** Several LID site design strategies will be employed to reduce the CN for the proposed condition. A lower CN value will be obtained by:

- Reducing impervious cover
- Disconnecting impervious areas
- Reducing the grading footprint to retain more wooded area
- Restoring the infiltration capacity of disturbed and compacted soils

Figure 10-8 shows the resulting site plan. A significant amount of disturbance to the woods and wetlands has been avoided by eliminating the centralized stormwater facility and distributing the stormwater management among LID components throughout the site. (The elimination or reduction of impacts to wetlands and water bodies may have a significant effect on permitting in many areas.) The condition of lawn areas will be improved by ensuring that adequate topsoil and aeration are included in the final grading and stabilization of the project. The road width has been reduced from 15 m (48 ft) to 9.8 m (32 ft). The parking areas have been maintained as head-in parking and the green space in the central island is expanded. Additional reductions in impervious area could be incorporated into the design, such as further reducing the road width or sharing driveways. Remaining impervious areas should be disconnected to the greatest possible extent. Table 10-5 summarizes the CN calculations for the proposed conditions using the LID site planning approach.

Figure 10-8. Map of Proposed Conditions (LID Design)

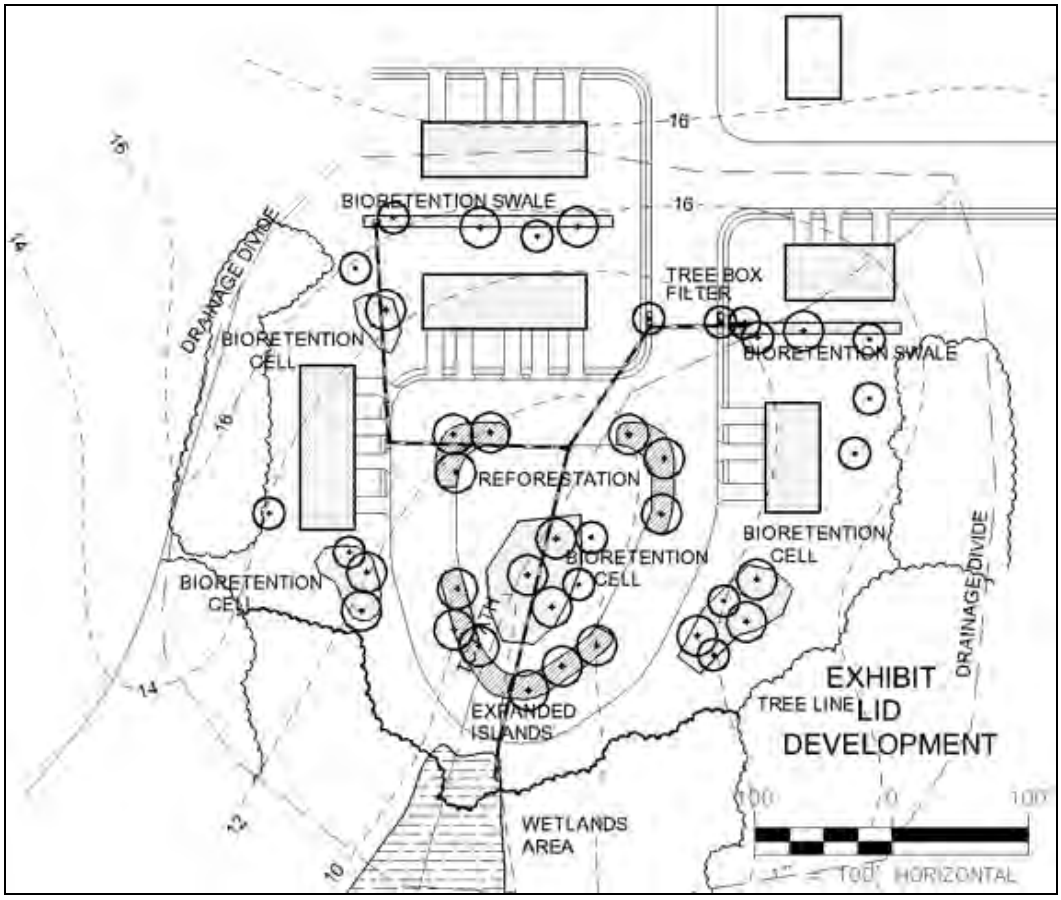


Table 10-5. Composite CN Calculation for Proposed Condition Using LID

Hydrologic Soils Group	Cover Description	CN (Table 2-2 TR-55)	Area (Acres)	Product of CN x Area
B	Lawn (good condition)	61	1.8	109.8
B	Woods, Fair	60	2.5	150.0
B	Impervious	98	2.2	215.6
			Sum of Products	**475.4**
			÷ Drainage Area	6.5
			Composite CN	**73**

10-2.5 **Time Of Concentration For Existing And Proposed Conditions.** The time of concentration (T_c) was calculated for the pre-development and conventional post-development conditions using the procedures in TR-55. A summary of these calculations is included in Appendix C. The conventionally developed condition causes T_c to decrease from 0.24 hours to 0.22 hours, or a 1.2 minute difference. The LID site design results in a T_c that matches the existing condition; in this case, 0.24 hours. Additional calculations for flow through the bioretention cells or rougher vegetated areas

were not included in the analysis, but would be expected to further increase post-development LID T_c.

10-2.6 **Storage Volume Comparison.** A comparison of the storage volumes required for the conventional and LID site designs is given below. The 2-year 24-hour and the 10-year 24-hour storms are often used as the design storms for channel protection and adequate conveyance. Although the design objective here is to maintain the peak runoff rate for the 2-year 24-hour storm, the 10-year 24-hour storm is also used to further illustrate the differences in peak runoff rate and volume between the two approaches. In order to determine the storage volume required to maintain the pre-development peak runoff rate for these design storms, the runoff depths and peak runoff rates for the existing condition and both proposed conditions were first calculated using the Graphical Peak Discharge Method from TR-55. Table 10-6 is a summary of those calculations.

Table 10-6. Summary of Graphical Peak Discharge Results

Condition	CN	T_c	Peak Discharge (CFS)		Runoff depth (in.)	
			2-year storm (3" depth)	10-year storm (5" depth)	2-year storm	10-year storm
Existing Condition	63	0.24	2	10	0.4	1.5
Proposed Condition – conventional CN	80	0.22	9	23	1.3	2.9
Proposed Condition using LID site design	73	0.24	6	17	0.9	2.3

The TR-55[43] computer program was used to estimate the post-development storage volume required to maintain the 2-year 24-hour pre-development peak runoff rate for both the conventional and LID site designs. As shown in Table 10-6 above, the target (existing) 2-year 24-hour peak outflow is 2 cfs and the target 10-year 24-hour peak outflow is 10 cfs. (It is purely coincidental that the values of the return periods match the values of the discharges.) The results are given in Table 10-7.

Table 10-7. Post-Development Storage Volumes

Design storm	Conventional site design		LID site design	
	Depth, inches (mm)*	Volume, ac-ft (m^3)	Depth, inches (mm)*	Volume, ac-ft (m^3)
2-year 24-hour	0.52 (13)	0.28 (347)	0.28 (7)	0.15 (187)
10-year 24-hour	0.85 (22)	0.46 (568)	0.53 (13)	0.29 (354)

** depth of runoff distributed across the 6.5 acre (2.6 ha) area*

[43] Ibid.

For the 2-year 24-hour storm, the LID site design results in a 46% reduction in required storage volume as compared to the conventional site design, and for the 10-year 24-hour storm, the volume reduction is 38%. The pond shown in Figure 10-7 was sized using the computed 2-year conventional detention basin storage volume. Appendix C shows a summary of the computer program results.

10-2.7 **Distributed Detention And Retention Storage Requirements.** The previous section demonstrates that significant reductions in runoff volume (and correspondingly, storage volume) can be achieved by following the LID site design approach. A conventional detention pond, however, will not normally be used in an LID design; instead, storage will be provided using *distributed* retention and detention. The LID Design Charts (see Appendix D)[44] were used to determine the total volume of storage required to maintain the pre-development 2-year 24-hour peak runoff rate using retention (Chart 1) and detention (Chart 2). The CN of 63 was used for the pre-development condition and the CN of 73 was used for the post-development condition. The depth of storage across the site needed to maintain the pre-development discharge rate using retention is 12 mm (0.48 in). Equation 10-7 shows that this is equivalent to a volume of 321 m^3 (0.26 acre-feet). Using detention, the required depth of storage across the site is 8 mm (0.3 in), or using Equation 10-7, a volume of 194 m^3 (0.16 acre-feet).

Storage Volume (acre-feet) = Drainage Area (acres) x Depth of Storage (feet) **Equation 10-7**

The soils are HSG B; therefore, they have good potential for infiltration and the use of retention is appropriate. Hybrid designs that use both retention and detention are intended for soils with poor infiltration capacity (HSG C and HSG D). The use of retention will also encourage recharge and maintain the water balance for the site.

A site may be required not only to maintain the pre-development peak discharge rate, but to maintain the pre-development runoff *volume* as well. The total storage volume required to maintain the pre-development runoff volume can be calculated using Chart 3 in Appendix D, and in this example it equals 11 mm (0.42 in). This is less than the volume needed to maintain the pre-development peak discharge rate (13 mm [0.48 in,] calculated above). Although maintaining the pre-development runoff volume is not a requirement in this case study, this calculation illustrates the feasibility of maintaining the pre-development recharge and runoff characteristics of the site (i.e. peak discharge *and* volume) for frequently occurring storm events up to and including the 2-year 24-hour storm. Therefore, there is full hydraulic and hydrologic control of small-scale, frequently-occurring storms.

10-2.8 **Selection of Appropriate IMPs.** The retention storage volume calculated above, 321 m^3 (0.26 acre-feet,) was used as the total storage volume to be distributed between the selected IMPs. The selected LID components include bioretention cells, bioretention swales, and tree box filters. A ponding depth of 305 mm (12 in) was used

[44] PGDER, 2000b.

to size each of the bioretention devices. Using Equation 10-8, the total area required for bioretention is approximately 1050 m^2 (11,300 sq. ft). Accounting for the volume of runoff that can be stored in the pore spaces in the bioretention media will further decrease the required storage area.

Bioretention Area = Storage Volume ÷ Bioretention Depth **Equation 10-8**

These features have been located to intercept and manage the stormwater drainage in small areas. The storm drain pattern remains the same as in the conventional system and provides adequate conveyance. Because of the runoff volume and peak reductions achieved by the LID site design and IMPs, a smaller storm drain diameter can be used if desired.

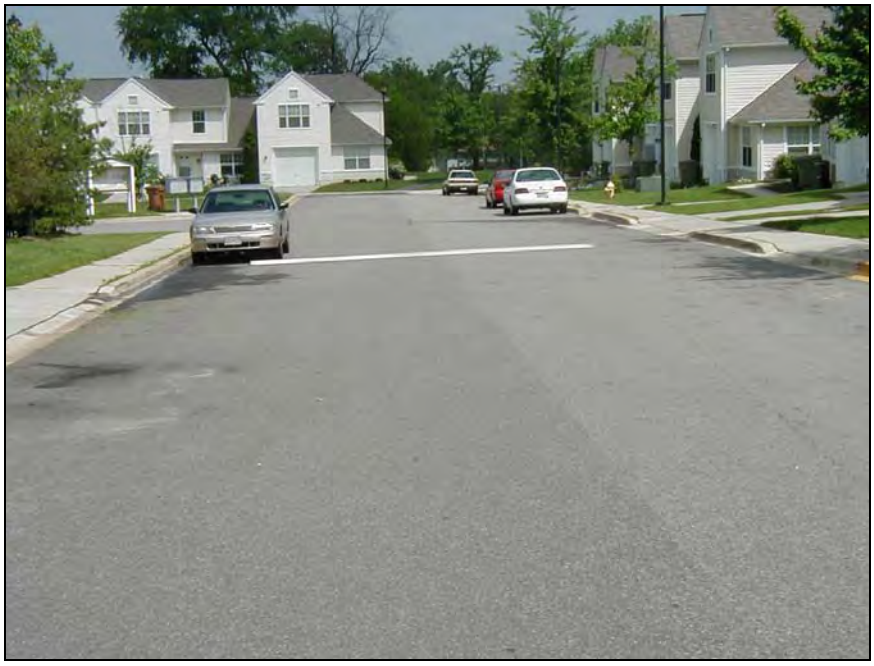
Figure 10-8 illustrates that the storage volume required to maintain the pre-development 2-year 24-hour peak discharge can be met by using distributed stormwater management. These components can be maintained by the residents, with the exception of the tree box filter. All of the facilities can be maintained by landscape maintenance crews, with minimal training. Figures 10-9 to 10-14 illustrate how the LID features can be incorporated into a residential development.

Figure 10-9. Street Island Modifications

Before

After

Figure 10-10. Street Alterations

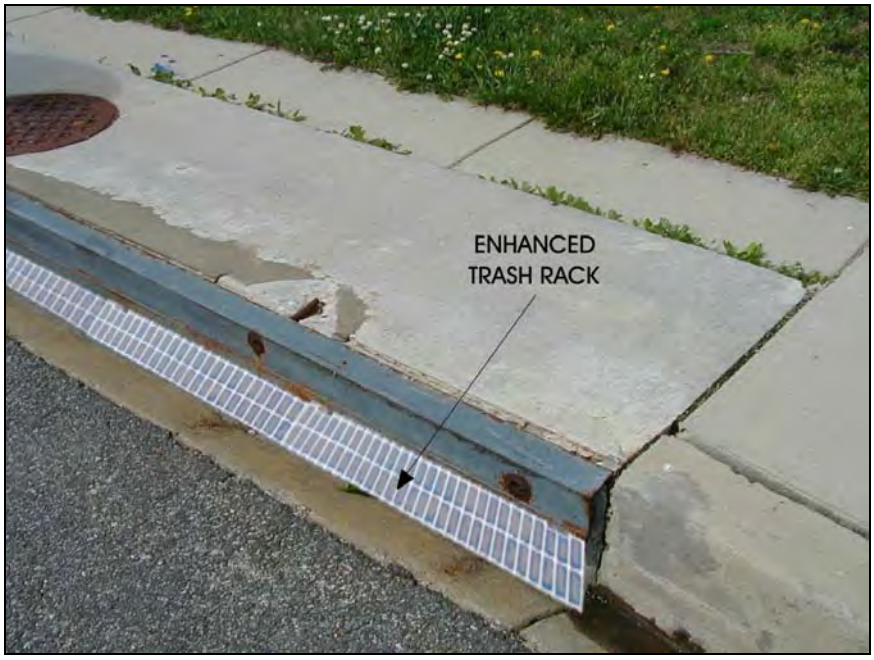


Before

After

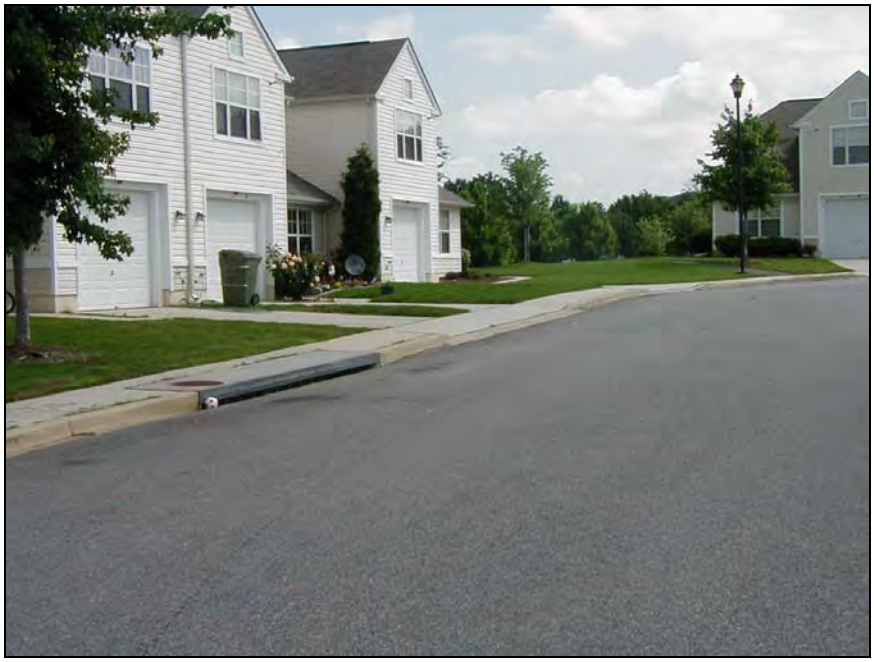
Figure 10-11. Trash Rack

Before



After

Figure 10-12. Tree Box Filter



Before

After

Figure 10-13. Bioretention (Rain Garden)

Before

After

Figure 10-14. Reforestation

Before

After

10-2.9 **WATER QUALITY CALCULATIONS.** There are a variety of strategies and methods available to provide water quality control. One conventional approach is to capture a certain volume of runoff and hold it in a detention pond to allow pollutants to settle out of the water. A common regulatory requirement is to store the first 13 mm (0.5 in) of runoff from impervious areas (e.g. roofs, pavement or walks).[45] Based on this requirement and the fact that there are 0.85 ha (2.1 acres) of impervious area in the proposed development, 111 m^3 (0.09 acre-feet) of water quality storage is needed. Since this is less than the total retention storage requirement of 321 m^2 (0.26 acre-feet,) the water quality storage volume is already contained in the proposed design.

Many LID components use the biological, chemical and physical processes of plant and soil interactions to filter and treat pollutants. The effectiveness of these components can be measured in terms of a relative reduction in pollutant concentration or a reduction in the total mass of the pollutant that reaches the receiving waters annually. For this method, the reduction is based on the removal efficiency and flow rates rather than a storage volume. A detailed analysis of the combined effectiveness of the LID components will demonstrate, in some cases, that a storage volume for water quality is not necessary.

10-2.10 **CONCLUSION.** This case study has shown how LID can be incorporated into the design of a residential housing development. The use of LID practices has eliminated the need for a traditional stormwater detention pond, thereby reducing the disturbance to existing forested area. The retention of this forested buffer will in turn reduce impacts to the wetland and receiving waters. The need for piped stormwater conveyances has been eliminated. The LID approach has the added benefit of improving the aesthetics of the development and can provide opportunities for community involvement in the protection and maintenance of the local environment.

[45] Novotny and Olem, 1994.

APPENDIX A

REFERENCES

GOVERNMENT PUBLICATIONS:

1. City of Portland
Bureau of Environmental Services

1120 SW Fifth Avenue, Room 1000
Portland, OR 97204
(503) 823-7740

Stormwater management manual. Revision 2. 2000.
www.cleanrivers-pdx.org/tech_resources/2002_swmm.htm

2. Department of the Air Force

Directorate of Environmental Quality
1260 Air Force Pentagon
Washington, DC 20330-1260

Air Force Instruction 32-7080, Civil engineering: pollution prevention program.
www.e-publishing.af.mil

3. Maine Dept. of Environmental Protection
Nonpoint Source Training and Resource Center

17 State House Station
Augusta, ME 04333
(207) 287-7726

Stormwater management for Maine: best management practices. 1995.
www.state.me.us/dep/blwq/training/npspubl.htm

4. Prince George's County Department of Environmental Resources (PGDER)
Programs and Planning Division

9400 Peppercorn Place, Suite 500
Largo, MD 20774
(301) 883-5810

Design manual for use of bioretention in stormwater management. 1993.

Low-impact development design strategies: an integrated design approach. 2000a.
www.epa.gov/owow/nps/lidnatl.pdf

Low-impact development hydrologic analysis. 2000b.
www.epa.gov/owow/nps/lid/lid_hydr.pdf

5. U.S. Department of Agriculture
Natural Resources Conservation Svc.
(formerly Soil Conservation Service)
National Water and Climate Center

   101 SW Main Street, Suite 1600
   Portland, OR 97204
   (503) 414-3031

   Technical release 55 (TR-55), urban hydrology for small watersheds. 1986.
   www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html

6. U.S. Department of Transportation
Federal Highway Administration
Planning, Environment, & Realty (HEP)

   400 Seventh Street SW
   Washington, DC 20590
   (202) 366-0116

   Young, G. Kenneth et al. 1996. *Evaluation and management of highway runoff water quality*. FHWA-PD-96-032.
   www.fhwa.dot.gov/environment/h2o_abs.htm

   Stormwater best management practices in an ultra-urban setting: selection and monitoring. 2000. FHWA-EP-00-002.
   www.fhwa.dot.gov/environment/ultraurb

7. U.S. Environmental Protection Agency
Office of Water (4101M)

   1200 Pennsylvania Avenue NW
   Washington, DC 20460
   (800) 438-2474

   Barbour, Michael T., Jeroen Gerritsen, Blaine D. Snyder, and James B. Stribling. 1999. *Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish.* Second edition. EPA 841-B-99-002.
   www.epa.gov/owow/monitoring/rbp

   Low Impact Development Center. 2000.

Low impact development (LID): a literature review. EPA-841-B-00-005.
www.epa.gov/owow/nps/lid/lid.pdf

Results of the nationwide urban runoff program. 1983. NTIS#PB84-185552.
www.ntis.gov/pdf/ordrform.pdf

Storm water technology fact sheet: bio-retention. 1999a. EPA-832-F-99-012.
www.epa.gov/owm/mtb/biortn.pdf

Storm water technology fact sheet: hydrodynamic separators. 1999b. EPA-832-F-99-017.
www.epa.gov/owm/mtb/hydro.pdf

Storm water technology fact sheet: infiltration trench. 1999c. EPA-832-F-99-019.
www.epa.gov/owm/mtb/infltrenc.pdf

Storm water technology fact sheet: vegetated swales. 1999d. EPA-832-F-99-006.
www.epa.gov/owm/mtb/vegswale.pdf

Urban stormwater BMP performance monitoring. 2002. EPA-821-B-02-001.
www.epa.gov/waterscience/stormwater/monitor.htm

NON-GOVERNMENT PUBLICATIONS:

1. American Society of Civil Engineers

   Publications Marketing Department
   1801 Alexander Bell Drive
   Reston, VA 20191
   (800) 548-2723 ext. 6251

   Coffman, Larry S., Robert Goo, and Rod Frederick. 1999. Low impact development: an innovative alternative approach to stormwater management. In *Water Resources Planning and Management Conference '99 - Preparing for the 21st Century* ed. by Erin M. Wilson. Reston, VA: ASCE.
   www.pubs.asce.org/WWWdisplaybn.cgi?0784404305

   Harrington, Bruce W. 1989. Design and construction of infiltration trenches. In *Design of Urban Runoff Quality Controls* ed. by Larry A. Roesner, 290-306. New York: ASCE.
   www.pubs.asce.org/BOOKdisplay.cgi?8902820

2. Cahill Associates

   104 South High Street
   West Chester, PA 19382
   (610) 696-4150

   Cahill Associates. 2003. *Porous pavement*. West Chester: Cahill Associates.

3. Chesapeake Research Consortium

   645 Contees Wharf Road
   Edgewater, MD 21037
   (410)798-1283

   Brown, Whitney E., and Thomas R. Schueler. 1997. *The economics of stormwater BMPs in the Mid-Atlantic region*. Prepared for the Chesapeake Research Consortium. Ellicott City, MD: Center for Watershed Protection.

4. Elsevier Scientific Publishing Company

   Science Direct Customer Service
   360 Park Avenue South
   New York, NY 10010 USA
   (888) 437-4636

   Sanders, R.A. 1986. Urban vegetation impacts on the hydrology of Dayton, Ohio. *Urban Ecology* 9: 361-376.
   www.sciencedirect.com/science/journal/03044009

5. Engineers Australia
   National Committee on Water Engineering (NCWE)

Engineering House 11 National Circuit Barton ACT 2600 +61 (02) 6270 6555	Wong, Tony. 2003. Introduction. In *Australian Runoff Quality* ed. by NCWE, 1-1 – 1-8. Barton: NCWE. rambler.newcastle.edu.au/~ncwe/ncweARQ/ARQ.pdf
6. Government Institutes	
4 Research Place, Suite 200 Rockville, MD 20850 (301) 921-2300	Lee, C. C. 1998. *Environmental engineering dictionary*. Third edition. Rockville: Government Institutes.
7. Greenhorne and O'Mara (G&O)	
9001 Edmonston Road Greenbelt, MD 20770 (866) 322-8905	G&O. 1998. *Case studies in low impact development: stormwater management comparison and economics evaluation*. Greenbelt: G&O.
8. Low Impact Development Center	
5010 Sunnyside Avenue, Suite 200 Beltsville, MD 20910 (301) 982-5559	LID Center. 2002. *Feasibility study for the use of low impact development to manage and control wet weather flows in urban areas*. Beltsville: LID Center.
9. Metropolitan Washington Council of Governments (MWCOG)	
Information Center 777 North Capitol Street NE, Suite 300 Washington, DC 20002 (202) 962-3356	Schueler, Thomas R. 1992. *A current assessment of urban best management practices*. Washington: MWCOG. Publication Number 92705. Schueler, Thomas R. 1987. *Controlling urban runoff: a practical manual for planning and designing urban BMPs*. Washington: MWCOG. Publication Number 87703.
10. Peterson, Chere	Personal interview. 2002.
11. Prentice Hall	
1 Lake Street Upper Saddle River, NJ 07458 (800) 282-0693	McCuen, Richard H. 1998. *Hydrologic analysis and design*. Second edition. Upper Saddle River: Prentice Hall.

12. Southeastern Wisconsin Regional Planning Commission (SEWRPC)

    P.O. Box 1607
    Waukesha, WI 53187
    (262) 547-6721

    SEWPRC. 1991. *Costs of urban nonpoint source water pollution control measures.* Technical Report 31. Waukesha: SEWPRC. Out of print; available at SEWPRC library.

13. University of Washington
    College of Forest Resources (CFR)

    Box 352100
    Seattle, WA 98195
    (206) 543-2730

    Chollak, Tracy, and Paul Rosenfeld. 1998. *Guidelines for landscaping with compost-amended soils*. Seattle: CFR.
    www.ci.redmond.wa.us/insidecityhall/publicworks/environment/pdfs/compostamendedsoils.pdf

14. University of Washington
    Dept. of Civil and Enviro. Engineering
    Center for Water and Watershed Studies (CWWP)

    21 Winkenwerder Hall
    Box 352100
    Seattle, WA 98195
    (206) 543-6920

    Colwell, Shanti R., Richard R. Horner, and Derek B. Booth. 2000. *Characterization of performance predictors and evaluation of mowing practices in biofiltration swales*. Seattle: CWWP.
    http://water.washington.edu/Research/Reports/swale%20mowing.pdf

15. Urban Land Institute

    1025 Thomas Jefferson Street NW
    Suite 500 West
    Washington, DC 20007
    (800) 321-5011

    Scholz-Barth, Katrin. 2001. Green on top. *Urban Land*, June, 82.

16. John Wiley & Sons

    111 River Street
    Hoboken, NJ 07030
    (877) 762-2974

    Gordon, Nancy D., Thomas A. McMahon, and Brian L. Finlayson. 1992. *Stream hydrology: an introduction for ecologists*. Chichester, England: John Wiley & Sons.

    Novotny, Vladimir, and Harvey Olem. 1994. *Water quality: prevention, identification, and*

management of diffuse pollution. New York: John Wiley & Sons.

