UNIFIED FACILITIES CRITERIA (UFC)

FINAL DRAFT
CIVIL ENGINEERING

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UNIFIED FACILITIES CRITERIA (UFC)

FINAL DRAFT CIVIL ENGINEERING

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

FOREWORD

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.

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 sources:

- 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

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UNIFIED FACILITIES CRITERIA (UFC)
NEW DOCUMENT SUMMARY SHEET

Document: UFC 3-200-10N, *Civil Engineering*

Description: This UFC 3-200-10N provides criteria for civil engineering design for design-build and design-bid-build projects.

Reasons for Document:

- Provide technical requirements for civil engineering design criteria.
- Establish design analysis requirements in support of design activities.
- Define minimum requirements for design drawings in terms of drawing types and content.

Impact: There are negligible cost impacts. However, the following benefits should be realized.

- Standardized guidance has been prepared to assist civil engineers in the development of the plans, specifications, calculations, and Design/Build Request for Proposals (RFP).
- This guidance has been prepared along with updates to the associated Performance Technical Specifications and Engineering Systems Requirements documents. The three types of documents have been aligned to allow improved consistency in the preparation of project requirements.
- The inclusion of state and local regulations should allow specific designs to better accommodate local materials and topography.

CONTENTS

TABLES

CHAPTER 1 INTRODUCTION{ TC "CHAPTER 1 INTRODUCTION" \F C \L "1" }

1-1 PURPOSE AND SCOPE.{ TC "1-1 PURPOSE AND SCOPE." \F C \L "2" }

The purpose of this UFC is to provide technical guidance and minimum technical requirements for the more typical aspects of the civil engineering and geotechnical engineering for all design and/or construction contracts for the Naval Facilities Engineering Command (NAVFAC). The guidance provided in this UFC will be utilized by engineers in the development of project proposals, plans, specifications, calculations, and all other project documentation defined by contract requirements and acquisition strategy. Where other statutory or regulatory requirements are referenced in the contract, the more stringent requirement shall be met in case of conflict.

1-2 APPLICABILITY.{ TC "1-2 APPLICABILITY." \F C \L "2" }

This UFC applies to all Navy Commands, Activities and their contractors that prepare construction contract documents and specifications for facilities on military installations under the cognizance of the Naval Facilities Engineering Command.

1-3 REFERENCES.{ TC "1-3 REFERENCES." \F C \L "2" }

Appendix A contains the list of references used in this document. Furthermore, this UFC references UFC 1-200-01, *General Building Requirements*, as applicable except as modified herein.

1-4 DEVIATIONS.{ TC "1-4DEVIATIONS." \F C \L "2" }

Engineering experience and judgment are integral parts of functional, economical site development. Where the designer of record can demonstrate substantial benefit to the government, slight variances from the requirements herein may be considered. Proposed deviations must be clearly identified in project review submittals and must be specifically approved by the Government's Civil Engineering Reviewer before they are incorporated in final construction documents.

1-5 COMMUNICATIONS.{ TC "1-5 COMMUNICATIONS." \F C \L "2" }

Direct communication with the Government's Project Manager and Civil or Geotechnical Reviewer is encouraged. The Project Manager can provide the reviewer's name, phone number and email address.

1-6 REGIONAL REQUIREMENTS.{ TC "1-6 REGIONAL REQUIREMENTS." \F C \L "2" }

When performing work for different installations, regional regulatory requirements may differ from those included herein. Consult with the Government's Civil or Geotechnical Reviewer for regional requirements that take precedent over the guidance included in this UFC.

1-7 SUSTAINABLE DESIGN.{ TC "1-7 SUSTAINABLE DESIGN." \F C \L "2" }

Incorporate sustainable development concepts to reduce energy consumption, operation and maintenance costs and reduce waste and pollution. Refer to LEED Guidance per NAVFACINST 9830.1, and the *Sustainable Building Technical Manual: Green Building Design, Construction, And Operations*.

1-8 ARCHITECTURAL COMPATIBILITY.{ TC "1-8 ARCHITECTURAL COMPATIBILITY." \F C \L "2" }

Design facilities to be compatible with the surrounding base architecture. Refer to UFC 3-100-10N, *Architecture*, Chapter 2, for more information. The following issue affects site design:

1-8.1 Base Design & Development Documents.{ TC "1-8.1 BASE DESIGN & DEVELOPMENT DOCUMENTS." \f C \l "3" }

Most military installations have published design guidelines that contain criteria relative to achieving, maintaining and emphasizing a positive exterior visual environment. These documents include Comprehensive Regional Planning Instructions, Regional Plans (Navy), Master Plans (Marines) and Base Exterior Architecture Plans (BEAP). Follow the design guidance contained in these documents carefully since these are published under the authority of the Secretary of the Navy (SECNAV.) Direction to deviate from these documents should be given in writing.

CHAPTER 2 DESIGN REQUIREMENTS{ TC "CHAPTER 2 DESIGN REQUIREMENTS" \F C \L "1" }

2-1 SITE DEVELOPMENT{ TC "2-1 SITE DEVELOPMENT" \F C \L "2" }

2-1.1 Preliminary Site Analysis{ TC "2-1.1 Preliminary Site Analysis" \f C \l "2" }

Conduct a preliminary site visit. Obtain photographs of the site. Research and obtain existing as-built record drawings and subsurface investigation data/reports as a potential source of general topographic information, utility and stormwater drainage availability and soil boring log information near the site. Conduct detailed consultations with the user in order to clearly define requirements and preferences. Based on the information obtained, determine the preliminary configuration and location of the major site elements (building location and orientation, parking areas, stormwater detention facilities, and access and egress to the site). Present the results of this analysis to the user for review.

2-1.2 Geotechnical Site Investigation{ TC "2-1.2 Geotechnical Site Investigation" \f C \l "3" }

Obtain all necessary soils exploration, testing and evaluation. A professional geotechnical engineer must certify the adequacy of the soil and foundation aspects of the design. Determine the amount of exploration and testing based on discussions with the Government's geotechnical engineer, structural engineer (for foundations), civil engineer (for pavements, wells, septic systems, etc.), and local stormwater permitting agency (for detention ponds). Additionally, if the site is known to have environmental contamination, contact the Government'sEnvironmental Reviewer for additional guidance. Soils sampling, testing and evaluation must be in accordance with UFC 3-220-03FA, *Geotechnical Engineering Procedures for Foundation Design of Buildings and Structures*, UFC 3-250-01FA, *Pavement Design for Roads, Streets, Walks and Open Storage Areas*, and UFC 3-260-02, *Pavement Design for Airfields*.

The contract documents must show the results of the subsurface investigation, including boring locations, boring logs, groundwater observations, a summary of laboratory test results, and any details required to convey requirements for site preparation.

2-1.3 Surveying{ TC "2-1.3 Surveying" \f C \l "3" }

Prepare and seal surveys in accordance with the requirements of the local governing authority and the licensing board in which the site is located. The order of the survey must be at a minimum third order.

Coordinate with the Government's Environmental Coordinator before entering the area with regards to any restrictions concerning vegetation cutting/clearing, natural resources, endangered species, etc.

2-1.3.1 Topographic Surveys.{ TC "2-1.3.1 **Topographic Survey**." \f C \l "4" }

Provide a topographic survey of the project site in accordance with the National Society

of Professional Surveyors (NSPS) *Model Standards for Topographic Surveys* with the following modifications:

a. Project a drawing by the Government shall be in english or metric as directed for each specific project.

b. Ensure that adequate adjacent areas are included within the survey limits to clearly indicate and accommodate setbacks required by antiterrorism criteria, offsite drainage and offsite utility connections impacting the project.

c. Provide a boundary survey and location of easements and security clear zones within the limits of the scope of work.

d. Show horizontal control used during field survey. Indicate the reference coordinate plane and provide two permanent control points for reference. Include description of points (PK nail in cap, etc.). Provide a minimum of three reference distances to existing permanent structures (reference points) so that control can be re-established.

e. Elevations on paved or impervious surfaces (including rims of utility structures) must be shown to the nearest 0.01 feet (0.005 meters for metric designs). Show elevations on unpaved or pervious surfaces to the nearest 0.1 feet (0.05 meters for metric designs).

f. Indicate the name of the surveying firm and date of survey.

g. If match lines are used involving more than three sheets, provide a key map with current sheet highlighted. Remove any extraneous lines and text from key map.

h. North should be oriented toward the top (or left edge) of the plotted sheet. Coordinate north direction with other disciplines so that all plans are oriented the same.

i. Accurately locate (by means of structures visible from the surface and through research of Activity utility maps, as-built drawings, data from local utility companies) the following list of utilities (both above and below ground), structures and features. Provide notes indicating the sources and any limitations or assumptions of the data and that the Contractor must field verify the location of all utilities prior to construction. The survey must include the following specific items and their related appurtenant above-ground features, but is not limited to:

Buildings: Describe building material and number of stories.

Pavements: Include type of material. In areas where pavement demolition is to occur, note all pavement thicknesses, including layer thicknesses and joint patterns for replacement. Pavement layer

thicknesses may be obtained by reviewing as-built information, digging at the edge of the pavement, core drilling, and consulting with Activity personnel. Where proposed pavements are expected to abut existing pavements, provide pavement markings, joint pattern and indicate joint types of the existing pavements.

Surface Drainage Features: Indicate normal water level for permanent standing water.

Utilities: Include rim elevations for utility structures; location and identification of lines as underground or aboveground; pipe sizes and materials. Identify water system as potable, nonpotable, high pressure or saltwater as applicable.

Fences: Note height, type of fabric, barbed wire, direction of outrigger, top or bottom rails, tension wires, gate locations and types.

Foundations: Indicate visible foundations of demolished buildings.

Fuel Pipes and Storage Tanks: Include fill ports, vent lines, tank drains, etc.

Pump Stations: Include invert of influent pipe and elevation of force main. Locate all aboveground elements including controls.

Railroads and Crane Rails: Include turnouts, rail sizes, compromise joint locations, and curve information, such as P.C., P.T., and P.I. as they may be applicable to the design requirements of the proposed project.

Tidal Shoreline: Note water elevation, time of day, date, and tidal condition at time of survey. Indicate normal high/low water elevations referenced to the datum used.

Trees/Woods: In wooded areas, locate outside drip line of wooded area, include general density and type of trees. Where selective clearing will be accomplished, locate individual trees and tree size over a 6-inch diameter.

