Administrative Changes to AFPAM 10-219, Volume 5, *Bare Base Conceptual Planning*

OPR: AFCESA/CEXX

OPR should be changed to: AFCEC/CX

References to Air Force Civil Engineer Support Agency (AFCESA) should be changed to Air Force Civil Engineer Center (AFCEC) throughout publication.

References to AFH 10-222V8, *Guide to Mobile Aircraft Arresting System Installation*, should be deleted; publication will be rescinded simultaneously with this AC.

References to AFH 10-222V9, *Reverse Osmosis Water Purification Unit Set-UP and Operation*, should be deleted; publication will be rescinded simultaneously with this AC.

References to AFH 10-222V6, *Guide to Bare Base Facility Erection*, should be deleted; publication will be rescinded simultaneously with this AC.

17 December 2012

BY ORDER OF THE SECRETARY OF THE AIR FORCE

AIR FORCE PAMPHLET 10-219, VOLUME 5

30 MARCH 2012

Corrective Action Applied on 4 April 2013

Operations

BARE BASE CONCEPTUAL PLANNING

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This pamphlet supports AFI 10-210, *Prime Base Engineer Emergency Force (BEEF) Program*, and AFI 10-211, *Civil Engineer Contingency Response Planning*. This volume describes the Air Force civil engineer's role in establishing and operating a bare base. It lists civil engineer tasks involved in the forward projection of airpower, with emphasis on the use of Basic Expeditionary Airfield Resources (BEAR). This volume is of particular importance to engineers and mobility team chiefs responsible for initial beddown planning and execution at bare base and forward operating locations. The volume makes frequent reference to volumes in the Air Force Handbook 10-222-series and applicable technical orders for additional information. Refer recommended changes and questions about this publication to the office of primary responsibility using the AF Form 847, *Recommendation for Change of Publication*: route AF Form 847s from the field through the appropriate functional chain of command and Major Command (MAJCOM) publications/forms managers. Ensure that all records created as a result of processes prescribed in this publication are maintained according to AFMAN 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Disposition Schedule (RDS) located at **https://www.my.af.mil/afrims/afrims/afrims/rims.cfm**. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

SUMMARY OF CORRECTIVE ACTIONS

Removed Compliance Statement from the Pamphlet

SUMMARY OF CHANGES

This document is substantially revised and should be completely reviewed. Of particular significance: it replaces legacy (Harvest Eagle/Falcon) assets with BEAR throughout; addresses recommended water use rates for bare base beddowns; updates ancillary equipment; transitions from BEAR to BEAR Order of Battle asset management and equipment configurations; and adds information on contract force multipliers including the Air Force Contract Augmentation Program. Also addresses civil engineer (CE) task standards and planning factors such as manpower, materials and equipment for potential contingency tasks. Additionally, engineer quick reference sheets were included to provide engineers with bare base planning information and examples in a quick reference format.

Chapter 1

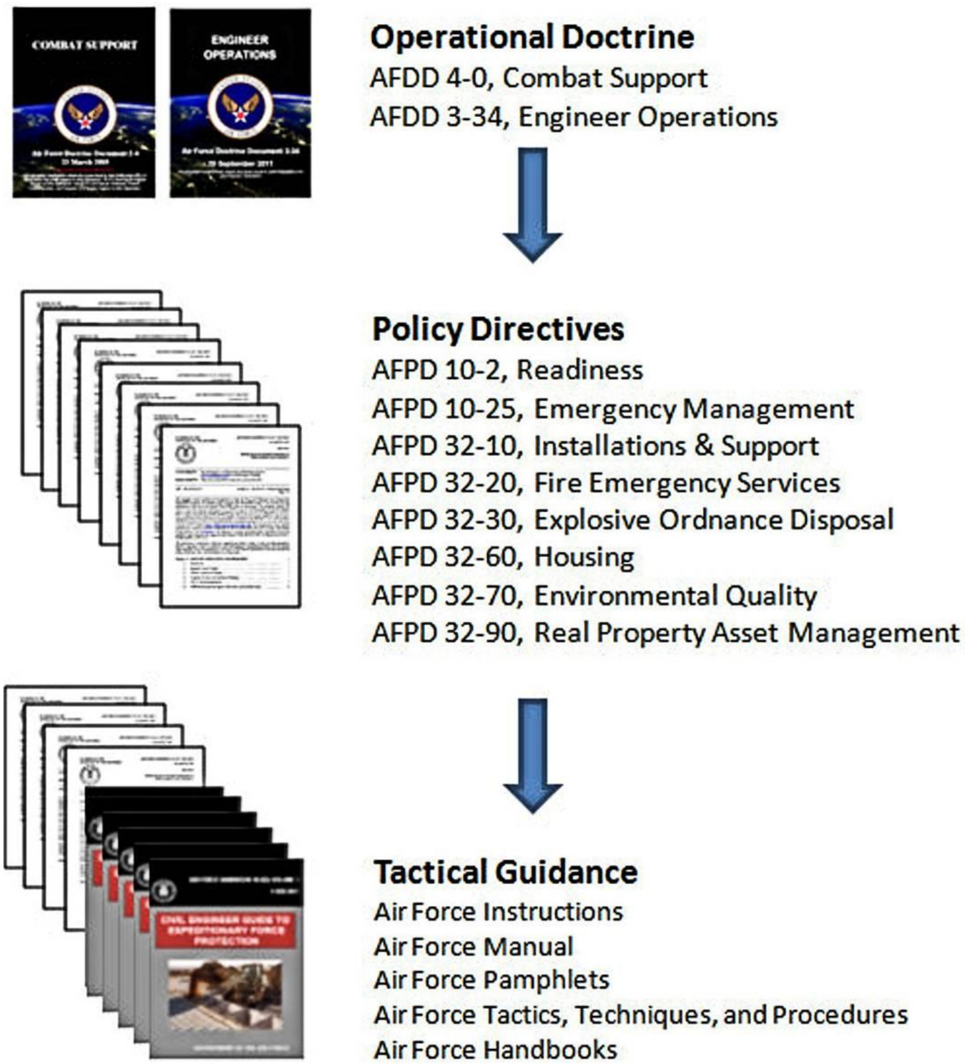
INTRODUCTION TO BARE BASE PLANNING

1.1. Purpose. To support modern air, space and cyberspace operations and meet requirements for rapid deployment, expeditionary airbase planners must understand and employ sound planning principles. This volume was developed to provide deployment data and employment information to engineer and logistic planners, field units and others involved in bare base activities. A bare base is defined as a base having minimum essential facilities to house, sustain and support operations to include (**if required)** a stabilized runway, taxiways, aircraft parking areas, and have a source of water that can be made potable. Specifically, this volume provides a comprehensive collection of information and illustrations related to construction, erection, operations and maintenance of bare base facilities and equipment (**Figure 1.1**). The intent is to provide deploying and deployed personnel, particularly planners, the ability to plan for multiple austere locations and to procure beddown assets.

Figure 1.1. Bare Base Facilities and Equipment

1.2. Scope. The information in this volume supports implementation of Air Force Policy Directive (AFPD) 10-2, *Readiness*, and contains tactics, techniques, and procedures (TTPs) for use by civil engineers in supporting precepts outlined in Air Force Doctrine Document (AFDD) 4-0, *Combat Support* and AFDD 3-34, *Engineer Operations*. This relationship is illustrated in the Air Force CE hierarchy of publications (**Figure 1.2**). Engineer planners and others may find the information in this volume is most helpful when used as a starting point for planning a bare base or supporting austere locations. While each location has its own special requirements and features, there are commonalities that will not change despite the location. The base and facility layouts, facility guide matrices, utility layouts and drawings in this volume can be used and adapted to meet almost any site-specific location. This volume highlights key features and considerations associated with Air Force bare base planning; provides a concept of employment and a sequence for bare base construction; and serves as a road map that leads bare base planners from the initial response phase to the material acquisition phase. It is a checklist to ensure each crucial action that affects the base's ability to function effectively is taken. This volume may not present the final or specific solution to a given problem. It is not expected to anticipate or solve all problems that might be encountered during beddowns. It simply addresses problems most likely encountered and gives guidance so important aspects of the task will not be overlooked. While this conceptual planning pamphlet was developed for use anywhere in the world, it deals most heavily with the Southwest Asia (SWA) theater of operations. It primarily addresses bare base locations that have little to no host nation support.

Figure 1.2. Air Force Civil Engineer Publications Hierarchy



1.3. Background. The shifting global geopolitical dynamics, closure of many main operating bases (MOB) overseas and the reluctance of many nations to permit permanent military bases on their soil have limited the basing options for United States (US) forces during contingency operations. This situation has increased the importance of the bare base concept as a viable solution to contingency basing shortfalls and requirements.

1.3.1. A bare base must be capable of supporting assigned aircraft and providing mission-essential resources. These resources include logistical support and service to the infrastructure composed of people, facilities, equipment and supplies. The bare base concept requires mobile facilities, utilities and support equipment that can be rapidly deployed and installed. Bare base equipment can transform undeveloped real estate into an operational air base virtually overnight. Fortunately, these kinds of assets have undergone more than five decades of intense research and development. The search for stronger, lighter-weight, and more efficient facilities and equipment continues today as new technological advances are being discovered. These advances will continually move the bare base concept into new areas unimaginable today. To help guide future actions, it is important to know the history of the bare base process.

1.3.2. Early requirements for mobile air bases arose with the advent of air warfare during World War II. This mobility concept specified that ground forces advance in increments by surface means. The advancing force had to conduct offensive operations while simultaneously establishing new operating bases (**Figure 1.3**). The tactical air units moved from one forward operating base to another in order to keep up with and provide air support for the advancing troops. These units had two choices—build base facilities as protection from contingency and environmental elements or erect substandard facilities such as tents and perform maintenance out in the open. This cycle repeated itself whenever battle zones changed. Similar challenges were experienced during the Korean Conflict in the 1950s.

Figure 1.3. Dozer Clearing an Airfield in World War II

1.3.3. It was not until the 1950s that military planners developed techniques to prepackage base support equipment. This World War II equipment consisted mainly of tents and related accessories, field kitchens, medical facilities, generators and other assorted equipment. It was bulky, heavy and required excessive labor-hours to layout, assemble and erect. This initial deployment kit was nicknamed **Gray Eagle**. In the mid-1960s, more equipment was added. Some items were redesigned to make them more air transportable, and the name was changed to **Harvest Eagle**. Harvest Eagle has been tested many times in worldwide deployments including Southeast Asia.

1.3.4. A new mobility concept was developed in the late 1960s. Under this concept, all facilities and equipment would be lightweight, modular and C-130 transportable. Some shelters would be hardwall and serve as their own shipping containers. Some of the mobility hardware would interface with weapons systems while other hardware would be developed to take care of housing, messing, infrastructure support and civil engineer (CE) needs. This concept would have everything needed to support a deployed force in the most austere environment. To test this concept, **EXERCISE CORONET BARE** was launched in October 1969 to evaluate this new prototype equipment package. In November 1970, a full-scale deployment exercise successfully tested the bare base mobility concept of being operational within 72 hours. After successful validation, the program became known as **Harvest Bare**.

1.3.5. Another iteration of bare base facility history occurred in the early 1980s. To support the AF portion of the Rapid Deployment Joint Task Force, the forerunner of US Central Command, the services made a major equipment purchase. Instead of procuring duplicate Harvest Bare packages, a mix of hard- and soft-walled facilities was obtained. This facility mix was lighter to airlift and eliminated several facilities that had maintenance problems in previous deployments. In addition to facility and utility systems, this new bare base package, nicknamed **Harvest Falcon**, contained several other major components. Typical of these components were vehicles, engineer equipment, unique tactical shelters, medical facilities and equipment and mobile flightline maintenance equipment. These Harvest Falcon packages provided support for several major multi-national exercises in the 1980s and during the Gulf War in 1990-91.

1.3.6. Today, the bare base concept for expeditionary airbases is as important as ever. While many foreign countries resist development of major fixed installations on their soil, they still possess airfields that could be offered to US forces during contingencies. There are hundreds of locations in the world that can support air operations, although many have limited and inadequate infrastructure. The AF must have the capability to deploy to and operate from available locations regardless of the current infrastructure. The majority of US bare base assets are prepositioned overseas for SWA support. A small number of assets are available at Holloman AFB, New Mexico for worldwide support.

1.3.7. The current Air Expeditionary Force (AEF) mobility concept is to deploy an expeditionary force rapidly, complete with facilities and related equipment, capable of independently supporting sustained combat operations (**Figure 1.4**). However, some support operations may have to exist as austere, because receipt of some support infrastructure may lag by a month or more. This is usually the case with support of joint forces, such as Army and Marine units and special operations forces. Expedient facilities provide the means for operating in initial austere locations. In 2002, deployments to Afghanistan reaffirmed the versatility of the bare base concept when captured airfields were quickly transformed into operational locations for use by multi-national forces.

Figure 1.4. Prime Power Generators Support Sustained Operations

1.4. Planning Process. The ambitious expeditionary mobility concept presents problems and challenges to planners, engineers and field units who have the ultimate responsibility of bare base development. The challenge is twofold for planners, who must consider both AF requirements and joint deployment requirements. The implications for joint planning and integration are discussed in further detail in **AFPAM 10-219 Volume 6**, *Planning and Design of Expeditionary Airbases*. In many cases, a bare base may support or host other US forces, allied military units and host nation agencies. These co-occupants can present planners with many challenges, since responsibilities and jurisdictional areas will have to be determined. Factors such as facility usage, equipment allocation, utilities and labor must also be worked out to the agreement of all parties. These challenges have an immediate effect on the mission; therefore planners must address them early in the bare base development process. The challenges could affect such features as airlift flow of bare base assets, construction sequence, projected use of local materials and the allocation of mobile facilities.

1.4.1. Additional data should be gathered to supplement this conceptual planning pamphlet since site-specific characteristics are important factors in the planning process. Existing facilities, airfield configuration, topography, climate, soil conditions, concept of operations and indigenous materials and available labor are some of the unknown characteristics that must be considered. The numbered AEF that deploys either a wing or other support force has primary responsibility for developing site-specific layouts. For potential bare base locations named in operational plans (OPLANs), advance echelon (ADVON) teams are responsible for site-specific planning. ADVONs are deployed ahead of the larger deploying force and may be included in the time-phased force deployment list (TPFDL). For short-notice deployments that have not been preplanned except in a concept plan (CONPLAN), the first unit on the scene is usually responsible for site-specific planning. The CONPLAN is an operation plan in an abbreviated format that requires considerable expansion or alteration to convert it into an OPLAN. Planners may have to gather additional site-specific data from intelligence sources or first-hand observation prior to laying out their plans. This is important since a well-planned and executed deployment hinges on the planner's ability to produce a comprehensive site layout, complete to the last detail.

1.4.2. One of the first pieces of information that must be gathered is the threat analysis for the bare base location. This information is normally available through the wing intelligence office. Planners must know whether the base is in a high-, medium-, or low-threat area. The reasons are threefold: (1) Aircraft must be able to survive while on the ground. (2) Aircraft must be able to get airborne to perform their mission during or after an attack. (3) Logistics infrastructure must survive to sustain air operations. The threat analysis will determine whether individual facilities and facility groups will be positioned in a dispersed or non-dispersed layout. It will also determine whether electrical and water plants will be dispersed or centrally located and whether revetments and airfield damage repair (ADR) sets will be required. In some of the forward and higher threat areas, it may be necessary to plan for camouflage, hardening, or even decontamination capabilities.

1.4.3. Topography and weather data should reveal prevailing wind direction and expected velocity, temperature ranges and humidity, annual rainfall, natural slope of the terrain, soil characteristics and latitude and longitude of the bare base site. This data is required to properly site the sewage lagoon downwind, determine heating and air conditioning requirements, restrict construction in natural water drainage areas during flash flooding, determine absorption rates of the soil and locate facilities in a way that minimizes shadows that can be detected through aerial reconnaissance.

1.4.4. It is important to know about the existing facilities and utilities in the preliminary planning stage. Consequently, any layouts, drawings, aerial photographs, etc., are vitally needed. Equally important are the lengths and widths of the existing runway(s), taxiways, ramps and aprons. Does runway lighting exist? If so, is it operational and adequate? Is there a requirement for an aircraft arresting system? What kinds of water sources are available? Is the water fresh, brackish, or salt water? Does it come from a well, river, or the ocean? What is its water temperature and how far away is the source? Is the area flood-prone or in a low-lying area subject to flooding or high water during heavy rains? There are many more questions and the more answers we get, the better prepared we are to meet mission objectives.

1.4.5. Having accumulated as much site data as possible, begin mapping out the specific details on the base plans. Following guidance in this volume, planners must develop each of the different elements, keeping in mind that this volume generally discusses the "worst case" scenario. For example, a five-day water supply is required for the base populace. This water may be pumped from a non-potable source several miles away, purified with reverse osmosis units and stored in collapsible bladders. If, however, the planner discovers on-site purified water in sufficient quantities, the requirement for water production equipment decreases significantly.

1.4.6. Priorities cannot be overemphasized during bare base development. The allocation of engineering resources must be balanced between mission essential and force beddown taskings. Thus, commanders of various organizations at all echelons must understand the importance of establishing clear mission priorities. Increased engineer requirements, especially during the base erection phase, could spread engineer resources too sparsely. For example, this volume recommends that base organizations erect their own shelters with minimum technical guidance from engineer personnel (**Figure 1.5**). If this practice is circumvented by tasking engineers to erect shelters for everyone, it may cause significant delay in accomplishing other critical tasks and be detrimental to overall mission accomplishment. Another consideration is quality-of-life taskings that always seem to surface during deployments. Typical Gulf War examples include repairing swimming pools and building recreational facilities and gazebos. These conveniences are obviously not too much to provide people who are risking their lives. However, quality of life tasks alone could have a drastic effect on civil engineers' ability to work on mission-essential tasks.

Figure 1.5. Medical Personnel Erect Shelters for Medical Support Operations

1.4.7. This publication highlights a variety of planning factors for particular topics. These factors are included to show the requirements that must be considered for a location that transitions from an austere combat contingency location to a short term bare base and then to a more permanent, long-duration bare base. Bare base equipment packages are frequently reconfigured to remove antiquated and unserviceable equipment and replace it with new equipment as technology advances. Successful bare base planning and development must remain flexible to inevitable changes.

1.4.8. Successfully erecting a bare base within a predetermined time schedule depends on many factors controlled outside of engineer channels:

1.4.8.1. Mobility assets must arrive in proper quantities and sequence. This is great for planning, but planners understand that most mobility assets *DO NOT* arrive in the proper quantities and sequence. No matter how good the plan or how far in advance notice is given, it just does not happen. Remain flexible and react to the situation as it develops.

1.4.8.2. Motorized support equipment, such as forklifts and trucks, must be available in the required quantities. Be prepared to share equipment and take care of it.

1.4.8.3. Craftsmen should be trained to erect, operate and maintain as much of the bare base equipment as possible. Since craftsmen do not typically work with these assets at home station, progress will likely be slow at first. However, as personnel become more familiar with the equipment their proficiency should increase quite rapidly.

1.4.9. Plan for success. Leadership, high-technology weapons, quality troops, sound planning and a long lead-time have contributed to US and coalition forces' successes during past contingency operations. Planners should review the assessments, after action reports and lessons learned from previous deployments to plan for the next one. Other factors to consider when planning engineer operations include: type of construction material available in theater, the construction standards required and availability of host nation resources and multinational forces.

1.4.10. Resource Planning Options**.** Several force multipliers are available to augment civil engineer, force protection and logistics capabilities during worldwide contingency operations. These contract tools and reach-back capabilities can provide significant relief to commanders, particularly over extended periods.

1.4.10.1. Air Force Contract Augmentation Program (AFCAP). Although principally intended to support contingencies and humanitarian efforts, AFCAP resources may also be used, to a limited extent, during major combat operations. This cost-plus, award fee contract offers virtually all capabilities within AF CE, Force Protection and Logistics functional areas (**Figure 1.6**). AFCAP has standing agreements with a number of contractors and vendors to provide specific support and consequently can provide skilled labor, extensive quantities of equipment and materials under short lead times. AFCAP support generally includes:

1.4.10.1.1. Base recovery after natural disasters, accidents and terrorist attacks.

1.4.10.1.2. Sustainment operations for all noncombatant operations to include construction.

1.4.10.1.3. Asset reconstitution at user-level during contingency operations.

1.4.10.1.4. All types of restoration, except those involving major environmental damage.

1.4.10.1.5. Backfills vacancies for home base forces at equal or greater skill levels during deployments.

Figure 1.6. Contract Augmentation and Support

1.4.10.2. AFCESA Reach-back Center. Another very valuable force multiplier for expeditionary and day-to-day operations is the civil engineer Reach-back Center at HQ AFCESA at Tyndall AFB FL. Since April 2005, the RBC has answered over 25,000 inquiries on contingency, expeditionary and base-level operations. It provides methods, templates, checklists, criteria, lessons learned and assistance on the agency's subject matter expertise. The RBC can be contacted via phone at 888-AFCESA1, stateside DSN at 523-6995, or international DSN at 312-523-6995. E-mails can be sent to **afcesareachbackcenter@tyndall.af.mil**, or through AFCESA's website at **http://www.afcesa.af.mil**.

1.4.10.3. Other Service Resources. The US Army and US Navy have established contract augmentation programs similar to AFCAP.

1.4.10.3.1. The Army uses the Logistics Civil Augmentation Program (LOGCAP) to augment its forces during wartime. LOGCAP provides for preplanned used of global corporate resources to free up soldiers to perform combat arms missions. With proper preplanning, coordination and training, it can support other services, federal agencies and coalition partners. LOGCAP has been used in Iraq, Somalia, Bosnia, Haiti and East Timor. Army Material Command Pamphlet 700-30, *LOGCAP*, outlines procedures for commanders to follow when requesting and implementing these services.

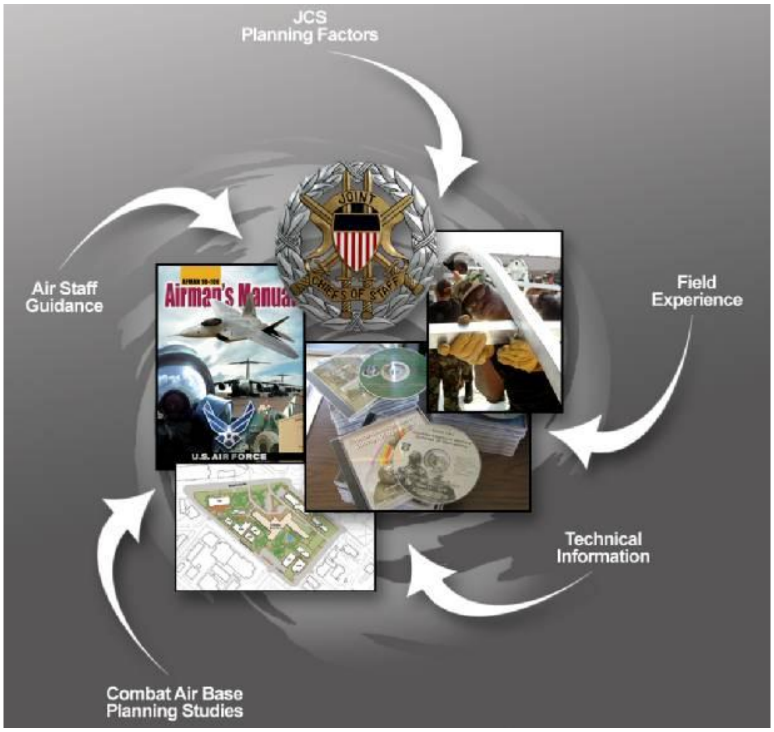
1.4.10.3.2. The Navy uses the Global Contingency Construction Contract and the Global Contingency Service Contract to allow contract augmentation to quickly respond and provide supervision, equipment, materials and labor in response to natural disasters, humanitarian assistance needs and worldwide conflict. These programs, and predecessor programs, have been used in operations as diverse as Djibouti (Africa), Iraq, Guantanamo Bay, California (wildfire response) and New Orleans (post Hurricane Katrina). For additional information on these resources, contact the lead commands: Naval Facilities Engineering Command (NAVFAC) Atlantic for construction and NAVFAC Pacific for services.

Chapter 2

BARE BASE PLANNING GUIDELINES

2.1. Introduction. Just like a construction project, the bare base planning process requires a foundation upon which to build the plan. In this case, the foundation consists of key assumptions and planning guidelines. An assumption is a statement accepted as true without proof or demonstration. Bare base assumptions are made in order to provide a common point of discussion. Detailed planning might, in some situations, prove some of these assumptions wrong. A planning guideline, on the other hand, is a combination of JCS planning factors, Air Staff guidance, results of expeditionary site planning studies and technical information obtained from publications and field experience (**Figure 2.1**). For the most part, the planning guidelines presented in this chapter assist planners in determining the type and amount of resources necessary to establish a bare base. Refer to AFI 10-401, *Air Force Operations Planning and Execution*, for additional planning guidance.

Figure 2.1. Elements of Bare Base Planning



2.2. Assumptions. The following basic assumptions provide a common departure point for conducting planning. The items are generally considered valid for a bare base situation.

2.2.1. Runway and taxiways are adequate to support or be repairable to support minimum weapon system operations.

2.2.2. Minimum (aircraft) on Ground (MOG) 2 - 24 hr Ops (C-17).

2.2.3. Water source that can be made potable.

2.2.4. Jet fuel and ground fuel are available from host nation with limited storage at location.

2.2.5. General purpose vehicles are available from host nation.

2.2.6. Limited Class IV construction materials are available on local economy.

2.2.7. Munitions storage and build up infrastructure is limited.

2.2.8. Approximate Population Flow:

2.2.8.1. 24 hrs: 150

2.2.8.2. 48 hrs: 550

2.2.8.3. C + 14: 2000

2.2.8.4. C + 30: 3000

2.2.9. Threat level is semi-permissive or uncertain, (i.e. Ground: special ops, sabotage, limited stand-off capability; localized CBRN attack possibility). See AFDD 3-10, *Force Protection*, for definitions of specific threat levels.

2.2.10. Environmental: high desert, mountainous, climate.

2.2.11. Medical Assessment: no unusual endemic diseases, standard immunizations required, no hazardous flora and fauna.

2.2.12. Host nation will authorize landing and overflight rights.

2.2.13. Host nation has bandwidth spectrum available.

2.2.14. Engineers are organized, trained, and equipped to erect and install mobile assets.

2.2.15. Contractor/HN support used when organic capability not available or used.

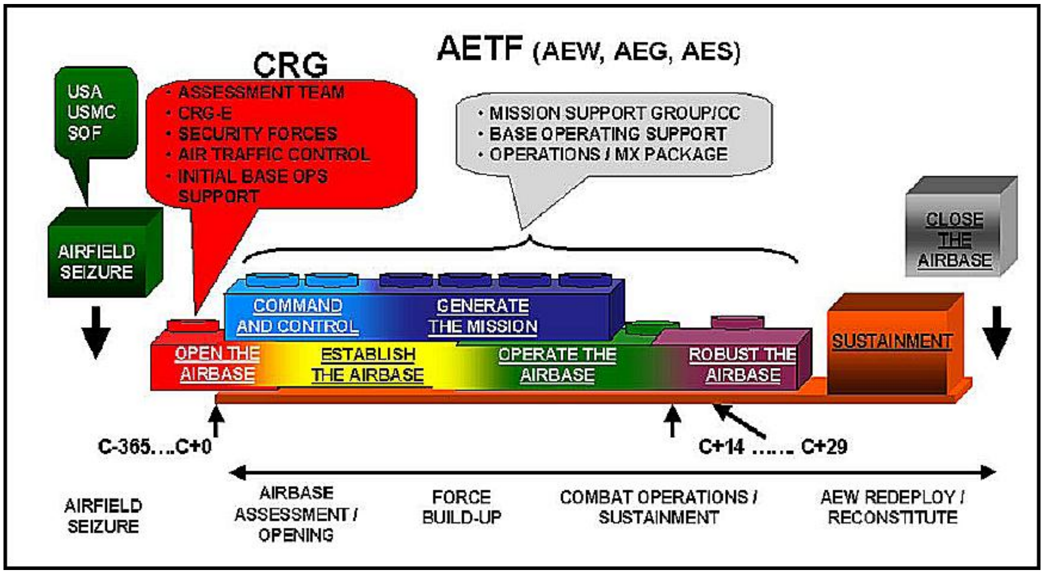
2.2.16. WRM/Prepositioned assets stored and maintained at storage and reconstitution sites.

2.2.17. Individual organizations erect their own tents and shelters with limited technical guidance from CE personnel. RED HORSE or personnel from the 49th Materiel Maintenance Group (49 MMG) will erect technically complex facilities, such as Aircraft Hangars (ACH), Dome Shelters, and Large Area Maintenance Shelters (LAMS).

2.3. Bare Base Force Module Planning. Global engagement has transformed the way the AF views combat support and the requirements to ensure that decisive combat power is readily available. Key features of the subsequent AF doctrine are agile combat support (ACS) and Air and Space Expeditionary Task Force (AETF) "force modules." ACS presents capabilities in a building block or modular/scalable approach, which prepares assets for quick response and allows positioning of forces within the required response time. Assets flow incrementally, and force beddown is effectively established. The AF developed a force module concept that tailors force packages to specific expeditionary tasks and allows systematic presentation of capabilities to rapidly open an airfield, generate a certain level of sorties, establish operational capability and sustain air, space and cyberspace operations.

2.3.1. A force module is a planning and execution tool that provides a means of logically grouping records, which facilitate planning, analysis and monitoring. Force modules consists of a "grouping of combat, combat support and combat service support forces, with their accompanying supplies and required non-unit resupply and personnel necessary to sustain forces for a minimum of 30 days." (Joint Pub 1-02). AETF force modules integrate combat unit type codes (UTC) with combat support UTCs to sustain a base population of approximately 3,000 personnel for at least 30 days. The six force modules (**Figure 2.2**) are not executed sequentially but rather overlap into a tiered effect that supports combat operations. The following paragraphs provide a brief description of each module. For in-depth information on AETF force modules, including the basic assumption made in developing each module, see **AFI 10-401**, *Air Force Operations Planning and Execution*.

Figure 2.2. AETF Force Module Construct



2.3.1.1. Open the Airbase. This module provides the capabilities to open an airbase and rapidly establish an initial operating capability (IOC), regardless of the mission, in approximately 24 hours after arrival of its forces. This module will likely deploy before operations commence (C-Day), and will: protect the forces, plan the reception and beddown follow-on forces, establish communications, prepare the airfield for initial flight operations and address host nation issues. The module normally includes one CE officer and one engineering craftsman who are primarily tasked with assessing the airfield's immediate capability to support mobility airlift operations. RED HORSE and Prime BEEF UTCs may be tasked to augment the Open the Airbase module to expedite use of the airfield.

2.3.1.2. Command and Control. This module establishes an air expeditionary wing or group command and control (C2) structure to assume responsibility from the Open the Airbase module. The C2 module includes initial maintenance group, operations group, medical group and mission support group leadership and staffs. Secure communications and intelligence are key capabilities in this module. A field grade CE officer and an engineering craftsman, both from the Prime BEEF UTC tasked in the Establish the Airbase module, deploy with the C2 module to provide initial beddown planning and coordinate with engineers in the Open the Airbase module.

2.3.1.3. Establish the Airbase. This module provides initial base expeditionary combat support capability to expand base infrastructure, establish round-the-clock operations and enhance force protection and communications. The module includes the majority of deploying civil engineers and other expeditionary combat support forces, including airfield operations, logistics plans, weather, chaplain and additional medical, security forces, force protection, supply and transportation elements. Housekeeping (e.g. billeting, food service, hygiene, environmental control units [ECU], etc), industrial operations and flightline assets are deployed with this module, along with personnel from the 49 MMG to assist with erection of technically complex mobile assets.

2.3.1.4. Generate the Mission. This module provides the primary weapon systems and systems operators and maintainers required to operate the weapon system and its subsystems. Module elements include maintenance supervision, munitions, intelligence, weather, operations support, flying squadrons and life support.

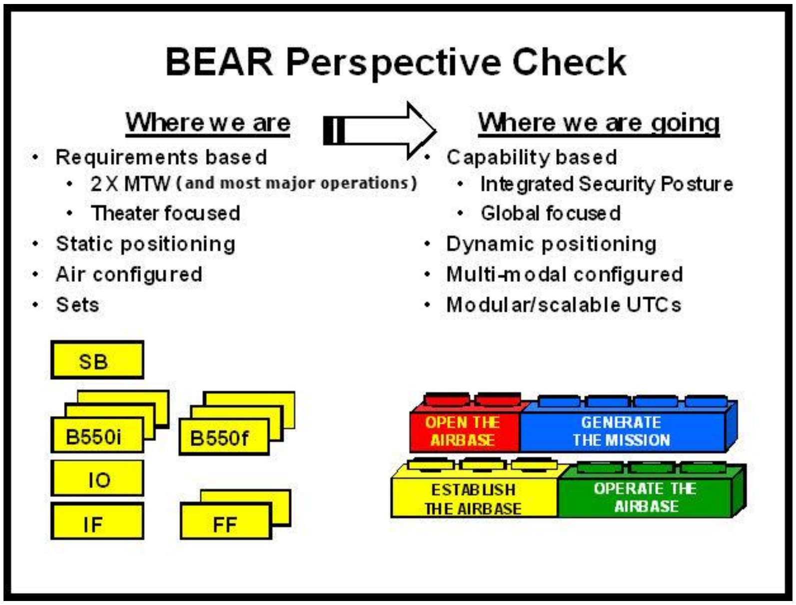
2.3.1.5. Operate the Airbase. This force module contains the mission support forces needed to achieve full operating capability and sustain those forces for up to 30 days. The module increases force protection, communications, cargo handling and materiel management and distribution. It also develops robust quality of life activities such as chaplain, fitness, library, health care, feeding and sheltering and reach-back capabilities (US mail and military pay).

2.3.1.6. Robust the Airbase. This force module provides additional expeditionary combat support to strengthen the capabilities already put in place by the previous force modules. The forces in this module will typically not arrive until 30 days after an operating location is established.

2.4. Bare Base Asset Deployment Planning Guidelines. Just as the base population is phased into a bare base, the facility and utility assets required to support the population and aircraft are also predetermined and incrementally flowed. Without this preplanning and asset sequencing, engineers would have plane loads of equipment sitting on the ramp waiting to be sorted before any meaningful beddown or support to combat sorties could be initiated. To meet this challenge, engineers and logisticians use asset management systems like Basic Expeditionary Airfield Resources (BEAR) and BEAR Order of Battle (BOB) to manage these critical resources. Assets in both systems are key enablers for AETFs to open the air base, generate the mission, and operate the air base. Currently, BEAR equipment sets are being transformed into smaller BOB packages, therefore BOB will be the main focus of this section.

2.4.1. Basic Expeditionary Airfield Resources (BEAR) Order of Battle (BOB). Similar to the reconfiguration of “Harvest” sets to lighter, leaner BEAR equipment sets, BOB is an example of the Air Force’s effort to continue implementing a flexible and responsive system for deploying BEAR assets. Under BOB, previously addressed BEAR 550-person sets are being reduced to smaller sizes (e.g. 250-person increments) to increase flexibility and efficiency and be postured for delivery by multi-modal shipping methods—a mix of air and surface delivery. It is also likely that units will deploy with equipment and spares in quantities of less than 30 days (e.g. a 10-day supply). In the same manner as BEAR, BOB supports the Agile Combat Support CONOPS goals of making the AF lighter, leaner and more responsive in planning and execution. Historically, beddown locations received equipment in entire “sets” even though each location had different needs. With order of battle priority sequencing, planners have a menu of capabilities to choose from because most or all BOB UTCs will be “playbook” options. The intent is to synchronize posturing of BEAR assets and give deployed commanders only what they need, exactly when they need it. BOB will provide a basic capability, but most assets and capabilities will be optional and mission specific. The policies that establish these processes are fully outlined in various publications, including **AFI 10-401** and **AFI 10-404**. **Figure 2.3** visually highlights the transition from BEAR to BOB asset management and the focus on flexibility and effect for the warfighter. The paragraphs that immediately follow also describe some of the elements of this transition. **Note**: the abbreviation "MTW" in the figure refers to major theater war but can also apply to most major operations.

Figure 2.3. Transition from BEAR to BOB Asset Management



2.4.1.1. Capability-Based Planning and Force Presentation. AF planners recognized inefficiencies in the architecture that presents forces on plan-based or theater-based requirements. When forces and assets are presented based on large modules, it usually creates the need for trimming or tailoring personnel and materiel to meet the actual need on the ground. To avoid this inevitable extra step, planners have transformed to a planning and execution process that allows delivery of a capability and an "effect" to combatant commanders. Presentation of capabilities in this manner helps reduce the overall engineer and logistics footprint compared to previous legacy and BEAR sets. Commanders can now employ only those capabilities required to meet the mission.

2.4.1.2. Dynamic Positioning Strategy. This capability involves planning that expedites placement and movement of assets to meet combatant commander requirements. Inherent in this strategy is the ability to gain/retain access to bases and infrastructure and move assets overtly and covertly. BEAR assets can be strategically and globally positioned to support not only AF requirements but international, joint service and coalition efforts.

2.4.1.3. Multi-Modal Configuration. One of the major challenges for legacy assets is the heavy dependence on limited airlift resources. With BOB, planners have a multi-modal and flexible transportation configuration and assets are efficiently packaged, transported and delivered by a range of air, land and sea options. With the exception of the BEAR 150, which because of the need for its rapid deployment has an exclusive airlift configuration, all other BOB UTCs can be configured for air or surface delivery. Currently about 30% of BEAR assets are configured for transportation by air and approximately 70% are planned to deploy via surface. **Table 2.1** lists the major BOB UTCs as currently configured. **Note**: surface includes commercial rail, ground and sealift.

Table 2.1. BOB Multi-Modal Configurations

Air Configured UTC	ASSET	Surface Configured UTC
XFA14	Combat Air Forces (CAF) Initial (8 Medium/8 Small Shelters)	XFS14
XFA16	Low Voltage Industrial (2 Ea. 60kW MEP-806's)	XFS16
XFA17	Water Distribution Initial	XFS17
XFA18	Water Distribution Follow-On	XFS18
XFA19	Engineering Management (2 Small Shelters)	XFS19
XFA21	Power Pro/CE Sup/Elect (3 Small Shelters)	XFS21
XFA23	TF-2 Lightcart (2 TF-2's)	XFS23
XFA3C	Mobility Air Forces (MAF) Initial (6 Medium/8 Small Shelters)	XFS3C
XFAAB	4K Dome (1 Shelter)	XFSAB
XFAAC	Field-Deployable Environmental Control Unit (FDECU), 12 Ea.	XFSAC
XFAAD	8K Dome (1 Shelter)	XFSAD
XFAAM	AM2 Matting (6 Bundles)	XFSAM
XFABL	Billeting (12 Small Shelters)	XFSBL
XFAC6	CAF Add-On (2 Medium/1 Small Shelter)	XFSC6
XFACB	CAF Follow-On (4 Small Shelters)	XFSCB
XFACC	Tactical Exchange (1 Small Shelter)	XFSCC
XFACD	Entomology (No Facility)	XFSCD
XFACF	Fire Ops/Crash Rescue (4 Small Shelters)	XFSCF
XFACH	Advanced Design Refrigerator, 300 CF (ADR-300), 1 Ea.	XFSCH
XFACJ	Large Area Maintenance Shelter (LAMS) 1 Ea.	XFSCJ
XFACL	Barrier Facility (1 Medium Shelter)	XFSCL
XFACW	Cold Weather (12 Heaters)	XFSCW
XFACX	CE Maintenance (1 Small Shelter)	XFSCX
XFAEC	CE Industrial (1 Small Shelter)	XFSEC
XFAEG	Power Distribution (2 Cable Reel Pallet Assembly)	XFSEG
XFAGC	Chaplain (1 Small Shelter)	XFSGC
XFAHL	High Line Dock (1 HLD)	XFSHL
XFAKC	Kitchen	XFSKC
XFALC	Shower/Shave/Latrine (2 Small Shelters)	XFSLC
XFALS	Self Help Laundry	XFSLS

XFAMP	Water Production, 1500-GPH Reverse Osmosis Water Purification Unit (ROWPU), 2 Ea.	XFSMP
XFAMS	Water Source Run	XFSMS
XFAMU	Munitions (1 Medium/1 Small Shelter)	XFSMU
XFAMX	Water Extension	XFSMX
XFANC	Camouflage Netting, 200 Ea.	XFSNC
XFAND	Water Production, 600-GPH ROWPU, 3 Ea.	XFSND
XFAPH	High Volt Power (2 MEP-12's; 2 10K Fuel Bladders; 1 Primary Switching Center (PSC); 1 Operating Remote Terminal (ORT)	XFSPH
XFAPL	Low Voltage Housekeeping (5 MEP-806's; 3 MEP-805's)	XFSPL
XFAPS	Postal (1 Medium Shelter; 1 FDECU)	XFSPs
XFAR4	Mobile Aircraft Arresting System (MAAS), 1 Ea.	XFSR4
XFARB	Packing/Crating (No Facility)	XFSRB
XFASC	Combat Supply (4 Small Shelter)	XFSSC
XFASD	Secondary Distribution Center (SDC's), 2 Ea.	XFSSD
XFATF	Single-Pallet Expeditionary Kitchen (SPEK) Messing	XFSTF
XFAVC	Vehicle Maintenance/Operations (1 Small Shelter)	XFSVC
XFAWC	Admin (4 Small Shelters)	XFSWC
XFAWR	Concertina Wire (480 Rolls)	XFSWR
XFAXN	Mortuary (1 Small Shelter)	XFSXN
XFAYC	Expeditionary Airfield Lighting System (EALS), 1 Ea.	XFSYC
XFAZC	Remote Area Lighting System (RALS), 2 Ea.	XFSZC
XFB1A	Swift BEAR	
Note: Water freeze protection UTCs are still under development.		

2.4.1.4. Modular/Scalable UTCs. UTCs that do not require tailoring is an important order of battle feature. BOB builds the smallest viable structure of personnel and equipment to provide a baseline level of capability for all deployment locations. The baseline can then be incrementally increased to meet location/mission specific requirements. The goal is to define right-sized UTCs that can operate across a wide range of operations, locations and environments and rapidly link to other UTCs in a building block manner when necessary. This is key to a flexible expeditionary capability and the cornerstone of BOB. **Figure 2.4** through **Figure 2.6** provide visual representation of how BOB is flexible and scalable to meet the specific situation and location. Shaded portions of the tables indicate capability not yet needed for that particular operation. **Figure 2.7** further demonstrates the BOB capability. An obvious contrast is that while BEAR sets were based on increments of 550 personnel, BOB assets are scaled to 250 personnel or down to the desired capability. And while legacy systems have very large UTCs with heavy airlift requirements, BOB has smaller, modular UTCs with flexible transportation modes.

Figure 2.4. Modular/Scalable UTC to Pax Flow Matrix (expanded capability)

	PERSONNEL FLOW													
CAPABILITY UTCs	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
Billeting (12 SSS)	2	+2 (4)	+2 (6)	+2 (8)	+2 (10)	+1 (11)	+2 (13)	+2 (15)	+1 (16)	+2 (18)	+2 (20)	+2 (22)	+1 (23)	+2 (25)
ECUs (12 ECUs)	4	+3 (7)	+2 (9)	+2 (11)	+3 (14)	+2 (16)	+2 (18)	+2 (20)	+1 (21)	+4 (25)	+3 (28)	+2 (30)	+1 (31)	+2 (33)
Showers/Latrines (1 each)	1	+1 (2)	+1 (3)	+1 (4)	+1 (5)	+1 (6)	+1 (7)	+1 (8)	+0 (8)	+1 (9)	+1 (10)	+1 (11)	+1 (12)	+0 (12)
Messing UTCs (1 SPEK, 1 MSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
SDCs (2 SDCs)	4	+4 (8)	+4 (12)	+4 (16)	+4 (20)	+4 (24)	+4 (28)	+4 (32)	+4 (36)	+4 (40)	+4 (44)	+4 (48)	+0 (48)	+0 (48)
Power (Low Voltage)*	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Power (High Voltage)**	1	+0 (1)	+1 (2)	+0 (2)	+1 (3)	+0 (3)	+1 (4)	+0 (4)	+0 (4)	+1 (5)	+0 (5)	+1 (6)	+0 (6)	+0 (6)
Power Distribution (1 Cbl Reel)	2	+0 (2)	+2 (4)	+0 (4)	+2 (6)	+0 (6)	+2 (8)	+0 (8)	+0 (8)	+2 (10)	+0 (10)	+2 (12)	+0 (12)	+0 (12)
External Lighting	4	+0 (4)	+0 (4)	+0 (4)	+4 (8)	+0 (8)	+0 (8)	+0 (8)	+0 (8)	+4 (12)	+0 (12)	+0 (12)	+0 (12)	+0 (12)
Water Distro (Initial)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Water Distro (Follow-on)	0	+0 (0)	+1 (1)	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+1 (3)	+1 (3)
Chaplain (1 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Supply (2 SSS, MHE)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Mortuary (1 SSS, 2 ADR)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
TFE (1 SSS, 1 ADR)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
CE (5 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Admin (4 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)

Figure 2.5. BOB Scaled to Support 50-Person Humanitarian Relief Operation

	PERSONNEL FLOW													
CAPABILITY UTCs	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
Billeting (12 SSS)	2	+2 (4)	+2 (6)	+2 (8)	+2 (10)	+1 (11)	+2 (13)	+2 (15)	+1 (16)	+2 (18)	+2 (20)	+2 (22)	+1 (23)	+2 (25)
ECUs (12 ECUs)	4	+3 (7)	+2 (9)	+2 (11)	+3 (14)	+2 (16)	+2 (18)	+2 (20)	+1 (21)	+4 (25)	+3 (28)	+2 (30)	+1 (31)	+2 (33)
Showers/Latrines (1 each)	1	+1 (2)	+1 (3)	+1 (4)	+1 (5)	+1 (6)	+1 (7)	+1 (8)	+0 (8)	+1 (9)	+1 (10)	+1 (11)	+1 (12)	+0 (12)
Messing UTCs (1 SPEK, 1 MSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
SDCs (2 SDCs)	4	+4 (8)	+4 (12)	+4 (16)	+4 (20)	+4 (24)	+4 (28)	+4 (32)	+4 (36)	+4 (40)	+4 (44)	+4 (48)	+0 (48)	+0 (48)
Power (Low Voltage)*	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Power (High Voltage)**	1	+0 (1)	+1 (2)	+0 (2)	+1 (3)	+0 (3)	+1 (4)	+0 (4)	+0 (4)	+1 (5)	+0 (5)	+1 (6)	+0 (6)	+0 (6)
Power Distribution (1 Cbl Reel)	2	+0 (2)	+2 (4)	+0 (4)	+2 (6)	+0 (6)	+2 (8)	+0 (8)	+0 (8)	+2 (10)	+0 (10)	+2 (12)	+0 (12)	+0 (12)
External Lighting	4	+0 (4)	+0 (4)	+0 (4)	+4 (8)	+0 (8)	+0 (8)	+0 (8)	+0 (8)	+4 (12)	+0 (12)	+0 (12)	+0 (12)	+0 (12)
Water Distro (Initial)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Water Distro (Follow-on)	0	+0 (0)	+1 (1)	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+1 (3)	+1 (3)
Chaplain (1 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Supply (2 SSS, MHE)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Mortuary (1 SSS, 2 ADR)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
TFE (1 SSS, 1 ADR)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
CE (5 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Admin (4 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)

Figure 2.6. BOB with Partial Host Base Support

CAPABILITY UTCs	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500
	PERSONNEL FLOW													
Billeting (12 SSS)	2	+2 (4)	+2 (6)	+2 (8)	+2 (10)	+1 (11)	+2 (13)	+2 (15)	+1 (16)	+2 (18)	+2 (20)	+2 (22)	+1 (23)	+2 (25)
ECUs (12 ECUs)	4	+3 (7)	+2 (9)	+2 (11)	+3 (14)	+2 (16)	+2 (18)	+2 (20)						
Showers/Latrines (1 each)	1	+1 (2)	+1 (3)	+1 (4)	+1 (5)	+1 (6)	+1 (7)	+1 (8)						
Messing UTCs (1 SPEK, 1 MSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)						
SDCs (2 SDCs)	4	+4 (8)	+4 (12)	+4 (16)	+4 (20)	+4 (24)	+4 (28)	+4 (32)						
Power (Low Voltage)*	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)						
Power (High Voltage)**	1	+0 (1)	+1 (2)	+0 (2)	+1 (3)	+0 (3)	+1 (4)	+0 (4)						
Power Distribution (1 Cbl Reel)	2	+0 (2)	+2 (4)	+0 (4)	+2 (6)	+0 (6)	+2 (8)	+0 (8)						
External Lighting	4	+0 (4)	+0 (4)	+0 (4)	+4 (8)	+0 (8)	+0 (8)	+0 (8)						
Water Distro (Initial)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)						
Water Distro (Follow-on)	0	+0 (0)	+1 (1)	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)						
Chaplain (1 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)						
Supply (2 SSS, MHE)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Mortuary (1 SSS, 2 ADR)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
TFE (1 SSS, 1 ADR)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
CE (5 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)
Admin (4 SSS)	1	+0 (1)	+0 (1)	+0 (1)	+1 (2)	+0 (2)	+0 (2)	+0 (2)	+0 (2)	+1 (3)	+0 (3)	+0 (3)	+0 (3)	+0 (3)

Host Base Providing:

- *Dorms for 1,000*
- *Messing*
- *Chapel*
- *Storage space*
- *Mortuary*
- *AAFES*
- *CE split use shops*
- *Admin space*

Figure 2.7. Comparison of BEAR and BOB Asset Management

- BEAR (550 - 3300 personnel)
  - Built in 550 pers. increments

    3 x B-550 Initial Housekeeping Set (XFB1H)
    - Billeting
    - Shower/Shave
    - Latrines
    - Low and High Voltage
    - Water Distribution
    - Camp Lighting
    - Limited Infrastructure
    - Mortuary/TFE/Chaplin

    3 x B-550 Follow-On H/K Set (XFBBF)
    - Billeting
    - Water System
    - Latrines
    - Shower/Shave
    - Additional Power
- Large UTCs, non-modular, heavy lift requirements
- Difficult to "break" kits
  - Low visibility of tailoring
  - Tough to define residual capability

- BOB (250 – 3500 personnel)
  - Built in 250-pax increments *and/or* desired capability
    - Billeting UTC
    - ECUs UTC
    - Showers/Latrines UTC
    - Messing UTC
    - SDCs UTC
    - Power (Low Voltage) UTC
    - Power (High Voltage) UTC
    - Power Distribution UTC
    - External Lighting UTC
    - Water Distro (Initial) UTC
    - Water Distro (Follow-on) UTC
    - Chaplain UTC
    - Supply UTC
    - Mortuary UTC
    - Tactical Field Exchange UTC
    - CE Support UTC
    - Admin Support UTC
- Small, modular UTCs by functional capability
- Enables easy/flexible site-specific tasking
- Extreme flexibility for mode of transportation/sequence/timing

Efficiencies for packing, delivery, and usage!

2.5. Complementary Systems and Equipment. Although BEAR contain many facilities and utility support systems, a bare base cannot operate in a mission-responsive posture using only BEAR assets. Several complementary programs exist which engineers must be aware of since some of these programs will require engineer support or directly assist engineer forces in accomplishing bare base taskings. Typically these other systems and equipment include:

2.5.1. Mobile Flightline Maintenance Equipment. For the most part, this equipment represents the powered and non-powered AGE used for aircraft maintenance purposes.

2.5.2. User Unique Tactical Shelters. Many other types of tactical shelters not directly associated with BEAR provide unique facility support for bare base users. The majority of these are aircraft-related maintenance shops dedicated to specific types of aircraft.

2.5.3. Vehicles. Vehicle packages, which provide a bare base with general and special purpose transportation equipment, are major support items.

2.5.4. Mobile Hospital/Clinics and Equipment. Expeditionary medical support facilities and related systems discussed in more detail in **Chapter 12**, fall in this category.

2.5.5. Communications Equipment. This grouping of facilities includes base communication networks and navigational aids (NAVAIDS) packages.

2.5.6. CE Construction Equipment. Typical of this category is airfield damage repair (ADR) additives to the base vehicle fleet.

2.5.7. Fuels Mobility Support Equipment (FMSE) and Fuels Operational Readiness Capability Equipment (FORCE). These include fuel bladders, air transportable hydrant refueling systems, pumps, filters and other equipment needed to store and distribute ground and aviation fuels in an expeditionary environment.

2.5.8. Unique Equipment from Other Functional Areas. This includes a myriad of equipment items that individually may not be major, but in total, represent a considerable weight and cube requirement for airlift movement.

2.5.9. In pursuit of lighter, leaner capability, the AF will continue to test and develop other rapidly deployable systems and components. The requirement to be prepared to respond to unpredictable situations and small-scale contingencies fuel much of this effort. However, lessons learned, individual initiative, suggestions and innovation are also factors. Air Force Special Operations Command (AFSOC), for instance, adopted the Air Rapid Response Kit (AARK) to meet the unique needs of special operations forces. This system uses a hybrid of lightweight military and commercial-off-the-shelf (COTS) components to provide various levels of basic shelter and hygiene for 10 to 100 persons for a limited period of time.

2.6. Engineer Planning Guidelines. The following guidelines reflect planning criteria for various major BEAR facility and utility requirement areas.

2.6.1. Airfield.

2.6.1.1. If pre-existing aircraft arresting systems are operational and adequate in number, they will require operational checks and maintenance. When inoperative, or where none exist, a mobile aircraft arresting system (MAAS) must be installed (**Figure 2.8**). **Note**: AF personnel can only perform checks and maintenance on US-owned aircraft arresting systems. They cannot certify systems constructed by other countries.

Figure 2.8. Servicing the Mobile Aircraft Arresting System

2.6.1.2. As a minimum, runway edge and approach lights are required. Distance-to-go and aircraft arresting system marker lights are required on runways supporting jet aircraft operations. The lights are also recommended for runways supporting propeller-type aircraft operations.

2.6.1.3. NAVAIDS are required. Communications and CE personnel will accomplish installation jointly.

2.6.1.4. An aircraft parking plan is required.

2.6.1.5. Aircraft revetments, when required, will be constructed 16 feet high on ramps, aprons, matting, or hardstands.

2.6.1.6. If additive aircraft parking surfaces are required to support surge, dispersal, or overcrowding conditions, stabilized areas will be required. If available, AM-2 matting should be the primary material considered. If using AM-2 matting, ensure the required technical expertise is available to install and evaluate AM-2 matting to withstand the rigors of aircraft movements. The U.S. Navy and Marine Corps has extensive experience in AM-2 matting installation. If needed, consider consulting with their experts at the **Naval Air Systems Command (NAVAIR),** Lakehurst, New Jersey for advice and assistance.

2.6.2. Site Preparation and Layout.

2.6.2.1. The site should have relatively flat terrain with minimal grading, brush, or tree removal required.

2.6.2.2. Blasting or large rock removal should not be required.

2.6.2.3. Major soil stabilization work should not be required.

2.6.2.4. The site will require expedient soil testing and surveying to establish base lines, major functional areas and specific areas using field expedient survey methods, when possible.

2.6.2.5. Petroleum, Oil and Lubricants (POL) site preparation consists of siting, grading, berming and furnishing and installing a 3-inch dike drain pipe and gate valve. All fuel bladders, regardless of size and content, will be bermed; all fuel bladder dikes will be fitted with a protective liner to prevent environmental damage and contamination (**Figure 2.9**). Bladders, headers, adapters, fill stands and associated attachments will be furnished and installed by base supply fuels operations personnel.

Figure 2.9. Fuel Berm with Protective Liner Installed

2.6.2.6. The munitions storage site preparation consists of siting, grading, berming and sandbagging. Construction of storage bunkers should begin as soon as possible after other more essential tasks are completed. In the interim period, munitions should be stored in temporary bermed, sandbagged areas if sandbags are available. Also, plan on providing a grounding system for the munitions area consisting of ground rods and a connecting grid system.

2.6.2.7. Medical unit site preparation consists of siting and grading approximately 0.9 acre for the 25-bed facility, 1.15 acres for the 50-bed Air Force Theater Hospital (AFTH) and 2.5 acres for the 114-bed AFTH. Medical units should be sited in lower threat areas of the base but as near as practical to force support facilities such as billeting, showers and laundry.

2.6.3. Facilities Siting and Construction.

2.6.3.1. Use existing structures and facilities as much as possible, consistent with operational economy and functional requirements.

2.6.3.2. Use locally-available construction materials and use temporary construction methods unless more permanent structures are required due to operational demands or cost factors.

2.6.3.3. Civil engineers are responsible for siting and locating all facility groups and for siting, locating and erecting all utility plants and systems.

2.6.3.4. Consider base defense requirements up front. Base layout should comply with theater-specific requirements and minimum antiterrorism standards (including hardening, standoff and separation distances) prescribed in UFC 4-010-01, *DOD Minimum Antiterrorism Standards for Building, Appendix D*, and UFC 4-020-01, *DOD Security Engineering Facilities Planning Manual*.

2.6.3.5. Comply with Quantity-Distance criteria for inhabited building according to AFMAN 91-201, *Explosives Safety Standards*.

2.6.3.6. Facility separation distances may be minimized to improve functional relationships and save on utility system costs, as long as minimum standoff, facility separation, and quantity-distance criteria is met.

2.6.3.7. Civil engineers erect their own facilities and furnish a minimum cadre of personnel to provide technical assistance to other base functions erecting their own facilities (**Figure 2.10**).

2.6.3.8. The contingency troop housing planning factor of 50 SF per person can be used for the bare base. Soft-walled shelters can be used for personnel billeting. Refer to AFI 34-246, *Air Force Lodging*, for additional planning factors during emergency/wartime conditions.

Figure 2.10. Civil Engineers Erect Medium Shelter System

2.6.4. Electrical Power.

2.6.4.1. Electrical power requirements should be based on 4.5 kilowatts (kW) per tent for the cantonment area. When an industrial capability is added, the planning factor may increase. These requirements should be used at contingency locations and during the initial bare base development stage. However, for longer term bare base locations, anticipate an increase in electrical power production to support quality of life requirements.

2.6.4.2. Even though centrally located high-voltage generators offer the most advantageous primary distribution system, they should be dispersed in a high-threat area between prime and slave power plant locations to improve survivability. Multiple power plants and primary distribution loops that interconnect these plants are especially critical in high-threat locations. If a power plant becomes inoperative for any reason, the electrical grid can be energized from the remaining power plant(s).

2.6.4.3. MEP generators (30-kW and 60-kW) can be dispersed throughout the base to satisfy initial power requirements for priority facilities until the base electrical distribution system (750-kW units) becomes fully operational. At that time, the MEP generators will become a backup source of mission-essential power for critical bare base functions.

2.6.4.4. RALS should be installed around POL, liquid oxygen (LOX), flightlines, medical units and munitions storage. Primary and secondary distribution systems should be extended to these areas to provide power for RALSs.

2.6.4.5. Since the total connected load will not be operating continuously, a diversification factor of seven-tenths (0.7) should be applied to all loads except air conditioning or unique loads which require full demand at all times.

2.6.5. Water.

2.6.5.1. Water treatment plants must be installed at base sites where water is nonpotable. A ROWPU is required for water desalinization, removal of suspended solids from fresh water and chlorination control of bacteria. Water use planning factors are in **Chapter 8** of this volume.

2.6.5.2. If available, one chilled fountain can be provided for approximately every 65 people. Due to the limited number available, chillers should be allocated to areas with the greater population densities such as the flightline, base operations, cantonment area and similar functional groups. Additionally, three chilled water fountains are required for each AFTH (one in each ward and one in outpatient area). These requirements are based on a chilled water fountain that produces 15 gph of 60-degree water when the input water temperature is 120 degrees Fahrenheit. Chilled water fountains should be strategically located in shower/latrine and functional areas where water is already available. Water lines should not normally be run to functional areas for the sole purpose of providing drinking water. Chilled water fountains must be of the type with a downward water flow, allowing containers to be filled without excessive waste.

2.6.5.3. In SWA, temperatures range from a daytime high of 130 degrees Fahrenheit to a nighttime low of 30 degrees Fahrenheit. Where possible, pipes should be buried to a depth of 18 inches or more to provide mechanical protection to the system and to prevent heat gain from high ambient temperatures.

2.6.5.4. Demineralized water may be required for some medical operations. Verify this requirement by location to determine the total amount of storage needed. When the requirement for demineralized water exists but exact quantities are unknown, allow one 20,000-gallon bladder for this purpose.

2.6.5.5. Where total dissolved solids content of water used for showers and laundry exceeds 500 ppm, soaps and detergents designed for "salt water use" should be used.

2.6.6. Waste Disposal.

2.6.6.1. Approximately 70 percent of all potable water will likely become wastewater that enters the sewer system for treatment at wastewater lagoons. The remaining 30 percent of potable water will be lost through leaks, perspiration, evaporation and food preparation.

2.6.6.2. When modular latrine units (field deployable latrine system) are used, the sanitary system treatment facilities should be sized to accept all human waste. When the field deployable latrine is used without piped sewage disposal, latrine holding tanks must be emptied periodically and the human waste transported to wastewater lagoons. Typical housing layouts contain a minimum of four deployable latrines; each latrine set has twelve toilets and two urinal troughs.

2.6.6.3. Depending on the salinity of the raw water source, for every gallon of potable water produced, up to two gallons of brine water can be produced. Provisions for the disposal of brine water must be made (e.g. dust control). Where feasible, brine water can be returned to the source. The lagoons discussed later in this pamphlet have not been sized to accept brine water since the salt content of the brine water would upset the biological treatment and evaporation processes.

2.6.6.4. Biodegradable soaps, paper and detergents should be used in an effort to eliminate unnecessary wastewater problems.

2.6.6.5. A combination of gravity flow and a force main sewer system is part of the BEAR wastewater distribution system. Grinders are used in the force main portion of the sewage ahead of lift pumps to grind waste material to slurry thereby reducing the power requirements and workload of the pumps.

2.6.6.6. Solid waste from dining halls should be buried or incinerated. A kitchen usually produces one-half to one pound of garbage per person per day. Kitchen grease traps should be maintained daily by Force Support personnel and inspected weekly by civil engineers.

2.6.6.7. Disposal of hazardous waste at expeditionary contingency bases must comply with DOD policy and guidance, Operations Plans and applicable international agreements. Usually, biological waste requires that an incineration site be established in a remote area of the base. Where incineration is not possible, a pit about 4 to 6 feet deep (depending on the water table) can sometimes be used to bury biological waste. Consult with base bioenvironmental (BEE) personnel for guidance and assistance on the handling and disposing of hazardous waste.

2.6.7. Fuels.

2.6.7.1. One 10,000-gallon fuel bladder should be provided for every two 750-kW diesel generators collocated at power plants. At full load each 750-kW diesel generator consumes approximately 55 gph of fuel.

2.6.7.2. At full load each 30-kW MEP generator consumes about 3 gph of diesel fuel and each 60-kW unit about 5 gph.

2.6.7.3. Internal tanks normally fuel MEP generators. Base supply fuels personnel are responsible for central storage and resupply of fuel for MEP generators.

2.7. Task Priorities. Many engineering tasks must be completed to establish an operational bare base at a fully mission capable level within desired time limits. Some tasks can be performed concurrently, others sequentially, and some may be dependent on BEAR asset flow and availability. A recommended order for bare base tasking accomplishment is provided in the priority taskings below. The priority of taskings reflects four stages of bare base development: initial, intermediate, follow-on and sustainment. See **AFH 10-222 Volume 1**, *Civil Engineer Bare Base Development*, for further information on the stages of bare base development.

2.7.1. Priority 1 Taskings (Initial Stage).

2.7.1.1. Runway Preparation. Consists of inspection, cleaning and striping of runways, as required. Also includes placement of appropriate airfield markers, e.g., distance-to-go, aircraft arresting system, taxiway, etc.

2.7.1.2. Runway Edge and Approach Lights. Required when night combat operations are necessary, during inclement weather (e.g. rain, fog, low visibility) and during periods of sustained logistics buildup (**Figure 2.11**). Runway edge lights must be installed by nightfall of day one.

Figure 2.11. Installing Airfield Lighting - Priority 1 Task

2.7.1.3. Navigational Aids. Involves site preparation to position NAVAIDS on clear and level surfaces.

2.7.1.4. MAAS. Installation of a MAAS is required where permanent or expedient aircraft arresting systems are inoperable or nonexistent. Perform operational checks of these systems prior to the arrival of fighter aircraft.

2.7.1.5. Emergency Pavement Repairs. Perform a runway condition survey to determine the scope of this task. Other considerations may include early expansion requirements and threat of attack.

2.7.1.6. Water Point. Requires clearance of an access route to a water point or source when installation of the water system is blocked by obstructions.

2.7.1.7. Water Treatment Plant(s). Install water plants so potable water is available.

2.7.1.8. Functional Groups and Facilities. Use survey stakes or other expedient marking devices to mark the location of functional groups and facilities.

2.7.1.9. Water Distribution System. Install pipes, pumps and storage tanks. Also install fill stands for firefighting and domestic fill points.

2.7.1.10. MEP. Install MEP generators to provide temporary power to mission-essential functions.

2.7.1.11. Primary Power. Involves installation and operation of the primary generation and distribution system.

2.7.1.12. Latrines. Requires establishment of expedient latrine facilities or erection of field deployable units.

2.7.1.13. Dining Facility (DFAC). Provide electrical power and water to food service facilities and construct flooring.

2.7.1.14. Control Center. Erect the CE control center shelter using personnel not performing other Priority 1 tasks.

2.7.1.15. Medical Treatment Facilities. Assist with erection of medical shelters (when requirement exceeds medical unit's organic capabilities) and connect medical facilities to bare base utility systems.

2.7.1.16. Fire Protection. Provide fire emergency services.

2.7.1.17. Warning System/Giant Voice Systems. Provide electrical power services. Support Communications Squadron in the installation and maintenance of base alerting system.

2.7.1.18. Unexploded Ordnance. Perform a survey of the entire beddown area to identify the presence of surface and subsurface unexploded ordnance.

2.7.1.19. Ammunition Storage. Complete site clearance and leveling and start berm construction in preparation for arrival of munitions.

2.7.2. Priority 2 Taskings (Intermediate Stage).

2.7.2.1. Airfield Clear Zones. Remove major obstructions that endanger safe landing, taxiing and takeoff.

2.7.2.2. Aircraft Ramps and Aprons. Sweep, clean and repair aircraft ramps and parking areas.

2.7.2.3. POL Storage. Level fuel bladder sites and construct protective earth berms and dikes.

2.7.2.4. Static grounds. Install static grounds and tie-downs at fueling points, munitions arm and dearm pads, hot cargo (munitions and hazardous materials) off-loading pads and parking areas.

2.7.2.5. Showers. Install personnel showers and temporary wastewater drains.

2.7.2.6. Facilities. Erect engineer shops and billets and provide technical guidance for shelter erection to other base functions using personnel not assigned to Priority 1 work.

2.7.2.7. Expedient Runway Repair. Accomplish expedient runway repairs to the extent required to support flying operations.

2.7.2.8. Expedient Aircraft Ramp Extensions. Construct additional aircraft pavements, ramps and aprons, when required; start early to prevent delay of logistical buildup mission. Use expedient paving materials such as AM-2 matting, etc. When AM-2 matting is used, remember that the Navy's **Expeditionary Airfield Systems Team** at Naval Air Systems Command (NAVAIR), Lakehurst, New Jersey, may be consulted for technical expertise if needed.

2.7.2.9. Aircraft Revetment. Construct revetments to protect tactical and strategic aircraft.

2.7.2.10. Security Fences and Anti-Vehicular Obstacles. Construct and Install perimeter and access way security features.

2.7.2.11. Pest Management. Provide entomological services to rid an installation of pests and maintain a sanitary environment under austere conditions.

2.7.2.12. Environmental Quality and Control/Disposal of Hazardous Materials. Clean up hazardous materials found upon arrival at an installation and maintain proper control of any such materials generated during base buildup and operations.

2.7.3. Priority 3 Taskings (Follow-on Stage).

2.7.3.1. Electrical Service. Extend the electrical service to all base facilities and install MEP generators for emergency backup.

2.7.3.2. Base Roads. Maintain roads to permit an unimpeded flow of facilities and logistic materials from the off-load ramp to the buildup sites.

2.7.3.3. Sanitary Fill. Construct trenches and burn pits for the disposal of solid wastes according to local requirements.

2.7.3.4. Wastewater Lagoons. Construct wastewater lagoons when required by environmental conditions.

2.7.3.5. Sewage Collection Systems. Install pipes, sump pumps, lift stations and other components of the sewage collection system; provide bare base site drainage; and connect showers and latrines to the sewage collection system.

2.7.3.6. Flooring. Construct flooring for noncritical facilities that was omitted during initial erection of these shelters.

2.7.3.7. Grease Pits, Septic Tanks and Leaching Fields. Construct grease traps at kitchens and required shops; install septic tanks and leaching fields for facilities that require wastewater disposal but are not tied into the sewage collection system.

2.7.3.8. Wash rack. Construct wash rack to meet aircraft maintenance requirements.

2.7.3.9. Facility Hardening. Use expedient methods (sandbags, protective earth berms, revetment, digging-in) to harden critical facilities.

2.7.3.10. Camouflage and Concealment. Apply these measures (primarily netting) to counter the enemy threat.

2.7.3.11. Air Base Defense. Construct defensive fighting positions for air base defense when threat conditions dictate their preparation as a Priority 3 task.

2.7.3.12. Emergency Disposal Range. Prepare a land area to be used by EOD personnel for munitions destruction.

2.7.4. **Priority 4 Taskings (Sustainment Stage).**

2.7.4.1. Operations and Maintenance. Continue to provide operation and maintenance of bare base and existing facilities, utilities, roads, pavements and similar bare base infrastructure.

2.7.4.2. Contingency Response Plans. Develop and update contingency plans to include recovery operations and natural disaster responses.

2.7.4.3. Training. Provide training and rehearse contingency tasks to include security measures, base recovery and base denial.

2.7.4.4. Quality of Life Improvements. As time permits, improve facilities and utilities (i.e., increased square footage, more access points, hot water, air conditioning).

2.7.4.5. Recreation Support. Construct basic recreation facilities and fields; provide utilities to these facilities as necessary.

2.7.4.6. Resource Accountability. Establish controls over materials, equipment and vehicles to preclude loss, damage or unauthorized use. This includes inventory, assignment of responsibility and providing protective features such as fencing, shelters, lighting, etc.

2.8. Climate and Weather. Planning guidelines for the effects of climate and weather vary with the location of the bare base. For example, close to the equator all seasons are nearly alike, with rain throughout the year. Farther from the equator, in areas such as Central America and Southeast Asia, there are distinct wet (monsoon) and dry seasons. Both regions have high temperatures, heavy rainfall and high humidity. All these climatic phenomena impact bare base operations in the tropics. Conversely, the common characteristics of all desert areas are their aridity. Rainfall has virtually never been recorded in some parts of the Atacama Desert in Chile, for example, but rain does fall in deserts. When it does occur, the rainfall may consist of a single violent storm in a year with high surface water run-off that, from a planning perspective, makes such rainfall a liability rather than an asset. While each climatic region confronts the bare base planner with its unique problems, none is as problematic as the arid desert environment. Extremely high daytime heat combines with near freezing temperatures at night (in the inland Sinai Desert, for example, day to night temperature can fluctuate as much as 72 degrees Fahrenheit), imposing an unusual strain on personnel and BEAR equipment. Consequently, climatic planning guidelines for the arid Southwest Asian environment receive prominent treatment in the following paragraphs of this chapter. The effects of climate and weather on bare bases located in other climatic zones are discussed throughout this volume.

2.8.1. SWA. Since SWA receives little rain, precipitation is not considered as a significant factor. But, as mentioned earlier, sudden and intense rains that occur several hundred miles away from the bare base may eventually cause flash flooding at the bare base. Construction in areas where there is a likelihood of ponding should be avoided. A thorough terrain analysis should reveal natural drainage swales subject to flash flooding.

2.8.2. Winds in SWA can achieve almost hurricane force, and dust and sand suspended within them can make life almost intolerable, make any type of activity difficult and restrict visibility to a few yards. Strong winds are invariably followed by rapid changes in temperature.

2.8.3. Burial of utility lines and shading of fuel bladders, generators and vehicles will be required to reduce the effects of intense sunlight emitted from a cloudless sky.

2.9. Manpower. The number of civil engineers required during the *establish the base* phase will not change radically at lower base populations because the tasks of preparing the runways and taxiways, installing runway lights, constructing POL and ammunition areas and installing utility systems remain relatively constant regardless of base population.

2.9.1. The maximum manpower requirement for heavy equipment operator, electrical, water and fuels systems maintenance and engineering personnel will exist during the establish the base phase of the force beddown. Maximum manpower requirements for power production and heating/air-conditioning personnel will exist during the longer-term *operate the airbase* and *robust the airbase* phases of the deployment. During the initial establish the airbase phase of the deployment, technicians in pest management, operations management, and structures can be used to assist electrical, utilities and engineering crews to erect civil engineer facilities and utilities. Additionally, specially trained personnel from any of these Air Force Specialties (AFSs) can be used to supervise other crews of base personnel in erection of base facilities.

2.9.2. Although this publication makes no allowances for temperature extremes in its time and labor estimates, each bare base location imposes its own set of constraints that translates into "additives." Allowances must be made for acclimatization, reduced working hours during extreme heat or intense cold and the difficulties of handling materials under severe climatic conditions. Again, the arid desert environment imposes the worst set of working conditions and is therefore singled out under the following recommendations and guidelines (guidance for manpower planning in less demanding climates is discussed in **Chapter 5**).

2.9.2.1. A period of approximately two weeks should be allowed for acclimatization, with progressive degrees of heat exposure and physical exertion.

2.9.2.2. When it is not possible for combat forces and combat support forces to become fully acclimatized before being required to perform heavy labor, personnel should work in shifts, strenuous work should be reduced during the hottest part of the day or limited to the cooler hours and personnel should be allowed to rest more frequently than normal.

2.9.2.3. The prevention of heat injuries, generally considered an individual responsibility in most situations, becomes a matter of command concern in an environment that is especially harsh to the inexperienced. Proper wear of clothing (loose-fitting, allowing plenty of ventilation), periodic intake of water, frequent rest breaks and any other measures necessary to preserve the war fighting capability of people are critical factors.

2.10. Heating, Ventilation and Air Conditioning. Heating should be provided in all personnel shelters that are used for detail work or occupied for extended periods of time in order to maintain an interior dry bulb temperature above 50 degrees Fahrenheit. Within permanent and semi-permanent facilities, an effective temperature of 65 degrees Fahrenheit should be maintained unless dictated otherwise by workload or extremely heavy clothing. Heating systems should be installed, when possible, so that hot air is not discharged directly on people.

2.10.1. A minimum of 20 cubic feet of air per minute of outside air per person should be introduced into any personnel enclosure to provide adequate ventilation. Air should be circulated within the space to prevent stratification or stagnation and delivered within the occupied zone (past a person) at a velocity less than 100 feet per minute. Under chemical, biological, radiological, nuclear and high-yield explosive (CBRNE) conditions, ventilation requirements should be modified as required. Ventilation or other protective measures must be provided to keep gases, vapors, dust and fumes within safe limits. Intakes for ventilation systems must be located to minimize the introduction of engine exhaust emissions or other contaminated air.

2.10.2. Air conditioning has been designed for use in all facilities except storage and those with little or no occupancy. Utility systems are designed to accept a total air conditioning package. Air conditioning should be installed so that cold air is not discharged directly onto people.

2.10.3. Humidity should be approximately 30-65 percent at 70 degrees Fahrenheit. Humidity should decrease with rising temperatures, but should be above 15 percent to prevent irritation and drying of the eyes, skin and respiratory tract. It is also important that the temperature of enclosed areas be held relatively uniform. The temperature at floor level and at head level should not differ by more than 10 degrees Fahrenheit.

2.11. Noise Suppression and Lighting. Personnel should be protected from noise levels that cause injury, interfere with voice or any other communications, cause fatigue, or in any other way degrade overall effectiveness.

2.11.1. Equipment such as diesel generators, which generate noise in excess of maximum allowable levels, should be placed sufficient distances away from facilities where people work or billet so as not to cause personal injury. If sufficient distances cannot be achieved, noise barriers or baffles should be installed. Concrete “Bitburg” type revetments have also proven effective in this regard. Workspace noise should be reduced to levels that allow the required degree of person-to-person and telephone communications, as well as an acceptable work environment.

2.11.2. Where equipment is to be used in enclosures and is not subject to blackout or special low-level lighting requirements, illumination should be distributed to reduce glare and reflection. Adequate illumination should be provided for maintenance tasks. General and supplementary lighting should be used, as appropriate, to ensure that illumination is compatible with each task situation. Portable lights should be provided for people performing visual tasks in areas where fixed illumination is not provided.

2.12. Transportation. Special and general-purpose vehicles will be required to erect BEAR assets and to improve and maintain the bare base site. Aerial port personnel will normally offload BEAR equipage brought into an installation by airlift onto a cargo-holding apron. Transportation personnel are responsible for moving cargo from the ramp to the point of use. Due to a limited number of vehicles, joint usage of vehicles by transportation and civil engineers may be required. Coordination is necessary between engineers and transportation during movement and placement of BEAR facilities, utilities and support items. To meet operational deadlines, engineers should be prepared to move BEAR assets from the holding area to sites of intended use without assistance from other organizations. This means having enough engineers licensed to operate material handling equipment such as forklifts and tractor trailers.

2.13. Medical Facilities Support. The Expeditionary Medical Support/Air Force Theater Hospital (EMEDS/AFTH) systems provide the entire spectrum of AF health care in a theater of operations (**Figure 2.12**). This system and facilities provide modular and tiered medical capability driven by mission, airlift availability and population at risk. The EMEDS/AFTH system was developed from the need for an easily transported and ready medical care platform closer to expeditionary and combat forces. The older Air Transportable Hospital (ATH) was deemed too large and was normally located miles from front line forces (to reduce possible battle damage), delaying access to immediate care. EMEDS is smaller and can be expanded in a component fashion. The EMEDS/AFTH systems must attain operational capability within 24 hours after employment. Further discussion of the capabilities and requirements of this system is found in **Chapter 12** of this volume and AFI 41-106, *Medical Readiness Program Management.*

Figure 2.12. Expeditionary Medical Support (EMEDS) System

2.14. Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive (CBRNE) Environment. The threat of CBRNE materials being used against a bare base, either during or after construction, is ever present. CE emergency management personnel must determine decontamination procedures and siting of decontamination stations. Provisions must be made for the disposal of contaminated water from the decontamination processes. This publication presents no specific planning guidelines for CBRNE threats; however, **AFMAN 10-2503**, *Operations in a Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive (CBRNE) Environment*, addresses this area. It provides explanations and procedures for the AF shelter program, contamination control measures, mission-oriented protective postures (MOPP) and wartime attack actions for each level of command. The impact of CBRNE attacks on bare base operations should be considered in the BCE Contingency Response Plan and during training exercises. Planners should recognize that time estimates for facility erection and completion of bare base tasks will be affected by MOPP conditions, even with well-trained, fully equipped CE crews.

2.15. Camouflage and Concealment. The fact that the bare base exists will be difficult to conceal from the enemy. Planning for concealment must therefore concentrate on decreasing the range of target acquisition by delaying recognition of targets and by concealing valuable BEAR assets, thus making precision bombing difficult.

2.15.1. Planning for concealment should be coordinated with bare base construction planning from the outset; it is much easier and less costly in time, manpower and camouflage materials to apply camouflage during the setup phase than to add camouflage as an after-the-fact effort. Early planning for camouflage increases the awareness in all personnel and helps eliminate unnecessary ground and terrain disturbances that would otherwise defeat the purpose of camouflage or require additional effort to conceal the disturbance.

2.15.2. Where natural cover and concealment are inadequate or absent, BEAR camouflage sets can be used to screen and conceal assets. These camouflage sets includes 200 desert-colored, lightweight radar scattering nets and 70 support systems to provide camouflage screening and shade for facilities and equipment. Each net is capable of covering approximately 200 square feet and the set can be configured to cover single or multiple structures.

2.15.3. Recognizing that camouflaging all assets on the bare base with nets would be logistically difficult to support, the planner must make every effort to reduce net requirements by taking maximum advantage of the natural concealment of existing terrain, by clustering several facilities or equipment items together and erecting a net over the entire group, or by placing nets only on the side of structures which contain the shadow.

2.15.4. Coordinated concealment planning will require compromises among the need for camouflage and dispersion, the efficiency of access, the maintenance security, the allocation of scarce resources and a number of similar considerations that depend on aspects unique to each bare base location and its mission. Additional camouflage and concealment planning factors are contained in **AFH 10-222, Volume 10**, *Civil Engineer Camouflage, Concealment & Deception Measures*.

2.16. Base Defense. While accomplishing their bare base mission, engineers generally rely on security forces to shield and extricate them from hostile action. In some situations (during the early stages of a deployment, for example), availability of security forces may be limited. In such a situation, engineers must employ their individual weapons, body armor, cover and concealment and defensive fighting positions for security and survival.

2.16.1. For the bare base planner, CE involvement in air base defense should be anticipated in these areas: design and construction of defensive fighting positions, vehicle fighting positions and entry control points; removal of foliage around critical resources (to establish clear zones); assistance in establishing sector command posts and the base defense operations center (to include electrical power hook-up); establishment of an armory and other storage facilities; and assistance in setting up sensor equipment and mounting thermal imagers. In addition, the bare base planner should anticipate, when ordered to do so by the wing commander, the integration of the engineer unit into the air base defense force to defend against enemy threats to the bare base.

2.16.2. The threat of terrorist activity directed against deployed forces must be assumed to exist anytime and anywhere a bare base is being established. In addition to the obvious requirement for an enhanced security posture of the CE force, the bare base planner must support base-wide antiterrorist measures. As the only unit on base that can create physical means to deter or impede a terrorist intrusion, civil engineers must be prepared to fabricate, install or emplace a variety of barriers, obstacles and fortifications (**Figure 2.13**). Volume 2 of this publication series contains instructions and guidance on how to support these types of construction efforts and participate as a member of the air base defense force.

Figure 2.13. Engineers Create Physical Barriers Against Terrorist Intrusions

2.17. Base Recovery and Denial. Bare base development and growth are evolutionary processes. Early efforts are concerned with the flying mission and protection of the base's inhabitants from the elements. As the base grows, place more emphasis on contingency training and planning to include base recovery and base denial. From a base recovery aspect, give serious up-front thought to such wartime-related features as equipment and material dispersal locations, access ways for response vehicles, personnel shelter locations, communication capability between facilities, utility system redundancy and facility dispersal and hardening. Base denial planning should consider not only the more common tactics of asset destruction, but also, and perhaps more importantly, address the removal and transport of BEAR assets away from the land battle area. Even though these initiatives come later in the bare base development cycle, they require early planning to ensure air base survivability and that materials and equipment are available, when required.