APPENDIX B

GLOSSARY: ACRONYMS AND ABBREVIATIONS

ADA	Americans with Disabilities Act
BMP	Best Management Practice
CN	Curve Number
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DoD	Department of Defense
EO	Executive Order
EPA	Environmental Protection Agency
EQI	Environmental Quality Initiative
FHWA	Federal Highway Administration
HEC	Hydraulic Engineering Center
IMP	Integrated Management Practice
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NURP	Nationwide Urban Runoff Program
P2	Pollution Prevention
PGDER	Prince George's County Department of Environmental Resources
RBP	Rapid Bioassessment Protocols
SCS	Soil Conservation Service
SPCC	Spill Prevention, Control, and Countermeasures
SWMM	Storm Water Management Model
T_c	Time of concentration
TCT	Tilled Compost-Amended Turf
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids

APPENDIX C

SUPPORTING CALCULATIONS FOR SECTION 10-2

Exhibit A. TR-55 Time of Concentration Calculation for Existing Condition

```
TIME OF CONCENTRATION AND TRAVEL TIME                              Version 2.10


Project : RESIDENTIAL CASE STUDY              User:          Date: 07-11-2003
County  :                     State:       Checked: ____     Date: ________
Subtitle: EXISTING CONDITION

------------------------------- Subarea #1 - 1 -------------------------------
Flow Type   2 year   Length   Slope  Surface   n   Area     Wp   Velocity  Time
             rain     (ft)   (ft/ft)   code      (sq/ft)  (ft)  (ft/sec)  (hr)
-----------------------------------------------------------------------------
Sheet        3        100      .02      E                                0.169
Shallow Concent'd     565      .02      U                                0.069
                                                 Time of Concentration = 0.24*
                                                                         =====

        --- Sheet Flow Surface Codes ---
    A Smooth Surface          F Grass, Dense     --- Shallow Concentrated ---
    B Fallow (No Res.)        G Grass, Burmuda   ---     Surface Codes    ---
    C Cultivated < 20 % Res.  H Woods, Light              P Paved
    D Cultivated > 20 % Res.  I Woods, Dense              U Unpaved
    E Grass-Range, Short      J Range, Natural
```

Exhibit B. TR-55 Time of Concentration Calculation for Proposed Condition

```
TIME OF CONCENTRATION AND TRAVEL TIME                              Version 2.10


Project : RESIDENTIAL CASE STUDY              User:          Date: 07-11-2003
County  :                     State:       Checked: ____     Date: ________
Subtitle: PROPOSED CONDITION

------------------------------- Subarea #1 - 1 -------------------------------
Flow Type   2 year   Length   Slope  Surface   n   Area     Wp   Velocity  Time
             rain     (ft)   (ft/ft)   code      (sq/ft)  (ft)  (ft/sec)  (hr)
-----------------------------------------------------------------------------
Sheet        3        100      .02      E                                0.169
Shallow Concent'd     150      .02      U                                0.018
Open Channel          415                                        4.0     0.029
                                                 Time of Concentration = 0.22*
                                                                         =====

        --- Sheet Flow Surface Codes ---
    A Smooth Surface          F Grass, Dense     --- Shallow Concentrated ---
    B Fallow (No Res.)        G Grass, Burmuda   ---     Surface Codes    ---
    C Cultivated < 20 % Res.  H Woods, Light              P Paved
    D Cultivated > 20 % Res.  I Woods, Dense              U Unpaved
    E Grass-Range, Short      J Range, Natural
```

Exhibit C. TR-55 Detention Basin Storage Volume Calculation for Proposed Condition, Conventional Site Design

TR-55 STORAGE VOLUME FOR DETENTION BASINS Version 2.10

>>>>> Identification Data <<<<< Date 04-23-2004

Project RESIDENTIAL CASE STUDY

Subtitle PROPOSED CONDITION (CONVENTIONAL)

>>>>> Basic Data <<<<<

Drainage Area **6.5** Acres

Rainfall-Type (I,IA,II,III) **II**

Rainfall Frequency **2** years 24-Hour Rainfall 3 inches

Runoff 1.25 inches Runoff Curve Number 80

Peak Inflow 9.3451 cfs Peak Outflow **2.3229** cfs

Detention Basin Storage Volume: 0.52 inches or 0.3 acre feet

TR-55 STORAGE VOLUME FOR DETENTION BASINS Version 2.10

>>>>> Identification Data <<<<< Date 04-23-2004

Project RESIDENTIAL CASE STUDY

Subtitle PROPOSED CONDITION (CONVENTIONAL)

>>>>> Basic Data <<<<<

Drainage Area **6.5** Acres

Rainfall-Type (I,IA,II,III) **II**

Rainfall Frequency **10** years 24-Hour Rainfall 5 inches

Runoff 2.89 inches Runoff Curve Number 80

Peak Inflow 22.638 cfs Peak Outflow **10.328** cfs

Detention Basin Storage Volume: 0.85 inches or 0.5 acre feet

Exhibit D. TR-55 Detention Basin Storage Volume Calculation for Proposed Condition, LID Site Design

TR-55 STORAGE VOLUME FOR DETENTION BASINS Version 2.10

>>>>> Identification Data <<<<< Date 04-23-2004

Project RESIDENTIAL CASE STUDY

Subtitle PROPOSED CONDITION (LID)

>>>>> Basic Data <<<<<

Drainage Area **6.5** Acres

Rainfall-Type (I,IA,II,III) **II**

Rainfall Frequency **2** years 24-Hour Rainfall 3 inches

Runoff .857 inches Runoff Curve Number 73

Peak Inflow 5.8163 cfs Peak Outflow **2.3229** cfs

Detention Basin Storage Volume: 0.28 inches or 0.1 acre feet

TR-55 STORAGE VOLUME FOR DETENTION BASINS Version 2.10

>>>>> Identification Data <<<<< Date 04-23-2004

Project RESIDENTIAL CASE STUDY

Subtitle PROPOSED CONDITION (LID)

>>>>> Basic Data <<<<<

Drainage Area **6.5**

Rainfall-Type (I,IA,II,III) **II**

Rainfall Frequency **10** years 24-Hour Rainfall 5 inches

Runoff 2.28 inches Runoff Curve Number 73

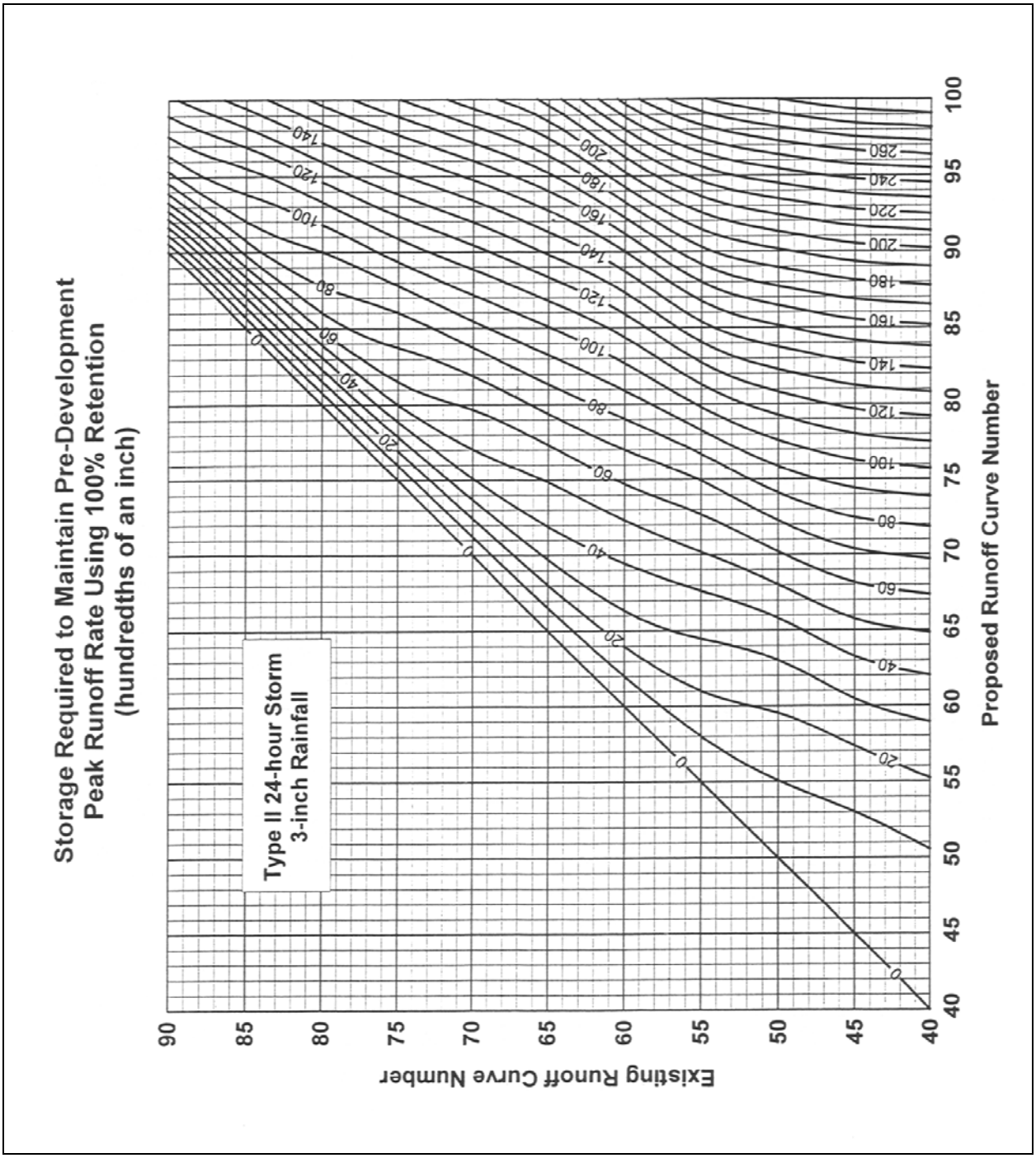
Peak Inflow 16.652 cfs Peak Outflow **10.328** cfs

Detention Basin Storage Volume: 0.53 inches or 0.3 acre feet

APPENDIX D

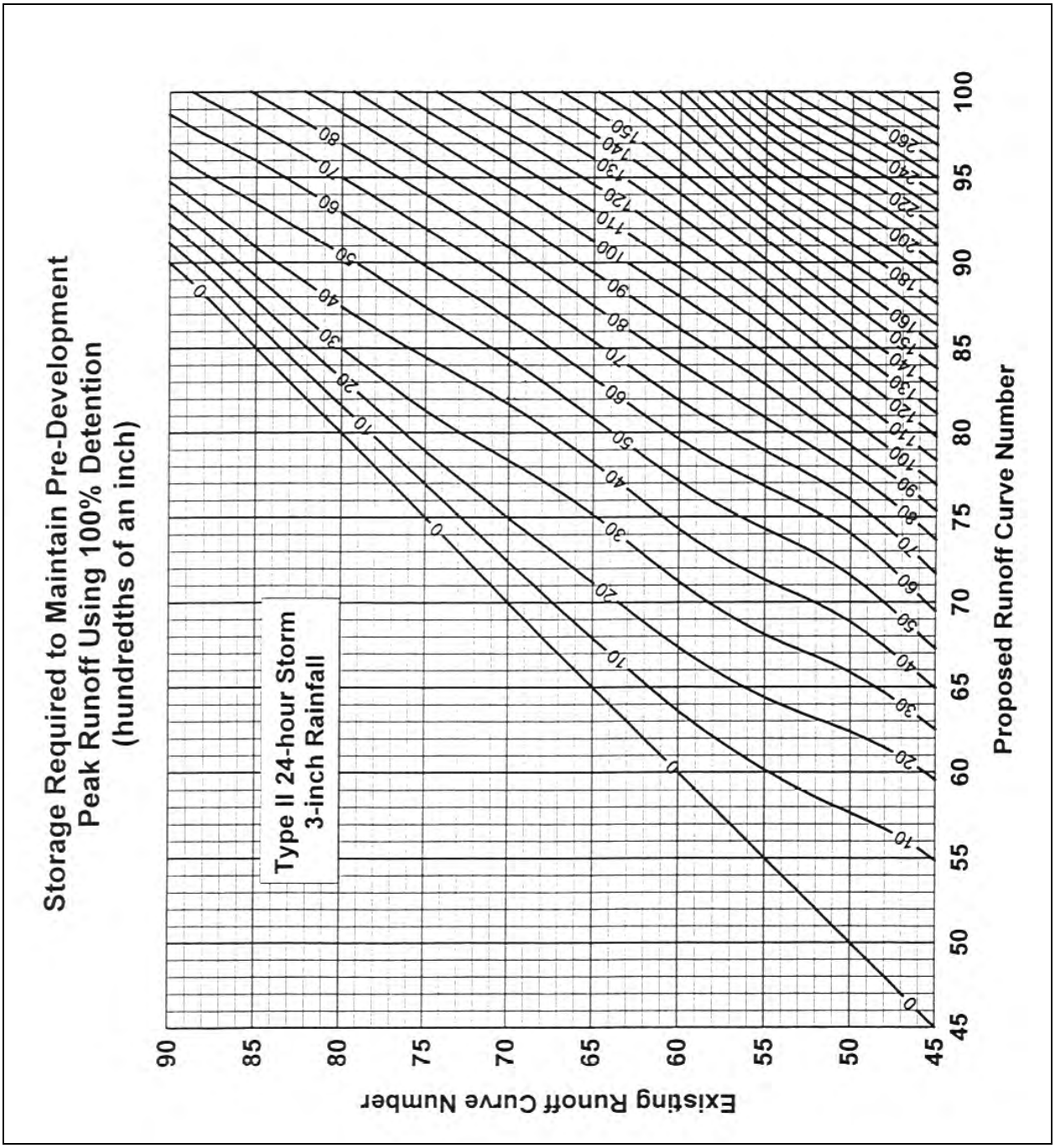
LID DESIGN CHARTS

Chart 1



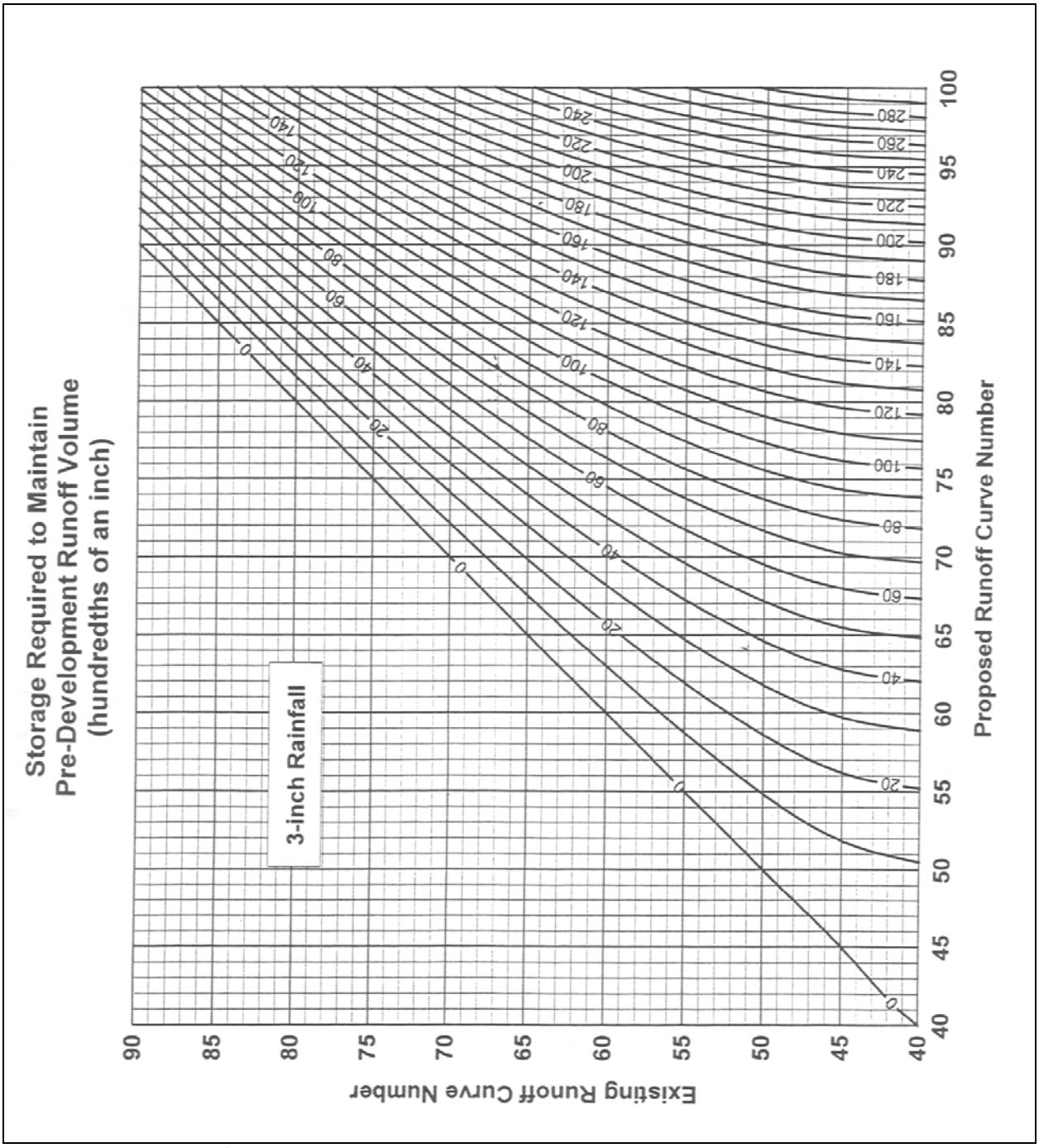
Source: PGDER, 2000b.

Chart 2



Source: PGDER 2000b.

Chart 3



Source: PGDER 2000b.

3.5 General Considerations

1.) 3.5.6 Cuts and Resurfaces

Cuts shall typically extend at least 6 inches beyond either side of the trench to provide a stable base for the surface material, unless the design package directs otherwise. Roads, streets, parking lots, etc., shall only be closed for as long as is necessary to complete the work required to place the duct (including tamping the backfill) and to allow the slurry, concrete, and/or asphalt to set IAW the manufacturer's specifications.

Once the concrete or slurry has set, the surface shall be restored to its original condition within 72 hours, unless otherwise approved by the Government. Certain streets or roadways may have cutting restrictions or special requirements that require traffic be resumed as soon as possible. Contractors shall be prepared to comply with these restrictions and requirements. As an option, steel plates may be used in order to open the street to traffic while the material is curing.

2.) 3.5.8 Backfilling

In accordance with UFGS-02300*,* all excavated areas around the new maintenance holes, ducts, or cables shall be backfilled with approved excavated materials consisting of earth, loam, sandy clay, sand, gravel, and soft shale, all of which shall be free from large clumps.

3.) 3.5.9 Restoration

Restoration to the same condition as found prior to construction shall be completed within 72 hours for all areas where no additional intrusion is required. Roads, streets, parking lots, etc. shall be closed only for as long as is required to complete the work and to allow the slurry, concrete, and/or asphalt to properly set IAW the manufacturers' specifications. Installations may have cutting restrictions or special requirements for certain streets or roadways that require the contractor to reopen the road as soon as possible. Designers shall ensure that the contractors are prepared to comply with these restrictions and requirements.

3.5.10 Detection of Buried Cables and Underground Conduits

4.) 3.5.10.1 Warning Tape

All warning tape shall be polyethylene (PE) plastic tape, a minimum width of 150 mm (6 inches), IAW the APWA Uniform Color Code, and imprinted with the words "WARNING - TELECOMMUNICATION CABLE BELOW" at not more than 1.2-m (48-inch) intervals. Minimum thickness of the tape shall be 0.10 mm (0.004 in). Tape shall have a minimum strength of 12.0 Megapascal (MPa) (1750 pounds per square inch [PSI]) lengthwise and 10.3 MPa (1500 PSI) crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector or underground cable detector typically used in the OSP industry when tape is buried up to 920 mm (3 feet) deep. The materials in the warning tape shall be chemically inert and will not degrade when exposed to acids, alkalis, and other destructive substances found in soil.

5.) 3.5.10.4 Permanent Tracer Wire

Permanent tracer wire shall be installed in all new duct banks. One tracer wire shall be installed per duct bank. The tracer wire shall be placed as centrically as possible in the top conduit formation. When dielectric cable is installed in existing conduit formations that do not contain toneable cables, a tracer wire shall be installed along with the dielectric cable. Splices in the tracer wire shall be connected by means of a compression type connector to ensure continuity. Wire nuts shall not be used. After installation, tracer wire shall be tested to verify continuity of the tracer wire system and a report indicating continuity shall be submitted to the permitting authority as part of the as-built construction records.

3.6 Outside Plant Cable Placement Options

6.) 3.6.1.4 Transition

The transition from plastic to RSC for entrance conduits shall take place at the bottom of the trench prior to sweeps or bends to the building.

3.7 Underground (Maintenance Holes, Cable Vaults, and Ducts)

7.) 3.7.1 Maintenance Holes

Maintenance holes are used to facilitate the placement and splicing of cables. Telecommunications maintenance holes shall not be shared with electrical installations other than those needed for the telecommunications equipment. Maintenance holes are reinforced concrete units provided with a removable lid that permits internal access to the housed components via ladder or rungs. The maintenance holes accommodate cables, splice closures, racking systems, and low-voltage electronic equipment. Maintenance holes shall be equipped with corrosion-resistant pulling irons and cable racks that are grounded and with a sump for drainage. The quality of the concrete pour and the construction of the maintenance hole shall be such that the rebar or visible rock shall not be seen in the surface of a maintenance hole wall. In other words, the pour shall not have any voids.

Maintenance holes shall be installed on a leveled, crushed, washed gravel base of sufficient depth, i.e., a minimum thickness of 6 inches (150 mm) under the entire maintenance hole, to allow for drainage and stability. Where maintenance holes are installed in roadways, the structure and lid (cover) shall support heavy vehicular traffic. Refer to Figure C-4 (Figure C-11 for Europe), Typical Maintenance Hole, for additional details.

8.) 3.7.1.1 Type

The preferred maintenance hole is a pre-cast reinforced concrete, splayed or non-splayed, multi-directional type with cast-in single or multiple plastic terminators to accept the conduits. Thin concrete knockout sections may be provided for terminating multiple-bore conduits. The preferred maintenance hole interior size is 12 feet x 6 feet x 7 feet (3.7 m [length] x 1.8 m [width] x 2 m [height]). Other sizes may be used only with U.S. Government approval. Splayed maintenance holes shall be provided near DCOs and remote switching units (RSU), where future duct expansion is expected. Maintenance holes shall have a load rating of HS-20 for heavy vehicular traffic.

9.) 3.7.1.2 Basic Layout

Maintenance holes in main or lateral duct runs shall be placed as defined below. Measurements between maintenance holes are from lid-to-lid (center-to-center) (C/C), unless otherwise indicated. Measurements from maintenance holes to buildings, to pedestals, to riser poles, etc., are from the maintenance hole lid to the outside wall, bottom of pole, etc. (center-to-point). New maintenance holes shall be placed to support the locations of junction points, offsets, load points, and curvature in the duct line.

The spacing of access points (maintenance holes or hand holes) in a maintenance hole and duct system is determined by the environment (containment area or range area); media to be installed (copper cables only, copper and fiber cables, or fiber cables only); proximity to cable origination points (DCO or nodes); and allowable pulling tension of the media. The following are a few design guidelines:

a. Maintenance holes and hand holes in duct systems in cantonment areas that have or will potentially have multiple cables (copper and fiber) shall not be spaced more than 600 feet apart.
b. Maintenance holes and hand holes in duct systems in sparsely populated areas or at the ends of runs that will contain only fiber or small copper cables (not to exceed 100 pair copper) can be spaced up to 1000 feet apart.
c. Maintenance holes and hand holes in duct systems in sparsely populated areas or at the ends of runs that will contain only fiber cables can be spaced up to 2000 feet apart.
d. Maintenance holes and hand holes used as splice points in direct buried systems (typically in ranges) can be placed as required (typically at the ends of reel splices).
The following are caveats:

a. Do not use a hand hole for copper cable splice points or for more than one fiber splice case.
b. Do not place maintenance holes or hand holes so far apart as to exceed the manufacturer's recommended pulling tension for the cables.
c. Maintenance holes and hand holes may be placed closer together to accommodate distribution designs.
d. The maintenance holes near a DCO or node need to be full-sized (6 feet x 12 feet x 7 feet H) due to existing or potential multiple cables and multiple splice cases.
e. Any deviations from these guidelines require prior approval of the U.S. Government.

3.7.1.3 Accessories

10.) a. Maintenance Hole Lids: A maintenance hole shall include a point of egress for maintenance personnel. The maintenance hole lid shall be circular and not less than 30 inches (765 mm) in diameter and shall not violate the H-20 load rating of the maintenance hole. Additional lids or oversized lids may be provided for maintenance holes with special uses, i.e., oversized maintenance holes, maintenance holes containing carrier or loading equipment, or maintenance holes located outside a DCO. The lid shall fit in a steel ring or frame and be equipped with a concrete collar to be at grade level, as required. The frame and collar shall be attached to the maintenance hole IAW the manufacturer's instructions, but as a minimum, the lid shall form a watertight seal and shall resist lateral movement if accidentally bumped. When stacked, collar sections shall be precisely matched with each other to prevent snagging of personnel or equipment when entering or exiting the maintenance hole. There shall be no overhangs between collar sections.

11.) b. Locking Covers: The first maintenance hole outside a DCO or wire node; maintenance holes at critical junctions; or maintenance holes equipped with carrier equipment will

have a lockable cover. Additional maintenance holes requiring lockable covers may be identified as such in the Statement of Work (SOW)/Engineering Design Plan (EDP). The preferred lockable lid cover is one that utilizes a lever and clamp mechanism placed into a receiver that is installed into the cover. The mechanism will allow the cover to be replaced without indexing the cover to the frame. When locked, the mechanism will be flush with the frame surface, minimizing the potential for the cover to be dislodged. The bolt used to secure the cover is available in many configurations and can only be turned with a socket provided by the manufacturer. The U.S. Government will select the bolt configuration. A disposable tamper-evident plastic cap snaps into the lock body covering the recessed bolt head, keeping dirt and debris out of the bolt area. An alternative means of securing the maintenance hole utilizes an inner, water-resistant cover that can be locked by means of a General Services Administration (GSA)-approved, changeable combination lock. The U.S. Government will provide the locks.

12.) **c. Sump:** A sump shall be cast into the floor of the maintenance hole. The floor shall slope toward the sump to provide drainage into the sump from all areas. The sump shall be approximately 13 in x 13 in (330 mm x 330 mm), or a 13-in (330-mm) diameter circle, and shall be 4 inches (100 mm) deep, covered with a removable perforated or punched plate to permit drainage. The cover shall be fastened to the housing by a chain, rope, or hinge.

13.) **d. Pulling-in Irons:** Cable pulling-in irons shall be installed on the wall opposite each main conduit entrance location, 3½ to 9 inches (90-230 mm) from the floor of the maintenance hole and in line with the conduit entrance. The pulling-in irons shall be placed and embedded during the construction of the maintenance hole wall.

14.) **e. Grounding in maintenance holes:** All new maintenance holes installed shall include ground rods and bonding ribbon. The ground rod and bonding ribbon may only be omitted when the following conditions apply:
(1) A maintenance hole has been designed and constructed with an integral ground system with all ironwork bonded together.
(2) The maintenance hole bears a visible manufacturer's label certifying that the structure contains an integral ground system.
(3) U.S. Government approval has been obtained.

All existing maintenance holes that require new splices, or those where existing splices are opened, shall be bonded and grounded. If no bonding ribbon and ground rod exist, they shall be installed, and all other existing splice cases shall be bonded and grounded. New cables installed in maintenance hole and conduit systems shall be bonded and grounded a minimum of every 1,000 feet (305 m). In accordance with RUS 1751F-802 and National Electrical Code, Article 250, the resistance for OSP grounding shall be nominally 25 ohms (Ω).

15.) **f. Ground Rod:** A ground rod of iron or steel that is galvanized or copper-clad and is a minimum of 5/8-in (16-mm) in diameter and a minimum of 9 feet (2.75 m) long shall be installed in the floor of each new maintenance hole. Four inches (100-mm) of the rod, plus or minus ½ inch, (1.3 mm) shall extend above the finished floor level. The rod shall not enter the maintenance hole more than 3 inches (80 mm) or less than 2 inches (50 mm) from the vertical surface of the adjacent wall. All maintenance hole splices shall be bonded to the maintenance hole ground. In existing maintenance holes, new ground rods and/or bonding ribbon shall be designed at each splice location if neither presently exists. The ground rod shall be installed and bonded IAW the National Electrical Code, Article 250.

16.) g. Bonding Ribbon: A bonding ribbon shall be installed in all new maintenance holes. The bonding ribbon shall be attached to all rack anchors and be pre-cast into the maintenance holes. The bonding ribbon shall be installed around the interior of each maintenance hole so that splice cases can be bonded to it.

17.) h. Hardware: A minimum of five cable racks, each containing at least 47 hook spaces mounted vertically, shall be provided on each long wall. Two of the cable racks shall be installed flush to the wall, and three shall be installed with standoffs to create splice bays. Refer to Figure C-4 (Figure C-11 for Europe). End wall maintenance hole racks shall be provided at the T-end of multi-directional maintenance holes. Corner racks shall be provided at the in-line end of the maintenance hole. Offset-cable racks shall set out from the wall a minimum of 3 inches (80 mm). Each cable rack shall be equipped with hooks to support all existing or new cables. If there are no existing/new cables, each rack shall be equipped with two cable hooks (minimum length 7½ inches, or 190 mm). All racks and hooks shall be of galvanized metal. A device or method to lock the hooks to the rack (i.e., Step Locks) shall be provided for the hooks that will support splice cases. Figure C-4 (Figure C-11 for Europe), Typical Maintenance Hole, shows a typical rack installation.

18.) i. Water Resistance: Reasonable efforts shall be made to prevent water from entering a telecommunications maintenance hole. The manufacturer's instructions for installing a maintenance hole shall be followed. As a minimum, the following guidance shall apply as long as it does not violate a manufacturer's recommendations or warranty. Additional requirements may be identified in the design package.
(1) A water-resistant gasket or seal shall be placed between the sections of pre-cast maintenance holes.
(2) Water-resistant gaskets or seals shall be placed between the lid frames, collars, and maintenance hole tops.
(3) The area around ducts penetrating the maintenance hole walls shall be sealed with a permanent, water-resistant material.
(4) Vacant ducts shall be sealed with a mechanical, screw-type, reusable duct plug.
(5) Ducts containing cables shall be sealed with water-blocking foam or another manufacturer-recommended sealant designed for this purpose.
(6) Ducts containing innerduct or multi-cell fabric mesh innerduct shall be sealed with the manufacturer's recommended materials or methods.

19.) 3.7.1.4 Duct Assignment and Cable Racking

Duct assignment and cable racking shall be engineered and installed IAW the Lucent Technologies Document 900-200-318, *Outside Plant Engineering Handbook*, Practices 632-305-215 and 919-240-300, and standard drawings, unless otherwise directed in the design package. Copper cables shall be racked to the maintenance hole sidewalls in such a manner so as to make the best use of the available wall space. When placing cables, care shall be taken to avoid blocking ducts in the sidewalls or access to splice cases. Fiber optic cables shall be engineered with a 20-foot (6-m) service loop installed in each pull-through maintenance hole or a 50-foot (15-m) splice loop installed on each side of a splice case. The service and splice slack shall be coiled and lightly secured in loops that do not violate the bending radius. The slack shall be placed in the maintenance hole in such a manner that the cables are out of the way and not wrapped around other cables or lying on the floor.

Main conduits entering poured-in-place or precast maintenance holes shall be located in the lower portion of the end wall and centered between end walls. Conduits entering side walls shall be

located a minimum of 4 inches (102 mm) from the end walls which are located farthest from the central office or serving node. Clearances of 12 inches (305 mm) shall be maintained between main conduit formations and the roofs or floors of maintenance holes. Unless the construction drawings indicate otherwise, wall recesses shall be provided at conduit entrances. Subsidiary conduits entering maintenance holes shall be located to provide clearances of 4 inches (102 mm) from roofs and adjacent walls.

20.) 3.7.1.5 Stenciling

All new maintenance holes shall be stenciled with a number designated by the NEC.

21.) 3.7.1.6 Depth of Cover

A minimum of 24 inches (600 mm) of top cover shall be provided above the top of the maintenance hole.