Wetland Areas: Wetland and marsh areas shall be flagged and numbered by the Government prior to the survey. Locate flags and label in the same manner as marked in the field. If unanticipated wetlands are found during the survey, advise the Government's Civil Reviewer to establish any additional survey requirements.

2-1.4 **Permits{** TC "2-1.4 **Permits**" \f C \l "3" **}**

Provide all necessary documentation to design, construct and maintain the intended facility. Construction and environmental permits are an integral part of the contract

documentation. The designer of record shall determine and comply with all imposed requirements of regulatory agencies at all phases of project development.

The designer of record shall determine all permits, approvals and fees required for development from federal, state and local regulatory authorities for the proposed project. Use the project's NEPA documentation and complete the Permits Record of Decision (PROD) Form obtained at the Download Tab of Part 6 of the NAVFAC Design-Build website at the following link http://ndbm.wbdg.org/system/html/6/453, to assist in this determination.

Obtain permits for overseas development in accordance with the applicable country-specific Final Governing Standards (FGS) or, for development in countries without an FGS, in accordance with the Overseas Environmental Baseline Guidance Document (DoD 4715.5-G). The Contractor is required to perform work in accordance with the obtained permits.

Consult with the Government project manager to determine the appropriate signatories for permit applications.

2-1.5 **Clearing and Demolition{** TC "2-1.5 Clearing and Demolition" \f C \l "3" **}**

Remove existing utilities under proposed buildings and facilities within ten (10) feet of the proposed foundations.

2-1.6 **Layout{** TC "2-1.6 Layout" \f C \l "3" **}**

The site layout shall satisfy the functional and operational requirements of the new facility. The design shall integrate the new construction into the context of the site and surrounding environment incorporating the following:

a. Incorporate setback and standoff requirements in compliance with respect to property lines, applicable codes, antiterrorism criteria and security.

b. Provide adequate access to existing traffic patterns

c. Locate new utilities to minimize the connection costs. New utilities shall be at least 10 feet from proposed structures, except for building connections. Existing utilities to remain that are under or within 10 feet of the proposed building shall be relocated.

d. Preserve natural topographic features to minimize cut and fill, impact on existing drainage patterns and tree removal.

e. Eliminate/minimize construction activities requiring permits.

f. Consider aesthetics.

g. Minimize maintenance and operating costs.

h. Include sustainable design elements.

i. Phase the project to accommodate constructability and security requirements of the site.

2-1.6.1 **Antiterrorism Criteria.{** TC "2-1.6.1 Antiterrorism Criteria." \f C \l "3" **}** Refer to UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings* and incorporate all applicable requirements for the project.

For fencing, gates and entrances into a Naval installation, comply with the latest edition of the UFC 4-022-01 *Security Engineering: Entry Control Facilities/Access Control Points*; MIL-HDBK-1013/1A, *Design Guidelines for Physical Security of Facilities*; MIL-HDBK-1013/10, *Design Guidelines for Security Fencing, Gates, Barriers, and Guard Facilities*; MIL-HDBK-1013/14, *Selection and Application of Vehicle Barriers*; OPNAVINST 5530.14C, *Navy Physical Security Manual*; MCO P5530.14 *Marine Corps Physical Security Program Manual*; and UG-2031-SHR, *User's Guide on Protection Against Terrorist Vehicle Bombs.*

2-1.6.2 **Handicap Accessibility.{** TC "2-1.6.2 **Handicap Accessibility**." \f C \l "3" **}** Provide barrier-free design in accordance with the requirements of the DEPSECDEF Memorandum "Access for People with Disabilities" dated Oct 31, 2008. The memorandum updates the DoD standards for making facilities accessible to people with disabilities. The US Access Board issued an update of the accessibility guidelines which the DEPSECDEF Memorandum implements with military unique requirements specified in the memorandum attachment. The new DoD, "ABA (Architectural Barriers Act) Accessibility Standard" and the DEPSECDEF Memorandum are located at http://www.access-board.gov/ada%2Daba/aba-standards-dod.cfm .

2-1.6.3 **Parking Layout.{** TC "2-1.6.3 **Parking Layout**." \f C \l "3" **}** Design the parking layout in accordance with the Military Surface Deployment and Distribution Command, Transportation Engineering Agency's Pamphlet 55-17, *Better Military Traffic Engineering*, Chapter 4, "Parking", dated January 1987. Nine (9') wide spaces shall be used, 90° parking is preferred. The parking area location and layout must conform to current antiterrorism requirements indicated in paragraph 2-1.4.1. The number of parking spaces is determined by the Basic Facility Requirements derived from NAVFAC Publication P-80, *Planning Criteria for Navy and Marine Corps Shore Installations*. Refer to scope of work (such as the DD Form 1391, Design/Build RFP, etc.) for total parking requirement (number of spaces). All striping must be 100 mm (4 in) wide, white in color except blue for handicap.

Where required by the project's scope of work, contact the Government's Project Manager concerning requirements for motorcycle parking. Motorcycle parking areas must be a minimum 100 mm (4 in) thick portland cement concrete and stalls must be 3.05 m long x 1.52 m wide (10 ft x 5 ft).

2-1.6.3.1 **Parking Area Circulation**. **{** TC "2-1.6.3.1 **Parking Area Circulation**." \f C \l "3" **}** The system must allow for all types of traffic that may be associated with the

facility, including deliveries, emergencies and garbage pick-up. The system must, however, discourage through traffic.

2-1.6.3.2 **Turning Radii**.**{** TC "2-1.6.3.2 **Turning Radii**." \f C \l "3" **}** Clearly indicate turning radii requirements on parking area entrances and islands. If access for fire, maintenance and trash service vehicles is required for a facility and routing through the parking lot is necessary, provide layout with turning radii in accordance with the latest edition of the AASHTO publication, *A Policy on Geometric Design of Highways and Streets* for appropriate design vehicle type.

2-1.7 **Site Appurtenances{** TC "2-1.7 Site Appurtenances" \f C \l "3" **}**

Provide site appurtenances in accordance with State or local standards where project is located. For remote locations without relevant local standards, consult the Government's Civil Reviewer to establish standards to be used.

2-1.7.1 **Sidewalks.{** TC "2-1.7.1 **Sidewalks**." \f C \l "3" **}** Determine sidewalks requirements on the basis of need, capacity and accessibility requirements. The user must be consulted on any special walk requirements for such facilities as barracks, where extra wide walks may be required for marching purposes and/or muster formation.

2-1.7.2 **Curb/Curb and Gutter.{** TC "2-1.7.2 **Curb/Curb and Gutter**." \f C \l "3" **}** Use concrete curb and gutter when sheet flow or overland flow cannot be achieved or when site compatibility and continuity with respect to adjacent facilities requires its use.

Asphalt-type curbs are not allowed.

2-1.7.3 **Wheelstops.{** TC "2-1.7.3 **Wheelstops**." \f C \l "3" **}** Provide 1.83 m (6 ft) long precast concrete wheelstops anchored to the pavement with rebar at parking spaces adjacent to sidewalks without curb, buildings, fences, in areas where part of a vehicle extending past the striped space would likely cause property damage, and in areas of extreme slope or areas adjacent to stormwater management facilities. Locate the front face of the wheelstop 750 mm (30 in) from the edge of the pavement or sidewalk.

2-1.7.4 **Bollards.{** TC "2-1.7.4 **Bollards**." \f C \l "3" **}** Bollards must be 1.22 m (4 feet) high, 100 mm (4 inch) diameter steel pipe filled with concrete and painted. Provide bollards around any structures subject to damage from vehicular traffic by incidental contact. Ensure that an adequate concrete foundation is designed for the bollard. For vehicular barrier applications, refer to MIL-HDBK-1013/14, *Selection and Application of Vehicle Barriers* for more information.

2-1.7.5 **Signage and Markings.{** TC "2-1.7.5 **Signage and Markings**." \f C \l "3" **}** Provide signs, and associated pavement markings to facilitate proper utilization of the project site. New traffic control devices (i.e.; signs, markings, etc.) must be provided in accordance with the latest edition of the United States Department of Transportation Federal Highway Administration's *Manual on Uniform Traffic Control Devices*.

2-1.7.5.1 **Security Signage.{** TC "2-1.7.5.1 **Security Signage**." \f C \l "3" **}** Comply with OPNAVINST 5530.14C and MCO P5530.14.

2-1.7.6 **Trash Dumpster Enclosures.{** TC "2-1.7.6 **Trash Dumpster Enclosures**." \f C \l "3" **}** Where dumpsters are required in a project, provide a dumpster pad with an enclosure. The dumpster enclosure must conform to the BEAP. Provide a concrete pavement pad to support and accommodate the dumpster(s) and front wheels of the service truck. Refer to 2-6 for rigid pavement design.

2-1.7.7 **Equipment Enclosures.{** TC "2-1.7.7 **Equipment Enclosures**." \f C \l "3" **}** Enclose outside mechanical and electrical equipment as directed. Additional enclosure requirements are included in the paragraph entitled “Antiterrorism Criteria”. The design and location of the enclosure is an interdisciplinary responsibility. The location of the enclosure must be reviewed to ensure that all servicing, clearance and code requirements are met and that no existing or new utility conflicts are present.

2-1.7.8 **Fences.{** TC "2-1.7.8 **Fences**." \f C \l "3" **}** Provide fencing as directed.

Provide security fencing in accordance with the physical security criteria in MIL-HDBK-1013/1A; MIL-HDBK-1013/10, OPNAVINST 5530.14C, MCO P5530.14, where required by the project scope.

For safety requirements, a fence of the appropriate design shall be provided around surface stormwater management facilities particularly in residential housing areas, playgrounds, child-care facilities, and other similar applications where a fence will enhance the welfare and safety of children. Provide fencing for stormwater management facilities in accordance with the applicable State regulations; minimum four (4) feet high with locking access gates; whichever is more stringent.

2-2 GRADING AND STORM DRAINAGE SYSTEMS{ TC "2-2 GRADING AND STORM DRAINAGE SYSTEMS" \F C \L "2" }

Design surface drainage, underground gravity drainage systems and stormwater management facilities in accordance with the requirements of the applicable regulatory agency that governs where the project is located; the guidance noted in this UFC; whichever is more stringent. Stormwater pump stations are not allowed without written approval from the Government Civil Reviewer of the project.