2.18. Asset Reconstitution. At the conclusion of a bare base deployment, the mobility assets used are normally placed back into storage to await future requirements and taskings. This part of the bare base operation often does not receive the proper degree of attention. A key step in this retrograde process is refurbishing and reconstituting worn out or damaged assets over the course of the deployment. The 49 MMG has primary responsibility for repair and maintenance of

BEAR mobility assets. At the end of contingency deployments, this organization normally receives these assets back at storage locations and subsequently proceeds to conduct inventories, identify component shortages, repair damaged or worn items and repackage assets for storage. Reconstitution is complex and time consuming since personnel must handle hundreds, if not thousands, of individual assets. To speed up this process and help prolong the product life of mobility assets, facility users and, in particular, engineers should take several actions.

2.18.1. Disassembly. Disassembly and tear down of mobile facility and utility assets should be carefully and properly accomplished. Follow technical order instructions and guidance provided by people who are familiar with the assets.

2.18.2. Inventory and inspection. In conjunction with a bare base systems quality assurance evaluator, inventory and inspect all BEAR assets and components. Identify those pieces that are missing, broken, or non-functional and ensure a written list of these deficiencies is included with the asset being redeployed. Determine specific requirements that must be met in order for the deployed civil engineer unit to be released from custodial accountability in accordance with **AFI 25-101**, *War Reserve Materiel (WRM) Program Guidance and Procedures*.

2.18.3. Cleaning. Ensure the asset is as clean as possible and free from any foreign material that might cause damage or contamination during shipment. Keep in mind that aircraft and customs inspections will have to be passed.

2.18.4. Packaging. Take care to properly put the asset in its shipping configuration or package the asset correctly in its shipping container. Again, follow the technical order instructions and the advice of people who know what to do. Make sure the deficiency list mentioned above is included in the shipping container or firmly attached to the asset itself if a container is not used.

Chapter 3

BARE BASE SITING AND CONSTRUCTION GUIDELINES

3.1. Introduction. For a bare base to withstand a harsh environment and to keep occupants reasonably comfortable, the location of a facility or utility should be determined by analyzing the constraints and features of the area. Overall siting analysis should include the climatic constraints of solar radiation, temperature, precipitation and prevailing wind. It should also include natural terrain features such as topography, ground cover and drainage patterns. Follow-on construction should be initiated during the early stages of bare base erection to address primary concerns: preparation of the airfield for its operational mission, establishment water treatment plants, and beddown and protection of inhabitants from the elements. As the base develops and its operational mission is assured, more emphasis can then be placed on base support functions such as administrative offices, personnel, finance, dining facilities and quality of life items. Work priorities and schedules should be established to ensure prudent use of CE manpower during the first 72 hours of employment. This increases the chance for a limited CE combat support force to accomplish all the essential tasks on time and helps ensure aircraft are launched and recovered as schedule. This chapter starts with a discussion of the basic principles involved in proper site selection and layout, including structure separation, standoff distances, and dispersed facility layouts. Then addresses construction sequence and task scheduling during the erection phase of bare base development followed by a brief review of theater construction standards. See **AFH 10-222, Volume 1**, for more information on bare base siting and construction.

3.2. Site Selection and Layout. The siting and layout of bare base facilities is influenced by the topography, climatic conditions, the principle of grouping related facilities to improve efficiency and the contrary principle of dispersing facilities to limit damage from enemy attack. Facility hardening, camouflage and concealment also increase protection from attack. Site-specific planning guidelines that take into account the many variables in topography and weather for the major climatic regions of the world are presented in **Chapter 4**. However, with a master bare base plan, facility siting tends to follow the pattern of existing roads and facilities. This may work out fine in some situations, but an overall siting plan which zones the base into functional areas with room for expansion helps manage orderly growth, boosts operational efficiency and conserves scarce resources.

3.2.1. Layout and Functional Grouping. The available real estate and configuration within the base defense boundary influences the layout and functional grouping of beddown facilities for expeditionary airbases. **Figure 3.1** illustrates a conventional site layout where support facilities, billeting, and force protection functions are sited farther away from the flightline than the industrial support functions. However, if the base is long and narrow, a more linear layout may be appropriate (**Figure 3.2**). In addition to real estate configurations, the functional relationships between base activities are also a key concern. For example, certain aircraft maintenance activities must be on the flightline to expedite on-board aircraft maintenance; however, some need not be. If space is limited, activities such as avionics and parachute shops do not necessarily require direct access to the aircraft and may be sited off the flightline. Also, instead of placing supply facilities in one area, consider siting each facility where they are needed most. Locate some warehouses near aircraft maintenance facilities to improve response times to the primary supply customers. Place the civil engineer and vehicle maintenance functions near one another since a large vehicle fleet is involved. Put the main dining hall near the lodging area to better serve base personnel. Regardless of the layout selected, review the structure separation and standoff distances and dispersed layout guidance in **paragraph 3.3** when planning layouts for facilities and groups. Also be very cognizant of the airfield clear/land use zones when planning facility layout. See UFC 2-260-01 and Chapter 6 in this pamphlet for additional details.

Figure 3.1. Conventional Base Layout

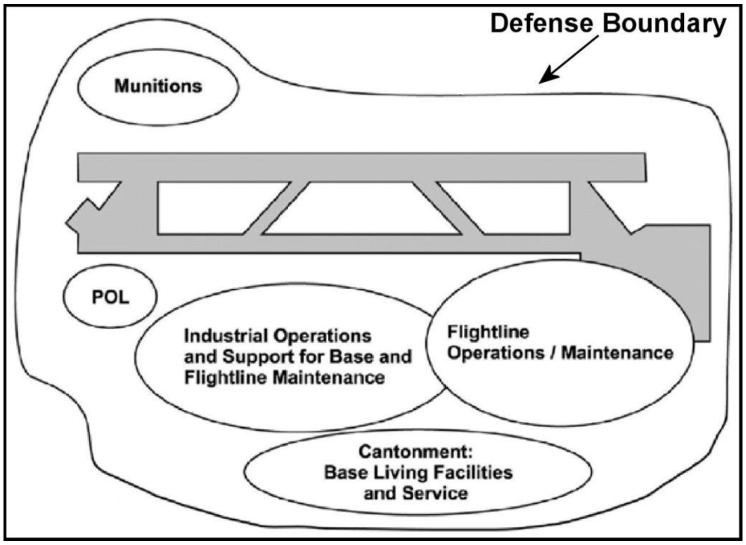
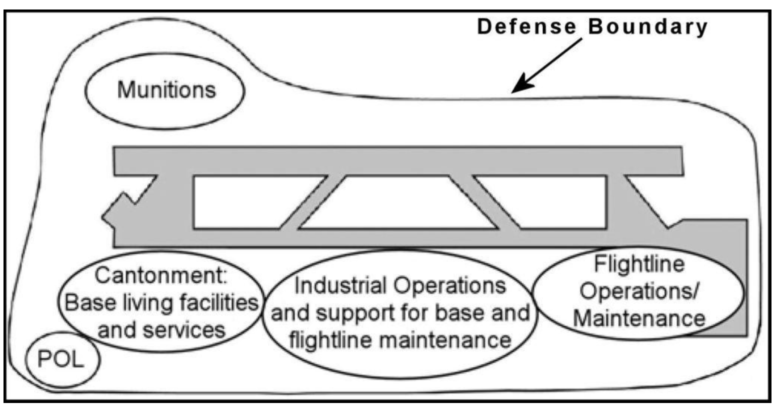


Figure 3.2. Linear Base Layout



3.2.2. Space for Expansion. Always plan for future expansion and growth requirements—including utilities and base defense requirements. **Figure 3.3** and **Figure 3.4** illustrate how a base layout plan can be structured to accommodate initial mission requirements while allowing for expansion due to mission changes. The first example is a 1100-person facility layout before expansion, the second is a 3300-person facility after a growth in mission and personnel. In the initial layout, planners included additional space in area requirements estimates to allow for expansion due to mission changes. Particularly for functions that could require numerous facility increases, such as billeting and supply warehousing and storage. Consider an additional buffer around munitions storage areas so that increased munitions levels do not expand or shift explosive clear zones into areas where personnel live or work, thereby creating a violation of quantity-distance criteria. Allow sufficient space around utility plants so capacity can be increased without significant modification. Area requirements for a facility should also include space for attendant facilities. For example, aircraft parking ramps should have enough space to park the aircraft plus sufficient additional area to add revetments.

Figure 3.3. Example 1,100-Person Facility Layout Before Expansion

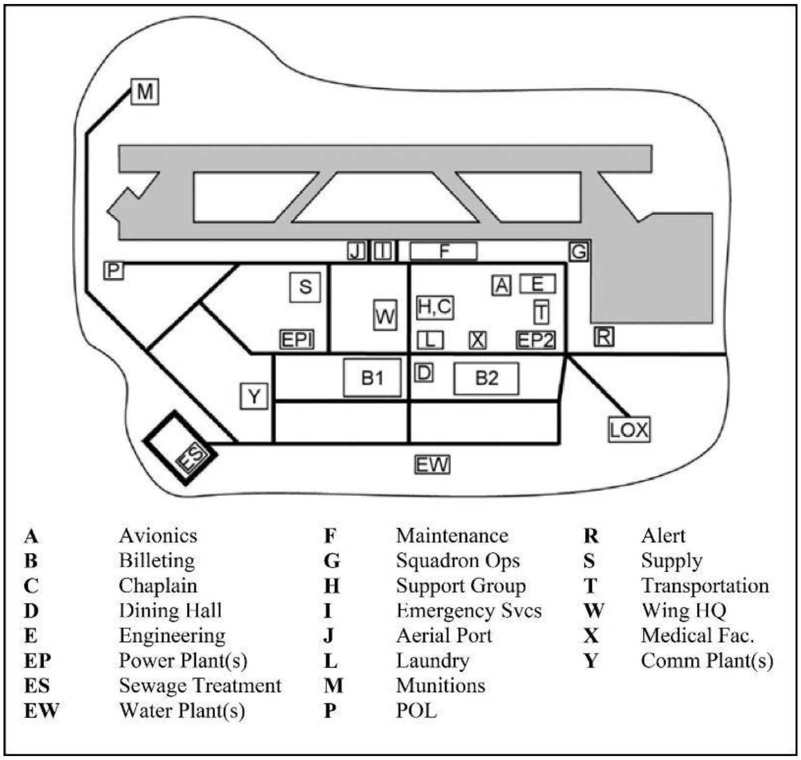
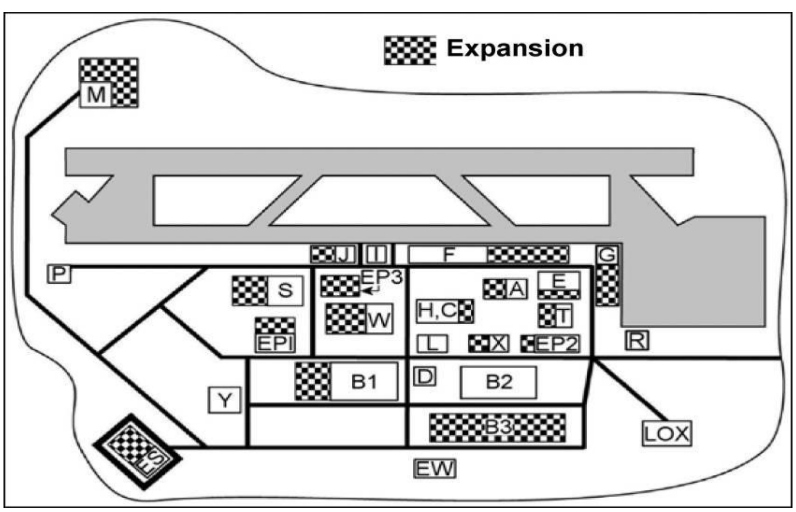


Figure 3.4. Example 3,300-Person Facility Layout After Expansion



3.2.3. Structure Separation, Standoff Distances and Dispersal Guidance. When making site layouts plans, the structure separation, standoff, and dispersal distances are key force protection measures that affect facility siting decisions. These measures help minimize the vulnerability of facilities and reduce the risk to personnel from a variety of threats. The minimum standoff distances and separation standards for new and existing facilities as well as expeditionary and temporary structures are contained in Unified Facility Criteria (UFC) 4-010-01, *DOD Minimum Antiterrorism Standards for Building*s and UFC 4-010-02, *DOD Minimum Antiterrorism Standoff Distances for Buildings* (FOUO). Planners may also consult AFTTP 3-2.68 IP, *Multi-service Tactics, Techniques, and Procedures for Airfield Opening*, for additional guidance.

3.2.4. Facility Group Spacing. A major consideration when developing a base layout plan is the location and spacing of key facilities and essential areas. The data in **Table 3.1** provides general planning guidance for spacing key facility groups when opening an airfield. See specific requirements for munitions areas in AFMAN 91-201, *Explosives Safety Standards*.

Table 3.1. Key Facility Group Spacing

Distance Between Facility Groups (feet) (Source: AFTTP 3-2.68 IP)									
Facility/Group	Billeting	MX	Base Ops/ FES	Aerial Port	Munitions	LOX	POL	Trans-portation	Medical
Billeting		1600	1600	1600	3160	1600	2640	900	200
MX	1600		1000	1600	3160	1600	2640	200	1600
Base Ops/FES	1600	1000		200	3160	1600	2640	1600	1600
Aerial Port	1600	1600	200		3160	1600	2640	1600	1600
Munitions	3160	3160	3160	3160		3160	1800	3160	3160
LOX	1600	1600	1600	1600	3160		2640	1600	1600
POL	2640	2640	2640	2640	1800	2640		2640	2640
Transportation	900	200	1600	1600	3160	1600	2640		200
Medical	200	1600	1600	1600	3160	1600	2640	200	

3.2.5. Structure Separation and Standoff Distances. Structure separation requirements are established to minimize the possibility that an attack on one structure causes injuries or fatalities in adjacent structures. The separation distance is predicated on the potential use of indirect fire weapons. Standoff distances are used to minimize the accessibility and vulnerability of a facility. These distance are critical when siting a facility and can effectively mitigate indirect fire and Improvised Explosive Device (IED) attacks. Standoff distances and separation for expeditionary and temporary structures are listed in **Table 3.2** and illustrated in **Figure 3.5**. For container structures and pre-engineered buildings, the stand-off guidance for new and existing buildings listed in **Table 3.3** apply. Always refer to UFC 4-010-01 and theater construction standards for specific requirements.

Table 3.2. Standoff Distances and Separation for Expeditionary and Temporary Structures

Location	Structure Category	Standoff Distance or Separation Requirements			
		Applicable Level of Protection	Fabric Covered Structures (1)	Other Expeditionary and Temporary Structures(1)(2)	Applicable Explosive Weight (TNT) (3)
Controlled Perimeter or Parking and Roadways without a Controlled Perimeter	Billeting	Low	31 m (102 ft.)	71 m (233 ft.)	I
	Primary Gathering Structure	Low	31 m (102 ft.)	71 m (233 ft.)	I
	Inhabited Structure	Very Low	24 m (79 ft.)	47 m (154 ft.)	I
Parking and Roadways within a Controlled Perimeter	Billeting	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Primary Gathering Structure	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Inhabited Structure	Very Low	10 m (33 ft.)	23 m (75 ft.)	II
Trash Containers	Billeting	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Primary Gathering Structure	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Inhabited Structure	Very Low	10 m (33 ft.)	23 m (75 ft.)	II
Structure Separation(4)	Separation between Structure Groups	Low	18 m (59 ft.)	18 m (59 ft.)	III(5)
	Separation between Structure Rows	Low	9 m (30 ft.)	9 m (30 ft.)	III(5)
	Separation between Structures in a Row	Very Low	3.5 m (12 ft.)	3.5 m (12 ft.)	III(5)

(1) See Attachment 1 for a complete definition of these structure types.
(2) For container structures, Table 3.3. applies.
(3) See UFC 4-010-02, for the specific explosive weights (kg/pounds of TNT) associated with designations – I, II, III. UFC 4-010-02 is For Official Use Only (FOUO)
(4) Applies to Billeting and Primary Gathering Structures only. No minimum separation distances for other inhabited structures.
(5) Explosive for building separation is an indirect fire (mortar) round at a standoff distance of half the separation distance.

Source: UFC 4-010-01

Figure 3.5. Standoff Distances and Separation for Expeditionary and Temporary Structures

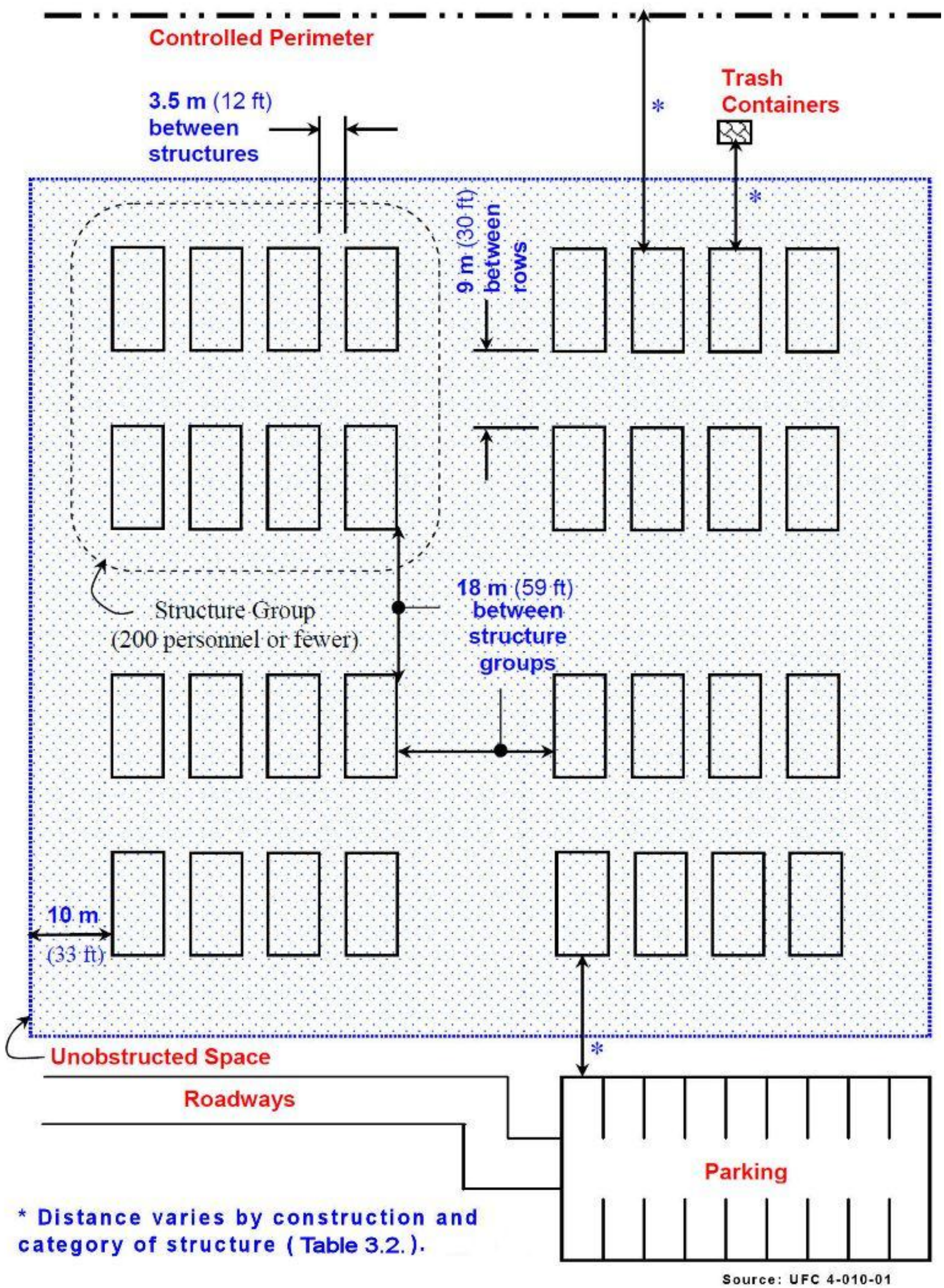


Table 3.3. Standoff Distances for New and Existing Buildings

Location	Building Category	Standoff Distance Requirements			
		Applicable Level of Protection	Conventional Construction Standoff Distance	Minimum Standoff Distance(1)	Applicable Explosive Weight (2)
Controlled Perimeter or Parking and Roadways without a Controlled Perimeter	Billeting and High Occupancy Family Housing	Low	45 m (3) (148 ft.)	25 m (3) (82 ft.)	I
	Primary Gathering Building	Low	45 m (3) (148 ft.)	25 m (3) (4) (82 ft.)	I
	Inhabited Building	Very Low	25 m (3) (82 ft.)	10 m (3) (33 ft.)	I
Parking and Roadways within a Controlled Perimeter	Billeting and High Occupancy Family Housing	Low	25 m (3) (82 ft.)	10 m (3) (33 ft.)	II
	Primary Gathering Building	Low	25 m (3) (82 ft.)	10 m (3) (4) (33 ft.)	II
	Inhabited Building	Very Low	10 m (3) (33 ft.)	10 m (3) (33 ft.)	II
Trash Containers	Billeting and High Occupancy Family Housing	Low	25 m (3) (82 ft.)	10 m (33 ft.)	II
	Primary Gathering Building	Low	25 m (3) (82 ft.)	10 m (33 ft.)	II
	Inhabited Building	Very Low	10 m (33 ft.)	10 m (33 ft.)	II

(1) Even with analysis, standoff distances less than those in this column are not allowed for new buildings, but are allowed for existing buildings if constructed/retro-fitted to provide the required level of protection at the reduced standoff distance.
(2) See UFC 4-010-02, for the specific explosive weights (kg/pounds of TNT) associated with designations – I and II. UFC 4-010-02 is For Official Use Only (FOUO)
(3) For existing buildings, see UFC 4-010-01, paragraph B-1.1.2.2 for additional options.
(4) For existing family housing, see UFC 4-010-01, paragraph B-1.1.2.2.3 for additional options.

Source: UFC 4-010-01

3.2.6. Dispersed Facilities. Facility orientation is generally by rows and columns as shown in **Figure 3.6**. However in high-threat areas, facilities are usually hardened, dispersed, or both. If facilities are staggered or sited in irregular locations to maximize passive defense, ensure dispersed locations are within the limitations of the utility systems. The same principle applies to the different area locations. Use extreme caution when staggering facilities to avoid infringement upon utility routings. Latitude and longitude should also be considered in orienting facilities in order to minimize shadows, solar radiation and winds. **Figure 3.7** depicts typical dispersed layouts that can be used to build all facility groups, except billeting. By simply combining the appropriate number of groupings, planners can lay out an entire facility group in a short period of time. Use **Figure 3.8** for billeting areas. Similarly, by combining this type of grouping, planners will be able to lay out an entire billeting group.

Figure 3.6. Typical Facility Orientation at Bare Bases

Figure 3.7. Dispersed Layout for 3, 6, 9 and 12 Facilities

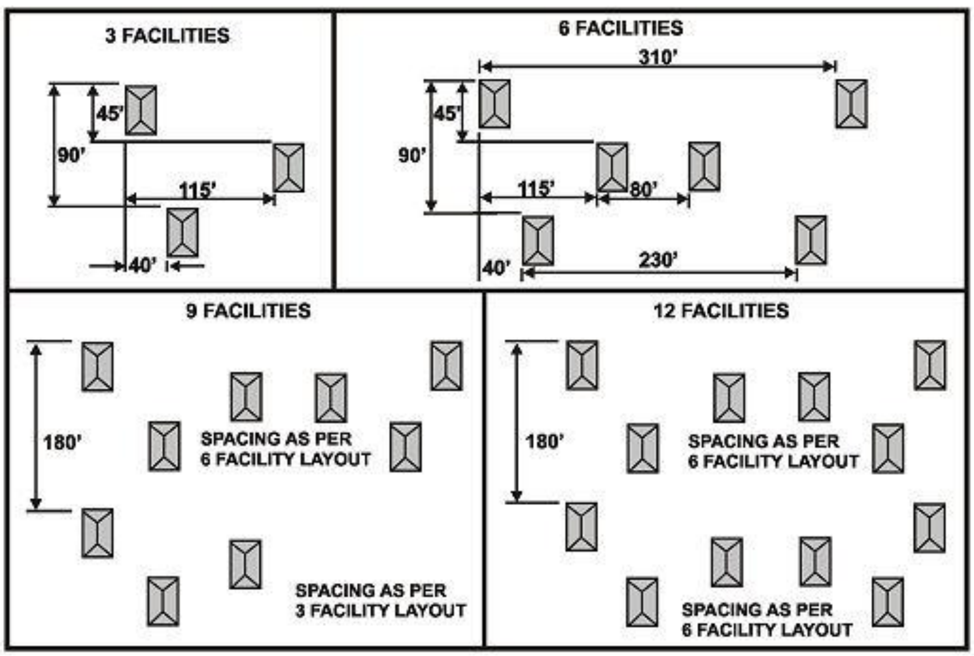
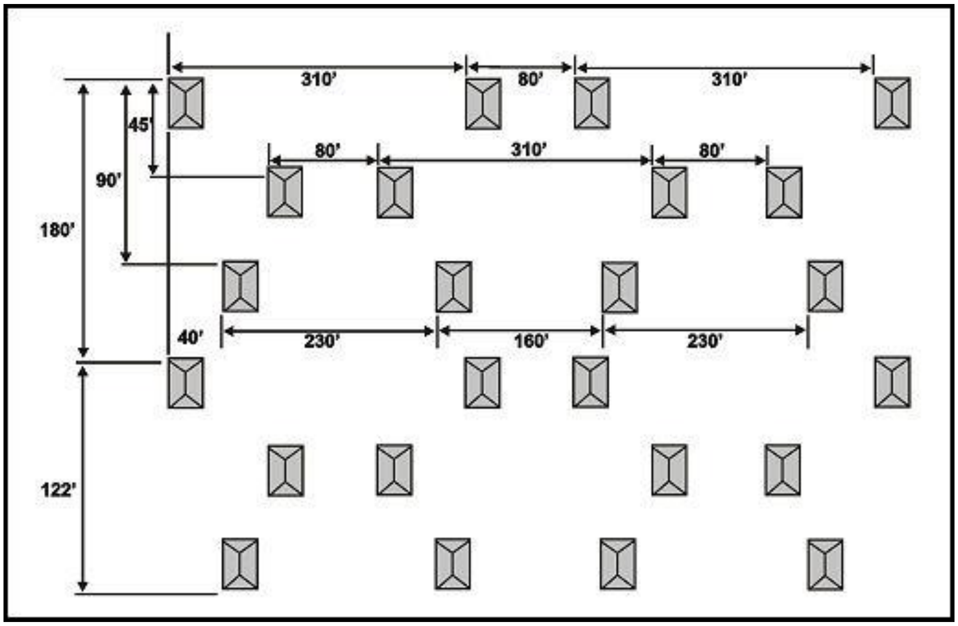


Figure 3.8. Dispersed Layout for 24 Facilities



3.3. Construction Sequence and Task Scheduling.

3.3.1. Construction Sequence**.** In general, bare base facilities and utilities should be constructed in the following sequence (for priority of the different construction jobs, see **Chapter 2**, Task Priorities). Many of these tasks can be accomplished simultaneously.

3.3.1.1. Runway preparation (sweeping, painting, etc.).

3.3.1.2. Runway edge and approach lights.

3.3.1.3. Water treatment plants.

3.3.1.4. Mission essential power (MEP).

3.3.1.5. Expedient sanitary latrine facilities.

3.3.1.6. Direct operational support functions.

3.3.1.7. Aircraft maintenance operational support functions.

3.3.1.8. Temporary munitions storage.

3.3.1.9. POL systems.

3.3.1.10. Medical treatment facilities.

3.3.1.11. Decontamination facilities.

3.3.1.12. Electrical distribution system.

3.3.1.13. Water distribution system.

3.3.1.14. Indirect operational support facilities (kitchen, dining hall, etc.).

3.3.1.15. Waste utility system.

3.3.1.16. General billeting.

3.3.1.17. Camouflage, concealment and personnel shelters.

3.3.1.18. Recreation.

3.3.2. Task Schedule**.** Major tasks listed in **Table 3.4** are to be accomplished during base erection. This list is not intended to be all-inclusive, but to serve merely as a guide. This schedule is predicated on launching the first aircraft within 72 hours after arrival at the bare base. There could be situations that would require altering this construction schedule so this deadline can be met. This 72-hour requirement does not imply that the base will be completed but that the minimum requirements of the runway, taxiway, water, communications, barriers, turn-around capability, fueling and arming capabilities and parking ramp are available. It is important to note that the construction schedule does not reflect the phases of operation when installing the utility systems. For example, before the main generating plants and primary distribution cables are installed, it is necessary to hook up the MEP generators, secondary cables and secondary distribution centers (SDC) relevant to providing electric power to all direct operational support requirements. Once this is complete, the remaining elements of the electrical distribution system can be constructed. The same approach applies to the water and waste utility systems. In other words, the water treatment and storage tanks are established before distribution lines are laid, and operational latrines are constructed ahead of the waste disposal system.

Table 3.4. Task Schedule

Major Task	Time (D + X) Requirement	Definition
Site Survey	1 – 5 Days	Develop BEAR assets, locate NAVAIDS and lay out base.
Site Preparation	1 – 10 Days	Clear land, establish access to raw water, construct gravel roads, establish drainage and construct POL and munitions revetments.
Airfield Lighting	D + 2 Days	Set up Expeditionary Airfield Lighting System (EALS).
Barriers	D + 30 Days	Install and maintain aircraft barriers.
Utility Lines and Shelter Locations	D + 5 Days	Stake facility locations.
Electrical Distribution	D + 10 Days	Install high-voltage cables, connect PSC (or PDC) & SDC and provide electric power to shelters.
Power Production	D + 2 Days	Set up MEP-12 generators/Interim BEAR Power Unit.
Water Treatment and Distribution	D + 10 Days	Lay water lines; develop water and waste program.
Civil Engineer Shelters	4 Days	Erect CE shops, office and billets. Provide technical assistance to other functional areas.
Static Grounds	4 Days	Locate/establish static grounds.
Paint Striping	D + 2 Days	Mark taxiways and runways.

3.4. Theater Construction Standards. Standards of construction in a theater of operations are specified by the Combatant Commander (CCDR) in coordination with the Service components and Force Support. This includes determining the location, types of materials, labor and construction techniques to be used. Theater construction standards provide criteria which minimize engineer effort while providing the quality of facilities consistent with mission requirements, personnel health and safety and the expected availability of construction resources. Keep in mind that construction standards are only guidelines; engineers must consider other factors during planning. There are generally two types of theater construction—contingency and enduring.

3.4.1. Contingency Construction**.** Contingency construction covers construction of facilities for initial beddown with a planned life expectancy of up to two years. The standards for contingency construction include organic, initial and temporary facilities (**Table 3.5**).

3.4.1.1. **Organic** construction uses host nation or unit organic equipment, facilities and labor to support deployments intended to last up to 90 days but may be used up to six months. Since construction is time consuming and often costly, the intent is to seek an alternative to new construction and use a minimum amount of labor and resources, until the arrival of the full engineer capability. Minimal or no land grading or site work, tents and pit latrines are examples of this standard. Although intended for use for up to 90 days, organic construction may be used for up to six months.

3.4.1.2. **Initial** construction is also characterized by relatively austere facilities and utilities that require minimal engineer effort. This construction is intended for use during the first six months of a contingency. Most of the expeditionary equipment assets described in this volume—wood framed tents with flooring, latrines with sewage lift stations, tactical generators for electrical distribution and portable refrigeration—are examples of this standard.

3.4.1.3. **Temporary** construction is characterized by facilities and utilities of a more substantial nature. It is used to increase efficiency and sustain operations for at least 24 months and with upgrades for up to 5 years. Wood frame buildings, bathhouses, commercial electric power and paved roads are examples of the temporary standard.

Table 3.5. Contingency Construction Standards in the Theater

<table>
<tr><td colspan="4">Organic Standard
1. Support on expedient basis with no external engineer support
1. Uses unit organic equipment and systems and/or host nation resources
1. Mission duration typically 1-90 days
1. Provides for initial force presence and maneuver activities until force flow supports arrival of engineer resources</td></tr>
<tr><td colspan="4">Initial Standard
1. Characterized by austere facilities and utilities requiring minimal engineer effort
1. Intended for immediate operational use by units upon arrival for a limited time ranging up to 6 months
1. May require replacement by more durable facilities during the course of operations</td></tr>
<tr><td colspan="4">Temporary Standard
1. Characterized by austere facilities and utilities requiring additional engineer effort above that required for initial standard facilities
1. Intended to increase efficiency of operations for use up to 24 months
1. Provides for sustained operations
1. Replaces initial standard in some cases where mission requirements dictate. The temporary standard may be used initially if so directed by the combatant commander</td></tr>
<tr><th>Type of Construction</th><th>Organic Standard</th><th>Initial Standard</th><th>Temporary Standard</th></tr>
<tr><td>Site Work</td><td>Minimal to no site work; maximized use of existing facilities</td><td>Clearing and grading for facilities including revetments of drainage, oils, petroleum, and ammo lubricants, storage and aircraft parking; soil stabilization</td><td>Engineered site including prep, paved surfaces for vehicle traffic and aircraft parking, building foundations, and concrete floor slabs</td></tr>
<tr><td>Troop Housing</td><td>Unit tents</td><td>Tents (may have wood frames and flooring)</td><td>Wood framed structures, relocatable structures and modular</td></tr>
</table>

			building systems
Electricity	Unit tactical generators	Tactical generators: high and low voltage distribution	Non-tactical or commercial power and high or low voltage
Water	Water points and bladders	Water points, wells and/or potable water production and pressurized water distribution systems	Limited pressurized water distribution systems that support hospitals, dining halls, firefighting and other major users
Cold Storage	Contracted or unit purchased	Portable refrigeration with freezer units for medical, food and maintenance storage	Refrigeration installed inside temporary structures
Sanitation	Unit field sanitation kits, pit latrines	Organic equipment, pit or burnout latrines, evaporative ponds, lagoons for hospitals and sewage lift stations	Waterborne to austere treatment facilities - priorities are dining facilities, hospitals, decontamination sites, bathhouses and other high volume users
Airfield Pavement*		Tactical surfacing, including matting, aggregate, soil stabilization and concrete pads	Conventional pavements
Fuel storage	Bladders	Bladders	Bladders and steel tanks
* The type of airfield surfacing used will be based on soil conditions and the expected weight and number of aircraft involved in operations.			

3.4.2. **Enduring Construction**. Enduring construction covers design, award and management of construction for facilities with a life expectancy of more than two years. Planning for the enduring phase, if necessary, usually begins not later than 90 days into a deployment. Planning for the enduring phase should include early involvement of the servicing Contracting Officer, Finance Officer and Staff Judge Advocate. The standards for enduring construction include semi-permanent and permanent facilities.

3.4.2.1. **Semi-Permanent** facilities are designed and constructed with finishes, materials and systems that provide at least moderate energy efficiency, maintenance, and life-cycle cost. Life expectancy for semi-permanent facilities is more than two years but less than ten years.

3.4.2.2. **Permanent** facilities are designed and constructed with finishes, materials and systems selected for high energy efficiency and low maintenance and life-cycle costs. Life expectancy for permanent standard construction is more than 10 years.

3.4.3. Construction standards need not be stepped through in succession. For instance if local factors make it more prudent, temporary standard (two year) facilities and systems may be used from the start of an operation. This is particularly relevant if the use of local labor and materials make it more cost effective to build an infrastructure that provides a higher quality of life from the start of a deployment. Also remember that while mobile facilities (e.g. tents and shelters) are considered to be initial construction standard, this does not mean the facilities and utilities will be totally replaced after just six months. It simply means these systems are used at the initial onset of a conflict. It is quite possible that some initial standard assets will last several years before needing replacement. For additional information on construction standards see Joint Publication (JP) 3-34, *Joint Engineer Operations.*

Chapter 4

SITE SPECIFIC PLANNING

4.1. Introduction. The guidelines and planning factors presented in the preceding chapters were mostly generic in nature. When directed at a particular geographic application, such as SWA, these special considerations were prompted by the worst case conditions imposed by a desert environment. In preparing a comprehensive bare base development plan, nothing should be taken for granted. Consider the plight of military engineers in two vastly different regions of the world. During an exercise deployment to SWA, engineers disembarked at a desert air base to find that the only drinkable water immediately available was that carried in their canteens. Army engineers, deployed to a Central American airfield expecting to find a lush, tropical environment with an abundance of water, but instead found a barren area engulfed in layers of dust—a common situation during the dry season, even in the tropics. The lesson learned here is that surface water conditions can change between the pre-deployment site survey and the time of the mission, and can have significant impact on the project or mission. Obviously, the information generally available about a given deployment area and bare base site should not be taken at face value; it must be supplemented with up-to-date planning data that takes into account specific characteristics such as airfield configuration, topography, climate, existing facilities and other similar factors.

4.2. Overview. The focus of this chapter is on providing information that assists the bare base planner and engineer in using a step-by-step approach to developing a comprehensive base development plan. General and specific planning considerations dictated by the climate and topography of a given area, should serve as a checklist to ensure the planner identifies questions that need to be answered about a specific site. Keep in mind that the planning considerations provided are not solely to determine use of BEAR assets, but rather are meant to address situations where no specific facility packages are identified. The intent is to give the planner and engineer advice, normally gleaned from experience, applicable to specific regional areas.

4.3. Data Collection. The importance of effective data collection was addressed briefly in **Chapter 1**. This section further defines the data collection process and suggests sources that may be tapped for current information. Although, much of the data highlighted in this section can be collected independently, most of it is available as byproducts of the Expeditionary Site Planning and Survey Process (ESSP) and the Installation Geospatial Information and Services (IGI&S) program referred to in paragraph **4.4**.

4.3.1. Mission Analysis. As with any military task, a thorough analysis of the mission is the keystone to effective bare base planning. What will be the primary mission of the bare base? Will the base support fighters, fighter-bombers, reconnaissance, or a combination of these weapons systems? Will the bare base serve as an aerial port supporting tactical aircraft, C-130s, C-17, or strategic airlift involving commercial wide-body transports? The answers to these questions will drive all subsequent planning steps. Equally important to mission analysis is determining what level of aircraft maintenance is planned at the base. The number of aircraft and level of maintenance are key determinants of the number and type of operational support facilities. Another mission data item of vital interest to the bare base planner is the size of the population required to support the deploying aircraft. Once the mission has been analyzed and an initial estimate of the expected base population is determined, the next step should be an analysis of the threat.

4.3.2. Threat Analysis. Threat analysis will determine (1) whether facilities and utility plants will be dispersed or non-dispersed, (2) whether revetment and airfield damage repair sets will be required and (3) the level of effort to be expended on defensive fighting positions, hardening, and camouflage. It could also indicate the degree of convoying, resource dispersal and work party security activities that might be necessary, all of which normally translate into longer construction times.

4.3.2.1. The prudent planner will make an allowance for the potential of chemical weapons being used against the bare base by, as a minimum, identifying the additional resources needed to provide the base with a decontamination capability.

4.3.2.2. During previous major modern conflicts, the vulnerability of a theater air base was largely determined by its proximity to the forward edge of the battle area. In today's major conflicts, the distinction between forward and rear areas has become blurred and predicting a base's vulnerability is more difficult. Consequently, the air threat against a particular bare base should be officially assessed and defined through AF intelligence channels. Office of Special Investigations (OSI) and intelligence organizations can assess ground threats.

4.3.3. Site Specific Data Analysis. This analysis involves gathering as much data as possible about a bare base location and then using it as a guide during the actual planning and layout of the base. Typical data to be collected include basic terrain features, soil condition and topography, weather and climatic factors from maps, atlases, aerial photos, drawings, layouts, climatic records and other similar sources. Additionally, information on existing facilities, utilities and pavement should be obtained. Planners can also gather information on supporting resources such as indigenous labor and contractor availability; assured host-nation support and supply; and construction material sources. Once all available data have been obtained, it must be studied and combined to predict the influence on site layout; installation of facilities, utilities, camouflage and defense positions; and the operation and maintenance of the base.

4.3.3.1. Site Visit. If an advance visit is possible, capable individuals should be dispatched to contact their local counterparts, if any, and to investigate those aspects of existing facilities and available resources that relate to their jobs. For example, send a qualified engineer to collect soil samples and assess airfield pavement capabilities and condition, power and water specialists to learn the local systems, engineer technicians to obtain or make base layout drawings; and logisticians to investigate supply procedures and materials at hand (an example of a checklist to use during a site visit is shown in **Attachment 3**). The senior engineer should personally contact the host-base engineer (or equivalent) to discuss engineer missions, operational procedures and mutual support. If significant host-nation support discussions are anticipated, consider including the servicing Contracting Officer and Staff Judge Advocate on the site visit.

4.3.3.2. Sources of Information. If a site visit and ground reconnaissance is not feasible, planners can still use the following sources to gather a considerable amount of essential data:

4.3.3.2.1. Flight Information Pamphlets. Carried by aircrews, these publications give nominal runway lengths and load capacities and are normally available at airfield management operations.

4.3.3.2.2. Airfield Database. The National Geospatial-Intelligence Agency (NGA) maintains information on every high-interest airfield in the world. The database provides information on airfield pavements, utilities, facilities, fuel and off-base support. Database extracts are available from MAJCOMs through the Global Command and Control System (GCCS). Another good source for airfield information is Headquarters Air Mobility Command (AMC). The AMC Operations Directorate (AMC/A3) does recurring site visits/assessments of airfields worldwide as part of their enroute and bare base mobility mission. Additionally, tri-service Pavement-Transportation Computer Assisted Structural Engineering (PCASE) project provides contingency airfield and road/railroad design, airfield parking planning software, access to unified facilities criteria and electronic versions of joint service handbooks on paved airfields.

4.3.3.2.3. Pavement Evaluation Reports. HQ AFCESA has compiled pavement data for many allied bases worldwide. Additionally, AFCESA can provide support when using Micro Paver, an automated pavement management system for developing maintenance and repair plans for airfields, roads and parking areas. Contact HQ AFCESA/CEO at Tyndall AFB, FL for additional information.

4.3.3.2.4. Air Navigation Charts (ANC). ANCs provide detailed information for airfields longer than 4,000 feet for most countries in the world. Published by NGA, these charts are described in the NGA catalog and should be available at airfield management operations. If map requirements (base names/locations) are identified, base operations personnel can order these products from NGA.

4.3.3.2.5. Topographic Maps. The NGA catalog of maps, charts and related products, has six volumes, each dealing with a portion of the world. The standard tactical maps listed in this extensive catalog are generally used for ground navigation and provide topographic information for a detailed terrain analysis of the bare base site and its surrounding areas. These topographic products can also be ordered through airfield management operations.

4.3.3.2.6. Climatic Data. The 14th Weather Squadron (formerly the Air Force Combat Climatology Center) should be able to provide all the climatic data required for planning worldwide military operations. For additional information on obtaining support, visit the squadron's web site at: **https://notus2.afccc.af.mil/SCISPublic**/. Furnish 14 WS a concise statement of requirements in terms of the environmental factors involved or the climatic information desired. In many instances, the data can be downloaded directly from the website.

4.3.3.2.7. Commercial/Government Literature. Another source of general foreign country information is brochures and publications written by the countries themselves. Contact the respective US Embassy or Consulate for such data.

4.3.3.3. Weather and Terrain. It is essential that terrain limitations and opportunities be recognized early in the planning process. Since most terrain factors are affected by the weather, it is equally important to understand what these relationships are in the climatic region where the bare base site will be located. Paragraphs **4.5** through **4.8** present some specific planning considerations related to four major climatic zones—temperate, tropic, frigid and desert (the Arctic has been excluded from consideration). Use these considerations as a checklist.

4.3.3.4. Internet. A good portion of the information planners need can be found by "surfing" the worldwide web, where information is readily available on climatic conditions, communications, maps, transportation networks and airports. When combined with official DOD sources, this public information can help planners prepare for deployments. It is better to have too much information, when deploying to an unknown location, than to not have enough.

4.3.4. Unpublished joint support plans (JSP). Keep in mind that even bases without formal JSPs might have been surveyed by a site development or assessment team, particularly if the base supports a combatant command OPLAN. Results of an advance assessment should be available at the MAJCOM level. The local logistics plans or operations plans shop should know which bases are part of an OPLAN.

4.4. Expeditionary Site Planning and Survey Process (ESSP) and Installation Geospatial Information and Services (IGI&S).

4.4.1. Expeditionary Site Planning and Survey Process. The ESSP is a critical source of site data for planners. It identifies potential contingency beddown locations and collects site data to support decision-making about those locations. MAJCOMs and other organizations (AFCESA, RED HORSE, etc) support this effort by providing resources to participate in site surveys as directed. Three expeditionary site planning resources engineer planners should become familiar with are the Base Support & Expeditionary (BaS&E) Planning Tool, GeoReach and Expeditionary Basing, and Geospatial Expeditionary Planning Tool (GeoExPT). These resources are briefly described below, but for additional information on the ESSP process and major roles and responsibilities see **AFI 10-404**, *Base Support and Expeditionary (BAS&E) Site Planning*.

4.4.1.1. BaS&E Planning Tool is a versatile, web-enabled application delivering the capability to collect and centrally store military value data to support beddown planning. This expedient identification of resources and critical combat support enables rapid assessment for potential beddown locations around the world. Contains access to imaging and command surveys and reports, including previous airfield, pavements, threat, and initial beddown assessments.

4.4.1.2. GeoReach and Expeditionary Basing provides a Common Installation Picture (CIP) using information acquired from intelligence sources and assists with various planning aspects such as aircraft parking, munitions storage, and other beddown force requirements.

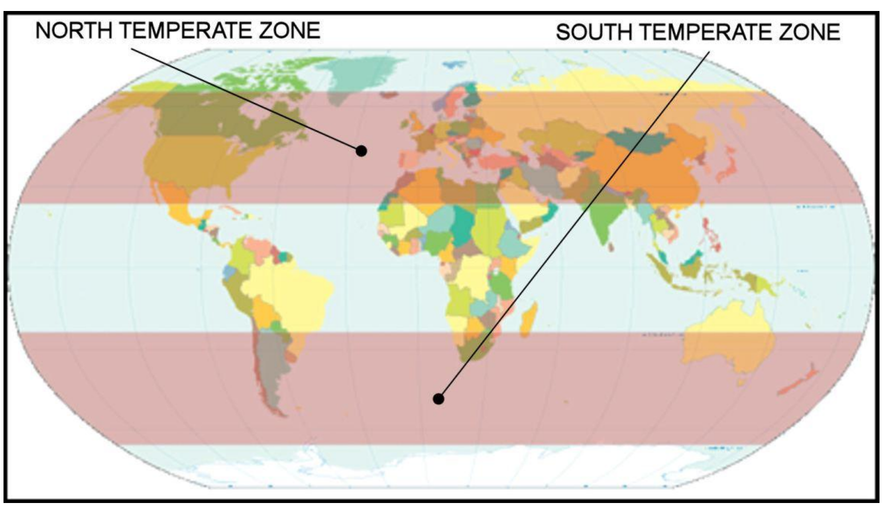
4.4.1.3. GeoExPT is an advanced expeditionary base planning tool that provides automated support for contingency beddown planning and sustainment operations. It uses geospatial source data and imagery from MAJCOM GeoReach cells and other national geospatial information sources.

4.4.2. Installation Geospatial Information and Services. IGI&S (formerly called GeoBase) is a program that uses Geographic Information System (GIS) technology to capture, store, maintain, display and analyze geospatial databases. It is a response to mapping processes being decentralized across US installations. While the geospatial structure includes information, imagery and imagery intelligence that facilitate planning, decision and action it also includes people, processes and resources. IGI&S attempts to deliver situational awareness by viewing a single digital map of the installation. Commanders, planners, and combat support personnel need access to a common installation picture (CIP) for mission success. The CIP is a high-quality picture that allows viewers to see complex, built-up infrastructures from desktop computers using point and click steps. When fully developed and integrated into planning, the system will include a worldwide database on geography, environmental science, geology and ecology. The IGI&S vision is "One installation, one map" to eliminate functional stovepipes and provide an authoritative CIP on demand. IGI&S enables users to visualize mission assets in a shared, intuitive, cross-functional manner, allowing a reduction in the time required for making decisions. IGI&S is currently comprised of four unique decision support environments: Expeditionary GeoBase; Garrison GeoBase; Strategic GeoBase; and GeoReach. For additional information on these systems and on IGI&S, see **AFI 32-10112**, *Installation Geospatial Information and Services (Installation GI&S)*.

4.5. Environmental Impact. Unfamiliar environmental conditions can severely affect civil engineer operations. Environmental extremes usually require specialized techniques, procedures and equipment. Since there are over 1,200 potential bare base locations scattered throughout the world, this discussion on environmental considerations is limited to those that are deemed most essential to support planning efforts.

4.5.1. **Temperate Zones**. Temperate zones (**Figure 4.1**) extends throughout the world and includes the variable climates of the middle latitudes, between the extremes of the tropical and frigid climates.

Figure 4.1. North and South Temperate Zones



4.5.1.1. Intermediate Hot-Dry Regions. Intermediate hot-dry climates are prevalent in parts of the North American continent, Europe, Southern Spain, Africa, Asia and Australia. Operational conditions could include an ambient air temperature of 105 to 110 degrees Fahrenheit, a maximum ground temperature of 130 degrees Fahrenheit and a wind velocity of 5 to 10 knots. A rainfall of 9.5 inches (maximum intensity: 0.45 in/min) during a 12-hour period is possible. Rains may be accompanied by intermittent wind velocity of 35 knots. Sites may be subject to winds of 45 knots for a 5-minute period; gusts may reach 65 knots. Snow and icing conditions are not uncommon in parts of the area designated intermediate hot-dry.

4.5.1.2. Intermediate Cold Regions. The intermediate cold regions of the temperate zone are located in the middle latitudes which encompass Iceland, Central Europe, parts of Asia (including the Korean peninsula) and some of the higher latitude coasts, including the southern coast of Alaska, where maritime effects prevent the occurrence of extremely low temperatures. The intermediate cold region of the temperate zone encompasses much of NATO's Allied Command Europe, which is best characterized by the cold and wet environment of Germany. Although there are warm, sunny days in summer and snow is common in winter, low overcast skies with rain prevails much of the year. During fall, winter and early spring, the fog frequently does not lift until midday. For one third of fall and winter mornings, visibility is less than one mile. The cloud layer over Western Europe is typically low with easterly movement; ceilings are 1,000 feet or less during December-February. In the winter, the ambient temperature may drop to -25 degrees Fahrenheit for six continuous hours. Infrequent wind velocities greater than 10 knots can be expected when temperatures are that low. Winds are generally less than 10 knots and solar radiation is negligible.

4.5.1.2.1. The urbanization of Central Europe, particularly Germany, has a major impact on military operations. Hundreds of towns and cities have populations over 50,000. Small villages have grown together and often surround air bases. The boundaries of these air bases were fixed 40 to 50 years ago and have not been expanded even though each year new missions and buildings were added. Additionally, some missions have been consolidated and relocated (e.g. operations at Rhein-Main AB moved to Ramstein AB) and have a major impact on space and infrastructure at the new location. The positioning of facilities during deployments to such crowded bases largely depends on availability of open space.

4.5.1.2.2. The Korean peninsula is a rugged, mountainous area with short, hot and humid summers and long, cold winters. The heavy rains that occur from June to September often cause damaging floods. Similar to Western Europe, air bases in Korea are crowded and surrounded by urban growth or extensive rice paddy agriculture.

4.5.1.3. Planning Considerations for the Temperate Zone.

4.5.1.3.1. Site Access. Avoid dense brush, timberland and rolling terrain requiring heavy clearing or grading. During terrain analysis, study slopes, drainage, vegetation, soil characteristics, flood-prone areas and any other unusual conditions affecting site development.

4.5.1.3.2. Soils. The free-draining, coarse-grained soil, which predominates in most regions of the temperate zone, makes the best subgrade and subbase materials and exhibits almost no tendency toward high compressibility or expansion.

4.5.1.3.3. Roads. Roads should be located on soil composed of grained, non-frost-susceptible material in regions of temperate zones which are prone to frost heave. Where drifting snow is expected, roads should generally be higher than the prevailing ground elevation and should not be constructed where existing vegetation or planned facility locations could block snow removal.

4.5.1.3.4. Solar Orientation. Plan to locate facilities so that energy consumption will be minimized without violating the concepts of functional grouping and dispersal. In the intermediate hot-dry environment of the temperate zone, orienting the facility's longer side along an east-west axis should minimize shelter wall exposure to the sun. In intermediate cold regions, orient facilities so the longer sides of the shelters are along a north-south axis to provide maximum solar radiation on walls.

4.5.1.3.5. Wind Orientation. The velocity varies with each particular area and season. Maximum wind speed occurs during periods of changing temperatures, and prolonged velocities above 90 knots have been recorded. Snow and silt begin drifting with winds above 8 knots.

4.5.1.3.6. Site Drainage. Grade the soil away from exterior walls by use of drainage swales. Fill the low spots or grade to drain.

4.5.1.3.7. Water Supply Requirements. The water use planning factor for the temperate zone is 50 gallons per person per day.

4.5.1.3.8. Water Sources. In temperate zones, the best water source is surface freshwater from lakes and streams. Other sources include the host-nation water system, fresh groundwater (wells, springs and well points), seawater in coastal areas and brackish water from swamps, ponds or wells.

4.5.1.3.9. Water Treatment. The ROWPU is the primary equipment used to produce potable water from seawater and brackish ground and surface water.

4.5.1.3.10. Water Storage. Provide 50 percent reserve for peak loads and emergencies. In the intermediate cold regions, make provisions for freeze protection (see **Chapter 8**). Immediately consider reducing water consumption (rationing) if more serious, longer-term problems arise such as major equipment breakdown or battle damage occurs.

4.5.1.3.11. Water Distribution. Use pressure class 150 polyvinyl chloride pipe. If pressure and temperature exceed 150 pounds per square inch, gauge (psig) and 140 degrees Fahrenheit, respectively, select steel or reinforced concrete piping. Position the pipe below the frost line. Above-ground piping should be electric traced or insulated to prevent freezing. Use metal pipe where heat tracing is required.

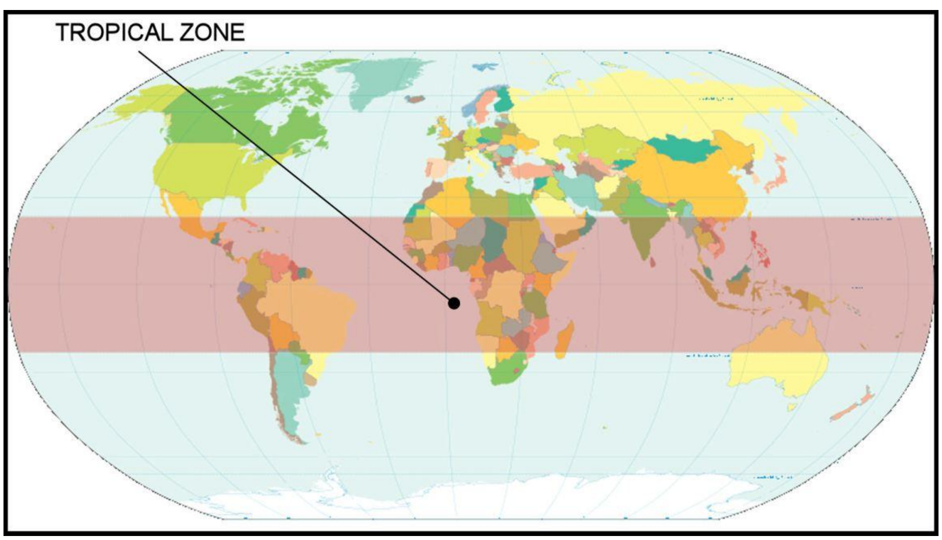
4.5.1.3.12. Sanitary Systems. Install sewer lines below the frost level.

4.5.1.3.13. Foundation Requirements. Spread or strip footings are most common for moderate loads. Carry depth below the frost line. Allowable bearing values vary due to varying soil and subsurface conditions. Use a thickened edge slab with lightweight structures where some slab cracking is permissible. Thicken edge slabs should only be used on coarse-grained soils. Use treated wood or concrete for foundations. Use treated wood, steel, or concrete piling where loads and low-bearing soil dictate.

4.5.1.3.14. Concrete Placement. In cold weather below 50 degrees Fahrenheit, use type III air entrained cement, or use richer mixes. Enclose the site with tents or use space heaters to keep the concrete warm. Keep concrete forms on longer and insulate in cold weather. Speed up strength gain by using calcium chloride (2 percent by weight of the concrete).

4.5.2. **Tropical Zone.** Wet-warm regions in the tropical zone (**Figure 4.2**) coincide with the major tropical rain forest areas of the world. In the western hemisphere, this area extends from the southern tip of Mexico through Central America to South America. Wet-warm conditions also prevail in the heavily jungled areas of Central and East Africa, Southeast Asia, the Asian Islands and the northern coast of Australia. Wet-hot conditions, characterized by high temperature and humidity and intense solar radiation, are found in the open tropical areas where rain forest gives way to deciduous and secondary forests and tropical savannas. The discomforts of tropical climates are often exaggerated, but it is true that the heat is more persistent. Many people experienced in the tropics feel that the heat and discomfort in some US cities in the summertime are worse than the climate in the jungle. Strange as it may seem, there may be more suffering from cold in the tropics than from the heat. Of course, low temperatures do not occur, but chilly days and nights are common. In some tropical areas, in winter months (the reverse season below the equator), the nights are cold enough to require a wool blanket for sleeping. Rainfall in many parts of the tropics is much greater than that in most areas of the temperate zones. Tropical downpours usually are followed by clear skies, and in most places the rain is predictable at certain times of the day. Except in those areas where rainfall may be continuous during the rainy season (for example, in Southeast Asia and Asian Islands), there are not many days when the sun does not shine at least part of the time.

Figure 4.2. Tropical Zone



4.5.2.1. Site Selection. Proper site selection for bare base development is the most important element in the tropical zone. Subgrade soil characteristics, groundwater and surface drainage are prime considerations for the planners.

4.5.2.2. Site Improvements. Site improvements at a bare base located in the tropics will generally involve construction and maintenance of taxiways, parking aprons, roads and protective revetments and shelters. The dense vegetation, gullies, cliffs, steep slopes and streams often found in the proximity of airfields complicate construction in the tropics. The heavy rainfall imposes a drainage problem of major concern. Groundwater is usually found a few inches below the surface, requiring special attention to subgrade drainage. Because of the ponding potential of surface water, parking aprons should be located on the runway's downhill side. It is advisable to cut the right-of-way of roads much wider than normal so that the sun can dry the roadbeds. Good fill material is often difficult to locate in the tropical environments. Most tropical soils have high clay content, will not drain well and are difficult to compact. Bare base roads constructed of such materials fail under heavy traffic when wet. Good drainage is vital when these types of soils are used.

4.5.2.3. Solar Orientation. Despite the availability of air conditioning equipment, adequate protection from the sun should be provided to maintain a comfortable internal temperature for facilities (particularly BEAR shelters). Tree cover, man-made screening, camouflage netting, or a combination of these methods can produce the desired effect. When the bare base site features rolling or hilly terrain on its environs, shelters can be placed on the shaded slope (north slope in the northern hemisphere, south slope in the southern hemisphere) to reduce exposure to solar radiation. On flat terrain, shelters should be sited in an east-west direction, which minimizes wall area exposure to the low angles of early morning and late afternoon sun. Reflected radiation also poses a problem in the tropics. Avoid siting shelters near large paved areas or bodies of water.

4.5.2.4. Wind Orientation. Wet regions in the tropical zone are characterized by mild trade winds blowing in the same direction for most of the year. High velocity winds occur from several directions during the monsoon season. Effective use of breezes sometimes provides the only relief to oppressive heat; nevertheless, solar orientation of facilities and shelters should take precedence over wind orientation.

4.5.2.5. Water Supply Requirements. Use a water planning factor of 50 gallons per person per day in the tropical zone.

4.5.2.6. Water Treatment. The ROWPU system will be the primary equipment used to produce potable water from seawater and brackish ground and surface water.

4.5.2.7. Water Storage. Provide a 50 percent reserve and install screens to protect storage facilities from insects and animals. Use bladder pillow tanks where feasible for initial and elevated storage for temporary construction.

4.5.2.8. Water Distribution. Protect buried water distribution lines from movement caused by expansive soils. Use inert sand or gravel base for bedding and backfill. Aboveground piping should be insulated and protected with a mold-resistant covering.

4.5.2.9. Electrical Power Generation. Advance planning should provide for generators to be conditioned for operation in a high-humidity, fungus-promoting atmosphere.

4.5.2.10. Interior Electrical. Electrical equipment used in the tropics must be specifically designed for use in this zone.

4.5.2.10.1. Use circuit breakers with bimetallic thermal elements treated to prevent corrosion or galvanic action, or replace them with suitably sealed or protected solid state tripping devices.

4.5.2.10.2. Use porcelain or fungus- and corrosion-resistant plastic switches and receptacles.

4.5.2.10.3. Equip motors larger than 1 horsepower, and generators rated above 10-kW, with heaters that are energized when the units are not running.

4.5.2.11. Exterior Electrical. The following special requirements must be considered.

4.5.2.11.1. Request salt spray test certification for equipment used in a salt-ladened atmosphere.

4.5.2.11.2. Use oil-filled transformers that are hermetically sealed or equipped with inert gas provided by a nitrogen cylinder.

4.5.2.11.3. Use silicon bronze, copper, aluminum encased steel, or hot dipped galvanized steel hardware.

4.5.2.11.4. Use jute protected, double-type armored cables when directly buried in coral backfill.

4.5.2.11.5. When buried, use cable that is resistant to roach, termite and microbial attack. Ensure all splices are waterproof.

4.5.2.12. Foundation Requirements. The raised-point foundation is the best solution for the tropics. This type of foundation absorbs much less of the stored heat from the ground, allows the floor system to be cooled by natural ventilation and separates the structure from the high moisture content of the ground. Slab-on grade systems do work in tropical areas, but moisture problems result and heat is absorbed from the ground.

4.5.2.13. Concrete Placement. The following procedures are recommended when the temperature exceeds 90 degrees Fahrenheit:

4.5.2.13.1. Keep all materials cool and store cement in the shade.

4.5.2.13.2. Spray the gravel with water and, if necessary, use ice water in the mix.

4.5.2.13.3. Set up windbreaks to prevent rapid water evaporation.

4.5.2.13.4. Work at night when temperatures are lower.

4.5.2.14. Unique Structural Considerations.

4.5.2.14.1. Treated lumber should be used where wood is in contact with soil or concrete.

4.5.2.14.2. Where field painting is required, structural steel surfaces should be cleaned and primed using red lead or zinc chromatic paint.

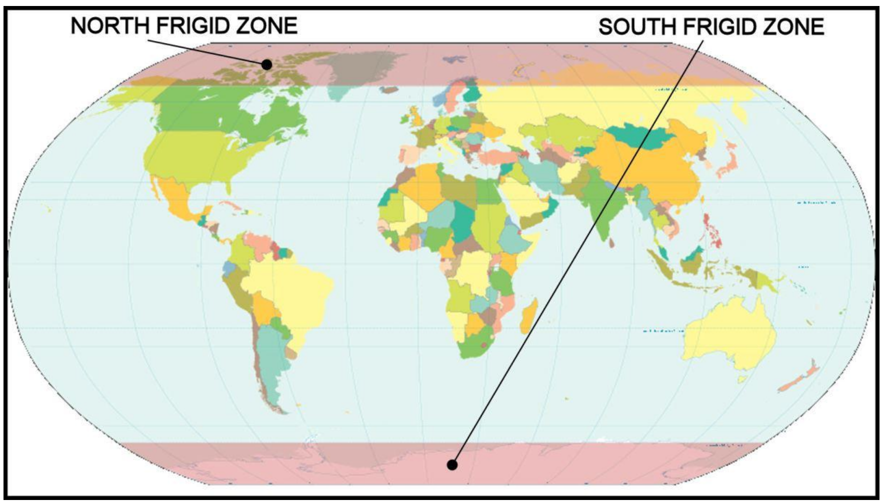
4.5.2.14.3. Aluminum alloys are excellent for use in the tropics. When in contact with concrete, mortar, or plaster, aluminum gives better service if coated with synthetic or rubber-based paint.

4.5.2.14.4. Use galvanized steel fasteners. Plain steel corrodes rapidly and promotes wood decay.

4.5.2.14.5. Use only paints, primers and enamels containing a fungicide to inhibit mold growth.

4.5.3. **Frigid Zones**. Frigid zones are generally the coldest parts of the earth and are usually covered with ice and snow. Frigid zone conditions exist in the northern hemisphere in Alaska, Canada, Greenland, northern Scandinavia and northern parts of Russia (**Figure 4.3**). The entire continent of Antarctica fills the southern hemisphere's frigid zone. Consider the following factors when planning operations in frigid zones:

Figure 4.3. Frigid Zones



4.5.3.1. Deep snow, permafrost, seasonally frozen ground, frozen lakes and rivers, glaciers and extreme cold temperatures characterize frigid zones (**Figure 4.4**). Besides climatic effects, the vast distances and isolation influence bare base operations in these areas. Frequent high winds and either very short or very long periods of daylight prevail. Seasonably frozen ground may exist to depths as great as 12 feet. Special lubricants, antifreeze, protective covers and warming equipment will likely be required. Cold temperatures make even simple tasks difficult. During the summer, this zone may be characterized by numerous and extensive swamps, lakes and rivers, abundant insects and, at times, continuous daylight. Spring hazards include flash floods from snow and ice melt. Freeze-thaw cycles occur frequently. Engineers accustomed to operating in warm weather should be prepared for frigid conditions by proper training that should include operation of special-purpose equipment such as snow removal machinery and portable duct heaters. This training should also include winterization of standard BEAR assets. Operation and maintenance of vehicles, power equipment and utility systems in very low temperatures are difficult. Extreme cold may result in rapid deterioration of metal, plastic and other materials. Special lubricants may be required as well as antifreeze, protective covers and warming equipment.

Figure 4.4. Special Planning Required for Frigid Zones

4.5.3.2. Temperatures. While temperatures vary considerably between locations during the winter season, six continuous hours with an ambient temperature of -50 degrees Fahrenheit can be expected in the extreme parts of the frozen zone. Summer maximum temperature expectancy is +95 degrees Fahrenheit well inland.

4.5.3.3. Winds. The velocity varies with the particular area and season. Maximum wind speed occurs during periods of changing temperature and prolonged velocities above 90 knots have been recorded. Snow and silt begin drifting with winds above 8 knots. High winds combined with heavy snow can produce whiteouts capable of bringing movement to a standstill.

4.5.3.4. Icing Phenomena. Ice fog occurs mainly at temperatures below +20 degrees Fahrenheit. At temperatures below -35 degrees Fahrenheit, ice fog may be quite dense and could limit visibility to a few feet.

4.5.3.5. Site Access. Plan to use trees, shrubs, snow fences, or even structures to keep drifting snow from reaching the site proper. In a non-dispersed layout, leave enough space between shelters to permit snow removal and locate structures in rows perpendicular to the wind. Dispersed shelters should be oriented with their longest axis parallel to the wind. During site planning, provide for snow-dumping areas downwind to eliminate large piles of snow and windrows in the camp area.

4.5.3.5.1. Locate major heat-producing facilities, including heated shelters and shops, downhill and downwind from the runway to guard against ice fog.

4.5.3.5.2. At least 150 feet should remain open between the near edges of parallel runways and taxiways to provide dumping space for removed snow.

4.5.3.5.3. Parking aprons should be a minimum width to facilitate snow removal and should permit maximum access to planned hangar locations, taking into account the prevailing winds. Locate parking aprons on the uphill side of the runway because of the ponding potential of the surface water. Parking aprons should be placed alongside – not upwind or downwind – of hangars and maintenance facilities.

4.5.3.5.4. Locate priority facilities toward the downwind end of the bare base where they are afforded protection by less important upwind shelters.

4.5.3.5.5. When planning to locate a facility, such as a ROWPU near a stream or river, be sure to check topographic data for the region to determine the maximum high-water level resulting from spring thaws, ice jams and similar conditions.

4.5.3.6. Road Construction. Mobility on the bare base may vary considerably during the winter season in the Frigid Zone. On frozen ground with minimal snow cover, maneuverability is generally excellent. Marginally frozen soil, tundra and thin frozen crust rapidly break down under the heavy traffic that can be expected at the deployment site. Where no permafrost is found, road construction design and procedures are generally the same for a frigid area as for a temperate climate. In permafrost regions where both wooded and open areas are available for road locations, it is better to cut through the wooded section for the additional protection trees offer against degradation of permafrost by radiant heat. Trees also protect against strong winds and snow drifts. Roadway grades should not exceed 3 to 5 percent to provide adequate vehicular wheel traction. Wheeled-vehicle mobility in deep snow can be improved by reducing tire inflation pressure up to 50 percent. Roads require a crown for surface drainage in summer and a flat crown for maximum traction and safety in the winter. Spring and fall grading operations for unpaved roads should be an expected requirement. Shoulder slopes of 5:1 should be used to prevent snowdrifts in open areas. Slopes may be a conventional 1-1/2:1 in protected areas. For longitudinal elevations, avoid cut sections where possible. Fill sections with minimum slopes of 4:1 should be used.

4.5.3.7. Solar Orientation. In subarctic areas, the long axis of shelters should be an east-west direction to take advantage of the maximum solar exposure. However, since the solar radiation received is small, the direction of prevailing winds should be the deciding siting factor.

4.5.3.8. Utility Systems. Adequate planning will be required to provide the necessary freeze protection. For water storage and distribution, preheating the water at the source, using the M-80 water heater, should be one of the first considerations. Where feasible, use electric trace and insulated lines.

4.5.3.9. Field Sanitation. Maintaining proper field sanitation in a frigid climate presents some unique problems. Edible garbage should be burned to avoid attracting roving animals, bears in particular. Get the pest managers involved in planning to control the rats and mice, which are commonly found in great numbers in most of the habitable cold regions of the world.

4.6. Desert Regions. Desert regions, for the purpose of this discussion, is described as two different climate subzones: the hot-humid coastal desert and the hot-dry interior desert. Characteristics common to both desert subzones are an arid, barren environment with stark contrasts of temperature, terrain, vegetation and weather. Temperatures vary according to latitude and season, from over 136 degrees Fahrenheit in Mexico and Libya to the bitter cold of winter in the Gobi desert in East Asia. In some desert areas, day to night temperature fluctuations can exceed 70 degrees Fahrenheit. Annual rainfall may vary from zero to 10 inches and is often totally unpredictable. Desert terrain also varies from place to place, the sole common denominator being lack of water with its consequent environmental effects (**Figure 4.5**).

4.6.1. Coastal Desert. Hot-humid conditions are limited to the immediate coast of bodies of water having a high surface temperature, such as the Persian Gulf and the Red Sea. These areas experience the highest water vapor in the world. In these coastal desert regions, relatively high temperatures (about 100 degrees Fahrenheit) often combine with large amounts of water vapor in the surface air. Higher temperatures occur occasionally, but humidity levels will not be as extreme. The reverse season daytime minimum temperature is 32 degrees Fahrenheit. Nighttime temperatures are moderate: 60 to 80 degrees Fahrenheit in the summer and 30 to 50 degrees Fahrenheit in the winter.

4.6.1.1. Expect a one-hour rainfall of 4 inches with a maximum intensity of 0.45 inches per minute and an intermittent wind velocity of 35 knots. Although annual total and frequency of rainfall are much less in hot-humid and hot-dry desert climates than in tropical and intermediate climates, when rainfall occurs it is often a quick, violent deluge causing flash flooding.

Figure 4.5. Rocky Desert Terrain

4.6.1.2. Bare base sites will be subject to winds of 45 knots for a 5-minute period with gusts to 65 knots. Prevailing winds blow from northwest or southeast almost exclusively.

4.6.2. Hot-Dry Subzone. Hot-dry conditions are found in the deserts of Northern Africa, the Middle East, Pakistan, India, Southwest United States, Northern Mexico and Australia. During the hottest month in a normal year, the temperature may be above the intermediate hot-dry extreme of 100 degrees Fahrenheit for more than 10 percent of that month. In Northern Africa temperatures exceed 120 degrees Fahrenheit as much as one percent of the hottest month. Substantial desert areas on all continents have long periods with temperatures above 100 degrees Fahrenheit in the hottest month. The temperatures cited are shelter/shade temperatures taken 4 to 6 feet above the ground. **Note:** Equipment operating in direct sunshine will be exposed to temperatures 30 to 50 degrees higher than the shade temperature.

4.6.2.1. Humidity in the hot-dry desert subzone is low, ranging from 5 to 20 percent. During the reverse season, expect a minimum temperature of about 25 degrees Fahrenheit.

4.6.2.2. A one-hour rainfall of 4 inches with a maximum intensity of 0.45 inches per minute and an intermittent wind velocity of 35 knots can be expected. Temperatures during heavy rainfall will be lower than 80 degrees Fahrenheit.

4.6.2.3. Sites are subject to winds of 45 knots for a 5-minute period with gusts to 65 knots. Prevailing winds blow from northwest or southwest almost exclusively.

4.6.3. Planning Considerations for the Desert Zone.

4.6.3.1. Site Access. Of the several landforms found in the desert zone, the Piedmont, Coastal Plain and Mesa are the most suitable for site development and are the ones most likely to have water sources nearby. An increase in elevation in the Piedmont and Mesa regions causes the temperatures and the relative humidity to decrease. Wind ventilation is also greatly improved. The Piedmont area slopes down from the mountains. Slopes facing away from the equator are preferable because they receive less solar radiation and have lower temperatures. Coastal plains slope toward the sea and suffer from high humidity. If the planned site will be located in this area, water availability and wind circulation will be more important planning considerations.

4.6.3.2. Trafficability. In the desert, rainfall and drainage seldom present problems. Soil is normally trafficable to all-wheel drive vehicles. After prolonged traffic, dust and blowing sand will become bothersome. Dust control can be achieved with minimal compaction and expedient grading effort followed by sprinkling with an asphalt emulsion, diesel or fuel oil, or even crude oil. Saltwater is a good treatment for unpaved roads at the bare base site. For additional guidance on mitigating dust at contingency locations see **Engineering Technical Letter (ETL) 09-3**, *Chemical Dust Control for Contingency Roads, Base Camps, Helipads, and Airfields.*

4.6.3.3. Solar Orientation. Plan to locate bare base facilities with their long axis in an east-west orientation to minimize exposure to the low-angled sun and to reduce the creation of shadows.

4.6.3.4. Wind Orientation. Winds in desert areas are practically unceasing and can achieve almost hurricane force. Because the wind moves great amounts of hot dry air, it has severe dehydrating effects. The wind carries fine soil particles, which clog mechanical systems, accumulate on every surface and can restrict visibility to a few yards. The Sahara "Khamseen" for example, can last for days at a time, although it normally only occurs in the spring and summer. Khamseen means "fifty" in Arabic and refers to the wind blowing for 50 days. The deserts of Iran are equally well known for the "wind of 120 days," with sand blowing almost constantly from the north with wind velocities up to 75 miles per hour. At the bare base the wind can be lifted, deflected and guided with a perimeter berm to shelter height, particularly on the prevailing wind side. Also consider placing the long side of shelters perpendicular to the prevailing wind. Experience has shown this orientation helps keep sand out of the tents.

4.6.3.5. Site Drainage. During site layout, avoid low-lying areas or "wadis," in the desert. Sudden and intense rains may cause flash flooding. Rainfall generally occurs during the winter season.

4.6.3.6. Water Planning Factor. In a true bare base environment, the scarcity of water in a desert zone makes proper water planning, conservation and discipline critical issues. Do not exceed the water use planning factor of 30 gallons per person per day.

4.6.3.7. Water Sources and Treatment. Plan to use ROWPUs to produce potable water from seawater and brackish ground and surface water sources. Resupply aircraft, tanker trucks, water trailers and bulk containers or pillow tanks strapped to flatbed trucks are additional water sources. Well water is available at various depths under most deserts; however, such water is seldom of potable quality without employing a ROWPU process.

4.6.3.8. Water Storage. In the desert, every effort should be made to store drinking water at a temperature of 70 degrees Fahrenheit. Earth cooling and night radiation could be used for cooling if mechanical cooling units are not available. Make provisions to use water chillers with water trailers or alternate bulk storage containers to provide small quantities of cool water reserved for human consumption only.

4.6.3.9. Water Distribution. Exposed water distribution lines (flexible hose type) must be insulated to prevent freezing.

4.6.3.10. Electrical Power Generation. Plan on installing sunscreens to protect the equipment from the intense solar radiation. Enclosures are not practical due to the excessive heat buildup. Equally important will be efforts to provide additional generator cooling capacity, using add-on radiators to allow generators to operate above their rated ambient temperature, normally 125 degrees Fahrenheit. Since the expected generator failure rate is above normal, plan on maintaining an adequate stock of replacement parts.

4.6.3.11. Electrical System Operation. Generator output is somewhat degraded in desert conditions. Units will continue to operate until one of its safety devices triggers, alerting to one of the following: high water temperature, high oil temperature, low fuel level, low oil pressure, or high alternator temperature. Some safety cutoffs can be manually overridden in critical situations. However, low oil pressure and high alternator temperature should never be overridden.

4.6.3.11.1. Underground or on-the-ground power distribution is recommended in the desert zone. On-the-ground cable should be protected from sunlight and blowing sands as much as practical. When crossing a road, the cable should be underground and protected by PVC conduit.

4.6.3.12. Sanitary Systems. Expect a minimal sewage flow due to water scarcity. In areas with acute water shortage, consider recycling wastewater from showers and laundry for nonpotable purposes such as dust abatement, concrete mixing, firefighting and aircraft and vehicle washing.

4.6.3.13. Shelter Foundation Requirements. Sand, when confined and compacted, makes an excellent base or foundation for BEAR shelter facilities. Wind erosion, particularly at the corners of the shelters, can be prevented by gravel backfill or chemical stabilization. Drifting sand can be controlled by placing snow fences at critical locations.

4.6.3.14. Ventilation Considerations. Take advantage of winds for ventilation. Hot, dry daytime winds must be lifted, deflected, or guided away from shelters. In low humidity regions with large variations between day and night air temperatures, ventilation should be as high as possible at night to cool down the interior walls. During the day, the ventilation should be as low as possible so that hot air will not raise the temperature of interior surfaces. In high humidity (coast desert) regions with little change between day and night air temperatures, there should always be ventilation for facilities not served by air conditioning.

4.7. Existing Facilities and Resources. Time is usually a critical factor in bare base deployments. Given all the possible contingency scenarios that may constrain the airlift of BEAR assets, an imaginative and prompt approach to planning the use of existing resources will be a key determinant of success or failure of the engineer support mission. Working and living space provided by mobile facility assets will only meet minimum essential requirements. Do not turn down any reasonable opportunity to use existing facilities to cover facility space shortfalls, improve working and living conditions, or supplement mobile assets.

4.8. Supplies and Construction Materials. Providing bare base upgrades, expansions, or repairs requires large quantities of materials. However, there are many potential sources of supplies and construction materials overseas. The challenge is to locate the needed materials, then determine how to acquire them. Sources may be on base, in the local area, in-theater, or in CONUS.

4.8.1. Base Supply. The first place to check is the official source, the standard base supply system. In some overseas locations, USAF main operating bases support deployment sites by processing requisitions. Bare base planners can expedite requisitioning by providing base supply the current stock numbers of common engineering materials. The nomenclature of AM-2 mat and accessories, sandbags and lumber may mean little to a supply specialist while valid stock numbers mean everything. Materials not in stock locally will be backordered from CONUS by base supply and shipped in by air or sea, depending on the priority. In a large contingency, airlift will be severely constrained, and it is not reasonable to expect that construction materials will preempt more important cargo.

4.8.2. Headquarters Staff. The staffs at numbered air force, MAJCOM headquarters, and combatant command theater staffs are an important source of material support. These staffs are generally aware of in-theater assets—either prepositioned WRM or stockpiles of deployed materials not in the standard supply system. Depending on other in-theater priorities, these assets may be available to support the bare base mission. Working through these headquarters elements, particularly those that might be in-theater or deployed forward, often produces more responsive results than standard requisitioning methods. The important point is: to ask for help and keep asking because headquarters staffs are there to assist.

4.8.3. Other Engineer Units. If certain materials are either not available or carry an unacceptable long lead-time, other local military units should be considered as a potential source. These include the host-nation base engineer, nearby host-nation, US Army combat engineer units or US Navy “Seabees.”

4.8.4. Local Purchase. Another possible source of material is the local economy. This is especially appropriate for bulky materials (cement, crushed stone, select fill, asphalt and lumber), which require significant airlift if shipped from a CONUS source. Local purchases require assistance from contracting, finance, an interpreter and a competent civil engineer to identify the right materials. Several common tools and factors for quickly converting lengths, volumes and measurements are included in **Attachment 4** and **Attachment 5** of this volume. Additionally, various internet sites provide free use of conversion applications and calculators. Some of the more popular ones include: **http://www.onlineconversion.com**; **http://www.metricconversion.ws**; and **http://www.infoplease.com/pages/unitconversion.html**. Also the "Google©" search engine will provide a conversion tool just by entering the conversion factors in the search box (for example enter "convert dollars to euros"). Local construction contractors are familiar with nearby sources of engineering materials. Experience has shown that blanket purchase agreements with local suppliers work well during contingencies where response and delivery are critical. Cultural differences have a definite effect on local purchase procedures. In many SWA countries for example, small businesses are accustomed to working strictly on a verbal, cash basis. They may regard written contracts and invoices as unnecessary or even as an insult to their integrity. Prices are generally not fixed, but are established by bartering. Sensitivity to local customs is recommended even if planners cannot always follow them.

4.9. Host-Nation Support Agreements. Air Force units deployed in past expeditionary operations were often tenants on bases belonging to the host nation. As tenants, Air Force civil engineers frequently relied on the host base engineers for assistance. The Air Force paid for much of this support. Even with reimbursement, good working relationships were important to the progress of base development. At many of these bases, joint support plans or country-to-country agreements defined the responsibilities for both the tenant and the host. Future deployments will also benefit from good host relationships. Some installations in Europe and joint-use bases in Korea are covered by JSPs, which list the facilities the host nation has agreed to share with, or turn over entirely to US forces upon deployment. In locations such as SWA, the US funds construction of facilities on host-nation bases for US use. For a base without a JSP or similar agreement executed prior to deployment, mutually acceptable arrangements for facility use, maintenance, work approval and reimbursement may have to be worked out informally and then approved by appropriate US and host-nation authorities. In these scenarios, early coordination with the servicing Staff Judge Advocate is strongly advised.