22.) 3.7.2 Hand Holes

Hand holes are reinforced concrete units provided with a lid that permits internal access to the housed components. Hand holes are typically used as pull points for small-diameter cables used for building access. A hand hole shall not be used in place of a maintenance hole in lateral runs or in a main conduit system. Hand holes shall not be used in runs of more than three 4-inch conduits. Hand holes shall not be used for splicing cables without prior U.S. Government approval. Telecommunications hand holes shall not be shared with electrical installations. The acceptable hand hole size is 4 feet x 4 feet x 4 feet (1.2 m x 1.2 m x 1.2.m). Hand holes installed where vehicular traffic may be present shall be load-rated as H-20 and shall be equipped with round maintenance hole lids.

23.) 3.7.2.1 Accessories

Each new hand hole shall be equipped with a lid, pull irons, cable racks, and hooks designed for use in telecommunications systems. Cable hooks shall be placed to support the weight of the cable.

24.) 3.7.2.2 Stencil

All new hand holes shall be stenciled with a number designated by the NEC.

25.) 3.7.3 Cable Vault

A schematic of an MDF and cable vault is provided in Figure C-8 (Figure C-15 for Europe), MDF and Cable Vault Schematic.

26.) 3.7.3.1 Size

The cable vault shall be sized to provide for future projected growth. As a minimum, it shall extend the entire length of the MDF.

27.) 3.7.3.2 Layout

A center rack shall be provided for splicing the tip cables to the OSP cables. However, wall racking, if cited in the design package, is permissible for small to medium central offices. The vault shall be designed to allow ample space for splicing of the cables. For planning, a typical vault splice is 1 foot x 3 feet (300 m x 900 m).

3.7.4 Conduit/Duct

Underground conduit structures consist of pathways for the placement of telecommunications cable between points of access. Underground installation of ducts/conduits shall be achieved by trenching, boring, or plowing.

28.) a. Examples of conduit types include the following:

Encased Buried (EB)-20 – for encasement in concrete (shall meet NEMA Standard TC-6)

EB-35 – for encasement in concrete (shall meet NEMA Standard TC-8)

DB-100 – for direct burial or encasement in concrete

DB-120 – for direct burial or encasement in concrete (shall meet NEMA Standard TC-8)

Rigid Nonmetallic Conduit Schedule 40 – for direct burial or encasement in concrete (shall meet NEMA Standard TC-2)

Rigid Nonmetallic Conduit Schedule 80 – for direct burial or encasement in concrete (shall meet NEMA Standard TC-2)

Multiple Plastic Duct (MPD) – for direct burial or installation in conduit

Rigid Metallic Conduit – for direct burial or encasement in concrete

Intermediate Metallic Conduit – for direct burial or encasement in concrete

Fiberglass Duct – for direct burial or encasement in concrete

Innerduct PE – for direct burial or installation in conduit

Innerduct PVC – for direct burial or installation in conduit

High Density Polyethylene (HDPE) – for directional drilling

29.) **b.** Nonmetallic conduits shall be encased in concrete of minimum 3,000 lb/in^2 (20,700 kPa) compressive strength where vehicular traffic (i.e., automotive, railway) is above the pathway or where a bend or sweep is placed.

30.) **c.** Spacers shall be used to properly support ducts that are to be concrete-encased and shall be installed IAW the manufacturer's specifications. If the manufacturer's specifications are unknown, a spacer shall be installed a minimum of one spacer every 10 feet (3 m). Ducts supplied in 20-foot (6.1-m) lengths require spacers every 5 feet (1.5 m). The duct shall not be damaged, cracked, or crushed prior to or during installation. Conduit systems not encased in concrete shall be installed in layers with backfill installed around and between the ducts. To provide integrity of orientation, spacers shall be used where conduits are not encased in concrete. Construction vehicles shall not be driven over DB conduits.

31.) **d.** Ensure the integrity of the orientation of the duct bank between maintenance holes. Do not allow the ducts to twist or tangle between maintenance holes.

32.) **e.** Ducts that are classified as stub-outs shall be plugged inside the maintenance hole or building; tagged, identifying them as stub-outs; and capped on the far end to prevent soil and water from entering the duct. A locator ball may be placed at the stub-out location to facilitate future locating of the stub-out.

33.) **f.** The duct system shall be concrete-encased in all main cantonment areas unless otherwise specified in the EDP/PWS. At a minimum, the duct system shall be encased where any bend/sweep exceeds 10 degrees in any direction; in any stream/drainage area subject to washing out; and in major construction zones. Ducts placed under paved road surfaces and certain heavy traffic, non-surfaced roads shall be protected by one of the following methods: Concrete-encased duct, galvanized RSC, steel pipe casings, or directional boring of HDPE ducts (when done IAW Paragraph 3.6.9).

34.) **3.7.4.2 Joints and Connectors**

Ducts shall be joined in such a manner as to be soil tight. Joints shall form a sufficiently smooth interior surface between joining sections so that cables shall not be damaged when pulled past the joint. Joints between dissimilar types of ducts (PVC, HDPE, galvanized steel pipe (GSP), EB, DB, etc.) shall use the appropriate connectors designed for the purpose of providing a seal between the ducts and preventing damage to cables pulled through these joints. All joint surfaces shall be

prepared IAW the manufacturer's instructions, and, at a minimum, the mating surfaces shall be wiped clean before they are joined.

35.) 3.7.4.3 Bends and Sweeps

Accomplish changes in the direction of runs exceeding a total of 10 degrees, either vertically or horizontally, by long sweeping bends having a minimum radius of 20 feet (6.1 m). Long sweeps may be made up of one or more curved or straight sections and/or combinations thereof. Bends made manually shall not reduce the internal diameter of the conduit. There shall be no more than the equivalent of two 90-degree bends (180 degrees total) between pull points, including offsets and kicks with a curvature radius of less than 100 feet (30 m). Back-to-back 90-degree bends shall be avoided. The following definitions apply:

a. 90-degree bend: Any radius bend in a piece of pipe that changes the direction of the pipe by 90 degrees.
b. Kick: A bend in a piece of pipe, usually less than 45 degrees, made to change the direction of the pipe.
c. Offset: Two bends usually having the same degree of bend, made to avoid an obstruction blocking the run of the pipe.
d. 90-degree sweep: A bend that exceeds the manufacturer's standard size 90-degree bend (e.g., 24 inches (600 mm) is standard for 4-inch (100-mm) conduit).
e. Back-to-back 90-degree bend: Any two 90-degree bends placed closer together than 10 feet (3 m) in a conduit run.

Utilize radius-manufactured bends to the maximum extent possible. Manufactured bends may be used on subsidiary/lateral conduits at the riser pole or building entrance. Manufactured bends shall have a minimum radius of 10 times the internal diameter of the conduit IAW Chapter 9 of the National Electrical Code and the ANSI/TIA/EIA-758 standard.

Bends and sweeps shall be concrete-encased to protect the duct from the pressures developed while pulling cables. Where a duct enters a building and sweeps up through a floor slab, galvanized RSC shall be used. For ducts transitioning from the lower duct window of a maintenance hole to the nominal trench depth, the transition shall be accomplished in no less than 30 linear feet (9.1 m) from the maintenance hole in order to reduce the radius of the bends. The duct shall be concrete-encased in the transition area.

36.) 3.7.4.4 Section Lengths

Without prior U.S. Government approval, the section length of conduit shall not exceed 600 feet (183 m) between pulling points in main conduit runs. The section length of duct is limited mainly by the size of the cable to be pulled into it and by the number of bends it shall contain. Table 3 lists the maximum section lengths.

3.7.4.6 Duct Installation Guidelines

37.) a. Depth of cover: At least 24 inches (600 mm) of cover are required above the top of the duct bank. At least 18 inches (457 mm) of cover are required under roads or sidewalks (if duct is concrete-encased). For ducts installed in solid rock, the cover shall consist of at least 150 mm (6 inches) of concrete. If rock is encountered below grade, the minimum cover above the concrete-encased duct shall be 12 inches (300 mm). Refer to Figure C-3 (Figure C-10 for Europe), Conduit Placement/Cut and Resurface, for details. The cover or fill shall be compacted IAW UFGS-02300.

38.) **b. Trench width:** The installer shall engineer the trench width to the minimum width required to support the size of the duct bank being installed. When installing ducts, the trench width depends on the number of ducts, size of ducts, arrangement of ducts, and space around ducts (at least 2 inches [50 mm]). Additional width may be required to work in deep trenches or with large-count duct banks. Shoring of walls or sloping shall be performed as required by the OSHA and/or local requirements. The trench width for DB conduit shall be of sufficient width to permit tamping of dirt on the sides of the conduit formation. Refer to Figure C-3 (Figure C-10 for Europe), Conduit Placement/Cut and Resurface, for details.

39.) **c. Concrete encasement:** In new construction (BRAC/MCA), the duct system shall be concrete-encased in all main cantonment areas. At a minimum, the duct system shall be encased under all traffic areas; where any bend/sweep exceeds 10 degrees in any direction; in any stream/drainage area subject to washing out; and in major construction zones. Concrete encasement of the ducts for a "core path" shall be required where no alternate paths are present. Concrete-encased duct, galvanized RSC, pipe casings, or HDPE duct placed by horizontal directional drilling (HDD) shall also be placed under all paved road surfaces and certain heavy traffic non-surfaced roads as documented in the design package. Concrete forms shall be utilized when encasing ducts into a maintenance hole to limit blockage of empty duct knock-outs or windows in the maintenance hole. The encasement/pipe shall be extended a minimum of 6 feet (1.8 m) beyond the roadbed for all road crossings. The installer shall use only one brand of Portland cement that conforms to American Society for Testing and Materials (ASTM) C 150. The concrete shall be a wet type mix and shall be placed in such a manner as to ensure the concrete completely surrounds all ducts and that no air or voids are trapped in the mix. (A dry bag of ready-mix type cement that has not been mixed with water but has been dumped in the trench is not acceptable.) Prior to pouring any concrete over the duct, the installer shall obtain the signature of the on-site U.S. Government QC/QA representative to signify the acceptability of the duct placement and spacing. Concrete used to encase conduits shall be a minimum compressive strength of 20,700 kPa (3,000 PSI).

40.) **d. Duct placement:** New ducts shall be swept down and installed in the lowest available duct positions within the lowest available duct window in the maintenance hole. Additional ducts required in the future shall be placed on top of the existing ducts. Ducts placed under this project shall not prevent placement of future ducts in the upper duct positions. Conduits shall terminate in bell ends or duct terminators at the point of entrance into the maintenance holes and buildings. Main conduits entering poured-in-place or precast maintenance holes shall be located in the lower portion of the end wall and centered between end walls. Conduits entering side walls shall be located a minimum of 4 inches (102 mm) from the end walls that are located farthest from the central office or serving node. Clearances of 12 inches (305 mm) should be maintained between main conduit formations and the roofs or floors of maintenance holes. Unless the construction drawings indicate otherwise, wall recesses shall be provided at conduit entrances. Subsidiary conduits entering maintenance holes shall be located to provide clearances of 4 inches (102 mm) from roofs and adjacent walls.

41.) **e. Rerouting of existing ducts:** Existing ducts shall be joined to new maintenance holes (pre-cast or cast-in-place) by rerouting the designated ducts from the demolished or abandoned maintenance hole to the new maintenance hole. Rerouting shall begin a sufficient distance from the old maintenance hole, at least 30 feet, to allow for standard bending radius and pulling tension. Continuity of operations on the affected cables shall be maintained during the duct rerouting actions.

42.) **f. Reinforcement of existing ducts:** New ducts installed to reinforce an existing duct bank shall be placed above the existing duct bank if the minimum top cover of 24 inches (600 mm)

can be maintained. If sufficient top cover is not available, the new duct shall be placed beside the existing duct bank.

43.) **g. Pull string/rope/tape:** After ducts are mandrelled to verify their integrity, a pull string, pull rope, or pull tape rated at not less that 200-lbs (890-newton (N)) tensile strength shall be installed in each new conduit and innerduct/sub-duct. A minimum of 5 feet (1.5 m) shall be provided at each end of the conduit. The string/rope/tape shall be coiled and secured at each end in such a manner as to prevent it from being accidentally pulled back into the duct.

44.) **h. Plugs:** All ducts, sub-ducts, and, innerducts, whether main or subsidiary runs, shall be plugged using universal duct plugs in maintenance holes, hand holes, and building entrances. Foam sealant is not acceptable in a building. Outdoor-rated ducts (sub-ducts, etc) entering a building will be fire-stopped IAW the National Electrical Code, local codes, and the manufacturer's instructions.

45.) **i. Duct seals:** The area between the entrance conduits and the penetrated floors and/or walls of a building or maintenance hole shall be sealed to be waterproof or shall be fire-stopped as appropriate. Use of hydraulic cement between the duct and wall is acceptable for waterproofing the duct entry point.

46.) **j. Toneable duct:** In a new duct bank containing only FOC, one duct shall contain an imbedded or installed toneable metallic wire for duct locates.

47.) **k. Duct tie-downs:** Duct systems to be concrete-encased shall be tied down to minimize, if not totally eliminate, movement of the duct system during the placement of concrete. All sections of conduit systems to be concrete-encased shall be tied down using an industry-recognized method such as metal rods (for stakes) and metal strapping (for securing the duct system). The metal strapping shall be wrapped completely around the conduit structure and securely attached to the metal rods. The metal rods shall be a minimum of ¼-inch thick. Rods will be driven into the ground a minimum depth of 12 inches depending on soil density. For example, clay would require the minimum depth; whereas, sandy soil shall be at an increased depth. The ducts shall be tied down every 10 feet or closer.

48.) **3.7.7.1 Rod Duct**

Rodding a duct entails inserting or pushing a rod into the duct to:

- Determine the length of the duct.
- Locate the other end of the duct.
- Determine if the duct is usable or blocked.
- Insert a pull string in the duct.

49.) **3.7.7.2 Mandrelling**

Mandrelling a duct consists of pulling a test mandrel or slug through the duct to ensure that the duct diameter is intact and ready for the installation of cables. Mandrelling can also be used to clean any mud, sand, or dirt out of the duct. The mandrel's diameter, 1/2-inch (13-mm) less than the duct's inside diameter, depends on the type and size of the duct. New ducts in main and subsidiary duct runs shall be mandrelled with a test mandrel (non-flexible) or slug with an approximate length of 12 inches (300 mm) and a diameter that is ½ inch (13 mm) less than the duct's inside diameter. The test mandrel shall be used to verify the integrity of the duct joints, to test for out-of-round duct, and to verify that sweeps are not so severe as to preclude the placement of large-diameter cables. The 12-inch (300-mm) test mandrel shall not pass through ducts with 90-degree sweeps. A 6-inch (150-mm) length test mandrel may be used to test duct runs to buildings or riser poles. Flexible mandrels, wire brushes, rubber duct swabs, leather washer duct cleaners, etc., may be used to clean the ducts.

Sample mandrel sizes are as follows:

- DB120 = 3.75 in mandrel based on a 4.24 in ID
- SCH40 = 3.50 in mandrel based on a 3.99 in ID

50.) 3.7.8 Sub-duct/Innerduct/Multi-duct/Fabric-mesh Innerduct

Innerduct, sub-duct, multi-duct, or fabric-mesh innerduct is typically a nonmetallic pathway and may be placed within or in place of a duct to subdivide the space and facilitate initial and subsequent placement of multiple cables in a single duct space. All subdivided spaces shall have a pull rope or pull tape installed. The PVC sub-ducts that do not have cables installed shall be plugged with a duct plug. A minimum of one out of every four new ducts shall be subdivided with innerduct, sub-duct, multi-duct, or fabric-mesh innerduct. For projects with fiber optic cables only, a minimum of two out of every four new ducts shall be subdivided with innerduct, sub-duct, multi-duct, or fabric-mesh innerduct.

3.7.8.1 Sub-duct

Sub-duct shall provide the equivalent of four each 1¼-in (32-mm) diameter (minimum) conduits in the space that is normally occupied by a 4-inch (100-mm) conduit. The sub-ducts shall be held in relation to each other with spacers.

3.7.8.2 Multi-duct

Multi-ducts are pre-manufactured duct systems that are equipped with four, fully-integrated 1.19-inch (30-mm) (minimum) sub-ducts.

3.7.8.3 Innerduct

Innerducts are smaller diameter ducts, typically 1-inch (25-mm) diameter (minimum), that are placed inside existing ducts. The innerduct shall consist of a minimum of three each, 1-inch (25-mm) PE ducts installed inside a single, 4-inch (100-mm) duct. Innerducts shall be used in existing conduit systems, in RSCs, or in split RSCs. Rigid-type innerducts with pull strings shall be provided.

3.7.8.4 Fabric-mesh Innerduct

Fabric-mesh innerducts are made of a stiff, fabric-mesh cloth, folded and sewn in such a way as to create individual cells through which a cable may be installed without entangling cables in other cells. Fabric-mesh innerducts may be used as approved by the U.S. Government and shall be limited to a maximum of three cells per tape, unless otherwise approved by the U.S. Government. The preferred fabric-mesh size is 3-inch cells by three cells. Any deviation requires prior Government approval. Smaller-sized cells shall not be used in standard OSP designs. The size and number of cells shall not exceed the manufacturer's recommendation. The preferred configuration is two, three-cell tapes per conduit. The designer may specify up to three, three-cell tapes per conduit. Multi-cell fabric mesh shall have an uninterrupted, shared, sewn spine to prevent twisting. The multi-cell fabric mesh shall be cut off in each hole, leaving a minimum of 2 feet of slack in the material and a minimum of 5 feet of pull string that will be attached to a permanent part of the maintenance hole structure, such as tied to the pulling irons. Conduit formations shall not be undersized based on the increased modularity of the fabric-mesh innerduct. Fiber optic cables shall not be "home run" from buildings to serving nodes because of the increased modularity of fabric type innerducts. Fabric-mesh innerduct is available with tracer wire which eliminates the need to install locator wire in empty conduit banks or conduit banks containing dielectric cables only.

3.9 Crossing Obstructions

51.) 3.9.1 Pavement Crossing

Cut and resurface is the preferred method to be used when crossing any paved area. Push/bore and/or horizontal directional drilling shall be used for special circumstances only as specified in the design package. The preferred method of cut and resurface is the "T" cut. That is, the outer edge of the cut of the road surface is to extend six inches beyond the edge of the trench on both sides. Refer to Figure C-3 (Figure C-10 for Europe), Conduit Placement/Cut and Resurface, for placement details.

3.10 Aerial Cable

Supporting documentation for aerial placement is available in RUS Bulletins 1751F-630 and 1751F-635. Aerial cable runs shall be used only with U.S. Government approval in extenuating circumstances or for long runs outside of the cantonment area, as specified in the design package.

52.) 3.10.1 Messenger Strand

The smallest messenger strand used for all new installations shall be 6.6 m. A 2.2-m strand shall be used only as an extension of existing 2.2-m strands. Fiber optic cable shall be installed on its own messenger. Copper and fiber cables shall not be lashed on the same messenger without U.S. Government approval. Figure 8 cable may be used; however, no additional cable shall be lashed to it.

53.) 3.10.2 Guys and Anchors

Place new guys and/or anchors for each new messenger strand at each applicable location (cable turns, wind loading, cable ends, etc.). The down guy shall be sized to the next larger strand.

3.15 General Cable Specifications

54.) 3.15.2 Cable ID/Cable Tags

Cable ID/cable tags shall be installed at all termination points (terminals) and splices, including house cables. In maintenance holes, all new and existing cables that are part of the project shall be tagged/retagged between the splice and the wall and on both sides of a splice loop or maintenance loop. When a cable is re-homed to a new node, DCO, cross-connect box, etc., all existing cable tags and terminal labels on the re-homed cable shall be re-tagged and re-labeled to reflect the new information. One tag is required for a copper cable pull-through, and two tags are required for an FOC pull-through. Labels in maintenance holes and hand holes shall be machine- produced on a durable material suitable for the environment. Handwritten labels are not acceptable.

55.) 3.15.3.3 Splices

a. Copper and FOC splicing shall be performed IAW RUS Bulletin 1735F-401, *Standards for Splicing Copper and Fiber Optic Cable*, February 1995.
b. Cable shall be spliced into one continuous length. All copper splices shall be of the fold-back type to facilitate future work in the splice. Fiber optic cable shall contain splice loops in trays IAW the manufacturer's recommendations.
c. Completed splices shall meet similar performance and mechanical specifications of a single cable of the same overall length.
d. Self-piercing, electrical, filled connectors shall be used when plastic-insulated conductors are spliced. The installer shall place and install connectors using a tool specifically designed to place

those particular connectors. In North America, a 25-pair splicing module, 3M-type MS2 or equal shall be used. The same modules shall be used throughout the project and shall be consistent with previously-installed connectors to preclude a requirement for a variety of installation tools. B-wire connectors shall not be used. In Europe, a 10-pair splicing module system is used.
e. Binder group integrity shall be maintained.
f. All dead pairs in a copper cable shall be spliced through if the size of the continuing cable shall allow a clear and cap at the end. Only UL-listed material shall be used for capping cable pairs.
g. All underground and buried splice cases shall use encapsulant-fillable closures and shall be filled with encapsulant upon completion of the splice IAW RUS Bulletin 345-72 (PE-74). To ensure sheath continuity, cable sheaths at all cable splices shall be bonded with bonding harnesses.
h. Splice cases shall not be installed in such a manner that their weight is supported by the cables on the cable hooks in the maintenance hole. The use of non-encapsulated, re-enterable splice cases (for both copper and FOC) that are suitable for environmentally-sealed telephone splices in the aerial or underground non-pressurized network are acceptable for non-DB locations. The preferred method for installing splice cases is to hang them from an overhead support, such as a pipe supported by the set of cable hooks above the splice case.

3.17 Building Terminations

56.) 3.17.2 Terminals and Hardware

Terminals and hardware shall be UL-listed and shall be made of a flame-retardant construction and equipped with a built-in splice chamber; 5-pin gas protector modules; locking cover; and output on 110 blocks or RJ21 connectors. The PET for European projects will be equipped with protected, line-sharing adapter plus (LSA+) terminal blocks. All PETs shall be connected to the lightning protection grounding system for the building.

57.) 3.17.3.2 Fiber Terminations

All terminations shall be made using subscriber connector (SC) or straight tip (ST) connectors (ST™-compatible) or as defined in the SOR/PWS. Per the ANSI, duplex SC is the recommended connector for OSP cable terminations. Use of the Physical Contact (PC) family of connectors may be required based on the performance requirements of the network or system to be installed, the interface of the terminal electronics, or planned upgrades to the system or network. Physical Contact connectors are also referred to as Polished Connectors. The PC family of connectors includes Ultra PC (UPC), Super PC (SPC), and Angle PC (APC). These connectors shall typically be used to support systems with 10-Gb or higher connection rates. All OSP fibers shall be fusion-spliced to factory-produced pigtails.

3.18 Grounding

58.) 3.18.1 Building Ground

The building EES forms the primary electrical, life-safety grounding system. Typically, a grounding electrode conductor connects the main building-grounding electrode to the main electrical entrance panel or cabinet. Article 250, Section III of NFPA 70 provides guidance on the grounding electrode system and conductor. The EUBs and ADNs shall have a resistance-to-earth of 10 ohms or less, following MIL-STD-188-124-B. The switch manufacturers may specify the resistance-to-earth as 5 ohms or less for a telephone switch or DCO. The designer shall be conscious of the proposed

utilization of the facility and shall plan accordingly. Sites shall provide proper supporting documentation and specifications to the designer to support any resistance-to-ground requirements that are more stringent than those of NFPA 70 or MIL-STD-188-124-B for non-voice switch buildings. Proper documentation includes international, national, or local codes; DOD and DA standards; and/or manufacturers' equipment specifications.

59.) 3.18.2 Cable Entrance Grounding

All metallic shields and strength members for OSP cable entering a building shall be connected to the lightning protection ground system. The designer shall ensure that the lightning protection is IAW MIL-STD-188-124-B and NFPA 780, *Standard for the Installation of Lightning Protection Systems*, most recent issue.

60.) 3.18.2.4 Copper Protector Block

All OSP copper cables shall be terminated on primary protector blocks equipped with 5-pin solid state or gas protector modules. The protector blocks shall be bonded to the lightning protection ground with a No. 6 AWG or larger copper ground wire. Terminals and hardware shall be UL-listed, made of a flame-retardant construction, and equipped with a built-in splice chamber; 5-pin gas protector modules; locking cover; and output on 110 blocks, or RJ21 connectors. The PET for European projects will be equipped with protected, LSA+ terminal blocks. All PETs shall be connected to the lightning protection grounding system for the building. The protector block shall be placed as close to the lightning protection ground as possible.

3.19 Final Acceptance Test

61.) 3.19.1 Telecommunications Cable Plant (Copper)

Testing will consist of, but will not be limited to, the following cable tests:

- Insulation resistance.
- Shorts/crosses.
- Grounds.
- Opens.
- Reversals.
- Splits.
- Transpositions.
- Shield continuity.
- Loop resistance.
- Insertion loss (performed only when specified).
- Capacitance.

62.) 3.19.2 Fiber Optic Cable

Testing will consist of Optical Time Domain Reflectometer (OTDR) measurements for one strand in each 12-strand bundle of fiber, and Power Source/Power Meter tests on every strand in all cables. Each strand of fiber cable not terminated at each end will be tested with the OTDR. While using the OTDR, measure the length of the strand and look for any circuit discontinuities and/or splice points. Run a strip chart for each fiber strand tested, and record the cable ID, strand ID, source location,

meter location, and dB loss at each specified nm wavelength and fiber length, and note whether the strand passed or failed the test. The following tests will also be included as a minimum:

Attenuation.

Bandwidth.

Power Source/Power Meter: This test will consist of bi-directional, dual-window (1,300/1,550 nm) testing of every fiber strand installed.