The design of the storm drainage system and stormwater management must consider:

a. The stormwater management plan must comply with federal, state, and local regulatory requirements. Include regional or site-specific stormwater management agreements.

b. Ensure that temporary and permanent erosion and sediment control practices are provided in accordance with regulatory requirements during both the construction and operational phases of the project.

c. The grading must complement the features and functions of the natural drainage system and the existing contours. Also consider the groundwater table elevation in the siting and sizing of stormwater management facilities.

d. Use surface drainage ("sheet flow" or "overland flow") in lieu of gravity sewer systems if land uses permit. Pump stations and transmission mains are not allowed.

2-2.1 Design Criteria{ TC "2-2.1 Design Criteria" \f C \l "3" }

The facility's minimum finished floor elevation and mechanical/electrical equipment pads must be above the 100 year flood elevation as indicated on the latest edition of the Flood Insurance Rate Maps, prepared by the Federal Emergency Management Agency (FEMA). The degree of protection (in years) for pavements must be in accordance with local permitting or regulatory requirements. Ensure proper correlation between different elevation datums.

Storm drainage design and associated construction must be in accordance with the guidance noted herein; the State Department of Transportation's (DOT) Drainage Manual where the project is located or the applicable regulatory agency that governs stormwater management, whichever is more stringent.

For design of the drainage system, use a minimum 10-year storm frequency or the minimum required by the local governing authority, whichever is more stringent. For design of the drainage system for airfields, the requirements are as follows:

a. Runway and Taxiway Pavements - 2 year storm frequency;

b. Apron Pavements - 5 year storm frequency (obtain concurrence from the Government's Civil Reviewer.)

c. Hangar and Other Flightline Structures - 10 year storm frequency.

2-2.2 Roof Drainage

Where roof drainage is discharged to grade, provide splash blocks/paved channels to direct the flow away from the structure. Eliminate safety hazards from ice, ponding, flooding, etc., in pedestrian and vehicular traffic areas.

Where underground collection of roof drainage is used, provide an air break between the downspouts and underground piping. Size underground piping in accordance with the International Plumbing Code (IPC) or 6 in. I.D. minimum, whichever is greater. No more than three downspouts shall be collected in a single outlet before connecting to a storm drainage structure, and the length of pipe from the most distant downspout to a drainage structure shall not exceed 150 feet. Provide a cleanout for each downspout connection and the collection header.

2-2.3 **Surface Storm Drainage{** TC "2-2.3 Surface Storm Drainage" \f C \l "3" **}**

2-2.3.1 **Grading.{** TC "2-2.3.1 **Grading.**" \f C \l "3" **}** Grade the site to provide positive drainage away from the facility. For the first 3.05 m (10 ft), provide a minimum slope of five (5) percent. Establish finished floor elevations at least 150 mm (6 in) above finished grade at the perimeter of the building. Ensure that the grading and associated stormwater runoff do not adversely affect surrounding sites. Base grading on the minimum slopes indicated in Table 2-2 unless otherwise directed by the Government's Civil Reviewer. Design in accordance with AASHTO's *A Policy on Geometric Design of Highways and Streets* for maximum grades and *UFAS* for handicap accessibility.

TABLE 2-1: GRADING{ TC "TABLE 2-1: GRADING" \f C \l "3" }

Item No.	Item Description	Requirement
1	Longitudinal grades of roadways	Min. 0.3%
2	Transverse grades of roadways	Min. 2.0%
3	Concrete pavement in parking areas, sheet flow	Min. 1.5% Max. 5.0%
4	Curb & Gutter Valley Gutter	Min. 0.3%
5	Bituminous pavement in parking areas, sheet flow	Min. 2.0% Max. 5.0%
6	Handicap areas in parking areas	Max. 2.0%
7	Walks, Transverse	1.5% for drainage as required
8	Walks, longitudinal	Min. 0.3% Max. 5.0%
9	Concrete Landings	Max. 2.0%
10	Paved Concrete Ditches, longitudinal	Min. 0.3%
11	Unpaved Ditches, longitudinal	Min. 0.5%
12	Pervious Surfaces	Min 2.0%

2-2.3.2 **Open Channels.{** TC "2-2.3.2 **Open Channels**." \f C \l "3" **}** Limit maximum velocities to prevent erosion on soil type and lining in accordance with the State Department of Transportation's (DOT) Drainage Manual where the project is located; the applicable regulatory agency which governs stormwater management; or the State *Erosion and Sediment Control Manual* and regulations where the project is located; whichever is more stringent.

2-2.3.3 **Erosion and Sediment Control.{** TC "2-2.3.3 **Erosion and Sediment Control**." \f C \l "3" **}** Provide erosion and sediment control measures in conformance with the requirements of the State or applicable regulatory agency where the project is located. In locations where specific regulations do not exist, apply erosion and sediment control measures from a similar or appropriate jurisdiction and reference the governing standards that were used.

2-2.4 **Underground Storm Drainage{** TC "2-2.4 Underground Storm Drainage" \f C \l "3" **}**

The drainage system design shall comply with the local regulatory agency's standards and requirements, or the following guidance, whichever is more stringent.

a. Provide straight alignments for piping between storm drainage structures with deflection at structures no greater than 90 degrees for main line flow (24" diameter and greater) and 120 degrees for contributory flow lines. Use of curvilinear alignment is not allowed. Additional design requirements follow:

b. Storm drainage piping must not pass under buildings and must be a parallel distance of at least 3 m (10 feet) from building foundations.

c. Conflicts with other utilities shall be avoided. Conflict structures will not be allowed without Government approval. Comply with state or applicable regulatory agency's requirements for separation distances between utilities and other public health and safety issues.

d. Provide a structure at collection and inlet points, at least every 92 m (300 feet) for pipes 610mm (24 inches) in diameter and less, pipe junctions, and at changes in horizontal or vertical alignment of a pipe run. Provide a structure at least every 122 m (400 feet) for pipes up to and including 1,220 mm (48 inches) in diameter, and at least 244 m (800 feet) for pipes larger than 1,220 mm (48 inches) in diameter. Provide a discharge structure wherever flow changes piped to open channel flow.

e. Provide inlets on roads to reduce spread in accordance with the State Department of Transportation's (DOT) *Drainage Manual* where the project is located or the requirements of the applicable regulatory agency that governs stormwater management, whichever is more stringent. The spread shall never more than be ½ driving lane based on a 5 year storm intensity.

f. In the design of culverts and storm drains, consider headwater and tailwater and their effects on hydraulic grade line and capacity. The hydraulic grade line for the drainage system shall not exceed an elevation one foot above the pipe crown, or one foot below the structure rim or gutter flow line at inlets, whichever is the lower elevation at each structure. Culverts shall not be surcharged more than one foot at either end. At

structures, the inlet pipe crown elevation must be equal to or greater than the outlet pipe crown elevation to minimize the hydraulic turbulence at the junction. Provide adequate slope in the structure's flow channel to accommodate the hydraulic losses through the structures. .

g. The pipe size must not decrease downstream in the direction of flow. This shall include connections of new collection systems to existing facilities. Pipe sizing must be in accordance with the State Department of Transportation's (DOT) *Drainage Manual* where the project is located or the requirements of the applicable regulatory agency that governs stormwater management, whichever is more stringent.

h. Locate drainage structures out of paved areas wherever possible. Adjust structure locations to avoid primary wheel tracks when structures must be located in roadways.

2-2.4.1 **Minimum Pipe Size.**{ TC "2-2.4.1 **Minimum Pipe Size**." \f C \l "3" } Storm drainage piping (not including roof drainage piping) must have a minimum inside diameter of 375 mm (15 in).

2-2.4.2 **Minimum Cover**.{ TC "2-2.6.2 **Minimum Cover**." \f C \l "3" } The minimum cover of pipes shall be 300 mm (12 in) regardless of class or strength of pipe selected. Measure the cover from the top of the pipe to the top of the pavement or finished grade. All pipes shall be evaluated for design dead and live loads that will be encountered. Increase depth of cover, pipe material strength, or bedding requirements to accommodate the imposed loads.

2-2.4.3 **Design Velocity**.{ TC "2-2.4.3**Design Velocity**." \f C \l "3" } Provide a minimum flow velocity of 2.5 feet per second and a maximum velocity of 10 feet per second using the Manning equation with the pipe flowing full and under no surcharge at peak flow conditions.

2-2.4.4 **Manning's Roughness Coefficient, "n".**{ TC "2-2.4.4 **Manning's Roughness Coefficient, "n"**." \f C \l "3" } Use Manning's roughness coefficient, "n" of 0.013 for circular, smooth pipe. For other drainage shapes and materials, see state or local regulatory agency's requirements.

2-2.4.5 **Material Selection.**{ TC "2-2.4.5 Material Selection." \f C \l "3" } Provide storm drain system materials in conformance with PTS Section G30 or UFGS. Material selections may be restricted when required to meet specific site conditions for a project. The use of corrugated aluminum or high-density polyethylene (HDPE) pipe shall be explicitly authorized by the Government's Civil Reviewer.

2-2.4.6 **Culverts and Outfalls.**{ TC "2-2.4.6 Culverts and Outfalls." \f C \l "3" } Culverts and outfalls must have headwalls, endwalls, wingwalls, flared or mitered end sections at free outlets. Provide appropriate erosion and sediment control measures at the outfall.

2-2.4.7 **Storm Structures.{** TC "2-2.4.7 **Storm Structures**." \f C \l "3" **}** Storm structures must be in accordance with the State Department of Transportation's (DOT) Standards and Specifications where the project is located or the requirements of the applicable regulatory agency that governs stormwater management, whichever is more stringent. Structures must provide access for maintenance. Internal dimensions must not be less than 600 mm (2 ft) in any one direction. Ensure that catch basins, curb inlets, and manholes are of adequate size to accommodate inlet and outlet pipes.

Provide structures of cast-in-place or precast concrete. Masonry structures must not be used in airfield construction but will be allowed on other projects only for shallow installations less than 5 feet in depth.

Design structure frames, covers and grates to withstand traffic loadings and meet any additional requirements set forth in the using agency criteria for the particular application, such as airfields. Airfield structures shall be designed in accordance with the Federal Aviation Administration's (FAA's) AC 150/5320-5B, *Airport Drainage* and require ductile iron or steel grates and covers. Isolate airfield structures from the pavement section. Use appropriate standard details for airfield structures available from the Government's Civil Reviewer.