4.10. Hardening Requirements. Hardening requirements have to be addressed if the base is situated in a high threat area. The simplest style of hardening is to use sandbags, revetments, soil-filled steel bins, or soil-filled containers of any type that can be stacked and fastened together to form a wall (**Figure 4.6**). Testing has shown that for expedient revetments a thickness-to-height ratio no less than 40 percent provides reasonable stability against tipping over from a blast. While hardening effectively counters the threat from conventional munitions, it consumes great amounts of scarce manpower, materials and time. Revetment construction should be planned according to the priority of the resources to be protected. Aircraft come first, followed by command post, communications, functional control centers, billeting shelters, water pumps and treatment plants, fire vehicles, remaining working areas and so on as threat levels and other work dictate. Revetment descriptions are contained in **Chapter 6** of this volume. Construction details are included in Volume 2 of this pamphlet series.

Figure 4.6. Concertainer® Revetment Material

4.11. Camouflage and Concealment Requirements. Camouflage and concealment measures are almost as costly as facility hardening in terms of manpower, materials and time. Camouflage and concealment refers to the capability to reduce the effectiveness of attacking air and ground forces and reconnaissance assets. The nature of the threat, the importance of the base mission and the vulnerability of the base all affect the requirement and priority for establishing camouflage and concealment measures. To be practical, these measures must concentrate on decreasing the range of target acquisition by delaying recognition of targets and by concealing or decoying valuable assets within target areas, thus hampering precision bombing. Camouflage and concealment includes the principles of hide, blend, disguise and decoy to protect friendly assets and aim points with materials and equipment that alter or obscure part or all of their multispectral signatures. Camouflage net systems are an optional BEAR equipment item. See AFH10-222, Volume 10, *Civil Engineer Camouflage, Concealment, & Deception (CCD) Measures* for more information on this topic.

4.12. Environmental Considerations. The USAF is committed to achieving and maintaining environmental quality to ensure long-term access to the air, land and water needed to protect US interests. Maintaining a high level of environmental awareness and compliance during contingency operations presents a difficult challenge. All personnel involved in these operations have a role to play in protecting the environment. The goals of the AF Environmental Quality Program during contingency operations are to minimize risks to human health and the environment while maintaining readiness and accomplishing the mission. These goals are divided into five areas: protection of personnel; pollution prevention; planning for hazards; managing environmental functions; and mitigation and restoration policies. For additional information on the duties and responsibilities of engineers with respect to environmental programs during contingencies, see **AFH 10-222, Volume 4**, *Environmental Guide for Contingency Operations Overseas*.

Chapter 5

MANPOWER PLANNING

5.1. Introduction. Operational commands require its civil engineers to provide the flexibility to employ weapons systems without dependence on other command organizations. Civil engineers are located at most major AF bases and are totally integrated into the bases' peacetime force structure. These engineers are organized as Prime BEEF teams and accompany each flying squadron deployed to a bare base. The support they provide encompasses everything from force beddown and routine O&M to emergency and follow-on damage repair of the airbase. Each bare base will have a different airfield layout, site conditions and other criteria that will dictate the degree of engineering effort needed to prepare the site and sustain the base. A typical bare base could be a commercial airport or allied military airfield, of which the AF is given use, along with a water source and an area to erect BEAR facilities. In some cases, there may be facilities and services that can be used in lieu of BEAR assets. For example, an allied military airfield may have adequate airfield lighting, aircraft arresting systems and fire protection services to support the deploying flying mission. In some cases, billeting or similar support may also be available and would negate the need for certain BEAR facilities. Likewise, electrical power, water and waste systems may be available without further augmentation or development. Factors such as these dictate the overall level of effort needed to establish, operate and recover a bare base. The responsibility for identifying the specific engineer support requirements belongs with planners from both the overseas theaters and gaining commands. To aid in this endeavor, this chapter assumes a worst-case scenario—that there is no host-nation beddown support and no facilities, utilities or services other than those provided in BEAR support packages. Under this scenario, bare base operations will depend largely upon Prime BEEF and RED HORSE resources.

5.2. Overview. This chapter describes the Prime BEEF beddown force structure; phases of beddown operation; typical beddown, operation and maintenance and base recovery tasks; and factors which affect the productivity of the engineer force. Planners should review the entire CE UTC structure in **AFI 10-210** for manpower and equipment force packaging (MEFPAK) guidance.

5.3. Roles and Mission. While deterring nuclear attack will remain the US's national defense priority, deterrence using conventional forces remains essential in addressing conflicts that could threaten US interests and allies. Deterrence requires that US forces be flexible, rapidly responding, precise and lethal with global reach. USAF activities during Operations ENDURING FREEDOM and IRAQI FREEDOM are examples of this conventional deterrent in practice. In all cases where a mobile response was required, emphasis was placed on accelerated force projection and rapid initial beddown. Prime BEEF forces played key roles in these situations, assisting in the beddown and support of combat and air mobility forces and enabling operational commanders to display US national resolve and intent. Prime BEEF personnel must be able to mobilize and deploy at least as fast as the flying squadrons they support; able to provide immediate beddown, FES, EM and EOD support regardless of location; capable of performing base recovery quickly and effectively; and able to sustain base operations irrespective of the age, condition, or type of facilities.

5.3.1. Engineer Employment Concept. The primary mission of AF engineers is to provide force beddown and aircraft beddown. Prime BEEF teams install deployable facilities and utilities, conduct light repair and rehabilitation of existing bare base facilities and utilities and accomplish other contingency general engineering work required to make the bare base ready to conduct flying operations. Prime BEEF personnel have the responsibility for bare base operations and maintenance, sustainment of the AEF wing, squadron or group mission or support for joint operational units. This includes operating and maintaining USAF aircraft arresting systems, airfield lighting, utilities and facilities and providing engineering support such as FES, EOD, Pest Management and environmental support and waste collection and disposal. Prime BEEF forces are also responsible for emergency repair and recovery operations if the bare base is damaged. Prime BEEF forces are deployed by UTCs and identified as teams or individuals.

5.3.1.1. While team components and UTC designations may change, most Prime BEEF deployment operations follow traditional roles of civil engineer deployment teams. Prime BEEF teams deploy with the necessary command and control, individual protective equipment and clothing, weapons and ammo establish a beddown location, beddown incoming forces and support flying operations. Additionally, separate engineer UTCs provide FES; chemical, biological, radiological and nuclear (CBRN) passive defense and emergency management; EOD support; RED HORSE support; and staff augmentation. Additionally, two UTCs are provided by HQ AFCESA (airfield pavement evaluations and civil engineer maintenance, inspection and repair).

5.3.1.2. Additional engineer UTCs are brought in as the size and mission requirements of the bare base increase. Additional EM and EOD UTCs may be brought in based on threat and local operational support conditions.

5.3.1.3. Prime BEEF team members bring individual protective clothing, hand tools and selective team equipment. Separate UTCs for most construction equipment, special vehicles and bulk supplies are deployed to support personnel UTCs. Supporting UTCs and other programs provide specialized equipment/systems, O&M and sustainment support above the requirements in the basic engineer and augmentation UTCs. These include BEAR assets, WRM, personnel and equipment UTCs from 49 MMG, and AFCAP.

5.3.1.4. ***Tailored*** UTCs are used to adjust resources to the realities of operations requirements, timing and force capabilities. Adjustment often occurs when follow-on forces deploy to an AEF location and sustainment operations are required rather than beddown-buildup. Also, tailored UTCs may be used when special requirements are needed to support an operation or mission. In some cases, the tailored civil engineer force is included in a MAJCOM-unique team UTC, such as an AMC first-in operation or AFSOC mission. However, any AEF base with qualified personnel could be tasked to provide a tailored UTC for this type support.

5.3.2. Logistic Support. It is essential that a logistical support relationship be established when Prime BEEF teams are deployed to a theater of operation. Full logistic responsibility must rest with the theater MAJCOM being supported. This responsibility should include but is not limited to intelligence, communications, coordination and liaison with other agencies, personnel replacement, medical evacuation, transportation and vehicle maintenance support, rations, ammunition, beddown and construction materials, POL, maps, blueprints, charts and resupply. If engineer resources cannot reasonably be expected during the early phases of deployment and employment, the responsible theater MAJCOM must pursue other avenues to support the engineer teams; for example, individual mobilization augmentees (IMA), host-nation support and contract support. Engineer teams at each beddown location will provide their own capability to set up internal supply operations to include determining requirements and requesting, receiving, storing and distributing items necessary to fill engineer needs.

5.4. Beddown Force Structure. Engineer forces deploying from a single or possibly several different CONUS and theater locations will develop the bare base site, facilities and utilities (**Figure 5.1**). There can be several types of these forces; sometimes working alone, sometimes in combination.

Figure 5.1. Engineer Team Assembling a Medium Shelter System

5.4.1. Prime BEEF. From a bare base perspective, the Prime BEEF UTCs are the basic engineer manpower components. Historically, these UTCs were sized to support a squadron of aircraft and a standard 1,100-person deployed base population. In order to provide flexibility, particularly for joint missions, a CE transformation initiative has created a 26-person basic engineer team (BET) UTC. The BET represents the basic CE capability, regardless of mission, and is rounded-out by support UTCs. It must be remembered, however, that Prime BEEF teams are not heavily equipped and only have basic toolboxes and rudimentary team kits. The exception is EOD, which has a drive-on/drive-off capability as well as all the necessary equipment and explosives to operate. Vehicles, major shop machinery and all materials must be provided by separate UTC support packages, as prepositioned assets or via local contract support. See **Attachment 6** for a list of Prime BEEF and other engineer manpower planning factors that may be tasked to participate in beddown activities.

5.4.1.1. Engineering and Operations. Responsibilities include bare base operations, maintenance and sustainment of airfields for AF and joint beddown. Capabilities include maintaining airfield lighting, arresting systems, airfield surfaces, roads and BEAR facilities. Also performs pest management, environmental and contract support, base recovery after attack and light horizontal/vertical construction.

5.4.1.2. Emergency Management. Responsible for effective CBRN defense planning and swift disaster response operations. Capabilities include developing plans, training and equipment to respond to major accidents, natural and manmade disasters, HAZMAT and CBRN attack or terrorist use of CBRNE.

5.4.1.3. EOD. Responsible for locating, identifying, disarming, and disposing of hazardous explosives and ordnance. Capabilities include aircraft emergency recovery, force protection, recovery of airfields denied by ordnance, range clearance, counter-mine operations and support to organizations providing protection to US and foreign dignitaries.

5.4.1.4. FES. Responsible for aircraft rescue firefighting, emergency medical support and fire prevention education. Other capabilities include protecting life and property and HAZMAT mitigation.

5.4.1.5. Staff Augmentation. These “S-teams” provide C2 for CE at MAJCOM level. Capabilities include expertise in construction management, technical design and expeditionary site planning.

5.4.2. RED HORSE. RED HORSE is a self-sufficient, mobile heavy construction squadron capable of rapid response and independent operations in a Level 1 threat environment (see AFDD 3-10 for definitions of the different threat levels). RED HORSE supports force beddown requirements, siting and installation of air transportable facilities and equipment, well-drilling, aircraft arresting system installation and can repair enemy-inflicted damage or damage by friendly forces (**Figure 5.2**). RED HORSE teams have the internal capability for its own housing, medical, food service, vehicle maintenance, logistics planning, contracting and (limited) security. These forces are deployed with their own heavy construction equipment, tools and a limited amount of rations. Yet, it may take up to 30 days for all the equipment to join up with the deploying forces. Therefore, during the first 30 days of any anticipated bare base operation involving RED HORSE, prepositioned or indigenous equipment will be required. Bare base planners, however, must remember RED HORSE squadrons are a limited resource. Even with Air Reserve Component (ARC) forces fully mobilized, only a few RED HORSE squadrons are available. If major concurrent construction activities must be performed at several bare base locations, rigid prioritization of projects must be maintained to avoid diluting and fragmenting RED HORSE efforts.

Figure 5.2. RED HORSE Team Erect Warehouse at Forward Location

5.4.3. The **49th Materiel Maintenance Group** (49 MMG). The 49 MMG is a cadre of personnel possessing in-depth knowledge and unique expertise on BEAR equipment. Under normal operations, the 49 MMG is manned for storage, supply accountability, maintenance, training and logistics planning responsibilities for mobility assets stored at Holloman AFB, New Mexico (**Figure 5.3**), or at forward storage and maintenance locations. During bare base contingency operations, the 49 MMG plays a major role in the preparation for shipment, installation, erection and on-site maintenance of BEAR facilities.

Figure 5.3. 49 MMG BEAR Compound at Holloman Air Force Base

5.4.4. Other Engineers. Other heavy construction support, such as Army engineer construction forces, Navy Seabees, or local contractors, should be considered for special tasks, such as airfield resurfacing, ramp and apron expansions, installation of aircraft arresting systems, well drilling, large earth moving projects and follow-on war damage repair.

5.4.5. Local Nationals (LN). A potentially large source of manpower is the hiring of LNs. Also known as indigenous labor, these are citizens of the host nation. During the Korean and Vietnamese conflicts, LNs provided a major part of the work force to construct, operate and maintain USAF facilities. Hired individually or by contractors, LNs have worked as equipment operators, electricians, carpenters, masons and unskilled laborers. They have also been employed in the white-collar jobs such as administration, engineering design, drafting and production control. Availability of LNs during future deployments, especially the more skilled people, will depend on local economic conditions and local threat. If the host nation has mobilized for war, labor may be scarce, but military reserve units and national construction organizations may be able to assist in bare base development work.

5.4.6. Users. As mentioned earlier in this volume, individual organizations should erect their own shelters (TEMPER tents, ESCs, user-unique ISO containers) with technical aid from CE. If this requirement is circumvented and engineers are tasked to erect all shelters, it could cause major delays in engineers establishing utility systems and accomplishing other critical tasks.

5.5. Manpower Requirements. As mentioned in **Chapter 2**, bare base deployments normally occur with the phased movement of personnel, equipment, and supplies according to the AETF Force Module Construct. While some engineer representation is present and vital during the open the airbase and C2 deployment phases, the bulk of the engineer work force and the majority of engineer tasking will be realized during the *establish*, *operate*, and *robust* the airbase phases of the deployment.

5.5.1. Manpower Employment. Manpower employment and intensity fluctuates during the deployment phases. Demands on manpower will likely be more intensive initially, then gradually moderate as the base transitions to other phases of deployment. Transition from the establish the airbase phase to the operate the airbase phase for all work functions will not necessarily occur at the same time. For example, power plants and electrical distribution systems may be installed well ahead of water and waste distribution systems. Runways may meet all lighting and aircraft arresting system requirements and would transition immediately into the O&M phase. During the establish the airbase phase, the most critical skills are utilities, electrical, power production, heating and air conditioning, liquid fuels and equipment operations. The level of civil engineer support required during the establish the airbase phase will not change radically at the lower base population locations because the tasks of preparing runways and taxiways, installing airfield lights, constructing POL and ammunition areas and installing utility systems remain relatively constant regardless of base population levels.

5.5.1.1. Establish the Airbase Phase. The prompt beddown of deploying units is critical to mission success at contingency bare bases. Rapidly expanding bare bases will require the minimum facilities essential for air combat operations. Some existing facilities may have to be expanded or modified, or mobility shelters will have to be erected. During the early stages of deployment, engineer duties will not only concentrate on force beddown but also on preparation of the base to withstand the shock of an attack. Those activities include erecting mobile assets, installing backup power, hardening priority facilities and utilities and stockpiling and dispersing war reserve materiel. To provide enhanced base security from ground attack, heavy equipment operators will clear, cover, remove obstacles and sculpture terrain on and immediately off base to provide the integrated defense force with clear fields of fire and to deny the enemy and terrorists access to the base. If time allows prior to an attack, engineers will attempt to isolate utility systems to reduce the possibility of additional damage resulting from an attack. Engineers may be working around the clock. Nighttime operations may or may not be lit, and construction equipment will produce high noise levels throughout the base and surrounding area. Personnel will require time to become familiar with the base layout; as a result, disoriented vehicle and pedestrian traffic can be expected in unusual locations. Since construction equipment is generally not equipped with radios, operators and drivers must work from written or verbal orders. The following list, although not inclusive, shows the magnitude of the work projected for the beddown phase. See **Attachment 6** for planning factors for CE contingency tasks. Additionally, **Attachment 7** provides engineers a quick reference of useful information and examples related to bare base planning and development.

5.5.1.1.1. Laying aircraft matting for aircraft parking.

5.5.1.1.2. Revetting unsheltered aircraft.

5.5.1.1.3. Constructing earth berms and dikes for fuel bladders.

5.5.1.1.4. Installing airfield and perimeter lighting.

5.5.1.1.5. Establishing water distribution points.

5.5.1.1.6. Installing power generation equipment.

5.5.1.1.7. Erecting BEAR facilities.

5.5.1.1.8. Modifying existing facilities for alternate use.

5.5.1.1.9. Providing all essential utilities.

5.5.1.1.10. Constructing earth berms for bomb dumps and fuel bladders.

5.5.1.1.11. Constructing sewage lagoons.

5.5.1.1.12. Constructing communication tower locations.

5.5.1.1.13. Constructing defensive fighting positions, armories, vehicle fighting positions and command centers for the base defense force.

5.5.1.1.14. Constructing protective shelters to enhance survivability.

5.5.1.1.15. Laying out and cutting access roads and firebreaks.

5.5.1.1.16. Hardening critical facilities and utilities.

5.5.1.2. Operate the Airbase Phase. After completing the initial beddown, engineers must provide operations, maintenance and services for essential facilities and utilities required to support bare base operations. The following functions are involved:

5.5.1.2.1. Supporting force beddown of AF units and weapons systems.

5.5.1.2.2. Accomplishing operation and maintenance functions for existing, as well as newly installed, BEAR facilities and utilities.

5.5.1.2.3. Providing fire emergency services and fire suppression.

5.5.1.2.4. Providing liaison with 49 MMG to ensure ample BEAR technical expertise is on-hand.

5.5.1.2.5. Enhancing base C2 and overall survivability by providing wartime training and exercise support.

5.5.1.2.6. Selectively upgrading minimum quality expedient facilities to standards better capable of supporting sustained operations.

5.5.1.3. Base Recovery. After an attack, engineers will concentrate on restoring air operations as quickly as possible. Damage assessment, expedient airfield repair and emergency war damage repair to utility systems and priority facilities throughout the base complex will be necessary. The working environment could be laden with unexploded ordnance; contain disrupted utilities (live electrical lines, spewing fuel lines, broken water lines, raw sewage discharge, etc.); be subject to multiple, uncontrolled fires; include damaged facilities and pavements; and possibly be contaminated with chemical agents. Additionally, there may be casualties who must be rescued and attended to before repair efforts can begin in earnest. After minimizing the threat of air attack, engineers will begin replacing expedient repairs with more permanent repairs. In some cases, Army engineers may perform construction management of AF construction activities during rebuild of airfields, utilities, facilities and roads. If, as a last resort, denial operations are required, engineers may be directed to deny the enemy items that contribute to the war effort. This might include equipment, facilities, utilities, runways, roads and items of intelligence value. Engineer supplies and equipment will be evacuated whenever possible.

5.5.1.4. Levels of Effort. Expedient force beddown, airfield damage repair and war damage repair are typically based on a 72-hour workweek (each person working six days on 12-hour shifts). All other civil engineer operations and maintenance manpower requirements are typically based on a 60-hour work week (six days on 10-hour shifts). Manpower requirements also include the use of multi-skilled efforts whenever possible.

5.5.1.5. FES Manning. Staffing for FES activities is typically based on the fire protection vehicle requirements (see CE Supplement to WMP-1, Appendix 5). The bare base host MAJCOM will determine the structural vehicle requirements, while the bare base's assigned aircraft, sortie rate per day and number of aircraft on the ground will determine FES vehicle requirements. As a result, additional vehicles above the basic set identified in Allowance Standard 012 may be required. Once total fire protection vehicle requirements are known, staffing requirements can then be identified.

5.5.2. Factors Affecting the Engineer Force. All the planning covered in this volume are meaningless unless engineers—the human factor in the bare base equation—are capable of operating and surviving under adverse conditions. The following paragraphs are addressed not only to the planners, but to the CE organization as a whole.

5.5.2.1. Training. Mission success in a theater of operations depends on the level of individual and unit training. Engineers must train the way they expect to fight. Engineers must train to be innovative, because shortages of supplies, equipment and manpower will demand it. Training must stress flexibility and multiskilling capabilities, because casualties and unforeseen situations will challenge character. Engineers must train in combat skills, as well as their primary and secondary AF specialties. Field exercises must stimulate and test physical and mental limits to build stamina and minimize the trauma of war. Engineers must train for all conceivable missions in all kinds of weather and climate and for all types of CBRN considerations. And in preparation for violent and lethal conflicts, engineers must receive, as a minimum, enough defensive training to give them a reasonable chance of survival. CE officers and NCOs must train to be leaders in the wartime environment. As leaders, they must be imaginative, innovative and reliable. In summary, engineer proficiency depends on adequate training and professional leadership at all levels of command. In order to meet these demanding requirements, engineers must be prepared technically, physically and psychologically to operate in environments of extreme stress and must train at base level to work as teams. Every effort must be made to incorporate engineer training scenarios into wing-level training plans and exercises. This is critical in tying engineer wartime capabilities to the operational mission.

5.5.2.2. Survivability. Engineers are vital to sustaining forward combat operations. Engineers must be able to perform the most critical wartime taskings under chemical warfare conditions and be thoroughly knowledgeable of the procedures for wearing individual protective equipment, accomplishing shelter processing and responding properly to the various stages of alert. They must be capable of decontaminating limited areas and their own equipment and supply items. Engineers must also be able to repair and service the mechanical/electrical systems that support personnel shelters and decontaminate equipment and attack warning systems.

5.5.2.2.1. Engineers will be working in areas that could be laden with hundreds of unexploded ordnance. They must be trained to recognize signs of potential danger and what actions to take, or not to take, in the vicinity of unexploded ordnance. Engineers must be able to identify, report and mark such munitions.

5.5.2.2.2. Engineers may also be subjected to a high volume of direct or indirect fire while engaged in wartime recovery or even stability operations. They will likely be enemy targets of opportunity, since damage recovery work assignments and equipment will draw attention and be recognized as essential to sustaining air operations. Engineers may also be tasked to travel to and perform duties in the less populated areas of the base or in limited security areas outside the wire. Due to the variety and number of engineer work assignments, it will not be possible to provide on-scene, full-time armed protection for each work crew. Consequently, engineers could be vulnerable to attack by enemy forces, saboteurs, snipers, or terrorists. Prime BEEF personnel require work party security/convoy training and weapons to defend themselves from such attacks, until security forces fire teams can arrive to engage the hostile force and pull back to a safer area. In some situations, engineers may be called upon to help defend the base and may represent the difference between success and failure. During conflicts, engineers must rely on hardened vehicles, protected positions, deception, withdrawal and personal weapons for survivability. HQ

AFCESA/CEXX has developed home station training courses on work party security, tactical convoy operations, team leading procedures, weapons handling, and other subjects to help prepare engineers for this task. Many of these courses are located on the Civil Engineer Virtual Learning Center (CE VLC) at: **https://afcesa.csd.disa.mil/kc/login/login.asp**. Tactical convoy procedures is also addressed in AFTTP 3-2.58, *Tactical Convoy Ops*.

5.5.2.2.3. Also in the area of survivability, engineers must be prepared to implement dispersal and hardening activities. During beddown of forces, the vulnerability of mobile facility, equipment and material assets must be considered in terms of the potential enemy threat. If threat conditions warrant, assets should be dispersed within the practical limitations of distance and utility support capabilities. Make maximum use of natural cover and camouflage techniques. Hand-in-hand with dispersal actions are hardening activities. Engineers must be able to perform a wide range of hardening tasks. Revetting aircraft will be a requirement in almost any contingency of moderate-to-long duration in a high-threat environment. Engineers must be capable of hardening the most critical base facilities and utilities. They have to be prepared to use any available materials and methods ranging from concrete and metal revetment to earth berms and sandbags. Engineers used commercial, prefabricated defensive wall systems (**Figure 5.4**) during Operations IRAQI FREEDOM and ENDURING FREEDOM to mitigate and protect from small arms, rocket propelled grenades and mortars.

Figure 5.4. Defensive Walls Increase Survivability

5.5.2.3. Morale. During contingencies, high morale can make the difference between success and failure. Good leadership, discipline, comradeship, esprit de corps and devotion to a mission cultivate morale. Together, these quantities—all inspired through unit integrity—make people endure and show courage in times of fatigue and danger. In a contingency situation, engineer tasks of operations, maintenance and repair will be many times more demanding. Engineers will be asked to work faster with fewer people, fewer materials will be available, no detailed planning will have been accomplished, the environment will be foreign or perhaps hostile and there will be little room for error. These situations make the need for cohesion and unity more important than ever. In the final analysis, it may well be the quantity of unit integrity, and not the number of engineers and special equipment, that will make the difference.

Chapter 6

AIRFIELD REQUIREMENTS

6.1. Introduction. The airfield is defined, for the purpose of this pamphlet, as that part of the bare base devoted to the operation of aircraft. A typical airfield consists of runways, taxiways, hardstands, aprons and other airfield pavements. NAVAIDS, aircraft arresting systems, airfield lighting and markings, overruns and approach zones are also part of the airfield environment. However, the prerequisites for a bare base airfield demand only a usable runway, taxiway and parking area (**Figure 6.1**). Supporting areas such as aircraft parking aprons, arm and dearm pads, hot cargo off-loading pad, aircraft turn-around points and taxiways may require construction, modification, or upgrade to meet AF standards and mission requirements.

Figure 6.1. C-17 Landing at a Bare Base Airfield

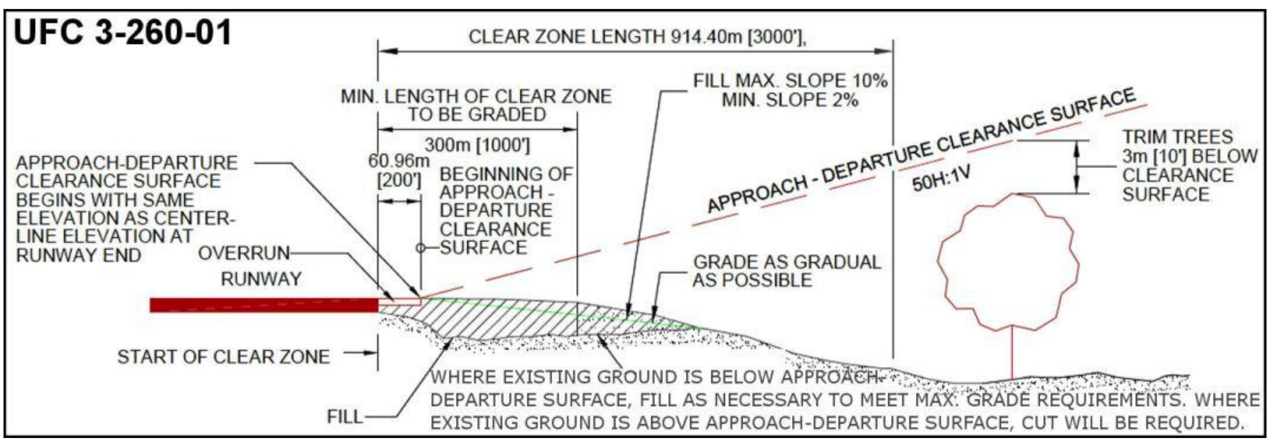
6.2. Overview. Working on the assumption that the bare base airfield meets its basic prerequisite, this chapter will describe the essential features of a runway, lists dimensions of aircraft and associated runway clearance requirements and then addresses the equipment and facilities needed to make the runway operational.

6.3. Bare Base Mission. It is critical to first determine the number and types of aircraft assigned to the base, identify all available aircraft parking areas and determine turn-around requirements (servicing, refueling and rearming). It is important to remember that even though many missions may be built around tactical aircraft, transport aircraft will airlift some or most of the BEAR supplies to the base. Consult **AFPAM 10-1403**, *Air Mobility Planning Factors*, when reviewing peacetime and wartime planning factors for air mobility aircraft. Bare base planning should consider airlift and tactical aircraft and, in some cases, strategic aircraft or unmanned aircraft systems. The ability of the bare base to accept, park and turn-around these aircraft must be evaluated as soon as possible. Limiting factors must be identified and transmitted to higher headquarters, enabling them to configure or schedule only aircraft that can properly land and carry out their mission. The data derived from the airfield evaluation also serves as the basis for any rehabilitation or upgrade effort required to make the bare base fully mission capable.

6.4. Airfield Planning Criteria. Design requirements for runways are based on MAJCOM and theater guidance. However, UFC 3-260-01, *Airfield and Heliport Planning and Design*, provides standardized criteria for layout, design and construction of runways, helipads, taxiways, aprons and related facilities, as well as dimensions for lateral clearance. Use this UFC during initial planning when determining runway criteria and layout requirements. Adjust the criteria as necessary in coordination with airfield management and wing flight safety offices based on theater and MAJCOM deployment requirements. **ETL 09-6**, *C-130 and C-17 Landing Zone (LZ) Dimensional, Marking, and Lighting Criteria*, provides dimensional, marking, and lighting criteria and guidance for planning, design, construction, and evaluation of landing zones (LZ) for aircrew training and contingency operations of C-130 and C-17 aircraft. Also, **ETL 09-1**, *Airfield Planning and Design Criteria for Unmanned Aircraft Systems (UAS)*, provides guidance and criteria for planning and designing airfields that support operations of UAS presently fielded. When airfields support large numbers of cargo aircraft, such as during joint operations and when Civil Reserve Air Fleet aircraft are used, consider AFPAM 10-1403, Table 1, *Aircraft Airfield Restrictions,* for evaluating airfield capabilities.

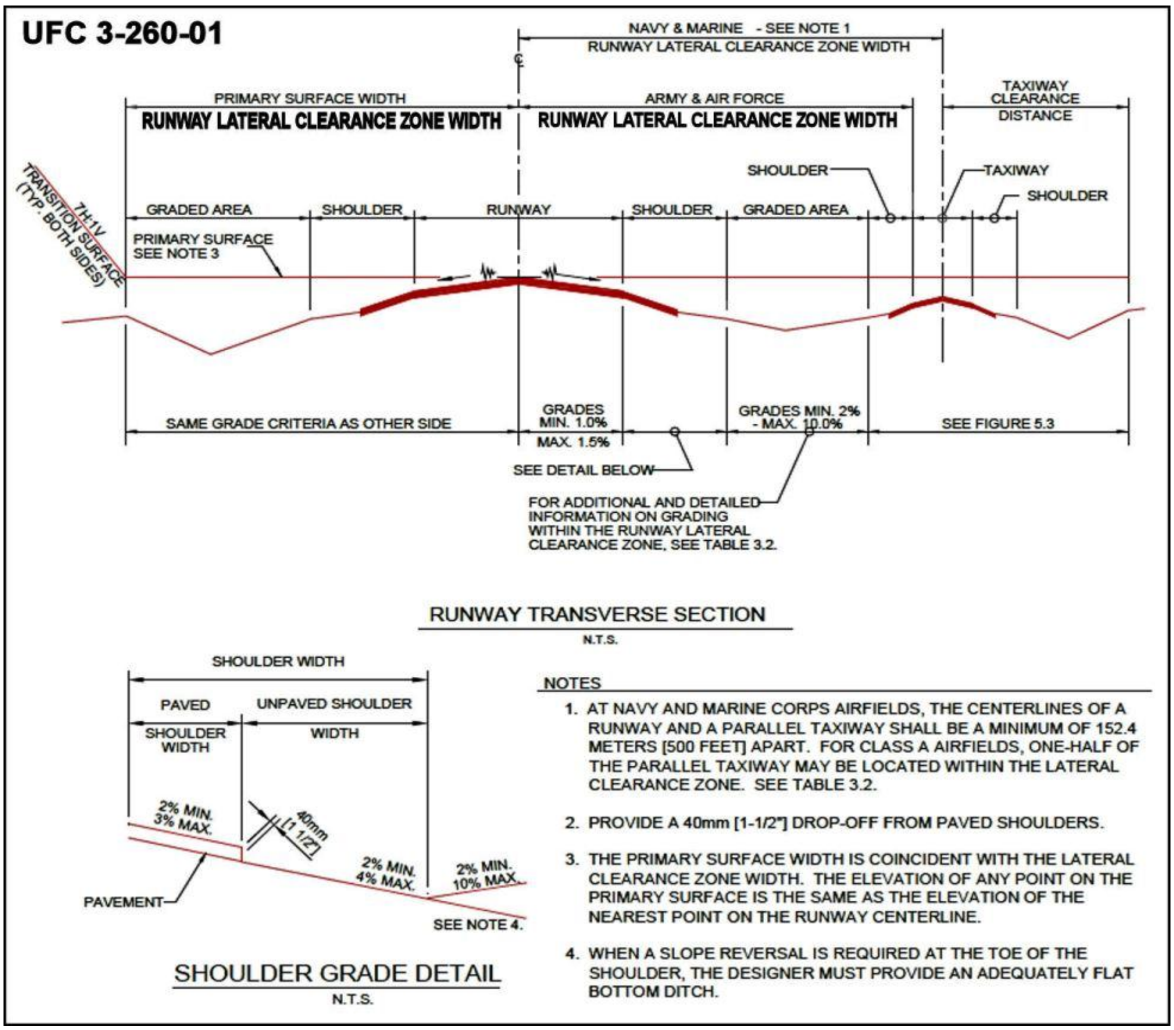
6.5. Runway Requirements. The essential features of a runway are its length, clearances (both on the ground and in the surrounding airspace) and surface condition. Required pavement strength is also important and is a function of aircraft type, weight and the amount of traffic expected. For general concepts and design criteria for airfield pavements, consult UFC 3-260-02, *Pavement Design for Airfields*. Also check aircraft-specific references and MAJCOM guidance for minimum runway lengths and widths by aircraft type and model. Although a normal landing or takeoff may use only part of the runway, adequate length and clearance is also needed to recover safely from emergencies. At each end of the runway is the clear zone. Runway end and clear zone details are illustrated in Figure 6.2.

Figure 6.2. Runway End and Clear Zone Details



6.5.1. In addition to the minimum runway dimensions, up to 1,000 feet of paved or compacted overrun should be provided at each end of the runway. Each end clear zone include the overruns. Clear zones should not contain any tree stumps, raised slabs, steep ditches or similar objects that would present a hazard to an out-of-control aircraft. The approach-departure clearance surface is an imaginary surface that forms the "floor" of the glide path. Except as shown in **ETL 09-6**, for C-17 and C-130 LZs, the approach-departure clearance surface begins 200 feet from the end of the runway (see **Figure 6.2**). It rises at a gradual slope from both ends of the runway, extending for several miles. No tree, utility pole, water tower, or elevated terrain feature should penetrate the approach/departure surface. In addition to the end clear zones, lateral runway clearances are also important safety features, especially when aircraft encounter control problems or strong crosswind conditions. The runway lateral clearance zone's lateral limits coincide with the limits of the primary surface (**Figure 6.3**). The ends of the lateral clearance zone coincide with the runway ends. The lateral clearance zone width is measured perpendicularly from the centerline of the runway and begins at the runway centerline. The clearance zone width is 1000 feet unless **ETL 09-6** criteria apply. The ground surface within this area must be clear of fixed or mobile objects. Runway shoulders, which should always slope away from the runway, are generally paved at permanent bases. At bare bases, runway shoulders should at least be dust stabilized. Extending out from the shoulders on both sides of the runway is a graded area. As a minimum, this area is rough graded to the extent necessary to minimize damage to aircraft. Slopes are to be as gradual as practicable and avoid abrupt changes or sudden reversals. Taxiing aircraft, fire emergency vehicles, aircraft arresting systems and navigational aids (when essential for their proper functioning) may be allowed in the runway lateral clear zone.

Figure 6.3. Runway Lateral Clearance Zones



6.5.2. Runway surfaces that are usable during initial bare base operations must be monitored and repaired as necessary to support continued sortie production. Additionally, bare base airfield management and maintenance programs should include regularly scheduled runway, taxiway and ramp sweeping as well as debris collection. This will minimize the damaging effects of the environment on aircraft operating in an austere location. Planners should ensure runway sweeping equipment is provided during the initial establishment of the bare base.

6.6. Taxiway Requirements. Bare bases that support a broad mix of aircraft require 75-foot wide taxiways. At a minimum, taxiways should be at least 60 feet wide to allow the use of C-17s during initial operations. Taxiway shoulders are normally paved/stabilized: 10 feet wide for fighter aircraft and 25 feet wide for most other aircraft. Taxiways require lateral clearance but no end clearance unless they serve as emergency runways. The lateral clearance to fixed and mobile obstructions is 200 feet from the taxiway centerline. This can be reduced per **ETL 09-6** for initial contingency operations with C-130s and C-17s.

6.7. Apron Requirements. There are no standard sizes for aircraft parking aprons. Aprons are individually designed to support specific aircraft and missions at each installation. The detailed dimensions are determined the by size, type and number of aircraft that require parking and maneuvering space and by the type of activity the apron serves. For bare base planning purposes, refer to AFH 32-1084, *Facility Requirements*, and UFC 3-260-01 for specific apron dimensions and aircraft clearance requirements.

6.7.1. Estimating New Apron Requirements. For broad planning purposes, the following method in AFH 32-1084 is used to estimate new apron requirements: Multiply the wingspan of the selected aircraft by its length. Multiply the product by a factor of 5.3 (use a factor of 4.4 for fighter-type aircraft). Example: To estimate apron requirements for 10 C-141 aircraft, multiply: 48.8 m x 51.3 m x 10 aircraft x 5.3 factor = 133,000 m2 of apron needed. This is a planning tool for sizing new aprons only. **Do not use it to estimate the number of aircraft (specifically, large aircraft) that can park on an existing apron.** Many variables (e.g., length, width, and taxi lane locations) determine an existing apron's suitability to support specific aircraft types. At existing bases, develop a conceptual aircraft parking plan to determine the apron square meter requirements.

6.7.2. Parking Aircraft on an Existing Apron. Operational aircraft are parked on mass aprons, strip aprons, or where authorized, on dispersed stubs. To determine how many operational aircraft require apron space, proceed as follows: Begin with 100 percent of the assigned aircraft as established by official OPLANs; from this subtract any aircraft that are located on separate aprons, such as alert aircraft. Subtract the aircraft that are normally located in maintenance hangars under maintenance schedules. And finally, subtract any aircraft that are parked elsewhere on existing pavement or hardstands. Following are other factors affecting the size and configuration of aprons for operational aircraft:

6.7.2.1. Aircraft Parking Arrangements. Aircraft are generally parked in rows on an apron and spaced according to their dimensions (**Table 6.1**) and specific clearance requirements. This spacing permits aircraft to move in and out of parking places under their own power. **Figure 6.4** illustrates a typical parking arrangement. Parking arrangements should be studied carefully to achieve the parking layout that requires the least amount of pavement per parked aircraft.

6.7.2.2. Fighter Aircraft. Fighter-type aircraft are often parked at a 45° angle (**Figure 6.5**). This is an efficient way to achieve adequate clearance to dissipate the temperature and velocity of jet blast to levels that will not endanger aircraft or personnel; that is, about 38° C (100° F), and 56 kilometers per hour (30.4 knots).

Table 6.1. Fixed-Wing Aircraft Dimensions

Aircraft[1]	Wingspan		Length		Height	
Type	Meters	Feet	Meters	Feet	Meters	Feet
B-1	22.7 to 41.7	77.8 to 136.7	46.0	150.7	10.3	33.6
B-52	56.4	185.0	47.8	156.6	12.4	40.8
C-5	67.9	222.7	75.6	247.8	19.9	65.1
C-9	28.5	93.4	36.4	119.3	8.4	27.5
MC-12	17.6	57.9	14.8	48.7	4.3	14.3
C-17	51.8	170	52.7	173	16.8	55.1
C-130	40.4	132.6	30.4	99.5	11.7	38.5
KC-135	39.9	130.8	41.5	136.2	12.7	41.7
KC-10	50.4	165.3	55.5	182.1	17.7	58.1
C-137	44.4	145.7	45.1	147.7	12.8	41.8
C-141B	48.8	160.0	51.3	168.4	12.0	39.3
E-3	44.4	145.7	46.6	152.9	12.9	42.2
E-4	59.7	195.7	70.7	231.8	19.6	64.3
A-10	17.5	57.5	16.2	53.3	4.5	14.9
F-5	8.5	28.0	15.8	51.7	4.0	13.2
F-15	13.0	42.8	19.4	63.8	5.9	19.2
F-16	10.0	32.8	14.5	47.6	5.0	16.4
F-22	13.6	44.5	18.9	62.1	5.1	16.6
F-35	10.7	35	15.4	51.1	4.6	15
Note 1: Dimensions vary between different models and configurations of aircraft.						

Figure 6.4. Typical Aircraft Parking Arrangement

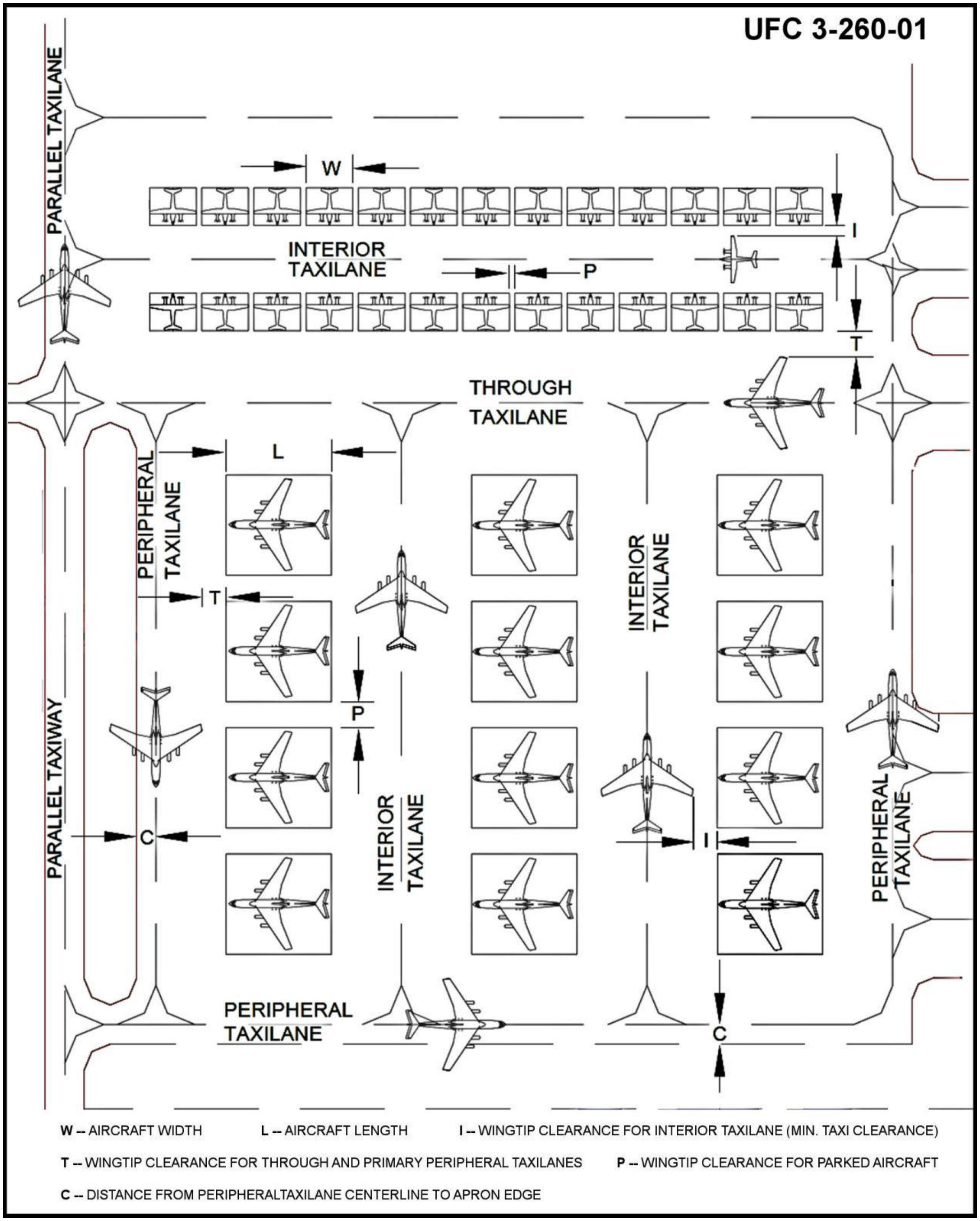
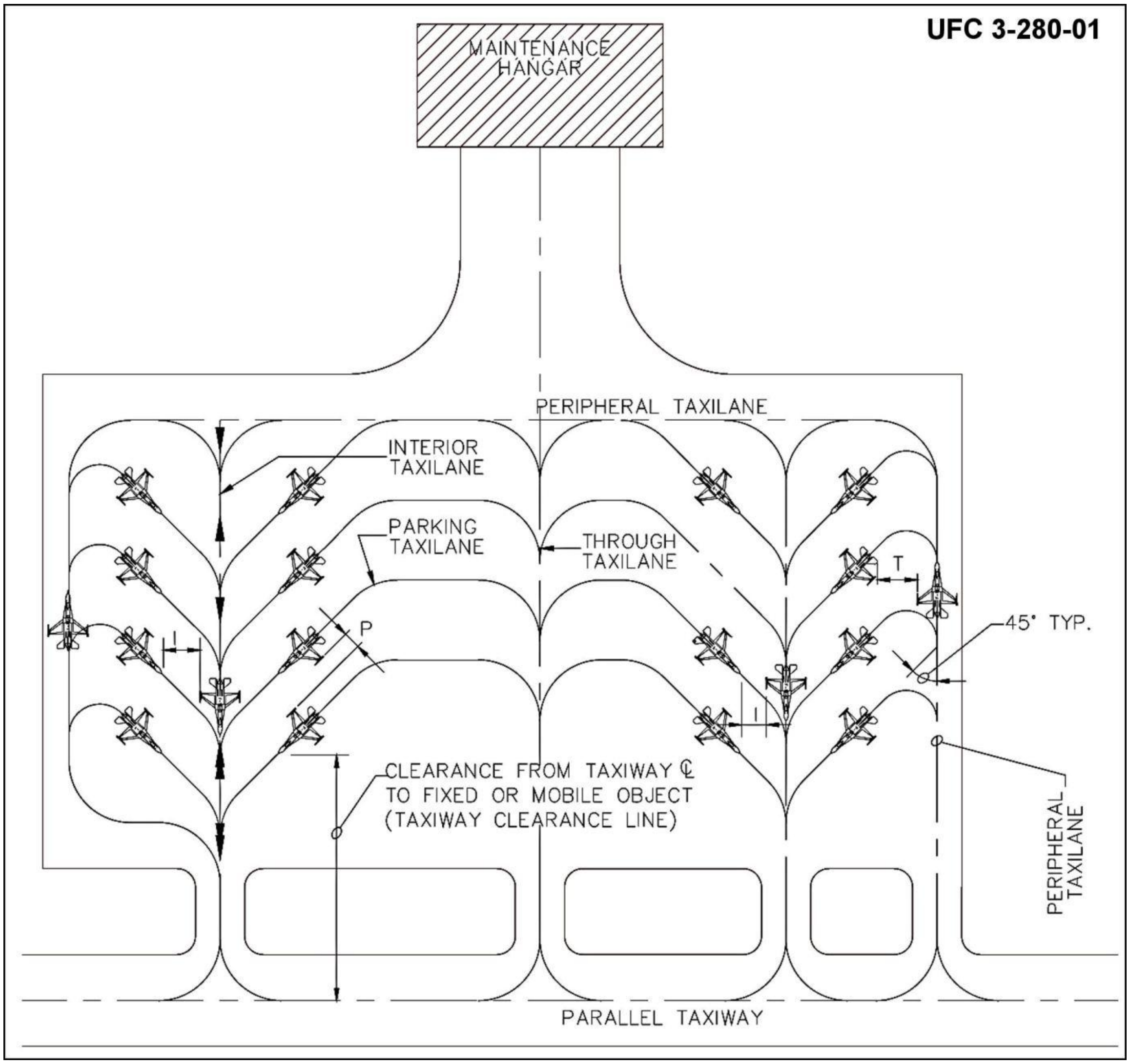


Figure 6.5. Fighter Aircraft Parked Diagonally on Apron



6.7.2.3. Rotary-Wing Aircraft. Mass parking of rotary-wing aircraft will require an apron designated for rotary-wing aircraft. Parking for transient rotary-wing aircraft at aviation facilities where only a few rotary-wing aircraft are assigned, may be located on aprons for fixed-wing aircraft. As with fixed-wing aircraft aprons, there is no standard size for rotary-wing aircraft aprons. Rotary-wing aircraft at Air Force facilities are parked in a layout similar to that of fixed-wing aircraft. Parking space, taxilane, and clearance dimensions will be based on the rotor diameter of the specific aircraft assigned to the facility. The wingtip clearance criteria provided in AFH 32-1084 is preferred. However, the Army criteria in UFC-3-260-01 may be used for all rotary wing aircraft except CH-53 and CH-54 (**Figure 6.6**). Air Force rotary-wing parking apron dimensions are based on the aircraft dimensions and separation distances for parked helicopters given in **Table 6.2**. For a rough estimate of the apron area needed, obtain the block area each helicopter occupies by multiplying its operating length by its operating width, then multiply each block area by 13. The apron is usually part of, or contiguous to, the main airfield apron.

6.7.2.4. Taxi Lanes. Interior and peripheral taxi lanes must exceed the required width for aircraft parked in the area if larger aircraft must taxi through en route to docks, hangars, or pads. Example: If E-4s taxi past a ramp of F-16s, taxi lane should be based on the wingspan of the E-4. Confine this width variation to the fewest taxi lanes possible.

Figure 6.6. Army Criteria for Type 1 Rotary-Wing Parking Apron (except CH-47)

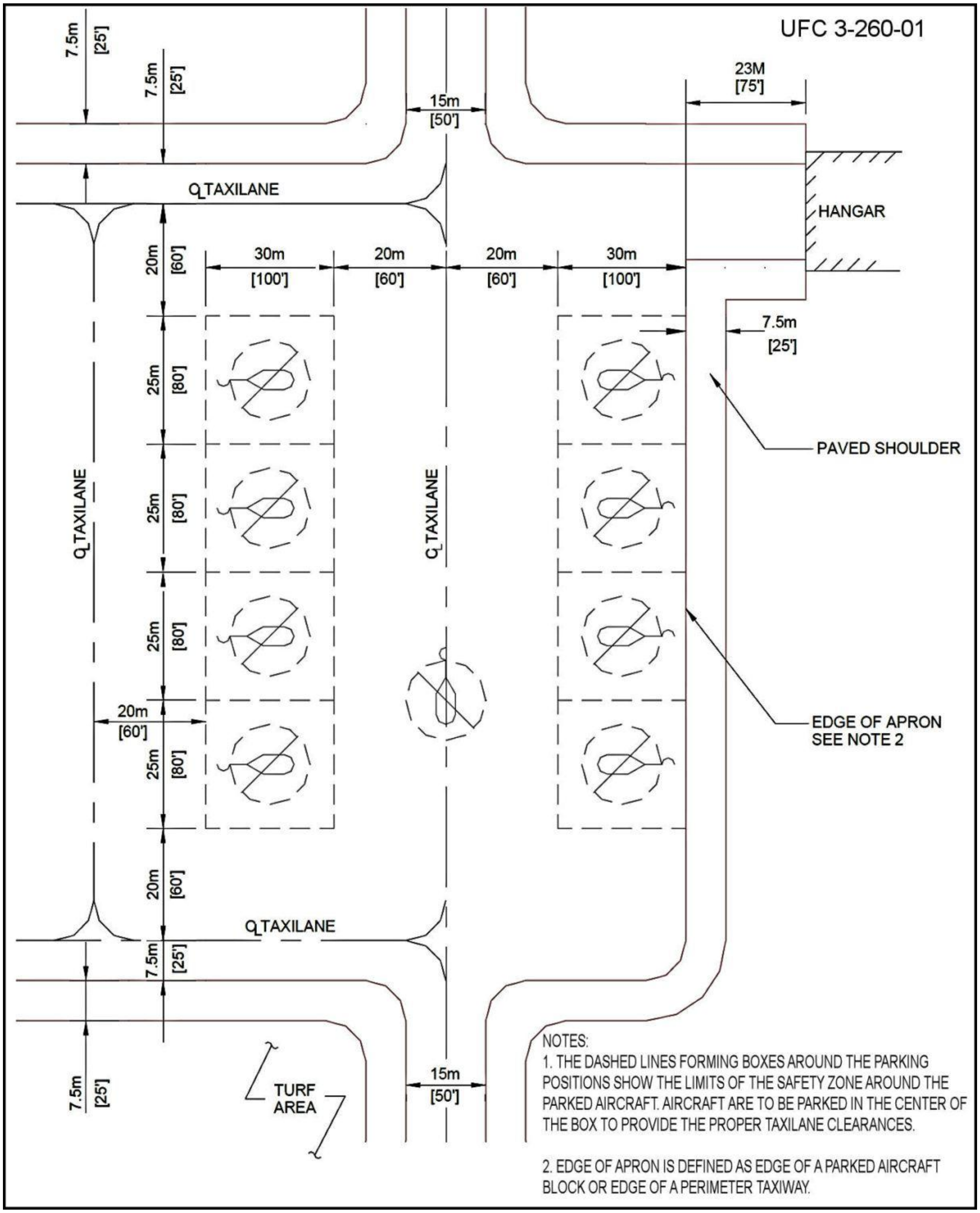


Table 6.2. Rotary-Wing Aircraft Dimensions, Distance, and Taxiway Width

Rotary-Wing[1]	Operating Length		Operating Width		Minimum Distance Between Centerline of Parked Aircraft[2]		Minimum Interior and Perimeter Taxi Lane Width[3]	
Type	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet
HH/MH-53	26.9	88.3	22.0	72.3	44.0	144.5	55.1	180.7
HH-1H	17.4	57.1	14.7	48.3	29.5	96.7	44.2	145.0
UH-1N57	17.5	57.3	14.6	48.0	29.3	96.0	43.9	144.0
UH/TH-1F/P	17.4	57.1	14.6	48.0	29.3	96.0	43.9	144.0
HH-60	19.8	64.9	16.4	53.7	32.7	107.4	40.9	134.2
CV-22	17.5	57.3	25.9	85.0	29.4	96.5	44.2	145.0

Notes:
1. Dimensions vary between different models and configurations of helicopters.
2. Distances represent two rotor diameters between center lines of parked aircraft.
3. Widths represent two and one-half rotor diameters for wheeled helicopters and three-rotor diameters for skid-mounted helicopters.

Ref: AFH 32-1084

6.7.2.5. Unmanned Aircraft Systems (UAS). In addition to planning and designing airfields that support manned aircraft, engineer planners may find it necessary to consider support for UAS operations as well. UFC 3-260-01, supplemented by **ETL 09-1**, provides basic criteria and requirements for UAS airfields. Like other aircraft, UAS are generally parked in rows on an apron and spaced according to their dimensions. See **Table 6.3** for specific UAS dimensions.

Table 6.3. Unmanned Aircraft Systems Dimensions

UAS	Wingspan	Length	Vertical Clearance	Height
Type	Feet	Feet	Inches	Feet
RQ-4A Global Hawk	116.2	44.4	19.5	15.2
RQ-4B Global Hawk	130.9	47.6	20.65	15.4
MQ-9A Reaper	66	36.2	20	11.8
RQ-1B/MQ-1B Predator	48.7(1)	27.0	5.3	6.9
MQ-1C ERMP Warrior	56.3	27.5(2)	TBD	9.9. (Level) (3)
RQ-7B Shadow 200	14	11.33	TBD	3.2

Notes.
(1) 55.25 feet for MQ-1B Block 10 & 15.
(2) 29 feet with Alpha Probe attached.
(3) 10.32 feet for uneven surfaces, allow for an additional 5 inches.

Ref: ETL 09-1

6.8. Airfield Lights. If airfield lighting is required, contingency forces can install the portable EALS available in BEAR.

6.8.1. The EALS can be used to support runway surfaces up to 150 feet by 10,000 feet and can be installed and secured on all types of surfaces, e.g., sand, frozen earth, mud, ice, asphalt and concrete. Packaged on six trailers (**Figure 6.7**), the system is air transportable, fitting within the space of three standard-sized transport pallet positions. The system includes runway edge lighting, approach lighting, threshold/end lighting, taxiway lighting, precision approach path indicator lights, distance-to-go marker lighting and obstruction lighting. Also included are a regulator, control panel, numerous transformers and various lengths of cable.

6.8.2. A six-person crew can normally layout and install the EALS on a minimum operating strip (50 feet by 5,000 feet) in approximately 2½ hours. Further details on setting up and operating the system can be found in **AFH 10-222, Volume 7**, *Emergency Airfield Lighting System (EALS,)* and Technical Order (T.O.) 35F5-3-17-1.

Figure 6.7. EALS Trailers

6.9. Aircraft Arresting Systems. While there are several types of aircraft arresting systems in the AF inventory, the MAAS is the type most often used in a bare base situation. The MAAS can be installed either by RED HORSE or Prime BEEF personnel.

6.9.1. The MAAS consists of two, trailer-mounted rotary friction energy absorbers (**Figure 6.8**). Its primary purpose is to provide for rapid deployment of aircraft recovery capability. The MAAS enables high cycle arrestment of hook-equipped tactical aircraft on airfields not having a compatible, permanently installed arresting system or those that have been expediently repaired after base attack. The MAAS is easily transportable by air or land and can be set up on various surfaces ranging from soil to asphalt to concrete. Each MAAS is equipped with a BAK-12 energy absorber.

Figure 6.8. Mobile Aircraft Arresting System (Towed)

6.9.2. While the MAAS is capable of bidirectional engagements, the basic MAAS is configured for unidirectional engagements of aircraft weighing up to 40,000 pounds and does not allow for wide-body aircraft operations, nor does it provide for both approach and departure end engagements. A MAAS upgrade kit has been developed to overcome these limitations. The kit employs a lightweight fairlead beam which permits the MAAS trailers to be moved back a maximum of 200 feet from the runway edge and improves the overall capability of the system. The kit contains two 1,500-foot nylon tapes, two lightweight fairlead beams and numerous anchoring components. All the items except the fairlead beams are organized in reusable shipping containers, and the entire kit is trailerized and air transportable.

6.9.3. The size of the MAAS installation crew and the time required to install the system will be dictated by the contingency situation. However, on average, an experienced 12-person crew should be able to install the MAAS in less than one hour.

6.9.4. The MAAS is currently an optional BEAR equipment UTC. Detailed installation and operating instructions for the MAAS are contained in AFH 10-222, Volume 8, *Guide to Mobile Aircraft Arresting System Installation*, and T.O. 35E8-2-10-1, *Arresting Systems, Aircraft, Mobile*.

6.10. Navigational Aids (NAVAIDS). If not already available at the bare base, NAVAIDS must be installed. The basic criteria for locating NAVAIDS are listed below. Final siting and installation are the responsibility of communications organizations. Whenever possible, install NAVAIDS in accordance with UFC 3-260-01.

6.10.1. Tactical Air Navigation (TACAN). TACAN should be located no closer than 500 feet from the runway centerline.

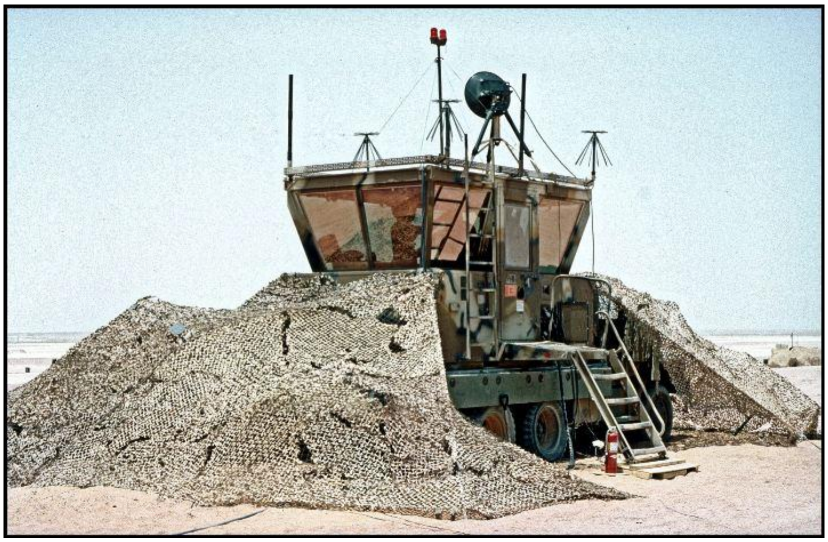
6.10.2. Radio. The physical location is flexible. A clear area for the scope antenna is required.

6.10.3. Radar Approach Control (RAPCON). Should be located a minimum of 500 feet from the runway centerline in a clear area where both approaches can be observed. The search antenna should be clear in all directions.

6.10.4. Mobile Air Traffic Control Tower. The mobile control tower (**Figure 6.9**) should be located a minimum of 500 feet from the runway centerline in a location which provides visual surveillance of all taxiways and runways.

6.10.5. Wind Cone. Should be located in an area visible to taxiing aircraft and should be at least 400 feet from the centerline of the runway.

Figure 6.9. AN/TSW-7 Mobile Control Tower



6.11. Aircraft Revetment. Enemy air, artillery, rocket and ground attacks against a bare base are likely to concentrate on aircraft which are by far the most lucrative and, when parked in the open, the most vulnerable targets available. Consequently, when the bare base site is located in a high-threat area, plan to provide revetments for the protection of parked aircraft (**Figure 6.10**).

6.11.1. Revetment Protection Features. Revetments protect parked aircraft from three dangers. First, they block shrapnel and deflect the blast from near misses by enemy aerial munitions and indirect fire weapons (artillery, rockets and mortars). Second, revetments screen aircraft from direct fire weapons on the ground. Third, revetments can prevent chain reaction explosions from one aircraft to the next. Dispersed revetment cells on separate parking pads (**Figure 6.11**) provide greater protection from air attack because they are point targets rather than line targets. Where dispersed revetment parking is not possible, revetments can be erected on the mass-parking apron in one or more of several cluster arrangements (**Figure 6.12**). The "U" shape cluster arrangement could be erected along a taxiway if AM-2 matting is available for parking pads. The multiple groups, "H" shape cluster arrangement provide each aircraft protection on three sides and have no line-of-sight to other parked aircraft. Line of sight parking posed a problem in Vietnam where parked aircraft were occasionally destroyed despite revetments because forward firing weapons on one aircraft pointed directly at other parked aircraft. The drive-through cluster layout shown in **Figure 6.12** allows quick entry and exit, but lacks the protection of a third wall. With proper positioning of the drive-through clusters, aircraft in adjacent rows still have line-of-sight protection.

Figure 6.10. Typical Revetment Installation at a Bare Base

Figure 6.11. Dispersed and Non-dispersed Revetment Cells

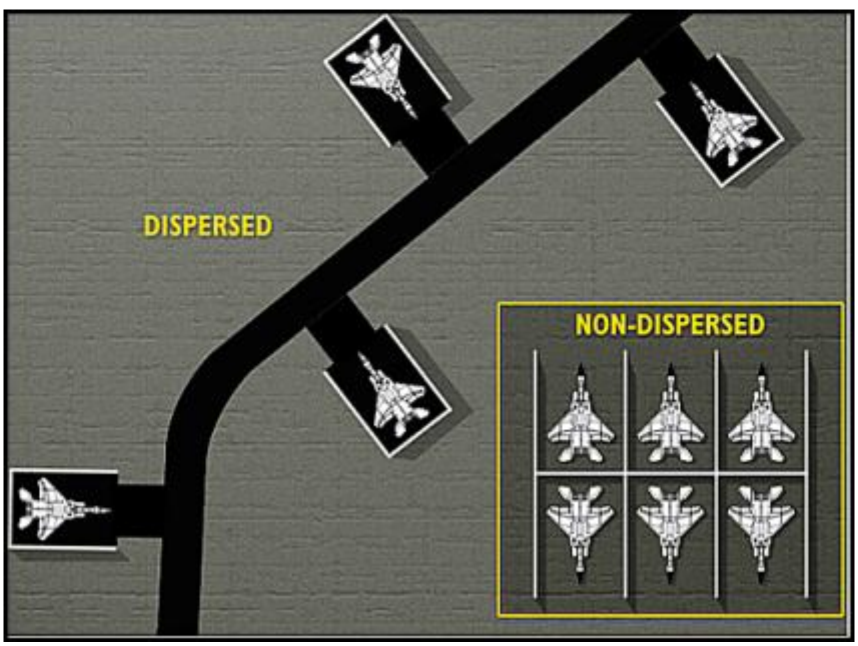
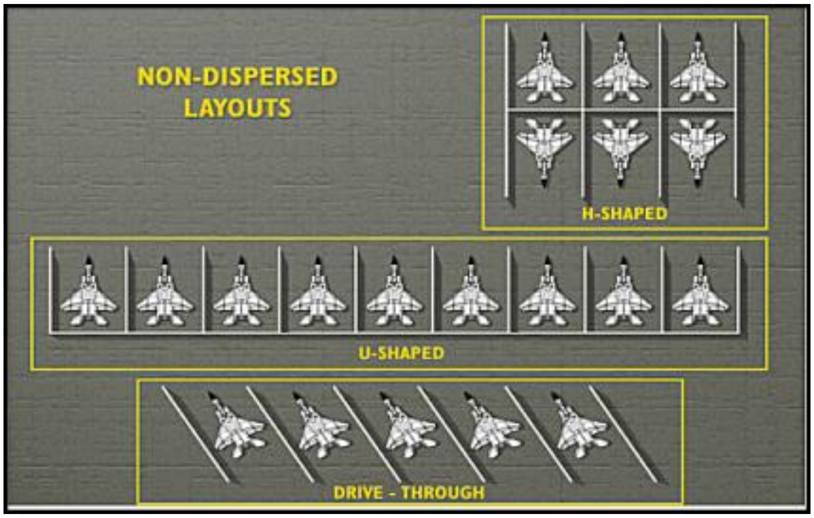


Figure 6.12. Cluster Arrangements for Aircraft Revetments



6.11.2. Standard Revetments. Several types of revetment systems are available; however, the one most likely to be available is the B-1 Revetment Kit. Although no longer in the BEAR package, the revetments are available as theater WRM assets. A standard kit contains 21 sections, each 12 feet long, and provides 252 linear feet of steel bins that are 16 feet high and nearly 7 feet wide. For bare base planning, one revetment kit is required for one tactical aircraft. Two revetment kits are required for each cargo or strategic aircraft; however, since two B-1 kits do not provide sufficient material for dispersed revetment cell construction, one of the cluster arrangements shown in **Figure 6.13** must be used for large aircraft. Revetments are assembled from 16- and 18-gauge corrugated steel panels pinned together with ¼-inch diameter rods (**Figure 6.14**). Assembled in place, the bins must be filled with soil, sand, or gravel. Detailed assembly instructions, list of materials, packing information and equipment required for B-1 assembly are contained in T.O. 35E4-170-2, *Aircraft Revetment Kit, Type B-1*.

Figure 6.13. B-1 Revetment Being Assembled

Figure 6.14. B-1 Revetment Being Pinned Together

6.11.3. Non-standard Revetments. Non-standard aircraft revetments can be constructed from shipping containers, timber cribs, retaining walls of wood or matting, berms of piled earth or soil cement and sandbags. Also, several other revetting systems are commercially available and employed by other military services (**Figure 6.15**). See **AFH 10-222, Volume 14**, *Guide to Fighting Positions, Obstacles, and Revetments*, for detailed employment methods and assembly instructions for revetments.

6.11.4. Critical Airfield Facility Revetments. Coordinate with other base agencies to determine which airfield facilities should be protected by revetments. Facilities commonly protected include utility plants and substations, squadron operations, command posts and communications, to name a few. When standard revetment materials are in short supply, it may be necessary to depend on non-standard expedient revetments to protect equipment essential to sortie generation.

Figure 6.15. Commonly Used Commercial Revetments

Chapter 7

ELECTRICAL UTILITY SYSTEMS

7.1. Introduction. BEAR electrical packages consist of both high- and low-voltage systems. Traditionally, high-voltage systems are associated with large (1,100-person) base populations; low voltage systems primarily with smaller (550-person) base populations. As new assets come into the inventory, low-voltage systems are being upgraded to high-voltage capability. High-voltage generators are 3-phase, 4,160 volt primary distribution and low-voltage system are (120/208 volt) (**Figure 7.1**). High-voltage systems must be used when ECUs are deployed.

Figure 7.1. Typical BEAR Low-Voltage Generator

7.2. Overview. The chapter provides a brief discussion of planning for electrical systems and power plant dispersal and environmental considerations. For specific operator and technician-level information on BEAR electrical power assets, see **AFH 10-222 Volume 5**, *Guide to Contingency Electrical Power System Installation*.

7.3. General Guidance.

7.3.1. Dispersed Layout. For maximum efficiency of both people and equipment, the optimum mode of operation is to generate all the primary power at a centrally located power plant. However, a dispersed layout could prevent the total loss of generating capability in an area with a high-threat of attack. Plan on providing separate power plants, each separated by distances of 1,500 to 3,000 feet. Plants should be electrically tied together to allow a back-feed capability in the event of enemy bomb damage. It also allows operators to switch generators off during periods of light load and maintenance shutdown.

7.3.2. Environmental Effects. High ambient temperatures can adversely affect the performance of BEAR electric generator sets. To help reduce these effects, generator sets should be located and spaced so that the prevailing winds (**Figure 7.2**) will carry the heat away from adjacent generators and occupied areas. It is recommended that these sets be shaded from direct sunlight to prevent engine overheating, derating output and generator shutdown. Additionally, these sets should be protected, to the highest practical extent, from blowing dust and sand entering cooling air intakes. Air intakes must not be restricted or heat will buildup and cause loss of power. **This cannot be overemphasized.** Protect air intakes and exhaust ports on non-operating sets and fuel and oil tanks during servicing operations. An accelerated maintenance schedule must be expected when operating in high-temperature and arid environments. A pressure washer for cleaning radiators should be procured early on during the initial stages of beddown. Keeping radiators clean is essential to providing reliable power. Specific recommendations are also in AFH 10-222, Volume 5, but from an overall perspective planners can avoid some problems by considering the following guidelines:

7.3.2.1. Locate generator sets as far apart as feasible, consistent with other requirements.

7.3.2.2. Place generator sets on a line perpendicular to the prevailing wind direction.

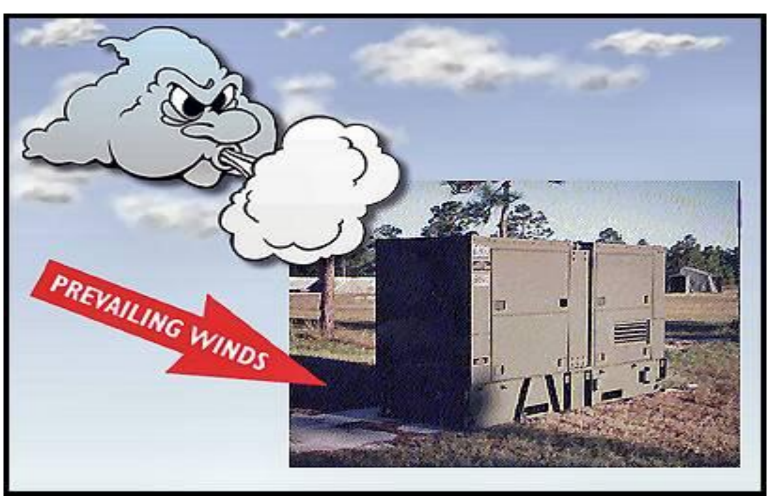
7.3.2.3. Avoid placing generator sets in direct sunlight, if possible. A shelter may have to be provided to shield units from the sun. Camouflage netting and screening can reduce heat-related failures on bladders and other major components, but should be configured to ensure they do not insulate the equipment and hold in the heat.

7.3.2.4. Do not attempt to bypass the thermal control, since excessive temperature can cause catastrophic damage.

7.3.2.5. Where possible, reduce the effects of blowing sand and dust by using a shelter.

7.3.2.6. High ambient temperatures influence the maximum allowable current in cables. Heat buildup within current-carrying conductors will not dissipate rapidly in high-temperature environments. Therefore, current-carrying ability of conductors must be reduced when installed in areas of high ambient temperature since an excessive increase in cable temperatures will cause insulation failure. High ambient temperatures also affect protective devices such as fuses, fused cutouts, time delay fuses, circuit breakers and motor control contactors. Additionally, sand and dust tend to build up in these electrical components causing operational problems. Finally, the standard methods for power plant or distribution system grounding will not offer adequate or safe grounding because of the extremely poor electrical conductivity of sand, sandy soils, or rocky soils when dry.

Figure 7.2. Generator Positioned to Allow Prevailing Winds to Disperse Heat



7.3.3. Electrical Distribution. Initial electrical power is normally provided to command posts, squadron operations facilities, control tower, communications systems and other mission-essential facilities using mobile, low-voltage MEP generators. Once the high-voltage power plant and distribution system are installed, electrical power can be provided to non-essential facilities, and the MEP generators can be used for emergency backup. A typical electrical distribution system for an 1100-, 2200-, and 3300-person camp is illustrated in **Figure 7.3** through **Figure 7.5** During construction, the base civil engineer may make an operational risk management decision to leave some or all of the high-voltage cable on the surface if soil conditions, time or equipment constraints prevent its immediate burial. But, engineers must take other measures to mitigate the risk of personnel injury or damage to the cables. At a minimum, bury or otherwise protect cables crossing roads and high-traffic walkways. Keep detailed maps of underground lines and the locations of splices and ensure utilities and communications personnel are aware of the layout. Locally constructed overhead primary distribution systems are not recommended because of the difficulty in designing and constructing a safe system given limited available materials and engineer labor.

Figure 7.3. Electric Distribution for an 1100-Person Camp (Typical)

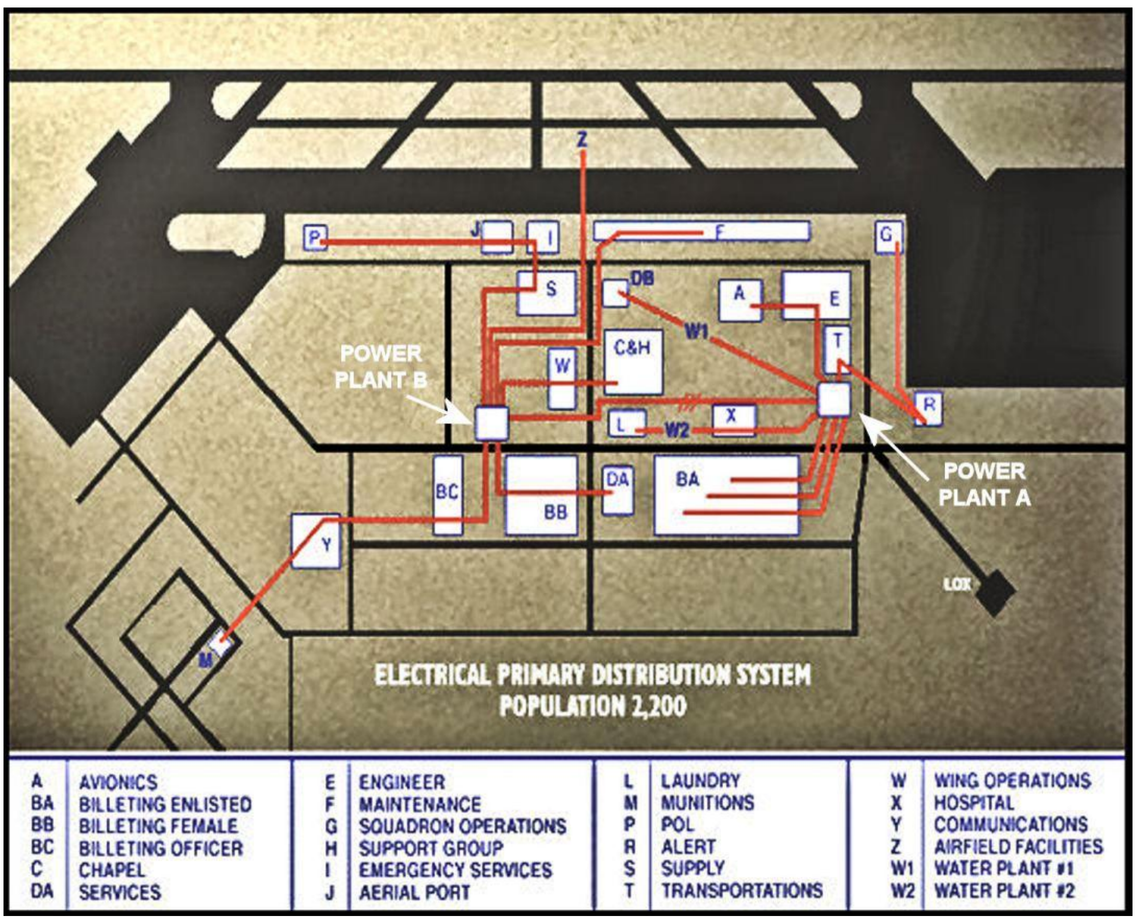


Figure 7.4. Electric Distribution for an 2200-Person Camp (Typical)

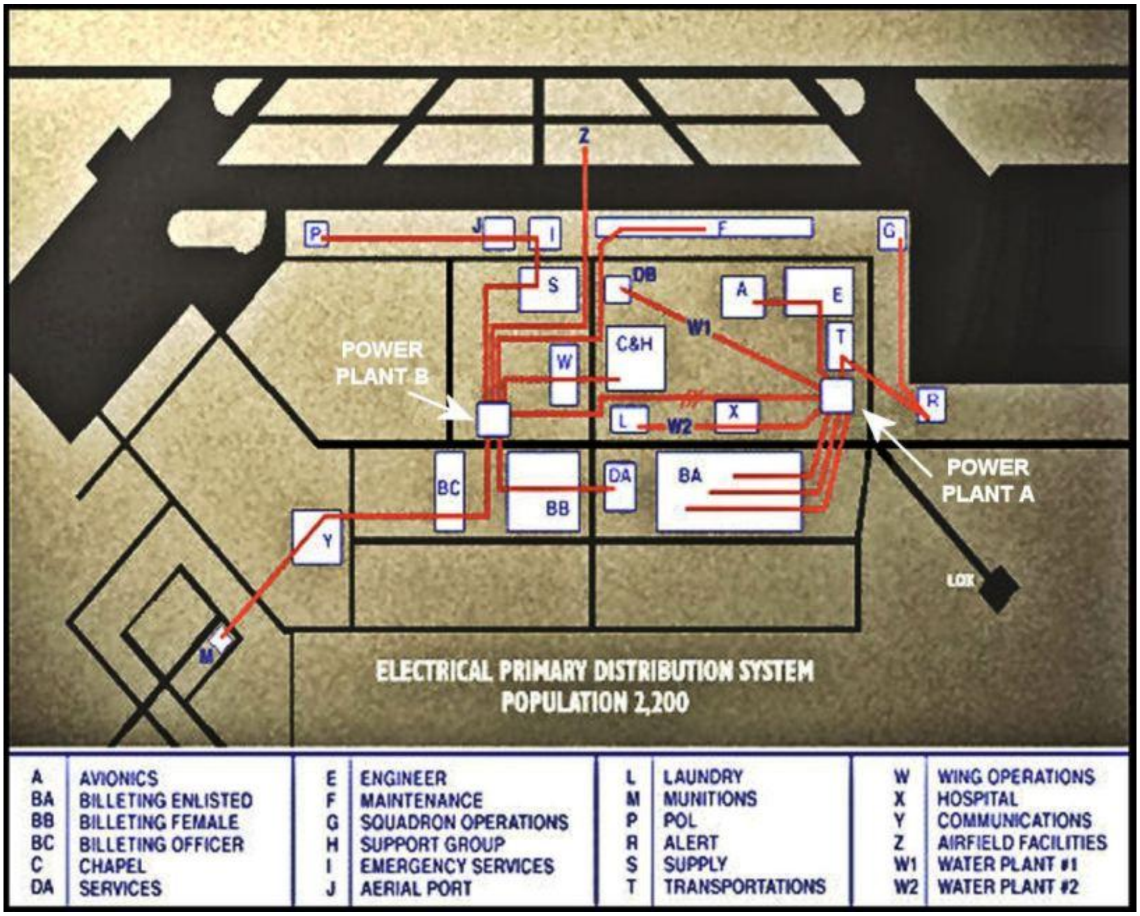
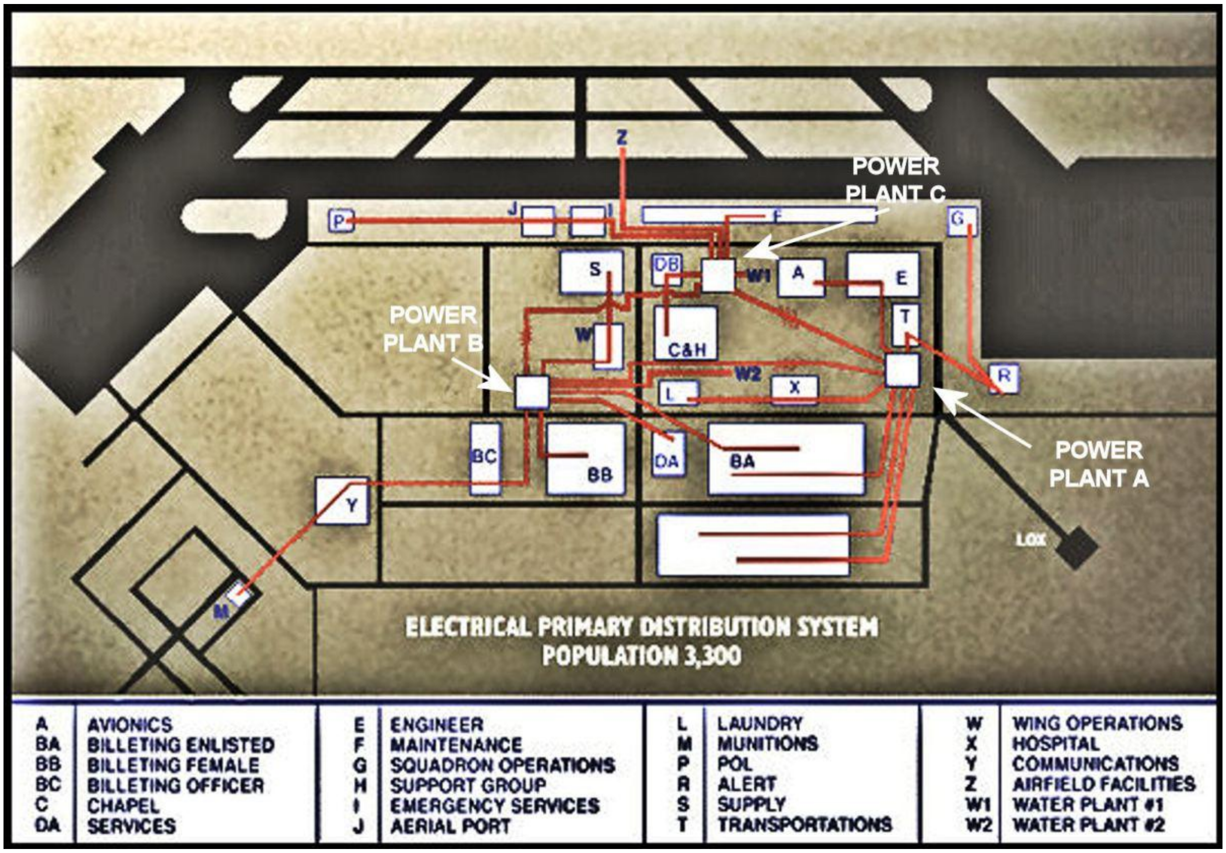


Figure 7.5. Electric Distribution for an 3300-Person Camp (Typical)



7.3.4. Power Conditioning. If power conditioning is required, the user must provide this capability with the specific equipment that requires conditioned power. Most BEAR assets work well with most types of incoming power, and at worst "hiccup" a bit when the power drops out or fluctuates. Computers, on the other hand, can corrupt data or stop working when subjected to power fluctuation. Equipment such as power supply units, surge/spike filter power boards, power filters and uninterrupted power supplies may all be used to overcome surges, sags, spikes and outages.