Final OSP QA Inspection Signoff

PROJECT LOCATION:	**DATE:**
BUILDING #	**ROOM #**
PROJECT NUMBER:	**CONTRACTOR:**
PROJECT MANAGER:	**ISEC QA Inspector:**

OUTSIDE PLANT Inspection Checklist

TYPE OF INSPECTION:

	Quality Item	Reference	Yes No N/A	Date Inspected	Date Corrected
Trenching / General Considerations					
1	Cuts and Resurfaces	I3A 3.5.6			
2	Backfilling	I3A 3.5.8			
3	Restoration	I3A 3.5.9			
Detection of Buried Cables and Underground Cables					
4	Warning Tape	I3A 3.5.10.1			
5	Permanent Tracer Wire	I3A 3.5.10.4			
Outside Plant Cable Placement Options					
6	Transition of conduits into buildings	I3A 3.6.1.4			
Maintenance Holes					
7	Gravel Base	I3A 3.7.1			
8	Type	I3A 3.7.1.1			
9	Basic Layout / Spacing	I3A 3.7.1.2			
Maintenance Holes / Accessories					
10	Maintenance Hole Lids	I3A 3.7.1.3 [a]			
11	Locking Covers	I3A 3.7.1.3 [b]			
12	Sump	I3A 3.7.1.3 [c]			
13	Pulling In Irons	I3A 3.7.1.3 [d]			
14	Grounding in Maintenance Holes	I3A 3.7.1.3 [e]			
15	Ground Rod	I3A 3.7.1.3 [f]			
16	Bonding Ribbon	I3A 3.7.1.3 [g]			
17	Hardware	I3A 3.7.1.3 [h]			
18	Water Resistance	I3A 3.7.1.3 [i]			
19	Duct Assignment and Cable Racking	I3A 3.7.1.4			
20	Stenciling	I3A 3.7.1.5			
21	Depth of Cover	I3A 3.7.1.6			
Hand Holes					
22	Type	I3A 3.7.2			
23	Accessories	I3A 3.7.2.1			
24	Stenciling	I3A 3.7.2.2			
Cable Vault					
25	Type	I3A 3.7.3			
26	Size	I3A 3.7.3.1			
27	Layout	I3A 3.7.3.2			

OUTSIDE PLANT Inspection Checklist

QUALITY ITEM#		Reference	Yes No N/A	Date Inspected	Date Corrected
Conduit / Duct					
28	Conduit Type	I3A 3.7.4 [a]			
29	Non-metallic encased in concrete	I3A 3.7.4 [b]			
30	Conduit Spacers	I3A 3.7.4 [c]			
31	Integrity of Orientation	I3A 3.7.4 [d]			
32	Stub-outs	I3A 3.7.4 [e]			
33	Duct system concrete encased	I3A 3.7.4 [f]			
34	Joints and Connectors	I3A 3.7.4.2			
35	Bends and sweeps	I3A 3.7.4.3			
36	Section Lengths	I3A 3.7.4.4			
Duct Installation Guidelines					
37	Depth of Cover	I3A 3.7.4.6 [a]			
38	Trench Width	I3A 3.7.4.6 [b]			
39	Concrete Encasement	I3A 3.7.4.6 [c]			
40	Duct Placement	I3A 3.7.4.6 [d]			
41	Rerouting of existing ducts	I3A 3.7.4.6 [e]			
42	Reinforcement of existing ducts	I3A 3.7.4.6 [f]			
43	Pull string/rope/tape	I3A 3.7.4.6 [g]			
44	Plugs	I3A 3.7.4.6 [h]			
45	Duct Seals	I3A 3.7.4.6 [i]			
46	Toneable duct	I3A 3.7.4.6 [j]			
47	Duct tie-downs	I3A 3.7.4.6 [k]			
48	Rod duct	I3A 3.7.7.1			
49	Mandrelling	I3A 3.7.7.2			
50	Inner-ducts	I3A 3.7.8.1 - 3.7.8.4			
Crossing Obstructions					
51	Pavement Crossings	I3A 3.9.1			
Aerial Cable					
52	Messenger strand	I3A 3.10.1			
53	Guys and Anchors	I3A 3.10.2			
General Cable Specifications					
54	Cable ID / Cable Tags	I3A 3.15.2			
55	Copper Splices	I3A 3.15.3.3			
Building Terminations					
56	PET / Terminals and Hardware	I3A 3.17.2			
57	Fiber Optic Terminations	I3A 3.17.3.2			
Grounding					
58	Building Ground	I3A 3.18.1			
59	Cable Entrance Grounding	I3A 3.18.2			
60	Copper Protector Block	I3A 3.18.2.4			
Final Acceptance Tests					
61	OSP Copper Cable (Count:)	I3A 3.19.1			
62	OSP Fiber Optic Cable (Count:)	I3A 3.19.2			

COMMENTS:

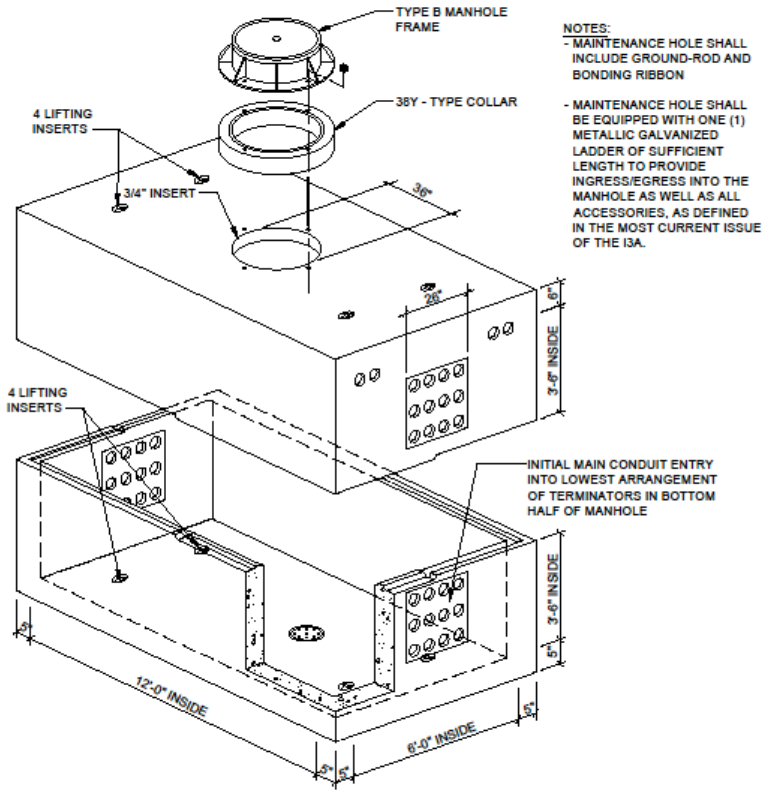
Quality Items not Listed Above:

COMMUNICATIONS MAINTENANCE HOLES

Ft. Sam Houston Requirements

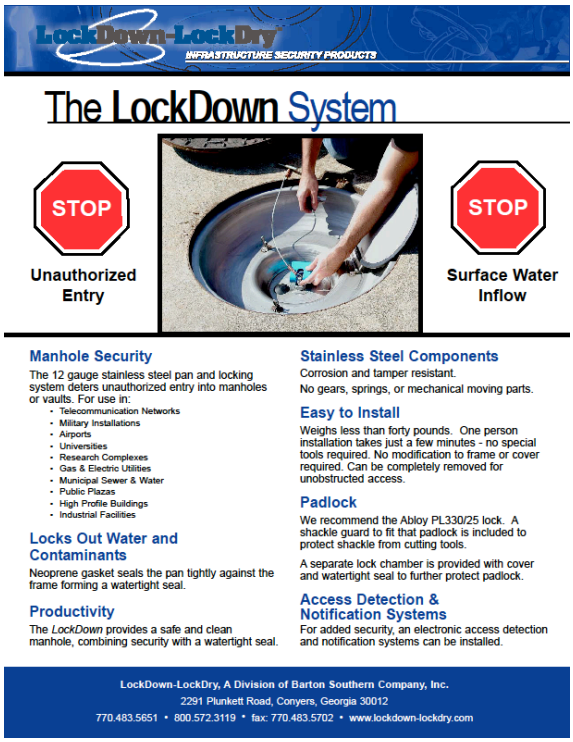
Revised 04-01-2010

- Maintenance holes shall be communications specific and conform to the most current issue of the I3A criteria.
- The size of the maintenance hole shall be 12’X6’X7’ (interior dimensions).
- Maintenance holes shall be equipped with pre-cast plastic terminators.
    - The main terminators shall be oriented in the bottom half of the maintenance hole and center aligned. See attached sketch.
    - The secondary terminators shall be oriented in the upper half of the maintenance hole and center aligned. See attached sketch.
    - Break-out terminators shall be located on end walls only and be spaced 4” from the closest interior side wall and 4” from the top interior ceiling.



- Main conduit entrances shall be non-splayed configuration.

- The collar and cover shall be located in the center of the top half of the maintenance hole and the maintenance hole shall have a minimum of 24” cover above the roof.
- All maintenance holes shall be provided with a galvanized steel ladder of sufficient length for ingress/egress capabilities.
- If the specific job dictates that the maintenance hole neck must be extended with additional collars, then galvanized steel collar steps/rungs must be installed
- All new maintenance holes installed shall be equipped with a locking cover. The approved locking cover for Ft. Sam Houston and Camp Bullis is the *LockDown-LockDry Security System*, or equivalent or better with prior Net work Enterprise Center (NEC) approval. See the enclosed attachment.
- All new maintenance holes shall have the assigned MH hole number stenciled in the collar/neck of the maintenance hole.
- On all maintenance holes (new and existing) all auxiliary lateral conduit entrances shall be accomplished from the end walls only. Side wall penetrations shall only be allowed with NEC approval prior to execution.
- All vacant conduits and inner-ducts shall be plugged with expandable duct plugs, both at the building location and the serving maintenance hole location. Tapered plugs (Flower-pots) are not acceptable.
- Fiber optic duct plugs shall be installed on all fiber optic cables placed and contained within inner-duct. Any void between the duct/inner-duct/cable shall be filled with an acceptable water blocking compound. Expandable foam compound is not allowed inside buildings.
- The contractor will be responsible for sealing all conduits/ducts/inner-ducts utilized during the placement of facilities for the assigned project.

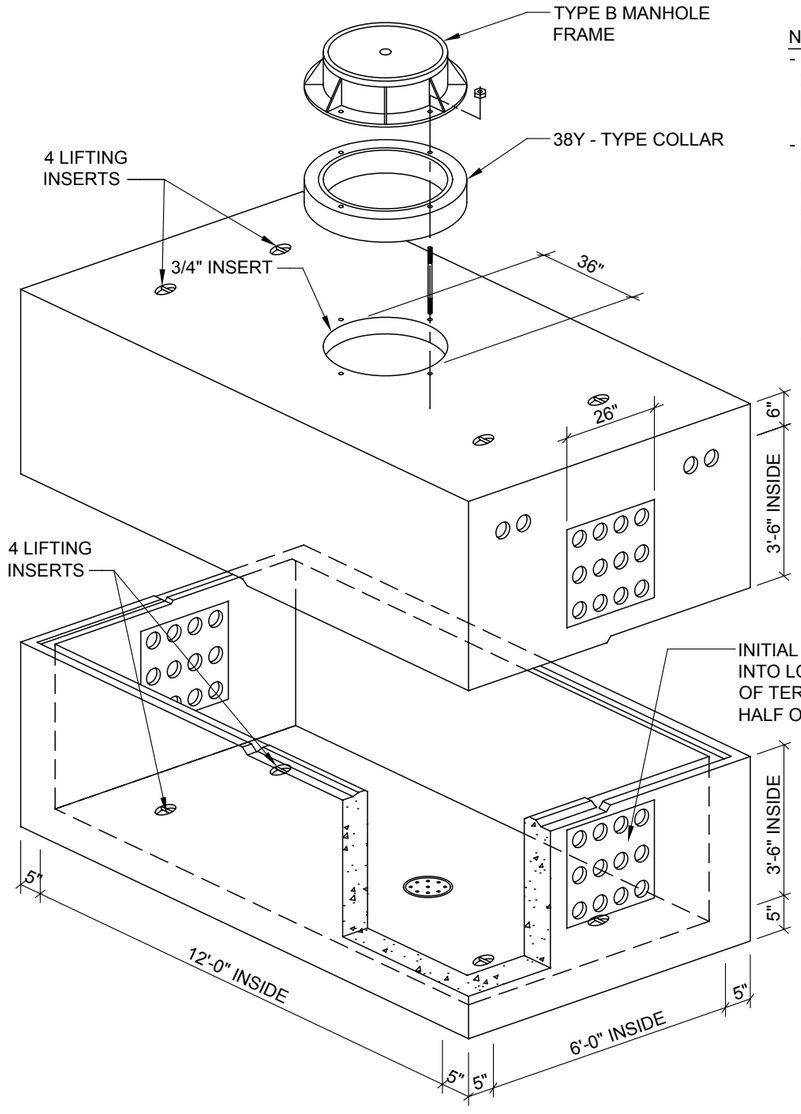


- Maintenance hole bonding and grounding
  - All maintenance holes shall be equipped with a ground rod of iron or steel that is galvanized or copper clad at least 5/8 inch in diameter and 9 feet in length. The

ground rod shall be installed through the floor of the maintenance hole between 2-3 inches from the vertical surface of the adjacent wall. Four inches of the rod, plus or minus ½ inch, shall extend above the maintenance hole floor.

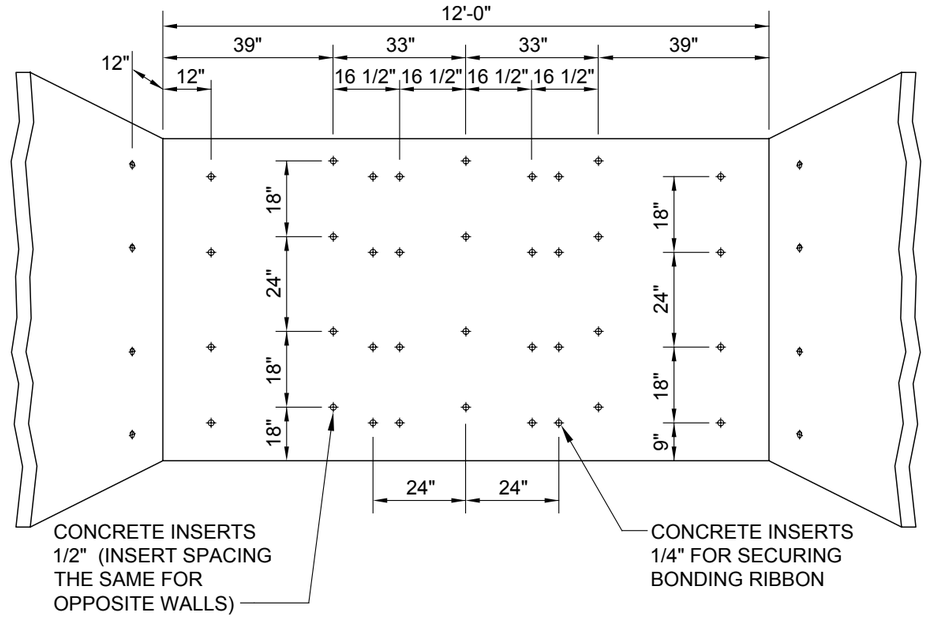
- The bonding ribbon shall be attached to all rack anchors and be pre-cast into the maintenance hole. The bonding ribbon shall be installed around the interior of the maintenance hole to provide bonding capabilities for splice cases.
- Bonding ribbon shall be flat tinned copper material, similar to the type that is pre-cast into the maintenance hole.

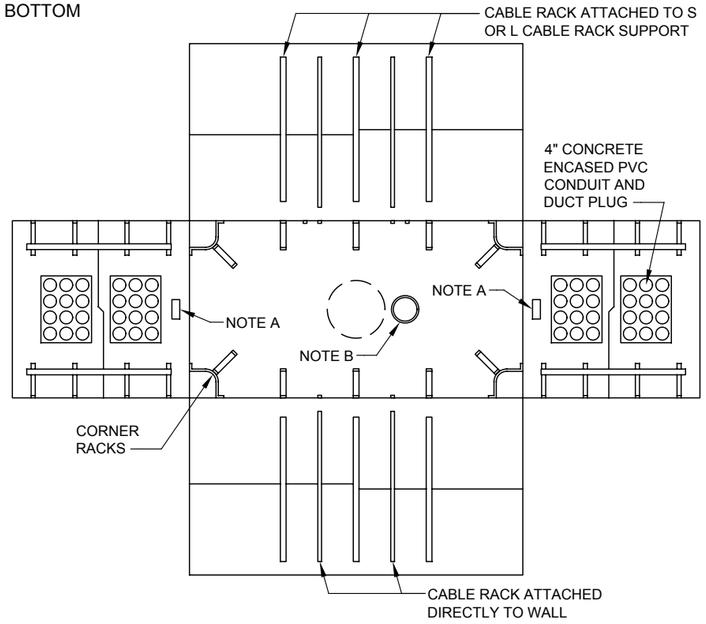
Note: Additional guidance is available in the most current issue of the I3A Guidelines.

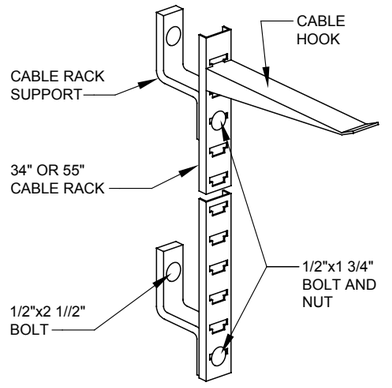


NOTES:
- MAINTENANCE HOLE SHALL INCLUDE GROUND-ROD AND BONDING RIBBON

- MAINTENANCE HOLE SHALL BE EQUIPPED WITH ONE (1) METALLIC GALVANIZED LADDER OF SUFFICIENT LENGTH TO PROVIDE INGRESS/EGRESS INTO THE MANHOLE AS WELL AS ALL ACCESSORIES, AS DEFINED IN THE MOST CURRENT ISSUE OF THE I3A.







NOTES:

A - PULLING IRONS PRE-CAST IN END WALLS OPPOSITE EACH MAIN CONDUIT ENTRANCE, IN LINE WITH CENTER OF CONDUITS, 3 1/2" - 9" FROM THE FLOOR OF THE MANHOLE

B - SUMP: 13" DIAMETER, 4" DEEP W/ PERFORATED PLATE FASTENED TO HOUSING W/ CHAIN OR HINGE

FT. SAM HOUSTON

NEC Network Enterprise Center

FORT SAM HOUSTON

MAINTENANCE HOLE DETAIL

SAN ANTONIO, TEXAS

DRAWN BY: M.E.

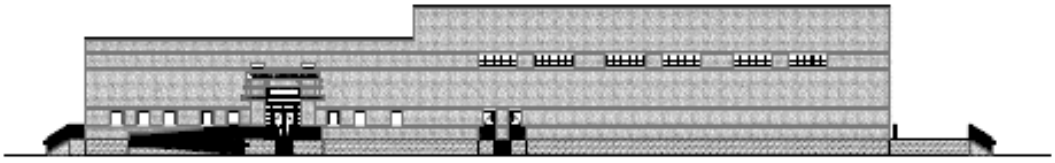
DATE ISSUED: 4-14-10

REVISIONS:

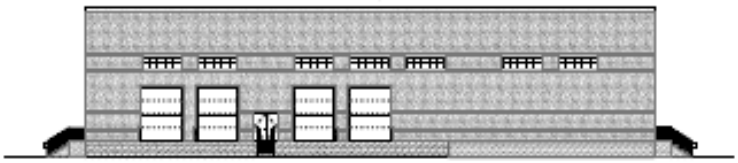
JOB NO.

SHEET NO. 1 of 1

Value Engineering Study Report



BUILDING ELEVATION



BUILDING ELEVATION

Training Support Center
Fort Sam Houston, Texas

PN 071116

May 2010

Prepared by

Value Management Strategies, Inc.

Thursday, October 28, 2010

VMS
Value Management Strategies, Inc.

"Value Leadership"

CORPORATE OFFICE:
613 W Valley Parkway
Suite 240
Escondido, CA 92025
T: 760 741 5518
F: 760 741 5617

1114 NE 39th Avenue
Portland, OR 97232
T: 503 957 9642
F: 760 741 5617

1874 Deer Park Circle S
Grand Junction, CO 81507
T: 970 216 1739
F: 760 741 5617

7309 Jones Avenue NW
Seattle, WA 98117
T: 206 679 8029
F: 760 741 5617

9022 West 65th Drive
Merriam, KS 66202
T: 816 206 0067
F: 760 741 5617

2020 X Street
Sacramento, CA 95818
T: 916 224 9812
F: 760 741 5617

8532 Woodbriar Drive
Sarasota, FL 34238
T: 941 323 5438
F: 760 741 5617

2670 Ravenoaks Place NE
Marietta, GA 30062
T: 678 488 4287
F: 760 741 5617

4 Admiral Drive, B226
Emeryville, CA 94608
T: 510 594 2257
F: 760 741 5617

321 Riverview Drive W
Great Falls, MT 59404
T: 406 952 4473
F: 760 741 5617

Date: May 24, 2010

Michael Huff, CESWF-PM-PMO
U.S. Army Corps of Engineers
819 Taylor, RM 3A28
Fort Worth, TX 76102

Subject: Final Value Engineering Study Report
Training Support Center, Fort Sam Houston

Dear Mr. Huff:

Value Management Strategies, Inc. is pleased to transmit this Final Value Engineering Study Report for the referenced project. This report summarizes the events of the study conducted 7 and 8 April, 2010.

We enjoyed working with you and are looking forward to continuing our work to assist USACE, Fort Worth District in its value engineering efforts.

If you have any questions or comments concerning this report, please contact me at (916) 224-9812 or email George@vms-inc.com.

Sincerely,

VALUE MANAGEMENT STRATEGIES, INC.

George Hunter, PE, PMP, CVS
VE Study Team Leader

Copy: (PDF) Addressee

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY
Project Description
VE Study Results
VE Alternatives
Design Suggestions
VE Team

2. VALUE ENGINEERING ALTERNATIVES
VE Alternatives
Design Suggestions
Summary of VE Alternatives
VE Alternative Documentation

3. PROJECT INFORMATION
Background
Project Description
Project Purpose and Need
VE Study Objectives
Information Provided to the VE Team
Project Drawings
Project Cost Estimate

4. PROJECT ANALYSIS
Summary of Analysis
Project Issues
Cost Model
VE Cost Estimate Review
Function Analysis
Functional Listing
FAST Diagram

5. IDEA EVALUATION
Evaluation Criteria
Evaluation Process
Idea Evaluation Forms

6. VALUE ENGINEERING PROCESS
Pre-Study Preparation
VE Study
VE Study Agenda
Meeting Attendees

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This Value Engineering (VE) Study Report summarizes the VE Study conducted by Value Management Strategies, Inc., on 7 and 8 April 2010, for U.S. Army Corps of Engineers, Fort Worth District. The subject of the study was the Training Support Center at Fort Sam Houston in San Antonio, Texas.

The purpose of the VE Study was to identify viable alternatives to enhance the project's value and functionality.

PROJECT DESCRIPTION

This project requires the construction of a 29,200 square foot standard design Training Aids Center (TAC). Primary facilities include the TAC, storage shed, installation of Intrusion Detection System (IDS), connection to Energy Monitoring and Control System (EMCS), antiterrorism measures and building information systems. Supporting facilities include electric service, water, paving, walks, curbs and gutters, sanitary sewer, site preparation/ improvements, and information systems. Special foundations are required and heating and air conditioning will be provided by self contained systems. Access for individuals with disabilities will be provided. Sustainable Design and Development (SDD) and Energy Policy Act of 2005 (EPAct05) features will be provided. This project will be certified LEED silver according to LEED version NC v 2.2 rating system.

The estimated contract cost (construction cost limit) according to the DD Form 1391, dated 8 January 2010, is $5.395 M. The equivalent estimated construction cost according to the latest project cost estimate is $5.15 M, which is $245,000 under the DD 1391 estimated construction cost. The cost estimate was prepared by HSW Engineering at the draft RFP/conceptual design phase, dated 2 April 2010. Estimated construction start is March 2011, with maximum one year construction duration.

VE STUDY RESULTS

The VE team developed six VE alternatives and sixteen design suggestions that recommend changes to the architectural, site, electrical, and mechanical features of the project design. Design suggestions improve the project but the cost impacts of these items are either insignificant or not currently quantifiable. In addition, suggested estimate corrections were documented to address items that were not adequately included in the initial cost estimate.

Of the six alternatives, five were rejected and one (Alternative 5) was accepted with modifications. A summary of all the VE alternatives and design suggestions can be found in the VE Alternatives section.

The VE study contributed to the following clarifications to the RFP package being prepared:

- The designers added a notation that the existing sanitary sewer must be relocated if it is under paving or the building. The contractor will have to come up with the best value combination to meet the construction schedule and budget.
- In reference to discussions about indicating in the RFP documents the floor loading requirements, to allow maximum (23') storage height, the designers would prefer to indicate

specific column loading (maximum capacity) of the racks at 23' and specify the dimensions of the rack.

- The designers acknowledge the potential to revise the conceptual site layout based on the ultimate sizing of the SWM ponds, to be done by the Contractor, however they stated that relocating the dock to a more downhill location may result in more roadway and earthwork. The conceptual layout, as originally provided to the VE Team, was not modified.
- Termite treatment requirements should be specified per the UFC and specific Ft. Sam Houston requirements.

VE ALTERNATIVES

The following list of VE alternatives and descriptions is provided below with implementation dispositions in italics. Detailed information on the VE alternatives and design suggestions can be found in the VE Alternatives section, including the VE team's determination of cost impact associated with the alternative.

Alternative 1: Split Warehouse and Training Center into Separate Buildings

The alternative concept sites two separate warehouse and training center buildings centered around and avoiding the existing sanitary sewer. The warehouse building will include secure operations storage, the vault, fabricated device storage, and the unisex toilet room/shower. All other program functions will be housed in the training center. The parking lot, drive aisles and truck drive are consolidated in this concept.

DD1391 does not allow a single facility to be split into pieces. The result is less efficient with a small staff covering both warehouse and administrative areas.

Alternative 2: Reorient the Building to Allow for Future Horizontal Expansion to East

This concept orients the building on a north-south axis, but further to the west to allow future expansion to the east of the building. Also, the concept condenses the drive aisle and parking, straightens the truck drive, and changes the configuration of the loading dock to minimize truck turning angles.

May be possible, but future expansion will be very limited on this site as added parking will be an issue if you try to expand classroom or training space. Using higher roof as indicated in the RFP to allow installation of taller racks in the future is a more economical way to achieve more storage capacity in the same footprint.

Alternative 3: Lengthen Loading Dock

This alternative increases the length of loading dock to 145 feet, the full length of the East side of the building.

No apparent advantage. Unusual, off-angle dock could lead to lift truck accidents as additional maneuvering would be required.

Alternative 4: Provide Single Lane Truck Drive

The alternative concept would retain the position of the truck drive but reduced to a 12' width and make it one way. The position of the south end of the truck drive would be relocated inside of the secure gate. A slight relocation of the storage shed would be required.

Fort Sam Houston minimum lane requirement for semi-trailers is 16 feet. Good design practice indicates that 12 feet would be too narrow for semi-trailers.

Alternative 5: Reconfigure Training Center Floor Plan by Moving Mechanical/Electrical Rooms to NW Corner of Building and Consolidating Egress Points

The alternative concept locates the mechanical and electrical rooms in the northwest corner of the building, and consolidates secondary egress points from the class rooms resulting in a reduction by one egress point. Furthermore, the floor plan changes allowed for the removal of one exterior door along the east elevation and eliminated one set of interior doors at the classrooms.

Concur with combining egress points. Placing mechanical rooms next to administrative office areas could create noise problems in offices and is not preferred.

Alternative 6: Place Skylights in the Warehouse.

Provide standard skylights at 20% of the exposed Warehouse area: 3,020 Square Feet.

The potential for leaks increases; translucent panels in side-walls are preferred.

DESIGN SUGGESTIONS

The VE team identified several issues that they wanted to bring to the attention of the U.S. Army Corps of Engineers, Fort Worth District. These include:

Project Management Suggestions:

- PM-1: Review Cost Estimate

Site Suggestions:

- S-6/7: Provide access to the Warehouse Loading Dock
- S-13/14: Review sizing of ponds for quality only

Electrical Design Suggestions:

- E-1: Centrally locate all motor starters in the electrical or mechanical room
- E-2: Define a minimal amount of hardware spares to be used in the control system
- E-3: Have separate panel boards for warehouse space and the other half of building
- E-4: Solar powered bollard lighting for outdoor walkways
- E-6: Photodiode controls for parking lot lighting

- E-7: Photovoltaic lighting
- E-9: Review Light Pollution
- E-10: Bug Control Lights
- E-11: RFP Conflict

Mechanical Design Suggestions:

- M-2/5: Zone building areas for conditioning and specify that corridors be included in a zone
- M-4: VAV boxes with Hot Water Reheats
- M-6: Use Water Softeners
- M-7: Geothermal Systems

The design team commented that most of the design suggestions are worth consideration as the project progresses. Additional design team comments relating to the architectural and mechanical design suggestions are included below for future reference.

Architectural: The Architectural/Site VE items that were discussed at the meeting and combined the stair stoops at the EST classrooms will be implemented. It was determined that the Mechanical room would not be moved to the front of the building.

Mechanical: The design team's mechanical engineer agrees with all mechanical design suggestions; however, the RFP Wizard does not allow edits to the Mechanical text that is standard to Ft. Sam Houston. These design suggestions will be noted for future implementation.

VE TEAM

The two-day study was performed during the period of 7 through 8 April 2010, at the offices of the U.S. Army Corps of Engineers in Building 4196 at Ft. Sam Houston, San Antonio, Texas. George Hunter, PE, PMP, CVS, of Value Management Strategies, Inc., led the VE Study.

The VE team members were:

George Hunter	Value Management Strategies, Inc.	VE Study Facilitator
Mariah Brink	Value Management Strategies, Inc.	Assistant Team Lead
Celia Hunter	Hunter Pacific	Cost Estimator
Darren Nielsen	HNTB	Architect
David Parker	HNTB	Mechanical Engineer
Terry Kinley	HNTB	Electrical Engineer

The VE team was also supported by the project designer and several representatives from the US Army Corps of Engineers.

VALUE ENGINEERING ALTERNATIVES

VE ALTERNATIVES

The results of this study are presented as individual alternatives to the original concept as developed by HSW Engineering.

VE ALTERNATIVES

Each alternative consists of a summary of the original concept, a description of the suggested change, a listing of its advantages and disadvantages, a cost comparison, and a brief narrative comparing the original design with the alternative. Sketches and calculations are also presented.

The cost comparisons reflect the comparable level of detail as in the original estimate. A life-cycle benefit-cost analysis for major alternatives is included where appropriate.

DESIGN SUGGESTIONS

The VE team identified several issues that they wanted to bring to the attention of the U.S. Army Corps of Engineers, Fort Worth District. These include:

Project Management Suggestions:

- **Design Suggestion PM-1: Review Cost Estimate**

A revised cost estimate is included in the Project Analysis section of this report.

Site Suggestions:

- **Design Suggestion S-6/S-7: Provide access to the Warehouse Loading Dock**

The current concept site plans show the loading dock (4 ft high) at the south end of the building and storage shed, which stores propane cylinders, is tied to the dock via a 10 foot concrete drive. To allow smaller trucks access to the loading dock, consider connecting the paved, truck turnaround area to the 10’ concrete ramp. Alternatively, provide a switchback ramp to the loading dock.

- **Design Suggestion S-13/S-14: Review sizing of ponds for quality only**

The current site is completely paved, except for the southerly edge of the site, which will remain as a drainage swale. The proposed site will have approximately 30 to 40 percent more pervious area than the existing site. There are four planned detention ponds that occupy a significant amount of the site, yet the runoff generated by the new site is less than existing. The requirement is to capture the volume of the first flush for quality concerns; on this basis the number of storm water detention ponds should be reviewed. Storm water detention ponds are a maintenance issue and furthermore could impact the future ability to expand the building or parking spaces.
Also, consider using the larger parking islands and green spaces as the bioswales. Any parking runoff that can be directed into bioswales will reduce the retention of the first flush and therefore could reduce the sizing of the detention ponds. Lastly, the swale that conveys water from areas upstream of Garden Road should be investigated for use as a detention pond; this will depend largely on the amount of runoff that drains into the swale.

Electrical Design Suggestions:

- **Design Suggestion E-1: Centrally locate all motor starters in the electrical or mechanical room**

Locate all motor starters in either the mechanical room or the electrical room. This consolidation will minimize installation costs with control system conductors and raceways and will provide clearer wall space in the vicinity of motorized equipment throughout the facility.

- **Design Suggestion E-2: Define a minimal amount of hardware spares to be used in the control system**

Direct Contractor to provide a minimal quantity (recommend 10% spare points, maximum) of installed spare input/output (I/O) processing hardware modules and to provide a minimum of 25% spare rack space for future I/O expansion modules. This will reduce the initial control system costs.

- **Design Suggestion E-3: Have separate panel boards for warehouse space and the other half of building**

Provide separate locally mounted panel boards (circuit breaker panels) for the warehouse area and the administrative/classroom portion of the building. This will reduce branch circuit wiring and raceway costs and provide more intuitive access to de-energize local circuits or reset tripped or faulted breakers.

- **Design Suggestion E-4: Solar powered bollard lighting for outdoor walkways**

Provide photovoltaic powered bollard type lighting for exterior walkways. This type of lighting will provide increased safety for facility users during low-light conditions while utilizing no cost solar energy.

- **Design Suggestion E-6: Photodiode controls for parking lot lighting**

Provide photodiode sensor and astronomical time clock based controls for parking lot lighting. This type of control will minimize operating costs and maximize operational flexibility over the life of the system.

- **Design Suggestion E-7: Photovoltaic lighting**

Provide photodiode sensor based dimming controls for warehouse area lighting. This type of control, used in conjunction with natural daylight utilization, will minimize operating costs of warehouse lighting and possibly provide LEED points.