Design grated covers to be of "bicycle proof" design where appropriate.

2-2.5 Stormwater Management Facilities{ TC "2-2.5 Stormwater Management Facilities" \f C \l "3" }

Design in accordance with the guidelines of the local regulatory agency governing stormwater management. The selected approach must conform to any stormwater management agreements. Obtain approval of the design from the Government's Civil Reviewer prior to the submittal to the local regulatory agency.

2-2.6 Safety and Security{ TC "2-2.6 Safety and Security" \f C \l "3" }

2-2.6.1 **Safety.{** TC "2-2.6.1 **Safety**." \f C \l "3" **}** The design of stormwater management facilities such as detention/retention ponds must incorporate protective measures in residential housing areas and other areas frequented by children. Protective measures include, but are not limited to, appropriate site selection for the storm water management facility and/or providing a fenced enclosure surrounding the facility to ensure the safety of children.

2-2.6.2 **Security.{** TC "2-2.6.2 **Security**." \f C \l "3" **}** Provide security barriers at all locations where security fences must cross drainage ditches or swales to assure that intruders are prevented from passing under the fence without a delay. Pipes crossing under security fences larger than 250 mm (10 in) in diameter require protective measures. Designs must comply with the physical security criteria included in MIL-HDBK-1013/1A, MIL-HDBK-1013/10, OPNAVINST 5530.14C, and MCO PS530.14.

2-3 WATER DISTRIBUTION SYSTEMS{ TC "2-3 WATER DISTRIBUTION SYSTEMS" \F C \L "2" }

2-3.1 Design Criteria{ TC "2-3.1 Design Criteria" \f C \l "3" }

Design the water distribution system, including water supply wells and storage tanks, in accordance with the requirements of the applicable regulatory agency that governs waterworks where the project is located, NFPA criteria, or the requirements of this UFC, whichever is more stringent.

The following water distribution systems parameters shall be met:

a. Determine the required flow based upon the peak demand. Consider fire protection, industrial and domestic demands and future growth.

b. Conduct a fire hydrant flow test in accordance with AWWA Manual M17, *Installation, Field Testing, and Maintenance of Fire Hydrants*, American Water Works Association, and National Fire Protection Standard (NFPA) 291, *Fire Flow Testing and Marking of Hydrants*, in the vicinity of the proposed point of connection to the existing water distribution system to determine the available flow and the system's residual pressure. Include the hydrant flow test information in the Basis of Design and/or Calculations.

c. The residual water pressure at peak flow must not be less than 20 psi. Coordinate with the mechanical/plumbing and fire protection engineers to determine whether a higher residual pressure is required for the specific project.

d. Where an automatic fire extinguishing system is being provided, residual pressure must meet the requirements for activation of the system while simultaneously providing 50 percent of the average domestic and industrial flows.

e. Do not exceed velocities greater than 1.52 m (5 ft) per second in PVC pipelines; do not exceed velocities greater than 3.05 m (10 ft) per second in pipelines constructed of materials other than PVC.

2-3.2 **System Layout{** TC "2-3.2 System Layout" \f C \l "3" **}**

The layout of the new water distribution system shall minimize the lengths of new lines and shall be looped as much as possible. If the firefighting water system is separate from the potable water distribution main such that there are no fire hydrants, include water main flushing devices in the design of the potable water distribution system at the same frequency that fire hydrants would be provided.

2-3.2.1 **Minimum Cover.{** TC "2-3.2.1 **Minimum Cover**." \f C \l "3" **}** Comply with local regulatory requirements. At a minimum protect pipe from freezing and imposed dead and live loads. Where installation requirements are not regulated, at least 0.91m (3ft) of cover is preferred.

2-3.2.2 **Maximum Hazen Williams' Roughness Coefficient, "C".{** TC "2-3.2.2 Maximum Hazen Williams' Roughness Coefficient, "C"." \f C \l "3" **}** Unless otherwise directed, use the following Hazen-Williams' roughness coefficients, C for various pipe materials and ages. Alternate values may be used when they are specifically derived from flow tests and modeling of the distribution system being modified.

TABLE 2-2: MAXIMUM HAZEN-WILLIAMS ROUGHNESS COEFFICIENT "C"{ TC "ABLE 2-2: MAXIMUM HAZEN-WILLIAMS ROUGHNESS COEFFICIENT \"C\"" \f C \l "3" }

Pipe Material	Age	C
Concrete	----	130
Ductile Iron	----	120
Cast Iron	5 years	120
	10 years	110
	20 years	90
	30 years	80
PVC	----	140

2-3.2.3 **Thrust Restraint.{** TC "2-3.2.3 **Thrust Restraint**." \f C \l "3" **}** Restrain all pipe, fittings, valves, and appurtenances against thrust in accordance with manufacturer's recommendations.

2-3.3 **Material Selection.{** TC "2-3.3 Material Selection." \f C \l "3" **}**

2-3.3.1 **Water Mains.{** TC "2-3.3.1 **Water Mains**." \f C \l "3" **}** New water main materials shall be in conformance with PTS Section G30.

2-3.3.1.1 **Polyvinyl Chloride (PVC) Pipe.{** TC "2-3.3.1.1 **Polyvinyl Chloride (PVC) Pipe**." \f C \l "3" **}** Do not use PVC piping for any aboveground applications. At velocities above 1.5 m/s (5 ft/s) in PVC pipe, the design shall address surge pressures and conditions.

2-3.3.1.2 **Ductile Iron Pipe.{** TC "2-3.3.1.2 **Ductile Iron Pipe**." \f C \l "3" **}** All ductile iron pipe must have cement mortar lining. In corrosive soil conditions, wrap ductile iron pipe in polyethylene.

2-3.3.1.3 **High Density Polyethylene (HDPE) Pipe.{** TC "2-3.3.1.3 **High Density Polyethylene (HDPE) Pipe**." \f C \l "3" **}** Provide adequate protection from sunlight, fire, flotation, and wheel loads for HDPE piping.

2-3.3.2 **Water Service Lines.{** TC "2-3.3.2 **Water Service Lines**." \f C \l "3" **}** New water service lines shall be in conformance with PTS Section G30.

2-3.4 **Backflow Prevention.{** TC "2-3.4 Backflow Prevention." \f C \l "3" **}**

Provide in accordance with the applicable, local regulatory agency's requirements.

2-3.5 **Valves.{** TC "2-3.5 **Valves**." \f C \l "3" **}**

Provide shut off valves on water distribution pipelines so that no more than two fire hydrants are taken out of service with a single break anywhere in the system.

Design in accordance with UFC 3-600-01, *Fire Protection Engineering for Facilities* for requirements for the following types of valves: gate valves, butterfly valves, sluice gates, air release valves, altitude valves, float valves, plug valves, pressure regulating valves, pressure relief valves, and vacuum valves. All valves must comply with the latest applicable American Water Works Association standards. Provide indicator posts for gate valves where required in compliance with UL 789.

2-3.6 **Hydrants.{** TC "2-3.6 **HYDRANTS**." \f C \l "3" **}**

Provide a shutoff valve with a valve box on the branch between the hydrant and the main. The branch line to the fire hydrant and valve must be a minimum of 150 mm (6 in) in diameter. Refer to UFC 3-600-01 for hydrant spacing requirements.

2-3.7 **Service Connections and Meters.{ TC "2-3.7 Service Connections and Meters." \f C \l "3" }**

Provide water meters as directed by the Government.

2-3.8 **Water Pump Stations{** TC "2-3.8 Water Pump Stations" \f C \l "3" **}**

Water booster pump stations and transmission mains are not allowed, unless explicitly authorized by the Government's Civil Reviewer.

2-4 **WASTEWATER COLLECTION SYSTEMS{** TC "2-4 **WASTEWATER COLLECTION SYSTEMS**" \F C \L "3" **}**

Design the wastewater collection system in accordance with the requirements of the applicable regulatory agency that governs sewer systems where the project is located or the guidance noted in this UFC, whichever is more stringent. Also, design industrial waste collection systems in accordance with UFC 3-240-02, *Design: Wastewater Treatment System Augmenting Handbook*. Gravity systems are preferred and shall be provided wherever possible. Obtain Government approval for pump station systems where they are deemed to be the only viable method to provide adequate sewerage service.

2-4.1 **Design Criteria{** TC "2-4.1 Design Criteria" \f C \l "3" **}**

Design new sewer system capacity using the average daily flow per capita of sewage with appropriate peak factor. Use per capita sewage flow rates and peak factors as required by the State sewerage regulations where the project is located.

Minimum peak design capacity of main sewers must be 250% of the average annual daily flow. For populations less than 100,000, the minimum peak design capacity of main sewers must be 400% of the average annual daily flow.

Evaluate downstream capacity and upgrade existing system to carry existing and proposed additional flow.

Where regulatory standards do not adequately address per capita rates by facility type, obtain guidance from the Government's Civil Reviewer.

2-4.2 **System Layout{** TC "2-4.2 System Layout" \f C \l "3" **}**

2-4.2.1 **Minimum Pipe Size.{** TC "2-4.2.1 **Minimum Pipe Size**." \f C \l "3" **}** No sewer mains shall be less than 200 mm (8 in) in diameter. The minimum lateral size for building service connections shall be at least 100 mm (4 in) in diameter.

2-4.2.2 **Minimum Cover.{** TC "2-4.2.2 **Minimum Cover**." \f C \l "3" **}** Minimum cover over sewer pipes shall be 0.61 m (2 ft); greater than frost penetration according to UFC 3-310-01; or sufficient to support imposed dead and live loads for the pipe materials used; which ever is more stringent.

2-4.2.3 **Flow Velocity.{** TC "2-4.2.3 **Flow Velocity**." \f C \l "3" **}** For exterior lateral connections and sewer mains, the minimum flow velocity shall be 0.60 meters per second (2.0 feet per second) and the maximum velocity shall be 3.0 meters per second (10 feet per second) when calculated using the Manning's formula and a roughness coefficient value of 0.013.

2-4.2.4 **Layout.{** TC "2-4.2.5 **Layout**." \f C \l "3" **}** Lay all sewer lines with straight alignment between manholes and/or cleanouts. The maximum spacing between manholes shall be 120 m (400 ft). Provide a manhole at any change in direction or slope. For service connections 100 mm and 150 mm (4 and 6 in) in diameter, where a change in slope and/or direction occurs, the manhole may be replaced by a cleanout, provided that the length of service line downstream of the cleanout is not longer than 30.5 m (100 ft). Combining sewer laterals from multiple buildings will not be allowed. Each building must have its own lateral to the sewer main.