7.3.5. Host Nation Power. A major assumption often included in exercise scenarios—and in this chapter—is that host nation electric power will not be available for, or is not compatible with, bare base power demands. However, many countries do have limited electric power distribution networks that would be useful when troops start to build the base. If host nation power is available, plan to use it to supplement BEAR generation capability; this will vastly reduce fuel consumption. The base must, however, maintain its own internal generation and distribution system in case host nation power is cut off. Most power grids outside the US and Canada use power generated at 50 cycles or hertz (Hz), single- or 3-phase, which can be used in many cases to power electric lights and heating elements. However, only equipment specifically designed as compatible with 50 Hz power should be connected. Most AF equipment and utilities are designed for 60 Hz, and operating at 50 Hz will cause permanent damage. **Table 7.1** lists electric power characteristics available in various countries around the world. For additional quick reference, **Attachment 2** lists the diversity of electric power and its characteristics in various countries of SWA. It should be noted that the quality of power in SWA is generally poor, frequency stability and voltage regulations are often substandard and high-level voltage transients are possible.

Table 7.1. Air Base Commercial Power Supplies

Country	3-Phase System			1-Phase System		
	Voltage	Wire	Frequency	Voltage	Wire	Frequency
Belgium	220/380	4	50 Hz	110/220	2	50 Hz
Canada	550 or 220	4	60 Hz	220	2	60 Hz
Denmark	220/380	4	50 Hz	*	**	50 Hz
France	220/380	4	50 Hz	220	2	50 Hz
Germany	220/380	4	50 Hz	220	**	50 Hz
Greece	220/380	4	50 Hz	*	2	50 Hz
Italy	220/380 or 127/220	4	50 Hz	220	2	50 Hz
Netherlands	220/380	4	50 Hz	220	2	50 Hz
Norway	220 220/380	3 4	50 Hz 50 Hz	220 240	2	50 Hz
Portugal	220/380	4	50 Hz	120/240	2	50 Hz
United Kingdom	240/416	4	50 Hz		**	50 Hz
United States	120/208 or 277/480	4	60 Hz		3	60 Hz

* 1-Phase supply generally possible.
** 2 Plus Ground

NOTE: Voltages on 3-phase systems shown as 220/380; for example, indicate 220 volt line to neutral and 380 volt line to line.

7.4. Low Voltage Electrical System. The urgency of most bare base deployments dictates that electrical utility lines and distribution panels be provided on the ground on short notice. This type system depends solely on the use of low-voltage generators. It is not sized to accept air conditioning loads, however it can provide lighting and duplex convenience outlets for billeting, organizational shop, administrative, office and command-level tents. These type systems depend primarily on 30-kW and 60-kW generators. Low-voltage electrical distribution systems provide open loop (one path of power flow to the load), 120/208-volt, 3-phase power.

7.4.1. Electrical Computation. Computations of generator demands and feeder peak loads are based on 4,500 watts or 4.5-kW per tent. That product is then multiplied by a 0.7 diversification factor. MEP generators are capable of 10 percent overloads for several hours at a time and should be able to handle peak loads. If the load exceeds the generator's capability, low priority branch circuits can be shed until a safe operating range is achieved.

7.4.2. Generators. A 550-person population can normally be powered by either two 60-kW or four 30-kW generator sets. Running generators is a labor-intensive operation. Engine failures and breakdowns will inevitably occur, and response and repair times will be lengthened due to field conditions. Fueling generators will be a constant task since typical day tanks must be refilled approximately every six to eight hours. Ideally, refilling generators should be accomplished using a refueling vehicle, but under contingency conditions, it may be necessary to resort to towed fuel trailers or even “jerry” cans.

7.5. High Voltage Electrical System. The high-voltage electrical system is basically composed of three major components: power generation, high-voltage primary distribution (4,160-volt) and low-voltage secondary distribution (120/208-volt).

7.5.1. Power Generation. In many cases primary power will be obtained from 750-kW diesel-driven electric generator sets, like the MEP-012A (**Figure 7.6**), providing 3-phase, 4,160-volt, 60-cycle power. The MEP-012A generator is towable by most bare base vehicles and is air transportable. Normally, three generators are required to provide power to a 1,100-person base and a fourth generator is required to provide periodic rotational maintenance capability. These generators permit routine maintenance to be performed on all units on a preplanned basis without having to purposely shut down major portions of the base electrical system. Obviously, the number of generators required will depend on the mission and population at the particular location. Also supporting the power generation system is a predetermined set of spares and consumable used for performing required maintenance and routine operations.

7.5.2. Installation. Procedures for setting up power generation plants and primary and secondary distribution can be found in **AFH 10-222 Volume 5**.

7.5.3. Generator Plants. The controls for the generators are normally assembled on a panel located inside a small shelter system, an expandable shelter container, or TEMPER tent. Plan on manning generator plants around the clock with at least a two-shift operation. Electrical personnel can augment power production personnel in this regard. Also plan on providing a generator training program for personnel not fully familiar with the operation of the 750-kW units. Communications squadrons usually deploy with their own power production personnel. It is generally useful to try absorbing these personnel into the plant’s operation to help spread the workload over the entire power mission. Recommend the forward headquarters be contacted as soon as possible for sustainment manning once the total manpower requirements are determined. In addition, put consumable parts on order as soon as possible to start the logistics flow. Use the item listing attached to the support and spare boxes as a guide.

Figure 7.6. MEP-012A 750-kW Generator

7.5.4. Generator Fuel System. 10,000-gallon-size fuel bladders are provided for generator sets (**Figure 7.7**). The objective is to have approximately a 7-day fuel supply at each power generation plant. Ensure the fuel bladders are positioned equal to or higher than the fuel distribution manifolds. Fuel berms or dikes should not be built higher than necessary to contain the contents of the bladder in the event of a collapse. Excessively high berm walls pose siphoning and gravity feed issues that are hard to overcome in a field environment. Refer to **AFH 10-222, Volume 1**, AFPAM 23-221, *Fuels Logistics Planning*, and T.O. 37A12-15-1, *Collapsible Fuel Bladders*, for other fuel dike or berm construction details. Where feasible, convert temporary bladders to above ground steel tanks for long duration deployments.

Figure 7.7. Generators with 10,000-Gallon Fuel Storage Bladder

7.5.5. Interim Power Unit (IPU). The IPU is fielded to supplement BEAR high power UTC shortfalls. The versatile IPU has a prime power rating of 1100kW and provides 3-phase, 2,400-/4,160-volt 60-cycle power. It consists of a generator set housed inside a 40-foot ISO container mounted on a 40-foot trailer (**Figure 7.8**). The unit has sound-reduction features, switch gear, battery and starter components, shore power components, and a 300-gallon fuel tank. It has remote control capability and weighs approximately 52,000 pounds.

Figure 7.8. Interim Power Unit (IPU)

7.5.6. Electrical Computation. The layout of facilities (including maximum dispersed distance) should be compatible with the electrical distribution system assets available in the BEAR equipment packages. If deployment is to a low-threat area where maximum dispersal is not required, minimum spacing distances may be used between facilities. This non-dispersed pattern will reduce cable requirements considerably. In contrast, however, when facility layout is widely dispersed due to terrain features or other constraints, it may be necessary to have a sufficient stock of extra cables of different lengths so that some secondary circuits can be extended. **AFH 10-222, Volume 5** describes the power requirements for each element within a facility group, presents example feeder schedules and shows schematics of a basic electrical distribution system. The feeder schedule provides examples of the various electrical loads of different SDCs and methods of supplying power to air conditioners and to mobile electric power, where necessary.

7.5.6.1. Computation of electric feeder loads is accomplished using data from shelter configuration agencies and applying appropriate diversification factors. All loads are 3-phase. The total load for each SDC is determined by first adding all the shelter loads; second, diversifying this total by multiplying by seven-tenths (0.7); and lastly, adding either the heater or air conditioner load, whichever is larger (the heater and air conditioner should not run simultaneously). The resulting load is the total kVA load on the SDC. A quicker way to estimate requirements is to figure one SDC per every eight to twelve facilities (take into account that shelter occupants will invariably install and use personal electrical appliances).

7.5.6.2. If power is required in remote areas of the base, some facilities can be satisfied by: (1) running power from an adjacent shelter exterior receptacle, (2) fabricating a junction box to service one or more of the facilities simultaneously from one 60-amp connector on the SDC, or (3) using the generator on a TF-2 light cart (**Figure 7.9**) or similar lighting unit.

Figure 7.9. TF-2 Light Carts

7.5.6.3. The RALS also depend on power from a SDC or other source such as a remote area generator. Area lighting (flightline, supply areas, aerial port facilities) can be accomplished using a RALS (**Figure 7.10** and **Figure 7.11**). The RALS provides a flexible solution to support illumination requirements. It features 13 telescoping poles, 12 of which are positionable through the use of "left side" and "right side" cable loop assemblies emanating from the RALS container. The thirteenth pole is attached to the RALS container. Each pole is 15 feet high with one single 150-watt, 16,000-lumen, high-pressure sodium (HPS) lamp. Poles are positioned 125 feet apart on a flat plate with outriggers. "Left side/right side" lighting string length is 750 feet per side (comprised of two 375 feet RALS loop cord sections), for a total string length of 1,500 feet.

Figure 7.10. Remote Area Lighting System (RALS)

Figure 7.11. RALS Deployed

7.5.6.4. Water purification plants are shown on the base layout plan. Once these plants have been sited, an electrical installation team will determine exact locations of SDCs and MEP generators that support the water plants.

7.5.6.5. Sewage lift stations and treatment plants are indicated on the base water and sanitary layout plans. Electrical power must be provided from the nearest SDC.

7.6. Grounding. In any electric power generation and distribution system, appropriate electrical grounding of equipment such as generator sets, transformers, junction boxes and bus bars is generally very important to ensure safe and reliable operation of the system. Traditional guidance requires 25 ohms resistance to ground, or less, at all normally grounded locations. However, the nature of the soils in many locations will not permit this level of assured grounding with traditional ground rods or expedient techniques. In dry, rocky, or sandy regions, 25 ohms or less grounding to earth can only be obtained using more involved and equipment-intensive methods that may not be available to bare base engineers.

7.7. Future BEAR Electrical Power Generation and Distribution System. The AF is exploring several options as a “future” system of electrical power distribution as a replacement for 750kW generators. The new system will support contingency operations ranging in size from relatively small deployments to large operations of total electrical support. The US Army is currently using a prime power unit, the MEP-PU-810A, which was tested but not fielded by the AF. Testing and fielding of a final, deployable system may take several more years. In the meantime, the IPU addressed in paragraph 7.5.5. is being fielded to fill any BEAR high power UTC shortfalls.

Chapter 8

WATER UTILITY SYSTEMS

8.1. Introduction. In bare base operations it is absolutely essential to determine if a source of water, that can be made potable, is available before consideration is given to almost any other requirement.

8.2. Overview. This chapter addresses the sources, uses, treatment and distribution of water in arid and non-arid environments. Since water is generally scarce in an arid environment, it must be used wisely. Consequently, a portion of this chapter will be devoted to describing proper water supply and use in the context of a worst case situation—a bare base in an arid environment. The final portion of this chapter is on water system equipment and procedures.

8.3. Water Sources.

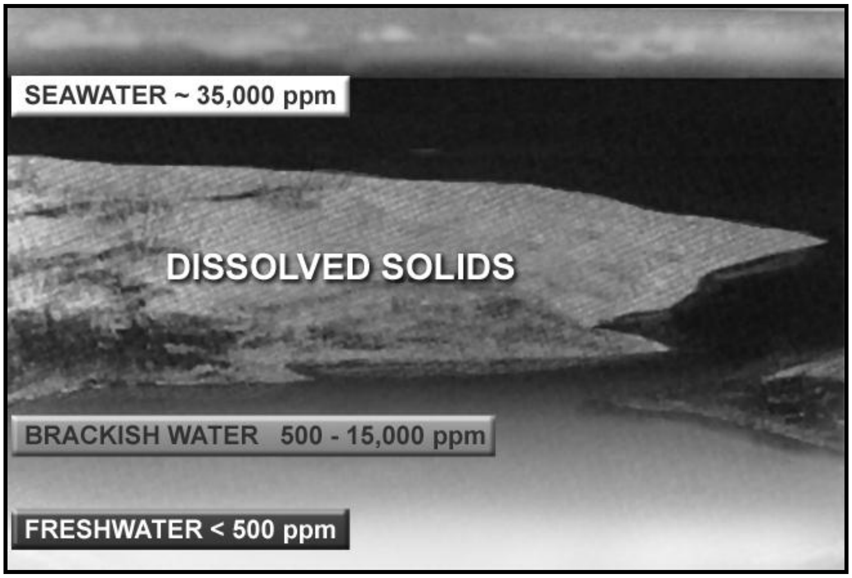
8.3.1. Non-Arid Environments. In non-arid (temperate, arctic and tropical) environments, water is generally readily available in streams, rivers and lakes. The water usually requires only clarification and disinfection to make it potable. Groundwater is also abundant and often can be used immediately after it is disinfected. However, groundwater near industrial areas should be tested for the presence of hazardous wastes and all water must be examined for the presence of human waste.

8.3.2. Arid Environments. Probably the most distinguishing characteristic of arid areas is the lack of water. Surface water is limited to a few rivers and intermittent streams that benefit from sparse rainfall. Except for limited areas, primarily along the coast, groundwater is also scarce and is generally unfit to drink because of the dissolved solids content. Because of the widespread unsanitary practices, all water in underdeveloped countries, no matter what the source, should be considered to be contaminated with disease-causing organisms until proven otherwise. As a result, a contingency force must be prepared to produce its own potable water and must constantly strive to conserve this mission-essential resource, regardless of the water's quality and ultimate use.

8.3.3. Seawater. Seawater obtained offshore at a location removed from a sewage outfall is normally relatively clean. It is salty and contains suspended particles of sand and bacteria. Seawater may be used without adverse effects for electrical grounding, housekeeping tasks, firefighting (although **not** in fire vehicles), some construction tasks, showering and laundering. It should not be used where continued use could corrode critical metal surfaces. When used for showers, laundries and personal hygiene purposes, it must be disinfected.

8.3.4. Brackish Water. Surface water and groundwater containing 500 to 15,000 parts per million (ppm) of dissolved solids are called ***brackish***. The solid content is much less than seawater (35,000 ppm) but is high enough to give the water a distinctively salty taste (**Figure 8.1**). Brackish water may contain dissolved salts. This makes the water difficult to lather (forms curds) and, when heated, leaves hard mineral deposits on the wetted surface of the container. As with seawater, brackish water may be used for construction, electrical grounding, firefighting and general housekeeping tasks. It is not generally recommended for those purposes where it is to be heated to near-boiling temperatures. Additionally, some aquifers may be contaminated by oil. Other less common contaminants, such as ammonia, arsenic and radioactive isotopes, may be encountered.

Figure 8.1. Dissolved Solids



8.3.5. Freshwater. Freshwater (less than 500 ppm of dissolved salts) has no apparent salty taste, but when found on the surface (river, stream, oasis), may contain suspended materials, dissolved minerals, fecal matter, bacteria and other disease-causing organisms. When obtained from local wells or the municipal water supply systems, freshwater may appear clean with no significant odor. Despite its appearance, such water sources may contain dissolved minerals, salts and bacteria. Disinfection through chlorination is often the only treatment required to make the local water drinkable. On the other hand, drinking freshwater containing significant amounts of dissolved salts may produce a laxative effect.

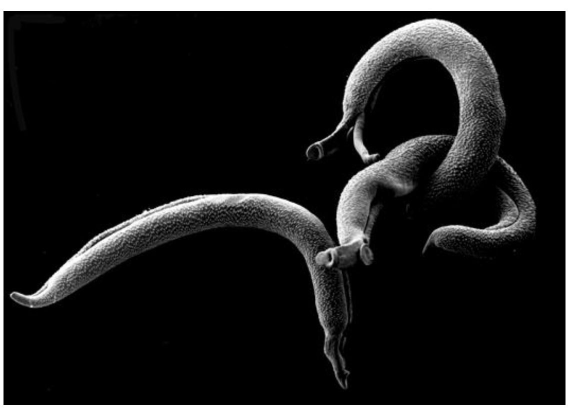
8.3.5.1. Freshwater can be used for most cleaning and nonconsumptive purposes without purification. Conventional water purification procedures are normally adequate to make most freshwater sources potable; however, when the dissolved solids content is too high, water should be purified by reverse osmosis treatment. To reemphasize a point made earlier; do not make the mistake of assuming that a particular water supply is safe. Some countries do not treat water to the standards required by the AF. To safeguard the health of the deployed forces, indigenous water sources must be tested before being declared suitable for human consumption.

8.3.5.2. Surface freshwater sources can also be a major health hazard. These waters, primarily rivers, often serve the indigenous population for the disposal of all forms of wastes (including human waste) and for that reason is a source of pathogenic organisms. Surface freshwater also harbors a variety of other organisms that may infect humans through bodily contact with the water (**Figure 8.2**).

Figure 8.2. Surface Freshwater Sources May Contain Infectious Organisms

8.3.5.3. Drinking water from a source such as depicted above is obviously dangerous. Even more health threatening are the blood flukes (small worms spawned by several types of snails) that cause a disabling disease known as Schistosomiasis. Prevalent in Africa and SWA, these immature worms (Schistosomes, **Figure 8.3**) are released from snails' bodies into the water. The worm penetrates the skin of people who are in the water to bath, swim, or do their laundry. Once in the body, these worms block circulation and cause scarring in the liver, bladder and intestines, giving rise to severe swelling. Schistosomiasis can occur in less than 30 days. Treatment for this disease is very painful and, to make matters worse, there is no vaccine for Schistosomiasis.

Figure 8.3. Schistosomes Worms



8.4. Water Use. Water consumption is based on the size of the deployed force and its consumption requirements. Joint Publication 4-01, *Joint Bulk Petroleum and Water Doctrine*, describes **essential** water requirements as: drinking, personal hygiene, field feeding, medical treatment, heat casualty treatment, personal contamination control, patient decontamination in CBRN environments, and in arid regions, vehicle and aircraft maintenance. When requirements exceed production, all but essential consumption should be reduced. After performing a preventive medicine risk assessment, commanders may decide to use nonpotable water for activities that generally use potable water (e.g. showering, laundry, etc). Various AF engineer panels have recommended that when mobile water treatment and distribution assets are used, the water-use planning factor should be 30 gallons per person per day (gpppd) at a bare base. If a permanent water treatment plant and adequate storage capability are available at the beddown location, a 60-gpppd factor may be used. A breakdown of the 30-/60-gpppd planning factor, by function, is shown in **Table 8.1**. A description of each of the functions follows the table as well as a discussion of ice requirements. Depending on location, climate and other factors, commanders may determine that these quantities need to be reduced to conserve water. **Note**: keep in mind that water consumption may be affected by considerations other than military populations. For instance, consumption by host nation labor forces, enemy prisoners of war or displaced persons (e.g. refugees). Planners should be aware of requirements and obligations that may arise from various international protocols, agreements and conventions at specific locations.

Table 8.1. Water Use Planning Factors

Functions	**Water Usage Factor (gal/person/day)**	
Potable Water	**Using BEAR Assets**	**Using Fixed Water Treatment Plant**
Drinking	4.0	4.0
Personal Hygiene	3.0	3.0
Shower	5.0	15.0
Food Preparation	4.0	5.0
Hospital	1.0	2.0
Heat Treatment	1.0	1.0
Nonpotable Water	**Using BEAR Assets**	**Using Fixed Water Treatment Plant**
Laundry	2.0	14.0
Construction	2.0	2.0
Graves Registration	0.5	0.2
Vehicle Operations	0.5	1.8
Aircraft Operations	2.0	3.0
Firefighting	2.0	4.0
10% Loss Factor	3.0	5.0
Total	**30.0**	**60.0**

8.4.1. Potable Water.

8.4.1.1. Drinking. Approximately four gallons of cooled drinking water will be provided each individual per day. Those engaged in strenuous physical activities will normally require this amount of water to maintain their strength during the hottest period of the day. Those who are less active will drink less. Under all circumstances, everyone needs to develop a habit of drinking frequently during the day, whether thirsty or not. Every contingency since Operation DESERT STORM has made providing packaged or bottled water almost a standard operating procedure. While this is one quality of life factor that should not be deleted, there are drawbacks to using bottled water, including extensive shipping and handling. Many people are not in the habit of drinking a lot of water. It's a hard habit to learn, but one that can be directly related to mission capability. Practice the following tips:

8.4.1.1.1. Drink extra water ***before*** starting any mission or hard work.

8.4.1.1.2. Drink small quantities frequently.

8.4.1.1.3. Drink water even if not thirsty.

8.4.1.1.4. Refill water jugs and canteens at every opportunity.

8.4.1.2. Personal Hygiene. Approximately 3 gallons of water are to be provided for personal hygiene each day. Personal hygiene should consist of brushing teeth, shaving, and washing face and hands. It is allocated in a contingency environment in the following manner: brushing teeth with a brief rinse 1/3 gallon; shaving (once a day) and washing 2/3 gallon; based on three times per day, the total requirement would be 3 gallons per day (gpd). In austere environments washing three times a day and shaving each day may not be possible; however, the minimum planning factor of 2.7 gpd should be used. Electric shavers are very popular and may help to reduce a small portion of the personal hygiene water requirement.

8.4.1.3. Shower. In order to maintain the health and mental well being of personnel at bare base locations, a daily shower is recommended. However, prior to all BEAR assets being operational or when source water is limited, a time limit may need to be established for the length of showers. There may be occasions when bacterially safe nonpotable water, such as from a river or stream, can be used by contingency forces. In these instances, approval to use this water without treatment should be obtained from the unit medical officer. The BEAR showerhead flow rate is 1.5 gallons per minute, and a daily 2–minute shower would require 3.0 gpppd.

8.4.1.4. Food Preparation. The amount of water used for food preparation varies with the type of meal being served. In arid regions, two "B" type meals and one "C" type meal will be served daily. Preparation of these meals will require 0.7 gpppd. Another 0.3 gpppd are required due to additions of tilt grilles, coffee pots and steam tables in the BEAR 550 Kitchen. And 3 gpppd are required for kitchen cleanup. The total water requirement for food preparation is 4 gpppd.

8.4.1.5. Hospital. The hospital consumption planning factor is 1.0 gpppd. This figure comes from a projection of 65 gpd for each patient and 10 gpd per hospital staff member. These rather significant quantities of water are based on daily baths for the medical staff and the majority of patients; changes of uniforms and bedding each day; and the various general sanitation, food preparation and housekeeping tasks accomplished each day in support of patients and the hospital staff. See **Chapter 12** of this volume for additional information on support of bare base medical facilities.

8.4.1.6. Heat Treatment. Approximately 1.0 gpppd is planned for use in the treatment of heat casualties. Heat casualties are normally treated by submersion in cool water and by forced intake of liquids.

8.4.2. Nonpotable Water.

8.4.2.1. Laundry. About 5.0 gpppd are allocated to launder individual and organizational clothing. Although potable water is not required, consider the constraints imposed by the use of untreated water. First, hard water not only reduces the cleaning power of laundry detergents, but may also deposit insoluble residue on the clothing being laundered. Second, brackish and saltwater rapidly corrode metal components of the laundry system. However, both problems can be overcome or at least tolerated for a short period of time in an austere environment. Saltwater detergents, developed primarily for shipboard use by the Navy, are available commercially and usually in the DOD inventory. Corrosion tolerance is essentially a trade-off between immediate requirements and increased equipment wear and subsequent maintenance work. The BEAR Self-Help Laundry is made up of standard commercial washers and dryers. According to the manufacturer, the new and more efficient commercial washers use 46 gallons per wash cycle. To allow for locally purchased washers that might be less efficient than the BEAR units, 49 gallons per wash cycle was used as the planning factor. It is estimated that two washings per person per week will sustain sanitary conditions and provide for morale and welfare in a bare base environment. Therefore, the recommended planning factor for laundry with a fixed water treatment plant is 14 gpppd.

8.4.2.2. Construction. Approximately 1 gpppd is planned for construction. Concrete mixes for most contingency field applications can use nonpotable quality water. In general, satisfactory concrete can be mixed using natural surface water, brackish water and seawater, or any water that is free of oil and suspended organic matter, especially sugar. Brackish or seawater should not be used however in reinforced concrete, because the steel reinforcement will corrode. Depending on the type of cement used, curing time may be extended. Also, sewage effluent that has undergone the equivalent of secondary treatment is suitable for concrete. There may be some occasions to use wastewater as a dust control agent.

8.4.2.3. Graves Registration. A planning factor of 0.5 gpppd is used for graves registration. This involves the handling of the remains, which demand the application of good sanitation practices, especially among the graves registration personnel. Some water is used for washing the remains' hands and feet for identification purposes, but most is used for hygiene. Handlers are required to wash and disinfect themselves frequently. While this planning factor usage is low, the total quantity set aside for this task should be sufficient.

8.4.2.4. Vehicle Operations. Use 0.5 gpppd in planning for vehicle operations. Water will be used primarily for radiator coolant makeup. Washing vehicles should be kept to a minimum to conserve water. However, be prepared to increase this amount at facilities with limited hard-top roadways, FOD-prevention measures may require that vehicle undercarriages and wheel-wells be washed at entry control points (ECPs) before entering flightline areas.

8.4.2.5. Aircraft Operations. Aircraft operations will require 2.0 gpppd. The water will be used primarily for cleaning engine intakes and to prevent engine damage from ingested sand. Water will also be used to clean other surfaces that could be damaged by abrasion.

8.4.2.6. Firefighting. A minimum of 2.0 gpppd should be stored strictly for firefighting purposes.

8.4.3. Ice Requirements. Hot weather and strenuous physical activity cause the body's temperature to increase and the body sheds this increase by producing sweat. This natural cooling system is efficient, and the body continues to function well if its water losses are replaced. When not replaced, dehydration occurs and with it comes a corresponding loss in body function efficiency. If dehydration is allowed to progress, an individual can quickly become incapacitated and then must be treated for heat stroke.

8.4.3.1. The normal thirst sensation is not a reliable indicator of the water requirement. It will be necessary, therefore, for individuals to drink water frequently during the hot and most active part of the day. It may be necessary to cool the water to at least 90 degrees Fahrenheit (60 degrees Fahrenheit is more desirable) to make it more palatable. If water cannot be sufficiently cooled for consumption, then it is important to alter the taste. For example, when added to water most powered drink mixes are generally palatable at 85 degrees Fahrenheit; however, plain water is not. Water that is converted to ice to cool drinking liquids will more likely be consumed and is considered part of each individual's daily allocation.

8.4.3.2. The dining hall will dispense 0.5 gallons of water per person each day as beverage during meals and another 0.09 gallons (12 ounces) per person of water converted into ice to cool that beverage. Dining halls will have their own dedicated ice machines.

8.4.3.3. About half of the base population will perform duties away from the areas where drinking fountains are available; therefore, drinking water or other beverages may be transported to job sites in 5- and 10-gallon insulated containers. It takes 2.88 gallons of water or beverage per person per day to meet these requirements. It takes another 0.53 gallons of water converted to ice (4.4 pounds) to cool a 75 degrees Fahrenheit liquid to a desired 60 degrees Fahrenheit for three to four hours when the ambient temperature is 120 degrees Fahrenheit.

8.4.3.4. The ice needed by medical treatment facilities located at the bare base represents an additive requirement. The quantity of ice to be allocated to each type of medical facility is addressed in Chapter 12, **Table 12.2**.

8.4.3.5. Ice requirements for the mortuary holding area (for graves registration when mechanical refrigeration is not available) are 1.7 pounds per person per day (0.2 gallons of water) in arid climates.

8.5. Water Purification. The primary water purification equipment item used in bare base operations is the ROWPU. It can produce potable water from almost any water source.

8.5.1. With the formation of the Rapid Deployment Force in the late-1970s, an increased need arose for water purification equipment that could produce potable water from seawater.

To meet this need, the AF fielded a 600-gallon-per-hour (gph) ROWPU, able to produce potable water from either seawater or freshwater (**Figure 8.4**). While this particular ROWPU was rated to produce 600 gph of potable water from seawater, it has produced up to 900 gph from freshwater without over-taxing the unit or causing excess wear to the membranes. Today, larger capacity ROWPUs that can produce 1500 gph or more of treated water are replacing the 600-gph ROWPU in the BEAR inventory (**Figure 8.5**).

8.5.2. ROWPUs normally do not come with their own power source, however electrical power is required to pressurize the water for the reverse osmosis process. The lower the dissolved solids content of the water, the lower the power requirement. For instance, purifying fresh water will consume less energy than purifying seawater.

8.5.3. The temperature of the feed water also affects the water purification capability. Very cold or very warm feed water will decrease the output and shorten the life of the purification membranes. When the temperature of the feed water exceeds 96 degrees Fahrenheit, plan on producing less water than usual. The dissolved solids concentration in raw water also influences the production capability. For additional details of the various ROWPUs and the BEAR water distribution system, see AFH 10-222, Volume 9, *Reverse Osmosis Water Purification Unit Set-Up and Operation*.

Figure 8.4. 600-GPH Reverse Osmosis Water Purification Unit (ROWPU)

Figure 8.5. 1500-GPH ROWPU

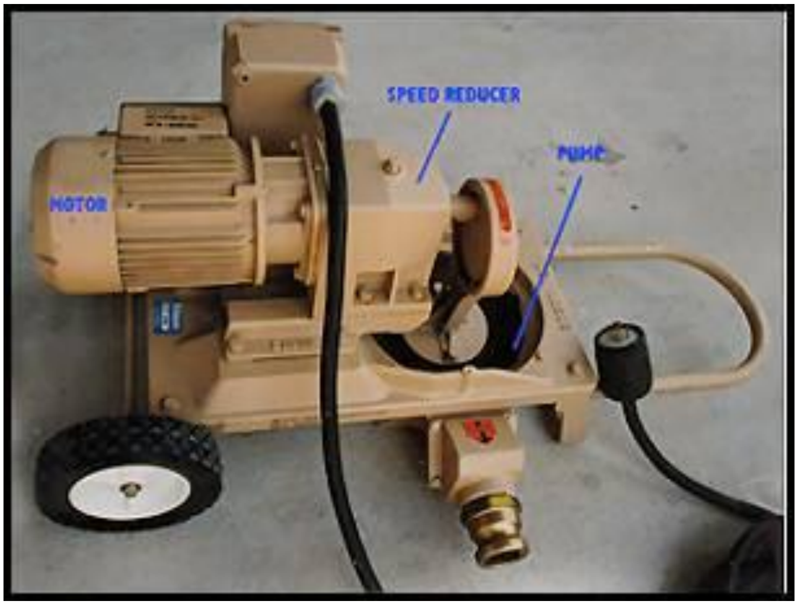
8.6. Water Purification Plants. When several water purification units must be used to meet the water requirements of a given base population, the individual units can be consolidated into water purification plants. In low threat areas where enemy attack is unlikely, one central water plant is most efficient. Less manpower and logistics support are required to operate one plant than two separate units that produce an equal amount of treated water. Where an enemy attack is likely, multiple water plants should be established to enhance survivability. The vital need of water at a bare base justifies sacrificing the economy of operation in a high-threat area. No more than two water purification plants are recommended; one should be located near the billeting area, the other near the flightline.

8.7. Water Storage. A bare base should have the capacity to store a 5-day supply of water. The storage capacity should consist of 60 percent potable water and 40 percent untreated water based on the 30-gpppd requirement. With three 20,000-gallon water bladders and four 3,000 gallon bladders, there are 72,000 gallons of potable water storage capacity in a typical 550-person package. This does not include the potential storage capacity for the source run (20,000-gallon), water production (52,000-gallon) and extension packages (6,000-gallon) which may also be attached. Using BEAR assets, a bare base of 3,300 personnel will have over 600,000 gallons of storage capability. This potential capacity exceeds the 5-day storage planning factor. At bases using two purification plants, the storage capacity should be fairly evenly split between the two plants.

8.8. Freeze Protection. For extreme cold-temperature operation, water purification units may be placed in a small shelter and 3,000-gallon tanks in separate tents. Where practical, two 3,000-gallon tanks can be enclosed within one tent. When necessary, the M-80 or WH-400 water heater can be used to circulate water through the tanks to prevent freezing (this may not be necessary when using the BEAR water distribution loop, since it has a circulating pump that will continuously move water into bladders). To minimize damage, hoses not being used to distribute water should be disconnected, drained and rolled up.

8.9. Wastewater Removal. Wastewater (or gray water) disposal is generally handled by electric-driven pumps (**Figure 8.6**), which are provided in each shower, kitchen and laundry location. Wastewater lines of a lightweight, flat hose are used to carry the water away from the inhabited area to natural drainage or to a waste disposal system. Even future latrine systems may require manually turning on pumps and using a wash-down spray wand to push heavy solids into the pump for disposal.

Figure 8.6. Electric-Driven Pump



8.10. Water Cooling. Water stored in some locations in SWA has been recorded at over 120 degrees Fahrenheit. While the effects of such temperature on human consumption have not been fully documented, it is obvious this water temperature must be brought within the range of 60 to 70 degrees Fahrenheit in order to encourage personal consumption and to avoid dehydration. Also, some cooling may be required prior to use for showers.

8.10.1. Several methods of providing cooled drinking water are available. Where water is already on hand, water coolers can be used. A centralized distribution point for chilled water and ice should be located at one of the water purification plants to provide for people who do not otherwise have access to water. Insulated containers and mobile water chillers are used to provide cooled drinking water to persons in remote areas of the base. The number of water coolers required for a specific base population is relative to the chilled water output of a given unit. Consider, for example, a water cooler, that provides 15 gph of cooled water at a temperature of 68 degrees Fahrenheit when the ambient air temperature is 120 degrees Fahrenheit and the supply water temperature is 110 degrees Fahrenheit. This cooler would theoretically cool 360 gallons of water per day. But to do this, the unit would have to operate continuously and would not account for a backlog of people who require a drink simultaneously during periods of peak shelter occupancy or following mass physical exercise or work. Therefore, the unit should be derated at least 30 percent or to an output of 252 gallons per day. Since each person should consume up to four gallons per day, one water cooler will service approximately 63 people. Water coolers should have a downward water flow, allowing water to be drawn to fill canteens and drinking containers without excessive waste. Since water fountains are not provided as part of the BEAR package, consider local purchase of suitable units.

8.10.2. It may be necessary to provide other methods to cool drinking water that will be consumed in remote work areas. For on-base personnel, potable chilled water points with provisions for making ice can be established at a selected water purification plant. For remote areas or off-base personnel, chilled water and ice can also be taken in insulated water containers to work sites.

8.10.3. The mobile water chiller (**Figure 8.7**) is also used to provide cooled drinking water at remote sites. The mobile water chiller mounts on the M-149 series water trailer. It is capable of cooling 120 degrees Fahrenheit water to 60 degrees Fahrenheit at a rate of 800 gallons per day. Assuming that half of the work force will require half of their daily drinking water cooled in this fashion, a requirement will exist to cool 1-gallon per person per day using mobile water chillers mounted on M-149 water trailers. Two M-149 water trailers and two chillers are adequate for each 1,100-person increment. For deployments greater than 2,200 people, two spare trailers and two chiller units should be included.

Figure 8.7. 400-Gallon "Water Buffalo" Trailer With Chiller Attached

8.11. Ice Plants. To supplement chilled water requirements, approximately 4.4 pounds of ice per person per day should be provided. Ideally, an ice plant should be set up at one of the water purification plants to support the base populace. Currently, however, ice-making machines capable of meeting overall ice requirements ***are not*** part of the BEAR inventory. Limited ice making capability is available at dining facilities but this is primarily for food service support. There are ice machines included with the BEAR 550 kitchen. **Table 8.2** shows ice requirements for initial bare base populations and **Figure 8.8** shows some typical large capacity ice machines.

Table 8.2. Basic Ice Machine Requirements

Base Population	Ice Requirements (pounds/day)
550	2,420
1,100	4,840
2,200	9,680
3,300	14,520

Figure 8.8. Typical Ice Machines

8.12. Water Conservation. As a culture, Americans generally do not use water sparingly. Consequently, part of the training before deploying to arid regions must include instruction on water conservation. Such training should be accompanied by measures that make water less available. This will reduce the temptation to return to wasteful habits. While everyone in the chain of command must assist in the conservation effort, command emphasis is the backbone of water conservation. Additionally, planners must be aware of the need to save water and must learn to take advantage of opportunities to reuse wastewater for other purposes.

8.12.1. Planners play a major role in conserving water through proper siting of activities and facilities. For example, activities that require large amounts of potable water should be located near water terminals and tank farms to minimize transportation requirements and losses during handling. In addition, activities/facilities that can use nonpotable water should be sited, when possible, near those that generate wastewater. For example, wastewater from laundry and shower units could be used for mixing concrete, compacting soil and controlling dust.

8.12.2. Planners should also consider using seawater or brackish water. Both sources can be used for concrete, soil cement, soil compaction and dust control. The two latter tasks are likely to constitute major civil engineer efforts. The existing road network at most bare bases is limited and will require expansion, and the rapid deterioration of existing and newly established roads from heavy traffic will demand continuous maintenance. Also, nonpotable water can be used in the decontamination of certain CBRN-contaminated equipment, should the need arise.

8.12.3. Much can be learned from some of the water-conserving habits of the region's inhabitants. Everyone operating in a water-scarce, arid environment should observe the basic water conservation principles listed below. Desert dwellers, particularly the nomadic tribes, have relied on similar water discipline for centuries.

8.12.3.1. Make it a responsibility shared by everyone to conserve water by avoiding wasteful practices. Also, create a shared awareness that there is a useful purpose for wastewater or potable water that is hot and therefore unpalatable.

8.12.3.2. Place command emphasis on water conservation and water reuse.

8.12.3.3. Protect potable water from all sources of contamination, including sand and dust.

8.12.3.4. Do not dispose of water of any type without considering alternative uses.

8.12.3.5. Prohibit water thievery from storage containers and pipelines and the indiscriminate use of expedient showers.

8.12.4. The use of water of lesser quality is also a viable method of conservation. In SWA, where the dissolved solids content of water can be high, any opportunity to use local water and avoid the costly reverse osmosis purification process has both logistic and economic advantages. These benefits are most apparent when it comes to water for bare base construction tasks. Untreated seawater or brackish water is usually quite satisfactory for construction that is only intended for short-term use.

8.13. Legacy and Future Water Systems. Until recently, engineers deployed and trained on bare base water distribution systems developed in the 1980s. Many of the components were developed specifically for military bare base use, but the basic system layout was an industry standard. The design required specific UV-treated piping and connectors that greatly increased the cost and added labor hours to the setup time.

8.13.1. Lessons learned from Operations DESERT STORM and PROVIDE HOPE, and more recently in Operations ENDURING FREEDOM and IRAQI FREEDOM have broadened AF knowledge of creating water systems that are more efficient for real-world operations. Changes in camp layouts, efficient contract purchasing methods and more precise water usage estimates have all contributed to development of better systems. Changes in technology have vastly improved material, while commercial inventory and vendor availability have made it more efficient and less costly to procure sustainable equipment. Consequently, the AF has developed a new BEAR water system. The new system combines proven characteristics from legacy Harvest assets with new technology to create a system suitable for current and future operations.

8.13.2. The BEAR water system is intended to fulfill potable water and wastewater recovery needs at austere locations. The water system is modular in design and consist of a series of pumping, piping, and storage equipment; applicable fittings; and other components such as fluid control valves. It is capable of drawing source water, purifying, storing, and then distributing potable water to user facilities. The water system provides water to support kitchens, latrines, showers, laundries, and other bare base facilities and recovers the wastewater for appropriate disposal. One complete water system is comprised of five distinct subsystems: Source Run, Water Production (1500 ROWPU or 600 ROWPU), 550 Initial, 550 Follow-on, and Industrial Operations & Flightline Extension. From a bare base perspective, the new water system is easier to set up, maintain, and be trained on and is more efficient than older systems. From an overall program perspective, the system is easier to store, takes up less airlift space, is easier to procure (less parts) and should prove to be cost-effective in the long run. The AF is constantly looking for ways to be lighter, leaner and more effective in deploying forces for expeditionary operations. The new BEAR Water System is a substantial complement to that effort. See T.O. 40W4-21-1, *BEAR Water System*, and AFH 10-222, Volume 11, *Contingency Water System Installation and Operation*, for water system configuration and operation.

Chapter 9

WASTE UTILITY SYSTEMS

9.1. Introduction. Since potable water is viewed as perhaps the most essential element to bare base operations, disposal of wastewater and other wastes may seem to be unimportant. This is not true. If waste is not quickly and properly disposed of, unsanitary conditions can rapidly develop. Flies, mosquitoes and rodents can overwhelm a bare base, spreading disease with them. During some previous major conflicts, the casualty rate from disease and other non-battle causes invariably exceeded the combat casualty rate. This was particularly true for theaters of operation that combine high temperatures and prevalence of indigenous disease.

9.1.1. Field Sanitation. Despite many medical and technological advances, the threat from insect-borne diseases and sanitation hazards remains as real today as it was in World War II, Korea and Vietnam. Troops deployed to areas with poor sanitary conditions and high rates of insect-borne diseases can still contract malaria during a 180-day deployment. During physically exhausting deployments, particularly those lacking permanent facilities, there is an individual tendency to relax sanitation and personal hygiene standards. This poses a threat to the entire base population and could seriously affect mission accomplishment. It is also a significant challenge for bare base planners who may have to rely on expedient methods for waste disposal during the early stages of deployments. With proper application of field sanitation and insect control methods, infection rates can be kept to a very low level.

9.1.2. Environmental Considerations. In addition to traditional waste disposal problems, engineers must also consider those types of waste that pose potential environmental problems if not monitored. Items such as fuels, chemicals and process byproducts must be controlled and properly disposed of to avoid health and safety hazards. If safe disposal is not an immediate option at a bare base, as a minimum an adequate, secure storage area should be established. Be especially observant of local-national activities that might be under AF control. Local environmental rules at a bare base may not be as strict as US standards and may pose environmental problems for US forces if not watched closely. For additional information on environmental considerations during contingency operations, see **AFH 10-222, Volume 4**, and the numerous references and checklists in its attachments.

9.2. Overview. To assist in planning, this chapter describes various methods to dispose of wastes. Expedient field methods for human waste disposal are addressed first, followed by a discussion of methods that use BEAR assets for disposing of liquid wastes during longer-term deployments. Finally, this chapter presents methods for disposing of solid wastes.

9.3. Expedient Human Waste Disposal Methods. During the early stages of most deployments, engineers may need to use expedient field methods to dispose of human wastes such as cat hole, burn-out, deep pit, and saddle trench latrines (**Figure 9.1**), and urine soakage pits. Later on, even when BEAR latrines and disposal systems are in place, there may be locations on the base that need expedient facilities due to the distances from main utility networks or lack of enough BEAR assets. See **AFPAM 10-219 Volume 7**, *Expedient Methods*, and **AFH 10-222 Volume 1,** for a thorough description of commonly-used and effective expedient latrines.

Figure 9.1. Typical Expedient Straddle-Trench Latrine with Privacy Screens

9.3.1. When planning for expedient latrine facilities, assume one toilet will serve 20 people. In areas where females will **not** routinely use the latrine, urinals may be substituted for one-third of the minimum required number of toilets. For instance, in a 550-person camp with all males, generally plan on a minimum of 28 toilets. However, if urinals were available, then only 19 toilets (and 9 urinals) would suffice. Keep in mind that separate latrines must still be provided for females. Since approximately 20 percent of AF personnel are women, plan on providing a corresponding percentage of bare base latrine facilities for them.

9.3.2. Like many other BEAR assets, field deployable latrines begin arriving over the course of the first several days of the deployment, and become more and more plentiful as the base is established. As deployable latrine units arrive and are set up, expedient latrines will be closed. Until deployable latrines are connected to the wastewater distribution system, wastewater from the holding tanks is collected using a wastewater disposal trailer (**Figure 9.2**). The trailer consists of a 1,000-gallon tank and a vacuum pump powered by a 12-hp gasoline engine. The vacuum pump removes air from the tank causing suction through the pickup hose. Large material can be removed in this way and not damage the pump. To empty the unit, the pump is reversed and the tank pressurized, thus forcing out the contents. For planning purposes, assume wastewater disposal trailers can make 15 trips a day and thus can dispose of 15,000 gallons of waste per day. Latrines should be emptied daily.

9.3.3. Wastewater from the disposal trailer should be emptied in uninhibited areas downwind from the base where contamination of drinking water sources is not possible. Dumping locations must be carefully considered since waste disposal in this manner may continue several days until a more permanent collection system is in place (i.e., septic system, lagoon, treatment facility, contracted disposal).

Figure 9.2. Wastewater Disposal Trailer

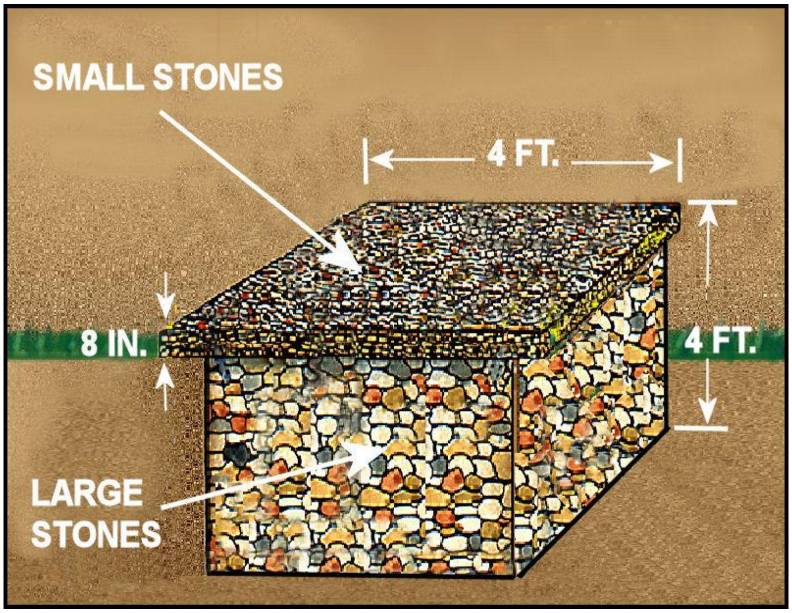
9.4. Expedient Wastewater Disposal Methods. Water usage generally results in wastewater that requires disposal. Depending on the source, wastewater may contain suspended solids and particulate matter, organic material, dissolved salts, biological and pathogenic organisms, and toxic chemicals. The volume of wastewater alone can cause significant problems in the field. The information in **Table 9.1**. is presented as a guide for estimating the quantities of wastewater generated under initial bare base conditions (prior to the entire collection system being installed). These quantities are less than those addressed later in this chapter because the water system will not be established and less water will be available. Also during this initial phase, less water will be used for showers and personal hygiene. Planning for expedient wastewater disposal in the early stages of a deployment is essential to protect the health of the force. The following paragraphs address several field-expedient wastewater disposal options.

Table 9.1. Wastewater Volumes—Initial Beddown

Purpose	Quantity (GPD)	Quantity To Be Disposed (GPPPD)	Comments
Drinking	4.0	2.0	1/2 of Drinking Water
Personal Hygiene	3.0	2.0	Portion of Personal Hygiene
Showers	5.0	5.0	100% Becomes Waste
Food Preparation	4.0	3.0	Only Kitchen Clean-Up Considered
Vehicles	0.5	0.0	No Wastewater Expected
Hospital	1.0	1.0	100% Becomes Waste
Heat Treatment	1.0	0.0	No Wastewater Expected
Construction	2.0	0.0	No Wastewater Expected
Graves Registration	0.5	0.0	No Wastewater Expected
Laundry	2.0	2.0	100% Becomes Waste
Aircraft Cleaning	2.0	0.0	No Wastewater Expected
Firefighting	2.0	0.0	No Wastewater Expected
Loss Factor (10%)	3.0	0.0	No Wastewater Expected
	30.0	**15.0**	

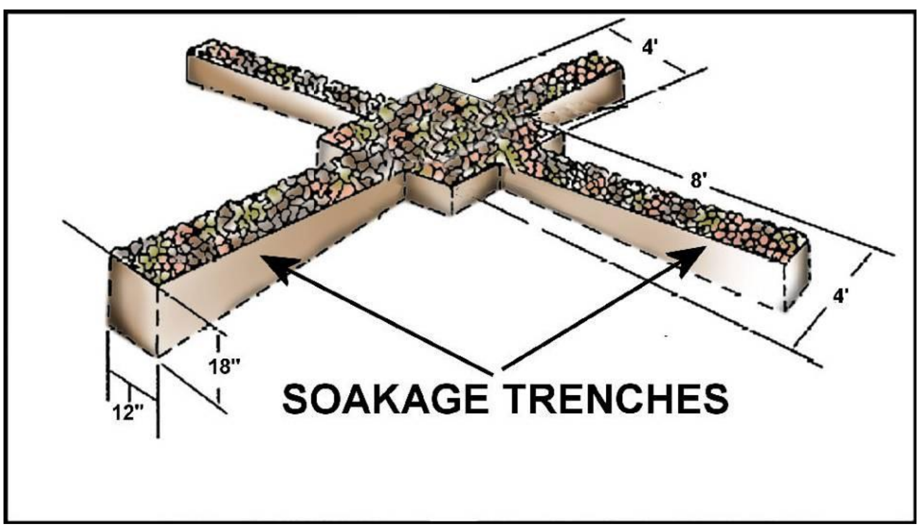
9.4.1. **Soakage Pits.** Soakage pits acts as a reservoir from which water is gradually absorbed by the surrounding soil (**Figure 9.3**). Its effectiveness depends on the cleanliness of the water being absorbed, level of the ground water table, permeability of the soil and dimensions of the soakage surface. In areas with good/rapid soil drainage, such as limestone or coral, average size soakage pits (4 feet square by 4 feet deep) should work well. In slow draining silt or desert sands pits must be much larger. Care must be taken in slow-drainage areas to clear the wastewater thoroughly before running it into a soakage pit. Soakage pits are generally not recommended in areas where soil percolation rates are poor—SWA, for example. Nevertheless, field studies may identify favorable conditions for pits even when percolation rates are known to be poor.

Figure 9.3. Soakage Pit



9.4.2. **Soakage Trenches.** In areas where ground-water level precludes digging a 4-foot deep pit, engineers can construct soakage trenches (**Figure 9.4**). First construct a 2 feet square by 1 foot deep pit and fill with coarse well-draining material, such as stones or gravel. Dig one foot wide trenches that radiate outward from the pit in several directions. Vary the depth of the trenches from 1 at the pit to 1.5 feet at the outer edges. Fill the trenches with the well-draining materials.

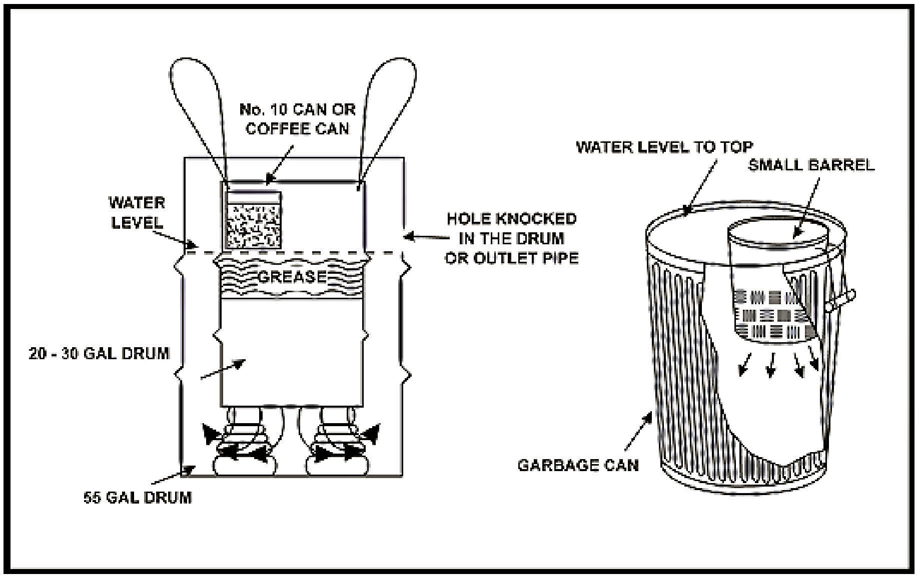
Figure 9.4. Soakage Trench



9.4.3. **Evaporation Beds.** Laundries, showers and kitchens generate many gallons of wastewater. When soil is compacted and makes it difficult to use soakage pits, use evaporation beds. To determine the size of evaporation beds, allow three square feet per person for kitchen wastewater and two square feet for shower and laundry waste. The beds should be placed so that wastewater can be channeled to any particular bed as desired. As an example, a BEAR kitchen configured to serve 1,100 personnel would require 3,300 square feet of evaporation bed. If divided into seven individual beds of 472 square feet, each bed would measure 22 feet by 22 feet. The kitchen will produce about 2 gpppd of wastewater for a total of 2,200 gallons or 294 cubic feet. Each bed should be about 0.62 feet deep, but to allow for free board each bed should be one foot deep.

9.4.4. **Expedient Grease Traps.** Grease traps should be constructed to prevent grease from entering the wastewater disposal beds. Grease will slow the evaporation process, clog and prevent water from leaching into the soil and provide food for insects. Several types of grease traps sufficiently remove grease from liquid wastes in the field. Some are superior to others in that they are easier to construct and last longer. The important thing about a grease trap is it should be of sufficient capacity so the hot, greasy water being added will not heat the cool water already in the trap. Otherwise the grease will remain uncongealed and pass through the trap. **Figure 9.5** depicts two types of expedient grease traps that are easy to construct.

Figure 9.5. Expedient Grease Traps



9.4.5. **Wastewater Collection Pit Boxes.** Other facilities that produce wastewater must have pits constructed to collect the wastewater. These type facilities are less common and are included here for legacy purposes. Facilities that produce relatively small quantities of wastewater should have a pit that holds 1,000 gallons. Facilities that produce larger amounts of wastewater should have a 2,000-gallon pit. Details for construction of these pits are shown in **Figure 9.6**, **Table 9.2** and **Table 9.3** The wastewater disposal trailer is also used to empty these collection pits.

Figure 9.6. Construction of Wastewater Collection Pit Boxes

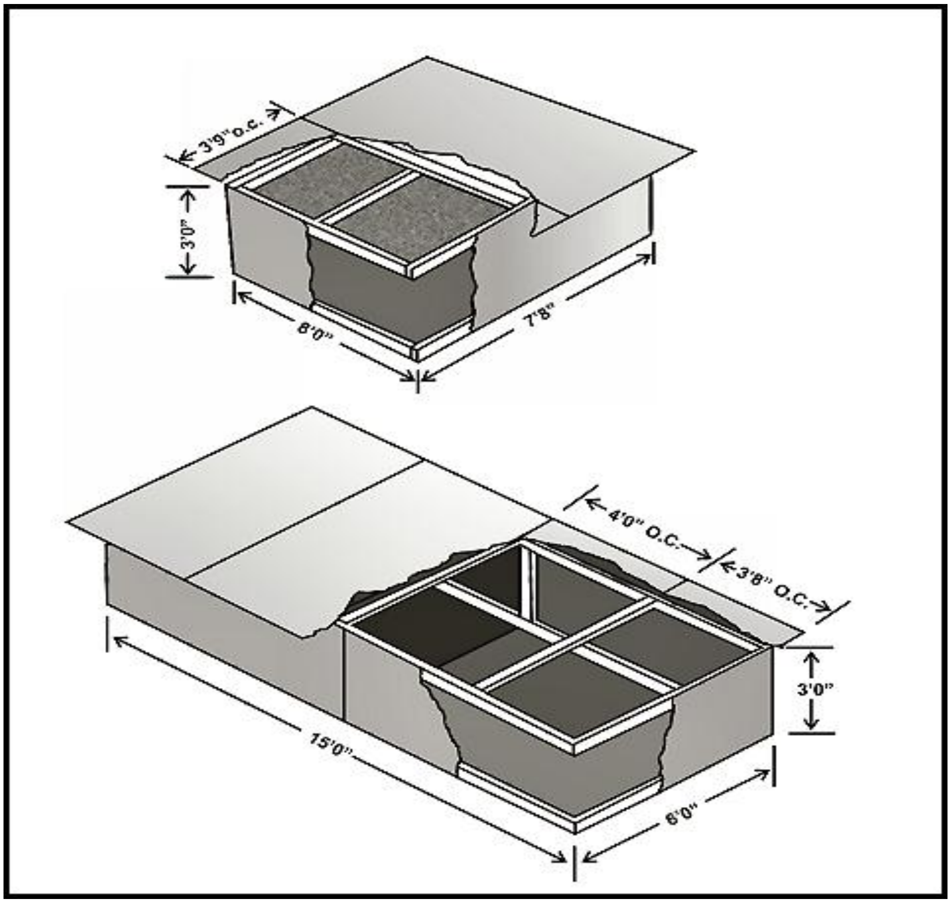


Table 9.2. Bill of Materials for Wastewater Collection Boxes (1,000 Gallon)

1,000-GALLON PIT BOX			
	Description	**Number Required**	**Remarks**
A	1/2″ x 6′-0″ x 7′-6″	1 ea	Floor
B	1/2″ x 3′-0″ x 7′-6″	2 ea	Side Panel
C	1/2″ x 3′-0″ x 6′-0″	2 ea	End Panel
D	2 x 4 x 7′-6″	4 ea	Framework
E	2 x 4 x 5′-8 3/4″	4 ea	Framework
F	2 x 4 x 5′-8 3/4″ 15′ x 15′ Sheet Plastic Nail 6d Nail 10d	1 ea 1 ea 1.00 lb 1.00 lb	Brace* Liner
*Line box with plastic before installing braces.			

Table 9.3. Bill of Materials for Wastewater Collection Boxes (2,000 Gallon)

2,000-GALLON PIT BOX			
	Description	**Number Required**	**Remarks**
A	1/2″ x 6′-0″ x 7′-6″	2 ea	Floor
B	1/2″ x 3′-0″ x 7′-6″	4 ea	Side Panel
C	1/2″ x 3′-0″ x 6′-0″	2 ea	End Panel
D	2 x 4 x 15′-0″	4 ea	Framework
E	2 x 4 x 5′-8 3/4″	4 ea	Framework
F	2 x 4 x 5′-8 3/4″	2 ea	Upright
G	2 x 4 x 5′-8 3/4″	3 ea	Brace*
H	1/2″ x 4′-0″ x 8′-0″ 15′ x 15′ Sheet Plastic Nail 6d Nail 10d	4 ea 1 ea 1.50 lb 2.00 lb	Cover Liner
*Line box with plastic before installing braces.			

9.5. BEAR Wastewater Disposal Methods. The BEAR wastewater disposal system operates similar to many municipal wastewater systems. Wastewater is collected and transported via pipes, hoses, lift stations and pumps to a centralized collection area. The wastewater system uses a 25,000-gallon wastewater collection tank (**Figure 9.7**). The system can also collect wastewater from BEAR facilities for disposal at an on-site treatment plant or by contract collection and transport to an off-site treatment facility. During initial bare base operations, collecting all wastewater from base facilities may not be feasible. It is recommended that gray-water drying beds or evaporation ponds be constructed for showers and laundry facilities and only latrines and kitchens be **initially** connected to the wastewater system. This will eliminate individual facility black water collection by pushing the wastewater through a series of force-main pumping stations to the central collection tank located outside the main bare base. Wastewater sent to the collection tank is mixed and aerated to maintain it in a liquid state for eventual disposal. Setting up the wastewater system takes time, so while the system is being constructed, wastewater is picked up at the point of generation by wastewater removal trailers. These trailers are discharged away from the base or into sewage or stabilization lagoons once they are completed. The BEAR wastewater system is packaged in increments designed to support various populations. Although the type and amount of equipment is specified, planners may need to design a system unique to the deployment location. To help in designing the system, the following paragraphs address the sources and quantities of wastewater, followed by a description of the collection system and wastewater treatment options.

9.5.1. Wastewater Sources. Of the 30 gpppd of potable water provided at a bare base for initial beddown, about 21 gpppd (70 percent) will become wastewater. **Table 9.4** can be used to calculate the quantity of wastewater generated in a given area. For example, a typical shower-latrine complex supports 275 people. Latrines and showers generate approximately 12.7 gpppd, so the latrine complex will generate about 3,500 gallons of wastewater per day or an average flow of 145 gallons per hour. Because of various work schedules and shifts, the maximum hourly flow is unlikely to exceed four times the average hourly flow. Therefore, the maximum hourly flow would be about 580 gallons per hour. This figure can be used for initial design purposes. Keep in mind locations with fixed water treatment plants and those with more quality of life improvements will see water usage increase and more wastewater being generated. Planners should be aware the initial design specifications for wastewater treatment and disposal facilities will more than likely have to be expanded. Potable water production and usage should be monitored to determine actual wastewater generation.

Figure 9.7. BEAR 25,000-Gallon Wastewater Collection Tank

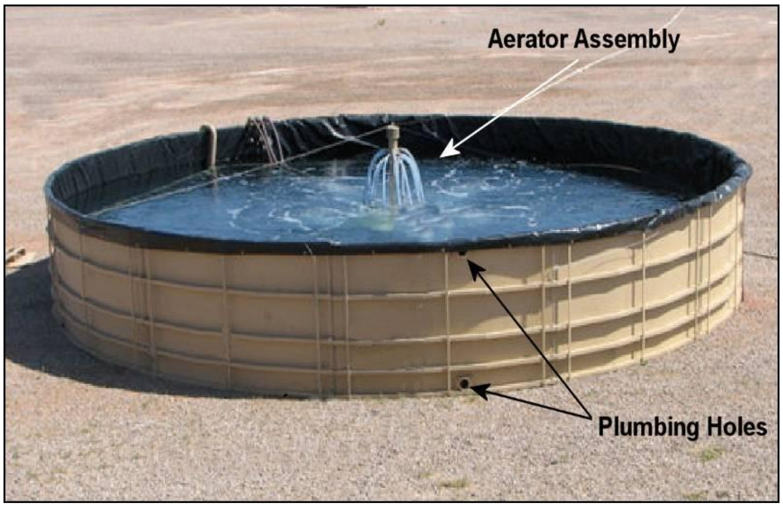


Table 9.4. Wastewater Sources and Estimates

Source	Gallons per person per day	
	BEAR Assets	Fixed Water Plant
Latrine	7.7	7.7
Showers	5.0	15.0
Food Preparation	4.0	5.0
Hospital	1.0	1.0
Laundry	2.0	14.0
Total	**19.7**	**42.7**

9.5.2. Wastewater Collection. Base camps are usually placed on fairly level ground making gravity-fed wastewater lines unfeasible. The BEAR water system uses forced wastewater lines; which makes them usable on level or uneven terrain. Waste output from user facilities (latrines, showers, kitchens, laundries, etc.) is processed by various pumps, lift stations, and wastewater lines that distribute the wastewater to lagoons or the wastewater collection tank for eventual disposal. Latrine and kitchen facilities also have an in-line, sewage ejector system (grinder pump) to help facilitate wastewater distribution (**Figure 9.8**). The ejector is attached to the latrine waste tank outlet and kitchen holding tank outlet. The latrines' waste is sent through the ejector and pushed to a macerator pump lift-station (**Figure 9.9**). From the lift-station the waste is pushed through a wastewater hose to a dual-pump lift-station (**Figure 9.10**). **Note:** Manual cleaning of the latrine tanks with the water wand will still be required.

The kitchen waste is sent through the ejector and sent to the dual-pump lift station. The dual pump lift-station collects all of the wastewater in the camp and pushes it into a central collection tank.

Figure 9.8. Latrine Facility with Sewage Ejector System

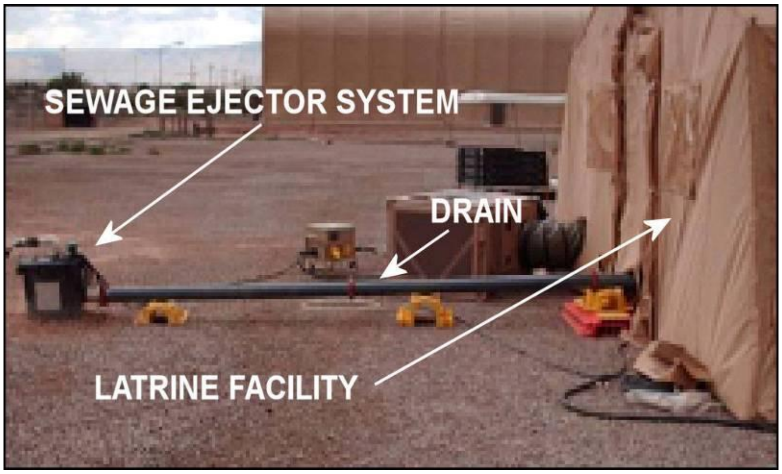
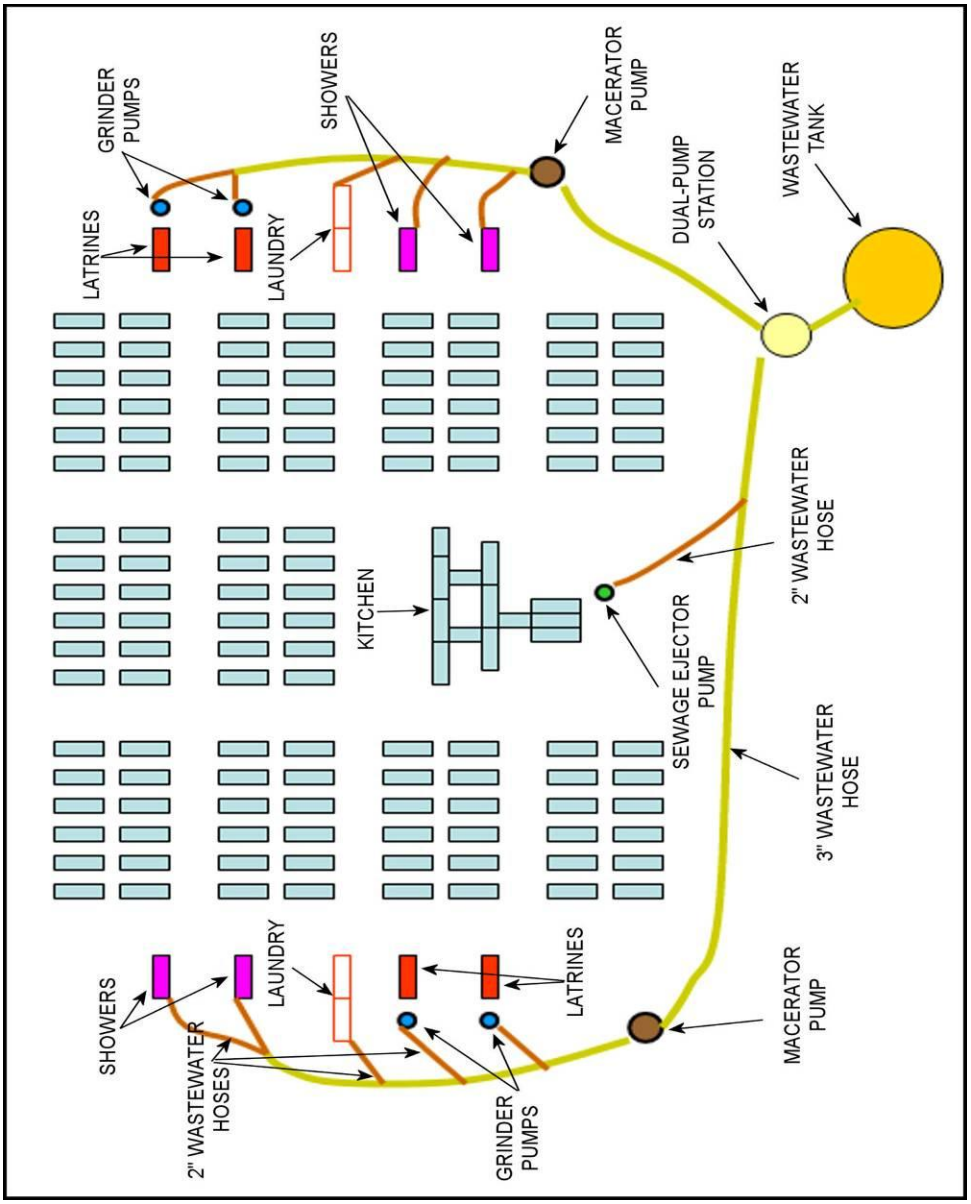


Figure 9.9. Macerator Pump Lift Station

Figure 9.10. Dual-Pump Lift Station

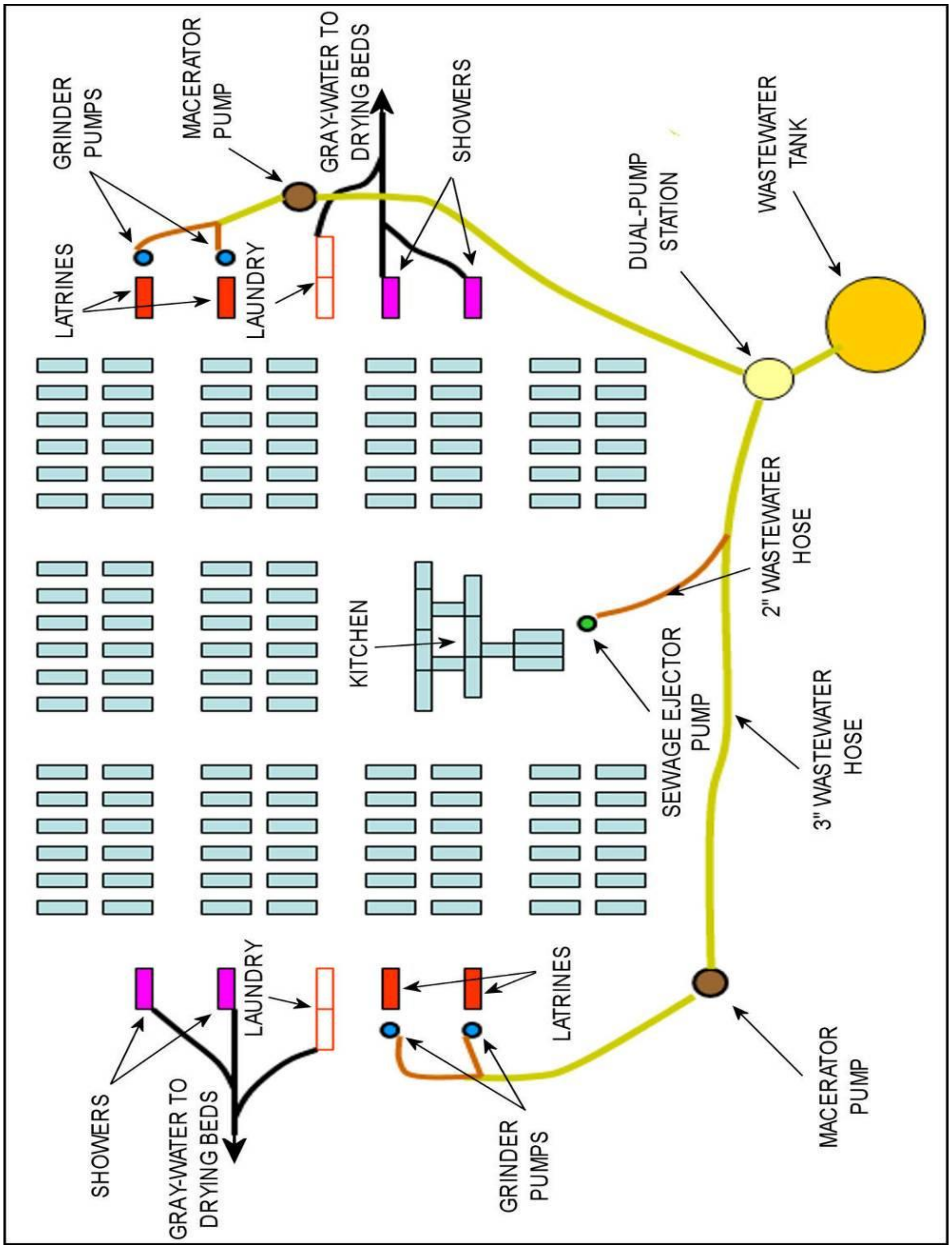
9.5.2.1. The layout and configuration of the wastewater system is largely dependent upon specific site conditions and requirements, including camp size, facility layout, and predominant wind direction. In the layout shown in **Figure 9.11**, all wastewater is distributed to a 25,000-gallon wastewater collection tank. In this configuration, it is estimated the wastewater tank will be required to be pumped out **one or more times per day**. The waste can be sent to a sewage or stabilization lagoon, leach field, treatment plant, etc.

Figure 9.11. Total Wastewater Collection Layout (1100-Person Camp)



9.5.2.2. In another configuration (**Figure 9.12**), only wastewater from latrines and kitchens is routed to the wastewater tank. The remaining wastewater from showers and laundries is sent to gray-water drying beds or lagoons. In this configuration, it is estimated that the wastewater tank will be required to be pumped out **once every five days**.

Figure 9.12. Partial Wastewater Collection Layout (1100-Person Camp)



9.5.2.3. Installation of these components, while not technically difficult, will be time consuming. Additionally, the same people responsible for installation of the wastewater system are also responsible for installing the more important water distribution system. Furthermore, some personnel will be used to support ROWPU operation and wastewater disposal functions. The bottom line is be prepared to operate the field deployable latrine and disposal trailers for an extended time since there will be several concurrent competing beddown demands vying for engineer assistance. Local contract support in this area may be a good alternative.

9.5.3. Wastewater Treatment and Disposal.

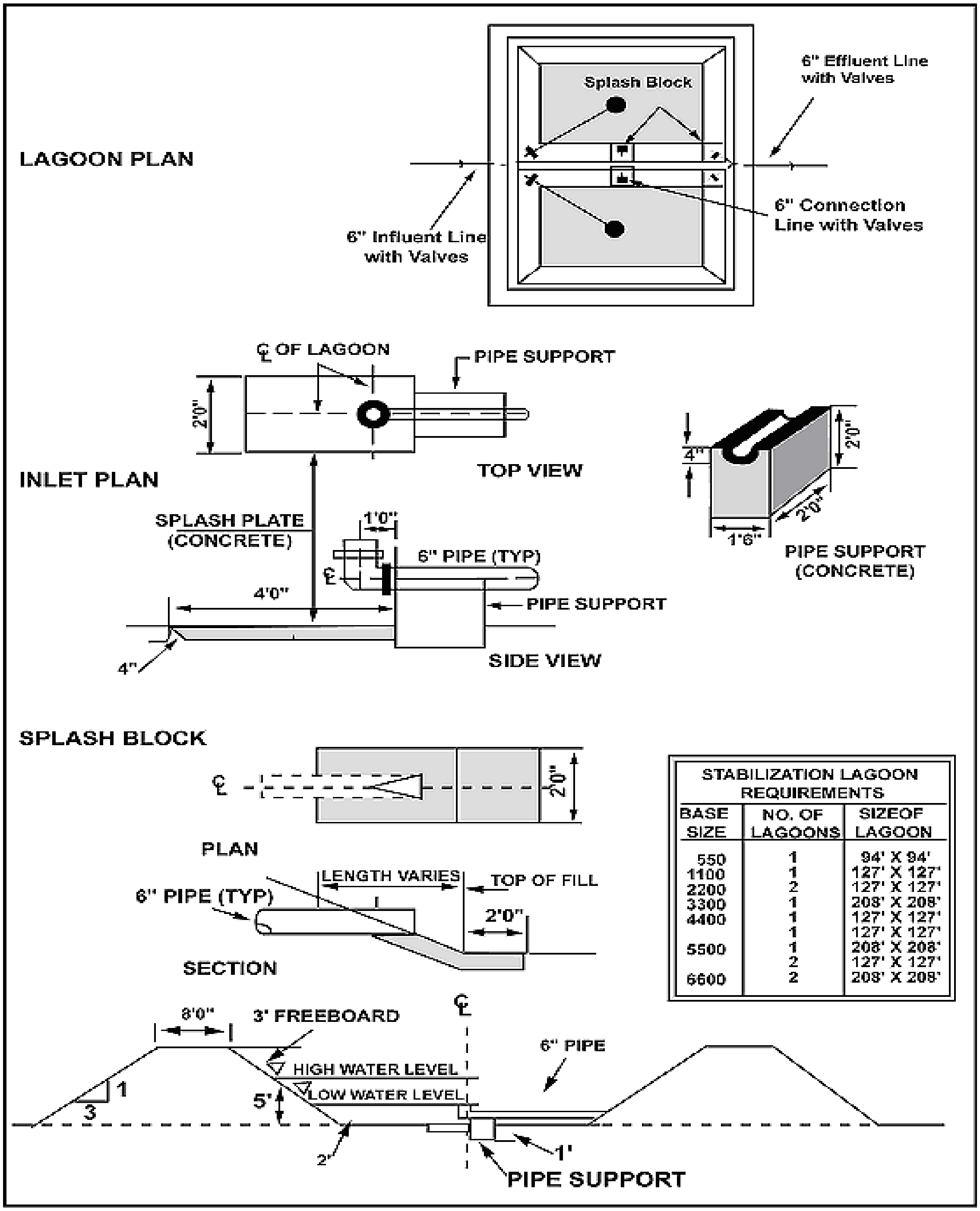
9.5.3.1. **Stabilization Lagoons.** In areas where sufficient natural drainage exists to carry wastewater away from the base, stabilization lagoons (**Figure 9.13**) can be constructed. A stabilization lagoon is a shallow artificial pond used to treat wastewater before it is discharged. Bacteria and protozoans metabolize waste organics in a stabilization lagoon. When the lagoon bottom is anaerobic (without oxygen), biological activity results in digestion of the settled solids. Algae in photosynthesis use nutrients released by the bacteria. The degree of stabilization produced in oxidation lagoons is significantly influenced by climatic conditions. During warm, sunny weather, decomposition and photosynthetic processes flourish, resulting in rapid stabilization of waste organics. Biochemical oxygen demand (BOD) reductions in warm weather usually exceed 95 percent. Stabilization lagoons are designed with long liquid retention times, usually 20 to 120 days. Lagoons discussed in this chapter have been designed with a retention time of approximately 20 days, suitable for a predominantly hot and sunny region (SWA or equivalent). Although much of the treatment occurs naturally through chemical processes, aeration devices may be used to add oxygen to the wastewater. Aeration makes treatment more efficient so that less land area is necessary.

Figure 9.13. Stabilization Lagoon

9.5.3.1.1. A wastewater stabilization lagoon should have a flat bottom pond and be enclosed by an earth dike. Operating liquid depth has a range of 2 to 5 feet with 3 feet of dike freeboard. Freeboard is the distance between the highest level of the wastewater and the top of the dike or berm. A minimum depth of 2 feet is required to prevent growth of rooted aquatic plants. Operating depths greater than 5 feet can create odorous conditions because of anaerobic bottom conditions. Influent lines discharge near the center of the pond and the effluent overflows in a corner on the windward side to minimize short-circuiting. When multiple lagoons are used, they should be able to operate individually or in a series. It may also be necessary to line or seal the bottom of the lagoon to prevent leaks and maintain its biological properties. A commonly used sealing agent is bentonite clay, although flexible synthetic membranes may also be used.

9.5.3.1.2. In multiple lagoon installations, the sequence of lagoon operation is regulated to provide control of the treatment process. Operating lagoons in series generally increases BOD removal by preventing short-circuiting. Parallel operation may be desirable to distribute the organic load and avoid potential odor problems. Since stabilization lagoons may emit odor, they should be located as far as practical from the base and on the leeward side so that prevailing winds are away from the base. Lagoons treating only domestic wastewater normally operate odor-free. **Figure 9.14** lists the requirements for stabilization lagoons for various base sizes. Construction details are shown in **Figure 9.15**. Excavation for the lagoons is based on balanced cut and fill.

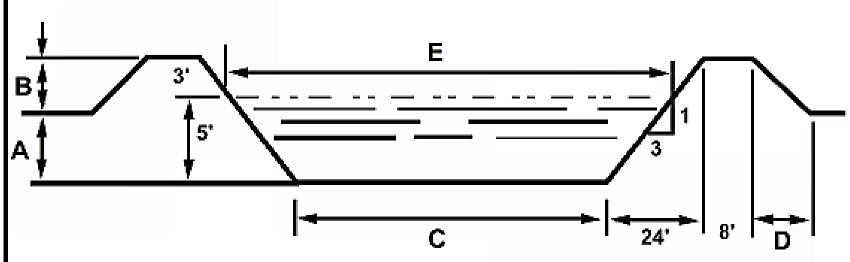
Figure 9.14. Stabilization Lagoon Requirements



STABILIZATION LAGOON REQUIREMENTS

BASE SIZE	NO. OF LAGOONS	SIZEOF LAGOON
550	1	94' X 94'
1100	1	127' X 127'
2200	2	127' X 127'
3300	1	208' X 208'
4400	1	127' X 127'
	1	127' X 127'
5500	1	208' X 208'
	2	127' X 127'
6600	2	208' X 208'

Figure 9.15. Stabilization Lagoon Construction Details



LAGOON SIZE	A*	B	C	D	E
94' x 94'	4.6'	3.4'	64'	10.2'	94'
127' x 127'	4.0'	4.0'	97'	12.0'	127'
200' x 200'	3.0'	5.0'	178'	15.0'	208'

* Shows depth of cut from original surface for balanced cut and fill, on level ground.