- **Design Suggestion E-9: Review Light Pollution**

Review exterior lighting designs with Fort Sam personnel to assess and reduce or eliminate potential light pollution issues.

- **Design Suggestion E-10: Bug Control Lights**

Utilize insect control lamps for exterior lighting, where applicable, to reduce maintenance requirements and increase operational efficiencies of luminaries and fixtures.

- **Design Suggestion E-11: RFP Conflict**

RFP should be edited to reconcile conflicting requirements between Section 5.8.3 and Section 6.11.3.1 with regard to control system architecture and requirements of Section 23 09 10.00 44 *Fort Sam Houston, Texas, Heating, Ventilation, and Air Conditioning (HVAC) Control Systems Design-Build Minimum Requirements (Generic) (Reference Section 15954, 15990 & 15995).*

Mechanical Design Suggestions:

- **Design Suggestion M-2/M-5: Zone building areas for conditioning and specify that corridors be included in a zone**

The draft RFP, Section 01 10 00, Paragraph 5.8, includes design requirements for conditioning spaces to meet indoor design conditions of UFC 3-410-01FA. Paragraph 5.8.2.3 allows for single and multi-zone systems. We do not see specific zone criteria in the RFP. If separate temperature control zones are necessary for the different functions of the facility as provided by Training Support Center Design Guide, they should be added to specific project requirements in Paragraph 6.11. For instance separate air-conditioning temperature control zones could be required for the administrative area, each simulation classroom, break/waiting room plus ancillary conditioned spaces.

- **Design Suggestion M-4: VAV boxes with Hot Water Reheats**

The design consideration is related to Idea M-2, Zone Building Areas for Air-Conditioning.
A variable air volume (VAV) system with hot-water reheat is a type of HVAC system that will provide for separate temperature control zones. This type of HVAC system can be utilized to meet the project energy conservation requirements and could be added as a requirement or preference to the RFP. One consideration is if this type of system is used at other facilities and is familiar to maintenance personnel.

- **Design Suggestion M-6: Use Water Softeners**

The draft RFP does not include a requirement for treating the building domestic water for water hardness. Fort Sam Houston personnel indicated a preference to provide a water softener for the facility. Water softeners will reduce mineral deposits on plumbing fixtures and possibly increase the useful life of the fixture.

- **Design Suggestion M-7: Geothermal Systems**

This design suggestion is related to Idea M-2, Zone Building Areas for Air-Conditioning.
A geothermal ground source heat pump (GSHP) uses the constant temperature of the earth to provide heated and cooled conditioned air to spaces. A closed-loop GSHP system would consist of one or more (See design suggestion M-2) compressor units that cool in the summer or heat in the winter, and utilize a pumped water loop to reject or obtain heat from the earth. The loop piping is buried horizontally or vertically in the ground. This type of HVAC system can be utilized to meet the project energy conservation requirements and could be added as a requirement or preference to the RFP.
Considerations for this type of system include:

- Higher initial cost versus other multi-zone type HVAC systems
- Familiarity of this system to maintenance personnel
- Space available on site for the horizontal or vertical loop piping
- Soil and rock type which affect heat rejection and installation costs
- Would not be considered for LEED points

The following table shows the potential savings associated with each of the VE alternatives and the disposition as identified by the project development team.

SUMMARY OF VE ALTERNATIVES

Alt. No.	Alternative Title	Initial Cost Savings	Disposition
1	Split Warehouse and Training Center into Separate Building	$127,000	Rejected
2	Reorient the Building to Allow for Future Horizontal Expansion to East	No Change	Rejected
3	Lengthen Loading Dock	($51,000)	Rejected
4	Provide Single Lane Truck Drive	$24,000	Rejected
5	Reconfigure Training Center Floor Plan by Moving Mechanical/Electrical Rooms to NW Corner of Building and Consolidating Egress Points	$8,000	Accepted with Modifications
6	Place Skylights in the Warehouse	($238,000)	Rejected

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*			
FUNCTION:	Site	**IDEA NO.** S1, S5, S12	**NUMBER** 1
TITLE:	Split Warehouse and Training Center into Separate Buildings		**PAGE NO.** 1 of 5

ORIGINAL CONCEPT:

The original concept sites a single warehouse/training center building adjacent to the easterly property boundary.

ALTERNATIVE CONCEPT:

The alternative concept sites two separate warehouse and training center buildings centered around and avoiding the existing sanitary sewer. The warehouse building will include secure operations storage, the vault, fabricated device storage, and the unisex toilet room/shower. All other program functions will be housed in the training center.

The parking lot, drive aisles and truck drive are consolidated in this concept.

ADVANTAGES:

- Avoids sewer relocation
- Allows lowering of floor elevation in training center building, taking advantage of the site topography
- Reduces paving
- Provides direct line of site between loading dock and training center entrance in support of authorizing equipment disbursements
- Reduces project schedule by eliminating the first order of work, i.e. relocating the sewer line

DISADVANTAGES:

- May not be in accordance with DD 1391
- Does not segregate truck and POV circulation
- Requires uncovered circulation between buildings

COST SUMMARY	INITIAL COST	O&M	LIFE-CYCLE COST
Original Concept	$ 6,248,000	$ 0	$ 6,248,000
Alternative Concept	$ 6,121,000	$ 0	$ 6,121,000
Savings	$ 127,000	$ 0	$ 127,000

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS
TITLE: Split Warehouse and Training Center into Separate Buildings	**NUMBER** 1	**PAGE NO.** 2 of 5

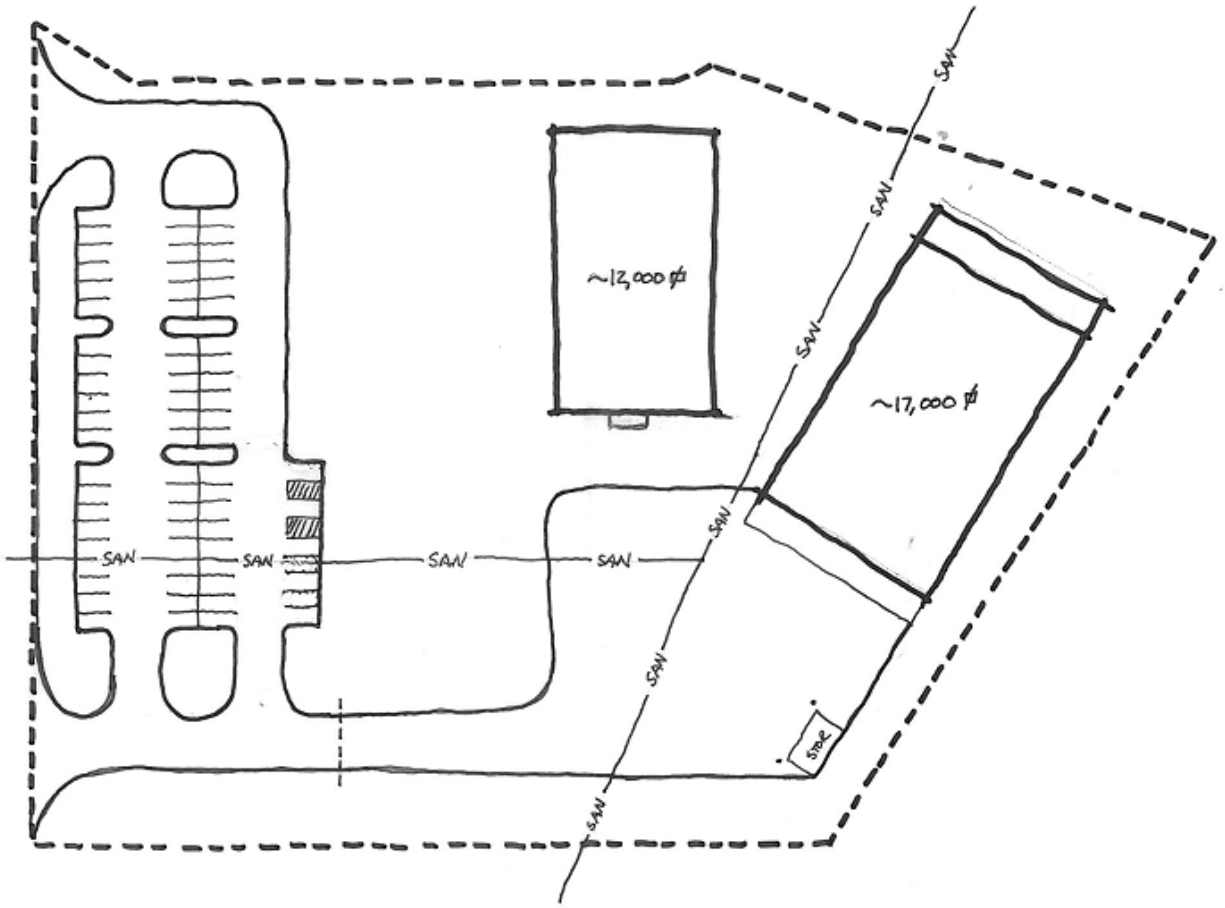
DISCUSSION / JUSTIFICATION:

This alternative was developed because the VE team thought it beneficial to avoid the relocation of the sewer line and the desire to take advantage of the site topography. This concept abides by the ATFP set-back requirements.

IMPLEMENTATION CONSIDERATIONS:

Requires an exception to DD 1391 requirements.

SKETCHES *Training Support Center – Fort Sam Houston*		VMS	
TITLE:	Split Warehouse and Training Center into Separate Buildings	**NUMBER** 1	**PAGE NO.** 3 of 5



Alternative Concept

ASSUMPTIONS and CALCULATIONS

Training Support Center – Fort Sam Houston

VMS

TITLE: Split Warehouse and Training Center into Separate Buildings

NUMBER	PAGE NO.
1	4 of 5

CONSTRUCTION ELEMENT		*Orginial Concept*			*Alternative Concept*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
Primary Facilities							
Training Aids Center - Training Center	Sf	29,000	130.64	$ 3,788,560	12,000	130.64	$ 1,567,680
Training Aids Center - Warehouse	Sf			$ -	17,000	130.64	$ 2,220,880
IDS Installation	Ls	1	7,855.38	$ 7,855	1	7,855.38	$ 7,855
EMCS Connection	Ea	1	26,511.92	$ 26,512	1	26,511.92	$ 26,512
Storage Shed, Covered	Sf	364	43.50	$ 15,834	364	43.50	$ 15,834
SDD and EPA	Ls	1	76,600.00	$ 76,600	1	76,600.00	$ 76,600
Antiterrorism Measures	Ls	1	90,300.00	$ 90,300	1	90,300.00	$ 90,300
Building Information Systems	Ls	1	37,300.00	$ 37,300	1	37,300.00	$ 37,300
				$ -			$ -
Supporting Facilities				$ -			$ -
Electric Service				$ -			$ -
Tie-In to Overhead Distribution	Ea	1	3,132.00	$ 3,132	1	3,132.00	$ 3,132
Underground Distribution Voltage - Road	Lf	60	160.00	$ 9,600	60	160.00	$ 9,600
Premium - Below active road	Lf	60	120.00	$ 7,200	60	120.00	$ 7,200
Electrical Box	Lf	1	622.00	$ 622	2	622.00	$ 1,244
Distribution Voltage	Lf	620	42.32	$ 26,238	660	42.32	$ 27,931
Transformers 150 kVA	Ea	1	15,353.35	$ 15,353	1	15,353.35	$ 15,353
Exterior Lighting	Lf	850	40.95	$ 34,808	850	40.95	$ 34,808
Remove Existing Secondary Overhead Lines	Sy	20,231	0.50	$ 10,116	20,231	0.50	$ 10,116
				$ -			$ -
Domestic & Fire Water Service				$ -			$ -
HDPE Piping	Lf	150	19.44	$ 2,916	150	19.44	$ 2,916
PVC, Schedule 40 - Domestic	Lf	270	31.18	$ 8,419	310	31.18	$ 9,666
PVC, Schedule 40 - Fire	Lf	130	31.18	$ 4,053	170	31.18	$ 5,301
Fire Hydrants	Ea	1	2,975.69	$ 2,976	1	2,975.69	$ 2,976
Meter, PIV, Backflow Preventor	Ea	1	11,776.00	$ 11,776	1	11,776.00	$ 11,776
Trench and Backfill	Cy	214	19.64	$ 4,203	214	19.64	$ 4,203
Valves and Cleanout	Ea	4	857.22	$ 3,429	4	857.22	$ 3,429
				$ -			$ -
Sanitary Sewer Service				$ -			$ -
Plastic Piping, reinforced	Lf	25	63.30	$ 1,583	65	63.30	$ 4,115
Manholes PCST 8' Deep	Lf			$ -			$ -
Connect into Existing Line (Hot)	Loc			$ -	1	20,240.00	$ 20,240
Trench and Backfill	Cy	10	19.64	$ 196	14	19.64	$ 275
Valves and Cleanout	Ea	4	857.22	$ 3,429	5	857.22	$ 4,286
				$ -			$ -
Relocation of Existing Sanitary Sewer				$ -			$ -
Relocated 20" Sanitary Sewer Pipe	Lf	430	63.30	$ 27,219			$ -
Manholes PCST 8' Deep	Ea	4	11,776.00	$ 47,104			$ -
Trench and Backfill	Cy	167	19.64	$ 3,280			$ -
Valves	Ea	2	857.22	$ 1,714			$ -
Connect into Existing Line (Hot)	Loc	2	20,240.00	$ 40,480			$ -
Remove Existing 20" Sanitary Sewer Pipe	Lf	330	45.00	$ 14,850			$ -
Remove Existing 8" Sanitary Sewer Pipe	Lf	90	25.00	$ 2,250			$ -
				$ -			$ -
Gas Service				$ -			$ -
Regulator and Meter	Ea	1	3,582.06	$ 3,582	1	3,582.06	$ 3,582
High Pressure Line	Lf	420	20.24	$ 8,501	420	20.24	$ 8,501
				$ -			$ -

ASSUMPTIONS and CALCULATIONS

Training Support Center – Fort Sam Houston

VMS

TITLE: Split Warehouse and Training Center into Separate Buildings

NUMBER	PAGE NO.
1	5 of 5

Storm Drain System				$ -			$	-
Concrete Piping	Lf			$ -			$	-
Catch Basins, 6' Dpth	Ea			$ -			$	-
Concrete Flared End Section	Ea			$ -			$	-
Manholes, PCST	Lf			$ -			$	-
Excavation and Backfill	Cy			$ -			$	-
Storm Drain System (below grade)	Sy	14,856	8.28	$ 123,008	14,856	8.28	$	123,008
				$ -			$	-
Paving, Walks, Curbs & Gutters				$ -			$	-
Asphalt Parking and Drives	Sy	5,428	9.30	$ 50,480	5,571	9.30	$	51,810
Concrete Paving - Loading Dock Area	Sy	1,462	30.05	$ 43,933	2,962	30.05	$	89,008
Concrete Sidewalks / Ramps	Sy	430	30.05	$ 12,922	430	30.05	$	12,922
Base Course (Crushed Stone)	Sy	8,500	18.44	$ 156,740	8,500	18.44	$	156,740
Curbs and Gutters	Lf	3,310	15.68	$ 51,901	2,600	15.68	$	40,768
Gates - 24' Pair (Security)	Ea	1	1,451.42	$ 1,451	1	1,451.42	$	1,451
Exiting Landing (7 loc to 3 Loc)	Sf	490	41.40	$ 20,286	210	41.40	$	8,694
Exiting Stairs (8 loc - 3 loc)	Sf	250	82.80	$ 20,700	94	82.80	$	7,783
ADA Ramp and Railing - Entrance (32'x10')	Sf	320	41.40	$ 13,248		-	$	-
ADA Ramp and Railing - Dock (32'x14')	Sf	448	41.40	$ 18,547	448	41.40	$	18,547
Dock Platform	Sf	1,833	41.40	$ 75,886	1,833	41.40	$	75,886
Perimeter Fencing	Lf	420	13.60	$ 5,712	420	13.60	$	5,712
Entrance Gates 2 sets, Sliding	St	2	16,620.00	$ 33,240	2	16,620.00	$	33,240
				$ -			$	-
Site Improvements				$ -			$	-
Clearing & Grubbing	AC			$ -			$	-
Clearing & Grubbing - South Side Drainage	Sy	2,131	0.20	$ 426	2,131	0.20	$	426
Grading Rough	Sy	18,100	2.49	$ 45,069	18,100	2.49	$	45,069
Grading fine	Sy	9,700	1.20	$ 11,640	9,700	1.20	$	11,640
Concrete Pads	Ea	2	7,676.67	$ 15,353	2	7,676.67	$	15,353
Dumpster Enclosure	Ea	1	12,794.46	$ 12,794	1	12,794.46	$	12,794
Excavation Common Earth	Cy	4,800	8.11	$ 38,928	4,800	8.11	$	38,928
Grass Seeding	Sy	7,536	0.74	$ 5,577	7,536	0.74	$	5,577
Haul and Spread Topsoil	Cy	5,890	19.36	$ 114,030	5,890	19.36	$	114,030
				$ -			$	-
Demolition				$ -			$	-
Trench Machine	Cy			$ -			$	-
Backfill Machine	Cy			$ -			$	-
Remove Asphalt Paving	Sy	18,100	0.65	$ 11,765	18,100	0.65	$	11,765
Haul Off Site (assume 4")	Lds	110	420.00	$ 46,200	110	420.00	$	46,200
Dump Fee (NIC)	Cy	2,594	-	$ -	2,594	-	$	-
Remove Perimeter Fencing	Lf	1,690	2.60	$ 4,394	1,690	2.60	$	4,394
Information Systems				$ -			$	-
Information Systems	Ls	1	170,900.00	$ 170,900	1	170,900.00	$	170,900
				$ -			$	-
				$ -			$	-
Subtotal				$5,447,121				$5,336,256
Project Markups %	14.7%			$800,727				$784,430
TOTAL (Rounded)				$6,248,000				$6,121,000
						Savings		**($127,000)**

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS
FUNCTION: Site	**IDEA NO.** S2	**NUMBER** 2
TITLE: Reorient the Building to Allow for Future Horizontal Expansion to East		**PAGE NO.** 1 of 5

ORIGINAL CONCEPT:

The original concept sites the building adjacent to the easterly property boundary.

ALTERNATIVE CONCEPT:

This concept orients the building in a north-south axis, but further to the west to allow a future expansion to the east of the building. Also, the concept condenses the drive aisle and parking, straightens the truck drive, and changes the configuration of the loading dock to minimize truck turning angles.

ADVANTAGES:

- Allows for future expansion
- Reduces overall paving

DISADVANTAGES:

- Complicates operations at the dock

COST SUMMARY	INITIAL COST	O&M	LIFE-CYCLE COST
Original Concept	$ 6,243,000	$ 0	$ 6,243,000
Alternative Concept	$ 6,243,000	$ 0	$ 6,243,000
Savings	$ 0	$ 0	$ 0

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS	
TITLE:	Reorient the Building to Allow for Future Horizontal Expansion to East	**NUMBER** 2	**PAGE NO.** 2 of 5

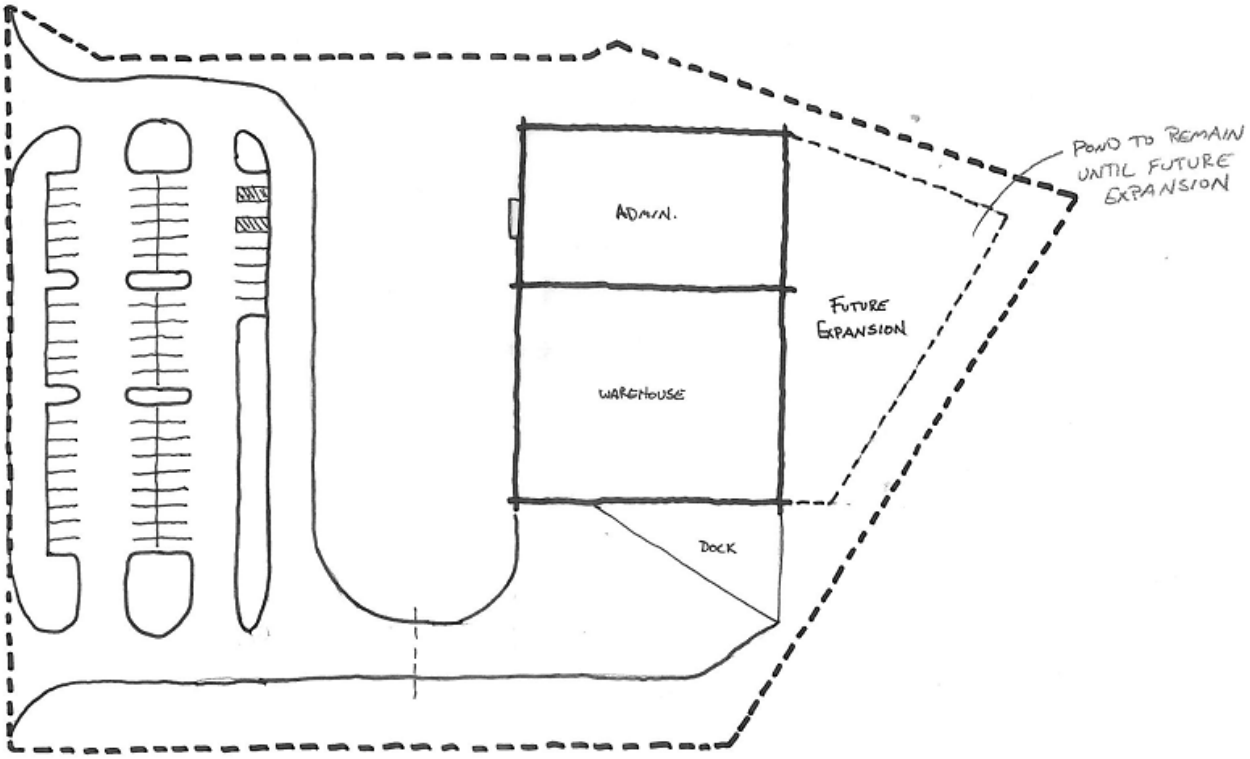
DISCUSSION / JUSTIFICATION:

This alternative was developed to allow greater flexibility in the use of the site for future expansion. This concept abides by the ATFP set-back requirements.

IMPLEMENTATION CONSIDERATIONS:

Include in documentation; consider as part of the informational packet for bidders

SKETCHES *Training Support Center – Fort Sam Houston*		VMS	
TITLE:	Reorient the Building to Allow for Future Horizontal Expansion to East	**NUMBER** 2	**PAGE NO.** 3 of 5



Alternative Concept

ASSUMPTIONS and CALCULATIONS

Training Support Center – Fort Sam Houston

VMS

TITLE: Reorient the Building to Allow for Future Horizontal Expansion to East

NUMBER 2

PAGE NO. 4 of 5

CONSTRUCTION ELEMENT		*Orginial Concept*			*Alternative Concept*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
Primary Facilities							
Training Aids Center / Warehouse	Sf	29,000	130.64	$ 3,788,560	29,000	130.64	$ 3,788,560
IDS Installation	Ls	1	7,855.38	$ 7,855	1	7,855.38	$ 7,855
EMCS Connection	Ea	1	26,511.92	$ 26,512	1	26,511.92	$ 26,512
Storage Shed, Covered	Sf	364	43.50	$ 15,834	364	43.50	$ 15,834
SDD and EPA	Ls	1	76,600.00	$ 76,600	1	76,600.00	$ 76,600
Antiterrorism Measures	Ls	1	90,300.00	$ 90,300	1	90,300.00	$ 90,300
Building Information Systems	Ls	1	37,300.00	$ 37,300	1	37,300.00	$ 37,300
				$ -			$ -
Supporting Facilities				$ -			$ -
Electric Service				$ -			$ -
Tie-In to Overhead Distribution	Ea	1	3,132.00	$ 3,132	1	3,132.00	$ 3,132
Underground Distribution Voltage - Road	Lf	60	160.00	$ 9,600	60	160.00	$ 9,600
Premium - Below active road	Lf	60	120.00	$ 7,200	60	120.00	$ 7,200
Electrical Box	Lf	1	622.00	$ 622	2	622.00	$ 1,244
Distribution Voltage	Lf	620	42.32	$ 26,238	660	42.32	$ 27,931
Transformers 150 kVA	Ea	1	15,353.35	$ 15,353	1	15,353.35	$ 15,353
Exterior Lighting	Lf	850	40.95	$ 34,808	850	40.95	$ 34,808
Remove Existing Secondary Overhead Lines	Sy	20,231	0.50	$ 10,116	20,231	0.50	$ 10,116
				$ -			$ -
Domestic & Fire Water Service				$ -			$ -
HDPE Piping	Lf	150	19.44	$ 2,916	150	19.44	$ 2,916
PVC, Schedule 40 - Domestic	Lf	270	31.18	$ 8,419	270	31.18	$ 8,419
PVC, Schedule 40 - Fire	Lf	130	31.18	$ 4,053	130	31.18	$ 4,053
Fire Hydrants	Ea	1	2,975.69	$ 2,976	1	2,975.69	$ 2,976
Meter, PIV, Backflow Preventor	Ea	1	11,776.00	$ 11,776	1	11,776.00	$ 11,776
Trench and Backfill	Cy	214	19.64	$ 4,203	214	19.64	$ 4,203
Valves and Cleanout	Ea	4	857.22	$ 3,429	4	857.22	$ 3,429
				$ -			$ -
Sanitary Sewer Service				$ -			$ -
Plastic Piping, reinforced	Lf	25	63.30	$ 1,583	25	63.30	$ 1,583
Trench and Backfill	Cy	10	19.64	$ 196	10	19.64	$ 196
Valves and Cleanout	Ea	4	857.22	$ 3,429	4	857.22	$ 3,429
				$ -			$ -
Relocation of Existing Sanitary Sewer				$ -			$ -
Relocated 20" Sanitary Sewer Pipe	Lf	430	63.30	$ 27,219	430	63.30	$ 27,219
Manholes PCST 8' Deep	Ea	4	11,776.00	$ 47,104	4	11,776.00	$ 47,104
Trench and Backfill	Cy	167	19.64	$ 3,280	167	19.64	$ 3,280
Valves	Ea	2	857.22	$ 1,714	2	857.22	$ 1,714
Connect into Existing Line (Hot)	Loc	2	20,240.00	$ 40,480	2	20,240.00	$ 40,480
Remove Existing 20" Sanitary Sewer Pipe	Lf	330	45.00	$ 14,850	330	45.00	$ 14,850
Remove Existing 8" Sanitary Sewer Pipe	Lf	90	25.00	$ 2,250	90	25.00	$ 2,250
				$ -			$ -
Gas Service				$ -			$ -
Regulator and Meter	Ea	1	3,582.06	$ 3,582	1	3,582.06	$ 3,582
High Pressure Line	Lf	420	20.24	$ 8,501	420	20.24	$ 8,501
				$ -			$ -
Storm Drain System				$ -			$ -
Storm Drain System (below grade)	Sy	14,856	8.28	$ 123,008	14,856	8.28	$ 123,008
				$ -			$ -

ASSUMPTIONS and CALCULATIONS

Training Support Center – Fort Sam Houston

VMS

TITLE: Reorient the Building to Allow for Future Horizontal Expansion to East

NUMBER 2

PAGE NO. 5 of 5

Paving, Walks, Curbs & Gutters				$ -			$	-
Asphalt Parking and Drives	Sy	5,428	9.30	$ 50,480	4,400	9.30	$	40,920
Concrete Paving - Loading Dock Area	Sy	1,462	30.05	$ 43,933	1,210	30.05	$	36,361
Concrete Sidewalks / Ramps	Sy	430	30.05	$ 12,922	480	30.05	$	14,424
Base Course (Crushed Stone)	Sy	8,500	18.44	$ 156,740	8,500	18.44	$	156,740
Curbs and Gutters	Lf	3,310	15.68	$ 51,901	2,648	15.68	$	41,521
Gates - 24' Pair (Security)	Ea	1	1,451.42	$ 1,451	1	1,451.42	$	1,451
Exiting Landing	Sf	490	41.40	$ 20,286	490	41.40	$	20,286
Exiting Stairs	Sf	250	82.80	$ 20,700	250	82.80	$	20,700
ADA Ramp and Railing - Entrance (32'x10')	Sf	320	41.40	$ 13,248	320	41.40	$	13,248
ADA Ramp and Railing - Dock (32'x14')	Sf	448	41.40	$ 18,547	448	41.40	$	18,547
Dock Platform	Sf	1,833	41.40	$ 75,886	2,400	41.40	$	99,360
Perimeter Fencing	Lf	420	13.60	$ 5,712	420	13.60	$	5,712
Entrance Gates 2 sets, Sliding	St	2	16,620.00	$ 33,240	2	16,620.00	$	33,240
				$ -			$	-
Site Improvements				$ -			$	-
Clearing & Grubbing	AC			$ -			$	-
Clearing & Grubbing - South Side Drainage	Sy	2,131	0.20	$ 426	2,131	0.20	$	426
Grading Rough	Sy	18,100	2.49	$ 45,069	18,100	2.49	$	45,069
Grading fine	Sy	9,700	1.20	$ 11,640	9,700	1.20	$	11,640
Concrete Pads	Ea	2	7,676.67	$ 15,353	2	7,676.67	$	15,353
Dumpster Enclosure	Ea	1	12,794.46	$ 12,794	1	12,794.46	$	12,794
Excavation Common Earth	Cy	4,800	8.11	$ 38,928	4,800	8.11	$	38,928
Grass Seeding	Sy	7,536	0.74	$ 5,577	7,672	0.74	$	5,677
Haul and Spread Topsoil	Cy	5,890	19.36	$ 114,030	5,890	19.36	$	114,030
				$ -			$	-
Demolition				$ -			$	-
Remove Asphalt Paving	Sy	18,100	0.65	$ 11,765	18,100	0.65	$	11,765
Haul Off Site (assume 4")	Lds	110	420.00	$ 46,200	110	420.00	$	46,200
Information Systems				$ -			$	-
Information Systems	Ls	1	170,900.00	$ 170,900	1	170,900.00	$	170,900
				$ -			$	-
				$ -			$	-
Subtotal				$5,442,727				$5,442,605
Project Markups %	14.7%			$800,081				$800,063
TOTAL (Rounded)				$6,243,000				$6,243,000
						Savings		**$0**

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS	
FUNCTION:	Site	**IDEA NO.** S17	**NUMBER** 3
TITLE:	Lengthen Loading Dock		1 of 3

ORIGINAL CONCEPT:

The original concept has the loading dock length 90'.