2-4.3 **Material Selection{** TC "2-4.3Material Selection" \f C \l "3" **}**

Sewer mains and laterals must conform with PTS Section G30.

2-4.4 **Sanitary Structures{** TC "2-4.4 Sanitary Structures" \f C \l "3" **}**

2-4.4.1 **Manholes**.{ TC "2-4.4.1 **Manholes**." \f C \l "3" } The minimum diameter of manholes must be 1.20 m (48 in); larger diameters are required for large diameter sewers. The minimum clear opening diameter of the manhole cover is 610 mm (24 in,) unless otherwise indicated. Provide traffic loadings to determine traffic requirements for frames and covers.

Provide manholes of cast-in-place or precast concrete construction. Masonry manholes will be allowed on projects only for shallow installations of less than 5 feet in depth.

2-4.4.2 **Drop Manholes**.{ TC "2-4.4.2 **Drop Manholes**." \f C \l "3" } Provide drop manholes for any manhole where the difference between the inlet pipe invert elevation and the manhole invert elevation is greater than 610 mm (24 in). The drop connection shall be made on the exterior of the manhole and shall be concrete encased such that it is integral to the main structure and supported on the same foundation slab.

2-4.4.3 **Flow Channel**.{ TC "2-4.4.2 **Flow Channel**." \f C \l "3" } The flow channel through the manhole must be made to conform as closely as possible to shape and slope of the connecting sewers. Whenever connections are made to existing manholes, the bench of the manhole must be reworked to provide proper flow channels.

2-5 PUMP STATIONS AND TRANSMISSION SYSTEMS{ TC "2-5 **PUMP STATIONS AND TRANSMISSION SYSTEMS**" \F C \L "2" }

Use pump stations only where specifically identified in the project scope of work or upon written approval from the Government's Civil Reviewer.

Provide new pump stations and upgrades to existing pump stations in accordance with guidance noted herein; the requirements of the utility provider; or the requirements of the applicable regulatory agency which governs pumping systems where the project is located; whichever is more stringent.

2-5.1 Wastewater Pump Stations{ TC "2-5.1 Wastewater Pump Stations" \f C \l "3" }

Design wastewater pump stations in accordance with the Ten States' *Recommended Standards for Wastewater Facilities* except as noted herein. Wastewater pumps, except grinders, must be capable of passing 80 mm (3 in) solids. Provide wet wells of precast concrete or fiberglass construction. Provide an emergency pump connection and appropriate valving capable of rapid connection to a portable pump that can bypass the pump station from the wet well to the force main.

2-5.2 Design Criteria{ TC "2-5.2 Design Criteria" \f C \l "3" }

2-5.2.1 **Redundancy and Reliability**.{ TC "2-5.2.1 **Redundancy and Reliability**." \f C \l "3" } Provide redundancy for duplex and triplex systems such that peak flow is provided with one pump out of service. Select the pump motor horsepower such that it will accommodate any variation in flow and head along the entire design impeller curve without motor overload or failure. Provide for emergency power operation in conformance with applicable regulatory requirements.

2-5.2.2 **Access.{** TC "2-5.2.2 **Access.**" \f C \l "3" **}** Pump stations must have adequate access for personnel and equipment maintenance and replacement. Access points must be lockable.

2-5.2.3 **Piping.{** TC "2-5.2.3 **Piping.**" \f C \l "3" **}** Piping for pumping systems shall conform with requirements of PTS Section G30. System flow velocities shall conform with applicable jurisdictional regulations. Where none exist, the velocity shall be no less than 0.6 mps (2.0 fps) or more than 3.0 mps (10 fps)

2-5.2.3.1 **Polyvinyl Chloride (PVC) Pipe..{** TC "2-5.2.3.1 **Polyvinyl Chloride (PVC) Pipe.**" \f C \l "3" **}** At velocities above 1.5 m/s (5 ft/s) in PVC pipe, the design shall address surge pressures and conditions.

2-5.2.3.2 **Ductile Iron Pipe.{** TC "2-5.2.3.2 **Ductile Iron Pipe.**" \f C \l "3" **}** All ductile iron pipe must have a cement mortar lining. In coastal areas and where corrosion may be a problem, wrap ductile iron pipe in polyethylene. Provide restrained joints in accordance with *Thrust Restraint Design for Ductile Iron Pipe*.

2-5.2.4 **Piping Accessories.{** TC "2-5.2.4 **Piping Accessories**." \f C \l "3" **}** For dry pit/wet pit pump stations, provide pressure gages on discharge piping directly downstream of the pump. Provide air-release valves at high points. Provide flow meters if required by the utility provider.

2-5.2.5 **Minimum Cover.{** TC "2-5.2.5 **Minimum Cover**." \f C \l "3" **}** Minimum cover over the force mains must be 0.6m (2ft.); greater than frost penetration according to UFC 3-310-01, *sufficient to support impassed dead and live loads,* or greater than depth required to install valve riser; whichever is more stringent.

2-5.2.6 **Alarms.{** TC "2-5.2.6 **Alarms.**" \f C \l "3" **}** Pump station monitoring alarms shall comply with applicable jurisdictional requirements. Monitoring shall be to a location designated by the Government. The systems used shall be fully compatible with any existing systems and standards in use by the Activity or public utility operating the station. Where specific regulations are not in place, provide visual and audible high water alarms at the pump station.

2-5.2.7 **Ventilation and Lighting.{** TC "2-5.2.7 Ventilation and Lighting." \f C \l "3" **}** Provide pump stations with ventilation and lighting in accordance with jurisdictional requirements.

2-5.3 Water Pump Stations{ TC "2-5.3 Water Pump Stations" \f C \l "3" }

Design water pump stations in accordance with the Ten States' *Recommended Standards for Water Works* except as noted herein.

2-5.4 Stormwater Pump Stations{ TC "2-5.4 Stormwater Pump Stations" \f C \l "3" }

Design stormwater pump stations in accordance with the State Department of Transportation's (DOT) *Drainage Manual* where the project is located except as noted

herein. Stormwater pump stations may only be used with explicit authorization by the Government.

2-5.5 **Upgrades to Existing Pump Stations{** TC "2-5.5 Upgrades To Existing Pump Stations" \f C \l "3" **}**

Existing pump stations may be upgraded where a complete hydraulic analysis shows that the pump station can operate at the proposed capacity in conformance with the jurisdictional requirements for a new pump station of equal capacity. The hydraulic analysis shall include affects on the existing force main to its point of discharge, and it networked, the effects on all other pump stations connected to the system. This analysis is required whenever additional flow is added to a pump station, even if physical changes to the station are not proposed.

2-6 **FLEXIBLE AND RIGID PAVEMENTS{** TC "2-6 FLEXIBLE AND RIGID PAVEMENTS" \F C \L "3" **}**

2-6.1 **Flexible Pavements.{** TC "2-6.1 **Flexible Pavements**." \f C \l "3" **}**

Materials shall be in conformance with either the American Association of State Highway and Transportation Officials; the Asphalt Institute; or the local Department of Transportation in the state in which the facility is to be located.

2-6.2 **Rigid Pavements.{** TC "2-6.2 **Rigid Pavements**." \f C \l "3" **}**

Design rigid pavements as non-reinforced wherever possible. Provide reinforcement for odd-shaped slabs. An odd-shaped slab has a length to width ratio greater than 1.25. Clearly indicate on the drawings the specific individual slabs requiring reinforcement.

In all areas, consider possible alkali-silica reaction, cracking potential with local aggregates. Specify nonreactive aggregates, low-alkali cement or certain types of pozzolanic materials. Provide air entrainment in all concrete pavements.

Sawcut contraction and construction joints. Do not allow the use of insertable forms for contraction joints. Accomplish load transfer across expansion joints using thickened edge expansion joints. Accomplish load transfer across construction (longitudinal) joints using dowels or thickened edges. Contact the cognizant Government's Civil Reviewer for approval prior to use of key joints which may be considered based upon loadings and subgrade strength. Do not locate dowels within a distance equal to the pavement thickness on either side of a contraction joint.

2-6.3 **Repair and Maintenance.{** TC "2-6.3 **Repair and Maintenance**." \f C \l "3" **}**

Evaluate pavements in accordance with UFC 3-260-03, *Design: Airfield Pavement Evaluation*.

2-6.4 **Airfield Pavements{** TC "2-6.4 Airfield Pavements" \f C \l "3" **}**

Design in accordance with UFC 3-260-01, *Airfield and Heliport Planning and Design* and P-80.3, *Facility Planning Factor Criteria for Navy and Marine Corps Installations, Appendix E, Airfield Safety Clearances* for the geometric design of airfield pavements.

Design airfield pavements in accordance with UFC-3-260-02, *Pavement Design for Airfields*. Minimum thickness design of airfield pavement sections shall be in accordance with the latest version of *Pavement-Transportation Computer Assisted Structural Engineering (PCASE)* software.

All airfield pavement designs must be sealed by a registered professional engineer who is experienced in airfield pavement design, so that safe, high quality and geometrically correct airfield surfaces conforming to current applicable airfield criteria are maintained.

Porous pavements are not allowed in airfield design. Airfield pavements include any pavements supporting vehicles trafficing the airfield pavement.

2-6.4.1 **Airfield Pavement Markings.{** TC "2-6.4.1 Airfield Pavement Markings." \f C \l "3" **}** Airfield pavement markings for Navy and Marine Corps facilities must conform to NAVAIR 51-50AAA-2. Assault Landing Zone markings and heliport markings shall conform to TM 5-923-4, *Marking of Army Airfield-Heliport Facilities*.

2-6.4.2 **Other Design Factors of Airfield Pavements.{** TC "2-6.4.2 Other Design Factors of Airfield Pavements." \f C \l "3" **}** The design engineer on airfield pavement projects shall address the following: phasing of work; use of recycled materials; possibility of batching for asphalt or concrete; staging areas; haul routes; and temporary airfield markings or lighting required for construction.