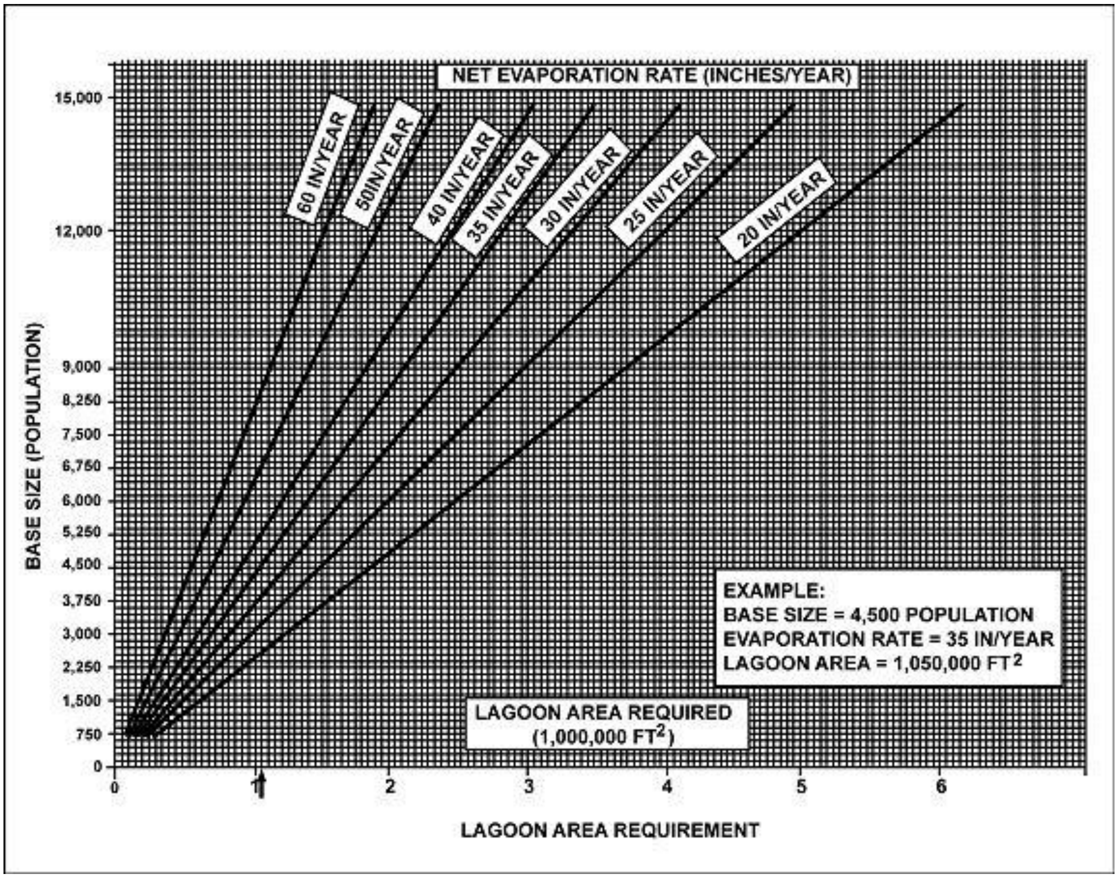
9.5.3.2. **Evaporation Lagoons.** In areas where it is impossible to discharge wastewater off base, evaporation lagoons will have to be constructed. Evaporation reduces the liquid volume of wastewater, returning water vapor to the environment. Solids settle to the bottom and form sludge. Because of the large construction requirements, evaporation lagoons should only be used as a last resort. Evaporation lagoons for the different size bases are presented in **Table 9.5**.

Table 9.5. Evaporation Lagoon Requirements

Base Size	Wastewater (GPD)	Lagoon Area Required (SF)	Number of Lagoons	Dimensions at 5' Depth
550	8,250	100,000	9	120′ x 120′
1100	16,500	200,000	9	164′ x 164′
2200	33,000	400,000	9	226′ x 226′
3300	49,500	600,000	9	273′ x 273′
4400	66,000	800,000	9	313′ x 313′
5500	82,500	1,000,000	9	348′ x 348′
6600	99,000	1,200,000	9	380′x 380′

9.5.3.2.1. Evaporation is dependent upon the net evaporation rate and surface area available for evaporation. The evaporation lagoons sized in this chapter are based upon a net evaporation rate of 46 inches per year and a wastewater flow rate of 15 gallons per person per day. **Figure 9.16** can be used to calculate lagoon requirements for other net evaporation rates.

Figure 9.16. Evaporation Lagoon Area Requirements

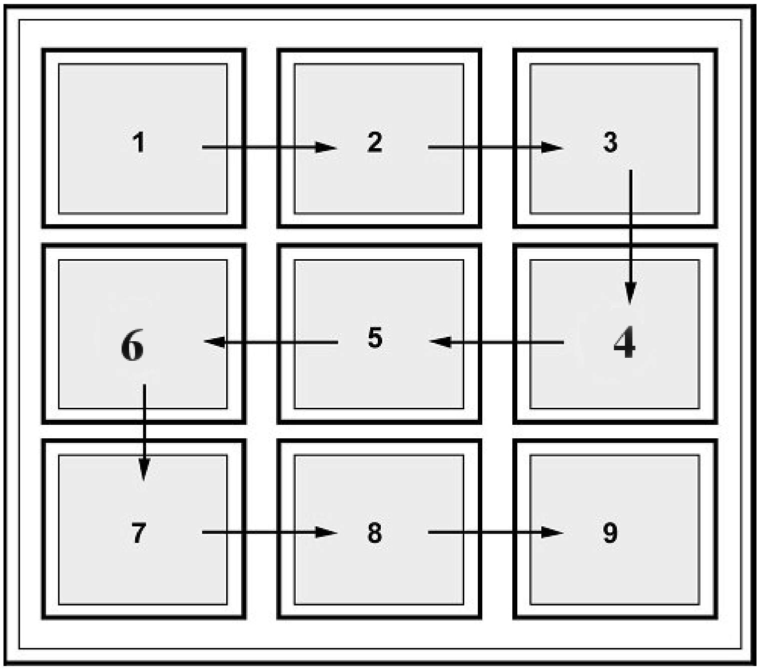


9.5.3.2.2. Evaporation lagoons should be constructed in increments. **Table 9.6** shows the time required for each of the lagoons to fill (in days). The time varies because as the lagoon area increases, the amount of water being evaporated increases, thus decreasing the net flow rate. For the 1,100-person base the first lagoon will fill in 46 days but the eighth lagoon will not fill until 932 days. Only construct lagoons that will be used during the anticipated deployment. Following the lagoon construction sequence in **Figure 9.17** will minimize construction requirements.

Table 9.6. Days Required to Fill Evaporation Lagoons

Base Population	Lagoon Number								
	1	2	3	4	5	6	7	8	9
1,100	46	99	161	233	324	445	617	932	--
2,200	50	108	175	255	353	484	674	1032	--
3,300	52	111	180	263	365	500	699	1059	--
4,400	53	114	184	269	375	514	721	1119	--
5,500	53	115	186	271	378	518	730	1133	--
6,600	54	116	188	275	383	525	737	1145	--
Notes: Based on 14 gallons of wastewater per person per day. Net evaporation rate of 46 inches per year. Lagoons are 5 feet deep with dike walls that slope at 3:1.									

Figure 9.17. Evaporation Lagoon Construction Sequence

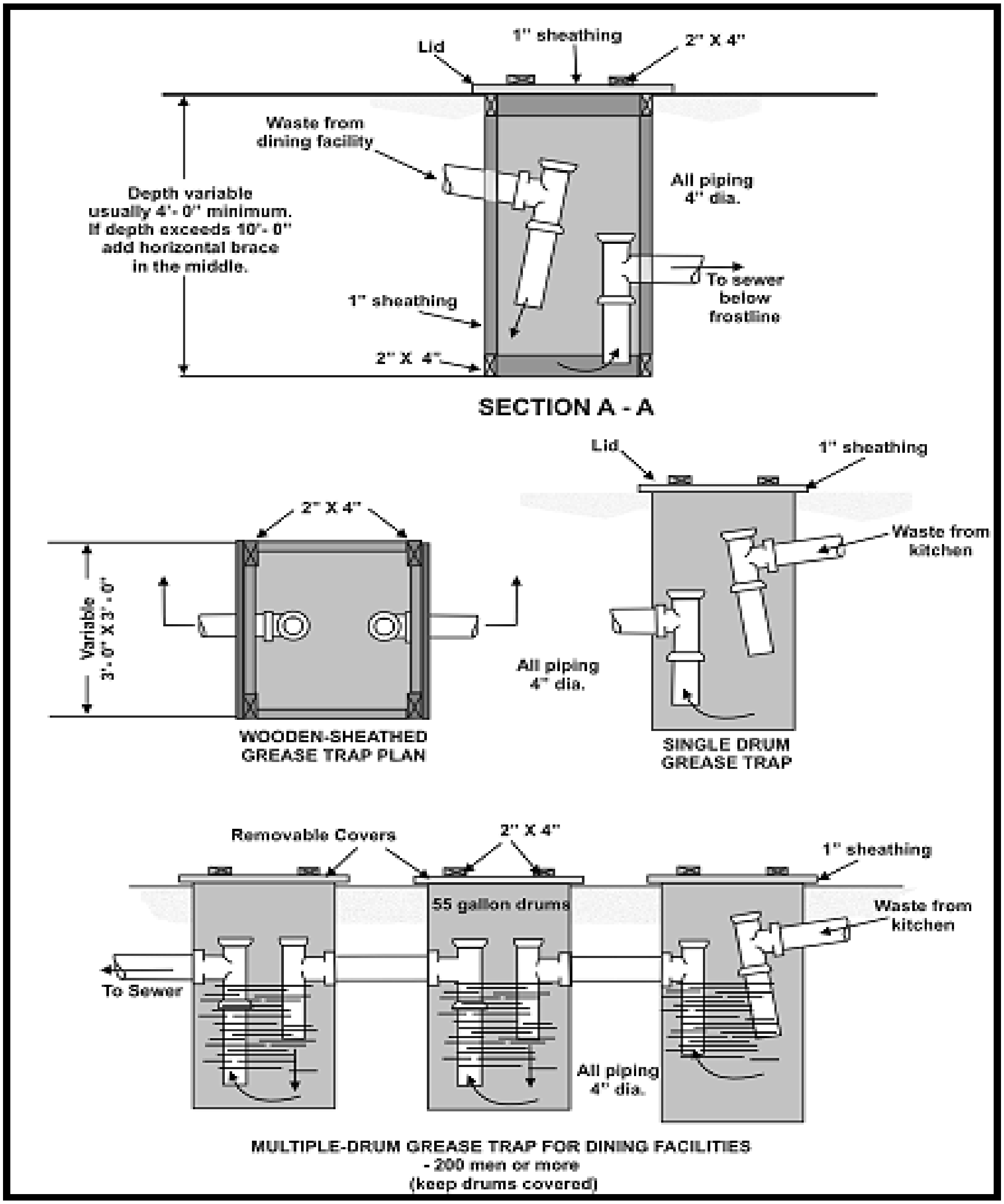


9.5.3.2.3. Where less than one gallon per hour is discharged from a shelter supplied with water for drinking or testing purposes, a dry pit (French) drain would adequately serve the area. The drain can be constructed using a 55-gallon drum (with the top and bottom removed) that is placed level in the ground and filled with rocks. No human or solid wastes should be discharged into the dry pit drain.

9.5.3.2.4. The lagoons in this chapter have not been sized to accept brine water discharged from ROWPUs. The brine water can be disposed of by returning it to the source, if the source is a body of water. If the source of the water is a well, some other method of disposal must be found. The ROWPU brine water flow rate depends on the source of water being treated, but can be twice the amount of potable water being produced (see **Chapter 9**).

9.5.3.2.5. Wastewater from kitchens must be treated to remove grease before entering the collection system. Construction details for typical grease traps supporting kitchen facilities are presented in **Figure 9.18**. The single-drum grease trap can be used for a 550-person kitchen and the larger version should be used for kitchens that serve 1,100 or more.

Figure 9.18. Kitchen Facility Grease Traps

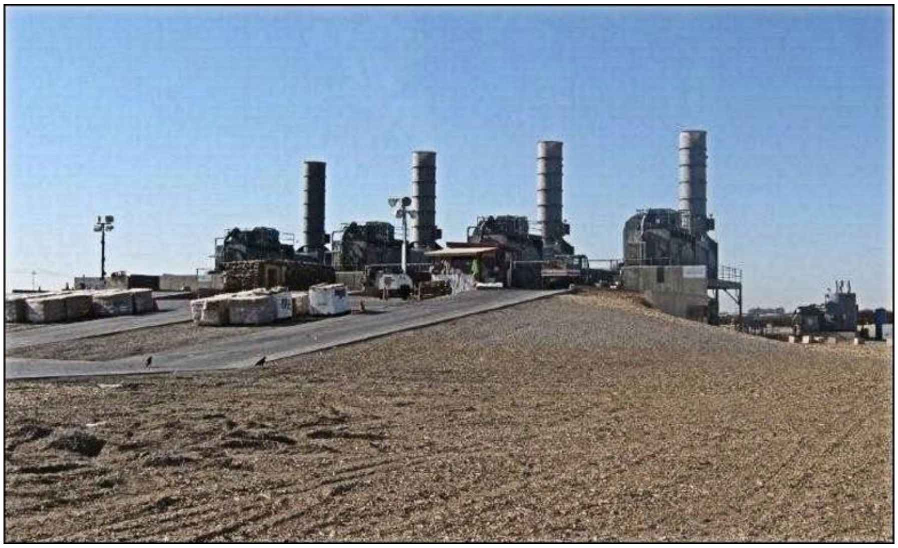


9.6. Solid Waste Disposal. Solid waste must also be collected and disposed. For planning purposes, expect four pounds per person per day of solid waste will be generated. This includes garbage (waste from preparation and serving of food), rubbish (paper, cartons, boxes, cans, etc.), ashes and industrial wastes. Although it is important to consider all available methods of solid waste disposal, disposal plans must adhere to theater-specific waste management guidance and procedures. Other sources of information include AFI 32-7001, *Environmental Management*, AFI 32-7042, *Waste Management*, UFC 3-240-10A, *Sanitary Landfill*, and AFH 10-222, Volume

4. These publications provide good solid waste management guidelines, however engineer planners must be aware of local, theater, and host-nation requirements.

9.6.1. Burning Operations. If solid waste disposal plans include burning, severe restrictions may apply to certain types of burning. If used, open-air burn pits must be operated in a manner that prevents or minimizes risks to humans and the environment. Review DODI 4715-19, *Use of Open-air Burn Pits in Contingency Operations*, for additional information. Open-air burn pits are a short-term solution to reduce the volume of solid waste during contingency operations. Long-term solutions include the use of incinerators (**Figure 9.19**) and landfills.

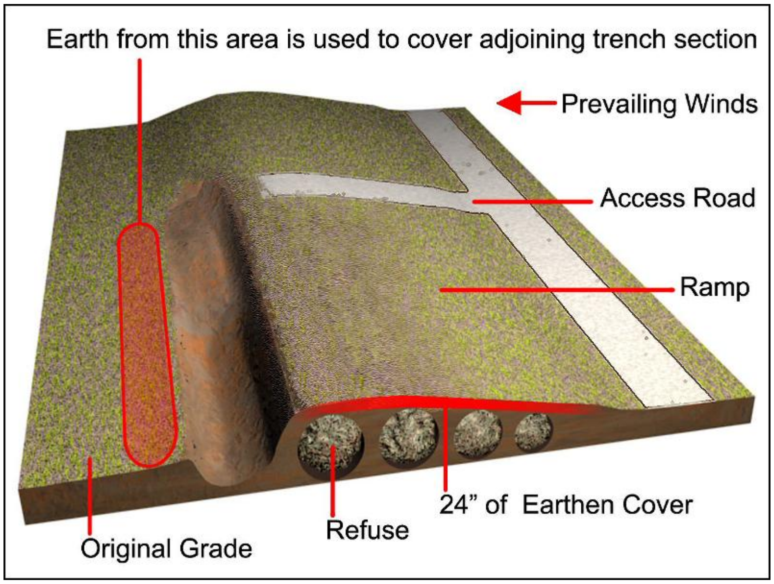
Figure 9.19. Incinerator Operations



9.6.2. Landfill Operations. Uncompacted solid waste weighs about 200 pounds per cubic yard. When compacted into a landfill, it weighs 700 to 1,000 pounds per cubic yard. A 1,100-person base generates about 4,400 pounds per day of solid waste. Uncompacted, the waste would have a volume of 22 cubic yards. A dump truck with a 5-cubic yard capacity would need to make five trips to carry a day's waste to the disposal site. However, daily burial at a landfill would compact it to between 4.4 and 6.3 cubic yards per day.

9.6.2.1. A typical trench method of landfill operation is shown in **Figure 9.20**. A crawler tractor digs a trench for waste to be dumped into. It also spreads and consolidates the waste. At the end of the day, the crawler of construction equipment covers the waste with 24 inches of earth. As a trench is filled or abandoned, it should be covered with 30 inches of earth and its boundaries marked.

Figure 9.20. Trench Method Construction of Sanitary Landfill



9.6.2.2. To minimize the possibility of underground pollution, follow these recommendations when siting a landfill:

9.6.2.2.1. Do not build on exposed rock strata. Keep a minimum of 30 feet clay-till overburden between strata and refuse unless studies indicate a lesser depth is satisfactory. Locate fill at least 500 feet from wells unless studies indicate subsurface seepage is not imminent.

9.6.2.2.2. Do not place garbage and refuse in mines or other areas where resulting seepage or leaching could carry waste to water-bearing strata or wells. Remember, chemical pollution emanating from a fill will travel longer distances than organic and bacterial pollution.

9.6.2.2.3. Do not locate sanitary fills on or near springs.

9.6.2.2.4. Locate the landfill in an area of stable soil and downwind from the installation. Avoid areas of sand dunes or other mobile earth deposits.

9.6.3. Commercial solid waste disposal systems are increasingly being targeted at meeting the unique challenges of deployed environments. These include containerized dehydration units that turn solid waste into ash or fine powder. These systems can potentially reduce the amount of water, logistics and labor needed for disposal operations and are easier on the environment.

9.6.4. Additional information on managing and disposing of solid, hazardous and medical waste can be found **AFH 10-222, Volume 4**.

Chapter 10

BEAR FACILITIES

10.1. Introduction. Modular, expandable and fabric-covered shelters and canvas tents provide structures needed on a bare base for billeting, shops, hangars and storage. All expandable facilities and tents can be set up for immediate use and packaged for redeployment by the same people who use them. It is important to keep in mind that BEAR shelters are made of lightweight materials that provide virtually no protection against weapons fire and munitions fragments. Consequently, in high-threat areas these shelters are dispersed and hardened to the maximum extent possible by using sandbags or other expedient revetment walls. In some instances, protective shelters may have to be constructed to obtain the required degree of survivability.

10.2. Overview. This chapter provides a brief description of BEAR contemporary and legacy shelters. It also covers the special handling procedures required for hardwall shelters. Throughout this chapter, keep in mind when siting facilities, areas should be level, firm, well-drained and relatively free of surface rock or stone. Also keep in mind the environmental limitation for these facilities is generally -25 degrees Fahrenheit to +125 degrees Fahrenheit and most can withstand steady wind loads of 60 knots with gusts to 90 knots. Refer to **AFH 10-222, Volume 6**, *Guide to Bare Base Facility Erection*, and applicable technical orders for detailed guidance on erection and disassembly of facilities in this chapter.

10.3. BEAR Shelters.

10.3.1. **Small Shelter System (SSS)**. This all-purpose tent-type shelter (**Figure 10.1**) is used for billeting, work areas, latrines and showers, storage, etc. It is stored and shipped in its own container, four containers per 463L pallet. When fully erected, this shelter measures 32.5 feet long by 20 feet wide by 10 feet high (650 sq ft). The SSS is equipped to accept 120/208 VAC, 60-cycle, single-phase power. This shelter is commonly referred to as the “Triple-S” and has been designated as the replacement for the TEMPER tent through attrition. Compared to the TEMPER tent, it is less costly, slightly lighter, tighter, and more vector proof. It also requires less day-to-day maintenance when erected, and its fabric is easier to repair. A minimum of six people are required to safely assemble this structure in about 1.5 hours (nine labor hours) and multiple buildings can be interconnected. See T.O. 35E5-6-11, *Alaska Small Shelter System (AKSSS)*, for further instructions.

10.3.2. **Medium Shelter System (MSS)**. This shelter is 52 feet long by 29.5 feet wide by 15 feet high (1,534 sq ft) and is used as an all-purpose, mid-sized shelter (**Figure 10.2**) in the maintenance, warehouse, storage and kitchen areas. The shelter is shipped and stored in its own containers. An all-terrain forklift and a hammer drill and bits are required for erection. It may be erected over soil, asphalt, or concrete. This shelter has a 120/208 VAC, 60-cycle, 3-phase, 5-wire input. The MSS is replacing the General Purpose Shelter in the inventory. It provides tighter protection against dust and insects, has lower maintenance costs and takes up less shipping space. These shelters are also known as the “M Double S.” A minimum of six people can safely assemble this structure in about 4 hours (24 labor hours) and multiple shelters can be interconnected. Consult T.O. 35E5-6-21, *California Medium Shelter System*, for more details.

Figure 10.1. Small Shelter System

Figure 10.2. Medium Shelter System

10.3.3. **Dome Shelter**. The Dome Shelter is a large shelter used as a warehouse, maintenance area, or small aircraft hangar (**Figure 10.3**). It is constructed of synthetic fabric over aluminum arch sections, with steel tension cables to provide rigidity. The standard configuration for the Dome Shelter is 120 feet long, 70 feet wide (8,400-sq-ft shelter) and 25.6 feet high at the arch apex. Dome Shelters with a gabled end are 89.3 feet long by 60 feet wide by 25.6 feet high for a 5,358-sq-ft building. The area needed to erect the standard shelter is 140 feet by 90 feet and with the gable end requires 110 feet by 90 feet. The location should be vehicle accessible as the shelter is shipped and stored in three 463L pallet containers. When installing on concrete, secure with thunder studs. Shelter can accept 120/208 VAC, 60-cycle, 3-phase, 5-wire electrical input. A minimum crew of eight is required to erect the Dome Shelter in about 32 hours (256 labor hours), and multiple buildings can be interconnected. See T.O. 35E4-216-1, *Bare Base Dome Shelter*, for more information on the shelter.

Figure 10.3. Dome Shelter

10.3.4. **International Standardization Organization (ISO) Shelter.** ISO shelters were developed to provide some degree of standardization in the various shelters used by the Armed Forces. The ISO designation means each structure conforms to the material handling requirements established by the ISO. Although there are not many of these shelters in the BEAR systems, some may be encountered at locations supporting joint services. As shown in **Figure 10.4**, these shelters are either rigid or expandable. No special equipment is needed for erecting ISO shelters and site preparation requirements are minimal.

10.3.4.1. The ISO 1:1 (rigid type) measures 8 by 20 feet and its gross weight is 13,900 pounds (3,900 tare weight and 10,000 payload).

10.3.4.2. The ISO 2:1 (one side expandable) has interior dimensions of 14 feet 6 inches by 19 feet 1 inch; ceiling height is 7 feet 1 inch. The gross weight of this shelter is 15,000 pounds (tare weight is 5,500 pounds). With four people assigned, erection takes 25 minutes.

10.3.4.3. With both sides expanded, the ISO 3:1 has a nominal interior dimension of 20 feet by 11 feet 6 inches; ceiling height is 6 feet 9 inches. Gross weight is 6,500 pounds (tare weight is 2,000 pounds). Six people can erect this ISO in 45 minutes.

Figure 10.4. ISO 2:1 Shelter

10.3.5. **Expandable Light Air Mobile Shelter (ELAMS)**. This all-purpose, softwalled shelter serves as a command post, medical clinic, maintenance shop, storage, or office area (**Figure 10.5**). Standard expanded configuration is 14.8 feet long by 20.25 feet wide by 8 feet high (300 sq ft). The shelter has a 120/208 VAC, 60-cycle, 3-phase, 5-wire input. A minimum of five personnel are can safely assemble the structure in about six hours (30 labor hours).

Figure 10.5. Expandable Light Air Mobile Shelter

10.3.6. **Large Area Maintenance Shelter (LAMS).** The LAMS (**Figure 10.6**) provides semi-portable housing for small aircraft and vehicle maintenance. Sized at approximate 129 feet long, 75 feet wide, and with a 31-foot height clearance at the center, it has electrically operated Clamshell end-doors at both ends. The shelter is equipped with explosion proof lights, outlets, wiring, and switches. It can be erected on a reinforced concrete pad (100 feet minimum x 135 foot minimum x 8 to 10 inch thick), asphalt, or earth surface. Once erected, the LAMS provide an unobstructed, weatherproof work area free of vertical supports that could hinder movement of aircraft and equipment within. A minimum of ten people are required to assemble the structure safely. Assembly time is approximately 300 man-hours. Consult T.O. 35E4-219-1, *Large Area Maintenance Shelter*, for additional information.

Figure 10.6. Large Area Maintenance Shelter

10.3.7. **Automatic Building Machines**. While not included in BEAR packages, automatic building machines can be and are used at most bare bases. Using rolls of galvanized steel or aluminum, these machines produce structural building arches of various widths that are erected and crimped together at the seams. The manufactured facilities, commonly called K-spans (**Figure 10.7**), can be used as aircraft hangars or covered storage buildings. When fitted with end walls and ventilating and mechanical systems, these facilities can serve as shops, recreational facilities and shelters. Some of these machines are prepositioned overseas and others are part of the RED HORSE squadron equipment package. A trained crew of 10 to 12 people can make a 10,000 SF facility in about a day using a trailer-mounted system.

Figure 10.7. RED HORSE Crew Assembling a K-Span Building

10.4. Legacy Shelters.

10.4.1. **Tent, Extendable, Modular, Personnel (TEMPER)**. Prior to the SSS, the TEMPER was the most frequently used facility in bare base packages. The TEMPER tent is a modular, soft shelter (synthetic material) supported by an aluminum frame structure (**Figure 10.8**). Its primary use is for troop billeting (12 personnel per tent) but it also supports other functions, such as shops and administrative space. This tent comes with roll up windows, mosquito netting and a flysheet (waterproof material that attaches above the tent top and allows free movement of air between the flysheet and the tent top). The tent comes in 8 foot by 20-foot sections that fasten together; the nominal tent size is 32 feet by 20 feet x 11 feet (640 sq ft tent). Also included is a white inner liner for insulation and a fabric floor. For special adaptations, solid doors and entry vestibules are available. An electrical wiring kit provides lights and convenience outlets. The TEMPER tent can be heated and cooled as required and a fabric plenum is provided to direct airflow. A minimum of six personnel are required to safely assemble this shelter in about 1.5 hours (9 labor hours). However, it is common to use a team of 10 personnel (of various skill levels) to erect it in about an hour. Multiple buildings can be interconnected. Consult **AFH 10-222, Volume 6**, and T.O. 35E5-6-1, *Tent, Extendable, Modular, Personnel (TEMPER)*, for detailed information on this shelter.

Figure 10.8. TEMPER Tent

10.4.2. **General Purpose (GP) Shelter.** The general-purpose shelter supports such functions as shops, storage and multipurpose use (**Figure 10.9**). The overall size of the shelter is approximately 48 feet long by 31 feet wide by 12 feet high. The shelter has windows, rigid doors and truck doors that give access to service equipment. Lighting and service outlets are provided through a distribution panel and cable arrangement on each side of the shelter. A membrane or rigid panel floor are optional features that may be installed in the shelter. Removable panels in the shelter allows for the installation of a heating and air conditioning unit. Shelter erection tools are provided and located in marked containers. A crew of six can erect the shelter on a prepared surface in about 15 hours, or about 20 hours if installed with a floor. The GP Shelter is packaged into an 8 feet by 8 feet by 10 feet container, which can be used for other purposes until the shelter is reconstituted. The GP shelter is being replaced through attrition by a softwalled Medium Shelter System described earlier in this chapter.

Figure 10.9. General Purpose Shelter

10.4.3. **Expandable Shelter Container (ESC)**. This shelter container is used primarily for flightline and industrial shops (**Figure 10.10**). When expanded, the ESC measures approximately 21 feet long by 13 feet wide by 8 feet high (273 SF) and weighs 12,500 pounds when shipped without an internal payload. When packaged, the unit is 8 feet by 13 feet by 8 feet. The unit may be expanded without removing whatever payload might be in the container. Panel inserts in one of the swing-out walls can be removed to connect one ECU, which is sufficient for heating and cooling this shelter. Double doors (cargo doors) are installed in one end wall of the center section and a personnel door in the other end wall. Double pane windows in the walls are nonopening, shatterproof, heat resistant and equipped with blackout curtains. An entire 3-phase electrical system is provided, along with installed lighting and electrical service equipment. The ESC can be erected with a crew of six people in approximately two hours.

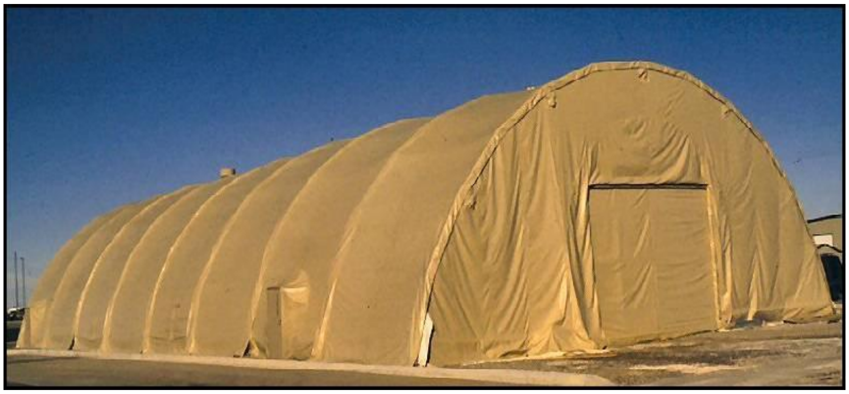
Figure 10.10. Expandable Shelter Container

10.4.4. **Aircraft Maintenance Hangar (ACH)**. This 77-foot-wide shelter is used for most on-aircraft maintenance functions or as a warehouse (**Figure 10.11**). It consists of a series of freestanding arches formed from individually shipped aluminum beams and honeycomb core and aluminum skin panels. The beams and panels are locked together at ground level to form an arch section. Each hangar is shipped in four containers that measure 10 feet by 8 feet by 8 feet each. These containers are positioned at each corner of the hangar to make vestibule-like personnel entrances/offices. Use existing concrete or asphalt surfaces, AM-2 matting or a locally supplied material as the floor. The ACH structure comes with 3-phase electric wiring and openings for ducts to interface with the BEAR electric and heating systems. The first choice for the hangar site is on, or close to, an airfield apron. If the apron site is impractical, a hard surface, approximately 125 by 150 feet, capable of withstanding aircraft weight should be selected. When erected, the hangar is 125.6 feet long by 77 feet wide and 25 feet high at the center (9,748 sq ft) with the doors closed. Personnel from RED HORSE or the 49 MMG will erect this shelter. Erecting the ACH requires a minimum of 10 people and generally takes about 40 hours (400 labor hours). Multiple buildings can be interconnected. Consult T.O. 35E4-133-1 for further information.

Figure 10.11. Aircraft Hangar

10.4.5. **Frame-Supported Tensioned Fabric Shelter (FSTFS)**. The FSTFS is a hangar-like structure fashioned by stretching a fabric skin over a series of metal arches (**Figure 10.12**). It supports functions requiring large floor spaces, such as supply storage, vehicle maintenance and various aircraft maintenance shops. The FSTFS can be set up directly on pavement or floors built from AM-2 matting. The most common sizes are 70 feet long x 60 feet wide x 25.6 feet high (4,200 sq ft) and 140 feet long x 60 feet wide x 26 feet high (8,400 sq ft). RED HORSE or the 49 MMG erects these facilities. A minimum of eight personnel are required to safely assembly the FSTFS and assembly time is about 32 hours (256 total labor hours) for the smaller version and 48 hours (384 total labor hours) for the larger version. Multiple buildings can be interconnected. FSTFSs are gradually being replaced by the Dome Shelters, which provide more utility and versatility. See T.O. 35E4-183-1 for detailed descriptions.

Figure 10.12. Frame Supported Tension Fabric Shelter (FSTFS)



10.5. Hygiene Facilities.

10.5.1. **Shower/Shave Unit**. This portable shower/shave unit (**Figure 10.13**) consists of a four-section shower element and four separate washstands. These units come with their own tents. Set up requires a minimum of four people approximately 6 hours (plus tent and boiler set up).

Figure 10.13. Shower/Shave Unit

10.5.1.1. Portable shower consists of six separate but identical and interchangeable modules. Each module has a pallet-like shower base pan with drains and fittings to connect the drain plumbing. Each shower module has two shower nozzles mounted on a surrounding framework, which serves as a support for the vinyl fabric shower enclosure. The entire shower system includes interconnecting hoses among the six modules for water inlet and draining, a water heater (usually an M-80) and pump for hot water supply and another pump with hose for removal of wastewater.

10.5.1.2. Each shave facility consists of a three-bowl washstand and a mirror with attached light fixture (**Figure 10.14**). The washstand features folding legs and contains all required plumbing. Four washstands (a total of 12 bowls) will be located with each field shower (two on each side).

Figure 10.14. Shave Facility Washstand

10.5.2. **Field Deployable Latrine**. The field deployable latrine is included in BEAR equipment. This latrine (**Figure 10.15**) consists of six toilets and a urinal trough mounted above a 135-gallon water tank, a hand-washing sink and a 180-gallon waste tank. Four deployable latrine units constitute one BEAR package and support 600 people. These packages come with their own tents. Setup (not including the shelter) takes two people about one hour.

Figure 10.15. Field Deployable Latrine

10.5.2.1. Water and waste tanks are supported by an aluminum frame and plywood partitions. There are privacy screens between the toilet commodes and the urinals. A pressurized water system, operating on 115-VAC power, supplies water for flushing the toilets. The vent pipes, curtains and frame dismantle and the urinal board folds down to provide a shipping package 88 inches wide by 104 inches long by 42 inches high. This latrine contains an electrical outlet and comes with a 100-foot power cable. The unit is self-packaging, can be forklifted and is stackable. Tie down and lifting eyes are provided.

The double-stacked latrine unit is air transportable on 463L pallets. This unit weights 1,530 pounds dry without the pump unit.

10.5.2.2. During the early stages of a deployment, this latrine can be operated in a stand-alone mode. That is, the water tank is periodically replenished and the waste tank is emptied using the wastewater disposal trailer (recall **Figure 9.2**). Once the water and waste distribution systems are in place, the unit can be connected directly to the service lines. For planning purposes, one six-commode field deployable latrine can serve 160 males (because it would also have urinals) and 120 females. As mentioned in the previous chapter, separate latrines must be provided for women. This provision may be accomplished by splitting one bank of the latrine assembly and separating them with a plywood wall between the two banks. This allows use of the same shelter, pumps, etc.

10.6. Food Service Facilities. The kitchen complex generally consists of several tents and associated kitchen equipment sized to feed 1,100 people. The 1,100-person kitchen package consists of two 550-person kitchens. In a typical setup for this population size, interconnected shelters provide space for storage, utensil washing, food preparation, serving and dining. Force Support personnel normally erect all tents associated with the kitchen; however, engineers provide supporting utility service (electric, water and wastewater) and install some of the more complicated equipment items, such as water heaters, walk-in refrigeration units and air conditioning units. Several expedient food service facilities are covered in the next chapter.

10.7. Offloading Facilities at the Bare Base. Dimensions and weight is determined by the mode of transportation from the aircraft to the site of erection. Basically, the shelters must be forklifted, hoisted, or trucked from one location to another. Engineers will need to have several people qualified on large, all-terrain forklifts. Provisions for forklifting tines are incorporated into the base assembly of all hardwall shelters. The tines must slide into the opening provided for forklift operation. The ship/store containers also have forklift tine holes. Site layout action must be well under way by the time facilities begin to arrive on base. This allows equipment operators to place facility assets correctly with respect to orientation and utility connections. More importantly, this also helps avoid having to move assets more than once during the initial beddown.

10.7.1. Containers. Many BEAR assets are transported in ship/store containers that are 90 inches high and sized for a 463L pallet. The containers have double doors on both 108-inch sides with adjustable shelves and a center divider. The containers have a tare weight of about 1,750 pounds and a maximum load capacity of 10,000 pounds. They are used to ship and store such assets as tents, shower/shave facilities, BEAR 550 kitchens and Dome Shelters. (Note: the overall dimensions of the 463L pallet are 88 by 108 inches, with usable dimensions of 84 by 104 inches. This allows two inches around the load to attach straps, nets, or other restraint devices. An empty 463L pallet weighs 290 pounds and with nets it weighs 355 pounds). Planners should expect to see 20-feet wide ISO containers become the primary packaging source for BEAR equipment assets.

10.7.2. Hoisting. Hoisting rings are also located on each roof corner of hardwall shelter containers. When three shelters are joined in a triple-mode concept, 12 rings are available. Inboard corners of outbound shelters or outbound corners of center shelters give the best cable angles for lifting the shelter and any internal payload. Ship/store containers also have external lifting rings.

10.8. Allowance Standards (AS). AS 157 is the allowance standard for BEAR equipment. The facilities and equipment lists presented in **Chapter 3** are derived from the information contained in the allowance standard. Be aware, however, that the allowance standard is not specific with respect to numbers and types of facilities for all functional areas. For example, security forces will likely want a base defense operations center, sector command posts, an armory, a storage facility and protective revetments; these potential requirements are not specifically delineated in the AS. Instead, there are several facility assets that are identified as multipurpose or common facilities, and these will have to be parceled out base wide to meet the various facility demands. The commander at the deployed location is normally the final authority in regard to facility allocation, but engineer planners must be prepared to provide advice and recommendations of facility scopes and base wide requirements based on population and the number of aircraft.

10.9. Survivability Considerations. As stated at the chapter's outset, the lightweight construction of modular BEAR shelters provides little, if any, protection even against small arms fire, much less the blast and fragmentation associated with explosions and aerial munitions. While dispersal of facilities in a high-threat environment enhances survivability, additional measures are necessary to protect personnel and critical resources. Volume 2 of this pamphlet series highlights basic planning for such enhancements and AFH 10-222, Volume 14 provides descriptions of various weapons effects and information on natural and manmade revetment materials. Construction methods for structural revetments and personnel protection shelters are presented in Volume 7 of this pamphlet series.

Chapter 11

BARE BASE ANCILLARY EQUIPMENT

11.1. Introduction. This chapter provides descriptions of ancillary equipment and mechanical systems that may require support by bare base engineers. Although CE may not own or operate most of this equipment, much of it is in UTC packages used by other functional communities (e.g. Force Support, Medical, etc), and CE will likely be involved in site preparation, installation and hardening and the connection of electrical power, water and waste disposal systems.

11.2. Overview. The description of equipment and systems in this chapter and Chapter 12 is intended as a guide for planning for the additional resources required to support these ancillary equipment items. This chapter is not intended to cover operations or detailed procedures. Planners should see applicable TOs, manuals, and other sources for additional information on these and other ancillary equipment and systems.

11.3. Fuels Mobility Support Equipment (FMSE). FMSE is designed to receive and issue fuel at bare bases and to augment locations with fixed-fuel facilities. It includes items such air-transportable fuel bladders, hydrant systems, bulk pumps, and filter separators. Details for two of these items are addressed below.

11.3.1. R-14 Air Transportable Hydrant Refueling System**.** The R-14 is a portable, hydrant-refueling system that can be airlifted or ground shipped anywhere in the world and made fully operational in a matter of hours. A complete system contains three identical, self-sufficient modules. Each module consists of a pumping unit; two 50,000-gallon bladder tanks; and all the hoses, valves, and fittings necessary for operation (**Figure 11.1**). The pumping module is configured on a four- wheeled trailer and features the same components found on conventional servicing equipment. Each R-14 module can fuel one heavy aircraft at 600 gallons-per-minute (gpm) or two fighter aircraft at 200 gpm. The number of R-14 units to be deployed to an installation is predicated on the number of aircraft to be supported. These units are sourced separately from BEAR assets and can vary in quantity from base to base. Additional 50,000-gallon bladders without the refueling module can also be deployed, normally in packages of four.

11.3.2. Fuel Bladders. Fuel bladders (sometimes referred to as pillow tanks) generally range in capacity from 500 gallons to 210,000 gallons (**Figure 11.2**). Typically, 10,000-gallon fuel bladders are used at low-demand sites such as vehicle refueling points. Larger 50,000-gallon fuel bladders support aircraft fuel storage and refueling and are commonly found with the R-14 refueling unit previously addressed. The 210,000-gallon bladders are used for bulk fuel storage. Collapsible fuel bladders, like aboveground steel tanks, require berms and liners to contain tank contents in case of rupture and to stop fragments and blast effects from near-miss explosions. Fuel bladders are actually less vulnerable than permanently installed steel tanks since they are close to the ground, have no vapor space, generate no sparks when penetrated and have much lower static head. Additional fuel bladder details are listed in **Table 11.1**. Refer to T.O. 37A12-15-1, for additional information relating to operation, service, repair, and berm construction details.

Figure 11.1. R-14 Refueling System Readied for Shipment

Figure 11.2. Collapsible Fuel Bladders

Table 11.1. Collapsible Fuel Bladder Details

Capacity	Bladder Dimensions										Weight Dry (Approx.)[2]
	Full (Approximately)[1]						Empty				
	Length		Width		Height		Length		Width		
	Ft	In	Ft	In	Ft	In	Ft	In	Ft	In	Pounds
500	13	5	9	0	5	8	5	1	4	4	250
3,000	12	6	12	6	4	0	14	0	14	0	210
10,000	20	6	20	6	4	0	22	0	22	0	375
20,000	26	6	22	6	5	2	28	0	24	0	680
50,000	66	0	22	6	5	5	68	2	28	1	1,500
50,000	62	8	22	7	5	2	65	0	24	6	1,026
210,000	68	5	68	5	6	5	70	0	70	0	5,000
210,000[3]	72	5	73	4	5	6	74	4	73	2	4,217

1-After settling (height is greater on initial fill)
2-Tank only. no accessories
3-Tanks produced by MPC Containment Systems after October 2008

11.4. Fuels Operational Readiness Capability Equipment (FORCE). A mobile, air-transportable, aircraft and ground fuel delivery system that is designed to replace older and less efficient Fuels Mobility Support Equipment (FMSE) previously addressed. Currently being fielded at numerous locations, FORCE fueling systems, like that shown in **Figure** 11.3, saves time and resources and improves safety, reliability, and flexibility of the deployed fueling systems.

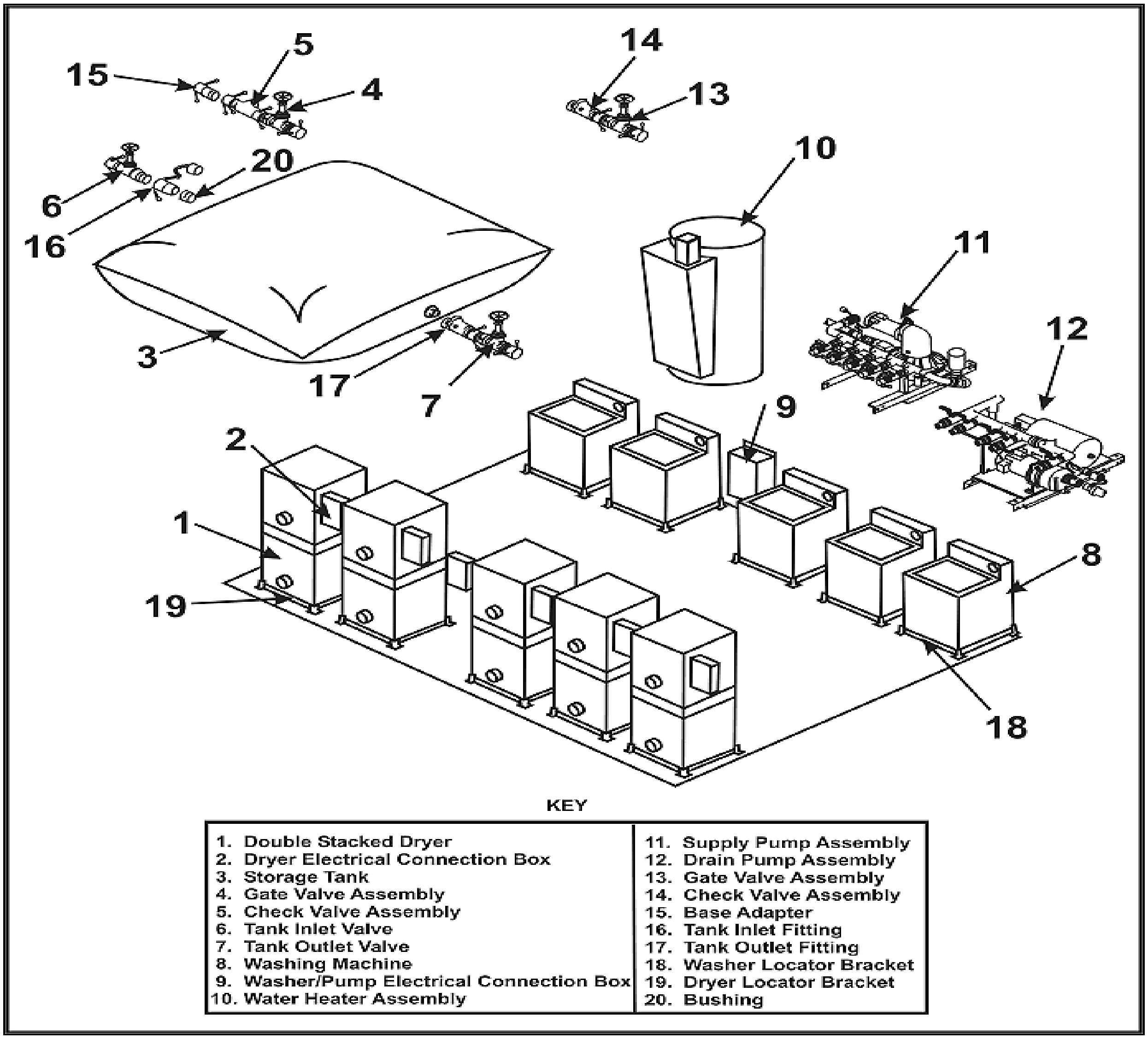
Figure 11.3. New FORCE Refueling System

11.5. Laundry Facility. Force Support personnel provide laundry service support at a bare base. Force Support is responsible for planning the quantities of washers, dryers and supplies for laundry operations or providing for contract support where available. For additional information on Force Support's role in laundry support, refer to **AFH 10-247, Volume 1**, *Guide to Services Contingency Planning—Beddown.* For planning purposes, each laundry unit normally supports 550 persons, although the capability will depend on the type of laundry system used. For the Self-Help Laundry System, plan on 5 washers and 10 dryers for every 200 people. For commercial-off-the-shelf equipment, plan on one washer and 1.5 dryers for every 20 people.

11.5.1. Self-Help Laundry**.** The self-help laundry is designed for rapid deployment and continuous operation as an efficient field laundry system. An entire set contains 10 washers, and 20 double-stacked dryers, water heater, 3,000-gallon collapsible bladder water tank, supply and drain pumps, electrical distribution panels and associated hardware. The washers, dryers and electrical connection boxes are to be operated inside a 32 feet long by 20 feet wide facility (TEMPER tent or small shelter system). The pumps, water heater and tank are all positioned outside the shelter. The set also includes benches, folding tables and temporary hanging racks. The set can be halved into a laundry center of 5 washers and 10 dryers per tent to support smaller populations (**Figure 11.4**). Bare bases also often use heavy-duty household or commercial washers and dryers as self-help laundries.

11.5.1.1. Utilities. The laundry requires a maximum of 300 amps, 3-phase, 60-cycle, 120/208 VAC electrical power. This laundry does not come with electrical generation equipment and must be connected to the local power source. It can also be operated without the water heater, which requires 208 VAC, 3-phase power. Adapters are provided to connect this system's 1-1/2 inch diameter inlet valve assembly to a 2-inch local water source. Cold water is then pumped to the washers and to the hot water heater. The drain pump draws wastewater and sends it to the local drain piping system or whatever disposal system is being used.

Figure 11.4. Self-Help Laundry Major Components



11.5.1.2. Site Preparation. The site selected for the laundry facility should be a relatively level area with adequate drainage. Laundry equipment requires approximately 75 square feet of space inside a TEMPER tent or general-purpose medium or small shelter system, which is erected by Force Support personnel.

11.5.2. Contract Laundry and Dry Cleaning. Depending on location and need, Force Support personnel may establish contract laundry, dry cleaning and linen exchange. This includes organizational laundry (e.g. medical) and other needs. Quality of life enhancements might include a covered porch, additional chairs and a rudimentary sound system for radio broadcasts.

11.6. BEAR 550 Kitchen. The BEAR 550 Kitchen is an optional asset and currently the most commonly used food service structure in the BEAR inventory (**Figure 11.5**). It is designed to serve up to 550 personnel and seat 120. That capacity is doubled (1100 personnel and 240 seats) when two 550 kitchens are combined (**Figure 11.6**). All tools, components and equipment, (except electrical and water supplies), that are required to unpack, set up, operate, maintain, strike, and repack the facility, are supplied in the shipping containers. Force Support personnel normally erect all tents associated with the kitchen; however, engineers provide siting layout and supporting utility service (power, water, and wastewater) and install some of the more complicated equipment items such as water heaters, walk-in refrigeration units and air conditioning units. The power distribution system takes electrical power from an external source and steps it down to the power level requirements of the various electric appliances and lights. The major components of the power distribution system of 550 kitchen facilities include secondary distribution boxes, cable assemblies and lighting harnesses. Electrical power requirements are one 225-Amp, 208 VAC, 3 Phase, 60 Hz power source and two 150-kVA secondary distribution centers. Refer to T.O. 35E4-169-31, *BEAR Base Harvest Falcon/Eagle Electric Kitchen with Mess Kit Laundry*, for more information on siting kitchen facilities.

Figure 11.5. BEAR 550 Kitchen (550-Personnel)

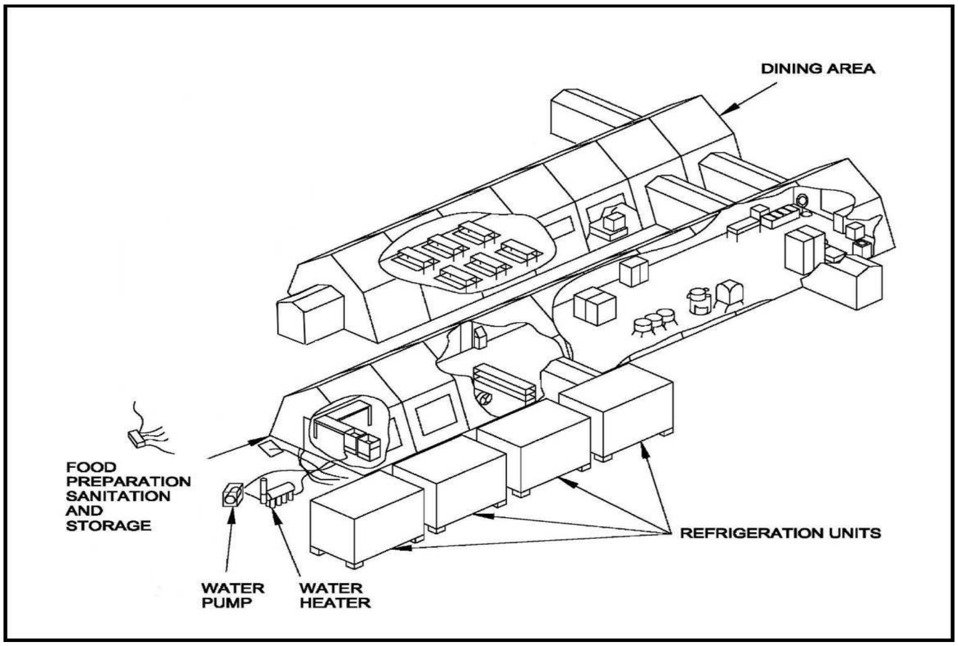
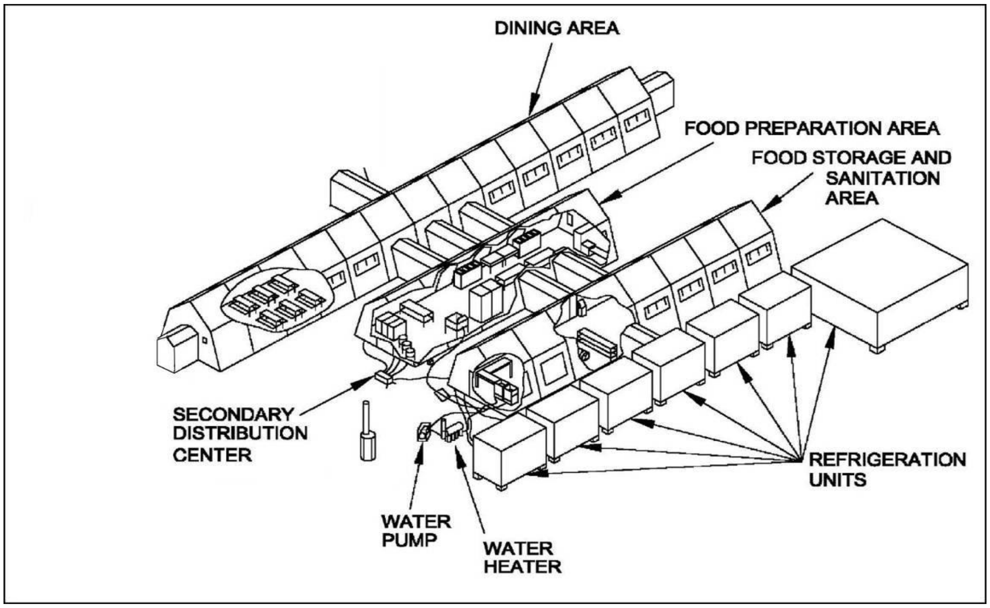


Figure 11.6. BEAR 550 Kitchen (1100-Personnel)



11.7. Single Pallet Expeditionary Kitchen (SPEK). This specially designed kitchen is deployed as a lightweight, highly mobile, temporary kitchen for use at remote and underdeveloped areas for periods of up to 30 days (**Figure 11.7**). As the name implies, the BEAR SPEK and all of its equipment fit onto a single 463L air cargo pallet. It is designed to feed 500 people twice a day in two-hour periods with tray-pack Unitized Group Rations-Heat and Serve (UGR-H&S). It comes in an expandable "EISU-90" container and includes a Medium Shelter System for diners' seating space. The SPEK's critical equipment items are the Tray Ration Heater (TRH), which is used to prepare the UGR-H&S menu items, and the Field Sanitation Unit (FSU), which is used for cleaning, washing and sanitizing kitchen utensils. The TRH and FSU can operate in temperatures from –20 degrees Fahrenheit to +120 degrees Fahrenheit and relative humidity ranging from 20 to 80 percent. Local support for water and wastewater disposal is required. A 2-kW diesel generator, provided with the kitchen, furnishes the electrical power source. The entire kitchen can be easily unpacked and assembled by a minimum of 8 personnel in about 2 hours and requires only 4 food service personnel to operate its equipment and serve food.

Figure 11.7. Single-Pallet Expeditionary Kitchen (SPEK)

11.8. M-80 Water Heater. The M-80 water heater (**Figure 11.8**) is the primary boiler component for several BEAR assets, namely the shave/shower unit, the 550-person kitchen and the standardized field laundry. The heater is self-contained and operates on either diesel or gasoline, consuming approximately five gallons per hour. It weighs approximately 465 pounds and is skid-mounted with forklift tine inserts for ease of movement. Its overall size is 52 inches long by 27 inches wide by 47 inches high. It has a capacity of 23.7 gallons and provides nine gallons of water per minute at 100 degrees Fahrenheit. The heater comes as an integral part of all the systems it supports; i.e., it does not have to be requested separately. Details on the operation of the M-80 water heater can be found in T.O. 35E7-4-27-1, *Heater, Water, Liquid Fuel, M-80*, and AFH 10-222, Volume 12, *Guide to Bare Base Mechanical Systems*.

Figure 11.8. M-80 Water Heater

11.9. WH-400 Water Heater. The WH-400 water heater (**Figure 11.9**) is being phased into the BEAR inventory as a replacement for the M-80. It is a fuel-fired, skid-mounted water heater suitable for military transport. It operates using a variety of fuels, including DF1, DF2, DFA, JP-

5, and JP-8. The heater dimensions are 75” H x 32” W x 55” L, and weighs 500 pounds in the fully functioning, ready-to-operate configuration. It delivers water at a rate of 9 gpm at temperatures between 60° F and 190° F (16° C and 88° C). It has a drum fill adaptor assembly that permits use of 55-gallon fuel drums for extended operations.

Figure 11.9. WH-400 Water Heater

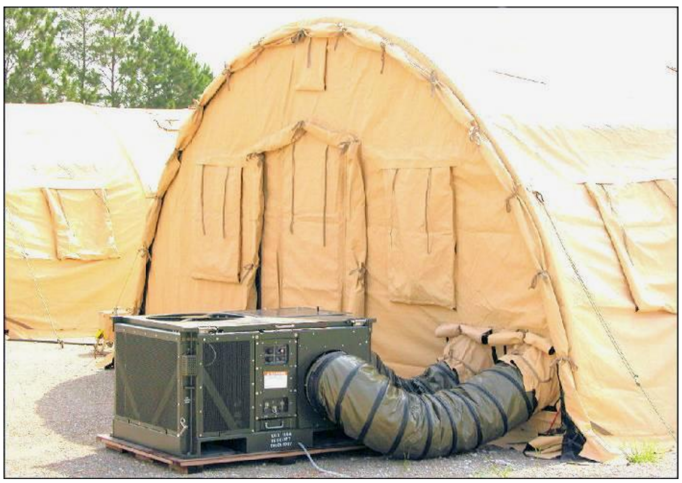
11.10. 130K Portable Heater. The 130K heater provides heated air for sleeping quarters and work facilities (**Figure 11.10**). This multi-fueled heater will deliver hot air at a minimum of 1000 cubic feet per minute and at temperatures ranging from 80° F to 180° F—making it ideal for extremely cold conditions. It can also provide forced fresh air ventilation without heating. Consult AFH-10-222, Volume 12, and T.O. 35E7-3-4-1, *Heater, 130K Multi-Fueled, Portable, Duct Type 130,000 BTUH Model Polar Bear1*, for additional information.

Figure 11.10. 130K Portable Heater

11.11. Environmental Control Units (ECUs). ECUs are used for heating, cooling, dehumidifying, filtering, and circulating air in tents, portable shelters and vans to meet the controlled environmental requirements of personnel and equipment. ECUs admit fresh air at a controlled rate. In a typical application, the air conditioner is located external to the controlled space (normally 4-6 feet away) and conditioned air is circulated into the controlled space through supply and return ducts. ECUs are included in BEAR assets in sufficient numbers to support the facilities included in each set.

11.11.1. Field-Deployable Environmental Control Unit (FDECU). The FDECU is the primary BEAR ECU (**Figure 11.11**). There are several different models fielded and each can be used to heat, cool, dehumidify, filter and circulate air in portable shelters and containers for personnel and equipment. It provides a maximum of 84,000 BTUs of heat and 67,000 BTUs of cooling per hour. This unit also uses “ozone friendly” R-134A refrigerant. Perhaps most important from a mobility aspect, the FDECU is smaller and considerably lighter than the other models. Weight and cube improvements have doubled the number of ECUs that can be packaged per pallet. FDECUs can be fitted with chemical, biological and radiological filters attached to an inside blower to pressurize the shelter and filter-out harmful agents. Additional information on the FDECU can be found in T.O. 35E9-314-1, *Field-Deployable Environmental Control Unit*.

Figure 11.11. Field-Deployable Environmental Control Unit



11.11.2. A/E32C-39. Commonly referred to as the Dash 39 (-39), the ECU-39 (**Figure 11.12**) is a BEAR legacy ECU that is being replaced by the FDECU previously addressed. In a standard application, the unit is located external to the controlled space and the conditioned air circulates through supply and return air ducts. The unit can also be adjusted to admit fresh air at a controlled rate. Approximate cooling capacity is 4.5 tons. Approximate heating capacity is 9.6 kilowatts (down to approximately 30° F). This unit uses R-22, an ozone-depleting refrigerant.

Figure 11.12. A/E32C-39 Environmental Control Unit

11.12. Walk-In Refrigeration Units. BEAR packages contain portable, walk-in refrigeration units or boxes that support food service storage operations or a field morgue. Refrigeration boxes are secure, insulated containers in which the mechanical refrigeration equipment is installed. These boxes can be moved by forklift utilizing the forklift holes provided in the aluminum skid, which is a permanent part of the boxes. Lifting loops are also provided on each corner near the top so that the boxes can be lifted by crane, boom, or helicopter. The walls, floor and ceiling of the boxes are aluminum-framed, filled with densely packed insulating foam and covered with sheet metal. These boxes must be placed on a smooth, level surface to allow ventilation under the floor and ensure proper fitting and closing of the door. Under non-wartime conditions, an individual must be universal chlorofluorocarbon (CFC)-qualified in order to purchase, dispose and recover refrigerants used in these units. Engineers are responsible for the setup, O&M of all refrigeration units.

11.12.1. Advanced Design Refrigerator, 300 Cubic Foot (ADR-300). The ADR-300 (**Figure 11.13**) replaces the 150-cf reefer. It weighs 3,285 pounds and is approximately 9 feet wide by 7 feet long by 8 feet high. It has forklift pockets and airlift cargo rails on all four sides. The ADR-300 has an internal capacity of 6,715 pounds which makes its maximum gross weight 10,000. It has interior racks with five removable shelves on each side wall that each holds up to 300 pounds. The unit is also approved for helicopter sling load operations. Since the mechanical refrigeration unit comes already attached, the ADR can be setup by one technician, using a 10K forklift, and operational in less than an hour. For additional information, refer to T.O. 40R7-6-1, *Operator's, Unit, and Direct Support Maintenance Manual, Advanced Design Refrigerator, 300 Cubic Foot, (ADR-300)* and **AFH 10-222, Volume 12**.

11.12.2. 150-Cubic Foot (CF) Refrigerator. The 150-cf refrigeration unit (**Figure 11.14**) is a BEAR legacy reefer. It is used for food service, mortuary and medical applications. It weighs 800 pounds and is approximately 7 feet wide by 7 feet long by 7 feet high overall. When in service, it must have a clear space of at least 3 feet around the condenser. These units come in two sections: an insulated box and a mechanical refrigeration unit (MRU). See paragraph 11.12.4. for more information on MRUs. The 150 cubic foot units are being phased-out of the inventory and replaced by the ADR-300 previously addressed.

Figure 11.13. Advanced Design Refrigerator, 300 Cubic Foot (ADR-300)

Figure 11.14. Inside a 150-Cubic-Foot Refrigeration Unit

11.12.3. 1200-Cubic Foot Refrigerator. The 1,200-cf refrigeration unit (**Figure 11.15**) is also a BEAR legacy reefer unit. It weighs 4,140 pounds and needs 6 feet of clear space on the ends to allow for installation and ventilation of the condenser. This unit comes unassembled, and takes 8 people approximately 8 hours (with a forklift) to set up. When set up, the unit is approximately 13 feet wide by 17 feet long and 8 feet high. Similar to the 150-cf reefer, this unit comes in two sections, insulated box and a mechanical refrigeration unit (MRU). See paragraph 11.13.4. for more information on MRUs.

Figure 11.15. Exterior of 1,200-Cubic Foot Refrigeration Unit

11.12.4. Mechanical Refrigeration Units (MRU). The main components of the MRU are a condenser, a compressor and an evaporator. This unit maintains the temperature of the boxes between 0 and 35 degrees Fahrenheit and uses R-12 refrigerant. Newer units being procured are also capable of using R-134 refrigerant. The unit supporting the 150-cubic-foot box (**Figure 11.16**) is rated at 5,000 BTUs and requires 220-volt, 3-phase electrical power. The unit associated with the 1,200-cubic-foot box is rated at 10,000 BTUs and requires 208-volt, 3-phase power. With the assistance of a forklift, two people can install the mechanical units on the boxes.

Figure 11.16. Mechanical Refrigeration Unit on a 150-Cubic-Foot Refrigeration Box

Chapter 12

MEDICAL FACILITIES

12.1. Introduction. Medical resources are of vital importance to contingency and wartime operations. Deployment of medical treatment facilities (MTF) is necessary to support and sustain sortie generation at the bare base. The basic premise is to treat and return to duty when possible or evacuate and replace. Using phased levels of care, the AF has developed multiple deployable MTFs to treat and evacuate casualties under all conditions (**Figure 12.1**). The Expeditionary Medical Support (EMEDS) system is a component of the Aerospace Medical Contingency Ground Support System. EMEDS is composed of UTC building blocks that provide personnel and equipment to meet specific operational requirements. These UTCs enable a deployed MTF to expand in an incremental or modular manner to meet the full spectrum of theater requirements. These capabilities are used to provide essential care, deferring definitive care to the continental United States (CONUS) or supporting theaters.

Figure 12.1. Aerial View of Expeditionary Medical Treatment Facility

12.2. Overview. This chapter begins with a discussion of the levels of AF medical assets in a theater, followed by an outline of CE responsibilities for the support of bare base MTFs. Each type of MTF is described in detail to permit planners to gain an appreciation of the magnitude of the engineer task involved. Facility layouts are also shown. Finally, engineer support requirements are summarized in ready reference tables for efficient use in the planning process.

12.3. Concept of Operations and Deployment Sequence. The Aerospace Medical Contingency Ground Support System has almost 200 equipment and personnel UTCs tailored to meet specific theater operational requirements. The UTCs enable the main unit of this system, the Air Force Theater Hospital (AFTH), to deploy in modules and expand to meet the full spectrum of specialty care requirements. The medical capability required at a beddown location is determined by the expected casualty rates, casualty types, base population, evacuation distances, etc. The AFTH starts with the Small, Portable Expeditionary Aeromedical Rapid Response (SPEARR) team and, using EMEDS building blocks, expands to as large as 114 beds.

The following paragraphs provide an overview of the major elements of the EMEDS/AFTH, (formerly called the Air Transportable Hospital). Air Combat Command (ACC) is responsible for Manpower and Equipment Force Packaging (MEFPAK) for the EMEDS. Tables in this chapter provide an overview of the civil engineer and other expeditionary combat support (ECS) required for EMEDS. For additional information on EMEDS, see Air Force Tactics, Techniques, and Procedures 3-42.7, *Aerospace Medical Contingency Ground Support System*.

12.3.1. EMEDS Basic. The EMEDS Basic package provides medical care for operations with a population at risk (PAR) of 1-2,000 personnel and is currently comprised of two modules.

12.3.1.1. Module 1—SPEARR Team. This 10-person mobile, clinically capable team provides care that includes physician-directed resuscitation and stabilization. It may also include advanced trauma management, emergency medical procedures and forward resuscitative surgery. Supporting capabilities include basic laboratory, limited x-ray, pharmacy and temporary holding facilities (**Figure 12.2**). Patients are treated and returned to duty (RTD), or are stabilized for movement to an MTF capable of providing a higher level of care. The SPEARR Team can sustain this capability for 5-7 days without resupply for a PAR of 1-500 personnel. The team can deploy as man-portable (no shelter for patient operations) or with a 6,000-pound sling loadable pallet trailer (patient care shelter included).

Figure 12.2. Expeditionary Medical Support (EMEDS) SPEARR Facility

12.3.1.2. Module 2—An additional 15 personnel, supplies and infrastructure to augment the previously deployed SPEARR team. When combined with Module 1, this package increases medical capability to serve a PAR of up to 2,000 personnel. If necessary, both modules may deploy at the same time as a single unit.

12.3.1.3. At full capacity, EMEDS Basic has 25 medical personnel plus equipment and provides forward stabilization, primary care, dental services, force health protection and preparation for aeromedical evacuation. This package has a limited inpatient care capability consisting of four holding beds. Full operational capability for EMEDS Basic is expected within 12 hours of arrival at the bare base. Again, ECS requirements are summarized later in this chapter.

12.3.2. EMEDS+10 Bed AFTH. This package adds another 31 personnel (total of 56) providing care that includes resuscitation, initial wound surgery and postoperative treatment. EMEDS+10 can provide care for seven days without resupply for a PAR of 2,000-3,000. It has 10 inpatient beds and one ambulance. Full operational capability for EMEDS+10 Bed AFTH is expected within 24 hours following arrival at the bare base. Full operational capability for any of the EMEDS increments is attained when facility and clinical functional areas (aerospace medicine, preventive medicine, dental, primary care, C2, emergency care, critical care and surgical capability) are fully established.

12.3.3. EMEDS+25 Bed AFTH. This package adds another 30 personnel (total of 86) providing the same level of medical/dental care as the EMEDS+10, but for a PAR of 3,000-5,000. The package deploys with seven days of supplies and increases inpatient capacity to 25 inpatient beds (cumulative) and one additional ambulance. Full operational capability for EMEDS+25 Bed AFTH is expected within 24 hours following arrival at the bare base.

12.3.4. EMEDS+50 Bed AFTH and up. The EMEDS+50 provides the surgical capability found in the smaller hospitals plus rehabilitative and recovery therapy for those who can RTD within the theater evacuation policy. This size facility is achieved by adding a 25-bed Hospital Medical Expansion Package (HMEP) or Hospital Surgical Expansion Package (HSEP) of 25 ward personnel and equipment to the EMEDS+25 Bed AFTH. With multiple expansion packages, the EMEDS AFTH is expandable to 114 beds and 299 medical personnel.

12.3.5. Transportable Blood Transshipment Center (TBTC). This Small Shelter System/ International Standardization Organization (ISO) shelter system is staffed with 12 personnel and is designed to store and ship frozen and liquid blood products during contingency operations. The EMEDS AFTH is only capable of storing about 60 units of blood, but each TBTC can hold up to 7,200 units. The TBTC is normally collocated with other supporting medical treatment facilities near a strategic airhead or major airfield. Twelve medical personnel, with support of a 13K forklift, can assemble the TBTC in 22 hours. It is, however, not mobile so it does require base support. Engineer support requirements consist of technical assistance (and physical assistance if TBTC staffing is inadequate) for shelter erection and provision of power (200-kW), water (300 gal/day) and ice (800 lbs/day).

12.4. Civil Engineer Support of Medical Facilities. In general, AF medical doctrine restricts staff capabilities to those actions that directly perform and support medically specific functions and technology associated with a medical unit's mission. For all other functions, the medical facility must rely upon CE and those ECS elements to which the medical support is provided. In a bare base environment, CE support translates into the following engineer tasks:

12.4.1. Site Preparation: Must meet the medical facility's specific layout requirements.

12.4.2. Shelter Erection: Furnish technical direction for shelter erection and, when required, augment medical personnel in the assembly of discrete, functional modules into an operating hospital complex. An all-terrain forklift must be available to set up the EMEDS/AFTH.

12.4.3. Utilities: Provide water; electricity; disposal of wastewater, liquids, solid and biological wastes; HVAC support to maintain specified temperatures; and the final connection of BEAR utility systems to the medical facility's utility interfaces.

12.4.4. O&M: Repair war damage to the physical plant, utility systems and installed non-medical equipment.

12.4.5. Fire Emergency Services: Establish a response posture to meet the fire emergency service requirement for the type of medical facility being supported. For determination of additive vehicles and personnel, see the Fire appendix in CE Supplement to WMP-1.

12.4.6. EOD: Provide instructions and procedures on how to conduct medical post-attack and recovery operations in an unexploded ordnance environment.

12.5. Support Requirement by Type of EMEDS Facility.

12.5.1. Facility Shelters. All medical functions are housed in Small Shelter Systems (SSS), except for surgery, x-ray and lab which are housed in ISO shelters. EMEDS Basic is housed in three SSSs (**Figure 12.3**). The EMEDS+10 adds three additional SSSs and the EMEDS+25 adds three more (for a total complex of nine SSSs) plus three ISO shelters. A 13K all-terrain forklift will be required to move these containers. Since the EMEDS is designed in a modular or incremental fashion, a quick response sub-set can be transported in one C-130 aircraft, as shown in **Table 12.1**.

Figure 12.3. EMEDS Small Shelter System

Table 12.1. EMEDS Airlift Impact

Facility	Airlift Requirement
SPEARR (with back packs)	Passengers only
SPEARR (full)	1 each C-130 sortie
EMEDS Basic	1 each C-130 sortie
EMEDS+10 AFTH	1 each C-17 sortie
EMEDS+25 AFTH	2 each C-17 sorties

12.5.2. EMEDS Basic has a one pallet SPEARR trailer, known as the Expanded Capability and Infrastructure Module (ECIM). It is sling-loadable which enables movement by helicopter if mission circumstances dictate.

12.5.3. Components and Equipment. The EMEDS deploys with tools needed for erection. One 10-kW (single-phase only) generator deploys with the SPEARR for initial power. EMEDS Basic requires base support for power. EMEDS+10 and +25 deploy with a total of two MEP-7 portable 100-kW generators (for initial and backup power) and a 400-gallon water trailer. One additional 100-kW generator is provided when adding a 25-bed HMEP or HSEP.

12.5.4. Site Requirements. The EMEDS should be sited in low-threat areas, but near support group services such as showers, billeting, kitchen, etc. Site grades must slope away from the shelter to preventing flooding.

12.5.5. External Support Requirements. The EMEDS is equipped and staffed to provide medical support only, and is therefore dependent on CE and base support as summarized in **Table 12.2**.

Table 12.2. Support Required for EMEDS/AFTH

Item	Basic	EMEDS+10 Bed AFTH	EMEDS+25 Bed AFTH
Site Preparation	15,000 ft^2	26,000 ft^2	40,000 ft^2
Work Shelter	1,950 ft^2	3,900 ft^2	5,850 ft^2
Billeting	25 people	56 people	86 people
Latrine/Showers*	29 people	67 people	113 people
Food Service Regular Liquid	 87 meals/day 3 meals/day	 198 meals/day 9 meals/day	 337 meals/day 12 meals/day
Laundry	1,000 lb/week	2,000 lb/week	3,600 lb/week
Power Power w/CP-EMEDS	65-kW 100-kW	100-kW 200-kW	200-kW 200-kW
Fuel Diesel Diesel w/CP-EMEDS	 0 gal/day 150 gal/day	 150 gal/day 300 gal/day	 300 gal/day 300 gal/day
Water (potable)	400 gal/day	800 gal/day	1,430 gal/day
Ice	0 lb/day	85 lb/day	150 lb/day
Water Chiller	-------	1	2
Water Trailer	-------	-------	-------
Medical Waste Liquid Solid	 700 gal/day 180 lb/day	 1,400 gal/day 610 lb/day	 2,500 gal/day 1,100 lb/day
Telephones	9 (4 cell, 3 land, 2 crash)	10 (4 cell, 4 land, 2 crash)	12 (4 cell, 6 land, 2 crash)
Satellite/Tele Medicine	1	1	1
Land Mobile Radio	8	8	8
STU III	1	1	1
Oxygen (LOX)	40 liter/day	60 liter/day	90 liter/day
ECUs	3	6	9
Pallets	4	17 (cumulative)	26 (cumulative)
Equipment Movement	6K forklift	13K forklift, flatbed truck	13K forklift, flatbed truck
* **Staff and patients.**			

Item	EMEDS+50 Bed AFTH (Estimated)	EMEDS+114 Bed AFTH (Estimated)
Site Preparation	50,000 ft^2	110,000 ft^2
Work Shelter	8,410 ft^2	TBD
Billeting	114 people	299 people
Latrine/Showers*	164 people	413 people
Food Service Regular Liquid	 492 meals/day 20 meals/day	 1239 meals/day 45 meals/day
Laundry	9,000 lb/week	20,920 lb/week
Power	200-kW	200-kW
Diesel	1,000 gal/day	2,280 gal/day
Water (potable)	5,500 gal/day	11,000 gal/day
Ice	300 lb/day	675 lb/day
Water Chiller	3**	7**
Water Trailer	1	1
Medical Waste Liquid Solid	 4,950 gal/day TBD	 11,286 gal/day TBD
Telephones	14 (4 cell, 8 land, 2 crash)	24 (4 cell, 18 land, 2 crash)
Satellite/Tele Medicine	1	1
Land Mobile Radio	TBD	TBD
STU III	1	1
Oxygen (LOX)	180 liter/day	410 liter/day
ECUs	16	33
Pallets	TBD	TBD
Equipment Movement	13K forklift, flatbed truck	13K forklift, flatbed truck
* Staff and patients ** Cumulative Total		

12.6. Aeromedical Staging Facilities.

12.6.1. **Mobile Aeromedical Staging Facility (MASF).** The MASF is a 13-person mobile, tented, temporary staging facility that provides rapid response patient staging, limited holding and supports small scale contingency (SSC), humanitarian and civil disaster response operations, and major theater war (MTW). Once deployed, the MASF is an aeromedical evacuation (AE) system asset subordinate to the expeditionary AE Squadron to which they are assigned and or attached. The MASF assists in the carrying out of the AE mission, and is normally located at or near airheads capable of supporting mobility airlift (**Figure 12.4**).

Figure 12.4. Patients Prepared for Aeromedical Evacuation

12.6.1.1. The MASF is equipped and staffed for routine wartime processing of 10 patients at a time, a maximum flow of 40 patients in a 24-hour period, and a maximum 6 hour patient hold time. It is made up of patient care and support personnel. An additional MASF package along with UTC FFQM2 (MASF Expansion Package +25) must be added to increase the wartime patient flow to 80 patients per 24 hour period.

12.6.1.2. Facility Shelters, Components and Equipment. The ASF uses 168 TEMPER tent sections. Tools needed for erection, portable 100-kW generators (for initial and backup power) and the environmental control systems are deployed with the ASF increments. The site should not have more than a 6-inch drop in 20 feet. The ASF must be sited near a base or support complex.

12.6.2. **Contingency Aeromedical Staging Facility (CASF).** The CASF provides personnel and equipment necessary for 24-hour staging operations for patients transiting the Aeromedical Evacuation (AE) system worldwide. The CASF coordinates and communicates with medical and AE elements to accomplish patient care and patient movement, including ground transportation. It provides patient reception, complex medical/surgical nursing, limited emergent intervention, and ensures patients are medically and administratively prepared for flights.

12.7. External Support Requirements. Table 12.3. lists support required for ASFs.

Table 12.3. Support Required for Aeromedical Staging Facilities

Item	25-Bed ASF	Mobile ASF (10-patient staging capability)
Site Preparation	40,000 ft^2	10,000 ft^2
Work Shelter	2,750 ft^2	2,750 ft^2
Billeting	34 people	13
Latrine/Showers*	59 (34 staff/25 patients)	23 (13 staff/10 patients)
Food Service Regular Liquid	 114 meals/day 3 meals/day	 69 meals/day 2 meals/day
Laundry	6,250 lb/week	2,415 lb/week
Power	100-kW	5-kW
Fuel (Diesel)**	250 gal/day	45 gal/day
Water (potable)	4,430 gal/day	1,725 gal/day
Ice	150 lb/day	60 lb/day
Water Chiller	2	1
Water Trailer	0	0
Medical Waste Liquid Solid	 2,500 gal/day 1,100 lb/day	 1,725 gal/day 414 lb/day
Telephones	9 (4 cell, 3 land, 2 crash)	4 (2 cell, 1 land, 1 crash)
Satellite/Tele Medicine	1	1
Land Mobile Radio	8	4
STU III	1	1
Oxygen (LOX)	90 liter/day	35 liter/day
ECUs***	4	0
Pallets	8 (cumulative)	Rolling stock packed on 2 HMMWV
Equipment Movement	13K forklift, flatbed truck	0
* Staff and patients.		
** Generator and 2 HMMWV.		
*** The Mobile ASF does not include ECUs. An FFQM3 Staging Support Pg can be requested to provide 2 ECU/60KW generator capability.		

12.8. Biological/Chemically Contaminated Casualties. The EMEDS, MASF and CASF do not have Collectively Protected (CP) shelters and any patients being treated or awaiting movement during an attack will require individual protective equipment (IPE) or protective patient wraps (See AFTTP 3-42.3, *Health Service Support in Nuclear, Biological, and Chemical Environments*, Table 4.1., Note 1).