ALTERNATIVE CONCEPT:

Increase length of loading dock to 145', the full length of the East side of building.

ADVANTAGES:

- Provides increase flexibility in the performance of shipping and receiving.

DISADVANTAGES:

- Increase Cost

COST SUMMARY	INITIAL COST	O&M	LIFE-CYCLE COST
Original Concept	$ 87,000	$ 0	$ 87,000
Alternative Concept	$ 138,000	$ 0	$ 138,000
Savings	$ (51,000)	$ 0	$ (51,000)

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		
TITLE: Lengthen Loading Dock	**NUMBER** 3	**PAGE NO.** 2 of 3

DISCUSSION / JUSTIFICATION:

Provides greater flexibility in the loading dock area.

IMPLEMENTATION CONSIDERATIONS:

None.

ASSUMPTIONS and CALCULATIONS

Training Support Center – Fort Sam Houston

VMS

TITLE: Lengthen Loading Dock

NUMBER	PAGE NO.
3	3 of 3

CONSTRUCTION ELEMENT		*ORIGINAL CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
				$ -			$ -
Dock Platform	Sf	1,833	41.40	$ 75,886	2,900	41.40	$ 120,060
(Orginal 90'x20', Increase to 145' x 20')				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
SUB-TOTAL				$75,886			$120,060
PROJECT MARK-UPS	14.7%			$11,155			$17,649
TOTAL (Rounded)				$87,000			$138,000
						Savings	**($51,000)**

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS
FUNCTION: Site	**IDEA NO.** S19	**NUMBER** 4
TITLE: Provide a Single Lane Truck Drive		**PAGE NO.** 1 of 4

ORIGINAL CONCEPT:

The original site shows a 24’ wide truck drive east of the POV parking.

ALTERNATIVE CONCEPT:

The alternative concept would retain the position of the truck drive but reduced to a 12’ width and make it one way. The position of the south end of the truck drive would be relocated inside of the secure gate. A slight relocation of the storage shed would be required.

ADVANTAGES:

- Reduces pavement
- Reduces the mixture of truck and POV traffic

DISADVANTAGES:

- Less flexibility in circulation
- Requires additional truck signage

COST SUMMARY	INITIAL COST	O&M	LIFE-CYCLE COST
Original Concept	$ 47,000	$ 0	$ 47,000
Alternative Concept	$ 23,000	$ 0	$ 23,000
Savings	$ 24,000	$ 0	$ 24,000

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		
TITLE: Provide a Single Lane Truck Drive	**NUMBER** 4	**PAGE NO.** 2 of 4

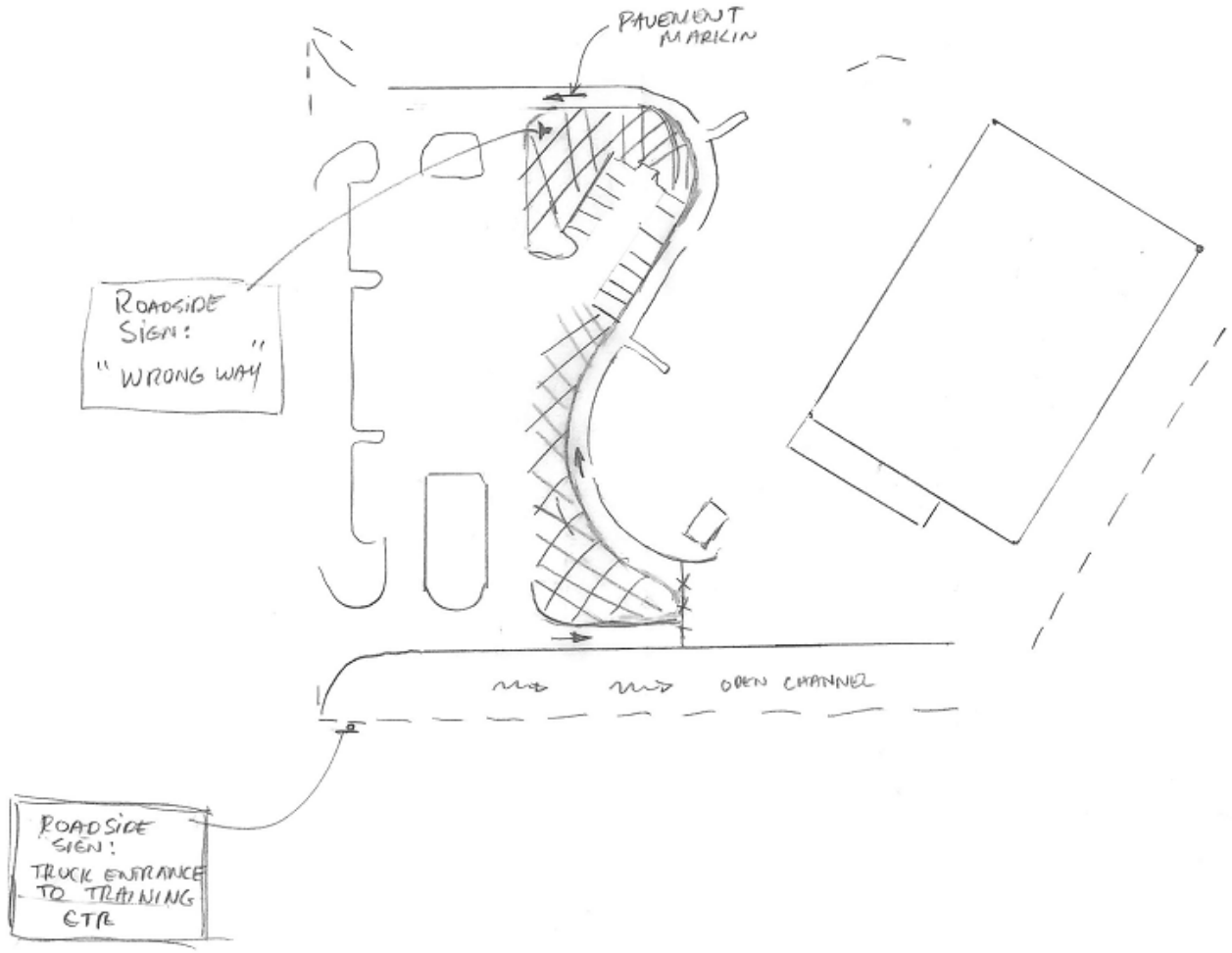
DISCUSSION / JUSTIFICATION:

This alternative was developed with the intent to reduce paving.

IMPLEMENTATION CONSIDERATIONS:

Include in documentation; consider as part of the informational packet for bidders.

SKETCHES *Training Support Center – Fort Sam Houston*		
TITLE: Provide a Single Lane Truck Drive	**NUMBER** 4	**PAGE NO.** 3 of 4



Alternative Concept

ASSUMPTIONS and CALCULATIONS *Training Support Center – Fort Sam Houston*		
TITLE: Provide a Single Lane Truck Drive	**NUMBER** 4	**PAGE NO.** 4 of 4

Original Area:

L = 550’

W = 24’

Area = 550’ x 24’

= 13,200 = 1466 square yards

New Truck Drive Area:

½ Original area = 733 square yards

Δ = 733 square yards of AC Pavement

CONSTRUCTION ELEMENT		*ORIGINAL CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
				$ -			$ -
Asphalt Parking and Drives	Sy	1,466	9.30	$ 13,634	733	9.30	$ 6,817
Base Course (Crushed Stone)	Sy	1,466	18.44	$ 27,033	733	18.44	$ 13,517
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
SUB-TOTAL				$40,667			$20,333
PROJECT MARK-UPS	14.7%			$5,978			$2,989
TOTAL (Rounded)				$47,000			$23,000
						Savings	**$24,000**

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*			
FUNCTION:	Architectural / Site	**IDEA NO.** A2/5, S15/16	**NUMBER** 5
TITLE:	Reconfigure Training Center Floor Plan by Moving Mechanical/Electrical Rooms to NW Corner of Building and Consolidating Egress Points		**PAGE NO.** 1 of 4

ORIGINAL CONCEPT:

The original concept located the mechanical and electrical rooms in the NW corner of the building, and provided three separate egress points along the northern side of the building.

ALTERNATIVE CONCEPT:

The alternative concept locates the mechanical and electrical rooms in the NW corner of the building, and consolidates secondary egress points from the class rooms resulting in a reduction by one egress point. Furthermore, the floor plan changes allowed for the removal of one exterior door along the east elevation and eliminated one set of interior doors at the classrooms.

ADVANTAGES:

- Reduces the data and comm. runs to the building
- Reduces the number of code-required egress points
- One less interior door to access the class rooms
- Simplifies egress paths within the class rooms

DISADVANTAGES:

- Places mechanical equipment adjacent to staffed office space (but removes it from adjacent to the class rooms)

COST SUMMARY	INITIAL COST	O&M	LIFE-CYCLE COST
Original Concept	**$** 26,000	**$** 0	**$** 26,000
Alternative Concept	**$** 18,000	**$** 0	**$** 18,000
Savings	**$** 8,000	**$** 0	**$** 8,000

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS	
TITLE:	Reconfigure Training Center Floor Plan by Moving Mechanical/Electrical Rooms to NW Corner of Building and Consolidating Egress Points	**NUMBER** 5	**PAGE NO.** 2 of 4

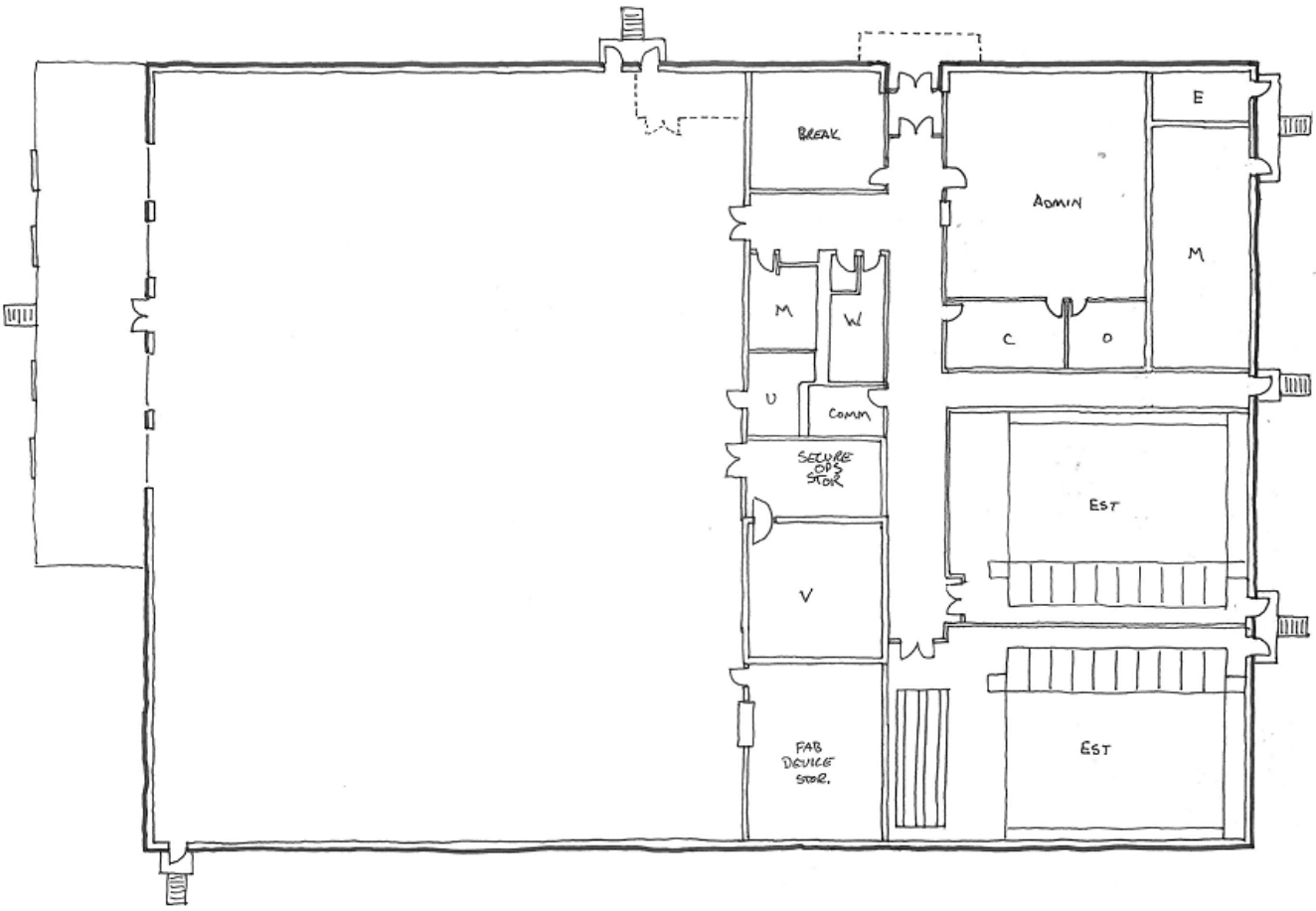
DISCUSSION / JUSTIFICATION:

This alternative was developed to shorten the runs of the electrical and comm. lines on site and to reduce egress points.

IMPLEMENTATION CONSIDERATIONS:

STC (sound transmission class) ratings must be addressed due to the mechanical noise and vibrations. Include in documentation; consider as part of the informational packet for bidders.

SKETCHES *Training Support Center – Fort Sam Houston*		VMS
TITLE: Reconfigure Training Center Floor Plan by Moving Mechanical/Electrical Rooms to NW Corner of Building and Consolidating Egress Points	**NUMBER** 5	**PAGE NO.** 3 of 4



Alternative Concept

ASSUMPTIONS and CALCULATIONS *Training Support Center – Fort Sam Houston*		
TITLE: Reconfigure Training Center Floor Plan by Moving Mechanical/Electrical Rooms to NW Corner of Building and Consolidating Egress Points	**NUMBER** 5	**PAGE NO.** 4 of 4

Assume a 150 kVA xmfr serving building

150 kVA x 1000 / 480 x sq rt 3 = 180 amps

Wire Size: Type THHN Cu Wire, 3/0 size, 75 deg C wire rated for 200 amps

Conduit Size: 3-inch.

Trench Size: 12”x24” deep

Cost Savings is for 200 ft of four (4) – 3/0 conductors in 3-inch conduit buried 24-inches below grade.

CONSTRUCTION ELEMENT		*ORIGINAL CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
				$ -			$ -
Distribution Voltage	Lf	620	42.32	$ 26,238	420	42.32	$ 17,774
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
SUB-TOTAL				$26,238			$17,774
PROJECT MARK-UPS				$0			$0
TOTAL (Rounded)				$26,000			$18,000
						SAVINGS	**$8,000**

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		VMS	
FUNCTION:	Architectural	**IDEA NO.** A6	**NUMBER** 6
TITLE:	Place Skylights in the Roof of the Warehouse		**PAGE NO.** 1 of 3

ORIGINAL CONCEPT:

Exposed ceiling with no provisions for the introduction of natural light.

ALTERNATIVE CONCEPT:

Provide standard skylights at 20% of the exposed Warehouse area: 3,020 Square Feet.

ADVANTAGES:

- LEED Point
- Natural Lighting
- Energy saving in conjunction with photodiode sensor based dimming controls

DISADVANTAGES:

- Additional maintenance

COST SUMMARY	INITIAL COST	O&M	LIFE-CYCLE COST
Original Concept	$ 0	$ 0	$ 0
Alternative Concept	$ 238,000	$ 0	$ 238,000
Savings	$ (238,000)	$ 0	$ (238,000)

VALUE ENGINEERING ALTERNATIVE *Training Support Center – Fort Sam Houston*		
TITLE: Place Skylights in the Roof of the Warehouse	**NUMBER** 6	**PAGE NO.** 2 of 3

DISCUSSION / JUSTIFICATION:

This alternative invests more in first costs but with energy savings over the life of the structure.

IMPLEMENTATION CONSIDERATIONS:

Revise RFP to include requirement for a specific percentage of warehouse square footage to be illuminated via day-lighting.

ASSUMPTIONS and CALCULATIONS

Training Support Center – Fort Sam Houston

VMS

TITLE: Place Skylights in the Roof of the Warehouse

NUMBER	PAGE NO.
6	3 of 3

CONSTRUCTION ELEMENT		*ORIGINAL CONCEPT*			*ALTERNATIVE CONCEPT*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
				$ -			$ -
Skylight w curb, flashing	Sf		-	$ -	3,020	68.75	$ 207,625
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
				$ -			$ -
SUB-TOTAL				$0			$207,625
PROJECT MARK-UPS	14.7%			$0			$30,521
TOTAL (Rounded)				$0			$238,000
						Savings	**($238,000)**

PROJECT INFORMATION

PROJECT INFORMATION

BACKGROUND

Army relocations to Fort Sam Houston will increase the quantity and type of live and virtual training devices used. Additional storage is needed to support the increases in training aid devices, and to protect the investment for those devices. Existing substandard warehouse buildings do not have additional capacity to support increased training aids and devices. Current warehouse buildings are fully engaged supporting existing missions.

This project has been coordinated with the installation physical security plan, and all physical security measures are included. All required antiterrorism protection measures are included. Alternative methods of meeting this requirement have been explored during project development. This project is the only feasible option to meet the requirement. The Deputy Assistant Secretary of the Army (Installations and Housing) certifies that this project has been considered for joint use potential. The facility will be available for use by other components. A parametric cost estimate based upon project engineering design was used to develop this budget estimate. Sustainable principles, to include Life Cycle cost-effective practices, will be integrated into the design, development, and construction of the project in accordance with the Executive Order 13423, 10 USC 2802(c), and other applicable laws and Executive orders.

PROJECT DESCRIPTION

This project requires the construction of a 29,200 square foot standard design Training Aids Center (TAC). Primary facilities include the TAC, storage shed, installation of Intrusion Detection System (IDS), connection to Energy Monitoring and Control System (EMCS), antiterrorism measures and building information systems. Supporting facilities include electric service, water, paving, walks, curbs and gutters, sanitary sewer, site preparation/ improvements, and information systems. Special foundations are required and heating and air conditioning will be provided by self contained systems. Access for individuals with disabilities will be provided. Sustainable Design and Development (SDD) and Energy Policy Act of 2005 (EPAct05) features will be provided. This project will be certified LEED silver according to LEED version NC v 2.2 rating system.

The estimated contract cost (construction cost limit) according to the DD Form 1391, dated 8 January 2010, is $5.395 M. The equivalent estimated construction cost according to the latest project cost estimate is $5.15 M, which is $245,000 under the DD 1391 estimated construction cost. The cost estimate was prepared by HSW Engineering at the draft RFP/conceptual design phase dated 2 April 2010. Estimated construction start is March 2011, with maximum one year construction duration.

PROJECT PURPOSE AND NEED

This project is needed to accommodate an increase in Army relocations to Fort Sam Houston. The quantity and type of live and virtual training devices used on base will increase as well, requiring additional storage to support the increase in training aid devices and to protect the investment for those

devices. To satisfy this need, the purpose of the project is to construct a Training Support Center that will provide additional training facilities and secure storage for training aid devices.

VE STUDY OBJECTIVES

The focus of the VE Study according to the project stakeholders is to study the building site, review the floor plan, and validate the cost estimate.

INFORMATION PROVIDED TO THE VE TEAM

The following project documents were provided to the VE team for their use during the study:

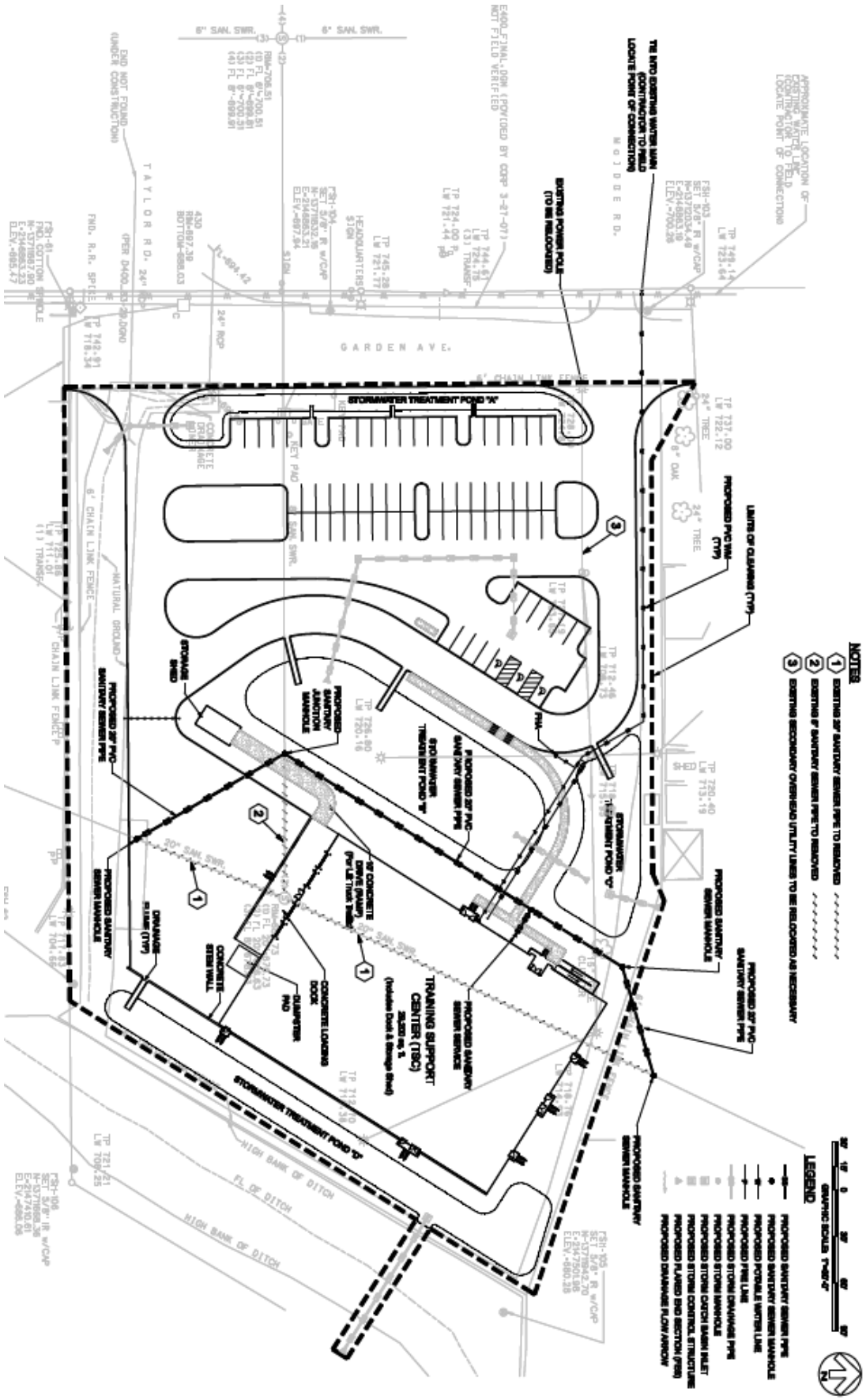
- Design Directive (includes DD 1391), 8 January 2010
- Draft RFP, 31 January 2010
- Summary Parametric Cost Report, 2 April 2010
- Fort Carson Training Support Center VE Study Report, 9 July 2009
- Project Definition Report, 16 February 2009
- Fort Sam Houston Training Support Center, Government Geotechnical Report, February 2010
- Revised floor plans, 7 April 2010

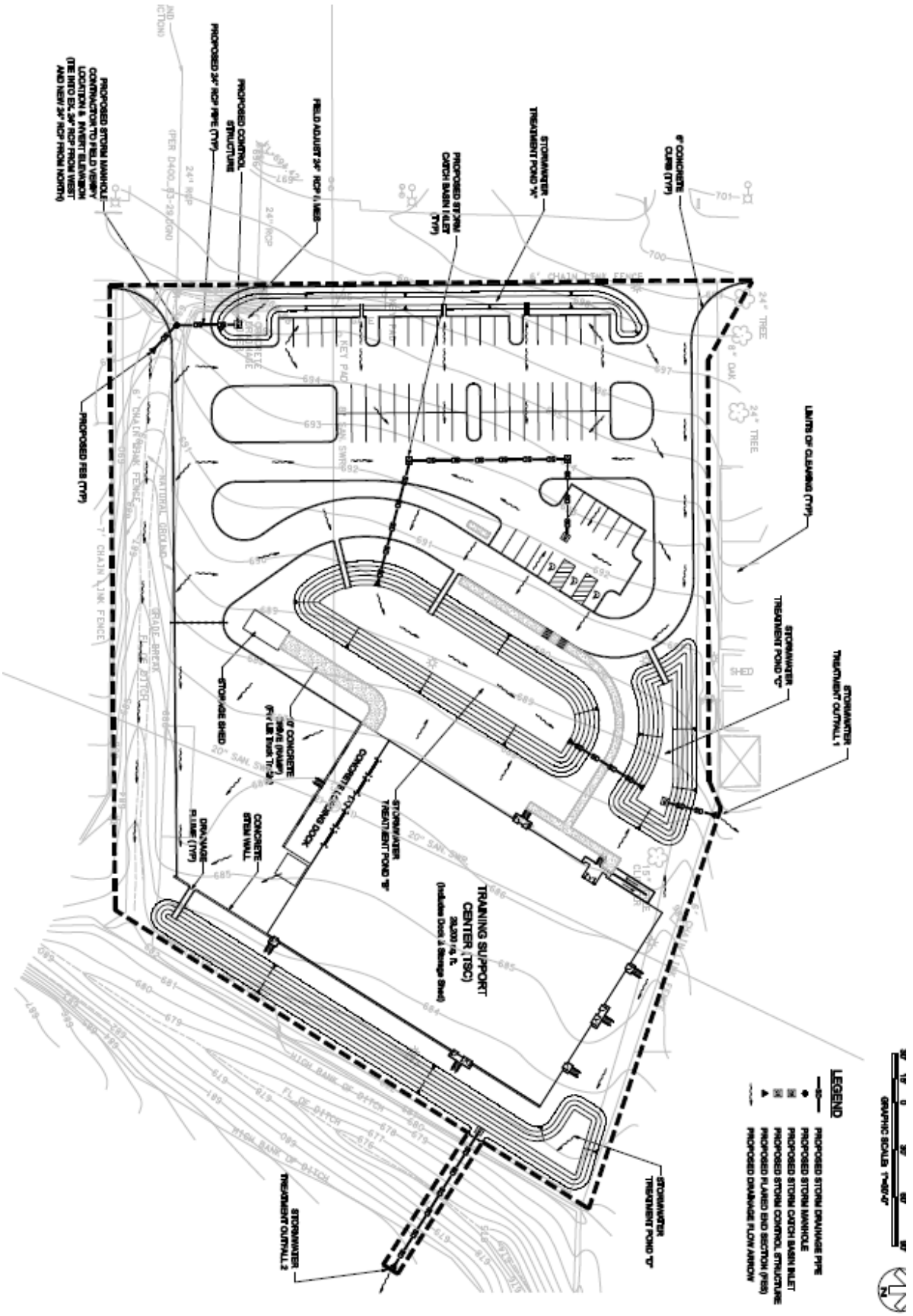
PROJECT DRAWINGS

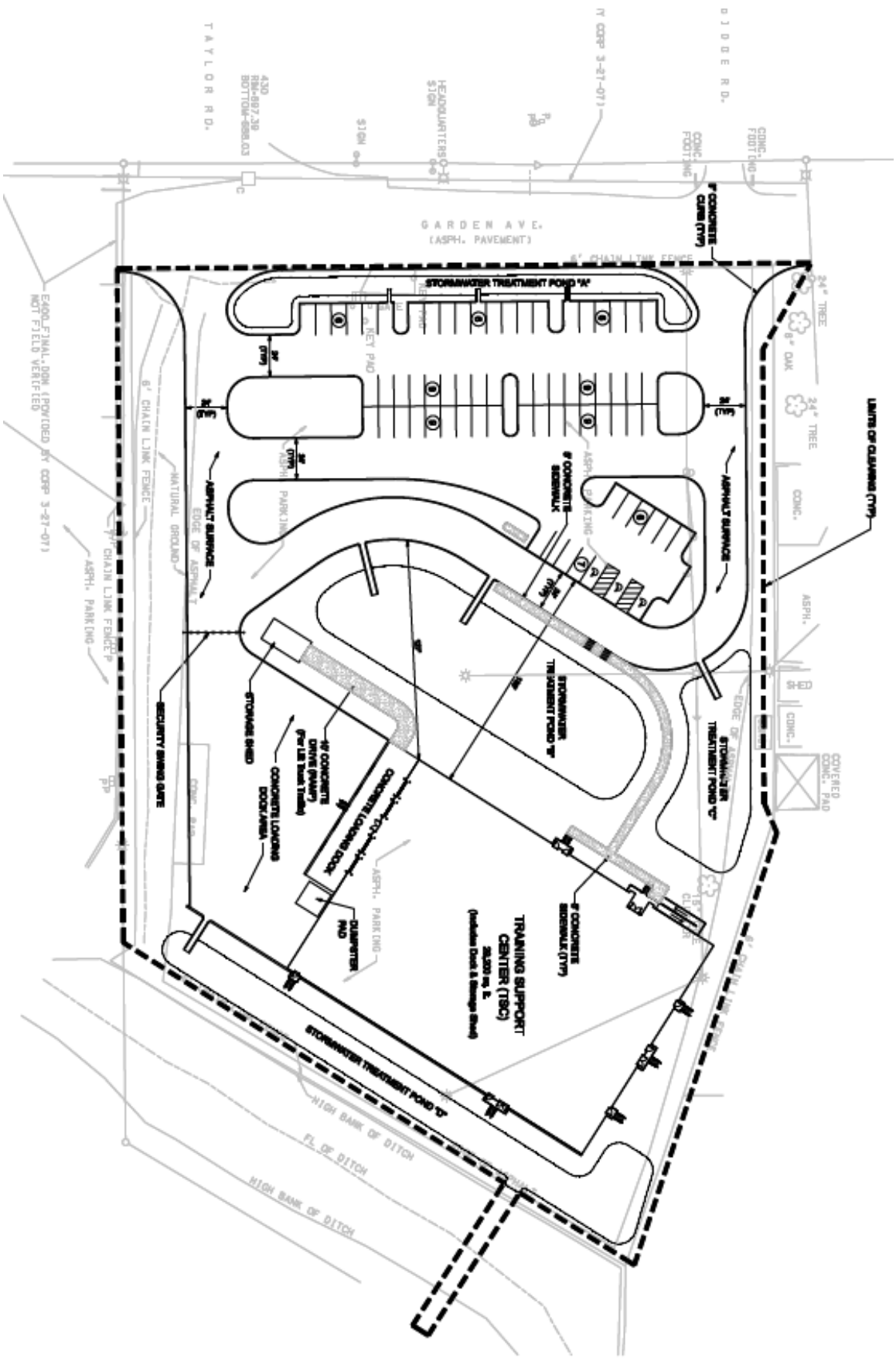
The project drawings are included on the following pages.