2-6.5 **Roads, Streets and Open Storage Areas.{** TC "2-6.5 Roads, Streets and Open Storage Areas" \f C \l "3" **}**

Design in accordance with UFC 3-230-18FA, *General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas,* and AASHTO's *A Policy on Geometric Design of Highways and Streets* for the geometric design of vehicular roads and streets. Porous pavements (encompassing not only stone pavers, but also grasscrete and other pavement mixes) shall not be used unless approved in writing by the cognizant Government Civil Reviewer.

Minimum thickness design of vehicular pavement sections shall be in accordance with PCASE, UFC 3-250 series and TM 5-822 series.

The minimum thickness of granular base shall be 6-inches. Provide a thicker aggregate base if required to reduce frost penetration into the subgrade or to increase the modulus values in weak subgrade soils.

2-6.5.1 **Flexible Pavements.{** TC "2-6.5.1 **Flexible Pavements**." \f C \l "3" **}** Materials shall be in conformance with the local Department of Transportation in the state in which the facility is located.

2-6.5.2 **Rigid Pavements**.{ TC "2-6.5.2 **Rigid Pavements**." \f C \l "3" **}** Materials shall be in conformance with the local Department of Transportation in the state in which the facility is located. Design rigid pavements as non-reinforced wherever possible.

2-6.5.3 **Repairs and Maintenance**.{ TC "2-6.5.3 **Repairs and Maintenance**." \f C \l "3" **}** Evaluate pavements in accordance with UFC 3-260-03.

2-6.5.4 **Pavement Markings**.{ TC "2-6.5.4 **Pavement Markings**." \f C \l "3" **}** Provide and install pavement markings in accordance with the *Manual on Uniform Traffic Control Devices (MUTCD)*. Coordinate with the Naval installation for their specific requirements.

2-6.5.5 **Traffic Control**.{ TC "2-6.5.5 **Traffic Control**." \f C \l "3" **}** Provide and install new traffic control devices (i.e.; signs, markings, etc.) in accordance with the *MUTCD*. Coordinate with the Naval installation for their specific requirements.

CHAPTER 3 DESIGN SERVICES{ TC "CHAPTER 3 DESIGN SERVICES" \F C \L "2" }

3-1 PRE-DESIGN SERVICES.

{ TC "3-1 **PRE-DESIGN SERVICES**." \F C \L "3" **}**

3-2 DESIGN SERVICES.**{** TC "3-2 **DESIGN SERVICES**." \F C \L "3" **}**

3-2.1 Civil Basis of Design (BOD).**{** TC "3-2.1 **Civil Basis of Design (BOD)**." \f C \l "3" **}**

3-2.1.1 **General.{** TC "3-2.1.1 **General.**" \f C \l "3" **}** Identify the governing codes and criteria including federal and military handbooks being used for the design. References may be noted in the related sections listed below. Include reference titles and date of publications. Provide BOD with adequate narrative to describe design logic and assumptions. Show adherence to scope of work.

3-2.1.2 **Existing Conditions.{** TC "3-2.1.2 **Existing Conditions.**" \f C \l "3" **}** Include the following:

a. Describe general site topography and vegetation type (grass, lightly wooded, brush). Describe existing site features.

b. Verify whether existing footings, foundations, steam pits etc. exist.

c. Describe existing soil conditions.

d. Describe existing utilities, including size, type, and general location. Discuss impact that this, and future projects, will have on utility systems.

e. Identify predominant drainage features, including any required downstream improvements. State whether field survey has been coordinated with delineation. Indicate the parties that have been notified of the presence of wetlands and are actively involved in this issue.

f. Verify if endangered species inhabit area.

g. Identify and describe existing traffic patterns on and around site.

h. Provide horizontal and vertical datums and other pertinent survey information.

3-2.1.3 **Geotechnical.{** TC "3-2.1.3 **Geotechnical.**" \f C \l "3" **}** Describe existing soil conditions. Address geotechnical investigation (status, findings, report, as applicable). Describe the geotechnical investigation program, the recommendations for the site preparation, and the pavement design. Include the Geotechnical Report as an appendix to the BOD. Indicate known soil contamination issues connected with the site.

3-2.1.4 **Demolition.{** TC "3-2.1.4 **Demolition."** \f C \l "3" **}** Discuss demolition relating to Civil issues only, typically 1.53 m (5 feet) outside of building line. Identify all buildings slated to be demolished by building number. Generally describe structure types (1-story frame, 2-story block, etc.); building specifics should be included under Architectural BOD. Describe pavement to be demolished, including existing pavement section. Describe underground and overhead utility demolition, relocation, and abandonment. Describe other features to be removed (play equipment, fencing, etc.)

3-2.1.5 **New Site Work.{** TC "3-2.1.5 **New Site Work."** \f C \l "3" **}** Describe new building and its function with respect to Civil issues such as vehicle ingress/egress, pedestrian movement, etc. Address internal functions under Architectural BOD. Describe pedestrian access. Identify number of parking spaces; include stall and aisle widths. Describe handicap access in and around site, number and size of handicap parking spaces. Identify physical security requirements, such as intrusion detection provisions, fencing type and height, and lighting requirements. Also identify antiterrorism standoff distance requirements for the specific site conditions. Identify vehicle type expected on project site; note non-standard vehicle sizes and weights. Identify design wheel loading. Define projected traffic volume. Define new pavement types and sections. For airfield pavement, discuss design parameters, including pavement use, loadings, design life adopted in design, design methodology to be used, and availability of materials anticipated for construction, and possible impacts construction may have on airfield operations – haul routes, closures, etc. For railroads, state type of service for which railroad track will be provided; anticipated volume and type of traffic; the ruling grade and the maximum curvature. Describe proposed type, source and thickness of ballast, weight of rail and source, treatment and dimensions of ties.

3-2.1.6 **Sustainable Design.{** TC "3-2.1.6 **Sustainable Design."** \f C \l "3" **}** Identify possible re-use of materials (crushed pavement, etc.). Provide an updated LEED checklist. The checklist must indicate progress towards obtaining the minimum LEED rating required by the RFP or the higher LEED rating established by the Contractor during the Post Award Kickoff Meeting. Describe how the sitework and civil work design submittal incorporates sustainable design features to achieve the LEED prerequisites and credits.

3-2.1.7 **Grading..{** TC "3-2.1.7 **Grading."** \f C \l "3" **}** Define minimum longitudinal and transverse slopes to be used on concrete and bituminous asphalt pavements, ditches, gutters, etc. Indicate 100-year flood elevation with respect to project datum. Indicate the projected finished floor elevation for each facility to be constructed. Discuss whether earthwork cuts and fills will be balanced, if suitable borrow material is available locally, and options for disposal of excess cut material. Verify existence of a base borrow source, base landfill and whether or not it is available for disposal.

3-2.1.8 **Water Supply.{** TC "3-2.1.8 **Water Supply."** \f C \l "3" **}** State design parameters; include domestic and fire flow, residual pressure, and recent flow test data. State anticipated demand. Describe water main and supply line sizes and capacities. Identify connection points. Identify connection methods. Identify whether existing infrastructure has capacity to support project. Identify requirements for backflow

protection and freeze protection. Identify needs for metering. Identify need for booster pumps or pressure reducing valves. Identify level of fire protection required for building. Identify number of fire hydrants required by latest fire protection criteria. State number of new hydrants. Provide number of wells and proposed pump rates.

3-2.1.9 **Water Supply Treatment..{** TC "3-2.1.9 **Water Supply Treatment.**" \f C \l "3" **}** Identify completed studies and briefly describe recommended process noting deviations from the studies. State sizes, elevations, capacity, etc., for reservoirs, treatment units, pumping stations, well pumps, etc.

3-2.1.10 **Sanitary Sewer.{** TC "3-2.1.10 **Sanitary Sewer.**" \f C \l "3" **}** Describe waste stream and whether it is from domestic or industrial source. Include sources of any hazardous substances. Identify design population, peak and average flows. State whether sewer will be gravity or force main. Identify pre-treatment requirements and solutions. State minimum pipe slopes and velocities. Identify special installation requirements. State new pipe sizes and capacities. Identify pump station type, wet/dry well, types of pumps, pump capacity and total dynamic head, horsepower, telemetry requirements and compatibility with existing on-base systems, backup power requirements, and assumed response time by Activity personnel. Consult Activity as to whether existing system is operating at or near capacity. Discuss adequacy of existing system to handle current and future flows.

3-2.1.11 **Wastewater Treatment.{** TC "3-2.1.11 **Wastewater Treatment.**" \f C \l "3" **}** Identify completed treatability studies. Briefly describe recommended process noting deviations from the treatability study. Define impact of stream condensation and cooling water discharges on sewer piping and treatment plants and the estimated cost of distribution and treatment of this additional loading.

3-2.1.12 **Storm Drainage System.{** TC "3-2.1.12 **Storm Drainage System.**" \f C \l "3" **}** Identify receiving waters, classification (if applicable), storm frequency, C factors, etc. Discuss adequacy of existing storm system and its effects on downstream facilities and systems. Discuss whether existing system will require upgrades. Identify use of collection system vs. sheet flow. Describe materials and pipe sizes. Describe how upstream flows that impact site will be handled.

3-2.1.13 **Stormwater Management.{** TC "3-2.1.13 **Stormwater Management.**" \f C \l "3" **}** Discuss best management practices (BMP's) and approach to stormwater management. Discuss compliance with Activity, State, & local requirements.

3-2.1.14 **Erosion & Sediment Control. {** TC "3-2.1.14 **Erosion & Sediment Control.**" \f C \l "3" **}**

Identify total disturbed area acreage. Discuss erodibility of soil, devices or methods to be used to control erosion and sediment losses, and protection devices at outfalls. Discuss compliance with Activity, State, and local requirements.

3-2.1.15 **Environmental Permits. {** TC "3-2.1.15 **Environmental Permits.**" \f C \l "3" **}**

Identify the permits necessary for both construction and operation of facilities. Identify fees associated with each permit. Submit PROD form with BOD. Refer to Chapter 3, paragraph 3-4 for more information.

3-2.1.16 **Antiterrorism.**{ TC "3-2.1.16 **Antiterrorism.**" \f C \l "3" } Identify the type of building and discuss minimum standoff distances from controlled perimeter, parking and roadways, trash containers, and other buildings. Discuss unobstructed space, drive-up / drop-off and access roads, site planning, and any special concerns. Discuss how the site plan layout meets the antiterrorism standards. This discussion should be handled as controlled information per all applicable requirements of NAVINST 5510.36. At a minimum this information should be treated as FOUO and in some cases higher levels of information control/classification may be warranted.