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DCS/Operations, Plans, and Requirements (A3/5)

Attachment 1

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Abbreviations and Acronyms

AB—Air Base

AC—Alternating Current; Aircraft

ACC—Air Combat Command

ACH—Aircraft Maintenance Hangar

ACS—Agile Combat Support

ADR—Airfield Damage Repair; Advanced Design Refrigerator

ADVON—Advance Echelon

AE—Aeromedical Evacuation

AEF—Air Expeditionary Force

AFCAP—Air Force Contract Augmentation Program

AFCESA—Air Force Civil Engineer Support Agency

AFDD—Air Force Doctrine Document

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFPAM—Air Force Pamphlet

AFPD—Air Force Policy Directive

AFS—Air Force Specialty

AFTH—Air Force Theater Hospital

AFTTP—Air Force Tactics, Techniques and Procedures

AGE—Aerospace Ground Equipment

AMC—Air Mobility Command

Amp— —Ampere

ANC—Air Navigation Charts

ANG—Air National Guard

AO—Area of Operations

AOR—Area of Responsibility

AS—Allowance Standard

ASF—Aeromedical Staging Facility

AWG—American Wire Gauge

BCE—Base Civil Engineer

BEAR—Basic Expeditionary Airfield Resources

BOB—BEAR Order of Battle

BOD—Biochemical Oxygen Demand

BTU—British Thermal Unit

C2—Command And Control

CASF—Contingency Aeromedical Staging Facility

CBRNE—Chemical, Biological, Radiological, Nuclear and High-Yield Explosive

CCD—Camouflage, Concealment and Deception

CE—Civil Engineering; Civil Engineer

CEMIRT—Civil Engineer Maintenance, Inspection and Repair Team

CFC—Chlorofluorocarbon

CIP—Common Installation Picture

CONPLAN—Concept Plan

CONOPS—Concept of Operations

CONUS—Continental United States

COTS—Commercial-Off-The-Shelf

CP—EMEDS —Collective Protection Expeditionary Medical Support

DC—Direct Current

DOD—Department Of Defense

EALS—Emergency Airfield Lighting System

ECU—Environmental Control Unit

EMEDS—Expeditionary Medical Support

EOD—Explosive Ordnance Disposal

ESC—Expandable Shelter Container

ETL—Engineering Technical Letter

FDECU—Field Deployable Environmental Control Unit

FEL—Front-End Loader

FFM—Folded Fiberglass Mat

F/L—Fork Lift

FOA—Field Operating Agency

FOL—Forward Operating Location

FORCE—Fuels Operational Readiness Capability Equipment

FSTFS—Frame Supported Tension Fabric Shelter

FSU—Field Sanitation Unit

Gal——Gallon

Gal/D—Gallon Per Day

GCCS—Global Command and Control System

GP—General Purpose (Tent)

GPD—Gallons Per Day

GPH—Gallons Per Hour

GPM—Gallons Per Minute; General Purpose Medium (Tent)

Gpppd— —Gallons Per Person Per Day

HE—Harvest Eagle

HF—Harvest Falcon

HMEP—Hospital Medical Expansion Package

HN—Host Nation

Hp——Horsepower

HSEP—Hospital Surgical Expansion Package

HVAC—Heating, Ventilation and Air Conditioning

Hz——Hertz

IOC—Initial Operating Capability

IPE—Individual Protective Equipment

IPU—Interim Power Unit

ISO—International Standardization Organization

JCS—Joint Chiefs of Staff

JSP—Joint Support Plan

Kg——Kilograms

Km——Kilometers

Kv——Kilovolt

kVA—Kilovolt Ampere

kW— —Kilowatt

LAM—Large Area Maintenance Shelter

LCN—Load Classification Number

LOGCAP—Logistics Civil Augmentation Program

LOX—Liquid Oxygen

LN—Local National

MAAS—Mobile Aircraft Arresting System

MAJCOM—Major Command

MASF—Mobile Aeromedical Staging Facility

MEP—Mobile Electric Power

MEFPAK—Manpower and Equipment Force Packaging

MMG—Materiel Maintenance Group

MOB—Main Operating Base

MOS—Minimum Operating Strip

MCO—Major Combat Operations

MSS—Medium Shelter System

MTF—Medical Treatment Facility

NAF—Numbered Air Force

NATO—North Atlantic Treaty Organization

NAVAIDS—Navigational Aids

NAVFAC—Naval Facilities Engineering Command

NSN—National Stock Number

O&M—Operation and Maintenance

OPLAN—Operations Plan

OSI—Office of Special Investigations

PAPI—Precision Approach Path Indicator

PAR—Population At Risk

PCN—Pavement Classification Number

PDC—Primary Distribution Center

POL—Petroleum, Oils and Lubricants

PPM—Parts Per Million

Prime BEEF—Prime Base Engineer Emergency Force

Prime RIBS—Prime Readiness In Base Services

PSC—Primary Switching Center

PSI—Pounds per Square Inch

RALS—Remote Area Lighting Set

RAPCON—Radar Approach Control

RBC—Reach Back Center

RHS—RED HORSE Squadron

ROWPU—Reverse Osmosis Water Purification Unit

RP—Reference Point

RTD—Return To Duty

SDC—Secondary Distribution Center

SF—Square Feet

SPEARR—Small Portable Expeditionary Aeromedical Rapid Response

SPEK—Single Pallet Expeditionary Kitchen

SSS—Small Shelter System

SWA—Southwest Asia

TACAN—Tactical Air Navigation

TBTC—Transportable Blood Transshipment Center

TEMPER—Tent Extendable Modular Personnel

TM—Technical Manual

T.O.——Technical Order

TPFDD—Time Phased Force and Deployment Data

TPFDL—Time Phased Force and Deployment List

UAS—Unmanned Aircraft Systems

UFC—Unified Facilities Criteria

UGR—H&S —Unitized Group Rations-Heat and Serve

UTC—Unit Type Code

VA—Volt-Ampere

VAC—Volts Alternating Current

WMP—War And Mobilization Plan

WRM—War Readiness Materiel

Terms

Aeromedical Evacuation—The movement of patients under medical supervision to and between medical treatment facilities, usually by air transportation.

Air Expeditionary Force—Deployed US Air Force wings, groups and squadrons committed to a joint operation.

Aircraft Arresting System—A series of components used to stop an aircraft by absorbing its momentum in a routine or emergency landing or aborted takeoff.

Airfield Damage Repair (ADR)—The process of using construction equipment, tools, portable equipment, expendable supplies and temporary surfacing materials to provide a minimum operating surface through expedient repair methods.

Air Base Defense—Those measures taken to nullify or reduce the effectiveness of enemy attacks on, or sabotage of, air bases to ensure that the senior commander retains the capability to assure aircraft sortie generation.

Air Force Civil Engineer Support Agency (AFCESA)—A field operating agency (FOA) located at Tyndall Air Force Base, Florida. The Readiness Support Directorate (HQ AFCESA/CEX) acts as the Air Force program manager for civil engineer contingency response planning.

Air Force Contract Augmentation Program (AFCAP)—A program under which civilian contractors/commercially available resources can be used to fill critical base operating support functions/asset requirements that occur during a wide range of contingency, crisis, and wartime operations. AFCAP uses civilian contractual assistance during peacetime to locate and plan for the acquisition of worldwide commercial resources (personnel and materiel) assets to meet AF wartime support requirements.

Area of Operations (AO)—An operational area defined by the joint force commander for land and naval forces. Areas of operation do not typically encompass the entire operational area of the joint force commander, but should be large enough for component commanders to accomplish their missions and protect their forces.

Bare Base—A base having minimum essential facilities to house, sustain and support operations to include, if required, a stabilized runway, taxiways and aircraft parking areas. A bare base must have a source of water that can be made potable. Other requirements to operate under bare conditions form a necessary part of the force package deployed to the bare base.

Base Denial—The destruction or denial of vital air base resources so the enemy cannot use them against friendly forces or for his benefit.

Base Development—The acquisition, development, expansion, improvement and construction or replacement of the facilities and resources of an area or location to support forces employed in military operations or deployed in accordance with strategic plans.

Basic Expeditionary Airfield Resources (BEAR)—Facilities, equipment and basic infrastructure to support the beddown of deployed forces and aircraft at austere locations; a critical capability to fielding expeditionary aerospace forces. Also known as BEAR, the resources include tents, field kitchens, latrine systems, shop equipment, electrical and power systems, runway systems, aircraft shelters and water systems needed to sustain operations.

Camouflage, Concealment and Deception—The use of concealment, disguise and decoys to minimize the possibility of detection or identification of troops, material, equipment and installations. It includes taking advantage of the natural environment as well as the application of natural and artificial materials.

Chemical Warfare—All aspects of military operations involving the employment of lethal and incapacitating munitions/agents and the warning and protective measures associated with such offensive operations. Since riot control agents and herbicides are not considered to be chemical warfare agents, those two items are referred to separately or under the broader term "chemical", which is used to include all types of chemical munitions or agents collectively (JP 1-02).

Collective Protection Shelter—A filtered air shelter that provides a contamination-free working environment for selected portions of the force such as command and control elements. The shelter allows relief from continuous wear of chemical protective equipment.

Collocated Operating Base—An active or Reserve allied airfield designated for joint or unilateral use by US Air Force wartime augmentation forces or for wartime relocation of US Air Force in-theater forces. COBs are not US bases.

Command and Control—The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities and procedures employed by a commander in planning, directing, coordinating and controlling forces and operations in the accomplishment of the mission (JP 1-02).

Contingency—An emergency, involving military forces, caused by natural disasters, terrorists, subversives, or by required military operations. Due to the uncertainty of the situation, contingencies require plans, rapid response and special procedures to ensure the safety and readiness of personnel, installations and equipment (JP 1-02).

Contingency Plan—A plan for major contingencies that can reasonably be anticipated in the principal geographic subareas of the command (JP 1-02).

Contingency Response Plan—A base civil engineer plan of action developed in anticipation of all types of contingencies, emergencies and disasters.

Decontamination—The process of making any person, object, or area safe by absorbing, destroying, neutralizing, making harmless, or removing chemical or biological agents or by removing radioactive material clinging to or around it.

Deployment—The relocation of forces and material to desired areas of operations or to a staging area. Deployment encompasses all activities from origin or home station through destination, specifically including within the United States, inter-theater and intra-theater movement legs, staging and holding areas. (JP 1-02). Deployment begins when the first aircraft, personnel, or item of equipment leaves the home base. The force is deployed when the last component of the unit has arrived at the desired area.

Dispersal—Relocation of forces for the purpose of increasing survivability.

Doctrine—Fundamental principles by which military forces guide their actions in support of the national objectives. It is authoritative but requires judgment in application (JP 1-02).

Expeditionary Operation—An operation conducted by an armed force organized to accomplish a specific objective in a foreign country. Examples of expeditionary operations include engaging in armed conflict; protecting US citizens or commerce abroad; providing humanitarian assistance after a natural or manmade disaster; and conducting peacekeeping operations.

Expeditionary Structures—Those structures intended to be inhabited for no more than 1 year after they are erected. This group of structures typically include tents, Small and Medium Shelter

Systems, Expandable Shelter Containers (ESC), ISO and CONEX containers, and General Purpose (GP) Medium tents and GP Large tents, etc.

Explosive Ordnance Disposal (EOD)—The detection, identification, on-site evaluation, rendering-safe, recovery and final disposal of unexploded explosive ordnance. It may also include explosive ordnance that has become hazardous by damage or deterioration.

Fabric Covered Structures—A construction type that can be identified by wood or metal (usually aluminum) posts or load-bearing frames with some type of fabric (such as canvas) stretched or pulled over the posts or frames. Examples of the types of structures that should be considered under this classification of structures include Frame-Supported Tensioned Fabric Structures (FSTFS); Tent, Extendable, Modular, Personnel (TEMPER Tents); and Small and Medium Shelter Systems (SSS and MSS); General Purpose (GP) Medium tents and GP Large tents; and air supported fabric

structures. Testing has shown that for these fabric structures, the posts and frames are

what cause hazards (UFC 4—010-01).

Facility—Any structure, pavement, or utility system that supports Air Force operations. For emergency planning purposes, the term facility in 40 CFR 355, as it applies to the Air Force, is considered equivalent to an installation.

Force Beddown—The provision of expedient facilities for troop support to provide a platform for the projection of force. These facilities may include modular or kit-type substitutes (JP 3-34).

Force Module—A grouping of combat, combat support and combat service support forces, with their accompanying supplies and the required nonunit resupply and personnel necessary to sustain forces for a minimum of 30 days. The elements of force modules are linked together or are uniquely identified so that they may be extracted from or adjusted as an entity in the Joint Operation Planning and Execution System databases to enhance flexibility and usefulness of the operation during a crisis (JP 1-02).

Forward Operating Base—An airfield used to support tactical operations without establishing full support facilities. The base may be used for an extended time period. Support by a main operating base will be required to provide backup support for a forward operating base (JP 1-02).

Harvest Eagle—A nickname for a legacy air transportable, tent-based system of housekeeping support facilities designed to provide basic living accommodations, field feeding and hygiene support under bare base conditions. Each kit is designed to provide softwall housekeeping support for 550 personnel. Facilities are not air conditioned and are powered with low voltage, tactical power generator systems. Examples of Harvest Eagle equipment are water purification units, tents and showers. Harvest Eagle packages are being entirely phased out and the equipment phased into BEAR modules.

Harvest Falcon—A nickname for a legacy air transportable system of hardwall shelters, tents, equipment and vehicles designed to provide worldwide support of personnel and squadron size aircraft deployments under bare base conditions. These sets provide direct mission and housekeeping support facilities for up to 55,000 personnel and 822 aircraft at up to 15 separate beddown locations. It includes facilities, equipment and supplies necessary to establish and maintain base support functions such as base civil engineering, vehicle maintenance, supply, chapel, pest management, field exchange, administration and chaplain support. Harvest Falcon is sized into 50, 1,100-person bare base housekeeping sets, 15 flightline initial sets, 25 flightline follow-on support sets and 15 industrial operations support sets. Harvest Falcon sets are being entirely phased out and the equipment phased into BEAR modules.

Hazardous Material—All hazardous substances, petroleum, natural gas, synthetic gas, acutely toxic chemicals and other toxic chemicals including hazardous waste.

High Threat Area—An area that, because of its location or strategic targets, is highly susceptible to enemy attacks.

Host Nation—A nation that receives the forces and or supplies of allied nations, coalition partners or NATO organizations to be located on, to operate in, or to transit through its territory.

Host Nation Support—Civil or military assistance rendered by a nation to foreign forces within its territory during peacetime, crisis or emergencies, or war based on agreements mutually concluded between nations.

Joint Support Plan—A plan for the reception and beddown of forces that is collectively developed by the host nation, the theater in-place sponsor and the affected augmentation unit. The plan outlines all facets of operations at a collocated operating base to include personnel, facilities and equipment.

Limiting Factor—A factor or condition that, either temporarily or permanently, impedes mission accomplishment. Illustrative examples are transportation network deficiencies, lack of in-place facilities, malpositioned forces or materiel, extreme climatic conditions, distance, transit or overflight rights, political conditions, etc.

Main Operating Base (MOB)—In special operations, a base established by a joint force special operations component commander or a subordinate special operations component commander in friendly territory to provide sustained command and control, administration and logistical support to special operations activities in designated areas. Also, a base on which all essential buildings and facilities are erected and organizational and intermediate maintenance capability exists for assigned weapon systems. The intermediate maintenance capability may be expanded to support specific weapon systems deployed to the MOB. Also called main ***operations*** base.

Manpower and Equipment Force Packaging (MEFPAK)—-A data system that supports contingency and general war planning with predefined and standardized personnel and equipment force packages. MEFPAK has two subsystems: the Manpower Force Packaging System (MANFOR) and the Logistics Force Packaging System (LOGFOR).

Manpower Force Packaging System (MANFOR)—A MEFPAK subsystem that provides: (1) the title of the unit or force element and its unique Joint Chiefs of Staff Unit Type Code, (2) the mission capability statement (MISCAP) containing the definition of a UTC's capability, and (3) the manpower detail by function, grade (officers only) and Air Force specialty required to meet the defined capability.

Operation Plan—Any plan, except for the Single Integrated Operation Plan, for the conduct of military operations. Plans are prepared by combatant commanders in response to requirements established by the Chairman of the Joint Chiefs of Staff and by commanders of subordinate commands in response to requirements tasked by the establishing unified commander. Operation plans are prepared in either a complete format (OPLAN) or as a concept plan (CONPLAN). The

CONPLAN can be published with or without a time-phased force and deployment data (TPFDD) file.

a. OPLAN—An operation plan for the conduct of joint operations that can be used as a basis for development of an operation order (OPORD). An OPLAN identifies the forces and supplies required to execute the combatant commander's strategic concept and a movement schedule of these resources to the theater of operations. The forces and supplies are identified in TPFDD files. OPLANs will include all phases of the tasked operation. The plan is prepared with the appropriate annexes, appendixes and TPFDD files as described in the Joint Operation Planning and Execution System manuals containing planning policies, procedures and formats.

b. CONPLAN—An operation plan in an abbreviated format that would require considerable expansion or alteration to convert it into an OPLAN or OPORD. A CONPLAN contains the combatant commander's strategic concept and those annexes and appendixes deemed necessary by the combatant commander to complete planning. Generally, detailed support requirements are not calculated and TPFDD files are not prepared.

c. CONPLAN with TPFDD—A CONPLAN with TPFDD is the same as a CONPLAN except that it requires more detailed planning for phased deployment of forces.

Playbook Option—Equipment available to but excluded from BEAR sets to allow planners greater tasking flexibility. While these items provide significant capability, they may not be needed in the core BEAR sets each and every deployment. Playbook options consist of 16 major UTCs including the MAAS, 550 kitchen, EALS, self-help laundry, AM-2 matting and ROWPU.

Potable Water—Water that is safe for drinking because it is free from contamination, pollution and harmful impurities.

Primary Circuit—An electrical circuit carrying greater than 600 volts.

Prime BEEF (Base Engineer Emergency Forces)—A headquarters US Air Force, major command (MAJCOM) and base-level program that organizes civil engineer forces for worldwide direct and indirect combat support roles. It assigns civilian employees and military personnel to both peacetime real property maintenance and wartime engineering functions.

Readiness—The ability of US military forces to fight and meet the demands of the national military strategy. Readiness is the synthesis of two distinct but interrelated levels: (a) Unit readiness – the ability to provide capabilities required by the Combatant Commanders to execute their assigned missions. This is derived from the ability of each unit to deliver the outputs for which it was designed. (b) Joint readiness – the Combatant Commander's ability to integrate and synchronize ready combat and support forces to execute his or her assigned missions (JP 1-02).

RED HORSE Squadrons (RHS)—These squadrons provide the Air Force with a highly mobile, self-sufficient, rapidly deployable civil engineering capability required in a potential theater of operations.

Reverse Osmosis Water Purification Unit (ROWPU)— A water purification device that uses a series of membranes to eliminate impurities. The ROWPU is capable of removing dissolved minerals.

Secondary Circuit—An electrical circuit carrying less than 600 volts.

Standoff—A steel or wood curtain erected approximately 10 feet in front of a protective structure to detonate shells and thereby reduce the penetrating effect.

Survivability—Capability of a system to accomplish its mission in the face of an unnatural (man-made) hostile, scenario-dependent environment. Survivability may be achieved by avoidance, hardness, proliferation, or reconstitution (or a combination).

Temporary Structures—Those structures that are erected with an expected occupancy of 3 years or less. This group of structures typically includes wood frame and rigid wall construction, and such things as Southeast Asia (SEA) Huts, hardback tents, ISO and CONEX containers, pre-engineered buildings, trailers, stress tensioned shelters, Expandable Shelter Containers (ESC), and Aircraft Hangars (ACH).

Terrorism—The calculated use of unlawful violence or threat of unlawful violence to instill fear; intended to coerce or to intimidate governments or societies in the pursuit of goals that are generally political, religious, or ideological.

Time-Phased Force and Deployment List (TPFDL)—Appendix 1 to Annex A of the operation plan which identifies types or actual units required to support the operation plan and indicates origin and ports of debarkation or ocean area. It may also be generated as a computer listing from the time-phased force and deployment data.

Unit Type Code (UTC)—A Joint Chiefs of Staff developed and assigned code, consisting of five characters that uniquely identify a "type unit."

War And Mobilization Plan (WMP)—The Air Force supporting plan to the Joint Strategic Capabilities Plan. The six volumes of the WMP extend through the Future Years Defense Program to provide continuity in short- and mid-range war and mobilization planning. It provides current planning cycle policies and planning factors for the conduct and support of wartime operations. It establishes requirements for development of mobilization and production planning programs to support sustained contingency operations of the programmed forces. The WMP encompasses all functions necessary to match facilities, manpower and materiel with planned wartime activity.

War Damage Repair—The repair of all facilities except airfield pavements.

War Readiness Materiel (WRM)—Materiel required in addition to primary operating stocks and mobility equipment to attain the operational objectives in the scenarios authorized for sustainability planning in the Defense Planning Guidance. Broad categories are: consumables associated with sortie generation (to include munitions, aircraft external fuel tanks, racks, adapters and pylons); vehicles; 463L palletization systems; materiel handling equipment; aircraft engines; BEAR assets; individual clothing and equipment; munitions and subsistence.

Attachment 2

ELECTRICAL CURRENT CHARACTERISTICS IN SOUTHWEST ASIA (SWA)

Table A2.1. SWA Electrical Current Characteristics

ELECTRICAL CURRENT CHARACTERISTICS IN SWA					
Country and City	**Type and Frequency of Current**	**Number of Phases**	**Nominal Voltage**	**Number of Wires**	**Frequency Stable Enough for Electric Clocks**
Afghanistan					
Charikar	a.c.60	1,3	220/380	2,4	Yes
Farah	a.c.50	1,3	220/380	2,4	Yes
Ghazni	a.c.50	1,3	220/380	2,4	Yes
Gulbahar	a.c.50	1,3	220/380	2,4	Yes
Heart	a.c.50	1,3	220/380	2,4	Yes
Jalalabad	a.c.50	1,3	220/380	2,4	Yes
Kabul	a.c.50	1,3	220/380	2,4	Yes
Kandshar	a.c.50	1,3	220/380	2,4	Yes
Kunduz	a.c.50	1,3	220/380	2,4	Yes
Maimana	a.c.50	1,3	220/380	2,4	Yes
Mazar-i-Sharif	a.c.50	1,3	220/380	2,4	Yes
Paghman	a.c.50	1,3	220/380	2,4	Yes
Pul-i-Khumri	a.c.50	1,3	220/380	2,4	Yes
Egypt					
Alexandria	a.c.50	1,3	220/380	2	No
Asyut	a.c.50	1,3	220/380	2,3,4	No
Aswan	a.c.50	1,3	220/380	2,3,4	No
Benha	a.c.50	1,3	220/380	2,3,4	No
Beni Suef	a.c.50	1,3	220/380	2,3,4	No
Cairo	a.c.50	1,3	220/380	2,3,4	No
Damanhur	a.c.50	1,3	220/380	2,3,4	No
Damietta	a.c.50	1,3	220/380	2,3,4	No
Heliopolia	a.c.50	1	110	2	No
		1,3	220/380	2,3,4	No
Helwan	a.c.50	1,3	220/380	2,3.4	No
Ismaila	a.c.50	1,3	220/380	2,3,4	No
Dafr el Zaiyat	a.c.50	1,3	220/380	2,3,4	No
Kena	a.c.50	1,3	220/380	2,3,4	No

ELECTRICAL CURRENT CHARACTERISTICS IN SWA					
Country and City	**Type and Frequency of Current**	**Number of Phases**	**Nominal Voltage**	**Number of Wires**	**Frequency Stable Enough for Electric Clocks**
Egypt (cont)					
Luxor	a.c.50	1,3	220/380	2,3,4	No
El Maadi	a.c.50	1,3	220/380	2,3,4	No
El Mansura	a.c.50	1,3	220/380	2,3,4	No
El Mahalla	a.c.50	1,3	220/380	2,3,4	No
Minia	a.c.50	1,3	220/380	2,3,4	No
Port Fouad	a.c.50	1,3	220/380	2,3,4	No
Port Said	a.c.50	1,3	220/380	2,3,4	No
Port Tewik	a.c.50	1,3	220/380	2,3,4	No
Sohag	a.c.50	1,3	220/380	2,3,4	No
Suez	a.c.50	1,3	220/380	2,3,4	No
Tanta	a.c.50	1,3	220/380	2,3,4	No
Zagazig	a.c.50	1,3	220/380	2,3,4	No
Iran					
Abadan	a.c.50	1,3	220/380	2,3,4	Yes
Ahwaz	a.c.50	1,3	220/380	2,3,4	Yes
Behshahr	a.c.50	1,3	220/380	2,3,4	Yes
Ghazvin	a.c.50	1,3	220/380	2,3,4	Yes
Hamadan	a.c.50	1,3	220/380	2,3,4	Yes
Isfahan	a.c.50	1,3	220/380	2,3,4	Yes
Karaj	a.c.50	1,3	220/380	2,3,4	Yes
Kashan	a.c.50	1,3	220/380	2,3,4	Yes
Kerman	a.c.50	1,3	220/380	2,3,4	Yes
Kermanshah	a.c.50	1,3	220/380	2,3,4	Yes
Korramshahr	a.c.50	1,3	220/380	2,3.4	Yes
Masjed Soleyman	a.c.50	1,3	220/380	2,3,4	Yes
Meshed	a.c.50	1,3	220/380	2,3,4	Yes
Pahlevi	a.c.50	1,3	220/380	2,3,4	Yes
Qom	a.c.50	1,3	220/380	2,3,4	Yes
Resht	a.c.50	1,3	220/380	2,3,4	Yes
Rezaiyeh	a.c.50	1,3	220/380	2,3,4	Yes
Shiraz	a.c.50	1,3	220/380	2,3.4	Yes
Tabriz	a.c.50	1,3	220/380	2,3,4	Yes
Tehran	a.c.50	1,3	220/380	2,3,4	Yes
Yazd	a.c.50	1,3	220/380	2,3,4	Yes

ELECTRICAL CURRENT CHARACTERISTICS IN SWA					
Country and City	**Type and Frequency of Current**	**Number of Phases**	**Nominal Voltage**	**Number of Wires**	**Frequency Stable Enough for Electric Clocks**
Iraq (Note 1)					
Baghdad	a.c.50	1,3	220/380	2,4	Yes
Basra	a.c.50	1,3	220/380	2,4	Yes
Kirkuk	a.c.50	1,3	220/380	2,4	Yes
Mosul	a.c.50	1,3	220/380	2,4	Yes
Israel (Notes 1 & 2)					
Beer Sheba					
Haifa	a.c.50	1,3	220/380	2,4	Yes
Holon	a.c.50	1,3	220/380	2,4	Yes
Natanya	a.c.50	1,3	220/380	2,4	Yes
Petah Tiqva	a.c.50	1,3	220/380	2,4	Yes
Ramat-Gan	a.c.50	1,3	220/380	2,4	Yes
Rehovot	a.c.50	1,3	220/380	2,4	Yes
Tel Aviv	a.c.50	1,3	220/380	2,4	Yes
Jerusalem	a.c.50	1,3	220/380	2,4	Yes
	a.c.50	1,3	220/380	2,3,4	Yes
Jordan (Note 1/ 2)					
Amman	a.c.50	1,3	220/380	2,4	Yes
Irbid	a.c.50	1,3	220/380	2,4	Yes
Nablus	a.c.50	1,3	220/380	2,4	Yes
Zerqa	a.c.50	1,3	220/380	2,4	Yes
Kuwait	a.c.50	1,3	240/415	2,4	Yes
Lebanon					
Aley	a.c.50	1,3	110/190	2,4	No
Beirut	a.c.50	1,3	110/190	2,4	No
Bhamdoun	a.c.50	1,3	110/190	2,4	No
Brummana	a.c.50	1,3	110/190	2,4	No
Chtaure	a.c.50	1,3	110/190	2,4	No
Dhour el Choueir	a.c.50	1,3	110/190	2,4	No
Sidon	a.c.50	1,3	110/190	2,4	No
Sofar	a.c.50	1,3	110/190	2,4	No
Tripoli	a.c.50	1,3	110/190	2,4	No
Tyre	a.c.50	1,3	220/380	2,4	No
Zahleh	a.c.50	1,3	110/190	2,4	No
	a.c.50	1,3	220/380	2,4	Yes

ELECTRICAL CURRENT CHARACTERISTICS IN SWA					
Country and City	**Type and Frequency of Current**	**Number of Phases**	**Nominal Voltage**	**Number of Wires**	**Frequency Stable Enough for Electric Clocks**
Libya (Notes 3 & 4)					
Al Aziziyah	a.c.50	1,3	127/220	2,4	No
Barce	a.c.50	1,3	230/400	2,4	No
Ben Gashir	a.c.50	1,3	127/220	2,4	No
Benghazi	a.c.50	1,3	230/400	2,4	No
Derna	a.c.50	1,3	230/400	2,4	No
El Baida	a.c.50	1,3	230	2,4	No
Homs	a.c.50	1,3	127/220	2,4	No
Misurata	a.c.50	1,3	127/220	2,4	No
Sebha	a.c.50	1	230	1	No
Tagiura	a.c.50	1,3	127/220	2,4	No
Tobruk	a.c.50	1,3	230/400	2,4	No
Tripoli	a.c.50	1,3	127/220	2,4	No
Zavia	a.c.50	1,3	127/220	2,4	No
Oman					
Muscat	a.c.50	1,3	220/440	2,3	No
Pakistan (Note 1)					
Abbotabad	a.c.50	1,3	230/400	2,3,4	Yes
Bahawalpur	a.c.50	1,3	230/400	2,3,4	Yes
Hyderabad	a.c.50	1,3	230/400	2,3,4	Yes
Islamabad	a.c.50	1,3	230/400	2,3,4	Yes
Karachi	a.c.50	1,3	230/400	2,3,4	Yes
Lahore	a.c.50	1,3	230/400	2,3,4	Yes
Lyallpur	a.c.50	1,3	230/400	2,3,4	Yes
Montgomery	a.c.50	1,3	230/400	2,3,4	Yes
Multan	a.c.50	1,3	230/400	2,3,4	Yes
Murree	a.c.50	1,3	230/400	2,3.4	Yes
Peshawar	a.c.50	1,3	230/400	2,3,4	Yes
Quetta	a.c.50	1,3	230/400	2,3,4	Yes
Rawalpindi	a.c.50	1,3	230/400	2,3,4	Yes
Saudi Arabia (Notes 5 & 6)					
Al Khobar	a.c.60	1,3	127/220	2,4	Yes
Buraydah	a.c.50	1,3	220/380	2,4	No
Dammam	a.c.60	1,3	127/220	2,4	Yes
Hofuf	a.c.50	1,3	230/400	2,4	Yes
Jiddah	a.c.60	1,3	127/220	2,3,4	Yes
Mecca	a.c.50	1,3	230/400	2,4	Yes
Medina	a.c.60	1,3	127/220	2,4	Yes
Riyadh	a.c.60	1,3	127/220	2,4	Yes
Taif	a.c.50	1,3	230/400	2,4	Yes

ELECTRICAL CURRENT CHARACTERISTICS IN SWA					
Country and City	**Type and Frequency of Current**	**Number of Phases**	**Nominal Voltage**	**Number of Wires**	**Frequency Stable Enough for Electric Clocks**
Sudan (Note 1)					
Atbara	a.c.50	1,3	240/415	2,4	Yes
Ed Daner	a.c.50	1,3	240/415	2,4	Yes
Ed Dueim	a.c.50	1,3	240/415	2,4	Yes
El Obeid	a.c.50	1,3	240/415	2,4	Yes
Hassa Heissa	a.c.50	1,3	240/415	2,4	Yes
Juba	a.c.50	1,3	240/415	2,4	Yes
Kassala	a.c.50	1,3	240/415	2,4	Yes
Khartoum	a.c.50	1,3	240/415	2,4	Yes
Khartoum N	a.c.50	1,3	240/415	2,4	Yes
Kosti	a.c.50	1,3	240/415	2,4	Yes
Malakal	a.c.50	1,3	240/415	2,4	Yes
Omdurman	a.c.50	1,3	240/415	2,4	Yes
Port Sudan	a.c.50	1,3	240/415	2,4	Yes
Sennar	a.c.50	1,3	240/415	2,4	Yes
Shendi	a.c.50	1,3	240/415	2,4	Yes
Wadi Halfa	a.c.50	1,3	240/415	2,4	Yes
Wau	a.c.50	1	240	2	Yes
Syria					
Aleppo	a.c.50	1,3	115/200	2,3,4	No
Damascus	a.c.50	1,3	115/200	2,3,4	No
Dayr-Al-Zawr	a.c.50	1,3	220/380	2,3,4	No
Hama	a.c.50	1,3	115/200	2,3,4	No
Homs	a.c.50	1,3	115/200	2,3,4	No
Latakia	a.c.50	1,3	115/200	2,3,4	No
Turkey (Note 2)					
Adana	a.c.50	1,3	220/380	2,3,4	Yes
Adapazari	a.c.50	1,3	220/380	2,3,4	Yes
Afyon	a.c.50	1,3	220/380	2,3,4	Yes
Ankara	a.c.50	1,3	220/380	2,3,4	Yes
Balikesir	a.c.50	1,3	220/380	2,3,4	Yes
Bursa	a.c.50	1,3	220/380	2,3,4	Yes
Eskisehir	a.c.50	1,3	220/380	2,3,4	Yes
Gaziantep	a.c.50	1,3	220/380	2,3,4	Yes
Istanbul	a.c.50	1,3	220/380	2,3,4	Yes
Izmir	a.c.50	1,3	220/380	2,3.4	Yes
Izmit	a.c.50	1,3	220/380	2,3,4	Yes
Kayseri	a.c.50	1,3	220/380	2,3,4	Yes
Knoya	a.c.50	1,3	220/380	2,3,4	Yes
Malatya	a.c.50	1,3	220/380	2,3,4	Yes
Manisa	a.c.50	1,3	220/380	2,3,4	Yes

ELECTRICAL CURRENT CHARACTERISTICS IN SWA					
Country and City	**Type and Frequency of Current**	**Number of Phases**	**Nominal Voltage**	**Number of Wires**	**Frequency Stable Enough for Electric Clocks**
Turkey (**Continued**)					
Mersin	a.c.50	1,3	220/380	2,3,4	Yes
Samsun	a.c.50	1,3	220/380	2,3,4	Yes
Sivas	a.c.50	1,3	220/380	2,3,4	Yes
Trabzon	a.c.50	1,3	220/380	2,3,4	Yes
Zonguldak	a.c.50	1,3	220/380	2,3,4	Yes
Yemen (Arab Rep)					
Hoeida					
Sana	a.c.50	1,3	220	2,3	No
Taiz	a.c.50	1,3	220	2,3	No
	a.c.50	1,3	220	2,3	No

NOTES:
1. A grounding conductor is required in the electrical cord attached to appliances.
2. The neutral wire of the secondary distribution system is grounded.
3. Electric current is now continuous in most of the cities and large towns.
4. The neutral wire of the secondary distribution system is grounded except in the case of Sebba.
5. Grounding conductors are not required and many houses are not wired for a separate ground.
6. Power supply being standardized at 60 cycle, 127/200V.

Attachment 3

EXISTING FACILITIES AND RESOURCES CHECKLIST

1. COUNTRY: ____

2. NAME OF AIRFIELD: ____

3. ALTERNATE NAMES: ____

4. DATE OF INFORMATION: ____

5. DESCRIPTION OF REFERENCE POINT (RP)

A. LATITUDE (RP): ______________________________

B. LONGITUDE (RP): ______________________________

C. LOCATION OF THIS REFERENCE POINT (RP): ______________________
____

D. ELEVATION OF RP: ____

6. DESCRIPTIVE LOCATION (NAME & DISTANCE TO CLOSEST TOWN):
____
____
____

7. BASE POPULATION: ________________________

A. MILITARY: ______________________________

B. CIVILIAN: ______________________________

8. NEAREST US MILITARY INSTALLATION: ___________________________

9. RUNWAYS/TAXIWAYS/AIRCRAFT SUPPORT STRUCTURE:

A. ORIENTATION (Bearing to nearest degree; indicate MAGNETIC or TRUE)
RUNWAY #1 ____/________ RUNWAY #2 _________________
(North/South/East/West End) (North/South/East/West End)

B. ELEVATION OF RUNWAY ENDS; RUNWAY GRADIENT
RUNWAY #1 ______/_______ RUNWAY #2 ________/________

C. LENGTH/WIDTH (Exact dimensions in feet or meters)
RUNWAY #1 ______ /_________ RUNWAY #2 _________/________

D. CONSTRUCTION (Type and thickness of surface; composition and depth of base type sub-base; condition of runway.)

RUNWAY #1 ____________________ RUNWAY #2 ____________________

E. CAPACITY (Gross weight for aircraft single wheel, twin wheel and twin tandem type landing gear; maximum psi runway will support. Give Load Classification Number (LCN) and Pavement Classification Number (PCN), if known.)

RUNWAY #1 ____________________ RUNWAY #2 ____________________

F. ARRESTING SYSTEM(S) (Type of system as barrier; cable or barrier/cable; identify system; capability; location identified by runway number and distance from runway end.)

RUNWAY #1 (Approach End) RUNWAY #2 (Approach End)

RUNWAY #1 (Departure End) RUNWAY #2 (Departure End)

G. RUNWAY OVERRUNS (Length, width, type, thickness and weight bearing capacity; composition and thickness of base; type sub-base and LCN, if known. Give extensibility of runways and indicate sterilized portions.)

RUNWAY #1 (Approach End) RUNWAY #2 (Approach End)

RUNWAY #1 (Departure End) RUNWAY #2 (Departure End)

H. RUNWAY REMARKS (Give surface, width and condition of shoulders. Describe runway numerals and other runway/taxiway markings. Give usability during wet seasons, if applicable; drainage, natural or artificial; take off and landing restrictions. Give type aircraft, at heaviest weight, if known, that have used the airfield and that could still be accommodated. Give description, location and height of obstructions along runways.)

RUNWAY #1	RUNWAY #2
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

I. TAXIWAYS (Number, type, width, markings and the same construction and static load data as for the runway; location from RP; stabilized shoulder surface, width and condition; give lateral clearances or restrictions to include description, location and height of obstructions along taxiways.)

(1) TAXIWAY (Name): _________________ Ref Point: ______________________________
Width (main surface): ___________________ Width (shoulder): _________________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _______________________________________
Obstructions: ____
Markings: ____

(2) TAXIWAY (Name): ______________________ Ref Point: __________________________
Width (main surface: ___________________________ Width (shoulder): ___________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _______________________________________
Obstructions: ____
Markings: ____

(3) TAXIWAY (Name): _____________________ Ref Point: ___________________________
Width (main surface): _____________________ Width (shoulder): _____________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _______________________________________
Obstructions: ____
Markings: ____

(4) TAXIWAY (Name): ___________________ Ref Point: ____________________________
Width (main surface): _____________________ Width (shoulder): _______________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _______________________________________
Obstructions: ____

Markings: ____

(5) TAXIWAY (Name): _______________ Ref Point: _____________________
Width (main surface) _________________ Width (shoulder): _________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): ____________________________
Obstructions: ____
Markings: ____

(6) TAXIWAY (Name): _________________ Ref Point: ____________________
Width (main surface): _________________ Width (shoulder): ___________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _____________________________
Obstructions: ____
Markings: ____

(7) TAXIWAY (Name): _________________ Ref Point: ______________________
Width (main surface): __________________Width (shoulder): ______________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _____________________________
Obstructions: ____
Markings: ____

(8) TAXIWAY (Name) : _______________ Ref Point: ______________________
Width (main surface): _________________ Width (shoulder): _________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _____________________________
Obstructions: ____
Markings: ____

(9) TAXIWAY (Name): ______________ Ref Point: ______________________
Width (main surface): ______________ Width (shoulder): _____________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): ____________________________
Obstructions: ____
Markings: ____

(10) TAXIWAY (Name): _____________ Ref Point: ______________________
Width (main surface): ________________ Width (shoulder): __________________
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): _____________________________
Obstructions: ____
Markings: ____

J. APRONS, HARDSTANDS, REVETMENTS, OTHER PARKING (Location, number, type, dimensions, surface, condition, weight bearing capacity, accessibility and clearance limitations. For revetments, give embankment height, structure, size of entrance, is revetment covered.)

(1) APRON (Name): _______________ Ref Point: _______________________
Dimensions: Width: _________________ Length: _________________________
Shoulder: ____
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): ____________________________
Obstructions: ____
Grounding Points: ____
Lighting: ____
Other Data: ____
____
Revetments: ____
____

(2) APRON (Name): _______________ Ref Point: __________________________
Dimensions: Width ______________ Length: ____________________________
Shoulder: ____
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): ____________________________
Obstructions: ____
Grounding Points: ____
Lighting: ____
Other Data: ____
____
Revetments: ____
____

(3) APRON (Name): _________________ Ref Point: _____________________
Dimensions: Width: _________________ Length: _______________________
Shoulder: ____
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): __________________________
Obstructions: ____
Grounding Points: ____
Lighting: ____
Other Data: ____
____
Revetments: ____
____

(4) APRON (Name): _________________ Ref Point: _________________________
Dimensions: Width: __________________ Length: ___________________________
Shoulder: ____
Asphalt, Concrete or other: ____
Load Bearing Capability/Capacity (LCN or PCN): ______________________________
Obstructions: ____

Grounding Points: ____
Lighting: ____
Other Data: ____
____
Revetments: ____
____

(5) APRON (Name): ____________ Ref Point: ______________
Dimensions: Width: ____________ Length: ______________
Shoulder:____
Asphalt, Concrete or other: ______________________________
Load Bearing Capability/Capacity (LCN or PCN): ______________
Obstructions: ____
Grounding Points: ____
Lighting: ____
Other Data: ____
____
Revetments: ____
____

(6) APRON (Name): ____________ Ref Point: ______________
Dimensions: Width: ____________ Length: ______________
Shoulder: ____
Asphalt, Concrete or other: ______________________________
Load Bearing Capability/Capacity (LCN or PCN): ______________
Obstructions: ____
Grounding Points: ____
Lighting: ____
Other Data: ____
____
Revetments: ____
____

K. AIRCRAFT SHELTERS (List size, type, interior dimensions, door size).
____
____
____

L. APPROACH OBSTRUCTIONS (On aerodrome or near vicinity; give location, description, height above ground and sea level, lighted or unlighted; i.e., towers, buildings, hills. Describe approach terrain, especially on final approach.)
____
____
____
____

M. NAVIGATIONAL AND LANDING AIDS.

(1) NAVIGATIONAL AIDS (Types, hours of operation, English spoken, location.)

(2) OTHER DATA: Submit layout plan; visual and instrument approach diagram; and graphics:

10. LIGHTING:

A. RUNWAY (For each runway, include high or low intensity lighting, the dimming capability, and if flush mounted or elevated; centerline; runway flood; runway strip; portable electric, goose necks; emergency; auxiliary power for lighting; and times of operation or are lights on request. If available, list backup power.)

B. APPROACH (Indicate type runway serviced, US standard, neon ladder, left row, etc.; state intensity; list touchdown zone lighting, approach light beacon, sequence flashing, VASI, REIL and VAPI.)

C. OTHER (Types of lighting, including taxiway, beacons, apron flood, threshold, obstruction, boundary, lighted wind indicator, hangar area, flares—all variations and details pertaining to lighting systems should be covered.)

11. OTHER DATA ON AIRFIELD:

A. VISUAL IDENTIFICATION (Location of markers, wind indicators, control tower and rotating beacon.)

____

B. OPERATING AND USING AGENCIES (Occupying military units, commercial air carriers and organizational units having airfield maintenance responsibility. List separately those activities that are categorized only as users. Give number and type of aircraft that have or are presently using this facility.)

____
____
____
____

C. CURRENT AND FUTURE CONSTRUCTION (Provide detailed information on proposed expansion plans and improvements program in progress; give status and proposed completion date(s).)

____
____
____
____
____
____

MAINTENANCE AND ACCESSORIES

11. HANGARS:

A. HANGAR (number/name): ____

DIMENSIONS IN FEET: ____

(1) Floor space: ____

(2) Doors (Height and Width): ____

ENVIRONMENTALLY CONTROLLED (Yes or No)

MATERIAL AND TYPE OF CONSTRUCTION (Double bay, open end, steel, concrete, wood, sheet metal)

____
____
____
____

LOCATION FROM REFERENCE POINT OR NEAREST RAMP:

____

B. HANGAR (number/name): ____

DIMENSIONS IN FEET: ____

(1) Floor space: ____

(2) Doors (Height and Width): ____

ENVIRONMENTALLY CONTROLLED (Yes or No)

MATERIAL AND TYPE OF CONSTRUCTION (Double bay, open end, steel, concrete, wood, sheet metal.):

____

____

____

____

LOCATION FROM REFERENCE POINT OR NEAREST RAMP:____

____

____

C. HANGAR (number/name): ____

DIMENSIONS IN FEET: ____

(1) Floor space: ____

(2) Doors (Height and Width): ____

ENVIRONMENTALLY CONTROLLED (Yes or No)

MATERIAL AND TYPE OF CONSTRUCTION (Double bay, open end, steel, concrete, wood, sheet metal.):____

____

____

____

LOCATION FROM REFERENCE POINT OR NEAREST RAMP:

____

____

13. GROUND SUPPORT EQUIPMENT (Give model, capacity and quantity of portable line equipment such as AC/DC generators, auxiliary power units, aircraft heaters, aircraft air conditioners, air compressors, hydraulic test stands, light carts and other powered aerospace ground equipment.):

____

____

____

____

14. ENGINE TESTING (Describe engine or aircraft tie-down points, test stand and blast fences, also note thrust load capabilities.):

____
____
____
____

15. HAZARDOUS CARGO PAD (describe size and location.):

____
____

16. HOT BRAKE PAD (Describe where aircraft with hot brakes rest while waiting for the brakes to cool.):

____
____
____

17. ORDNANCE STORAGE (Type munitions, type storage, e.g., bunker, underground, above ground, open field, etc. Indicate quantity of storage facilities, number and dimensions of buildings, security.):

A. BUNKER (Name): ______________________ Ref Point: ___________________________
Dimensions: Width: ________________________ Length: _____________________________
Height: ____
Earth Bank, Concrete or Other: ____
Capacity: ____
Distance to Loading Pad: ____
Lighting: ____
Other Data: ____

B. BUNKER (Name): ___________________ Ref Point: ____________________________
Dimensions: Width: ____________________ Length: _____________________________
Height: ____
Earth Bank, Concrete or Other: ____
Capacity: ____
Distance to Loading Pad: ____
Lighting: ____
Other Data: ____

C. BUNKER (Name): __________________ Ref Point: ____________________________
Dimensions: Width: ___________________ Length: _____________________________
Height: ____
Earth Bank, Concrete or Other: ____
Capacity: ____
Distance to Loading Pad: ____
Lighting: ____
Other Data: ____

D. BUNKER (Name): ___________________ Ref Point: ____________________________
Dimensions: Width: _____________________ Length: ______________________________
Height: ____
Earth Bank, Concrete or Other ____
Capacity: ____
Distance to Loading Pad: ____
Lighting: ____
Other Data: ____

E. BUNKER (Name): ____________________ Ref Point: ____________________________
Dimensions: Width: _____________________ Length: ______________________________
Height: ____
Earth Bank, Concrete or Other: ____
Capacity: ____
Distance to Loading Pad: ____
Lighting: ____
Other Data: ____

PETROLEUMS, OILS and LUBRICANTS (POL)

18. FUEL:

A. ON BASE (Give types and grades of military and commercial aviation fuels, normal stock level for each grade fuel listed. For commercial facilities indicate by whom owned and operated; what fuel additives are used. By product, list type of storage, e.g., steel tanks, above ground, underground, drum, etc. Indicate location, capacity each and/or total storage capacity).

____
____
____
____

B. OFF BASE STORAGE (data as above, if available from airport authorities. Also describe how this fuel gets to the airfield.)

____
____
____
____

C. FUEL DISPENSING METHOD (List refueling units by products, number, type. Describe hydrant and pumping system, location from RP, number, rated capacity of each hydrant (GPM) and pits, number and type hose carts or trucks, number and type nozzles. Give number of fill stands and rate (GPM) for each grade of fuel; indicate who owns and operates.)

____
____

____

____

19. OIL AND LUBRICANTS:

A. ON BASE (Stocks and grades maintained for reciprocating jet and turbine, list types of containers by product, capacity, stock level and resupply method).

____

____

____

____

B. OFF BASE STORAGE (data as above, if available from airport authorities.)

____

____

____

C. TRANSPORT (describe method of movement):

____

____

____

____

20. SPECIAL PURPOSE EQUIPMENT:

A. AIRCRAFT SUPPORT (tugs, ladder trucks, etc.):

____

____

____

B. CRASH AND FIRE EQUIPMENT (Number, type and class of units, condition, location on field or nearby, hours of availability. State in gallons the capacity of fire trucks. Indicate the availability of water hydrants, special water tanks, portable extinguisher and extinguishing agents and fire suppression helicopters.)

(1) Water Dispensing Aircraft: ____

(2) P-19: ____

(3) P-10: ____

(4) P-18: ____

(5) Other Water Tankers: ____

(6) P-20: ____

(7) Foreign Vehicles: ____

(8) Other USAF Vehicles: ____
____

(9) Command & Control Vehicle(s): ____
____

(10) 150 Pound Flightline Fire Bottles: ____

(11) K-12 Saws: ____

(12) Jaws of Life: ____

(13) Scott Air Packs: ____

(14) Ability to fill air tanks (Scott Air Packs): ____
____

(15) Types and availability of agents: ____
____
____

C. WRECKAGE REMOVAL EQUIPMENT (Number, type, e.g., wreckers, hoists, cranes, crash dollies and other equipment, condition.)
____
____
____

D. OTHER SPECIAL PURPOSE VEHICLES (e.g., sand removal, tractors, runway cleaners, graders, etc., condition.)

(1) Backhoes: ____
____
____

(2) Dozers: ____
____
____

(3) Dump Trucks: ____
____
____

(4) Excavators: ____
____
____

(5) Farm Tractors: ____
____
____

(6) Flatbeds: ____
____
____

(7) Forklifts: ____
____

(8) Graders: ____

(9) Kick Broom Sweepers: ____

(10) Loaders: ____

(11) Paint Machines: ____

(12) Rollers: ____
____

(13) Sewage Servicing/Fleet Servicing: ____
____

(14) Trailer Tractors: ____
____

(15) Trenchers: ____
____

(16) Vacuum Sweepers: ____
____

(17) Water Trucks/Tankers: ____
____

(18) Snow Removal Equipment: ____
____

E. CBRN DETECTION, WARNING AND REPORTING SYSTEMS (availability and types of equipment, condition, how activated):

____
____
____
____

21. BASE SERVICES/BASE INFRASTRUCTURE:

A. PERSONNEL ACCOMMODATIONS (Give number of permanent or temporary buildings, dimensions and conditions. Give normal and maximum capacity for all Airmen. State percentage of space utilization on base only).

____
____
____
____

B. LATRINES (number and location for both the living and working areas):

____
____
____

C. SHOWERS (number, condition and proximity to living area): ___________________________

____
____
____

D. MESSING FACILITIES (Give normal and maximum messing capacity for all Airmen. Availability of mess hall, dining rooms, field kitchens, etc., condition and accessibility).

____
____
____
____

E. LAUNDRY SERVICES: ____

____
____
____

F. MORTUARY SERVICES: ____

____
____
____
____

G. STORAGE (Give number, dimensions and conditions of warehouses, sheds, etc. Location and size of open storage areas, refrigerated storage areas. Indicate percentage in use.)

____
____
____
____

H. MEDICAL/DENTAL (Indicate name, type and location of all medical facilities available, normal bed capacity for each hospital. Indicate all medical staffing, i.e., doctors, dentists, nurses, etc. Indicate number of ambulances available).

____
____
____
____

I. WATER SUPPLY (Source of water, e.g., well, water shed, brought in by can, tank car. Quantity, normal and maximum gallons per 24 hours storage capacity, e.g., storage tank, reservoirs, potability. Indicate the location and amount of emergency water supply. Also indicate if water is treated (chlorine, fluoride, etc.) and if the water has been tested, list test results):

____
____
____
____

J. AVAILABLE BUILDINGS (Consider location, type, total floor space, number of personnel currently working within, expansion in contingency or emergency situations.)

____
____
____
____

(1) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: _________ Cycles/Hertz: ____________________
Latrines (type and quantity): ____
Drinking Water Available: ____
Environmentally Controlled (Yes/No): ____

(2) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: _________________________ Cycles/Hertz: ____________________
Latrines (type and quantity): ____
Drinking Water Available: ____
Environmentally Controlled (Yes/No) ____

(3) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: ____________________ Cycles/Hertz: ________________
Latrines (type and quantity): ____
Drinking Water Available: ____
Environmentally Controlled (Yes/No): _______________________________________

(4) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: ____________________ Cycles/Hertz: ________________
Latrines (type and quantity): ____
Drinking Water Available: ____
Environmentally Controlled (Yes/No): _______________________________________

(5) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: ____________________ Cycles/Hertz: ________________
Latrines (type and quantity): ____
Drinking Water Available: ____
Environmentally Controlled (Yes/No): _______________________________________

(6) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: ____________________ Cycles/Hertz: ________________
Latrines (type and quantity): ____
Drinking Water Available: ____
Environmentally Controlled (Yes/No): _______________________________________

(7) Building Number or Name: ____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: ____________________ Cycles/Hertz: ________________
Latrines (type and quantity): ____

Drinking Water Available: ____
Environmentally Controlled (Yes/No): ____________________________________

(8) Building Number or Name: ____
____
Floor Space: ____
Description of current use: ____
____
Lighting (Yes/No) Electrical Outlets (Yes/No)
Voltage: ____________________ Cycles/Hertz: ________________
Latrines (type and quantity): ____
____
Drinking Water Available: ____
____
Environmentally Controlled (Yes/No): ____________________________________

K. ELECTRICAL POWER SOURCES (Note location, reliability, type (A/C or D/C), capacity in kilowatts or kilovolt ampere, cycles, single or three phase, voltage (110/220 or 220/440). Indicate type of emergency equipment, output and reliability.)
____
____
____
____
____
____
____

L. SOLID WASTE DISPOSAL (Indicate method, source, capacity, frequency.)
____
____
____

M. SEWAGE (On-base capability, capacity, type of treatment; commercial capability, capacity, type of treatment.) ____
____
____
____
____

N. INSECT/RODENT CONTROL (Source, capability.) ___________________________
____
____
____
____

O. AIR PASSENGER TERMINAL (Give specific terminal information to include dimensions, internal layout, maximum capacity, installed baggage handling system, location and security.)

P. RAILROADS AND HIGHWAYS (Number of sidings and/or spurs on base and what facilities are serviced. Access roads supporting airfield along with type surface, width, condition, and capacity of highway and bridges.)

Q. TELEPHONES (Manual, automatic; number of switchboard lines, number of terminal points of direct line circuits. Hot line available?)

R. RADIOS (Types, frequencies, etc.)

S. OTHER COMMUNICATIONS (Area broadcasting systems/loudspeakers, local radio or television systems and locations.)

22. SUPPLIES AND/OR ADDITIONAL EQUIPMENT:

A. ON SITE AVAILABLE SUPPLIES OR EQUIPMENT (Prepositioned, stored locally, or loaned by the hosts.)

B. OFF SITE AVAILABLE MATERIALS (List sources for electrical, plumbing, carpentry, construction supplies, etc., and their proximity to the site.)

C. SUPPLIES AND MATERIALS NEEDED (To be sent with the deploying unit and/or headquarters element.)

D. CONTRACT SUPPLIED OR SERVICES AVAILABLE ____

____

____

____

____

E. LOCAL CONSTRUCTION COMPANIES ____

____

____

____

____

____

____

Attachment 4

CONVERSION FACTORS

Below is a small sampling of common U.S. and metric conversion factors. In addition, several internet sites provide free use of conversion applications and calculators. Some of the more popular ones include: http://www.onlineconversion.com; http://www.metricconversion.ws; and http://www.infoplease.com/pages/unitconversion.html .

Table A4.1. Common U.S. to Metric Conversion Factors

Length		
U.S. Unit	**Metric Equivalent**	
Inch	2.5400	Centimeters
Inch	25.4001	Millimeters
Feet	0.3048	Meters
Mile	1.6093	Kilometers
Area		
Square inch	6.4516	Square centimeters
Square feet	0.0929	Square meters
Pressure		
Pounds per square inch	0.0700	Kilogram-force per square centimeters
Volume		
Gallon (liquid)	3.7854	Liters
Gallon (dry)	4.4048	Liters
Cubic feet	0.0283	Cubic meters
Cubic inch	16.3870	Cubic centimeters
Mass (Weight)		
Pound	0.4536	Kilograms
Temperature		
Degrees 100 (F)	37.7777	Degrees (C)
Degrees 72 (F)	22.2222	Degrees (C)
Degrees 32 (F)	0.0000	Degrees (C)
Degrees 0 (F)	17.7777	Degrees (C)
Angle		
Degrees (angular)	17.7778	Mils

Table A4.2. Common Metric to U.S. Conversion Factors

Length		
Metric Unit	**U.S. Equivalent**	
Centimeter	0.3937	Inches
Millimeter	0.0393	Inches
Meter	3.2808	Feet
Kilometer	0.6213	Miles
Area		
Square centimeter	0.1550	Square inches
Square meter	10.7639	Square feet
Pressure		
Kilogram-force per square centimeter	14.2233	Pounds per square inch
Volume		
Liter	0.2642	Gallons (liquid)
Liter	0.2270	Gallons (dry)
Cubic meter	35.3146	Cubic feet
Cubic centimeter	0.0610	Cubic inches
Mass (Weight)		
Kilogram	2.2046	Pounds
Temperature		
Degrees 0 (C)	32.0	Degrees (F)
Degrees 15 (C)	59.0	Degrees (F)
Degrees 30 (C)	86.0	Degrees (F)
Degrees 45 (C)	113.0	Degrees (F)
Angle		
Mil	0.0562	Degrees (angular)

Attachment 5

FOREIGN WEIGHTS AND MEASURES

Table A5.1. List of Foreign Weights and Measures

Denominations	Where Used	U.S. Equivalents
Almude	Portugal	4.422 gals.
Ardeb	Sudan	5.6188 bushels
Are	Metric	0.02471 acre
Arr't'l or li'ra	Portugal	1.0119 lbs.
Arroba	Argentine Republic	25.32 lbs.
Arroba	Brazil	32.38 lbs.
Arroba	Cuba	25.36 lbs.
Arroba	Paraguay	25.32 lbs.
Arroba	Venezuela	25.40 lbs
Arroba (liquid)	Cuba, Spain and Venezuela	4.263 gals.
Arshine	Russia	28 in.
Arshine (sq.)	Russia	5.44 ft.2
Artel	Morocco	1.12 lbs.
Baril	Argentine Republic	20.077 gals.
Baril	Mexico	20.0787 gals.
Barrel	Malta (customs)	11.2 gals.
Berkovets	Russia	361.128 lbs.
Bongkal	Fed. Malay States	832 grains
Bouw	Sumatra	7,096.5 meters2
Bu	Japan	0.12 inch
Bushel	British Empire	1.03205 U.S. bu.
Caffiso	Malta	5.40 gals.
Candy	India (Bombay)	569 lbs.
Candy	India (Madras)	500 lbs.
Cantar	Egypt	99.05 lbs.
Cantar	Morocco	112 lbs.
Cantar	Turkey	124.45 lbs.
Cantaro	Malta	175 lbs.

Denominations	Where Used	U.S. Equivalents
Cast, Metric	Metric	3.086 grains
Catti	China	1.333 1/3 lbs.
Catti	Japan	1.32 lbs.
Catty	Java, Malacca	1.36 lbs.
Catty	Thailand	1.32 lbs.
Catty	Sumatra	2.12 lbs.
Centaro	Central America	4.2631 gals.
Centner	Brunswick	117.5 lbs.
Centner	Bremen	127.5 lbs.
Centner	Denmark, Norway	110.23 lbs.
Centner	Russia	113.44 lbs.
Centner	Sweden	93.7 lbs
Chetvert	Russia	5.957 bu.
Ch'ih	China	12.60 in.
Ch'ih (metric)	China	1 meter
Cho	Japan	2.451 acres
Comb	England	4.1282 bu.
Coyan	Thailand	2.645.5 lbs.
Cuadra	Argentine Republic	4.2 acres
Cuadra	Paraguay	94.70 yds.
Cuadra (sq.)	Paraguay	1.85 acres
Cuadra	Uruguay	1.82 acres
Cubic meter	Metric	35.3 cu. ft.
Cwt. (hund. weight)	British	112 lbs.
Dessiatine	Russia	2.6997 acres
Drachma (new)	Greece	15.43 gr., or 1 gram
Fanega (dry)	Ecuador, Salvador	1.5745 bu.
Fanega	Chile	2.75268 bu.
Fanega	Guatemala, Spain	1.53 bu.
Fanega	Mexico	2.57716 bu.

Denominations	Where Used	U.S. Equivalents
Fanega (doublé)	Uruguay	7.776 bu.
Fanega (single)	Uruguay	3.888 bu.
Fanega	Venezuela	3.334 bu.
Fanega (liquid)	Spain	16 gals.
Feddan	Egypt	1.04 acres
Frall (rais's)	Spain	50 lbs.
Frasco	Argentine Republic	2.5098 liq.qts.
Frasco	Mexico	2.5 liq. qts.
Frasila	Zanzibar	35 lbs.
Fuder	Luxemburg	264.18 gals.
Funt	Russia	0.9028 lb.
Gallon	British Empire	1.20094 U.S. gals.
Garnice	Poland	1.0567 gal.
Gram	Metric	15.432 grains
Hectare	Metric	2.471 acres
Hectolitre: Dry	Metric	2.838 bu.
Hectolitre: Liquid	Metric	26.418 gals
Jarib	Iran	2.471 acres
Joch	Austria (Germany)	1.422 acres
Joch	Hungary	1.067 acres
Ken	Japan	5.97 feet
Kilogram (kilo)	Metric	2.2046 lbs.
Kilometre	Metric	0.62137 mile
Klafter	Austria (Germany)	2.074 yds.
Koku	Japan	5.119 bu.
Kwamme	Japan	8.2673 lbs.

Denominations	Where Used	U.S. Equivalents
Last	Belgium (Netherlands)	85.135 bu.
Last	England	82.56 bu.
Last	Germany	2 metric tons (4,409 + lbs)
Last	Russia	112.29 bu.
Last	Scotland, Ireland	82.564 bu.
League (land)	Paraguay	4.633 acres
Li	China	1,890 ft
Libra (lb.)	Argentine Republic	1.0128 lbs.
Libra	Central America	1.014 lbs.
Libra	Chile	1.014 lbs.
Libra	Cuba	1.0143 lbs.
Libra	Mexico	1.01467 lbs.
Libra	Peru	1.0143 lbs.
Libra	Uruguay	1.0143 lbs.
Libra	Venezuela	1.0143 lbs.
Litre	Metric	1.0567 liq. qts.
Litre	Metric	0.90810 dry qts.
Livre (lb.)	Greece	1.1 lbs
Load, timber	England	50 cu. ft.
Lumber (std.)	Europe	165 cu. ft., or 1,980 ft.b.m
Manzana	Nicaragua	1.742 acres
Manzana	Costa Rica, Salvador	1.727 acres
Marc	Bolivia	0.507 lb.
Maund	India	82 2/7 lbs.
Metre	Metric	39.37 inches
Mil	Denmark	4.68 miles
Mil (geographic)	Denmark	4.61 miles
Milla	Nicaragua	1.1594 miles
Milla	Honduras	1.1493 miles
Mina (old)	Greece	2.202 lbs.
Morgen	Germany	0.63 acre

Denominations	Where Used	U.S. Equivalents
Oke	Egypt	2.8052 lbs
Oke (Ocque)	Greece	2.82 lbs.
Oke	Turkey	2.828 lbs.
Pic	Egypt	22.82 inches
Picul	Borneo, Celebes	135.64 lbs.
Picul	China	133 1/3 lbs.
Picul	Java	136.16 lbs.
Picul	Philippines	139.44 lbs.
Pie	Argentine Republic	0.94708 ft.
Pie	Spain	0.91416 ft.
Pik	Turkey	27.9 inches
Pood	Russia	36.113 lbs.
Pund (lb)	Denmark	1.102 lbs.
Quart	British Empire	1.20094 liq. qt.
Quart	British Emp	1.03205 dry qt.
Quarter	Great Britain	8.256 bu.
Quintal	Argentine Republic	101.28 lbs.
Quintal	Brazil	120.54 lbs.
Quintal	Castle, Peru	101.43 lbs.
Quintal	Chile	101.41 lbs.
Quintal	Mexico	101.47 lbs.
Quintal	Metric	220.46 lbs.
Rottle	Israel	6.35 lbs.
Sack (flour)	England	280 lbs.
Sangene	Russia	7 feet
Salm	Malta	8.2 bu.
Se	Japan	0.02451 acre
Seer	India	22-35 lbs.

Denominations	Where Used	U.S. Equivalents
Shaku	Japan	11.9303 inches
Sho	Japan	1.91 liq. qts.
Skalpund	Sweden	0.937 lbs.
Stone	British	14 lbs.
Sun	Japan	1.193 inches
Tael Kuping	China	575.64 grains (troy)
Tan	Japan	2.05 pecks
Tchvtert	Russia	5.96 bu.
To	Japan	2.05 pecks
Ton	Space measure	40 cu ft.
Tonde cereals	Denmark	3.9480 bu.
Tonde Land	Denmark	1.36 acres
Tonne	France	2204.62 lbs.
Tsubo	Japan	35.58 ft.2
Tsun	China	1.26 inches
Tunna (wheat)	Sweden	4.5 bu.
Tunnland	Sweden	1.22 acres
Vara	Argentine Republic	34.0944 inches
Vara	Costa Rita, Salvador	32.913 inches
Vara	Guatemala	32.909 inches
Vara	Honduras	32.953 inches
Vara	Nicaragua	33.057 inches
Vara	Chile and Peru	32.913 inches
Vara	Cuba	33.386 inches
Vara	Mexico	32.992 inches
Vedro	Russia	2.707 gals.
Verst	Russia	0.663 mile
Vloka	Poland	41.50 acres
Wey	Scotland and Ireland	41.282 bu

Attachment 6

CIVIL ENGINEER CONTINGENCY PLANNING FACTORS

A6.1. Introduction. This attachment outlines the basic planning factors for the many potential CE contingency tasks (see **Table A6.1**). It lists the manpower, major materials and equipment required for each and provides typical completion time frames.

A6.2. Column Definitions and Explanations. The planning factors are based on several considerations. Many are derived from field experience, others are extracted from technical orders and some are estimates. The following paragraphs describe the column headings in **Table A6.1**

A6.2.1. Task. Only tasks which represent an activity are shown. Knowledge-only tasks are not included since they do not have a clearly delineated duration or end result.

A6.2.2. Air Force Specialty (AFS). AFSs identified in this column are those most closely associated with the task. This could be from a peacetime perspective, a multi-skilling perspective, or contingency-only perspective.

A6.2.3. Number of Personnel. This column identifies the number of personnel normally required for a task to be completed within the planned timeframe.

A6.2.4. Standard. The standard estimates shown are either go/no-go or represent clock hours (duration), **not manhours**. They also represent common working conditions, e.g., fair weather vice snow storms or thundershowers. In many cases they portray completion of generic tasks, relatively uncomplicated in nature, and therefore should not be viewed as the "correct time" for completion of detailed, complex tasks using the same piece of equipment. When viewed in this optimum environment, the times should generally be conservative and a well-trained, fully equipped team or crew should be able to perform the tasks within the time frames indicated.

A6.2.5. Major Material and Equipment Requirements. This column lists the primary equipment and material items needed to perform each task. Obviously, some substitutions can be made. In both training and contingency instances, variations are not only possible but probable. For example, if a dozer is identified for construction of an evaporation lagoon or building a protective berm, it should not be construed to mean that no other piece of equipment can be used for these tasks. Additionally, not all materials or equipment items were identified—most tasks will require a multitude of hand tools and minor supply and consumable items.

A6.2.6. References. This column shows the primary references for the task.

Table A6.1. Air Force Civil Engineer Contingency Task Standards.