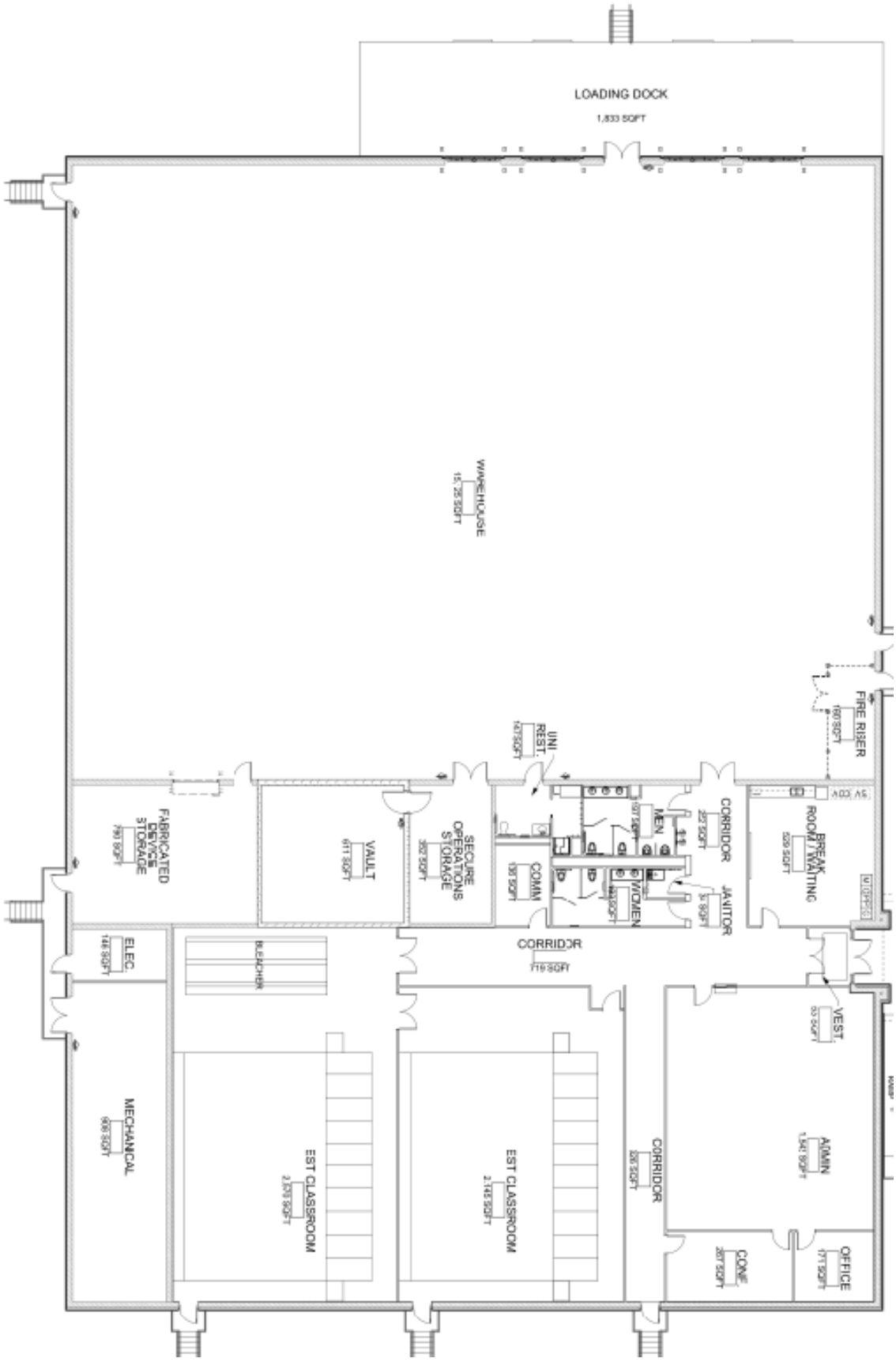
PROJECT COST ESTIMATE

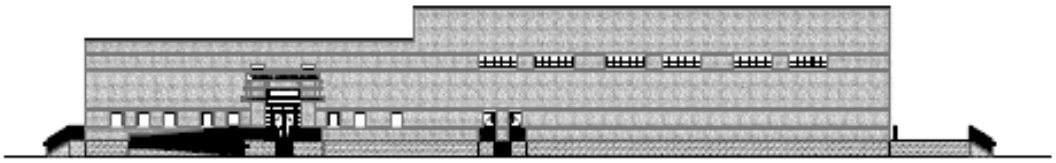
The project cost estimate is included at the end of this section.


NOTES:
1. EXISTING 20" SANITARY SEWER PIPE TO REMOVED
2. EXISTING 8" SANITARY SEWER PIPE TO REMOVED
3. EXISTING SECONDARY OVERHEAD UTILITY LINES TO BE RELOCATED AS NECESSARY
LEGEND
PROPOSED SANITARY SEWER PIPE
PROPOSED SANITARY SEWER MANHOLE
PROPOSED POTABLE WATER LINE
PROPOSED FIRE LINE
PROPOSED STORM DRAINAGE PIPE
PROPOSED STORM MANHOLE
PROPOSED STORM CATCH BASIN INLET
PROPOSED STORM CONTROL STRUCTURE
PROPOSED PLANTED SWD SECTION (PSS)
PROPOSED DRAINAGE FLOW ARROW
GRAPHIC SCALE: 1"=50'
STORMWATER TREATMENT POND "A"
STORMWATER TREATMENT POND "B"
STORMWATER TREATMENT POND "C"
TRAINING SUPPORT CENTER (TSC)
GARDEN AVE.
TAYLOR RD.
MOODE RD.
LIMITS OF CLEARING (TYP)
PROPOSED PVC WM (TYP)
PROPOSED 20" PVC SANITARY SEWER PIPE
PROPOSED SANITARY SEWER MANHOLE
PROPOSED SANITARY SEWER SERVICE
PROPOSED 8" PVC SANITARY SEWER PIPE
PROPOSED SANITARY JUNCTION MANHOLE
STORAGE SHED
CONCRETE STEM WALL
CONCRETE LOADING DOCK
DUMPSTER PAD
DRAINAGE FLUME (TYP)
HIGH BANK OF DITCH
FL OF DITCH
HIGH BANK OF DITCH
6' CHAIN LINK FENCE
NATURAL GROUND
EXISTING 20" SANITARY SEWER PIPE TO REMAIN
EXISTING POWER POLE (TO BE RELOCATED)
TIE INTO EXISTING WATER MAIN (CONTRACTOR TO FIELD LOCATE POINT OF CONNECTION)
APPROXIMATE LOCATION OF EXISTING WATER LINE TO BE TIED-IN. CONTRACTOR TO FIELD LOCATE POINT OF CONNECTION
6" SAN. SWR.
20" SAN. SWR.
24" ROP
24" TREE
6" OAK
END MOT FOUND (UNDER CONSTRUCTION)
FND. R.R. SPIKE
FSH-101 FND. COTTON SPINDLE
FSH-102 SET 5/8" R w/CAP
FSH-103 SET 5/8" R w/CAP
FSH-104 SET 5/8" R w/CAP
FSH-105 SET 5/8" R w/CAP
FSH-106 SET 5/8" IR w/CAP
HEADQUARTERS SIGN
CONCRETE DRIVE
KEY PAD
FIRE HYDRANT
STORAGE SHED
TRANSF.
TP 148.14 LW 123.64
TP 744+61 LW 724.78 (3) TRANSF.
TP 724.00 LW 721.44 PB
TP 745.28 LW 721.77
TP 737.00 LW 722.12
TP 712.46 LW 708.15
TP 726.90 LW 720.16
TP 730.40 LW 713.19
TP 711.00 LW 704.68
TP 721.21 LW 709.25
TP 142.91 LW 118.34
RIM=706.51 (10) FL @+699.81 (32) FL @+699.81 (33) FL @+700.31 (40) FL @+699.81
RIM=697.39 430 BOTTOM=688.03
ELEV.=700.36
ELEV.=697.84
ELEV.=695.47
ELEV.=695.23
ELEV.=700.85
ELEV.=695.38
ELEV.=696.06
N 13716867.80 E 2146883.23
N 13716930.81 E 2146883.21
N 13716942.70 E 2147501.98
N 13717010.61 E 2147410.61

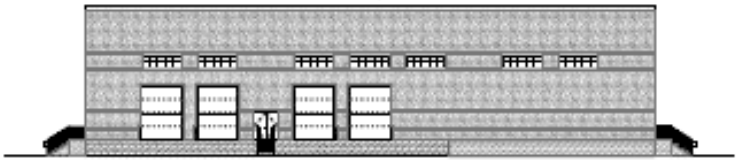

TRAINING SUPPORT CENTER (TSC)
28,700 sq. ft.
(Includes Dock & Storage Shed)
STORMWATER TREATMENT POND "A"
STORMWATER TREATMENT POND "B"
STORMWATER TREATMENT POND "C"
STORMWATER TREATMENT POND "D"
STORMWATER TREATMENT OUTFALL 1
STORMWATER TREATMENT OUTFALL 2
PROPOSED STORM MANHOLE
PROPOSED 24" RCP PIPE (TYP)
PROPOSED CONTROL STRUCTURE
FIELD ADJUST 24" RCP (LMED)
PROPOSED STORM CATCH BASIN INLET (TYP)
6" CONCRETE CURB (TYP)
LIMITS OF CLEARING (TYP)
PROPOSED FES (TYP)
CONCRETE RETAINING WALL
CONCRETE SPAN WALL
DRAINAGE FLUME (TYP)
STORAGE SHED
LEGEND
PROPOSED STORM DRAINAGE PIPE
PROPOSED STORM MANHOLE
PROPOSED STORM CATCH BASIN INLET
PROPOSED STORM CONTROL STRUCTURE (FES)
PROPOSED FLARED END SECTION (FES)
PROPOSED DRAINAGE FLOW ARROW
GRAPHIC SCALE 1"=60'-0"


GARDEN AVE.
(ASPH. PAVEMENT)
TAYLOR RD.
DODGE RD.
STORMWATER TREATMENT POND "A"
STORMWATER TREATMENT POND "B"
STORMWATER TREATMENT POND "C"
TRAINING SUPPORT CENTER (TSC)
STORAGE SHED
SECURITY SWING GATE
DUMPSTER PAD
ASPHALT SURFACE
6' CHAIN LINK FENCE
NATURAL GROUND
ASPH. PARKING
CONC.
LIMITS OF CLEARING (TYP)
HIGH BANK OF DITCH
FL OF DITCH

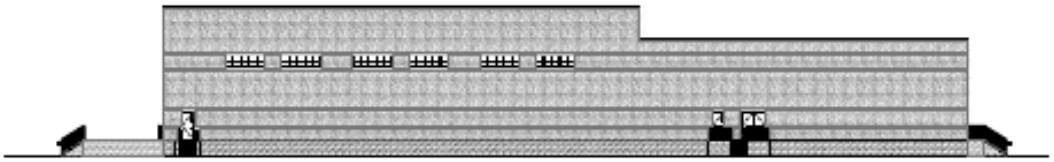

LOADING DOCK
1,833 SQFT
WAREHOUSE
15,283 SQFT
FIRE RISER
160 SQFT
UNI REST.
142 SQFT
MEN
197 SQFT
CORRIDOR
257 SQFT
BREAK ROOM / WAITING
539 SQFT
FABRICATED DEVICES STORAGE
790 SQFT
VAULT
611 SQFT
SECURE OPERATIONS STORAGE
382 SQFT
COMM
130 SQFT
WOMEN
JANITOR
CORRIDOR
719 SQFT
ELEC.
148 SQFT
BLEACHER
VEST.
MECHANICAL
606 SQFT
EST CLASSROOM
2,570 SQFT
EST CLASSROOM
2,142 SQFT
CORRIDOR
ADMIN
1,541 SQFT
CONF.
OFFICE



BUILDING ELEVATION



BUILDING ELEVATION



BUILDING ELEVATION

BUILDING ELEVATION

PC-Cost Detailed Report

Current Working Estimates For Budget Purposes

Fiscal Year: 2011
Estimate Name: FY11 FSH (TSC) 30% Design Build PN071116
Project Title: Training Support Center, Ft. Sam Houston, TX
Location: Fort Sam Houston, TX

Date Printed: 04/02/2010
Date Revised: 04/02/2010
Area Cost Factor: 0.94
Type of Construction: NPM New Permanent

Basis of Estimate: Project Definition
Concept Complete: 14.29 %
Design Complete: 5.00 %
Prepared By: David Nortman
Office: **Phone:** 817-886-1814

Name and Address of AE:
HSW Engineering / Mason & Hanger
3820 Northdale Blvd., Suite 210B
Tampa, FL 33624

Catcode	Description	UOM	Quantity	Unit Cost	Total Cost ($000)
Primary Facility					**4,192**
14129	**Training Aids Center**	**SF**	**29,000.00**	**130.64**	**(3,789)**
14129	**Special Foundations**	**SF**	**29,200.00**	**5.11**	**(149)**
88040	**IDS Installation**	**SF**	**1.00**	**7,855.38**	**(8)**
89240	**EMCS Connection**	**EA**	**1.00**	**26,511.92**	**(27)**
44222	**Storage Shed, Covered**	**SF**	**364.00**	**43.50**	**(16)**
00005	**SDD and EPAct05**	**LS**			**(77)**
00005	SDD and EPAct05	LS			76.6
88041	**Antiterrorism Measures**	**LS**			**(90)**
88041	Antiterrorism Measures	LS			90.3
80800	**Building Information Systems**	**LS**			**(37)**
80800	Building Information Systems	LS			37.3
Supporting Facilities					**958**

Fiscal Year: 2011 **Date Printed:** 04/02/2010
Estimate Name: FY11 FSH (TSC) 30% Design Build PN071116 **Date Revised:** 04/02/2010
Project Title: Training Support Center, Ft. Sam Houston, TX **Area Cost Factor:** 0.94
Location: Fort Sam Houston, TX **Type of Construction:** NPM New Permanent

Catcode	Description	UOM	Quantity	Unit Cost	Total Cost ($000)
Supporting Facilities (Continued)					
	Electric Service	**LS**			**(94)**
81242	UG Ducts 2-way-4"	LF	1,000.00	28.66	28.7
81360	Transformers - 150 kVA	EA	1.00	15,353.35	15.4
81230	Exterior Lighting	LF	850.00	40.95	34.8
93410	Cut and Fill	CY	100.00	15.36	1.5
	Primary Electrical Wire	LF	30.00	446.78	13.4
	Water, Sewer, and Gas	**LS**			**(67)**
83210	Plastic Reinforced (Sewer)	LF	225.00	63.30	14.2
83210	Concrete Manholes, PCST, 8' Deep (Sewer)	LF	50.00	397.44	19.9
82410	HDPE (Water)	LF	150.00	19.44	2.9
83210	PVC, Schedule 40 (Potable Water / Fire)	LF	270.00	31.18	8.4
89240	Fire Hydrants	EA	1.00	2,975.69	3.0
82410	Gas Regulator & Meter	EA	1.00	3,582.06	3.6
	Trench and Backfill	CY	250.00	19.64	4.9
	Valves and Cleanouts (Water / Sewer)	EA	12.00	857.22	10.3
	Paving, Walks, Curbs, and Gutters	**LS**			**(317)**
85110	A/C Surface (Asphalt Parking & Drive)	SY	5,428.00	9.30	50.5
85210	Concrete (Concrete Loading Dock Area)	SY	1,462.00	30.05	43.9
85110	Base Course (Crushed Stone)	SY	8,500.00	18.44	156.7
85211	Curb/Gutter 6" X 8"	LF	3,310.00	15.68	51.9
87250	Gates - 24 ft pair	EA	1.00	1,451.42	1.5
85210	Concrete (Sidewalks/Ramp)	SY	430.00	30.05	12.9
	Storm Drainage	**LS**			**(48)**
87110	Concrete Reinforced (Storm Pipe)	LF	250.00	44.45	11.1
83210	Catch Basins, 6' Deep	EA	6.00	2,853.92	17.1
87110	Concrete Flared End Section (FES)	EA	6.00	1,178.31	7.1
83210	Concrete Manholes, PCST, (Storm Manhole)	LF	8.00	369.07	3.0
87110	Excavation and Backfill	CY	630.00	15.36	9.7

Current Working Estimates For Budget Purposes

Fiscal Year: 2011 **Date Printed:** 04/02/2010

Estimate Name: FY11 FSH (TSC) 30% Design Build PN071116 **Date Revised:** 04/02/2010

Project Title: Training Support Center, Ft. Sam Houston, TX **Area Cost Factor:** 0.94

Location: Fort Sam Houston, TX **Type of Construction:** NPM New Permanent

Catcode	Description	UOM	Quantity	Unit Cost	Total Cost ($000)
Supporting Facilities (Continued)					
	Site Improvements	**LS**			**(246)**
93210	Site Clearing & Grubbing	AC	4.18	3,866.47	16.2
93210	Grading Rough	SY	12,800.00	2.49	31.9
93210	Grading Fine	SY	9,700.00	1.20	11.6
	Concrete Pads	EA	2.00	7,676.67	15.4
	Dumpster Enclosure	EA	1.00	12,794.46	12.8
93410	Excavation Common Earth	CY	4,800.00	8.11	38.9
93220	Seeding/Grass Hyd w/Fertilizer	SY	7,536.00	0.74	5.6
93220	Haul & Spread/Topsoil	CY	5,890.00	19.36	114.0
	Demolition	**LS**			**(14)**
93410	Trench-Machine	CY	1,200.00	5.53	6.6
93410	Backfill-Machine	CY	1,200.00	6.45	7.7
	Information Systems	**LS**			**(171)**
80800	Information Systems	LS			170.9

Estimated Contract Cost		**5,150**
Contingency	5.00 %	258
Subtotal		5,408
Supervision, Inspection, and Overhead	5.70 %	308
Design/Build - Design Cost	4.00 %	216

Current Working Estimates For Budget Purposes

Fiscal Year: 2011 **Date Printed:** 04/02/2010

Estimate Name: FY11 FSH (TSC) 30% Design Build PN071116 **Date Revised:** 04/02/2010

Project Title: Training Support Center, Ft. Sam Houston, TX **Area Cost Factor:** 0.94

Location: Fort Sam Houston, TX **Type of Construction:** NPM New Permanent

Catcode	Description	UOM	Quantity	Unit Cost	Total Cost ($000)
Project Cost					**5,932**
Project Cost (Rounded)					**5,900**

Construction Dates

Start Date	01 Mar 2011	2531
Midpoint Date	01 Sep 2011	2553
Completion Date	01 Mar 2012	2575

Currency Exchange Rate: 1.0000 DOLLARS

Percent of Supporting Costs to Primary Costs: 22.85 %

Project Incrementally Funded: No

PROJECT ANALYSIS

PROJECT ANALYSIS

SUMMARY OF ANALYSIS

The following value engineering tools were used to study the project:

- Project Issues
- Cost Model
- Function Analysis
  - Random Function List
  - FAST Diagram

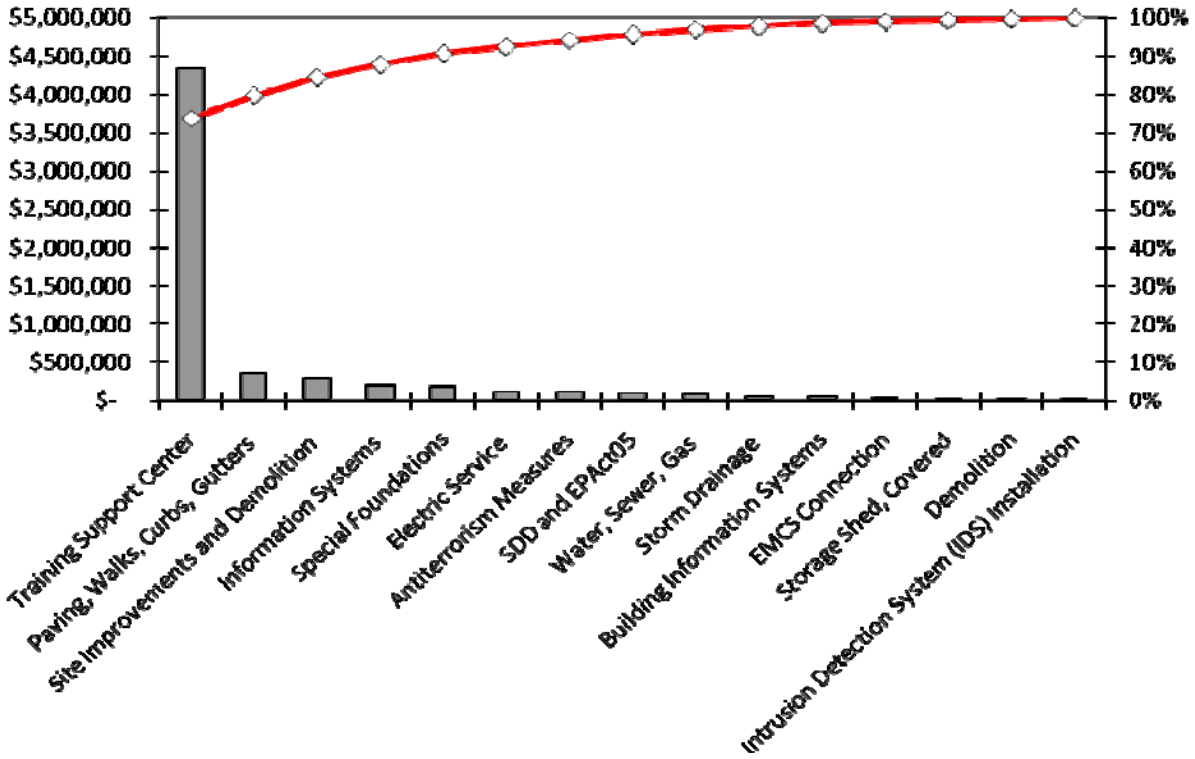
PROJECT ISSUES

- The estimated contract cost (construction cost limit) according to the DD Form 1391, dated 8 January 2010, is $5.395 M. The equivalent estimated construction cost according to the latest project cost estimate is $5.15 M, which is $245,000 under the DD 1391 estimated construction cost.
- Stormwater detention and quality improvement seems overdesigned; appears to be designed for both detention and quality but runoff is actually decreased by the project over the existing conditions.
- The site has a significant downward slope to the west and the team feels that the loading dock could be positioned to take advantage of this topography.
- Exterior finishes have not been determined. A local architect will be recommending a theme for this project, and would provide that information to the designers. Concrete block, metal panel, and EIFS (Exterior Insulation and Finish Systems) have all been used at Fort Sam Houston.
- The ATFP setback from the west, south, and the westerly half of the northern property line impacted the siting of the building on the lot. The easterly property line did not require any ATFP setback.
- The area of the warehouse portion of the building (15,000 SF) was used to determine the remaining functional spaces. The gross square footage for the building is roughly 29,200 SF.
- The Design Builder will be required to obtain a Silver LEED accreditation for this project. The preferences by Fort Sam Houston are currently being identified and will be incorporated into the RFP documents.

COST MODEL

The VE Team Leader prepared a cost model from the HSW Engineering cost estimates. The model is organized to identify major construction elements or trade categories, the designer's estimated costs, and the percent of total project cost for the significant cost items. This cost model clearly showed the cost drivers for the project and was used to guide the VE team during the VE Study.

Pareto Cost Model



PARETO COST MODEL *Training Support Center*				
Cost Item	**Cost**		**% of Total**	**Cumulative %**
Training Support Center	$	4,341,092	74%	74%
Paving, Walks, Curbs, Gutters	$	363,232	6%	80%
Site Improvements and Demolition	$	282,450	5%	85%
Information Systems	$	195,824	3%	88%
Special Foundations	$	169,802	3%	91%
Electric Service	$	107,709	2%	93%
Antiterrorism Measures	$	103,470	2%	94%
SDD and EPAct05	$	87,772	1%	96%
Water, Sewer, Gas	$	77,001	1%	97%
Storm Drainage	$	55,000	1%	98%
Building Information Systems	$	42,740	1%	99%
EMCS Connection	$	30,378	1%	99%
Storage Shed, Covered	$	18,143	0%	100%
Demolition	$	16,386	0%	100%
Intrusion Detection System (IDS) Installation	$	9,001	0%	100%
TOTAL	**$**	**5,900,000**	**100%**	**100%**

VE COST ESTIMATE REVIEW

Review of the Parametric Cost Estimate dated 2 April 2010 by HSW engineering resulted in the following revised cost estimate.