3-2.2 **Specifications**.{ TC "3-2.2 **Specifications**." \f C \l "3" }

See UFC 1-300-09N, *Design Procedures.*

3-2.3 **Calculations**.{ TC "3-2.3 **Calculations**." \f C \l "3" }

Provide calculations in accordance with UFC 1-300-09N. Provide design calculations for pavement and utility systems. Calculations must be signed and sealed by a Professional Engineer. For projects that include an irrigation system, provide the following irrigation calculations,

a. Calculations for valve at highest elevation

b. Calculations for valve at lowest level

c. Calculations for valve with highest GPM (L/M) and GPH (M^3/H)

d. Calculations for valve with lowest GPM (L/M) and GPH (M^3/H)

e. Calculation sheet indicating valve sequence number, total GPM/GPH, elevation of valve, water meter and highest irrigation head or emitter, total friction loss through all irrigation equipment and piping, operating PSI (kPa) of irrigation head or emitter and residual PSI (kPa)

3-2.4 **Civil Drawings**.{ TC "3-2.4 **Civil Drawings**." \f C \l "3" }

Drawings must be D-size drawings. Provide north arrows and graphic scales on all applicable drawings. All final drawings must be signed and sealed by a licensed civil engineer. See Appendices for regional requirements on preferred graphic scales. Refer to UFC 1-300-09N.

3-2.4.1 **Cover Sheet, Drawing Index, Vicinity Map, Location Plan, Abbreviations, Legend, and Notes, or First Civil Sheet.**{ TC "3-2.4.1 **Cover Sheet, Drawing Index, Vicinity Map, Location Plan, Abbreviations, Legend, and Notes, or First Civil Sheet.**" \f C \l "3" } General – If project is not a Civil Engineering lead, assure that

the following items are coordinated with the lead discipline responsible for creating cover sheet:

a. If General Development Maps (GDM) are used for the Vicinity and Location Maps, edit for the specific project being designed. Ensure street names, main gates, and the Public Works office of the base are identified. Ensure that text is legible at the plotted scale and remove extraneous lines.

b. The Vicinity Map must identify the Activity and have enough main highway names and street names to allow an out-of-town contractor to locate the work.

c. The Location Plan must allow the contractor to find the project on the base. This is generally a good place to show laydown areas, haul routes, any construction traffic routing restrictions, and off-site benchmark locations. Provide an adequate amount of street names to allow coordination between the Vicinity Map and the construction plans.

d. In general, it is desirable to show the Vicinity Map and the location Plan on the Cover Sheet along with the project title.

e. Coordinate with ROICC and Activity for laydown area.

f. Edit standard details, abbreviations, legends, and general notes for the specific project being designed.

g. Provide a single Civil legend on one sheet (preferably sheet C-001).

h. For projects near tidal waters, show datum sketch indicating project vertical datum and relationship to range of tide and other important datums.

3-2.4.2 **Demolition Plan.** Include the following information:**.{** TC "3-2.4.2 **Demolition Plan.**" \f C \l "3" **}**

a. Clearly show what is to be demolished at an appropriate scale. Coordinate/edit the legend to match the demolition plans.

b. Indicate the beginning and ending points of utility removals and methods of plugging pipes (cap, brick & mortar, etc.). Show locations of valves to be used for isolating work.

c. Show limit of pavement removal and pavement thickness.

d. Describe the existing items in detail with supplemental descriptions if necessary. Indicate depth of pavements/bases to allow uniform contractor bids.

e. Provide a sequence of demolition if necessary. Include any known requirement for continuous operation and limited shutdown requirements. These must be identified in the special scheduling paragraphs of the specification.

f. Do not show any items that are being demolished with the current project on subsequent Civil plan sheets.

g. Show locations of all erosion and sediment (E&S) control items and add E&S notes. Show erosion control details on drawings or refer to applicable details in the State *Erosion and Sediment Control Handbook* or manual. Verify that the erosion control legend is edited, clear and coordinated with the drawings.

h. Provide a Tree Protection Detail for existing trees, which are to be preserved during construction. All trees are not amenable to the same barrier fence application. Consult a Registered Landscape Architect or State Certified Arborist. As a minimum, show the following:

A 4-ft. high safety-orange, plastic barrier fence (with metal or 4 x 4 wood stakes at 8 ft. on center spacing) continuously located around the tree's drip-line, unless otherwise directed by a certified arborist. If trees are in a group or cluster, use only one fence to surround the entire cluster.

3-2.4.3 **Site Plan.** Include the following information:**{** TC "3-2.4.3 **Site Plan.**" \f C \l "3" **}**

a. Show all new aboveground features with adequate layout data and existing aboveground features, after demolition has occurred.

b. Label baselines to be used for project layout as 'construction baseline' as opposed to survey baseline.

c. Provide layout dimensions from the construction baseline, or another readily identified (and easily established) alignment in the field. Include horizontal control point locations and descriptions. Use of coordinates for layout purposes is discouraged, however their use may be considered on a case-by-case basis. Contact Civil Reviewer for approval prior to project submittal.

d. Show areas requiring pavement patching, repairs and new pavement. Provide pavement jointing plans for rigid pavements. Include separate pavement marking plans for airfield projects.

e. Eliminate extraneous items that may congest the drawing (contours, elevations, etc.) and detract from the layout information.

f. Show locations of any additional E&S control items not already included on the Demolition Plan. Coordinate with E&S notes, details, and legend.

g. Indicate all trees and plant material to remain

h. Provide statement concerning location of soil borings and soil information.

3-2.4.4 **Water and Sanitary Sewer Plan.** Include the following information:**{** TC "3-2.4.4 **Water and Sanitary Sewer Plan.**" \f C \l "3" **}**

a. Indicate whether new connections will be made by wet tap (tapping sleeve/valve) or by dry connection. Show nearest valve(s) for system isolation if the latter is the case. Indicate known scheduling issues in the special scheduling paragraphs of the specification.

b. Indicate surface materials (i.e. grass, bituminous, concrete, etc.).

c. Provide numbers (or letters) for each sanitary structure and water fitting so that plans and profiles are easily coordinated. This labeling system must be clearly distinct from that used for the storm drainage system and preferably distinct from labels used by other utility systems, i.e. electrical, etc.

d. Provide manhole rim and invert elevations, pipe slopes, pipe diameters and pipe materials. If profiles are provided, indicate slopes on the profile sheets and do not provide on the plan sheets.

e. For water treatment plants, provide details process and instrumentation diagram (P&ID).

3-2.4.5 **Water, Storm, and Sanitary Sewer Profiles.** Include the following information:**.{** TC "3-2.4.5 **Water, Storm, and Sanitary Sewer Profiles.**" \f C \l "3" **}**

a. Show profiles where needed for clarity and to avoid potential conflicts. Discuss profile requirements with EFD Civil Reviewer.

b. Indicate structure tops, pipe invert elevations, slopes, lengths, and diameters of all new gravity lines.

c. Coordinate structure numbers with plan sheets.

d. Reference the plan sheets where pipes/structures are shown.

e. Show and label existing and new surface materials, concrete pads, curbs, roads, etc. traversed by the new lines. Accurately show depth of existing pavements.

f. Show and label all crossing utility lines, both existing and new.

g. If depths of existing utilities are unknown, indicate the horizontal location of the utility and indicate the vertical location with a line representing the anticipated range of elevations where the utility will be found in the field.

Indicate the method of new utility installation routing above or below conflicts, i.e. concrete encasement, pressure pipe, etc.

3-2.4.6 **Grading and Drainage Plan.** Include the following information:**{** TC "3-2.4.6 **Grading and Drainage Plan.**" \f C \l "3" **}**

a. Provide existing spot elevations and existing contours at intervals to clearly indicate existing drainage patterns.

b. Provide new spot elevations and new contours when appropriate to clearly indicate new grading and drainage patterns. New spot elevations/contours must be easily distinguished (bolder font) from existing.

c. Indicate where new grading ties to existing grading (limits) and verify that new work will not block existing adjacent drainage.

d. Show all benchmarks, tbm's, other vertical control, and datum notes on this plan.

e. Show finish floor elevations on grading plans. Do not show finish floor elevations on the architectural or structural plans in order to avoid conflicts. Coordinate adjacent exterior grading with the architectural/structural plans to ensure positive drainage patterns away from the building.

f. Verify that the slopes indicated on the plans are suitable for the surface material involved, i.e. earth slopes, bituminous pavements, and concrete pavements. Consider if these slopes are maintainable for the service life of the facility.

g. Coordinate with the Landscaping Plans (L sheets) to prevent new plantings from blocking site drainage.

h. Provide numbers (or letters) for each drainage structure so that plans and profiles are easily coordinated.

i. Erosion and sediment control details should be shown.

3-2.4.7 **Site / Utility Details{** TC "3-2.4.7 **Site / Utility Details**" \f C \l "3" **}.** Incorporate details as follows:

a. If applicable, edit and update standard details provided by the EFD Civil Reviewer to apply to the particular conditions and requirements of the project.

b. Details of items shown in the construction standards of the Department of Transportation or other agencies of the state in which the project will be

built or other appropriate local/commercial standards are required on the plans.

c. Conform to the requirements of UFC 1-300-09N for all details and sections.

3-2.4.8 **Soil Boring Logs.{** TC "3-2.4.8 **Soil Boring Logs.**" \f C \l "3" **}** Provide soil boring logs as part of the drawings. Information on the drawing must include soil boring plotted locations, a summary of lab tests results, groundwater observations, and site preparation details or notes as applicable.

3-3 POST-DESIGN SERVICES.{ TC "3-3 POST-DESIGN SERVICES." \F C \L "3" }

3-3.1 As-Builts.{ TC "3-5.1 As-Builts." \f C \l "3" }

Revise contract documents to reflect the “as-built” conditions. Denote the changes from the original design in accordance with the direction of the Engineer in Charge (EIC).

APPENDIX A REFERENCES{ TC "APPENDIX A REFERENCES" \F C \L "2" }

GOVERNMENT PUBLICATIONS:

1. Department of Defense

Unified Facilities Criteria (UFC)
http://dod.wbdg.org/.