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
CBRN Defense					
Preposition M8/M9 Paper	3EXXX	1	Go/No Go	M8/M9 Paper	T.O. 11H2-14-5-1, T.O. 11H2-2-21
Demonstrate Contamination Detection Procedures on M8/M9 Paper	3EXXX	1	10 sec	M8/M9 Paper	T.O. 11H2-14-5-1, T.O. 11H2-2-21
Setup/Operate M256A1 Chemical Agent Detector	3E9X1	2	Go/No Go	M256A1 Chemical Agent Detector	T.O. 11H2-21-1, TM 3-6665-307-10
Setup/Operate M22 Chemical Agent Alarm	3E9X1	1	Go/No Go	M8A1 Automatic Chemical Agent Alarm	T.O. 11H2-23-1
Setup/Operate M90 Chemical Agent Alarm	3E9X1	1	Go/No Go	M90 Automatic Chemical Agent Alarm	M90 Users Manual
Setup/Operate M291 Skin Decontamination Kit	3EXXX	1	Go/No Go	M291 Skin Decontamination Kit	T.O. 11D1-1-131
Setup/Operate M17A3/E32U-8 Decontamination Apparatus	3E9X1	2	Go/No Go	M17A3/E32U-8 Decontamination Apparatus	TM 3-4230-218-12&P
Don MCU-2 Protective Mask w/Hood	3EXXX	1	15 sec	MCU-2 Mask and Hood	T.O. 14P4-15-1
Don Chemical Protection Ground Crew Ensemble	3EXXX	1	8 min	Ground Crew Ensemble	T.O. 14P3-1-141
Install Protective Mask Second Skin	3EXXX	1	Go/No Go	MCU2/P, Second Skin	AFMAN 10-2602, T.O. 14P4-15-1
Setup/Operate ADM 300A/B/C Multifunctional Survey Meter	3E9X1	2	Go/No Go	ADM 300 Multifunctional Survey Meter	T.O. 11H2-2-31
Setup/Operate CAM/ICAM	3E9X1	1	Go/No Go	CAM/ICAM	T.O. 11H2-20-1, T.O. 11H2-20-11
Expedient Methods - Beddown					
Erect Temper Tent	3EXXX	6	2 Hrs	Temper Tent	AFH 10-222V2, T.O. 35E5-6-1
Erect Small Shelter System (SSS)	3EXXX	6	2 Hrs	Small Shelter System	AFH 10-222V2, T.O. 35E5-6-11
Erect Medium Shelter System (MSS)	3EXXX	6	4 Hrs	Medium Shelter System	AFH 10-222V2, T.O. 35E5-6-21
Construct 16' X 32' X 4" Concrete Pad	3E2X1, 3E3X1	6	8 Hrs	Cement Mixer, Tools, Forms, Concrete Materials	UFC 3-250-09FA, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Construct 550-Person Bare Base	3EXXX	55	72 Hrs	Tools and Equipment	AFPAM 10-219V6
TASK	**AFS**	**CREW SIZE**	**STANDARD**	**MATERIAL/ EQUIPMENT**	**REFERENCE(S)**
Connect Power to Tactical Shelters	3E0X1, 3E0X2	2	4 Hrs	Cable and Connections	AFH 10-222V5, T.O. 35E4-1-141, Field Experience
Connect Water to Tactical Shelters	3E4X1	2	4 hrs	Pipes and Fittings	AFH 10-222V5, T.O. 35E4-1-141, Field Experience
Setup/Maintain Remote Area Lighting System (RALS)	3E0X1, 3E0X2	2	2 Hrs	Remote Area Lighting System/T.O./Tools	T.O. 35F5-5-22-1, AFH 10-222V5, Field Experience
Setup/Maintain Telescopic Floodlight Set	3E0X1, 3E0X2	1	30 Min	Telescopic Floodlight Set	AFH 10-222V5, T.O. 35F5-5-16-1, Field Experience
Setup Power Plant for 550-Person Base	3E0X1, 3E0X2	6	8 Hrs	2-4 750 Kw Generators	AFH 10-222V2, AFH 10-222V5, T.O. 35C2-3-474-1/4, Field Experience
Setup BEAR Electrical Distribution System for 550-Person Base	3E0X1, 3E0X2	7	148 Hrs	BEAR Electrical Distribution System, FEL, Forklift	AFH 10-222V5, AFH 10-222V10, T.O. 35C1-2-1-301, T.O. 35C1-2-1-331, Field Experience
Phase and Parallel Two 750kW Generators	3E0X2	1	Go/No Go	750 Kw Generator	AFH 10-222V5, Field Experience
Setup 10K Gal Fuel Bladder	3E0X2	4	3 Hrs	Fuel Bladder, Piping	AFH 10-222V5, AFH 10-222V10, T.O. 37A12-15-1, Field Experience
Install/Operate Preway Heater	3E1X1	1	1 Hr	Preway Heater	TM 5-4520-235-13, Field Experience
Setup/Operate M-80 Boiler	3E1X1	2	30 Min	M-80 Boiler	AFH 10-222V12, TM 10-4510-206-14
Setup/Operate M149 Water Chiller	3E1X1	1	30 Min	M149 Water Chiller	AFH 10-222V12, TM 10-4130-239-14
Setup 150 CF Refrigeration Unit	3E1X1, 3E2X1, 3E0X1	4	2 Hrs	150CF Refrigeration Unit, FEL, Forklift	TM 5-4110-240-13&P, Field Experience
Setup 1,200 CF Refrigeration Unit	3E1X1, 3E2X1, 3E0X1	8	4 Hrs	1200CF Refrigeration Unit, FEL, Forklift	AFH 10-222V2, T.O. 35E9-274-1/-4, Field Experience
Install/Operate BEAR A/C Unit	3E1X1	2	1 Hr	A/C Unit, FEL, Forklift	AFH 10-222V12, T.O. 35E9-163-11, T.O. 35E9-314-1, Field Experience
Setup/Operate ROWPU	3E4X1, 3E2X1, 3E0X1	5	4 Hrs	ROWPU, Tanks, Pumps, Hoses, FEL/Fork Lift	AFH 10-222V9, T.O. 40W4-13-41 Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Provide Power to ROWPU	3E0X1, 3E0X2	2	30 Min	Cable, Connectors	AFH 10-222V9, T.O. 40W4-13-41 Field Experience
Setup Onion Tank	3E4X1, 3E4X2, 3E4X3	4	1 Hr	Onion Tank	AFH 10-222V9, T.O. 40W4-13-41 Field Experience
Setup/Operate Water Plant for 550-Person Base	3E4X1, 3E4X3, 3E0X1	6	18 Hrs	ROWPUs, Tanks, Hoses, Pumps, FEL/Fork Lift	AFH 10-222V9, T.O. 40W4-13-41 Field Experience
Perform Water Test Using M272 Water Test Kit	3E4X1	1	Go/No Go	M272 Test Kit	AFH 10-222V9, Field Experience
Setup/Operate Water Distribution System for 550-Person Base	3E4X1, 3E4X2, 3E4X3	6	60 Hrs	Water Distribution System	AFH 10-222V5, T.O. 40W4-13-41 Field Experience
Construct Expedient Grease Trap	3E4X1, 3E4X3	2	Go/No Go	Barrel, #10 Cans, Piping	AFH 10-222V1, AFH 10-222V4
Construct Sanitary Landfill	3E2X1	2	4 Hrs	Dozer, Excavator (Lumber)	AFH 10-222V1, AFH 10-222V4
Setup BEAR Field Latrine	3E3X1, 3E4X1, 3E4X3	2	1 Hr	BEAR Equipment	AFH 10-222V2, T.O. 35E35-5-1
Setup/Maintain BEAR Shower/Shave Unit	3E4X1, 3E1X1	4	6 Hrs	BEAR Shower/Shave Unit	AFH 10-222V2, T.O. 35E35-3-1, T.O. 35E35-4-1
Develop Pre-fire Plan for 550-Person Base	3E7X1	1	Go/No Go	Planning Kit	AFI 32-3001, AFPAM 10-219V3
Plan Dispersed Layout	32EX, 3E5X1	4	Go/No Go	Survey Kit, Stakes	AFPAM 10-219V5, Field Experience
Plan Nondispersed Layout	32EX, 3E5X1	4	Go/No Go	Survey Kit, Stakes	AFPAM 10-219V5, Field Experience
Site and Stake Out Water and Electrical Distribution Systems	32EX, 3E5X1	4	8 Hrs	Survey Kit, Stakes	AFPAM 10-219V5, TM 10-4230-345-23P, Field Experience
Layout 10 Temper Tents, Limiting Shadows, Wind and Solar radiation	3E5X1	2	Go/No Go	Survey Kit, Stakes	AFPAM 10-219V5, Field Experience
Prepare 550-Person Beddown Site for Temporary Infrastructure	3E2X1	1	15 Hrs	Grader Dozer, FEL	AFPAM 10-219V5, AFPAM 10-219V6, Field Experience
Clear Fire Breaks of Flammable Vegetation (4K SF)	3E2X1	1	1 Hr	Dozer	AFPAM 10-219V3, Field Experience
Remove Obstacle From Clear Zone	3E2X1	1	30 Min	Dozer, Excavator	Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Construct 100 Yd Drainage Channel	3E2X1	1	30 Min	Dozer, Grader	FM 5-34, Field Experience
Site and Clear Area For NAVAID	3E2X1,3E5X1	4	2 Hrs	Dozer, Grader, Survey Equipment	AFPAM 10-219V4, Field Experience
Prepare Expedient Storage Area For Explosives	3E2X1, 3E8X1	2	Go/No Go	Dozer, Grader	AFMAN 91-201, DOD 6055.9-STD, Field Experience
Setup/Operate BEAR Low-voltage Generators	3E0X1, 3E0X2	2	30 Min	BEAR Generator Set	AFH 10-222V12, Field Experience
Operate BEAR Low-voltage Generators	32EX, 3E5X1, 3E6X1	1	5 Min	BEAR Generator Set	AFH 10-222V12, Field Experience
Camouflage Foxhole	3EXXX	1	30 Min	Camouflage Netting	AFPAM 10-219V2, TM 5-1080-200-13&P, Field Experience
Erect Netting Over Vehicle	3EXXX	6	1 Hr	Camouflage Netting	AFPAM 10-219V2, TM 5-1080-200-13&P, Field Experience
Erect Netting Over 20K Gal Storage Bladder	3E2X1, 3E3X1, 3E9X1, 3E4XX	12	1 Hr	Camouflage Netting	AFPAM 10-219V2, TM 5-1080-200-13&P, Field Experience
Expedient Methods – Construction					
Construct Earth Berms For 10K Gal Fuel Bladder	3E2X1	1	4 Hrs	Dozer, FEL, Bladder	AFH 10-222V14, Field Experience
Construct Earth Berm For 30’ X 30’ Munitions Pad	3E2X1	2	4 Hrs	Backhoe Dozer, FEL, Dump Truck	AFH 10-222V14, Field Experience
Construct Oxidation Lagoon (11K SF)	3E2X1, 3E4X1	3	24 Hrs	Backhoe, Dozer, FEL, Dump Truck	AFPAM 10-219V5, Field Experience
Build Evaporation Lagoon (33K SF)	3E2X1, 3E4X1	3	24 Hrs	Backhoe Dozer, FEL, Dump Truck	AFPAM 10-219V5, Field Experience
Construct Straddle Trench Latrine (10’ X 2’)	3E2X1, 3E4X3	3	2 Hrs	Shovels/Backhoe	AFH 10-222V4, Field Experience
Construct Ventilated Improved Pit Latrine	3E3X1, 3E4X3	4	8 Hrs	Plywood, Screening, Lumber, Shovels, Backhoe	AFH 10-222V4, Field Experience
Construct Urine Soakage Pit	3E4X1, 3E4X3	2	2 Hrs	Shovels, Backhoe, Gravel	AFH 10-222V4, Field Experience
Pump Out Septic Tank	3E4X1	1	2 Hrs	Waste Water Disposal Vehicle	MIL-HDBK-1138, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Construct Expedient 20' Timber Bridge	32EX, 3E2X1, 3E3X1	7	12 Hrs	FEL, Dump Truck, Grader, Timber, Power Saws	AFJMAN 32-1088, FM 5-34, Field Experience
Design and Construct Expedient Culvert	32EX, 3E2X1, 3E3X1	4	4 Hrs	Matting, FEL, Backhoe, Fill Material	AFPAM 10-219V2, FM 5-34, Field Experience
Design and Construct ¼ Mile, Two Lane Soil Cement Road	32EX, 3E2X1	6	10 Hrs	Grader, Dump Trucks, Tractor Mounted Tiller, FEL, Cement Spreader, Water Distributor, Cement, Water	FM 5-34, Field Experience
Construct ¼ Mile Asphalt Road	3E2X1	8	24 Hrs	Asphalt Distributor, Asphalt, Paver, Roller, Grader, Dump Trucks, Handtools	FM 5-34, Field Experience
Expedient Methods – Repair					
Identify Surface UXO Features	3E5X1, 3E8X1	3	30 Min	HMMWV, Binoculars	T.O. 60A-1-1-2, Field Experience
Identify Crater and Runway UXO Coordinates	3E5X1, 3E8X1	3	30 Min	HMMWV, Grid Map	AFPAM 10-219V4, Field Experience
Correctly Identify Bombs, Mines, Rockets, and IEDs to the Unit Control Center	3EXXX	1	Go/No Go	UXO Report Forms and Comm System	AFVA 32-4022
Properly Mark 100' X 100' UXO Area	3EXXX	2	Go/No Go	Paint, String, Marker Signs	TM 3-9905-001-10
Locate 5 UXOs on Runway	3E8X1, 3E5X1	4	15 Min	HMMWV	AFPAM 10-219V4
Locate Subsurface UXO (Camouflet)	3E8X1	4	30 Min	HMMWV	AFPAM 10-219V4
Safe UXO Located on MOS	3E8X1	2	30 Min	Special/General Purpose Tool Kits	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Use Field Rigging and Hoisting to Remove 500lb GP Bomb	3E8X1, 3E2X1	4	1 Hr	Rope, Block and Tackle, Dump Truck, FEL	T.O. 60A-1-1-5, Field Experience
Setup/Operate Concrete Saw	3E2X1, 3E3X1	2	30 Min	Concrete Saw	UFC 3-270-04, AFJMAN 32-1040, Users Manual, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Repair Two Craters	32EX, 3E1X1, 3E2X1, 3E3X1 3E4X1, 3E4X3 3E5X1	18	2 Hrs, 30 Min	Crater Repair Set and Specialized Vehicles	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair Three Craters With 100 Spalls	3EXXX		3 Hrs, 30 Min	Crater Repair Set and Specialized Vehicles	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair Six Craters With 200 Spalls	3EXXX		3 Hrs, 30 Min	Crater Repair Set and Specialized Vehicles	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair 12 Craters With 400 Spalls	3EXXX		3 Hrs, 30 Min	Crater Repair Set and Specialized Vehicles	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Sweep and Clean MAOS	3E2X1, 3E4X1 3E4X3, 3E6X1	7	2 Hrs, 15 Min	Vacuum Sweepers, Kick Brooms, Graders	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Stripe 5,000' MOS	3E3X1	2	1 Hr	Paint Machine, Tow Vehicle, Runway Paint	AFH 10-222V16, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Perform Maintenance on Crater to Include Cover Removal, Fill Maintenance and Cover Installation	3E2X1	10	30 Min	FEL, Vibratory Roller, Dump Truck, Grader, Power Tools, Compressor	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7, T.O 36C35-7-1, Field Experience
Install/Operate EALS (50'x5000' MOS)	3E0X1, 3E0X2	6	2 Hrs, 30 Min	EALS, Tow Vehicle	AFH 10-222V7, T.O. 35F5-3-17-1/-4, Field Experience
Rapid MAAS Unidirectional Soil Installation	3E2X1, 3E0X2	6	2 Hrs	MAAS, Tools, Equipment	AFH 10-222V2, AFH 10-222V8,T.O. 35E8-2-10-1/-4, Field Experience
Recycle MAAS	3E0X2, 3E7X1	3	5 Min	MAAS, Tools, Equipment	AFH 10-222V8,T.O. 35E8-2-10-1/-4, Field Experience
Install Lightweight Fairlead Beam (LWFB)	3E0X2, 3E5X1	7	2 Hrs	Lightweight Fairlead Beam	AFH 10-222V8, T.O. 35E8-2-11-2, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Install Mobile Runway Edge Sheave (MRES)	3E0X2, 3E5X1	7	2 Hrs	Mobile Runway Edge Sheave	AFH 10-222V8, Field Experience
Assemble AM-2 Patch (54' X 77'6")	3E1X1, 3E2X1, 3E3X1, 3E4X1	10	45 Min	AM-2 Matting Patch Kit, F/L, FEL, Tools, Generator.	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Install AM-2 FOD Cover	3E2X1, 3E3X1, 3E4X1, 3E1X1	10	45 Min	AM-2 Matting Patch Kit, F/L, FEL, Tools, Generator	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair Damaged FOD Cover (10 Mats)	3E2X1, 3E3X1	4	2 Hrs	AM-2 Matting Patch Kit, F/L, FEL, Tools, Generator	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Install Folded Fiberglass Mat (54' X 60')	3E2X1, 3E5X1, 3E3X1, 3E4X3	7	30 Min	FFM Patch Kit, F/L, FEL, Tools, Generator	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair Single Crater Using Crushed Stone and AM-2 Matting	3E1X1, 3E2X1, 3E3X1, 3E4X1	20	1 Hr, 45 Min	AM-2 Matting Patch Kit, F/L, FEL, Dump Truck, Tools, Generator	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair Single Crater Using Crushed Stone and Folded Fiberglass Mat	3E2X1, 3E3X1, 3E5X1	16	1 Hr, 45 Min	FFM Patch Kit, F/L, FEL, Tools, Generator	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-2-7, T.O. 35E2-3-1 T.O. 35E2-5-1, Field Experience
Repair 12 Spalls w/Polymer Concrete	3E1X1, 3E2X1	4	18 Min	Polymer Material, Truck, Drill, Mixing bit, Concrete Finishing tools, Wheel barrow	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Repair 12 Spalls w/Quick Set Concrete	3E1X1, 3E2X1	4	18 Min	Quick Set Material, Truck, Drill, Mixing bit, Concrete Finishing tools, Wheel barrow	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience
Select MOS Surface Including 50' X 5000' and Taxi Routes	32EX, 3E5X1, 3E6X1	4	30 Min	MOS Templates, Grid Maps	AFPAM 10-219V4, UFC 3-270-07 T.O. 35E2-3-1, T.O. 35E2-2-7 Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Layout 50' X 5000' MOS	3E3X1, 3E5X1	4	1 Hr	Surveyor's Kit, Cones	UFC 3-270-07, AFH 10-222V16, T.O. 35E2-3-1, T.O. 35E2-2-7 T.O. 35E2-6-1, Field Experience
Layout Minimum Airfield Operating Surface Marking System (MAOSMS)	3E5X1, 3E1X1, 3E3X1		1 Hr	MAOSMS Kit	T.O. 35E2-6-1, AFI 32-1042, AFH 10-222V16
Layout 4000' Taxi Routes	3E3X1, 3E5X1	4	30 Min	Surveyor's Kit, Cones	UFC 3-270-07, AFH 10-222V16, T.O. 35E2-3-1, T.O. 35E2-2-7 T.O. 35E2-6-1, Field Experience
Conduct RQC Calculations	32EX, 3E5X1, 3E6X1	2	30 Min	Surveyor's Kit, Cones	AFPAM 10-219V4, T.O. 35E2-4-1
Conduct Line-of-Sight Crater Evaluation	3E2X1, 3E3X1, 3E5X1	3	Go/No Go	Stanchion Kit	AFPAM 10-219V4, T.O. 35E2-4-1
Accurately Assess/Report Facility/Utility Damages	32EX, 3E0X1, 3E1X1, 3E3X1, 3E4X1, 3E4X2	12	1 Hr	Vehicles, Radios, Maps	AFPAM 10-219V3, Field Experience
Provide Damage Report Estimates	32EX, 3E0X1, 3E1X1, 3E3X1, 3E4X1, 3E4X2	12	3 Hrs	Vehicles, Radios, Maps	AFPAM 10-219V3, Field Experience
Identify Isolation Points For Critically Damaged Utilities	3E0XX, 3E1X1, 3E4XX	1	10 Min	Vehicles, Radios, Maps	AFPAM 10-219V3, Field Experience
Initiate Damage Reporting	3E2X	1	3 Hrs	Vehicles, Radios, Maps	AFPAM 10-219V3, Field Experience
Isolate Critically Damaged Utilities	3E0X1, 3E1X1, 3E4X1, 3E4X2	2	15 Min	Utility Maps, Tools	AFPAM 10-219V3, Field Experience
Install In-Line High Voltage Primary Splice	3E0X1, 3E0X2	2	4 Hrs	Splice Kit, Protective Gear	AFPAM 10-219V3, Field Experience
Install High-Voltage Termination Kit	3E0X1, 3E0X2	2	4 Hrs	Termination Kit, Protective Gear	AFPAM 10-219V3, Field Experience
Climb and Descend 20 feet on Wooden Utility Pole Using Gaffs	3E0X1	1	1 min	Climbing Gear, Wooden Pole	AFPAM 10-219V3, Field Experience
Install Grounding Set on Overhead Electrical Lines	3E0X1	2	5 min	Grounding Set, Grip-All Stick	AFPAM 10-219V3, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Repair High-Voltage Overhead Primary Feeder Cable	3E0X1, 3E0X2	3	2 Hrs	Protective Gear, Cable, Come-Along, Line Truck	AFPAM 10-219V3, Field Experience
Install and Operate Emergency Generator	3E0X1, 3E0X2	2	2 Hrs	Generator, Cable, Tow Vehicle	AFPAM 10-219V3, Field Experience
Splice De-energized Airfield Lighting Cable	3E0X1, 3E0X2	1	30 Min	Airfield Cable Splice Kit	AFPAM 10-219V3, Field Experience
Replace Runway Edge Light and Isolation Transformer	3E0X1, 3E0X2	1	1 Hr	Light Fixture, Isolation Transformer	AFPAM 10-219V3, Field Experience
Bypass Damaged Airfield Lighting Control Cable	3E0X1, 3E0X2	2	2 Hrs	Control Cable	AFPAM 10-219V3, Field Experience
Replace Constant Current Regulator in Airfield Lighting Vault	3E0X1, 3E0X2	2	2 Hrs	Regulator Cable	AFPAM 10-219V3, Field Experience
Repair 6” Main Water Distribution Line	3E4X1, 3E4X2	3	2 Hrs	Pipe, Clamps, Backhoe	AFPAM 10-219V3, Field Experience
Isolate Broken 6” Main Water Line	3E4X1, 3E4X2	3	2 Hrs	Backhoe, Pump, Tools	AFPAM 10-219V3, Field Experience
Join 4” Feeder Pipe to Main POL Line	3E4X1, 3E4X2	2	2 Hrs	Tap Kit, Nonsparking Tools, Backhoe, Pumps	AFPAM 10-219V3, Field Experience
Join 6” Feeder to Main POL Line	3E4X1, 3E4X2	2	1 Hr	Tap Kit, Nonsparking Tools, Backhoe, Pumps	AFPAM 10-219V3, Field Experience
Repair 6” Sewage Pipe	3E4X1, 3E4X2	3	2 Hrs	Backhoe, Pump, Tools	AFPAM 10-219V3, Field Experience
Replace Sewage Lift Pump	3E4X1, 3E4X2	2	2 Hrs	Pump	AFPAM 10-219V3, Field Experience
Replace Pole-mounted Transformer	3E0X1, 3E0X2	3	3 Hrs	Line Truck, Protective Gear, Transformer	AFPAM 10-219V3, Field Experience
Replace Low-Voltage Service Entrance Cable	3E0X1, 3E0X2	2	2 Hrs	Cable	AFPAM 10-219V3, Field Experience
Isolate Substation Circuit	3E0X1	1	15 Min	All Protective Gear	AFPAM 10-219V3, Field Experience
Replace Base Alert Siren	3E0X1, 3E0X2	2	2 Hrs	Siren, Line Truck	AFPAM 10-219V3, Field Experience
Install Emergency Light	3E0X1, 3E0X2	2	1 Hr	Light Fixture	AFPAM 10-219V3, Field Experience
Isolate Damaged Hot Water/Steam Pipe	3E1X1, 3E4X1	2	1 Hr	Piping, Clamps	AFPAM 10-219V3, Field Experience
Repair 8” Heating Line	3E1X1, 3E4X1	3	2 Hrs		AFPAM 10-219V3, Field Experience
Isolate Damaged Chilled Water Line	3E1X1, 3E4X1	2	45 Min		AFPAM 10-219V3, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Patch 40 SF Hole in Roof	3E3X1	2	1 Hr	Plywood, Felt, Cold Patch	AFPAM 10-219V3, Field Experience
Patch 40 SF Hole in Building Exterior	3E3X1	2	1 Hr	Plywood, Lumber	AFPAM 10-219V3, Field Experience
Replace Damaged Exterior Personnel Door	3E3X1	2	2 Hrs	Exterior Door, Hardware	AFPAM 10-219V3, Field Experience
Replace Window Pane	3E3X1	1	1 Hr	Tools, Glass, Supplies	AFPAM 10-219V3, Field Experience
Replace 60' of Damaged Electrical Feeder Cable	3E0X1, 3E0X2	2	1 Hr	Cable	AFPAM 10-219V3, Field Experience
Repair Water Line (10' of 2" Pipe)	3E4X1, 3E4X2	2	2 Hrs	Pipe, Clamps	AFPAM 10-219V3, Field Experience
Replace 10 LF of Fencing	3E2X1, 3E3X1	2	1 Hr	Wire, Fencing Fabric	AFPAM 10-219V3, Field Experience
Replace Entry Gate Rollers	3E2X1, 3E3X1	2	2 Hrs	Rollers	AFPAM 10-219V3, Field Experience
Buttress 150 SF Hole in Masonry Wall	3E3X1	3	7 Hrs	Sandbags, Sand	AFPAM 10-219V3, Field Experience
Fabricate/Install 20 LF of Temporary Ductwork	3E1X1, 3E3X1	2	4 Hrs	Accordion Ducting/Duct Board	AFPAM 10-219V3, Field Experience
Install Mobile Heating Unit	3E1X1	2	1 Hr	Mobile Heating Unit	AFPAM 10-219V3, Field Experience
Install Mobile Air Conditioner	3E1X1	2	1 Hr	Portable Air Conditioner	AFPAM 10-219V3, Field Experience
Setup/Operate Precision Lightweight GPS Receiver (PLGR)	3E5X1, 3E6X1, 3E7X1, 3E8X1, 3E9X1	1	Go/No Go	PLGR, Topographical Map	T.O. 31R4-2PSN11-1, T.O. 31R4-2PSN11-31
Setup/Operate Defense Advanced GPS Receiver (DAGR)	3E5X1, 3E6X1, 3E7X1, 3E8X1, 3E9X1	1	Go/No Go	DAGR, Topographical Map	T.O. 31R42PSN13-1, T.O. 31R4-2PSN13-8-1
Explosive Ordnance					
Determine UXO Hazard Distances	3E8X1	1	15 Min		T.O. 60A-1-1-4, Field Experience
Construct Protective Measures	3E8X1	2	1 Hr	Sandbags, Fill Material	FM 21-16, Field Experience
Operate Radiac Instruments	3E8X1	1	15 Min	Radiac Instruments	TM 11-6665-365-12&P, Field Experience
Perform Render Safe Procedures on Nuclear Weapon (Simulation)	3E8X1	4	2 Hrs	Training Weapon or Mockup	T.O. 60N-60-6, Field Experience
Package Nuclear Weapon or Components For Disposal	3E8X1	2	1 Hr	Nuclear Packaging Kit	T.O 60N Series, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Execute Standoff Munitions Disruption Techniques	3E8X1	2	2 Hrs	.50-Cal/7.62 Rifle	T.O. 60A-2-1-59, Field Experience
Demonstrate Thermal (Nonexplosive) Techniques	3E8X1	2	1 Hr, 30 Min	Thermite Grenades	T.O. 60A-1-1-41, Field Experience
Demonstrate Shape Charges, Other Explosive Techniques	3E8X1	2	1 Hr	Shaped Charges	T.O. 60A-2-1-51, Field Experience
Immobilize Fuses	3E8X1	2	1 Hr	Demo Range, Mockups, Explosives, Tool Kits	T.O. 60A-2-1-60, Field Experience
Remove Fuses	3E8X1	2	1 Hr	Demo Range, Mockups, Explosives, Tool Kits	T.O. 60A-2-1-1, T.O. 60A-2-1-4, Field Experience
Disable Electrical Components	3E8X1	2	1 Hr	Demo Range, Mockups, Explosives, Tool Kits	T.O. 60A-2-1-3, T.O. 60A-2-1-3-2, T.O. 60A-2-1-20, Field Experience
Disrupt Firing Trains	3E8X1	2	1 Hr	Demo Range, Mockups, Explosives, Tool Kits	T.O. 60A-2-1-3, T.O. 60A-2-1-3-2, T.O. 60A-2-1-20, Field Experience
Use Shape Charges and Other Explosive Techniques	3E8X1	2	1 Hr	Demo Range, Mockups, Explosives, Tool Kits	AFPAM 10-219V3, Field Experience
Fire Protection					
Perform Aircrew Extraction From Wide Body Aircraft	3E7X1	3	12 Min	P-10	AFPAM 10-219V3, Field Experience
Perform Aircrew Extraction From Tactical Aircraft	3E7X1	2	15 Min	P-10	AFPAM 10-219V3, Field Experience
Suppress Wide Body Aircraft Fire	3E7X1	14	5 Min	Fire Training Area; P-15, P-23 (2 ea), P-20 (2 ea) or P-23 (4 ea), P-20 (2 ea)	AFPAM 10-219V3, Field Experience
Suppress Tactical Aircraft Fire	3E7X1	10	3 Min	Fire Training Area, P-19 (3 ea), P-20	AFPAM 10-219V3, Field Experience
Demonstrate Capability To Suppress a Structural Fire	3E7X1	7	20 Min	P-8, P-12, P-18, P-19, P-22	AFPAM 10-219V3, Field Experience
Demonstrate Capability To Suppress a Vehicle Fire	3E7X1	7	5 Min	P-8, P-12, P-18, P-19, P-20, P-22, P-24	AFPAM 10-219V3, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	**AFS**	**CREW SIZE**	**STANDARD**	**MATERIAL/ EQUIPMENT**	**REFERENCE(S)**
Demonstrate Capability To Suppress a Tent City Fire	3E7X1	7	5 Min	P-8, P-12, P-18, P-19, P-22, P-24	AFPAM 10-219V3, Field Experience
Demonstrate Capability To Rescue Individual From Fire Environment	3E7X1	2	2 Min	P-10, P-28	AFPAM 10-219V3, Field Experience
Demonstrate Capability To Rescue Three Individuals From Fire Environment	3E7X1	2	8 Min	P-10, P-28	AFPAM 10-219V3, Field Experience
Demonstrate Capability To Rescue Individual From Wrecked Vehicle	3E7X1	2	30 Min	P-10 and Jaws of Life	AFPAM 10-219V3, Field Experience
Demonstrate Capability to Suppress Bulk Fuel Storage Fire	3E7X1	10	20 Min	P-18, P-19, P-22, P-24	AFPAM 10-219V3, Field Experience
Expedient Methods - Destruction					
Demolish 1K SF Structure	3E0X1, 3E1X1, 3E2X1, 3E3X1, 3E4X3, 2S0X1	4	8 Hrs	Dozer, FEL, Dump Truck	AFPAM 10-219V3, Field Experience
Cut 12” I-Beam with Torch	3E2X1, 3E3X1	1	30 Min	Cutting Torch	AFPAM 10-219V3, Field Experience
Load 20 CY of Material on Dump Truck	3E1X1, 3E2X1, 3E3X1, 3E4X3	2	2 Hrs	FEL, Dump Truck	AFPAM 10-219V3, Field Experience
Load Damaged 10K Gal Fuel Tank on Truck	3E2X1, 3E3X1	3	2 Hrs	Crane, Lowboy	AFPAM 10-219V3, Field Experience
Cut 200 LF of Damaged Concrete Pavement	3E2X1, 3E3X1	2	2 Hrs	Concrete Saw, Water Truck	AFPAM 10-219V3, Field Experience
Clean 20K SF Area with Sweeper	3E2X1, 3E4X3, 3E6X1	1	30 Min	Towed Sweeper/Kick Broom	AFPAM 10-219V3, Field Experience
Demolish 30 Yds of Road	3E2X1, 3E3X1	4	4 Hrs	Dozer, FEL, Dump Trucks, Jack Hammer, Compressor	AFPAM 10-219V3, Field Experience
Base Defense					
Construct Hasty One-Man Fighting Position	3EXXX	1	1 Hr	Shovel, Natural Cover	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Construct Deliberate Two-Man Fighting Position	3EXXX	2	4 Hrs	Shovels, Local Materials	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Construct 20 Yds Indirect Fire Position	3E2X1	1	15 Min	Dozer	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Construct Sandbag Personnel Revetment	3EXXX	2	8 Hrs	250 Sandbags, Fill Material	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Construct Sandbag Equipment/Vehicle Revetment	3EXXX	12	24 Hrs	5,000 Sandbags, Fill Material	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Construct Bitburg Revetment	3E3X1	3	8 Hrs	Concrete, Re-bar, Lumber, Cement Mixer	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Position Bitburg Revetment	3E2X1	1	15 Min	FEL w/Atch, Bitburg Revetment	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Site 252 LF of B-1 Revetment	3E5X1	1	5 Hrs	Tape Measure, Survey Equipment/Kit	AFPAM 10-219V5, AFH 10-222V3, AFPAM 10-219V2, AFH 10-222V14, Field Experience
Erect Portion of B-1 Revetment	3E2X1, 3E3X1	8	1 Hrs	B-1 Revetment Kit, FEL, Dump Truck, Fill Material, Plastic Sheeting	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, T.O. 35E4-170-2, Field Experience
Erect Full B-1 Revetment	3E2X1, 3E3X1	20	16 Hrs	B-1 Revetment Kit, FEL w/Atch, Dump Truck, Crane, Fill Material, Plastic Sheeting	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, T.O. 35E4-170-2, Field Experience
Construct 100 Linear Yds of 5' High Earth Revetment	3E2X1	2	10 Hrs	Dozer, FEL, Dump Trucks, Asphalt, Soil, Plastic Sheeting	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Install Log Crib Obstacle (16'L x 4"H)	3E3X1	4	6 Hrs	Logs, Tools, Supplies	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Install Concrete Tumble Block (3 ea)	3E2X1, 3E3X1	2	30 Min	FEL w/Atch, Concrete Tumble Blocks	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Install Steel "H" Beam (4'H)	3E2X1, 3E3X1	3	1 Hr	Beam, FEL w/Atch, Concrete	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Install 100 Yds of Tangle Foot Wire	3E2X1, 3E3X1	3	4 Hrs	Barbed Wire, Stakes, Tools, Protective Gear	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience

TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
TASK	AFS	CREW SIZE	STANDARD	MATERIAL/ EQUIPMENT	REFERENCE(S)
Install 100 Yds of Concertina Wire	3E2X1, 3E3X1	3	2 Hrs	Concertina Wire, Stakes, Wire Cutters, Protective Gear	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Install 100 Yds of Barbed Wire	3E2X1, 3E3X1	3	4 Hrs	Barbed Wire, Stakes, Tools, Wire Cutters, Protective Gear	AFPAM 10-219V2, AFH 10-222V3, AFH 10-222V14, Field Experience
Install 100 Yds of Razor Wire	3E2X1, 3E3X1	3	4 Hrs	Barbed Tape, Wire Cutters, Protective Gear	AFPAM 10-219V2, AFH 10-22V3, AFH 10-222V14, Field Experience
Deployment Support					
Exercise Alerting Procedures	3EXXX	Any	30 Min	Communications System, Key Personnel Recall Roster	AFPAM 10-219V2, Field Experience
Implement Recall Procedures	3EXXX	Any	15 Min	Communications System, Recall Roster	AFPAM 10-219V2, Field Experience
Perform Personnel Processing	3EXXX	Any	18 Hrs	Processing Line	AFPAM 10-219V2, Field Experience
Complete Deployment Processing	3EXXX	Any	24 Hrs	Processing Line, Palletized Equipment	AFPAM 10-219V2, Field Experience
Exercise Mobility Recall	3EXXX	Any	1 Hr	Communications System, Key Personnel Recall Roster	AFPAM 10-219V2, Field Experience
Complete Mobilization Recall	3EXXX	Any	28 Hrs	Processing Line, Palletized Equipment	AFPAM 10-219V2, Field Experience

Attachment 7

CIVIL ENGINEER QUICK REFERENCE SHEETS

A7.1. Introduction. This attachment provides civil engineers with bare base planning information and examples in a quick reference format. **Table A7.1** lists each of the quick references in this attachment.

ENGINEER QUICK REFERENCE PLANNING SHEETS

Table A7.1. Listing of Quick References

Equipment	
Table A7.1.1.	BEAR Equipment UTCs.
Facility Planning and Layout	
Table A7.1.2.	Facility Group Dispersed Distances
Figure A7.1.1.	Facility Layout Example (1100-Person)
Table A7.1.3.	Typical Bare Base Facility Allocations
Table A7.1.4.	Standoff Distances and Separation for Expeditionary and Temporary Structures
Figure A7.1.2.	Separation Distances for Expeditionary and Temporary Structures
Construction Planning and Development	
Table A7.1.5.	Base Erection Schedule
Table A7.1.6.	Typical Bare Base Development Priorities
Table A7.1.7.	Design and Construction Matrix for Hardening Methods
Figure A7.1.3.	Common Examples of Siting Revetments
Figure A7.1.4.	Protecting a Building with Concrete Modular Revetments
Figure A7.1.5.	Typical Burn Pit Layout Surrounded by a Soil Berm
Figure A7.1.6.	Road Design Cross Section
Figure A7.1.7.	Construction Diagram of Base Defense Berms and Ditches
Table A7.1.8.	Construction Man-Hour Comparisons for Revetments
Table A7.1.9.	Construction Estimates for Clearing Operations
Table A7.1.10.	Estimated Vehicle Turning Radius for Road/Intersection Construction
Figure A7.1.8.	Turning Diagram for 48-Foot Semi-Trailer
Figure A7.1.9.	Turning Diagram for 45-Foot Passenger Bus
Airfield Planning and Layout	
Table A7.1.11.	Rotary-Wing Aircraft Dimensions, Separation, and Taxiway Widths
Table A7.1.12.	Fixed-Wing Aircraft Dimensions

Table A7.2. BEAR Equipment UTCs

Air UTC	ASSET	Surface UTC
XFA14	Combat Air Forces Initial (8 Med/8 Small Shelters)	XFS14
XFA16	Low Voltage Industrial (2 MEP-806's)	XFS16
XFA17	Water Distribution Initial	XFS17
XFA18	Water Distribution Follow-On	XFS18
XFA19	Engineering Management (2 Small Shelters)	XFS19
XFA21	Power Pro/CE Sup/Elect (3 Small Shelters)	XFS21
XFA23	TF-2 Lightcart (2 TF-2's)	XFS23
XFA3C	Mobility Air Forces Initial (6 Med/8 Small Shelters)	XFS3C
XFAAB	4K Dome (1 Shelter)	XFSAB
XFAAC	Field-Deployable Environmental Control Unit (FDECU), 12 Ea.	XFSAC
XFAAD	8K Dome (1 Shelter)	XFSAD
XFAAM	AM2 Matting (6 Bundles)	XFSAM
XFABL	Billeting (12 Small Shelters)	XFSBL
XFAC6	CAF Add-On (2 Medium/1 Small Shelter)	XFSC6
XFACB	CAF Follow-On (4 Small Shelters)	XFSCB
XFACC	Tactical Exchange (1 Small Shelter)	XFSCC
XFACD	Entomology (No Facility)	XFSCD
XFACF	Fire Ops/Crash Rescue (4 Small Shelters)	XFSCF
XFACH	Advanced Design Refrigerator, 300 CF (ADR-300), 1	XFSCH
XFACJ	Large Area Maintenance Shelter (LAMS) 1 Ea.	XFSCJ
XFACL	Barrier Facility (1 Medium Shelter)	XFSCL
XFACW	Cold Weather (12 Heaters)	XFSCW
XFACX	CE Maintenance (1 Small Shelter)	XFSCX
XFAEC	CE Industrial (1 Small Shelter)	XFSEC
XFAEG	Power Distribution (2 Cable Reel Pallet Assembly)	XFSEG
XFAGC	Chaplain (1 Small Shelter)	XFSGC
XFAHL	High Line Dock (1 HLD)	XFSHL
XFAKC	Kitchen	XFSKC
XFALC	Shower/Shave/Latrine (2 Small Shelters)	XFSLC
XFALS	Self Help Laundry	XFSLS
XFAMP	Water Production, 1500-GPH Reverse Osmosis Water Purification Unit (ROWPU), 2 Ea.	XFSMP
XFAMS	Water Source Run	XFSMS
XFAMU	Munitions (1 Medium/1 Small Shelter)	XFSMU
XFAMX	Water Extension	XFSMX
XFANC	Camouflage Netting, 200 Ea.	XFSNC
XFAND	Water Production, 600-GPH ROWPU, 3 Ea.	XFSND
XFAPH	High Volt Power (2 MEP-12's; 2 10K Fuel Bladders; 1 Primary Switching Center; 1 Operating Remote Terminal	XFSPH
XFAPL	Low Voltage Housekeeping (5 MEP-806; 3 MEP-805's)	XFSPL
XFAPS	Postal (1 Medium Shelter; 1 FDECU)	XFSPs
XFAR4	Mobile Aircraft Arresting System (MAAS), 1 Ea.	XFSR4
XFARB	Packing/Crating (No Facility)	XFSRB
XFASC	Combat Supply (4 Small Shelter)	XFSSC
XFASD	Secondary Distribution Center (SDC's), 2 Ea.	XFSSD
XFATF	Single-Pallet Expeditionary Kitchen (SPEK) Messing	XFSTF
XFAVC	Vehicle Maintenance/Operations (1 Small Shelter)	XFSVC
XFAWC	Admin (4 Small Shelters)	XFSWC
XFAWR	Concertina Wire (480 Rolls)	XFSWR
XFAXN	Mortuary (1 Small Shelter)	XFSXN
XFAYC	Expeditionary Airfield Lighting System (EALS), 1 Ea.	XFSYC
XFAZC	Remote Area Lighting System (RALS), 2 Ea.	XFSZC
XFB1A	Swift BEAR	

Table A7.3. Facility Group Dispersed Distances

Dispersed Distances (feet) (Source : AFTTP 3-2.68 IP, Airfield Opening)									
Facility/Group	**Billeting**	**MX**	**Base Ops/ FES**	**Aerial Port**	**Munitions**	**LOX**	**POL**	**Transportation**	**Medical**
Billeting		1600	1600	1600	3160	1600	2640	900	200
MX	1600		1000	1600	3160	1600	2640	200	1600
Base Ops/FES	1600	1000		200	3160	1600	2640	1600	1600
Aerial Port	1600	1600	200		3160	1600	2640	1600	1600
Munitions	3160	3160	3160	3160		3160	1800	3160	3160
LOX	1600	1600	1600	1600	3160		2640	1600	1600
POL	2640	2640	2640	2640	1800	2640		2640	2640
Transportation	900	200	1600	1600	3160	1600	2640		200
Medical	200	1600	1600	1600	3160	1600	2640	200	

Figure A7.1. Facility Layout Example (1100-Person)

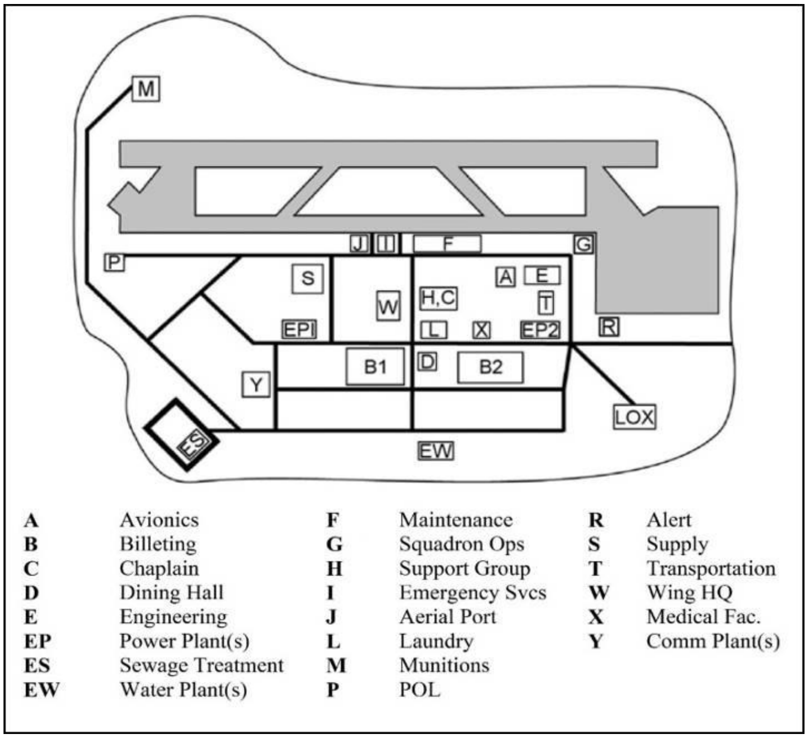


Table A7.4. Typical Bare Base Facility Allocations

Function	Type Facility Support
Aviation Operations	Small Shelters, Medium Shelters
Aviation Maintenance	Medium Shelters, Small Shelters, Dome Shelters, Aircraft Hangars
Aircraft Maintenance Additive	Aircraft Hangars
Munitions Maintenance	Medium Shelters, Small Shelters
ADR	Small Shelters, Aircraft Hangars, Medium Shelters
Supply	Small Shelters, Dome Shelters
Transportation	Small Shelters, Dome Shelters
Engineers	Small Shelters, Medium Shelters
Aviation Admin, Aviation Supply, Aviation Intelligence, Aviation Medical, Headquarters, Fuels, OSI, Intelligence Additive, Weather, Combat Camera, Medical, Postal, Security Police, Information Management, Personnel, Finance, Base Operations, Contracting, and MWRS	Small Shelters

Table A7.5. Standoff Distances and Separation for Expeditionary and Temporary Structures

Location	Structure Category	Standoff Distance or Separation Requirements			
		Applicable Level of Protection	Fabric Covered Structures (1)	Other Expeditionary and Temporary Structures(1)(2)	Applicable Explosive Weight (TNT) (3)
Controlled Perimeter or Parking and Roadways without a Controlled Perimeter	Billeting	Low	31 m (102 ft.)	71 m (233 ft.)	I
	Primary Gathering Structure	Low	31 m (102 ft.)	71 m (233 ft.)	I
	Inhabited Structure	Very Low	24 m (79 ft.)	47 m (154 ft.)	I
Parking and Roadways within a Controlled Perimeter	Billeting	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Primary Gathering Structure	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Inhabited Structure	Very Low	10 m (33 ft.)	23 m (75 ft.)	II
Trash Containers	Billeting	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Primary Gathering Structure	Low	14 m (46 ft.)	32 m (105 ft.)	II
	Inhabited Structure	Very Low	10 m (33 ft.)	23 m (75 ft.)	II
Structure Separation(4)	Separation between Structure Groups	Low	18 m (59 ft.)	18 m (59 ft.)	III(5)
	Separation between Structure Rows	Low	9 m (30 ft.)	9 m (30 ft.)	III(5)
	Separation between Structures in a Row	Very Low	3.5 m (12 ft.)	3.5 m (12 ft.)	III(5)

Notes:
(1) See UFC 4-010-01 for a complete definition of these structure types.
(2) For container structures, see UFC 4-010-01.
(3) See UFC 4-010-02, for the specific explosive weights (kg/pounds of TNT) associated with designations – I, II, III. UFC 4-010-02 is For Official Use Only (FOUO)
(4) Applies to Billeting and Primary Gathering Structures only. No minimum separation distances for other inhabited structures.
(5) Explosive for building separation is an indirect fire (mortar) round at a standoff distance of half the separation distance.

Source: UFC 4-010-01

Figure A7.2. Separation Distances for Expeditionary and Temporary Structures

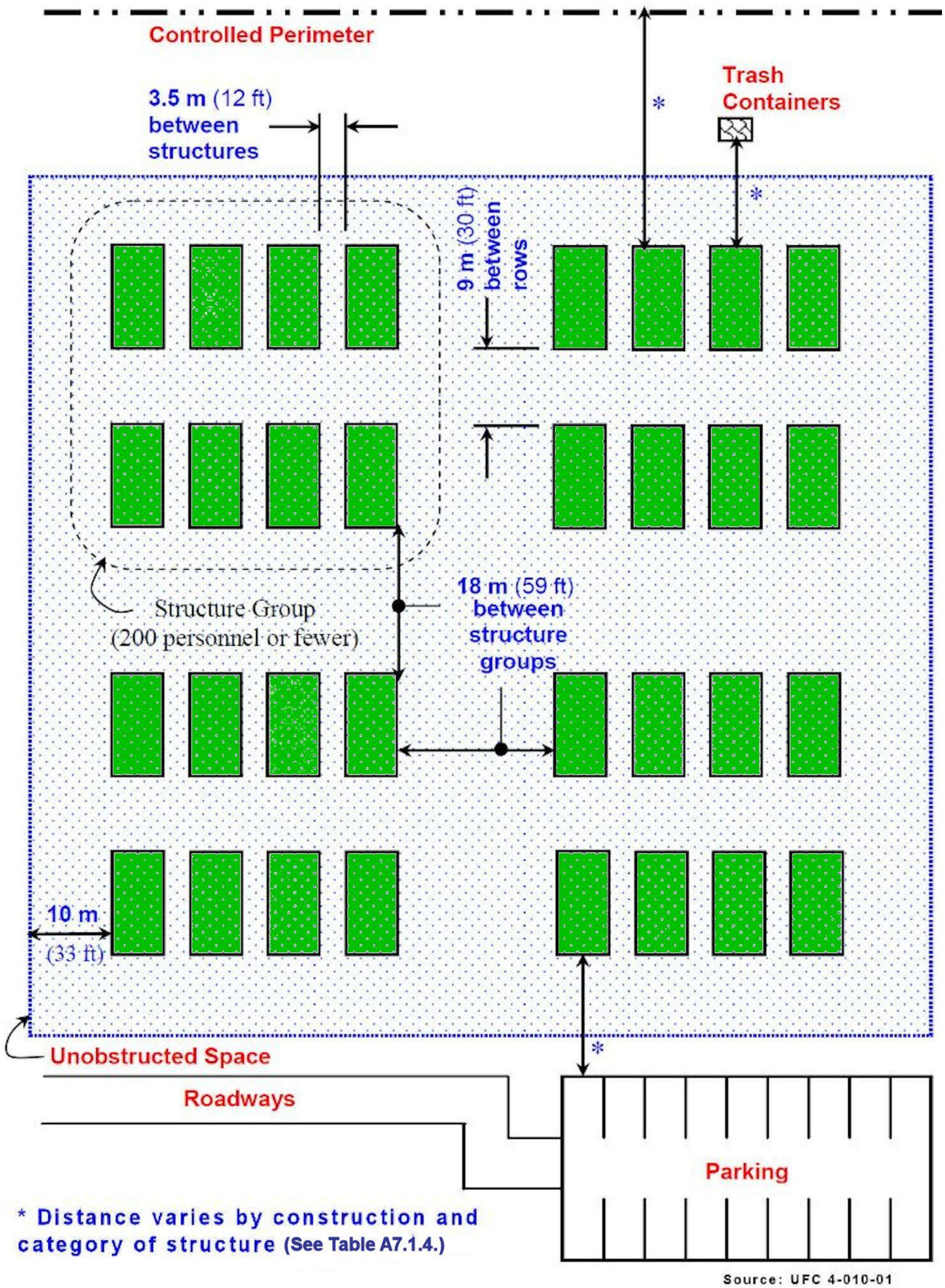


Table A7.6. Base Erection Schedule

Major Task	Time (D + X) Requirement	Definition
Site Survey	1 – 5 Days	Develop BEAR assets, locate NAVAIDS and lay out base.
Site Preparation	1 – 10 Days	Clear land, establish access to raw water, construct gravel roads, establish drainage and construct POL and munitions revetments.
Airfield Lighting	D + 2 Days	Set up Expeditionary Airfield Lighting System (EALS).
Barriers	D + 30 Days	Install and maintain aircraft barriers.
Utility Lines and Shelter Locations	D + 5 Days	Stake facility locations.
Electrical Distribution	D + 10 Days	Install high-voltage cables, connect PSC (or PDC) & SDC and provide electric power to shelters.
Power Production	D + 2 Days	Set up MEP-12 generators/Interim BEAR Power Unit.
Water Treatment and Distribution	D + 10 Days	Lay water lines; develop water and waste program.
Civil Engineer Shelters	4 Days	Erect CE shops, office and billets. Provide technical assistance to other functional areas.
Static Grounds	4 Days	Locate/establish static grounds.
Paint Striping	D + 2 Days	Mark taxiways and runways.

Table A7.7. Typical Bare Base Development Priorities

Priority	Task
1	Operational requirements
2	Utility systems and services
3	Transportation network
4	Essential support facilities
5	Other support facilities

Table A7.8. Design and Construction Matrix for Hardening Methods

METHOD	EQUIPMENT	LABOR	MATERIALS	SPACE (TYPICAL)
Soil Berm	Backhoe/Loader Hand Shovel[1] Truck/Trailer[5]	Unskilled[2,3]	Soil[4]	>6 ft
Sandbags	Hand Shovel Truck/Trailer[5]	Unskilled[3]	Soil/Gravel Bags or other expedient container[6]	1-4 ft
Sand Grids	Backhoe/Loader Hand/Shovel[1] Truck/Trailer[5]	Unskilled[2,3]	Soil/Gravel Grid Forms	~3 ft
Modular Concrete Revetments	Crane/Forklift	Unskilled Skilled[2]	Precast Modular Units Straps and bolts for connections Sandbags[7]	4-8 ft
Bin Revetments	Backhoe/Loader Hand Shovel[1] Crane/Forklift Truck/Trailer[5]	Unskilled Skilled[2]	Soil/Gravel/Rock Rubble Container Straps & bolts for connections Sandbags[7]	2-10 ft
Sacrificial Panels	Crane/Forklift	Unskilled Skilled[2] Engineering[8]	Varies[9] Hardware for connections	<1 ft

[1] Hand construction/shovel filling possible if heavy equipment unavailable.
[2] Skilled labor required for operation of heavy equipment.
[3] Engineering required for determination of allowable loads when placed overhead or against non-hardened walls (berms only).
[4] Requires facing to control erosion and blowing dust problems.
[5] For transport of fill material if not available at site.
[6] Acrylic fabric bags recommended for durability.
[7] Sandbags should be used to protect corners of revetment array.
[8] Engineering design required for thickness of panel, sizing of air space, and design of structural attachment.
[9] A variety of materials may be used, from plywood to asphalt to concrete to modern composites.

Figure A7.3. Common Examples of Siting Revetments

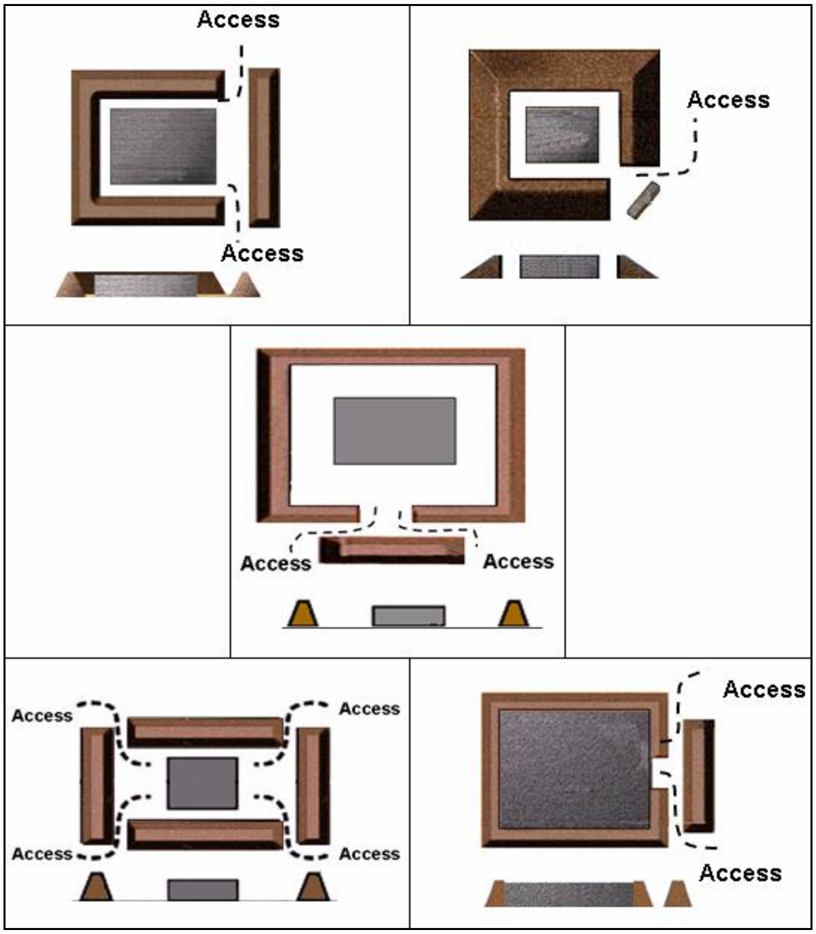


Figure A7.4. Protecting a Building with Concrete Modular Revetments

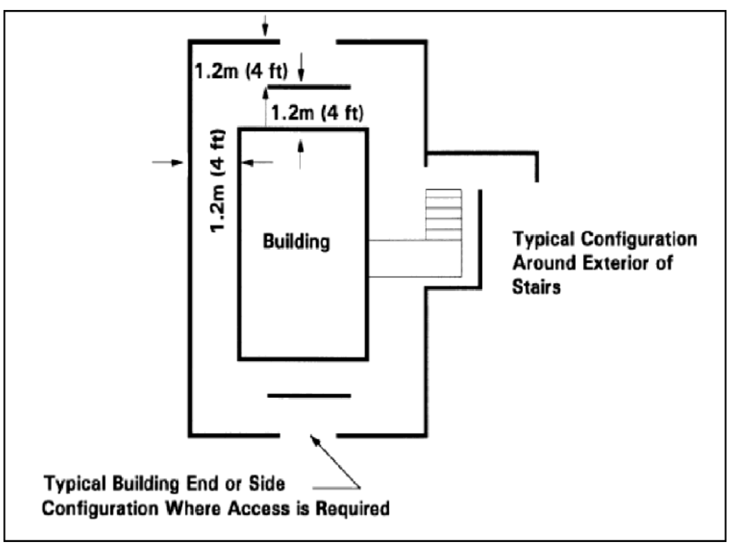


Figure A7.5. Typical Burn Pit Layout Surrounded by a Soil Berm

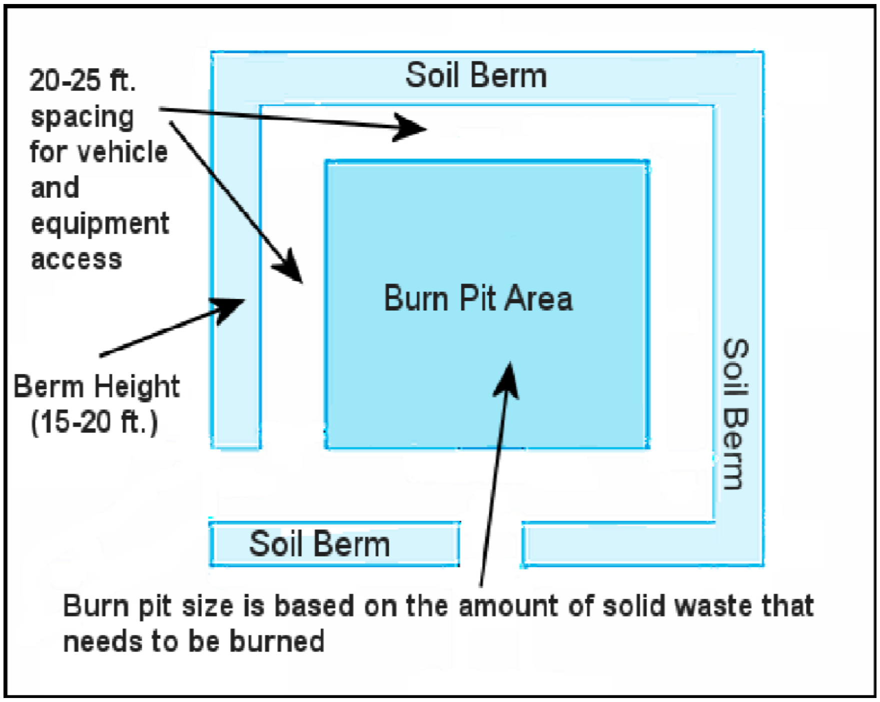


Figure A7.6. Road Design Cross Section

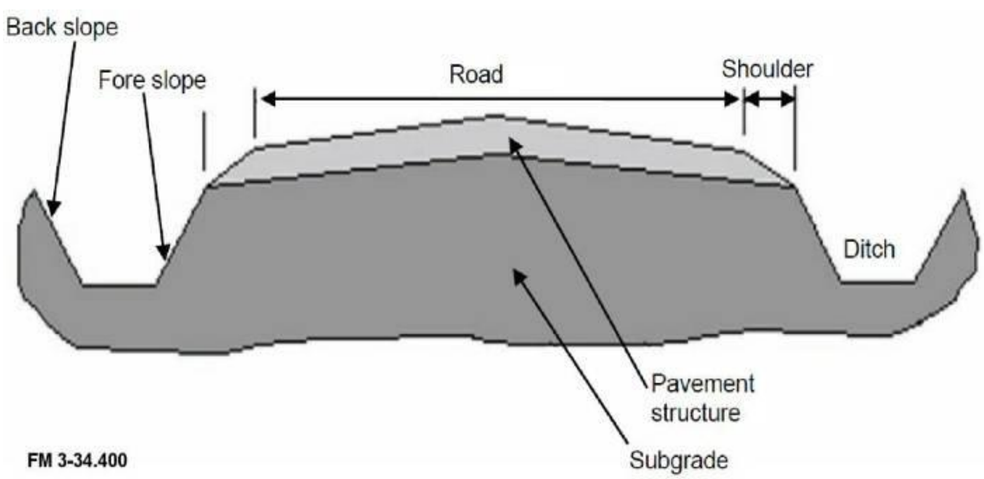


Figure A7.7. Construction Diagram of Base Defense Berms and Ditches

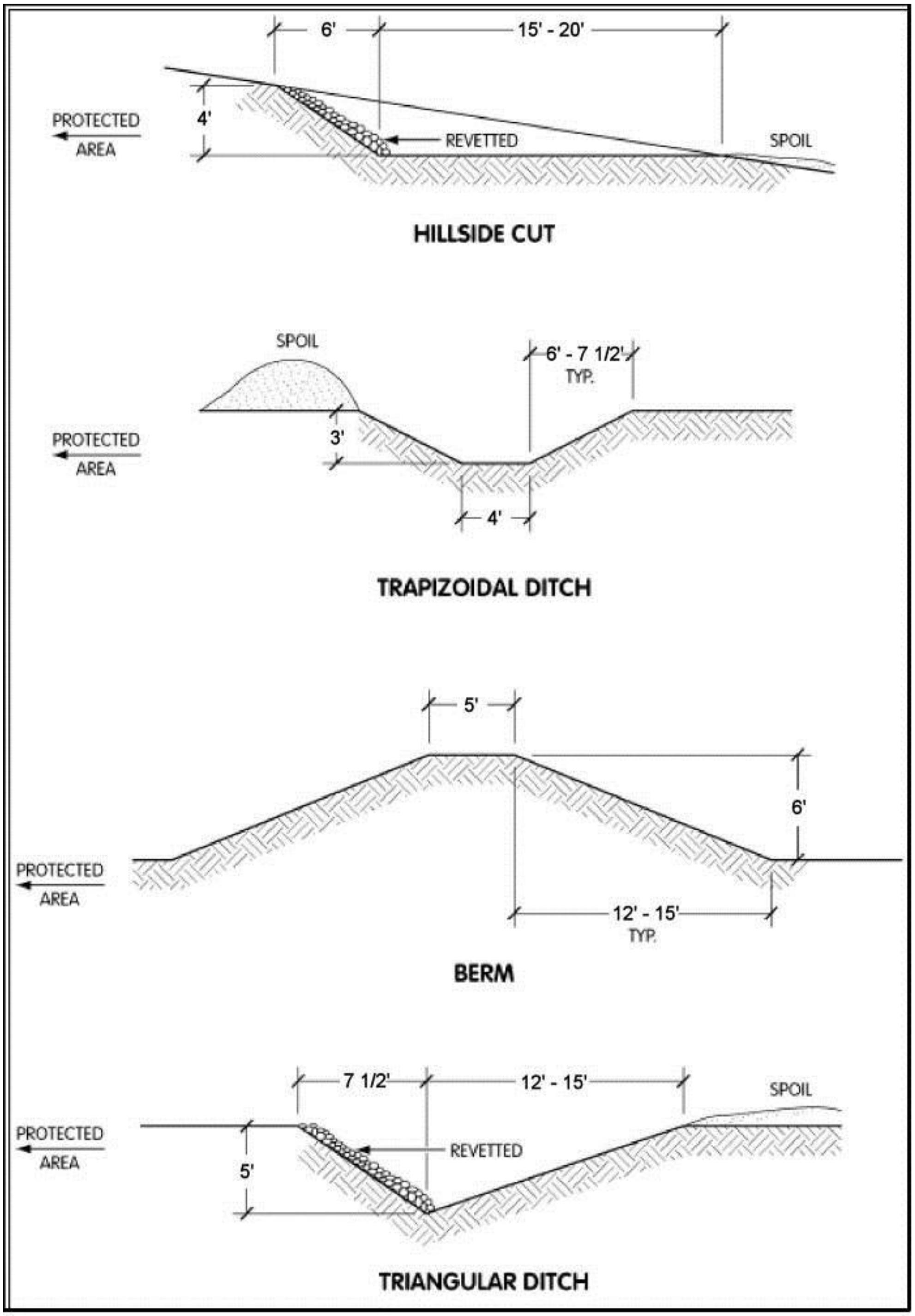


Table A7.9. Construction Man-Hour Comparisons for Revetments

Revetment Type	Size	Construction Man-Hours Per 100ft^2 of Vertical Protection
Freestanding Berm	10 feet high by 3-foot crest	2.7
Bermed Wall	10 feet high by 3-foot crest	1.6
Sandbag Wall	10 feet high by 2.67 feet wide	90.0
A-1 Steel Bin Revetment	12 feet high by 5.25 feet wide	20.1
B-1 Steel Bin Revetment	16 feet high by 6.9 feet wide	22.6
Sandgrid	8 feet high by 3.17 feet wide	16.0
4-Meter Aircraft Revetment	13.7 feet high by 0.8 foot thick	0.9
Bitburg Revetment	6.58 feet high by 1 foot thick	0.9
Assumptions: 1. Berms will be built using a front-end loader 2. 4-Meter Aircraft and Bitburg Revetments are pre-positioned 3. Ten sandbags could be filled and stacked per man-hour		

Table A7.10. Construction Estimates for Clearing Operations

Equipment	Equipment (Hours Per Acre)		
	Light (12 Inches of Less*)	Medium (12 to 18 Inches*)	Heavy (18 Inches*)
Bulldozer			
Medium tractor	2.5	5.0	10.0
Heavy tractor	1.5	3.0	8.0
Shear blade			
Medium tractor	0.4	0.8	1.3
Heavy tractor	0.3	0.5	0.8
*Maximum tree size. Note. These clearing rates are average for tree counts of 50 trees per acre. Adverse conditions (slopes, rocks, soft ground) can reduce these rate significantly.			

Table A7.11. Estimated Vehicle Turning Radius for Road/Intersection Construction

Design Vehicle Types	Minimum Design Turning Radius (ft)	Centerline[1] Turning Radius (CTR) (ft)	Minimum Inside Radius (ft)
Passenger Car	24	21	14.4
Single Unit Truck	42	38	28.3
Intermediate Semi-trailer	40	36	19.3
Interstate Semi-trailer (48 ft trailer)	45	41	7.9
Interstate Semi-trailer (53ft trailer)	45	41	4.4
Intercity Bus (Motor Coach)	45	40.8	27.6
Note 1: The turning radius assumed by a designer when investigating possible turning paths and is set at the centerline of the front axle of a vehicle. If the minimum turning path is assumed, the CTR approximately equals the minimum design turning radius minus one-half the front width of the vehicle. (Ref. Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials (AASHTO))			

Figure A7.8. Turning Diagram for 48-Foot Semi-Trailer

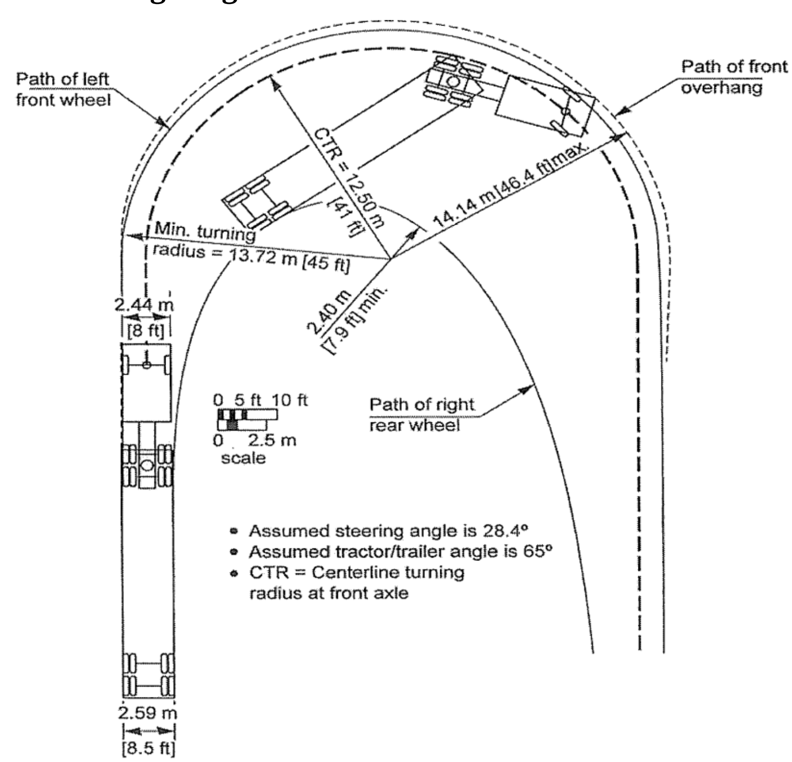


Figure A7.9. Turning Diagram for 45-Foot Passenger Bus

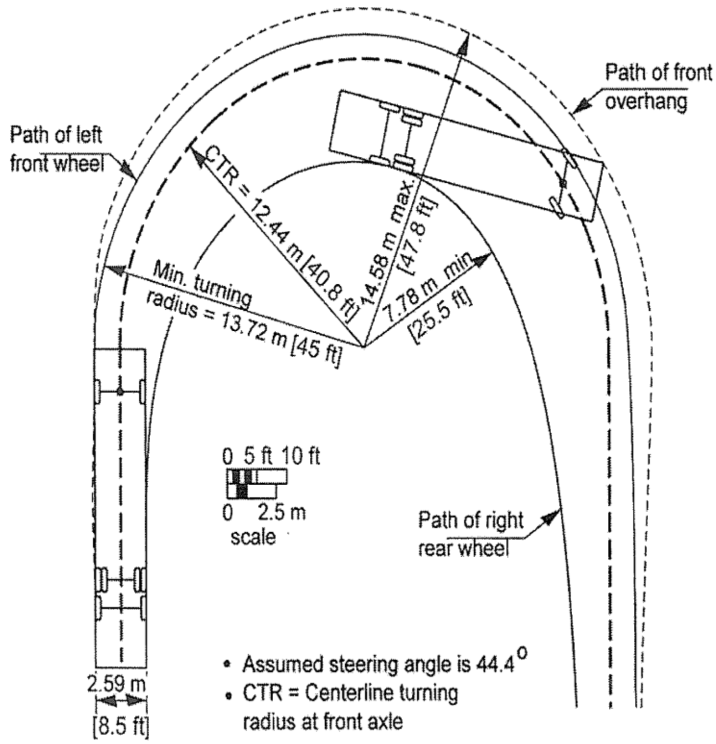


Table A7.12. Rotary-Wing Aircraft Dimensions, Separation, and Taxiway Widths

Rotary-Wing[1]	Operating Length		Operating Width		Minimum Distance Between Centerline of Parked Aircraft[2]		Minimum Interior and Perimeter Taxi Lane Width[3]	
Type	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet
HH/MH-53	26.9	88.3	22.0	72.3	44.0	144.5	55.1	180.7
HH-1H	17.4	57.1	14.7	48.3	29.5	96.7	44.2	145.0
UH-1N57	17.5	57.3	14.6	48.0	29.3	96.0	43.9	144.0
UH/TH-1F/P	17.4	57.1	14.6	48.0	29.3	96.0	43.9	144.0
HH-60	19.8	64.9	16.4	53.7	32.7	107.4	40.9	134.2
CV-22	17.5	57.3	25.9	85.0	29.4	96.5	44.2	145.0

Notes:
1. Dimensions vary between different models and configurations of helicopters.
2. Distances represent two rotor diameters between center lines of parked aircraft.
3. Widths represent two and one-half rotor diameters for wheeled helicopters and three-rotor diameters for skid-mounted helicopters.

(Ref: AFH 32-1084)

Table A7.13. Fixed Wing Aircraft Dimensions

Aircraft[1]	Wingspan		Length		Height	
Type	Meters	Feet	Meters	Feet	Meters	Feet
B-1	22.7 to 41.7	77.8 to 136.7	46.0	150.7	10.3	33.6
B-52	56.4	185.0	47.8	156.6	12.4	40.8
C-5	67.9	222.7	75.6	247.8	19.9	65.1
C-9	28.5	93.4	36.4	119.3	8.4	27.5
MC-12	17.6	57.9	14.8	48.7	4.3	14.3
C-17	51.8	170	52.7	173	16.8	55.1
C-130	40.4	132.6	30.4	99.5	11.7	38.5
KC-135	39.9	130.8	41.5	136.2	12.7	41.7
KC-10	50.4	165.3	55.5	182.1	17.7	58.1
C-137	44.4	145.7	45.1	147.7	12.8	41.8
C-141B	48.8	160.0	51.3	168.4	12.0	39.3
E-3	44.4	145.7	46.6	152.9	12.9	42.2
E-4	59.7	195.7	70.7	231.8	19.6	64.3
A-10	17.5	57.5	16.2	53.3	4.5	14.9
F-5	8.5	28.0	15.8	51.7	4.0	13.2
F-15	13.0	42.8	19.4	63.8	5.9	19.2
F-16	10.0	32.8	14.5	47.6	5.0	16.4
F-22	13.6	44.5	18.9	62.1	5.1	16.6
F-35	10.7	35	15.4	51.1	4.6	15
Note 1: Dimensions vary between different models and configurations of aircraft.						

Figure A7.10. Runway End and Clear Zone Details

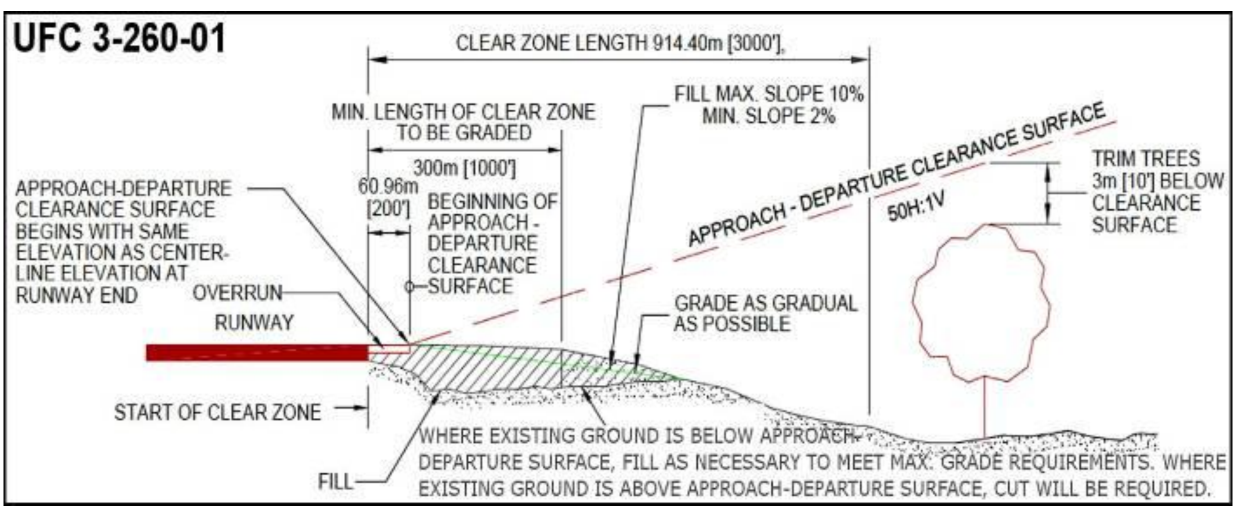


Table A7.14. Unmanned Aircraft Systems Dimensions

UAS	Wingspan	Length	Vertical Clearance	Height
Type	Feet	Feet	Inches	Feet
RQ-4A Global Hawk	116.2	44.4	19.5	15.2
RQ-4B Global Hawk	130.9	47.6	20.65	15.4
MQ-9A Reaper	66	36.2	20	11.8
RQ-1B/MQ-1B Predator	48.7(1)	27.0	5.3	6.9
MQ-1C ERMP Warrior	56.3	27.5(2)	TBD	9.9. (Level) (3)
RQ-7B Shadow 200	14	11.33	TBD	3.2

Notes.
(1) 55.25 feet for MQ-1B Block 10 & 15.
(2) 29 feet with Alpha Probe attached.
(3) 10.32 feet for uneven surfaces, allow for an additional 5 inches.
(Ref: AFCESA ETL 09-1)

Figure A7.11. Fighter Aircraft Diagonal Parking Diagram

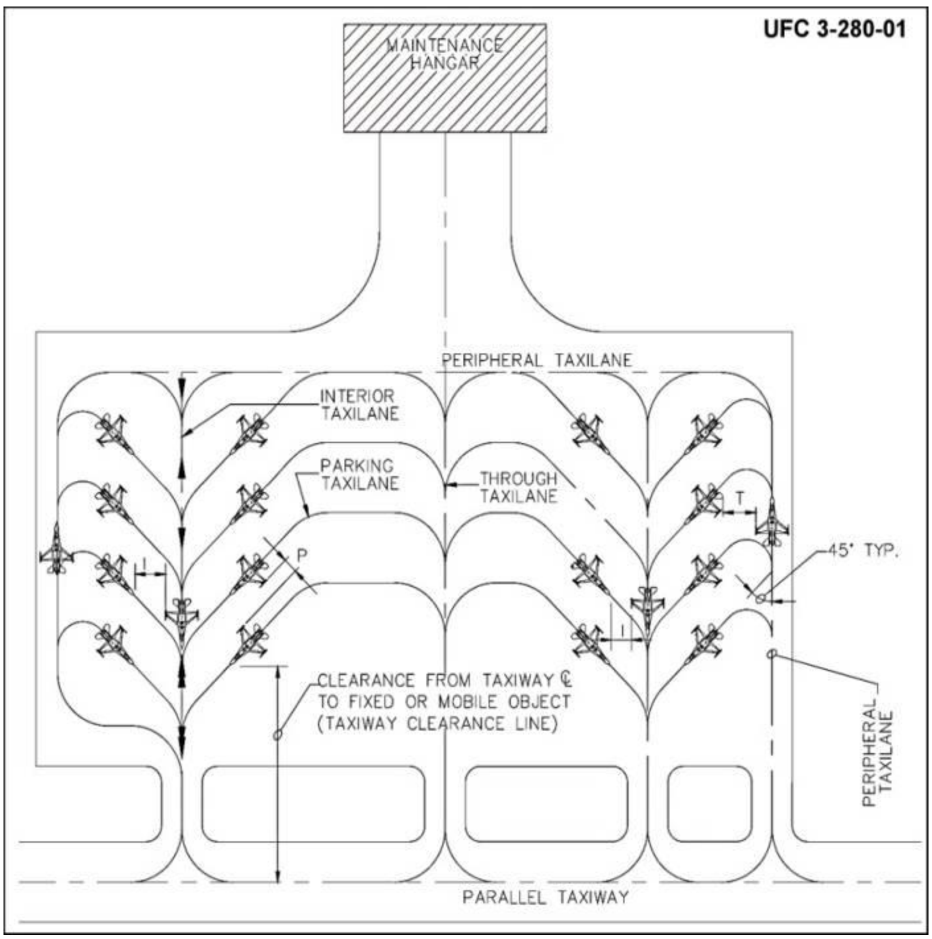


Figure A7.12. Typical Aircraft Parking Arrangement

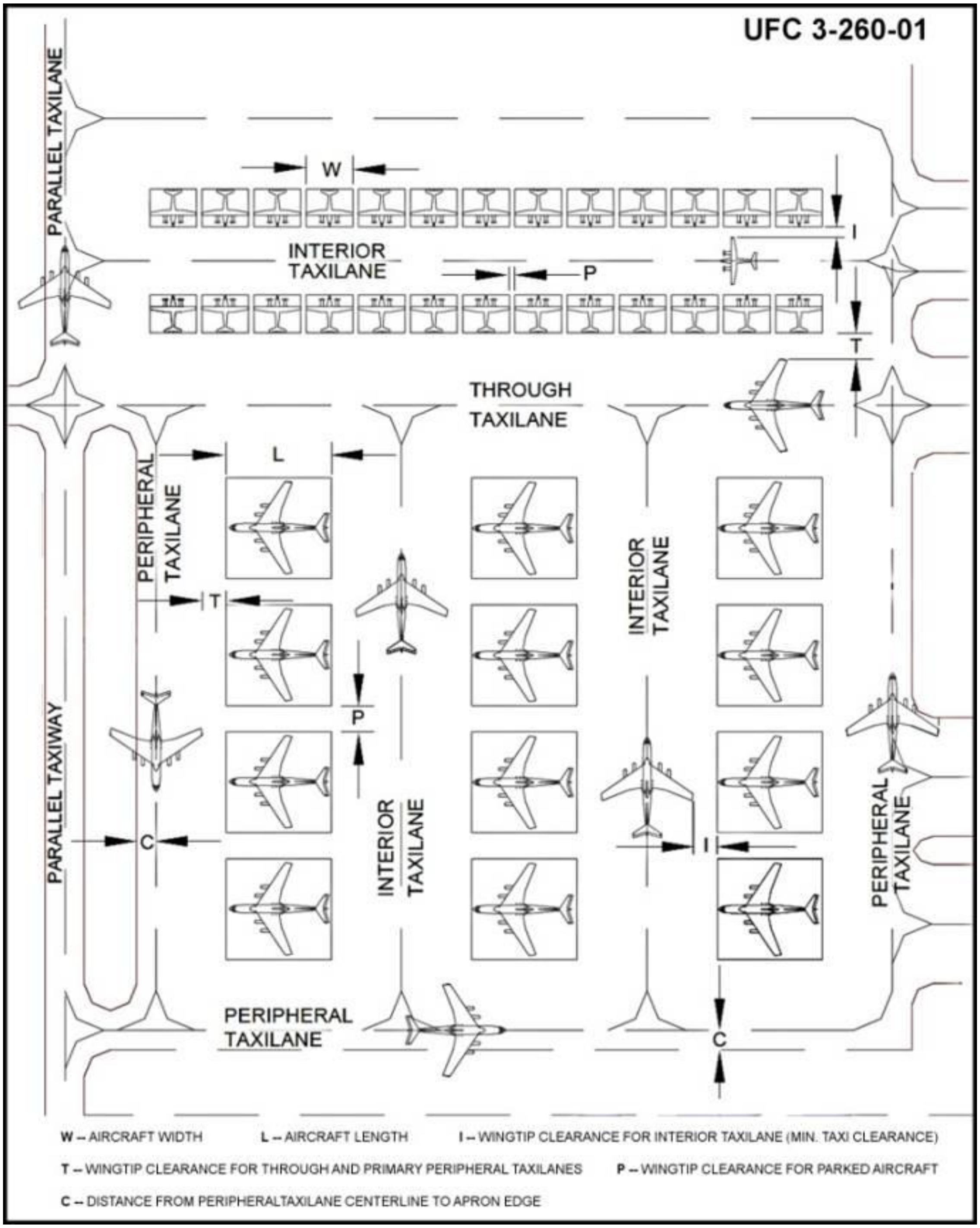


Figure A7.13. Non-dispersed Aircraft and Revetments Layout

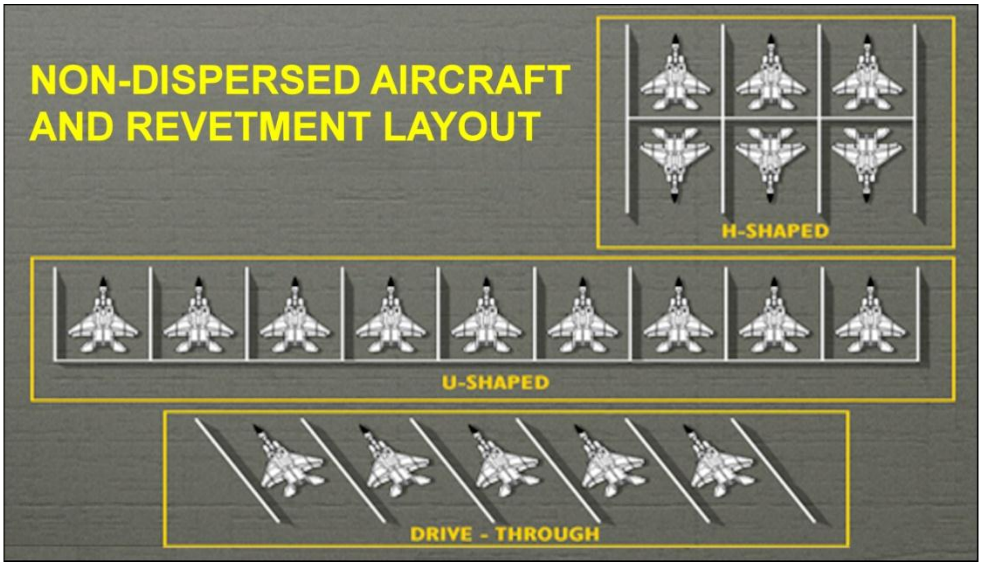


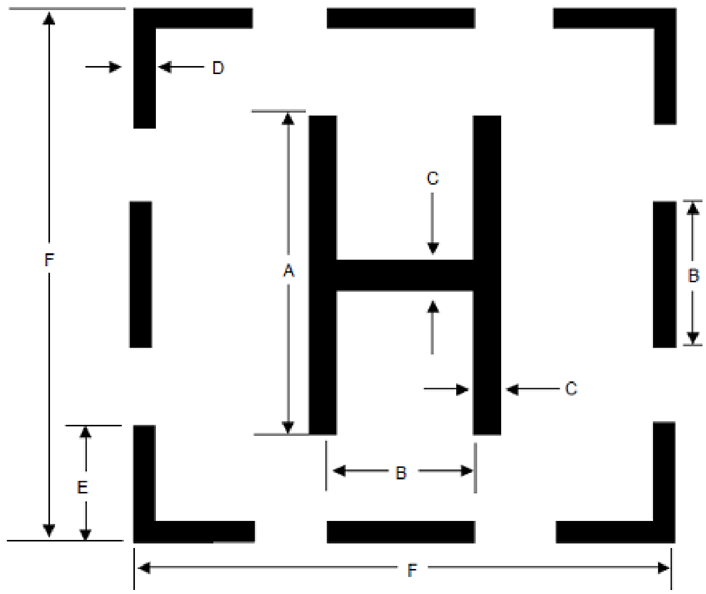
Figure A7.14. Dispersed Aircraft and Revetments Layout

Figure A7.15. Examples of Expedient Aircraft Revetments

Table A7.15. Minimum Operating Strip (MOS) Layout Tasks

MOS Layout Tasks		☑
1	MOS Centerline	
2	MOS Corners	
3	Taxiway entrances or exits	
4	"T" Clear Zones	
5	Mobile Aircraft Arresting System (MAAS)	
6	Distance-To-Go (DTG) Markers	
7	Precision Approach Path Indicators (PAPI)	
8	Edge Markers	
9	Taxiway holding lines, centerlines, and changes in direction	
10	Emergency Airfield Lighting	

Figure A7.16. Helipad Identification Markings



IDENTIFIER DIMENSIONS

DIMENSION A = 0.6 OF DIMENSION F (MAXIMUM OF 20.12 m [66'])
DIMENSION B = 0.5 OF DIMENSION A

	HELIPAD SIZE (F)	PATTERN LINE WIDTH (C)	BORDER EDGE WIDTH (D)	CORNER EDGE LENGTH (E)
METERS	13 m TO 18 m	914 mm	396 mm	1.52 m
FEET	43' TO 59'	3'	1.3'	5'
METERS	18 m TO 24 m	1.22 m	610 mm	2.13 m
FEET	60' TO 79'	4'	2'	7'
METERS	24 m TO 30 m	1.52 m	610 mm	3.05 m
FEET	80' TO 98'	5'	2'	10'
METERS	30 m OR LARGER	1.98 m	762 mm	3.51 m
FEET	99' OR LARGER	6.5'	2.5'	11.5'

Figure A7.17. Hospital Helipad Identification Markings

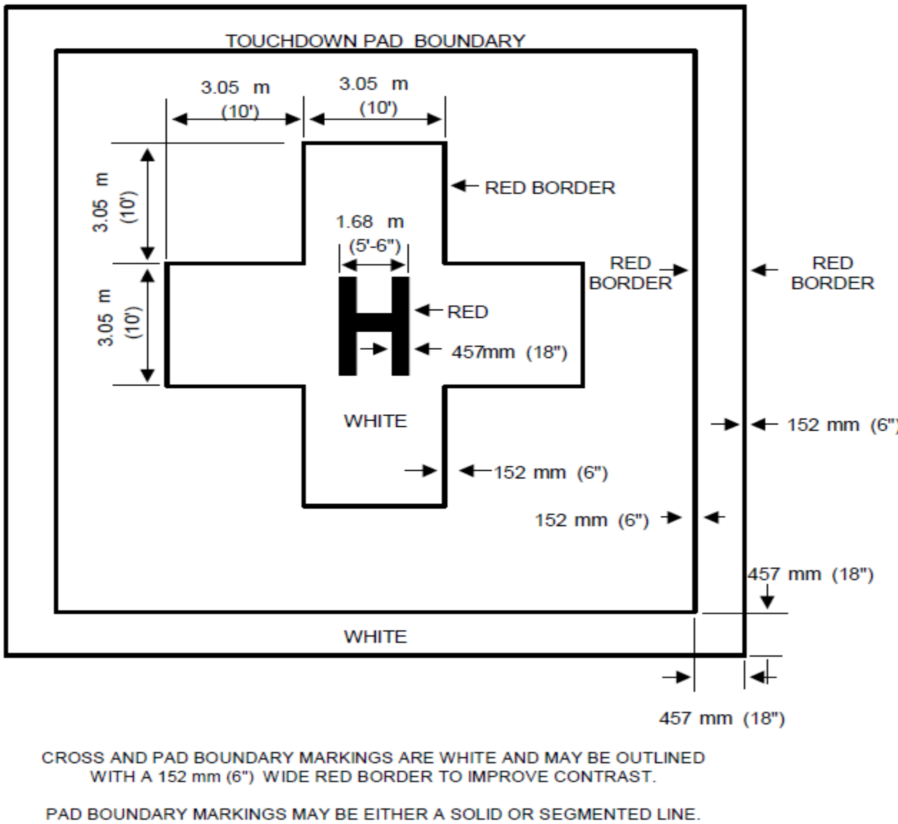


Figure A7.18. Aircraft Parking Apron Static Ground Tie-Down

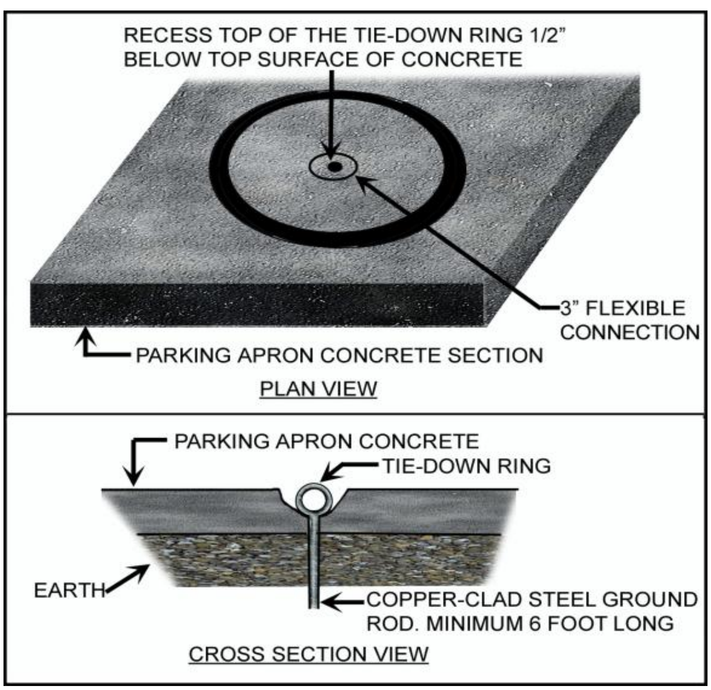


Figure A7.19. B-1 Revetment Layout

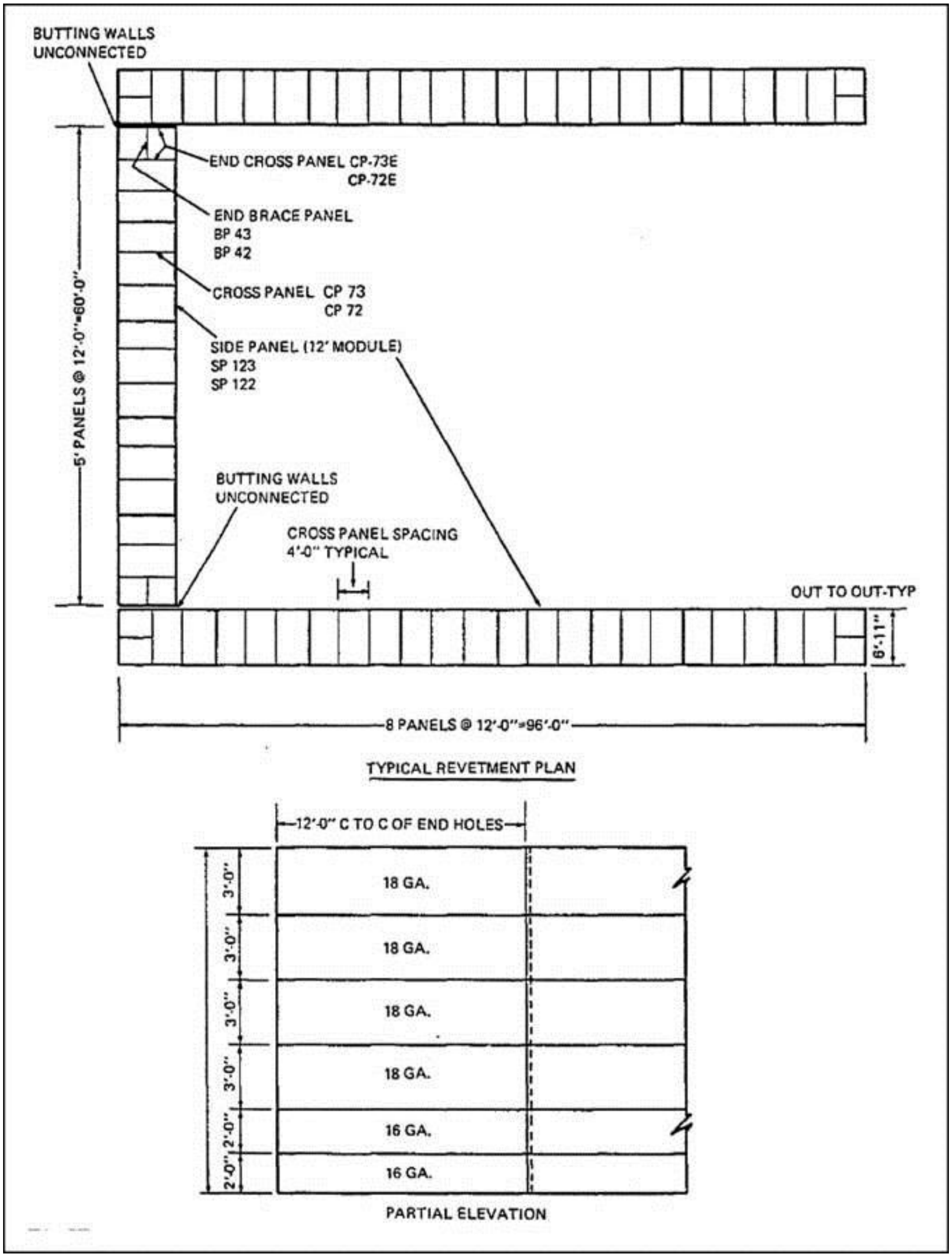


Table A7.16. Power Poles Height and Class

Pole	Minimum Height (feet)*	Minimum Class	Normal Class
Line Pole	30	7	5
Corner Pole (guyed)	30	6	4
Corner Pole (unguyed)	30	2	2
Dead End Pole (guyed)	30	5	4
Dead End Pole (unguyed)	30	2	2
Transformer Poles	35	**	
* Increase heights by 5 feet if telephone or signal wires are carried or likely to be installed. ** Refer to Table 5.9.			