CONSTRUCTION ELEMENT		*HSW Engineering 4/2/2010*			*VE REVIEW 4/8/2010*		
Description	**Unit**	**Quantity**	**Cost/Unit**	**Total**	**Quantity**	**Cost/Unit**	**Total**
Primary Facilities							
Training Aids Center (200' x 145')	Sf	29,000	130.64	$ 3,788,560	29,000	130.64	$ 3,788,560
Special Foundations	Sf	29,000	5.11	$ 148,190	29,000	5.11	$ 148,190
IDS Installation	Ls	1	7,855.38	$ 7,855	1	7,855.38	$ 7,855
EMCS Connection	Ea	1	26,511.92	$ 26,512	1	26,511.92	$ 26,512
Storage Shed, Covered	Sf	364	43.50	$ 15,834	364	43.50	$ 15,834
SDD and EPA	Ls	1	76,600.00	$ 76,600	1	76,600.00	$ 76,600
Antiterrorism Measures	Ls	1	90,300.00	$ 90,300	1	90,300.00	$ 90,300
Building Information Systems	Ls	1	37,300.00	$ 37,300	1	37,300.00	$ 37,300
				$ -			$ -
Supporting Facilities				$ -			$ -
Electric Service				$ -			$ -
Tie-In to Overhead Distribution	Ea			$ -	1	3,132.00	$ 3,132
Underground Distribution Voltage - Road	Lf			$ -	60	160.00	$ 9,600
Premium - Below active road	Lf			$ -	60	120.00	$ 7,200
Electrical Box	Lf			$ -	1	622.00	$ 622
Distribution Voltage	Lf			$ -	620	42.32	$ 26,238
Transformers 150 kVA	Ea	1	15,353.35	$ 15,353	1	15,353.35	$ 15,353
UG Ducts 2 -4"	Lf	1,000	28.66	$ 28,660	0	28.66	$ -
Primary Electrical Wire	Lf	30	446.78	$ 13,403	0	446.78	$ -
Cut and fill	Cy	100	15.36	$ 1,536	0	15.36	$ -
Exterior Lighting	Lf	850	40.95	$ 34,808	850	40.95	$ 34,808
Remove Existing Secondary Overhead Lines	Sy			$ -	20,231	0.50	$ 10,116
				$ -			$ -
Domestic & Fire Water Service				$ -			$ -
HDPE Piping	Lf	150	19.44	$ 2,916	150	19.44	$ 2,916
PVC, Schedule 40 - Domestic	Lf	270	31.18	$ 8,419	270	31.18	$ 8,419
PVC, Schedule 40 - Fire	Lf			$ -	130	31.18	$ 4,053
Fire Hydrants	Ea	1	2,975.69	$ 2,976	1	2,975.69	$ 2,976
Meter, PIV, Backflow Preventor	Ea			$ -	1	11,776.00	$ 11,776
Trench and Backfill	Cy	163	19.64	$ 3,201	214	19.64	$ 4,203
Valves and Cleanout	Ea	8	857.22	$ 6,858	4	857.22	$ 3,429
				$ -			$ -
Sanitary Sewer Service				$ -			$ -
Plastic Piping, reinforced	Lf	225	63.30	$ 14,243	25	63.30	$ 1,583
Manholes PCST 8' Deep	Lf	50	397.44	$ 19,872			$ -
Trench and Backfill	Cy	87	19.64	$ 1,709	10	19.64	$ 196
Valves and Cleanout	Ea	4	857.22	$ 3,429	4	857.22	$ 3,429
				$ -			$ -
Relocation of Existing Sanitary Sewer				$ -			$ -
Relocated 20" Sanitary Sewer Pipe	Lf			$ -	430	63.30	$ 27,219
Manholes PCST 8' Deep	Ea			$ -	4	11,776.00	$ 47,104
Trench and Backfill	Cy			$ -	167	19.64	$ 3,280
Valves	Ea			$ -	2	857.22	$ 1,714
Connect into Existing Line (Hot)	Loc			$ -	2	20,240.00	$ 40,480
Remove Existing 20" Sanitary Sewer Pipe	Lf			$ -	330	45.00	$ 14,850
Remove Existing 8" Sanitary Sewer Pipe	Lf			$ -	90	25.00	$ 2,250

Gas Service				$ -			$ -
Regulator and Meter	Ea	1	3,582.06	$ 3,582	1	3,582.06	$ 3,582
High Pressure Line	Lf			$ -	420	20.24	$ 8,501
				$ -			$ -
Storm Drain System				$ -			$ -
Concrete Piping	Lf	250	44.45	$ 11,113			$ -
Catch Basins, 6' Dpth	Ea	6	2,853.92	$ 17,124			$ -
Concrete Flared End Section	Ea	6	1,178.31	$ 7,070			$ -
Manholes, PCST	Lf	8	369.07	$ 2,953			$ -
Excavation and Backfill	Cy	630	15.36	$ 9,677			$ -
Storm Drain System (below grade)	Sy			$ -	14,856	8.28	$ 123,008
				$ -			$ -
Paving, Walks, Curbs & Gutters				$ -			$ -
Asphalt Parking and Drives	Sy	5,428	9.30	$ 50,480	5,428	9.30	$ 50,480
Concrete Paving - Loading Dock Area	Sy	1,462	30.05	$ 43,933	1,462	30.05	$ 43,933
Concrete Sidewalks / Ramps	Sy	430	30.05	$ 12,922	430	30.05	$ 12,922
Base Course (Crushed Stone)	Sy	8,500	18.44	$ 156,740	8,500	18.44	$ 156,740
Curbs and Gutters	Lf	3,310	15.68	$ 51,901	3,310	15.68	$ 51,901
Gates - 24' Pair (Security)	Ea	1	1,451.42	$ 1,451	1	1,451.42	$ 1,451
Exiting Landing (7 loc)	Sf			$ -	490	41.40	$ 20,286
Exiting Stairs (8 loc, 24 Lf)	Sf			$ -	250	82.80	$ 20,700
ADA Ramp and Railing - Entrance (32'x10')	Sf			$ -	320	41.40	$ 13,248
ADA Ramp and Railing - Dock (32'x14')	Sf			$ -	448	41.40	$ 18,547
Dock Platform	Sf			$ -	1,833	41.40	$ 75,886
Perimeter Fencing	Lf			$ -	420	13.60	$ 5,712
Entrance Gates 2 sets, Sliding	St			$ -	2	16,620.00	$ 33,240
				$ -			$ -
Site Improvements				$ -			$ -
Clearing & Grubbing	AC	4	3,866.47	$ 16,162			$ -
Clearing & Grubbing - South Side Drainage	Sy			$ -	2,131	0.20	$ 426
Grading Rough	Sy	12,800	2.49	$ 31,872	18,100	2.49	$ 45,069
Grading fine	Sy	9,700	1.20	$ 11,640	9,700	1.20	$ 11,640
Concrete Pads	Ea	2	7,676.67	$ 15,353	2	7,676.67	$ 15,353
Dumpster Enclosure	Ea	1	12,794.46	$ 12,794	1	12,794.46	$ 12,794
Excavation Common Earth	Cy	4,800	8.11	$ 38,928	4,800	8.11	$ 38,928
Grass Seeding	Sy	7,536	0.74	$ 5,577	7,536	0.74	$ 5,577
Haul and Spread Topsoil	Cy	5,890	19.36	$ 114,030	5,890	19.36	$ 114,030
				$ -			$ -
Demolition				$ -			$ -
Trench Machine	Cy	1,200	5.53	$ 6,636			$ -
Backfill Machine	Cy	1,200	6.45	$ 7,740			$ -
Remove Asphalt Paving	Sy			$ -	18,100	0.65	$ 11,765
Haul Off Site (assume 4")	Lds			$ -	110	420.00	$ 46,200
Dump Fee (NIC)	Cy			$ -	2,594	-	$ -
Remove Perimeter Fencing	Lf			$ -	1,690	2.60	$ 4,394
Information Systems				$ -			$ -
Information Systems	Ls	1	170,900.00	$ 170,900	1	170,900.00	$ 170,900
				$ -			$ -
				$ -			$ -
Subtotal				$5,149,110			$5,595,311
Project Markups %	14.7%			$756,919			$822,511
TOTAL (Rounded)				$5,906,000			$6,418,000
						Savings	**($512,000)**

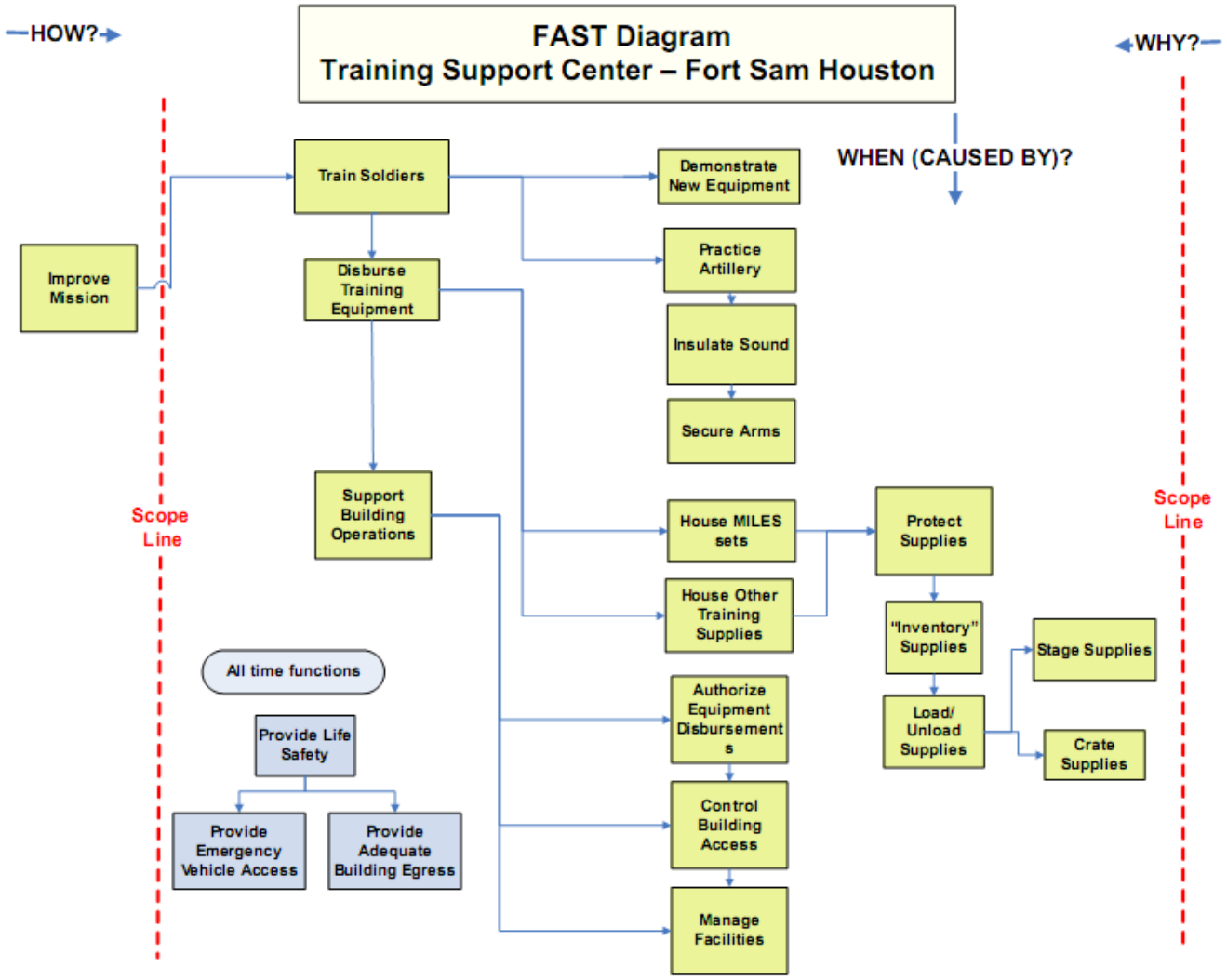
FUNCTION ANALYSIS

Function analysis was performed and a Function Listing and FAST Diagram were produced, which revealed the key functional relationships for the project. This analysis provided a greater understanding of the total project and how the issues, project cost, and function requirements are related.

Functional Listing

Item	Verb	Noun
Classrooms	Train	Troops
	Practice	Firing
	Demonstrate	New equipment
	Insulate	Sound
	Provide	Egress (life safety)
Bleachers	Review	Others training
	Wait	Turn
Warehouse	House	MILES sets, TADSS
	Handle	Stuff
	Load/unload	Stuff
Facilities Sizing	Locate	1.05 Brigades
Retail Space	Issue	Tags
Admin Area	Monitor	Circulation
	Accommodate	Flexible Personnel amount
	Assemble	Personnel
Break room	Provide	Refreshments
	Assemble	Informal events
Vault	Secure	Arms
GTA Storage	Store	General supplies
	Provide	Open warehouse area
Secure Ops Storage	Secure	High-value/sensitive equipment
Fabricated Device repair/storage	Fabricate	Shipping Crates
Mechanical Room	Contain	HVAC, etc.
Electrical Room	Store	Electrical Equipment

FAST Diagram



IDEA EVALUATION

IDEA EVALUATION

The ideas generated by the VE team were carefully evaluated, and project-specific attributes were applied to each idea to assure an objective evaluation.

EVALUATION CRITERIA

The VE team used the following criteria to evaluate each idea:

- Operations and Maintenance
- Meeting User's Needs
- Meeting Schedule
- LEEDs

The team developed the evaluation criteria based on project objectives and constraints provided by the owner and their design consultant, HSW Engineering at the In-Briefing meeting to reflect their specific requirements.

EVALUATION PROCESS

The VE team, as a group, generated and evaluated ideas on how to perform the various functions. The idea list was grouped by function or major project element.

The team compared each of the ideas with the original concept for each of the performance attribute to determine whether it was better than, equal to, or worse than the original concept. The team reached a consensus on the ranking of the idea. High-ranked ideas would be developed further; low-ranked ones would be dropped from further consideration.

IDEA EVALUATION FORMS

All of the ideas that were generated during the creative phase using brainstorming techniques were recorded on the following Idea Evaluation forms. These ideas were discussed and the advantages and disadvantages of each were listed.

IDEA EVALUATION

Training Support Center – Fort Sam Houston

VMS

Ideas		Advantages	Disadvantages	$	RANK
No.	**Function**				
SITE					
S-1	Reorient the building to take advantage of the natural topography	♦ Reduce earthwork ♦ Reduce overall building height ♦ Improved drainage	♦ Dealing with AT/FP ♦ Impacts on stormwater detention	+	5
S-2	Reorient the building to allow for future horizontal expansion	♦ Greater future flexibility	♦ AT/FP issue	0	See S1
S-3	Construct outdoor canopy to allow for outside activities/training	♦ Cost savings	♦ Counts toward total square footage of structure- therefore would deduct from building square footage	+	2
S-4	Reduce POV	♦ Cost savings ♦ Less run-off	♦ Does not meet UFC requirements	+	2
S-5	Consolidate parking and drive aisles	♦ Cost savings ♦ Less run-off	♦ Reduces ability to segregate traffic	+	See S1
S-6	Minimize detention areas	♦ Less runoff generated by the new site ♦ Quality in lieu of quantity improvements many the only requirement ♦ Cost savings	♦ Detention may be required per(438 req.)	+	DS
S-7	Use outer islands as part of the detention system	♦ Cost savings ♦ Less run-off	♦ Possible maintenance concerns ♦ Landscaping issues may be a concern	+	See S6
S-8	Use southern drainage swale as detention pond	♦ Possible cost savings	♦ May not be technically feasible	+	See S1

Ranking Scale:
5 = Significant Value Improvement
4 = Good Value Improvement
3 = Minor Value Improvement
2 = Minor Value Degradation
1 = Significant Value Degradation or Does Not Meet Project Purpose and Need
DS= Design Suggestion
ABD = Already Being Done

Performance Attributes: Significant Improvement +2, +1, 0, -1, -2 Significant Degradation

IDEA EVALUATION

Training Support Center – Fort Sam Houston

VMS

Ideas		Advantages	Disadvantages	$	RANK
No.	**Function**				
S-9	Add decel/accel lanes (on property)	♦ Reduces collision potential (heavily travelled road) ♦ Improves access to site	♦ Cost increase ♦ Impacts usable land within the site Less run-off	-	2
S-10	Use ponds to benefit grading scheme	♦ Earthwork benefit ♦ Use of spoils from pond ♦ Possible cost savings	♦ Technically infeasible	+	2
S-11	Underground detention system	♦ Minimize grading drainage areas	♦ Cost increase ♦ Possible geotechnical issues	-	2
S-12	Reorient the building to avoid relocation/ replacement of the sanitary sewer	♦ Eliminates cost of replacing existing pipe	♦ Limits placement of the building	+	4
S-13	Connect 10’ wide ramp to paved loading area	♦ Improves loading/unloading operations	♦ Cost increase	-	DS
S-14	Connect loading dock with switchback ramp	♦ Improves loading/unloading operations	♦ Cost increase	-	ABD
S-15	Reduce the undergrounding of the electrical feed	♦ Cost reduction	♦ Requires relocation of building	+	See S1
S-16	Reduce the undergrounding of the data feed	♦ Cost reduction	♦ Requires relocation of building	+	See S1
S-17	Lengthen loading dock	♦ Maximizes loading/unloading ops	♦ Increase costs	-	4
S-18	Add photovoltaic panels over select parking spaces	♦ Can be applied towards LEED credits	♦ Covered space counts against total SF ♦ Increase costs	-	2

Ranking Scale: **5** = Significant Value Improvement; **4** = Good Value Improvement; **3** = Minor Value Improvement; **2** = Minor Value Degradation; **1** = Significant Value Degradation or Does Not Meet Project Purpose and Need; **DS**= Design Suggestion; **ABD** = Already Being Done

Performance Attributes: Significant Improvement +2, +1, 0, -1, -2 Significant Degradation

IDEA EVALUATION

Training Support Center – Fort Sam Houston

VMS

Ideas		Advantages	Disadvantages	$	RANK
No.	**Function**				
S-19	Provide single lane truck drive	♦ Could reduce drive aisle by 12' ♦ Reduces first costs	♦ Reduces vehicle access options	+	4
♦ ARCHITECTURE					
A-1	Design slab for full-height stacks (18')				ABD
A-2	Consolidate two EST egress points into one	♦ Eliminates one stair ♦ Reduces cost	♦ None apparent, if technically feasible	+	4
A -3	Put the admin area on 2nd level	♦ None apparent	♦ Adds cost	-	2
A -4	Relocate electrical room to SE corner of building	♦ Shortens underground run ♦ Reduces cost	♦ None apparent, if technically feasible	+	4
A -5	Relocate electrical room to NE corner of building	♦ Shortens underground run ♦ Reduces cost	♦ None apparent, if technically feasible	+	4
A -6	Place skylights in the warehouse	♦ Increases day lighting ♦ Reduces energy consumption ♦ Improves ambient lighting	♦ Added maintenance	_	4
A -7	Large fans in the warehouse	♦ Reduces energy consumption	♦ Coordination between positions of fans and stacked storage	+	DS
A -8	Address column location/interference				ABD

Ranking Scale: **5** = Significant Value Improvement
4 = Good Value Improvement
3 = Minor Value Improvement
2 = Minor Value Degradation
1 = Significant Value Degradation or Does Not Meet Project Purpose and Need
DS= Design Suggestion **ABD** = Already Being Done

Performance Attributes: Significant Improvement +2, +1, 0, -1, -2 Significant Degradation

IDEA EVALUATION

Training Support Center – Fort Sam Houston

VMS

Ideas		Advantages	Disadvantages	$	RANK
No.	**Function**				
A -9	Position loading area near front of building (west side)	♦ Added convenience for users	♦ AT/FP setback issue ♦ Requires floor plan changes ♦ Not taking advantage of terrain(depending of repositioning of the building)	0	See S1
A -10	Review floor plan	♦ Possible improvements to the currently design floorplan	♦ None apparent, if technically feasible	0	4
A -11	Redesign building per lower AT/FP setback requirements at security gate	♦ Could allow improved layout options for the building	♦ DPW usually specifies higher AT/FP requirements	0	See S1
A -12	Roof downspouts directly to detention ponds				ABD
A -13	Review roof systems				ABD
ELECTRIC					
E-1	Centrally locate all motor starters in either the electrical or mechanical room	♦ Reduce cost of control system conduit / conductors	♦ None apparent, if technically feasible	+	DS
E-2	Define a minimal amount of hardware spares used in the control system	♦ Reduced initial cost of control system	♦ Less future flexibility	+	DS
E-3	Have separate panel boards for warehouse and the other half of building	♦ Some cost reduction	♦ None apparent, if technically feasible	+	DS
E-4	Bollard lighting for outdoor walkways	♦ Less light pollution (lamps closer to the ground) ♦ Could be more aesthetically pleasing ♦ Reduces costs	♦ None apparent, if technically feasible	+	DS

Ranking Scale: **5** = Significant Value Improvement; **4** = Good Value Improvement; **3** = Minor Value Improvement; **2** = Minor Value Degradation; **1** = Significant Value Degradation or Does Not Meet Project Purpose and Need; **DS**= Design Suggestion; **ABD** = Already Being Done

Performance Attributes: Significant Improvement +2, +1, 0, -1, -2 Significant Degradation

IDEA EVALUATION

Training Support Center – Fort Sam Houston

VMS

Ideas No.	*Ideas* Function	Advantages	Disadvantages	$	RANK
E-5	Light the dock				ABD
E-6	Photodiode controls for parking lot lighting	♦ Increased costs	♦ None apparent, if technically feasible	-	DS
E-7	Photovoltaic lighting	♦ Increased costs	♦ None apparent, if technically feasible	-	DS
E-8	Review exterior egress lighting				ABD
E-9	Review light pollution	♦ Possible LEED credit	♦ Requires review of cut-off fixtures and other lighting pollution control issues	0	DS
E-10	Bug control lighting	♦ May be intent of the users from the start	♦ None apparent	0	DS
E-11	RFP Conflict reconcile conflicting requirements between Section 5.8.3 and Section 6.11.3.1	♦ Conflict resolved	♦ None apparent	0	DS
MECHANICAL					
M-1	Rooftop HVAC system to save space (screened)	♦ Cost savings ♦ Space efficiency	♦ Added rooftop costs ♦ Less accessible / maintenance	+	3
M-2	Zone building areas for conditioning	♦ Reduced energy consumption	♦ Slightly more hardware	+	DS
M-3	Tankless hot water heater	♦ Saves space ♦ Reduces plumbing needs ♦ May save energy consumption	♦ Increases electrical demand/cost ♦ LCC analysis required to determine the feasibility	0	DS

Ranking Scale: **5** = Significant Value Improvement; **4** = Good Value Improvement; **3** = Minor Value Improvement; **2** = Minor Value Degradation; **1** = Significant Value Degradation or Does Not Meet Project Purpose and Need; **DS**= Design Suggestion; **ABD** = Already Being Done

Performance Attributes: Significant Improvement +2, +1, 0, -1, -2 Significant Degradation

IDEA EVALUATION

Training Support Center – Fort Sam Houston

VMS

Ideas		Advantages	Disadvantages	$	RANK
No.	**Function**				
M-4	VAV boxes with hot water reheats	♦ Saves space ♦ Reduces plumbing needs	♦ Increases electrical demand/cost	+	DS
M-5	Specify that corridors be included in a zone	♦ "Nails down" the zoning requirement	♦ None apparent	0	DS
M-6	Use water softeners	♦ Intended requirement	♦ Increased maintenance of softener	0	DS
M-7	Geothermal systems	♦ Reduced energy consumption ♦ Reduces maintenance ♦ Lengthens life of fixtures/plumbing	♦ Large First Cost ♦ LCC analysis required to determine the feasibility ♦ Maintenance unfamiliarity (may be an issue)	0	DS
M-8	Review the specs for waterless urinals	♦ Intended requirement	♦ None apparent	0	ABD

Ranking Scale: **5** = Significant Value Improvement
4 = Good Value Improvement
3 = Minor Value Improvement
2 = Minor Value Degradation
1 = Significant Value Degradation or Does Not Meet Project Purpose and Need
DS= Design Suggestion **ABD** = Already Being Done

Performance Attributes: Significant Improvement +2, +1, 0, -1, -2 Significant Degradation

VALUE ENGINEERING PROCESS

VALUE ENGINEERING PROCESS

This report section describes the procedures used during the Value Engineering Study. It is followed by separate write-ups and conclusions concerning the topics noted below:

- VE Study Agenda
- VE Study Participants and Daily Attendance Sheets

A systematic approach was used in the VE Study and the key procedures followed were organized into two parts: (1) pre-study preparation and (2) VE Study.

PRE-STUDY PREPARATION

In preparation for the VE Study, the facilitator (CVS) and VE team members attended an Orientation Meeting. At this meeting, the Agency and the design team representatives presented an overview of the project, decisions that have influenced the development of the project, and its current status. This included an overview of the project and its operational requirements, which enhanced the VE team's knowledge and understanding of the project. This was followed by a site visit.

Between the Orientation Meeting and the start of the VE Study, the VE team reviewed documents provided by the designer to become better prepared for the study.

VE STUDY

This Value Engineering Study was a three-day study effort. The VE job plan was followed to guide the teams in the search of high cost areas in the design and in developing alternative solutions for consideration. The job plan phases are:

- Information Phase
- Function Analysis Phase
- Creative Phase
- Evaluation Phase
- Development Phase
- Presentation Phase

Information Phase

At the beginning of the VE Study, the design team presented a more detailed review of the design and the various systems. This included an overview of the project and its operational requirements, which further enhanced the VE team's knowledge and understanding of the project. The designer also answered questions posed by the VE team.

Function Analysis Phase

Key to the VE process is the function analysis techniques used during the Function Analysis Phase. Analyzing the functional requirements in a project design is key to assuring an owner that the project has been designed to meet the stated criteria. The analysis of these functions in terms of cost and design is a primary element in a VE Study, and is used to develop alternatives without removing necessary items. This procedure is beneficial to the VE team, as it forces the participants to think in terms of functions and their related worth, and ensures that all the team members agree on the project scope. This facilitates a comprehensive analysis of the project design.

Creative Phase

This VE Study phase involves identifying and listing creative ideas. During this phase, the VE team participates in a brainstorming session to identify as many means as possible to provide the necessary functions within the project. Judgment of the ideas is not permitted at this point. The VE team looks for a large quantity of ideas and association of ideas. The idea list is grouped by category.

The creative idea worksheets listing all ideas suggested during the study are provided in this report. These ideas should be reviewed, since they may contain ideas that are worthy of further evaluation and may be used as the design develops. These ideas could also help stimulate additional ideas by others.

Evaluation Phase

The purpose of the evaluation phase is to systematically reduce the large number of ideas generated during the creative phase to a number of concepts that appear promising in meeting the project objectives. The key criteria against which the ideas need to be evaluated were identified as cost, schedule, agency impact, and public impact. Each idea was tested with respect to these criteria to determine if it added or removed value from the original concept. Once each idea is fully evaluated, it is given a total rating number. This is based on a scale of 1 to 5, as indicated by the following rating index:

5 Improves Cost and Performance—the project will benefit greatly. Significant cost and/or significant functional improvements.

4 Improves Cost or Performance—will improve the project. Some cost and/or other functional improvements.

3 Technically Feasible— but will require additional analysis to verify if cost and/or functional improvements are possible. May challenge design criteria. Needs further development.

2 Scope Reduction—will reduce cost, but at the expense of project performance.

1 Significant disadvantages – drop from consideration.

Based upon the total rating, ideas rated positively were developed further and documented on the Value Engineering Alternative forms.

Development Phase

During the development phase, each idea was expanded into a workable solution. The development consisted of the recommended design, life cycle cost comparisons, and a descriptive evaluation of the advantages and disadvantages of the proposed alternatives. Each alternative was written with a brief narrative to compare the original design to the proposed change. Sketches and design calculations, where appropriate, were also prepared during this part of the study. The VE alternatives are included in the Study Results section of this report.

Presentation Phase

The VE Study concludes with a preliminary presentation of the VE alternatives that have been developed. This provides others impacted by the results of the study with an opportunity to preview the alternatives and develop an understanding of the rationale behind them.

VE STUDY AGENDA

Training Support Center

Fort Sam Houston, PN 071116

VE Study Location: Fort Sam Houston – Building 4196.

Day 1 – Wednesday, April 7, 2010

Kick-Off Meeting

0730 PASS & ID Office
0815 VA Team Set-up
0830 Introductions (All) and VE Agenda Review (VE Team Leader)
0835 Project Overview (Project Manager and Engineers)
0910 Base Comments, Issues and Concerns
0925 ***Conclusion of Kick-Off Meeting***
0930 Team Recap /Discuss In-Brief Information, Review Project Information and Cost Estimate
1000 Function Analysis/Fast Diagram
1100 Team Brainstorming
1200 Lunch
1300 Team Brainstorming
1430 Idea Evaluation
1700 Adjourn

Day 2 – Thursday, April 8, 2010

0700 PASS & ID Office
0730 Evaluation of Ideas (Cont)
0830 Team Assignments for Development / Review Alternative Development Process
0845 Research and Refine Ideas
0930 Alternative Development
1200 Lunch
1300 Alternative Development (Cont)
1400 Finalize Alternatives and Prepare Presentation
1500 ***Presentation of VE Alternatives Meeting*** **(Presentation of VE Study Findings to Management and Stakeholders)**
1600 Adjourn

(The above agenda was modified at the request of the USACE project manager to accommodate travel plans with a presentation at 1300)

MEETING ATTENDEES

TRAINING SUPPORT CENTER - FORT SAM HOUSTON

U.S Army Corps of Engineers, Forth Worth District

2010 April				NAME	ORGANIZATION	POSITION	PHONE/CELL	EMAIL
PS	7	8	IM					
	X	X		George Hunter	VMS	VE Team Lead	916-224-9812	george@vms-inc.com
	X	X		Mariah Brink	VMS	Assistant VE Team Lead	541-980-7896	mariah@vms-inc.com
	X	X		Darren Nielsen	HNTB	Architect	816-509-8502	dnielsen@hntb.com
	X	X		Terry Kinley	HNTB	Electrical Engineer	425-455-3555	tkinley@hntb.com
	X	X		David Parker	HNTB	Mechanical Engineer	425-455-3555	dparker@hntb.com
	X			Leonard Davis	Garrison Safety	Safety & Health Specialist	210-221-4576	leaonard.davis@conus.army.mil
	X	X		Raul Villar	DPW/FSH	Prov. Manager	210-221-5209	raul.villar@us.army.mil
	X	X		Gary Hagerman	TSC/DPTMS FSH	TSC Manager	210-221-5203	Gary.hagerman@us.army.mil
	X	X		David Nortman	CESWF PM	Project Manager	817-886-1814	david.l.nortman@usace.army.mil
	X	X		Georganne Ramsey	CESWF PM-PMO	Program Specialist VEO Assistant	817-886-1477	georganne.r.ramsey@usace.army.mil
	X	X		Maj. Carnell Maynard	C. ATSC	ATSC Representative	757-878-2910 Ext. 2067	carnell.maynard@us.army.mil
	X	X		Marcus Searles	CEHNC / Range MCX	Architect	256-895-1672	marcus.j.searles@usace.army.mil

MEETING ATTENDEES

TRAINING SUPPORT CENTER - FORT SAM HOUSTON

U.S Army Corps of Engineers, Forth Worth District

2010 April				NAME	ORGANIZATION	POSITION	PHONE/CELL	EMAIL
PS	7	8	IM					
	X	X		Celia Hunter	Hunter Pacific	Estimator	619-322-2485	celia@hunterpacificgroup.com
	X	X		Dennis Peek	HSW Engineering	PM - A/E Prime	813-220-3736	cdpeek@hsweng.com
	X	X		Aasiya McCoy	Mason & Hanger	Architect	859-252-9980	aasiya.mccoy@masonandhanger.com
	X	X		Michael Swenson	DPTMS	Chief Trainer	210-221-0822	michael.swenson@us.army.mil
		X		Lee Ebron	DMWR	Project Manager	210-295-4471	lee.ebron@us.army.mil

Value Management Strategies, Inc.

Offices in Escondido, Sacramento, and Emeryville, California; Grand Junction, Colorado; Sarasota, Florida; Marietta, Georgia; Portland, Oregon; Seattle, Washington; Kansas City, Kansas; and Great Falls, Montana

Thursday, October 28, 2010

Value Engineering Study Report
TRAINING SUPPORT CENTER – FORT SAM HOUSTON
U.S. Army Corps of Engineers, Fort Worth District

Value Management Strategies, Inc.

Value Engineering Study Report
TRAINING SUPPORT CENTER – FORT SAM HOUSTON
U.S. Army Corps of Engineers, Fort Worth District

May 2010

Value Management Strategies, Inc.

Value Engineering Study Report
TRAINING SUPPORT CENTER – FORT SAM HOUSTON
U.S. Army Corps of Engineers, Fort Worth District

May 2010

Value Management Strategies, Inc.

Value Engineering Study Report
TRAINING SUPPORT CENTER – FORT SAM HOUSTON
U.S. Army Corps of Engineers, Fort Worth District

May 2010

Value Management Strategies, Inc.

Value Engineering Study Report
TRAINING SUPPORT CENTER – FORT SAM HOUSTON
U.S. Army Corps of Engineers, Fort Worth District

May 2010

Appendix LL

Special Project Procedures for Fort Sam

1.0 Cable TV Requirements

Cable TV (CATV) is not required for this project. See Paragraph 6.4.6.6 in Section 01 00 00.