UFC 1-200-01, *General Building Requirements*

UFC 1-300-09N, *Design Procedures*

UFC 3-100-10N, *Architecture*

UFC 3-220-01, *Geotechnical Engineering Procedures for Foundation Design of Buildings and Structures*

UFC 3-230-18FA, *General Provisions and Geometric Design for Roads, Streets, Walks and Open Storage Areas*

UFC 3-240-02, *Design: Wastewater Treatment System Augmenting Handbook*

UFC 3-250-10FA, *Pavement Design for Roads, Streets, Walks and Open Storage Areas*

UFC 3-260-01, *Design: Airfield and Heliport Planning and Design*

UFC 3-260-02, *Pavement Design for Airfields*

UFC 3-260-03, *Design: Airfield Pavement Evaluation*

UFC 3-270-01, *O&M: Asphalt Maintenance and Repair*

UFC 3-270-02, *O&M: Asphalt Crack Repair*

UFC 3-270-03, *O&M: Concrete Crack and Partial-Depth Spall Repair*

UFC 3-270-04, *O&M: Concrete Repair*

	UFC 3-270-05, *O&M: Paver Concrete Surfaced Airfields Pavement Condition Index (PCI)*
	UFC 3-270-06, *O&M: Paver Asphalt Surfaced Airfields Pavement Condition Index (PCI)*
	UFC 3-270-07, *O&M: Airfield Damage Repair*
	UFC 3-310-01, *Design: Load Assumptions for Buildings*
	UFC 3-600-01, *Design: Fire Protection Engineering for Facilities*
	UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*
	UFC 4-022-01, *Security Engineering: Entry Control Facilities/Access Control Points*
http://www.access-board.gov/indexes/pubsindex.html	*DoD Architectural Barriers Act (ABA) Accessibility Standard*
2. Department of the Air Force	AFI 32-1042, *Standards for Marking Airfields*
	ETL 94-01, *Standard Airfield Pavement Marking Schemes*
3. Department of the Army	TM 5-923-4, *Marking of Army Airfield-Heliport Facilities*;
	EM 1110-1-1003, *NAVSTAR Global Positioning System Surveying*;
	EM 1110-1-1004, *Geodetic and Control Surveying*;
	EM 1110-1-1005, *Topographic Surveying*
4. Department of the Navy	DM-5.4, *Pavements*;
Standardization Documents Order Desk 700 Robbins Avenue, Bldg. 4D Philadelphia, PA 19111-5094	MCO P5530.14, *Marine Corps Physical Security Program Manual*;
	MIL-HDBK-1005/7A, *Water Supply*

	Systems, 1999 and Change 1, 24 January 2001;
	MIL-HDBK-1013/1A, *Design Guidelines for Physical Security of Facilities*;
	MIL-HDBK-1013/10, *Design Guidelines for Security Fencing, Gates, Barriers, and Guard Facilities*;
	MIL-HDBK-1013/14, *Selection and Application of Vehicle Barriers*;
	NAVAIR 51-50AAA-2;
	NAVFAC INST 9830.1
	NAVINST 5510.36
	OPNAVINST 5530.14C, *Navy Physical Security Manual*;
	P-80, *Planning Criteria for Navy and Marine Corps Shore Installations*;
	P-80.3, *Facility Planning Factor Criteria for Navy and Marine Corps Installations*, Appendix E, Airfield Safety Clearances, January 1982;
	UG-2031-SHR, *User's Guide on Protection Against Terrorist Vehicle Bombs*
	Electronic Bid Solicitation – Manual of Policies and Procedures
5. Federal Aviation Administration (FAA)	AC 150/5340-1, *Marking of Paved Areas on Airports*
6. United States Department of Transportation, Federal Highway Administration	FHWA-NHI-01-021, *Urban Drainage Design Manual*, 2001
	Manual on Uniform Traffic Control Devices, (MUTCD) latest edition

NON-GOVERNMENT PUBLICATIONS:

7. American Association of State Highway and Transportation Officials 444 North Capitol Street, N.W., Suite 249 Washington, D.C. 20001	*A Policy on Geometric Design of Highways and Streets*, latest edition
8. American Concrete Pipe Association 8320 Old Courthouse Road Vienna, VA 22180	*Concrete Pipe Design Manual*, latest edition
9. American Iron and Steel Institute 1000 16th Street, N.W. Washington, D.C. 20036	*Modern Sewer Design*, 1980
10. American Water Works Association	AWWA M17, *Installation, Field Testing and Maintenance of Fire Hydrants*, 1989 AWWA M23, *PVC Pipe – Design and Installation*, 2002 AWWA M41, *Ductile-Iron Pipe and Fittings*, 2003
11. Ductile Iron Pipe Research Association 245 Riverchase Parkway East, Suite O Birmingham, AL 35244-1856	*Thrust Restraint Design for Ductile Iron Pipe*, Fifth Edition, 2002.
12. Great Lakes – Upper Mississippi River Board of State Public Health and Environmental Managers	*Recommended Standards for Water Works*, 1997 Edition *Recommended Standards for Wastewater Facilities*, 1997 Edition
13. The McGraw-Hill Companies, Inc. Two Penn Plaza New York, NY 10121-2298	*Pump Handbook*, Third Edition, Igor J. Karassik, et.al., 2001
14. National Fire Protection Association	NFPA 291, *Fire Flow Testing and Marking of Hydrants*
15. Public Technology, Inc.	*Sustainable Building Technical Manual: Green Building Design, Construction, and Operations*, Public Technology, Inc. and the U.S. Green Building Council, 1996
16. Submersible Wastewater Pump	*Submersible Sewage Pumping Systems*

Association (SWPA) 1866 Sheridan Road, Suite 210 Highland Park, IL 60035 http://www.swpa.org/resources/handbook	*Handbook*, Second Edition, 1997
17. Uni-Bell PVC Pipe Association 2655 Villa Creek Drive, Suite 155 Dallas, TX 75234	*Handbook of PVC Pipe: Design and Construction*, 2001 UNI-TR-6-97, *PVC Force Main Design*
18. Water Environment Federation (WEF) 601 Wythe Street Alexandria, VA 22314-1994	*Design of Wastewater and Stormwater Pumping Stations*, Manual of Practice FD-4, 1993

APPENDIX B BEST PRACTICES{ TC "APPENDIX B BEST PRACTICES" \F C \L "2" }

1-1 GRADING AND STORM DRAINAGE SYSTEMS

1-1.1 Underground Storm Drainage

1-1.1.1 Material Selection.

1-1.1.1.1 **Reinforced Concrete Pipe**. For design parameters, refer to the latest edition of the *Concrete Pipe Design Manual*.

1-1.1.1.2 **Corrugated Aluminum or Steel Pipe**. For drainage parameters for corrugated steel pipe, refer to the latest edition of *Modern Sewer Design*.

1-1.1.1.3 **Polyvinyl Chloride (PVC) Pipe**. For design parameters, see the latest edition of the *Handbook of PVC Pipe: Design and Construction*.

1-1.1.1.4 **High Density Polyethylene (HDPE) Pipe**. For design parameters, see the pipe manufacturer's information concerning design and construction.

1-1.2 Stormwater Management Facilities

Consult local jurisdictional regulations and standards for typical stormwater management procedures that have been determined to be successful at the project's location.

1-2 WATER DISTRIBUTION SYSTEMS

Refer to the design manuals and standards by the American Water Works Association as applicable to the project.

1-2.1 Material Selection.

1-2.1.1 **Polyvinyl Chloride (PVC) Pipe**. For design parameters including thrust restraint, see the latest edition of the *Handbook of PVC Pipe: Design and Construction*, and Manual M23, *PVC Pipe – Design and Installation*.

1-2.1.2 **Ductile Iron Pipe**. For design parameters including thrust restraint, see the latest edition of Manual M41, *Ductile-Iron Pipe and Fittings*.

1-2.1.3 **High Density Polyethylene (HDPE) Pipe**. For design parameters, see the pipe manufacturer's information concerning design and construction.

1-3 WASTEWATER COLLECTION SYSTEMS

Refer to the manuals of practice prepared by the Water Environment Federation as applicable to the project.

1-3.1 **Minimum Slopes**.

Recommended minimum slope for 100 mm (4 in) and 150 mm (6 in) sewer laterals is 1.042 m/100 m (ft/100 ft).

1-4 PUMP STATIONS AND TRANSMISSION SYSTEMS

For wastewater and stormwater pump stations, see *Design of Wastewater and Stormwater Pumping Stations*. For wastewater submersible pump stations, refer to *Submersible Sewage Pumping Systems Handbook*.

1-4.1 Piping.

1-4.1.1 **Polyvinyl Chloride (PVC) Pipe.** For design parameters including thrust restraint, see the latest edition of the *Handbook of PVC Pipe: Design and Construction*, UNI-TR-6-97, *PVC Force Main Design*; and Manual M23, *PVC Pipe – Design and Installation*.

1-4.1.2 **Ductile Iron Pipe.** For design parameters including thrust restraint, see the latest edition of Manual M41, *Ductile-Iron Pipe and Fittings*.

1-5 FLEXIBLE AND RIGID PAVEMENTS

1-5.1 Airfield Pavements

1-5.1.1 **Repair and Maintenance.** The repair and maintenance of airfield pavements are covered by UFC 3-270-01, *O&M: Asphalt Maintenance and Repair*; UFC 3-270-02, *O&M: Asphalt Crack Repair*; UFC 3-270-03, *O&M: Concrete Crack and Partial-Depth Spall Repair*; UFC 3-270-04, *O&M: Concrete Repair*; UFC 3-270-05, *O&M: Paver Concrete Surfaced Airfields Pavement Condition Index (PCI)*; UFC 3-270-06, *O&M: Paver Asphalt Surfaced Airfields Pavement Condition Index (PCI)*; and UFC 3-270-07, *O&M: Airfield Damage Repair*.

1-5.1.2 **Airfield Pavement Markings.** Additional military references include AFI 32-1042, *Standards for Marking Airfields*; ETL 94-01, *Standard Airfield Pavement Marking Schemes*; the Federal Aviation Administration's (FAA's) AC 150/5340-1J, *Standards for Airport Markings*.

1-5.2 Roads, Streets and Open Storage Areas

1-5.2.1 **Repairs and Maintenance.** The repair and maintenance of pavements are covered by UFC 3-270-01; UFC 3-270-02; UFC 3-270-03; UFC 3-270-04; and UFC 3-270-07. These UFC, while focused on airfield applications, have universal applications.