Table A7.17. Power Pole Classes for Various Sized Transformers

New Pole for Transformer	Existing Pole	Maximum Transformer Size (kVA)	
Minimum Class	Minimum Class	One-Phase	Three-Phase
6	7	5	
5	6	15	5
4	5	50	37 ½
2	3	75	75
2	2	100	100

Table A7.18. Pole Height and Depth

Pole Height (feet)	Depth of Setting (feet)	
	In Soil	In Rock
20	**5.0**	**3.0**
25	**5.5**	**3.5**
30	**5.5**	**4.0**
35	**6.0**	**4.0**
40	**6.0**	**4.0**
45	**6.5**	**4.5**
50	**7.0**	**4.5**
55	**7.5**	**5.0**
60	**8.0**	**5.0**

Table A7.19. . Guy Anchor Suitability

Type of Anchor	General Soil Type	No.	Classification Description
Rock	Hard	1	Solid bedrock
		2	Dense clay; compact gravel; dense fine sand; laminated rock; slate; schist; sandstone
		3	Shale; broken bedrock; hardpan; compact clay-gravel mixtures
Expanding	Ordinary	4	Gravel; compact gravel and sand; claypan
		5	Medium-firm clay; loose sand gravel; compact coarse sand
Swamp or as Suitable	Soft	6	Soft-plastic clay; loose coarse sand; clay silt; compact fine sand
		7	Fill; loose fine sand; wet clays; silt
		8	Swamp; marsh; saturated silt; humus

Figure A7.20. Example National Electric Safety Code (NESC) Minimum Clearances

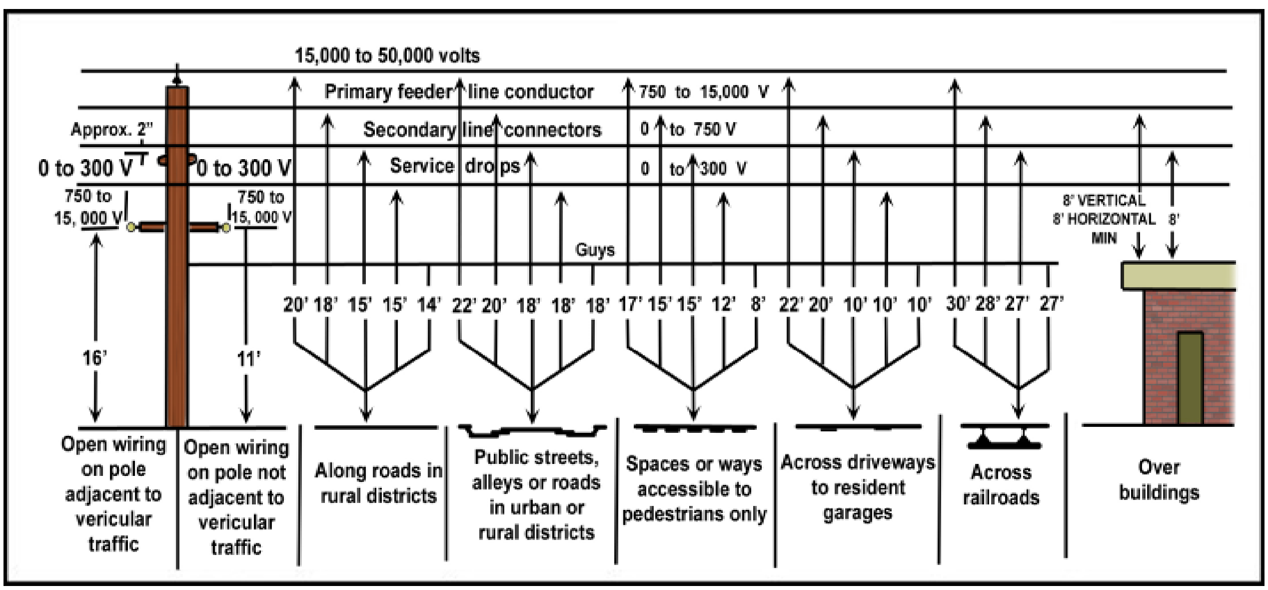


Table A7.20. KVA Load-Carrying Capacity of Wire

Wire Size[1] (AWG)[2]	Maximum Amperes	Type of Circuit				
		1Ø 2W 120V (kVA)	1Ø 3W 120/240V (kVA)	3Ø 4W 127/220V (kVA)	1Ø 2W 2,400V (kVA)	3Ø 4W 2,400/4,160 V (kVA)
8	75	9	18	29	180	540
6	100	12	24	38	240	720
4	150	18	36	57	360	1,080
2	180	22	44	69	432	1,296
1/0	250	30	60	95	600	1,800
4/0	435	52	104	166	1,044	3,130

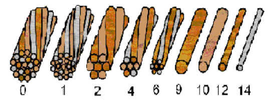
[1]Overhead wires with weatherproof insulation or bare wires.
[2] American Wire Gage

Table A7.21. Number of Wires Allowable in Various Sized Conduits

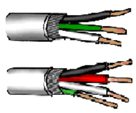
Wire Size	NUMBER OF WIRES IN VARIOUS SIZED CONDUIT								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
18	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	3/4
16	1/2	1/2	1/2	1/2	1/2	1/2	3/4	3/4	3/4
14	1/2	1/2	1/2	1/2	3/4	3/4	3/4	1	1
12	1/2	1/2	1/2	3/4	3/4	1	1	1	1 1/4
10	1/2	3/4	3/4	3/4	1	1	1 1/4	1 1/4	1 1/4
8	1/2	3/4	1	1	1 1/4	1 1/4	1 3/4	1 3/4	1 3/4
6	1/2	1	1 1/4	1 1/4	1 1/2	1 1/2	2	2	2
4	3/4	1 1/4	1 1/4	1 1/2	2	2	2	2	2 1/2
2	3/4	1 1/4	1 1/2	1 1/2	2	2	2 1/2	2 1/2	2 1/2
1	3/4	1 1/2	1 1/2	2	2	2 1/2	2 1/2	3	3
1/0	1	1 1/2	2	2	2 1/2	2 1/2	3	3	3
2/0	1	2	2	2 1/2	2 1/2	3	3	3	3 1/2
3/0	1	2	2	2 1/2	3	3	3	3 1/2	3 1/2
4/0	1 1/4	2	2 1/2	2 1/2	3	3	3 1/2	3 1/2	4

Note: Rubber-covered or weatherproof wire

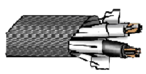
Figure A7.21. Wire Sizes, Types and Uses



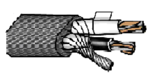
WIRE SIZE: THE SMALLER THE NUMBER THE LARGER THE SIZE. NUMBER 6 AND LARGER WIRES ARE STRANDED. SIZES TO 0000 ARE AVAILABLE FOR SPECIAL WORK.



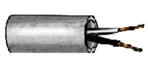
CABLE IS CLASSIFIED ACCORDING TO THE NUMBER OF WIRES IT CONTAINS AND THEIR SIZE AND GAGE. TWO WIRE CABLE ACTUALLY CONTAINS THREE WIRES: THE BLACK (HOT) WIRE, THE WHITE (NEUTRAL) WIRE, AND A THIRD THAT IS THE GROUND WIRE. SIMILARLY, 3-WIRE CABLE CONTAINS FOUR WIRES: BLACK, WHITE, AND RED (WHICH IS ALSO A HOT WIRE) AND A GROUND WIRE.



SERVICE ENTRANCE CABLE: USED TO TRANSMIT POWER TO MAIN ENTRANCE SWITCH. CAN BE USED INDOORS OR OUTDOORS.

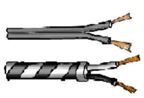


NONMETALLIC SHEATHED CABLE: FOR INDOOR USE. HAS A MOISTURE-RESISTANT, FLAME-RESISTANT COVERING. IT IS MADE WITH AND WITHOUT A GROUND WIRE. THE WIRES ARE COPPER OR ALUMINUM. NUMBER 6 AND LARGER ARE STRANDED.

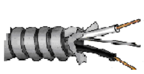


THIN-WALL STEEL CONDUIT: INSTALLED SAME WAY AS PIPING; WIRES ARE PULLED THROUGH AFTERWARD. ACTS AS ITS OWN GROUNDING CONDUCTOR. MADE IN 10-FT LENGTHS; JOINED BY SPECIAL CONNECTORS.

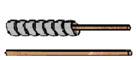
UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE: CAN BE USED UNDERGROUND, INDOORS OR OUT. DOES NOT REQUIRE A CONDUIT WHEN BURIED. RESISTS WATER AND CORROSION.



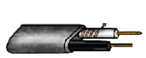
EXTENSION AND APPLIANCE CORDS: COME IN LIGHT AND HEAVY DUTY TYPES. LAMPS USUALLY USE PLASTIC COVERED TYPES. APPLIANCES AND MOTORS TAKE HEAVIER FORMS WITH WIRE SIZE TO SUIT THE LOAD.



ARMORED CABLE: USED ONLY IN DRY, INDOOR LOCATIONS. WIRES ARE COPPER; BARE GROUND MAY BE ALUMINUM. MUST BE USED WITH STEEL JUNCTION AND SWITCH BOXES MADE IN 2- AND 3-WIRE TYPES.



GROUND WIRE: USED TO GROUND AN ELECTRICAL SYSTEM TO A COLD-WATER LINE, OR TO A COPPER ROD BURIED IN THE GROUND. GENERALLY SINGLE-WIRE ARMORED CABLE. WIRE SIZE DEPENDS ON SERVICE WIRE SIZE.



LEAD-ENCASED UNDERGROUND CABLE: GENERALLY USED TO TRANSMIT POWER TO OUTBUILDINGS FROM MAIN POWER SOURCE.

Table A7.22. Approximate Voltage Drops In Secondary Distribution Cables

Approximate Voltage Drops In Secondary Distribution Cables						
Rated Amperage/Pins	**Cable Length and Approximate Voltage Drop**					
	15 ft	**25 ft**	**50 ft**	**100 ft**	**200 ft**	**300 ft**
200 amp/8 pin cables (3-ph)	1V	1.6V	3.2V	6.4V	12.8V	19.2V
100 amp/8 pin cables (3-ph)	0.4V	0.7V	1.4V	2.8V	5.6V	8.4V
60 amp/5 pin cables (3-ph)	0.5V	0.9V	1.6V	3.5V	6.4V	10.5V
40 amp/5 pin cables (3-ph)	0.3V	0.6V	1.1V	2.3V	4.4V	6.9V
60 amp/4 pin cables (1-ph)	0.5V	0.9V	1.7V	3.4V	6.8V	10.2V
20 amp/3 pin cables (1-ph)	1.1V	1.8V	3.6V	7.2V	14.4V	21.6V

Figure A7.22. Common Wire Splices

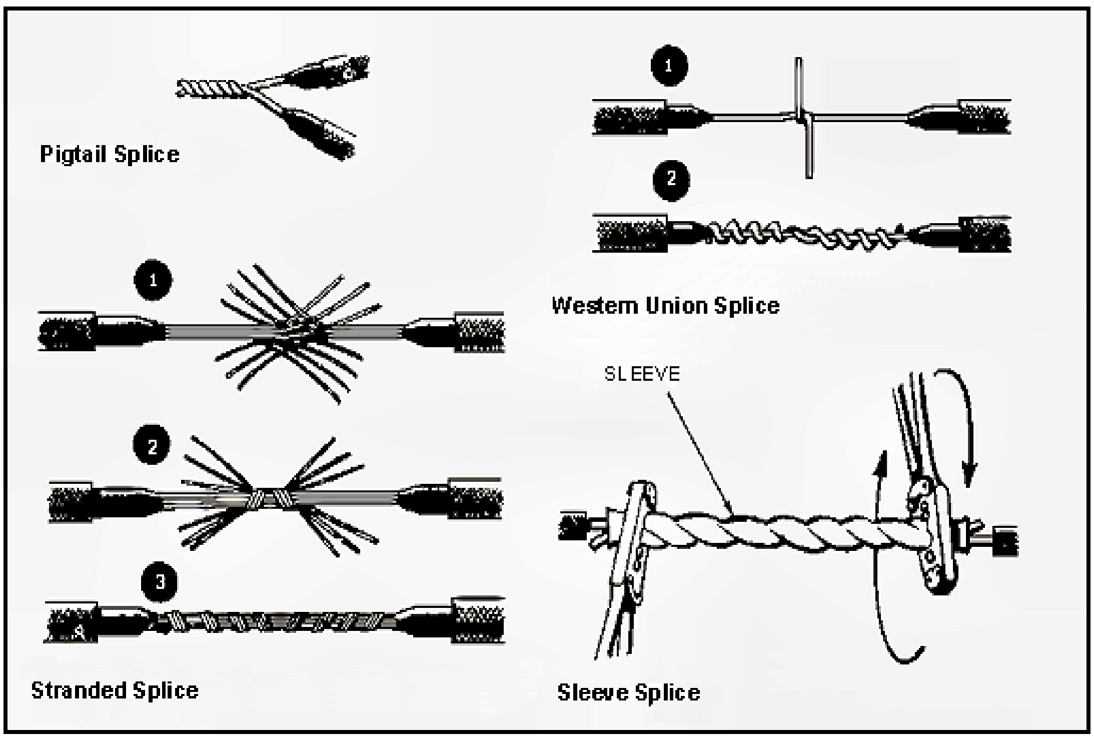


Table A7.23. Electrical Current Characteristics In SWA

Country	Type of Current	Frequency	Number of Phases	Nominal Voltage	Number of Wires	Frequency Stability
Afghanistan	A.C.	50	1,3	220/380	2,4	Yes
Egypt	A.C.	50	1,3	220/380	2,4	Yes
Iran	A.C.	50	1.3	220/380	2,3,4	Yes
Iraq	A.C.	50	1.3	220/380	2,4	Yes
Israel	A.C.	50	1.3	220/380	2,4	Yes
Jordan	A.C.	50	1.3	220/380	2,3,4	Yes
Kuwait	A.C.	50	1.3	240/415	2,4	Yes
Lebanon	A.C.	50	1.3	110/190, 220/380	2,4	No
Libya	A.C.	50	1.3	220/380	2,4	Yes
Oman	A.C.	50	1.3	240/415	3,4	Yes
Pakistan	A.C.	50	1.3	230/400	2,3,4	No
Saudi Arabia	A.C.	60	1.3	127/220	2,3,4	Yes
Sudan	A.C.	50	1.3	240/415	2,4	Yes
Syria	A.C.	50	1.3	220/380	2,3,4	No
Turkey	A.C.	50	1.3	220/380/154	2,3,4	Yes
Yemen	A.C.	50	1.3	220/380	2,4	No

Figure A7.23. Loop Power Distribution Layout

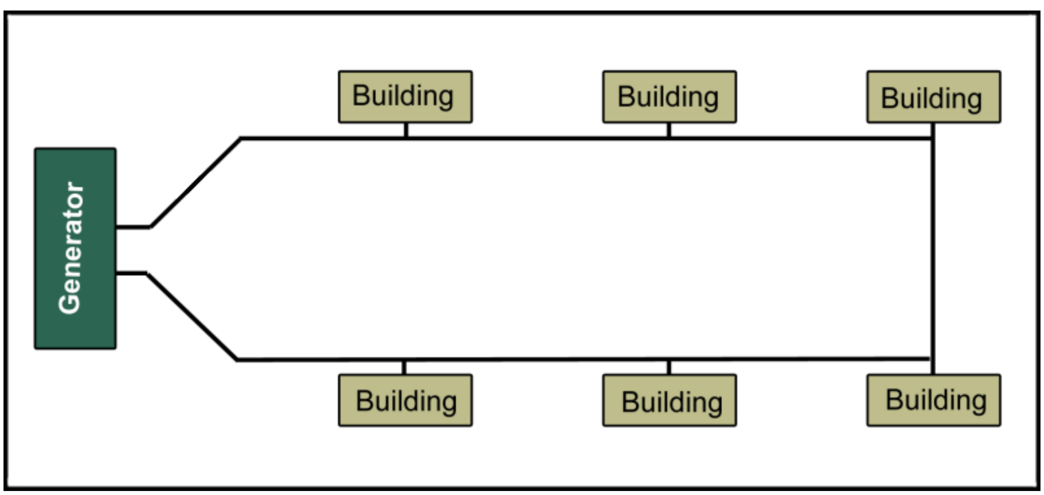


Figure A7.24. Radial Power Distribution Layout

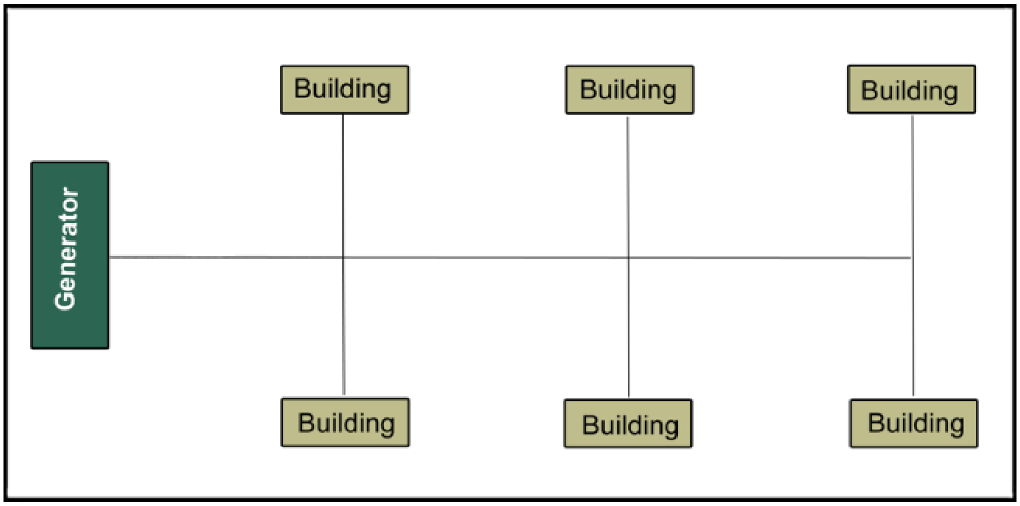


Figure A7.25. Power Cables Underground Roadway Crossing

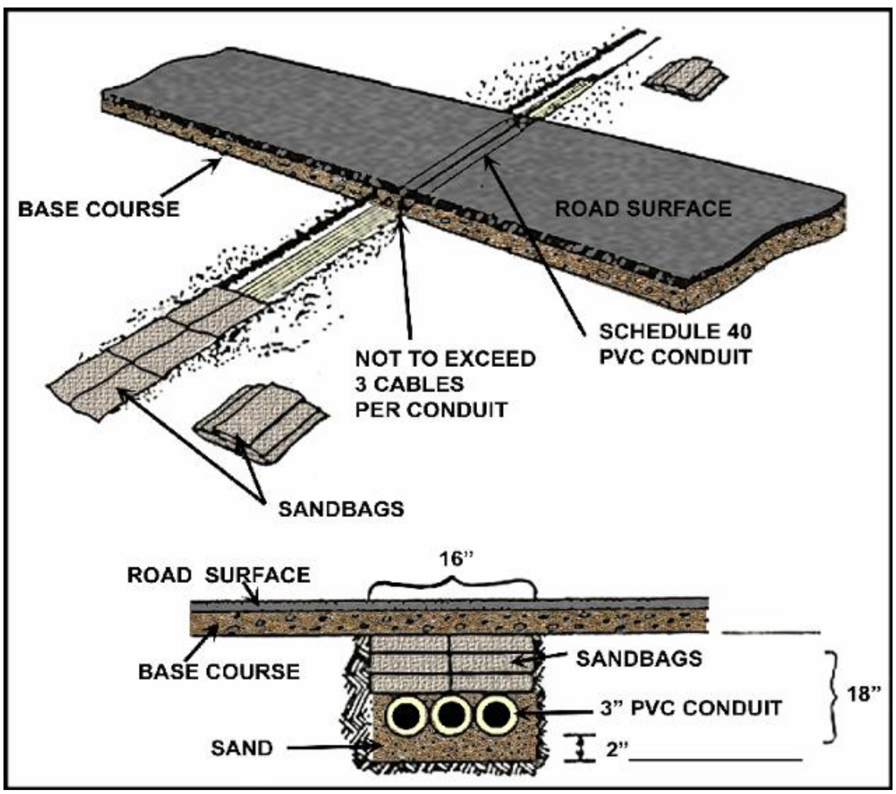


Figure A7.26. Basic Electrical Distribution System Schematic

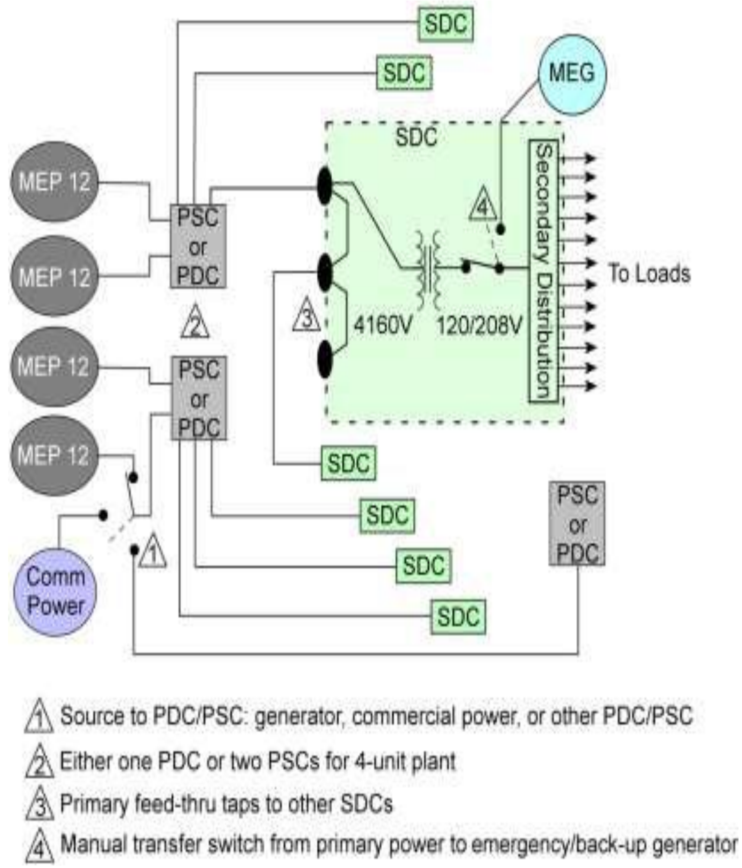


Figure A7.27. Secondary Distribution Center (SDC) Placement for Non-Dispersed 24-Facility Grouping

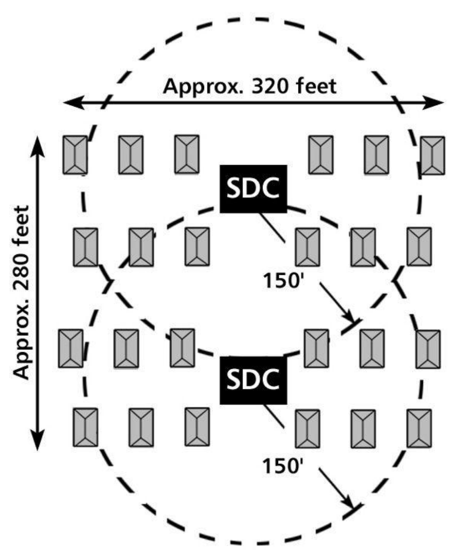


Figure A7.28. General Plant Configuration w/Power Distribution Panels (PDC) by Base Population

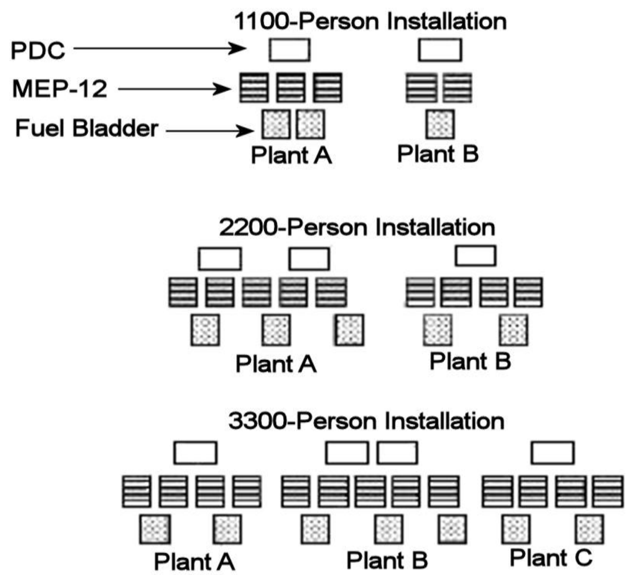


Table A7.24. Water Use Planning Factors

Functions	**Water Usage Factor (gal/person/day)**	
Potable Water	**Using BEAR**	**Using Fixed Water Treatment Plant**
Drinking	4.0	4.0
Personal Hygiene	3.0	4.0
Shower	5.0	15.0
Food Preparation	4.0	5.0
Hospital	1.0	1.0
Heat Treatment	1.0	1.0
Non-Potable Water	**Using BEAR**	**Using Fixed Water Treatment Plant**
Laundry	2.0	14.0
Construction	2.0	2.0
Graves Registration	0.5	0.2
Vehicle Operations	0.5	1.8
Aircraft Operations	2.0	3.0
Firefighting	2.0	4.0
10% Loss Factor	3.0	5.0
Total	**30.0**	**60.0**

Figure A7.29. Example Water Production Subsystem Layout

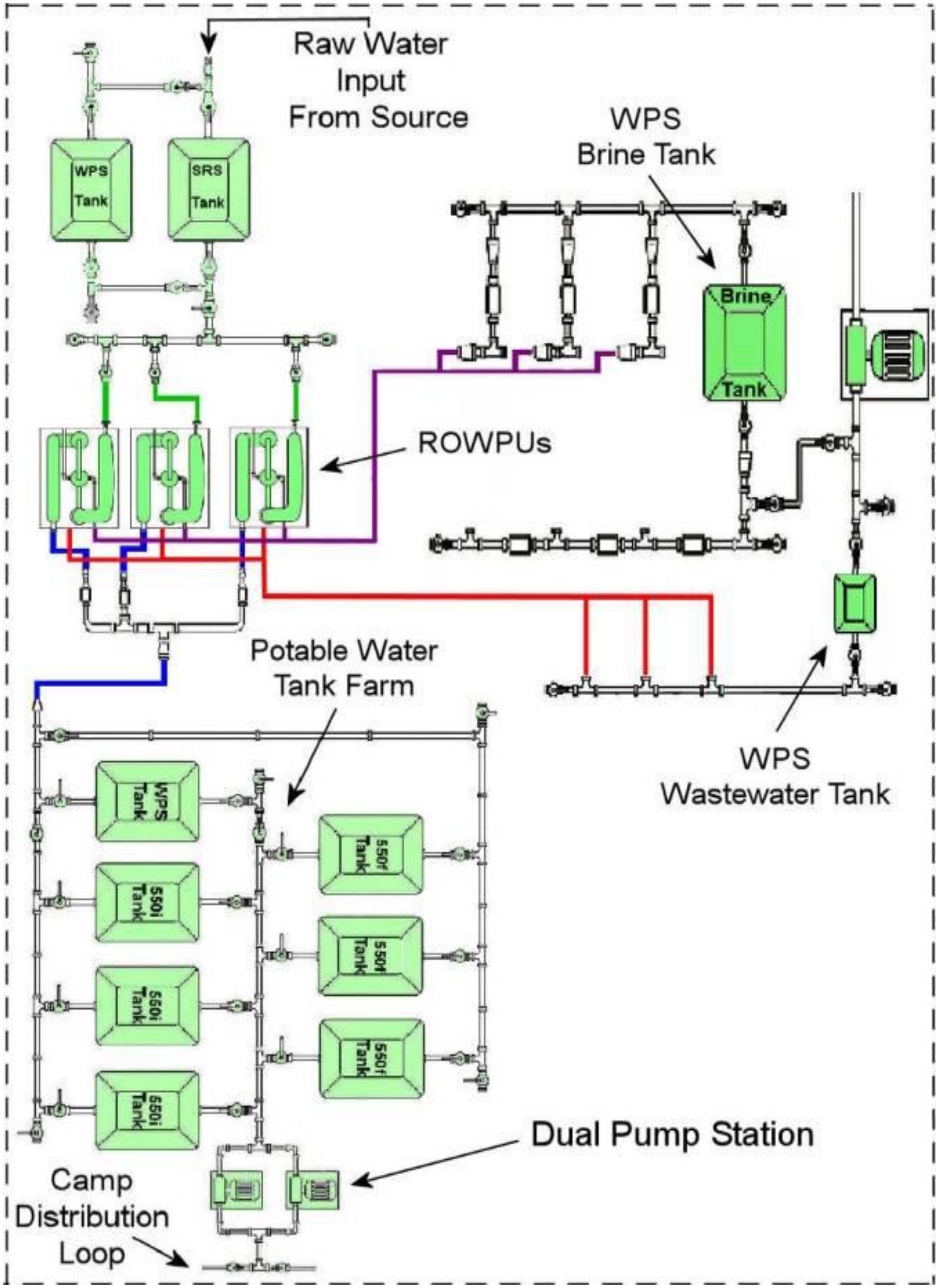


Figure A7.30. Total Wastewater Collection Layout (1100-Person Camp)

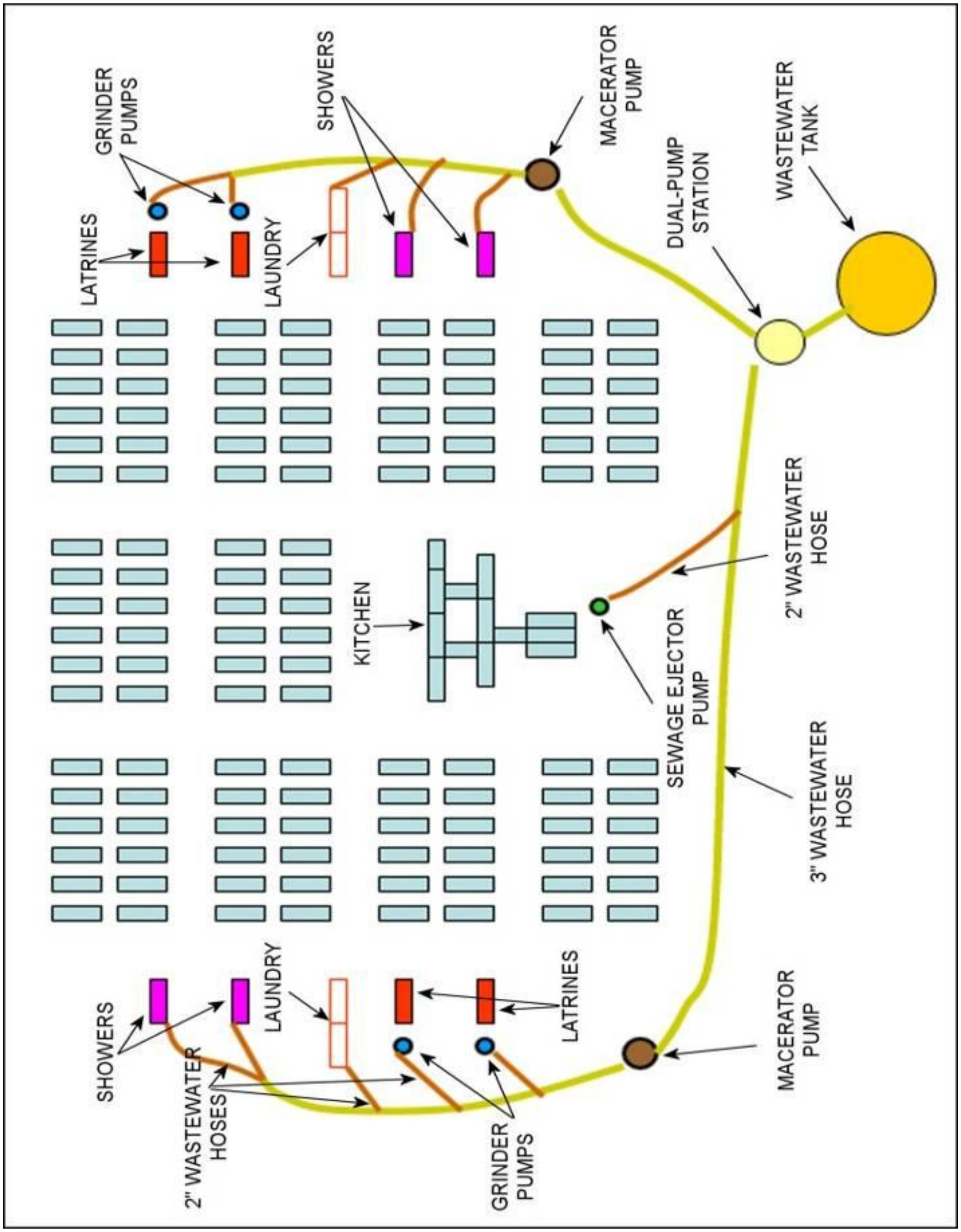


Figure A7.31. Partial Wastewater Collection Layout (1100-Person Camp)

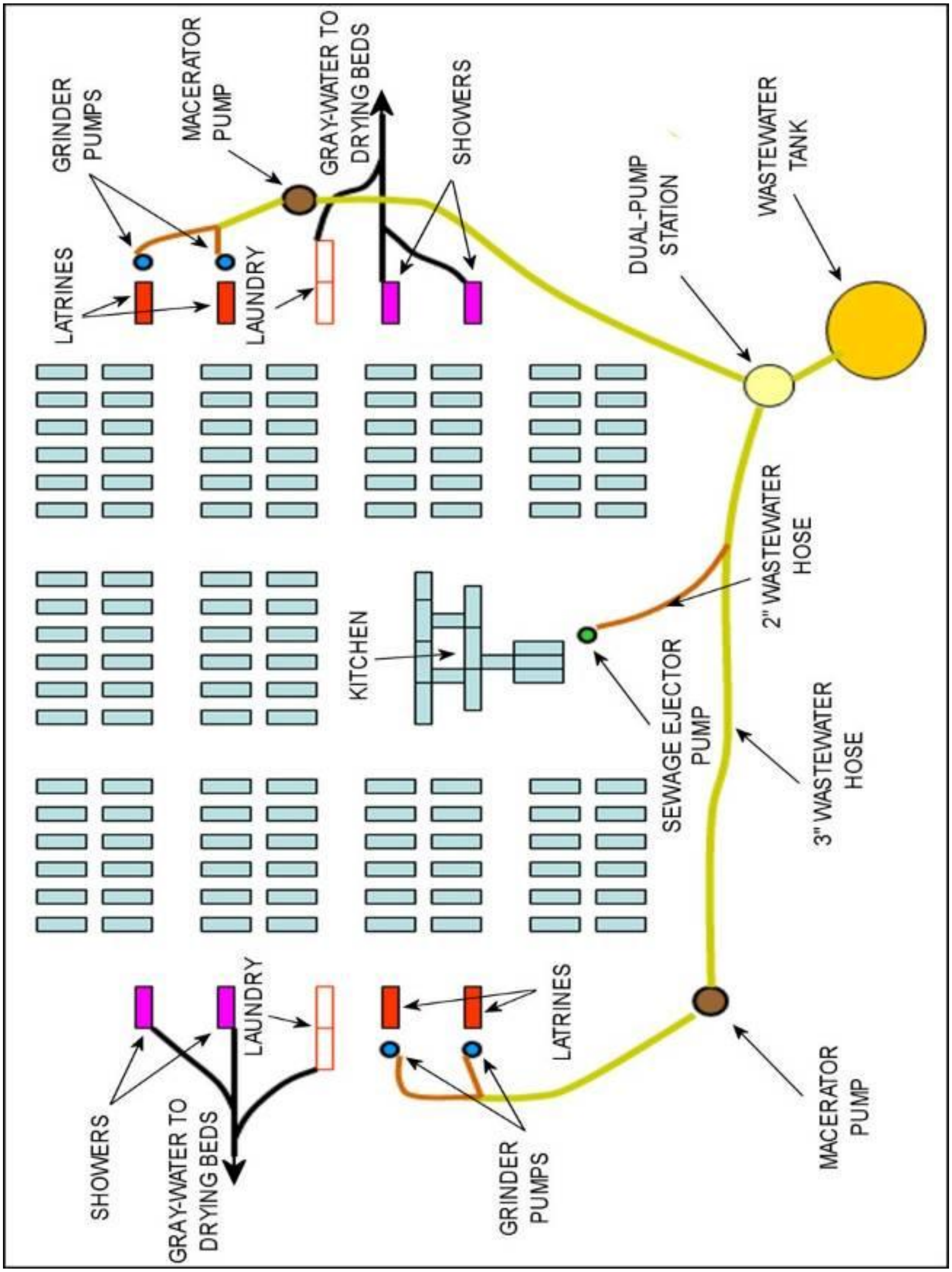


Table A7.25. Size of Water Operations Area and Water Production Subsystems

Camp Populace	Total Gallons Required Per Day[1]	Tank Farm Area[2]	Tank Farm Area w/600 WPS[2,3]	Tank Farm Area w/1500 WPS[2,4]	600 WPS[3] Quantity	1500 WPS[4] Quantity
550	16,500	50 x 130	160 x 230	140 x 230	1	1
1100	33,000	80 x 130	160 x 230	140 x 230	1	1
1650	49,500	160 x 130	250 x 230	140 x 230	2	1
2200	66,000	160 x 160	250 x 260	210 x 260	2	2
2750	82,500	160 x 190	340 x 290	280 x 290	3	2
3300	99,000	160 x 190	340 x 290	280 x 290	3	2
4400	132,000	200 x 220	430 x 320	350 x 320	4	3

Notes:
1. At a rate of 30 gallons per person per day (30 GPPPD).
2. Required area in feet (width x length).
3. Each 600 Water Production Subsystem (WPS) has 3 ROWPUs capable of producing 36,000 gallons per day (GPD).
4. Each 1500 Water Production Subsystem WPS has 2 ROWPUs capable of producing 60,000 gallons per day (GPD).

(Ref: T.O. 40W4-21-1)

Table A7.26. Calculate Quantity of Water Flowing in a Stream

Calculation of Quantity of Water Flowing in a Stream
Formula: Q = 6.4 x A x V where Q = Quantity of water in gallons per minute 6.4 = Constant. There are 7.5 gallons of water per cubic foot. However, because of error in stream measurement, 7.5 is reduced to 6.4. V = Velocity of the stream in feet per minute. This figure is obtained by noting the time it takes a twig or floating object to travel a known distance. A = Area of the stream in square feet. This figure is obtained by multiplying the width of the stream by the depth of the stream.
Illustrative Problem: A stream has an average depth of 2 feet and a width of 16 feet. A twig floats 13.3 feet per minute. How many gallons per minute are flowing in the stream? Q = 6.4 x A x V = 6.4 x 2 x 16 x 13.3 = 2,732.8 gallons per minute

Table A7.27. Convert Volume to Weight of Water

Conversion of Volume to Weight of Water
Formula: Weight of water in pounds = Cubic feet of water x 62.4
Illustrative Problem: What is the weight of water in a full tank with a volume of 470 cubic feet? Weight of water = Cubic feet x 62.4 = 470 x 62.4 = 29, 328 pounds (Ref: FM 10-52-1)

Table A7.28. Convert Pounds Per Square Inch to Vertical Feet of Water

Conversion of Pounds Per Square Inch to Vertical Feet of Water
Formula: Vertical feet of water = Pounds per square inch = 2.3
Illustrative Problem: How many vertical feet of water are in a tank that is 45 feet high? A pressure gauge at the bottom of the tank reads 9 pounds per square inch. Vertical feet of water = Pounds per square inch x 2.3 = 9 x 2.3 = 20.7 (Ref: FM 10-52-1)

Table A7.29. Convert Volume to Gallons of Water

Conversion of Volume to Gallons of Water
Formula: Gallons of water = Cubic feet of water x 7.5
Illustrative Problem: How many gallons of water are in a tank with 400 cubic feet of water? Gallons of water = Cubic feet of water x 7.5 = 400 x 7.5 = 3,000 (Ref: FM 10-52-1)

Table A7.30. Convert Gallons of Water to Cubic Feet

Conversion of Gallons of Water to Cubic Feet
Formula: Cubic feet = $\frac{\text{Gallons of water}}{7.5}$
Illustrative Problem: How many cubic feet of tank space are needed to store 1,500 gallons of water? Cubic feet = $\frac{\text{Gallons of water}}{7.5}$ = $\frac{1{,}500}{7.5}$ = 200 (Ref: FM 10-52-1)

Table A7.31. Calculate Volume of Rectangular Water Tank

Calculation of Volume of Rectangular Water Tank
Formula for Rectangular Tank: V = L x W x H where V = Volume in cubic feet L = Length in feet W = Width in feet H = Height in feet
Illustrative Problem: What is the volume of a rectangular tank that is 10 feet long, 7 feet wide, and 4 feet high? V = L x W x H = 10 x 7 x 4 = 280 cubic feet (Ref: FM 10-52-1)

Table A7.32. Calculate Volume of Cylindrical Water Tank

Calculation of Volume of Cylindrical Water Tank
Formular for Cylindrical Tank: V = πr^2 H where V = Volume in cubic feet π = 3.14 or 22/7, a constant r = Radius (half of the diameter) of the tank H = Height in feet
Illustrative Problem: What is the volume of a cylindrical tank that has a radius of 4 feet and is 7 feet high? V = $\pi r^2 H$ = 3.14 x 4^2 x 7 = 3.14 x 16 x 7 = 351.68 cubic feet (Ref: FM 10-52-1)

Table A7.33. Calculate Velocity of Water in Existing Channel

<table>
<tr><th>Calculation of Velocity of Water in Existing Channel</th></tr>
<tr><td>Estimate the volume of water that an open channel carries:

$Aw = \frac{(W_1 + W_2)H}{2}$

Volume Calculation
Aw = cross-section area of storm-water runoff, in square feet
W1 = channel width at the watermark, in feet
W2 = channel width at the bottom, in feet
H = water height, from the bottom of the stream to the watermark, in feet</td></tr>
<tr><td>Cross-Sectional Area of Water

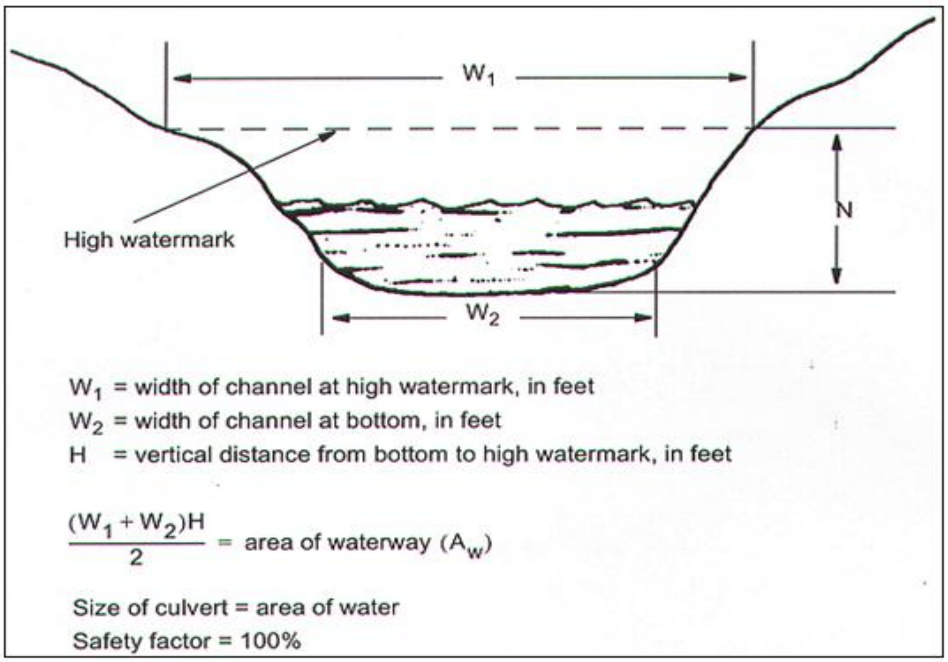

</td></tr>
</table>

Figure A7.32. Diagram of Pipe Urinal with Soakage Pit

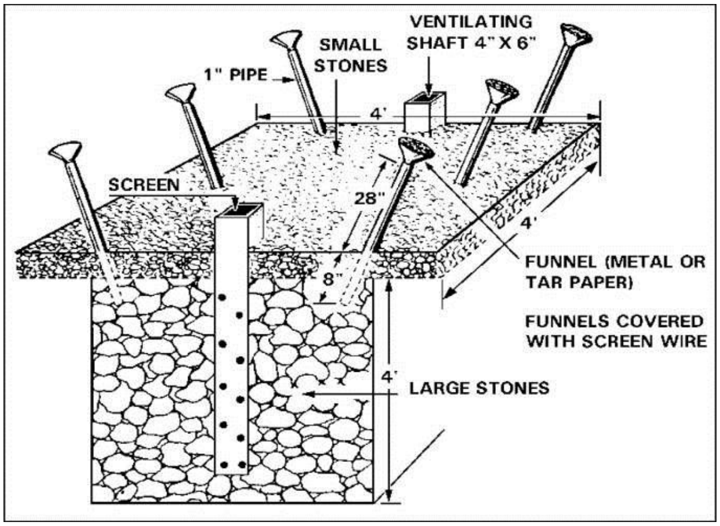


Figure A7.33. Expedient Straddle Trench Latrine Without Partitions

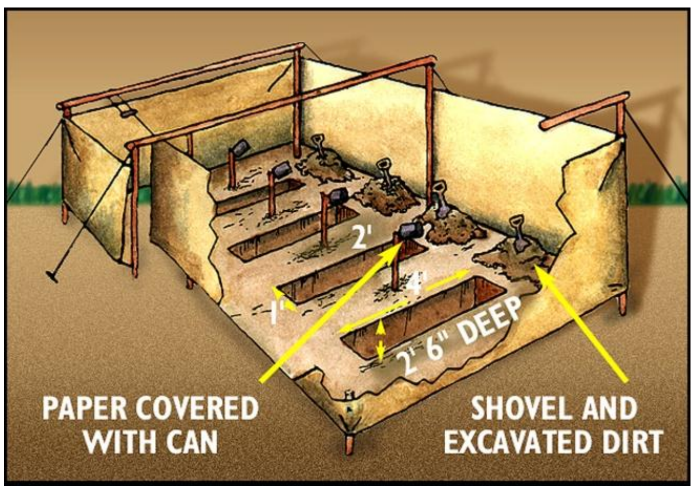


Figure A7.34. Common Grease Trap Concept/Layout

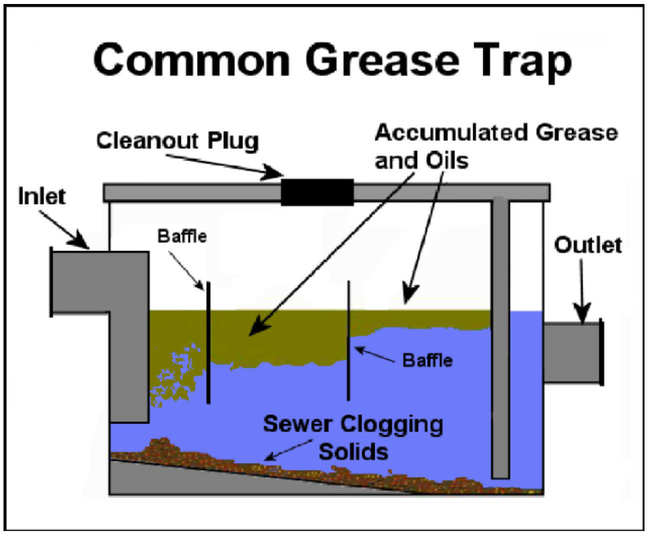


Table A7.34. Wastewater Volumes—Initial Beddown

Purpose	Quantity (GPD)	Quantity To Be Disposed (GPPPD)	Comments
Drinking	4.0	2.0	1/2 of Drinking Water
Personal Hygiene	3.0	2.0	Portion of Personal Hygiene
Showers	5.0	5.0	100% Becomes Waste
Food Preparation	4.0	3.0	Only Kitchen Clean-Up Considered
Vehicles	0.5	0.0	No Wastewater Expected
Hospital	1.0	1.0	100% Becomes Waste
Heat Treatment	1.0	0.0	No Wastewater Expected
Construction	2.0	0.0	No Wastewater Expected
Graves Registration	0.5	0.0	No Wastewater Expected
Laundry	2.0	2.0	100% Becomes Waste
Aircraft Cleaning	2.0	0.0	No Wastewater Expected
Firefighting	2.0	0.0	No Wastewater Expected
Loss Factor (10%)	3.0	0.0	No Wastewater Expected
	30.0	**15.0**	

Table A7.35. Basic Ice Requirements

Base Population	Ice Requirements (pounds/day)
550	2,420
1,100	4,840
2,200	9,680
3,300	14,520

Table A7.36. Evaporation Lagoon Size

Base Size	Wastewater (GPD)	Lagoon Area Required (SF)	Number of Lagoons	Dimensions at 5’ Depth
550	8,250	100,000	9	120´ x 120´
1100	16,500	200,000	9	164´ x 164´
2200	33,000	400,000	9	226´ x 226´
3300	49,500	600,000	9	273´ x 273´
4400	66,000	800,000	9	313´ x 313´
5500	82,500	1,000,000	9	348´ x 348´
6600	99,000	1,200,000	9	380´x 380´

Table A7.37. Ground Fuels Specifications and Properties

	MGX	DF-1/FO-2	DFM	DF-2
Density (lb/gal)	6.2	6.9	7.0	6.9
Flash Point (°F)	-30 (approx)	100	140	125
Freeze Point (°F)	-75 (approx)	41 (approx)	30	34 (approx)
API Gravity (max)	71	-	-	42
API Gravity (min)	47	-	-	33
MIL-SPEC	VV-G-190	ASTM D975	MIL-F-16884	ASTM D975
NSN	9130-00-264-6128	9130-00-286-5286	9140-00-273-2377	9140-00-286-5294
NATO/ASCC Symbol	F46/F49/F50	F-54	F-76	F-54
Centane Number	-	45	45	45
Cloud Point °F-max -		-60	30	Spec by user
Pour Point °F-max	-	Spec by user	20	Spec by user
Viscosity min	-	1.4cSt	1.8cSt	2.0cSt
Viscosity max	-	3.0cSt	4.5cSt	4.3cSt
Sulfur % max	0.10	0.5	1.00	0.5
Operating Temp	-	-25 to 32	-	-
Flash Point F-min	-	-	140	-
TO Reference	42B 1-1-1	42B 1-1-1	42B 1-1-1	42B 1-1-1

Figure A7.35. Typical Fuel Dike Layout (10K Bladder)

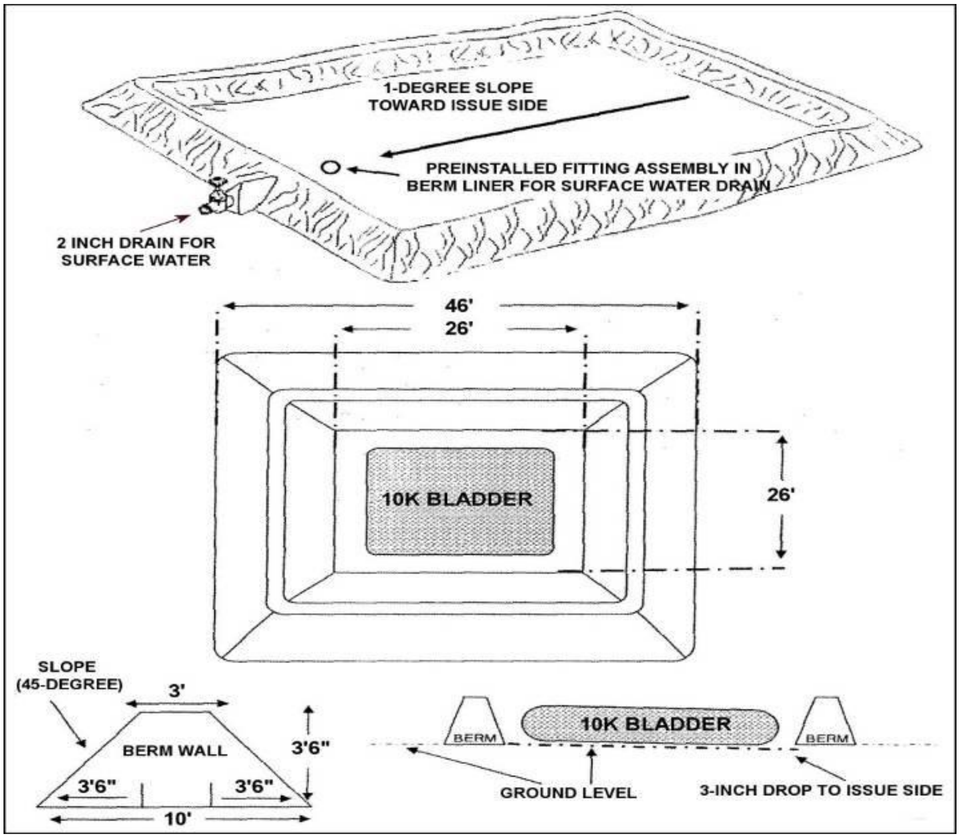


Table A7.38. Fuel Bladder Specifications

Capacity	Bladder Dimensions										Weight Dry (Approx.)[2]
	Full (Approximately)[1]						Empty				
	Length		Width		Height		Length		Width		
	Ft	In	Ft	In	Ft	In	Ft	In	Ft	In	Pounds
500	13	5	9	0	5	8	5	1	4	4	250
3,000	12	6	12	6	4	0	14	0	14	0	210
10,000	20	6	20	6	4	0	22	0	22	0	375
20,000	26	6	22	6	5	2	28	0	24	0	680
50,000	66	0	22	6	5	5	68	2	28	1	1,500
50,000	62	8	22	7	5	2	65	0	24	6	1,026
210,000	68	5	68	5	6	5	70	0	70	0	5,000
210,000[3]	72	5	73	4	5	6	74	4	73	2	4,217

1-After settling (height is greater on initial fill)
2-Tank only. no accessories
3-Tanks produced by MPC Containment Systems after October 2008

(Ref: T.O. 37A12-15-1)

Figure A7.36. Typical Berm/Dike Layout For 50k and 210k Fuel Bladders

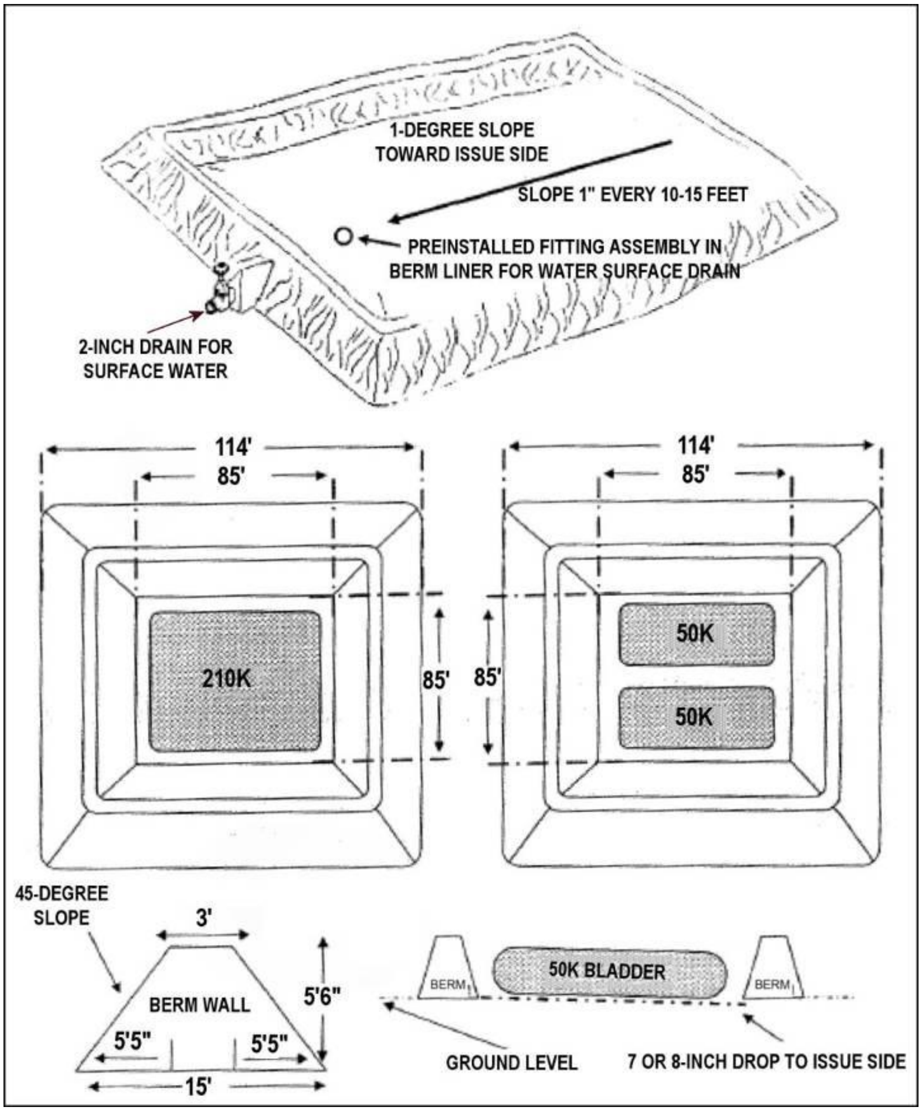


Figure A7.37. Primary and Secondary Dikes Around Fuel Bladder

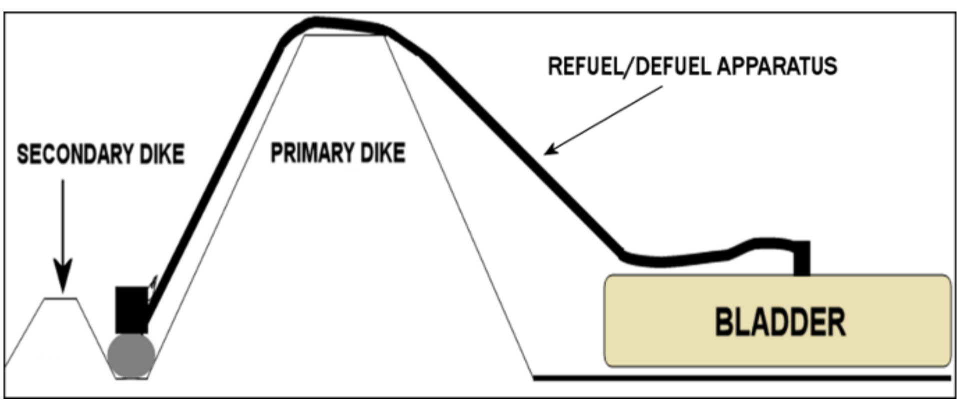


Table A7.39. Cryogenics Fuel Specifications and Properties

DATA	OXYGEN	NITROGEN
Boiling Point	-297 (F), -183 (C)	-320 (F), -196 (C)
Freezing Point	-361 (F), -218 (C)	-346 (F), -210 (C)
Liquid Density	9.52lb/gal at -297 (F)	6.74lb/gal at -320 (C)
Liquid Density	1.14g/ml at -183 (C)	0.807g/ml at -196 (C)
Odor	None	None
Purity (% by vol)	99.6 min/no limit	99.5 min
TO Reference	42B6-1-1	42B7-3-1-1
Specification	MIL-O-27210	MIL-P-27401

(Ref: AFPAM 23-221)

Table A7.40. Fuel Reference Data

Fuel Reference Data

(The alternate emergency fuel in a given category is listed in order of preference indicated by alphabetical letters)

FUEL	JP-4 Support Equipment	Diesel Support Equipment	Diesel Power Generation	Heating Plant Boilers
JP-4 or Commercial Jet B	Primary	D[1,2]	D[1,2]	--
JP-5	Primary	B[3]	B[3]	A[4]
JP-8	Primary	B[3]	B[3]	A[4]
TS-1 (with US DOD fuel additives)	Primary	C	C	--
AVGAS	Blended C[1,5]	--	--	--
Leaded MOGAS	Blended C[1,5]	--	--	--
Unleaded MOGAS	Blended B[1,5]	--	--	--
Fuel Oil Grades 1& 2	--	C	C	Primary
Diesel Fuel Marine (DFM)	B[1,9]	C	A	A[4]
Commercial Jet A	Primary	B[3]	B[3]	A[4]
Commercial Jet A-1	Primary	B[3]	B[3]	A[4]
Diesel Low Sulfur 1-D	A[1,6]	Primary	Primary	A[4]
Diesel Low Sulfur 2-D	A[1,6]	Primary	Primary	A[4]
B20	--	A	B[1]	B[1]

Notes:

1. EMERGENCY ONLY.
2. Blended with 50% Diesel (DF-2 only) by volume. Aviation Fuel Grade JP-4 (or Jet B) should be used only when no other fuels are available. JP-4 (or Jet B) and mixtures of JP-4 (or Jet B) and other fuels are dangerous due to the extremely low flash point of the JP-4 (or Jet B). When this fuel or fuel mixtures must be used in DAY TANKS or operating tanks located inside buildings or structures, every precaution must be taken to protect the product from any ignition source. Base Ground Safety Personnel must be consulted prior to implementing use of JP-4 in diesel engines. Tanks containing this mixture should be temporarily marked - BLENDED FUEL IN USE — DANGER.
3. Some units powered by diesel fuels are authorized to operate on JP-5/JP-8 as a primary or alternate fuel. Refer to the applicable equipment manual for instructions.
4. Blending and burning alternate fuels with conventional boiler fuel must be coordinated with civil engineering at command level. For detailed engineering data on blending, contact AFCESA/CESM, 139 Barnes
Drive, Suite 1, Tyndall AFB, FL 32403-5319; COMM - (850) 283-6222, DSN - 523-6222.
5. Blended 50/50 with JP-4. Under no circumstances should this blend be premixed and stored. Equipment utilizing this blend should be tagged - BLENDED FUEL IN USE.
6. Some mobile electric power units are authorized to operate on diesel fuels as an alternate fuel. Refer to the applicable equipment manual for clarification. Contact the applicable AFMC technical office if further clarification is required. (Ref. AFPAM 23-221)

Figure A7.38. Rock Identification

Foliated			Very fine-grained; splits along thin planes		Slate
Foliated			Metallic reflection; splits into slabs and flakes or thin semitransparent sheets		Schist
Foliated			Contains streaks or bands of light and dark minerals; breaks to bulky, angular fragments		Gneiss
Very Fine-Grained	Frothy		Light colored; lightweight; easily crushed		Pumice
Very Fine-Grained	Frothy		Dark colored; cindery		Scoria
Very Fine-Grained	Glass		Light colored; massive; extremely hard		Quartz
Very Fine-Grained	Glass		Dark colored; may have some gas bubbles		Obsidian
Very Fine-Grained	Stony	Soft	No acid reaction	Earthy; clay odor; platy	Shale
Very Fine-Grained	Stony	Soft	No acid reaction	May have small pieces of glass; low density	Tuff
Very Fine-Grained	Stony	Soft	Acid reaction	Sugary appearance Dull and massive	Marble Limestone
Very Fine-Grained	Stony	Hard	Waxy; very hard; weathers to soft white		Chert
Very Fine-Grained	Stony	Hard	Dull; may contain some gas bubbles or visible crystals	Light colored Dark colored	Felsite Basalt
Very Fine-Grained	Stony	Hard	Sandy; mostly one mineral (quartz)	Gritty sandpaper feel Sugary; not gritty	Sandstone Quartzite
Coarse-Grained	Hard		Sandy; mostly one mineral (quartz)	Gritty sandpaper feel Sugary; not gritty	Sandstone Quartzite
Coarse-Grained	Hard		Mixed minerals; salt-and-pepper appearance	Light colored Dark colored	Granite Gabbro-diorite
Coarse-Grained	Hard		Fragmental; appearance of broken concrete		Conglomerate
Coarse-Grained	Soft		Fragmental; may contain small pieces of glass	Low density	Tuff
Coarse-Grained	Soft		Acid reaction	Sugary appearance Shell fragments	Marble Limestone

Figure A7.39. Rock Characteristics

Rock Type	Toughness	Hardness	Durability	Chemical Stability	Surface Character	Crushed Shape	Use as Aggregates		Use as Base Course or Subbase
							Concrete	Asphalt	
Granite	Good	Good	Good	Excellent	Fair to good	Good	Fair to good	Fair to good**	Good
Syenite							Good	Good	
Gabbro diorite	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Excellent
Diabase basalt	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Excellent	Excellent	Excellent
Felsite	Excellent	Good	Good	Questionable	Fair	Fair	Poor*	Fair	Fair to good
Conglomerate breccia	Poor	Poor	Poor	Variable	Good	Fair	Poor	Poor	Poor
Sandstone	Variable	Variable	Variable	Good	Good	Good	Poor to fair	Poor to fair	Fair to good
Shale	Poor	Poor	Poor	Questionable	Fair to good	Poor	Poor	Poor	Poor
Limestone	Good	Good	Fair to good	Good	Good	Good	Fair to good	Good	Good
Dolomite							Good	Good	
Chert	Good	Excellent	Poor	Poor	Fair	Poor	Poor*	Poor**	Poor to fair
Gneiss	Good	Good	Good	Excellent	Good	Good to fair	Good	Good	Good
Schist	Good	Good	Fair	Excellent	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor-fair
Slate	Good	Good	Fair to good	Excellent	Good	Poor	Poor	Poor	Poor
Quartzite	Excellent	Excellent	Excellent	Excellent	Good to fair	Fair	Good	Fair to good**	Fair to good
Marble	Good	Fair	Good	Good	Good	Good	Fair	Fair	Fair

*Reacts (alkali-aggregate)
**Use antistripping agents.

(Ref: FM 5-430-00-1)

Figure A7.40. Soil Characteristics

Symbol	Description	Drainage Characteristics	Airfield Index (frost susceptibility)	Value as a Subgrade	Value as a Subbase	Value as a Base	Compaction Equipment
G	Gravels and sands; Gravels with little or no fines	Excellent	None to very slight	Good to excellent	Good to excellent	Fair to good	Crawler tractor Rubber-tire roller Steel-wheel roller
GM	Silty gravels; Gravel-sand silt mixture	Fair to practically impervious	Slight to medium	Good to excellent	Fair to good	Not suitable	Rubber-tire roller Sheepsfoot roller
GC	Clayey gravels; Gravel; Sand-clay mixtures	Poor to practically impervious	Slight to medium	Good	Fair	Not suitable	Rubber-tire roller
S	Sands and gravels; Sand with little or no fines	Excellent	None to very slight	Fair to good	Fair to good	Not suitable	Crawler tractor Rubber-tire roller
SM	Silty-sands; Sand-silt mixtures	Fair to practically impervious	Slight to medium	Fair to good	Poor to fair	Not suitable	Rubber-tire roller Sheepsfoot roller
SC	Clayey sands; Sand-clay mixtures	Poor to practically impervious	Slight to high	Poor to fair	Poor	Not suitable	Rubber-tire roller Sheepsfoot roller
M	Inorganic silts and very fine sand; Rock four; Clayey silts with slight plasticity	Fair to poor	Medium to high	Poor to fair	Not suitable	Not suitable	Rubber-tire roller Sheepsfoot roller
CL	Inorganic clays, low to medium plasticity; Gravely or sandy clays	Practically impervious	Medium to high	Poor to fair	Not suitable	Not suitable	Rubber-tire roller Sheepsfoot roller
CH	Inorganic clays of high plasticity	Practically impervious	Medium	Poor to fair	Not suitable	Not suitable	Sheepsfoot roller
O	Mineral grains containing highly organic matter	Poor to practically impervious	Medium to high	Poor to very poor	Not suitable	Not suitable	Rubber-tire roller Sheepsfoot roller
PT	Peat and other highly decomposed vegetable matter	Fair to poor	Slight	Not suitable	Not suitable	Not suitable	Compaction not practical

Figure A7.41. . Soil Particle Size

Component	Size Range
Cobbles	Above 3 inches
Gravel Coarse Fine	3 inches to No. 4 sieve 3 inches to 3/4 inch 3/4 inch to No. 4 sieve
Sand Coarse Medium Fine	No. 4 to No. 200 sieves No. 4 to No. 10 sieves No. 10 to No. 40 sieves No. 40 to No. 200 sieves
Fines (clay or silt)	Below No. 200 sieve (no minimum size)

Figure A7.42. Soil Classification Symbols

Soil Groups	Symbol
Gravel	G
Sand	S
Silt	M
Clay	C
Organic (silts and clays)	O
Organic (peat)	Pt
Soil Characteristics	**Symbol**
Well graded	W
Poorly graded	P
Low LL (less than 50)	L
High LL (50 or greater)	H

(Ref: FM 5-472)

Figure A7.43. Grain Size Group

Size Group	Sieve Size	
	Passing	Retained On
Cobbles	No maximum size*	3 inches
Gravels	3 inches	No. 4
Sands	No. 4	No. 200
Fines (clay or silt)	No. 200	No minimum size
* In military engineering, the maximum size of cobbles is accepted as 40 inches, based on the maximum jaw opening of a rock-crushing unit.		

Figure A7.44. Hasty Field Identification of Soils (Part 1)

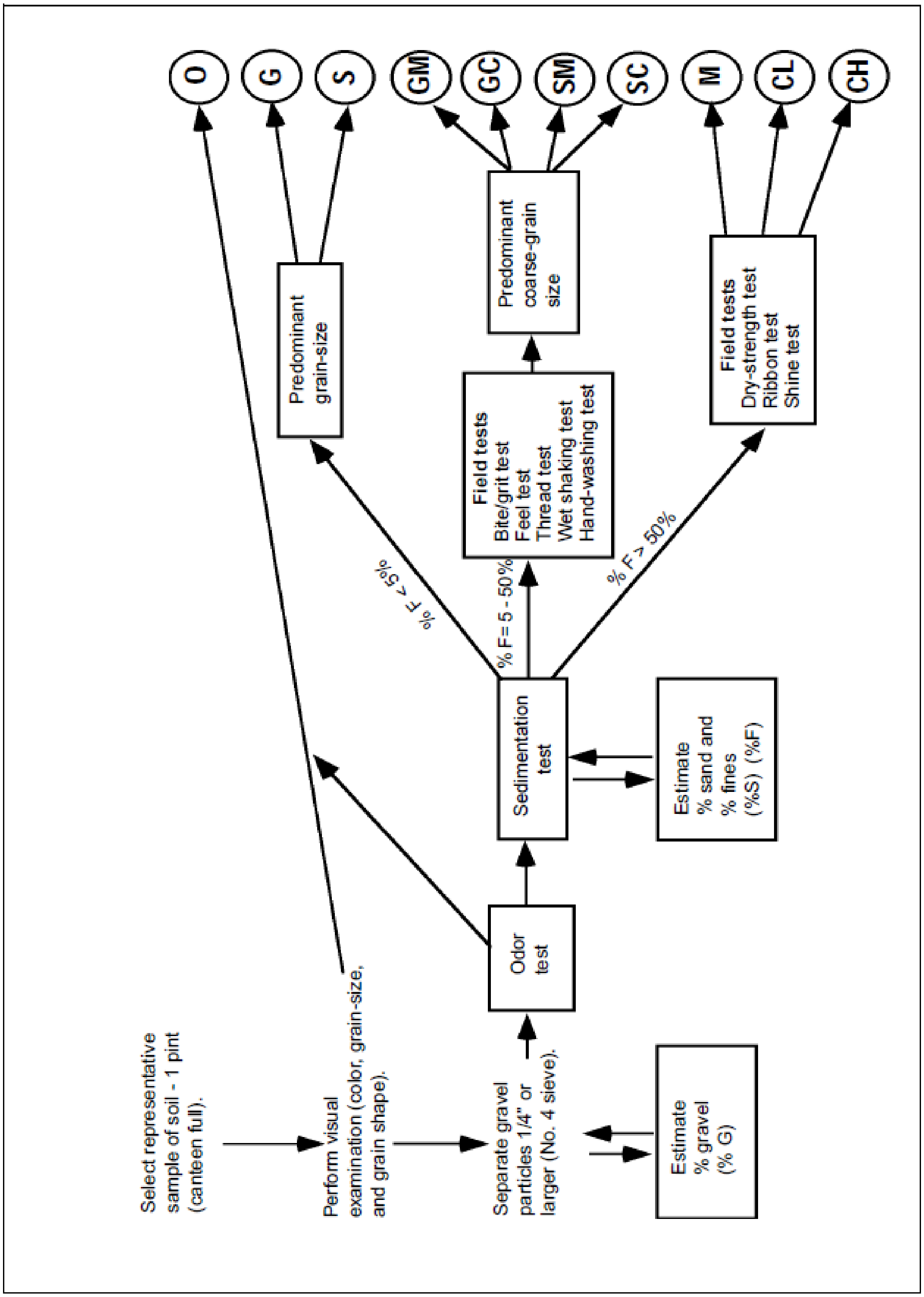


Figure A7.45. Hasty Field Identification of Soils (Part 2)

1. Perform a visual examination of the sample.
   a. Color.
   b. Grain size.
   c. Grain shape.
   d. Contents— leaves, grass, and other possible organic material.

2. Separate the gravel.
   a. Remove from the sample all particles larger than 1/4 inch in diameter (No. 4 sieve).
   b. Estimate the % G.

3. Perform the odor test.
   a. Heat the sample (less gravel) with a match or open flame.
   b. If the odor becomes musty or foul smelling, there is a strong indication that organic material is present.

4. Perform the sedimentation test to determine the % S.
   a. Place approximately 1 inch of the sample (less gravel) in a glass jar.
   b. Mark the depth of the sample with a grease pencil.
   c. Cover the sample with 5 inches of water with at least 1 inch space to the top of the jar.
   d. Cover and shake the mixture for 3 to 4 minutes.
   e. Place on a flat surface and allow sand particles to settle for 30 seconds.
   f. Compare the settled material after 30 seconds to the grease-pencil mark and estimate the percent that has settled.
   g. Determine % S for the overall sample.
   % S = (% settled) x (100% - % G)
   h. Determine % F for the overall sample.
   % F = 100% - (% S + % G)

*5. Perform the bite or grit test. Place a pinch of the sample between the teeth and bite.
- If the sample feels gritty, the sample is silt (M).
- If the sample feels floury, the sample is clay (C).

*6. Perform the feel test. Rub a portion of dry soil over a sensitive part of the skin, such as the inside of the wrist.
- If the feel is harsh and irritating, the sample is silt (M).
- If the feel is smooth and floury, the sample is clay (C).

*7. Perform the roll or thread test.
   a. Form a ball of moist soil (marble size).
   b. Attempt to roll the ball into a thread 1/8 inch in diameter.
   - If a thread is easily obtained, it is clay (C).
   - If a thread cannot be obtained, it is silt (M).

*8. Perform the wet shaking test.
   a. Place the pat of moist (not sticky) soil in the palm of your hand (the volume is about 1/2 cu in).
   b. Shake the hand vigorously and strike it against the other hand.
   c. Observe how rapidly water rises to the surface.
   - If it is fast, the sample is silty (M).
   - If there is no reaction, the sample is clayey (C).

*9. Perform the breaking or dry-strength test.
   a. Form a moist pat 2 inches in diameter by 1/2 inch thick.
   b. Allow it to dry with low heat.
   c. Place the dry pat between the thumb and index finger only and attempt to break it.
   - If breakage is easy, it is a silt (M).
   - If breakage is difficult, it is a clay of low plasticity (CL).
   - If breakage is impossible, it is a clay of high plasticity (CH).

*10. Perform the ribbon test.
   a. Form a cylinder of moist soil, approximately cigar shape and size.
   b. Flatten the cylinder over the index finger with the thumb, attempting to form a ribbon 8 to 9 inches long, 1/8 to 1/4 inch thick, and 1 inch wide.
   - If 8 to 9 inches is obtained, it is (CH).
   - If 3 to 8 inches is obtained, it is (CL).
   - If less than 3 inches is obtained, it is silt (M).

*11. Perform the shine test. Draw a smooth surface, such as a knife blade or a thumbnail, over a pat of slightly moist soil.
- If the surface becomes shiny and lighter in texture, the sample is a highly plastic clay (CH).
- If the surface remains dull, the sample is a low plasticity clay (CL).
- If the surface remains very dull or granular, the sample is silt or sand (M).

*These tests are conducted only with material that passes the No. 40 sieve.

Table A7.41. Soil Stabilization Methods

Soil Stabilization Methods Most Suitable for Specific Applications		
Purpose	**Soil Type**	**Method**
Subgrade Improved load carrying and stress distribution characteristics	Fine granular	SA, SC, MB, C
	Coarse granular	SA, SC, MB, C
	Clays of low PI	C, SC, CMS, LMS, SL
	Clays of high PI	SL, LMS
Reduce frost susceptibility	Fine granular	CMS, SA, SC, LF
	Clays of low PI	CMS, SC, SL, LMS
Waterproofing and improved runoff	Clays of low PI	CMS, SA, LMS, SL
Control of shrinkage and swell	Clays of low PI	CMS, SC, C, LMS, SL
	Clays of high PI	SL
Reduce resiliency	Clays of high PI	SL, LMS
	Elastic silts or clays	SC, CMS
Base course stabilization Improvements of substandard materials	Fine granular	SC, SA, LF, MB
	Clays of low PI	SC, SL
Improved load carrying and stress distribution characteristics	Course granular	SA, SC, MB, LF
	Fine granular	SC, SA, LF, MB
Reduction of pumping	Fine granular	SC, SA, LF, MB, membranes
Dust palliative	Fine granular	CMS, SA, Oil or bituminous surface spray, APSB
	Plastic soils	CMS, SL, LMS, APSB, DCA 70

LEGEND: Where the methods of treatment are:	
APSB = Asphalt penetration surface binder	MB = Mechanical blending
C = Compaction	SA = Soil-asphalt
CMS = Cement modified soil	SC = Soil-cement
DCA70 = Polyvinyl acetate emulsion	SL = Soil-lime
LF = Lime fly ash	PI =Plasticity Index
LMS = Lime modified soil	

Table A7.42. Recommended Dust Palliatives and Product Application

Application	Primary Solution(s)				Secondary Solution(s)			
	Product Category	Application Rate	Dilution Ratio	Application Type	Product Category	Application Rate	Dilution Ratio	Application Type
Fixed-wing Airfields	Synthetic Fluid	0.4 gsy	N/A	Topical	Polymer Emulsion	1.2 gsy	3:1	Admix*
Roads	Polymer Emulsion	0.8 gsy	3:1	Admix**	Synthetic Fluid	0.6 gsy	N/A	Topical
Helipads	Synthetic Fluid	0.4 gsy	N/A	Topical	Polymer Emulsion	1.2 gsy	3:1	Topical
Base Camps	Synthetic Fluid	0.4 gsy	N/A	Topical	Polymer Emulsion	0.6 gsy	3:1	Topical
					Polysac-charide	0.6 gsy	3:1	Topical

* Depth of mixing should be a minimum of 4 inches (102 millimeters).
** Depth of mixing should be a minimum of 3 inches (76 millimeters).

(Ref: ETL 09-3)

Figure A7.46. Recommended Slump for Various Types of Construction

Types of Construction	Slump, in Inches	
	Maximum *	Minimum
Reinforced foundation walls and footings	3	1
Plain footings, caissons, and substructure walls	3	1
Beams and reinforced walls	4	1
Pavements and slabs	4	1
Mass concrete	2	1

* **May be increased 1 inch for consolidation by hand methods such as rodding and spading.**

Table A7.43. Contingency Airfield Pavement Smoothness Requirements

Pavement Category	Direction of Testing	Tolerance
Runways and taxiways	Longitudinal	3 mm (0.125 in)
	Transverse	6.5 mm (0.25 in)
All other airfield and helicopter paved areas	Longitudinal	6.5 mm (0.25 in)
	Transverse	6.5 mm (0.25 in)

Table A7.44. CBR Ratings for Commonly Used Base Courses for Roads and Airfields

Type	CBR
Graded, crushed aggregate	**100**
Water-bound macadam	**100**
Dry-bound macadam	**100**
Bituminous base course, central plant hot mix	**100**
Lime rock	**80**
Bituminous macadam	**80**
*Stabilized aggregate (mechanically)	**80**
Soil cement	**80**
Sand shell or shell	**80**
*It is recommended that stabilized aggregate base-course material not be used for tire pressures in excess of 100 psi.	

(FM 5-430-00-1)

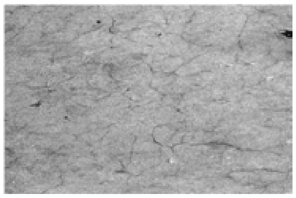
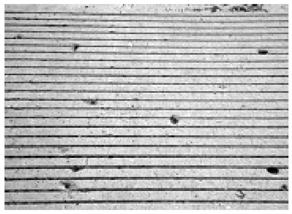
Table A7.45. Troubleshooting Guide for Portland Cement Concrete

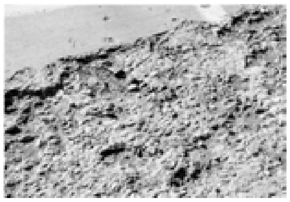
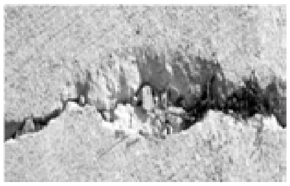
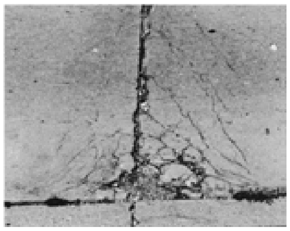
Problem	Cause or Definition	Action
False set	Unusual stiffening of concrete far ahead of initial set with little evolution of heat (rare)	Do not add water Plasticity can be restored with additional mixing Notify cement supplier
Premature hardening	Improper use of accelerator High concrete temperature	Use retarders Avoid Type III, lower concrete temperature Use pozzolans
Problem	Cause or Definition	Action
Slump out of specification or varying	Change in water content or aggregate gradation Concrete temperature too high (stiffens with temperature increase)	Check aggregate moisture contents and gradations Check water being added at the plant Check if water has been added onsite Lower concrete temperature
Fluctuating air content	Pozzolan varying Cement brand changed Sand gradation changed Worn mixer blades Overloading mixer Excessive/variable mixing Organic contamination Interaction with admixtures such as calcium chloride Improper air entraining agent or change in brand	Check materials and construction procedures
Excessive concrete temperature	High ambient temperatures Hot cement	Lower concrete temperature by chilling water, cooling aggregate, paving at night
Failure to set	Organic contamination Retarder not dispersed	Check water, aggregates, equipment for contamination Better mixing to disperse retarder
Sticky mix	Sand too fine Using wood float on air-entrained concrete	Change sand gradation Use magnesium or aluminum floats
Honeycombing	Inoperative vibrators Inadequate vibration Excessive vibrator spacing Concrete segregation	Check vibrators Improve material handling, mixing, and placing procedures to avoid segregation
Excessive edge slump	Poor and/or nonuniform concrete Improper equipment operation and/or unskilled labor	Adjust mix design and construction procedures

Problem	Cause or Definition	Action
Smoothness problems	Nonuniform concrete “Stop-and-go” paver operation Too much or too little concrete in front of paver	Improve mixing and construction procedures
Popouts	Unsound aggregates Clay balls	Check aggregates
Scaling	Overfinishing Premature freezing of concrete	Improve finishing technique Protect concrete from freezing
Contraction cracking	Sawing too late Slab size too large	Saw sooner Check slab dimensions
Raveling of saw cut	Sawing too soon	Wait longer to saw
Plastic shrinkage cracking	Excessive loss of moisture due to temperature, humidity, wind, and/or curing procedures	Lower concrete temperature Use wing breaks and sun screens Pave at night Improve curing procedure
Low-strength concrete	Improper sample preparation, curing, and testing Excessive water/cement ratio Contamination Batching errors Improper mixing Inadequate consolidation Inadequate curing	Check sampling, materials, batching, mixing, construction, and curing procedures
Joint spalls	Excessive hand finishing Adding concrete to fix low spots Nonuniform concrete Damage from equipment	Improve construction practices

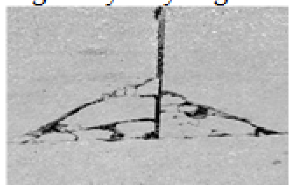
(Ref: ETL 09-2)

Table A7.46. Pavement Surface Defects

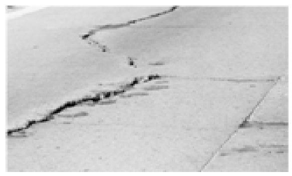
Defects and Examples
Map cracking. Fine surface cracks caused by either improper cure, overworking the surface during finishing, or aggregate quality problems know as alkali-silica reactivity (ASR). 
Pop-outs. Individual pieces of large aggregate pop out of the surface. Often caused by absorbent aggregates that deteriorate under freeze-thaw cycles. 

Scaling. Surface deterioration that causes loss of fine aggregate and mortar. The cause often is using concrete which has not been air-entrained, making the surface susceptible to freeze-thaw damage. 
Spalling. The loss of a piece of the concrete pavement from the surface or along the edges of cracks and joints. Cracking or freeze-thaw action may break the concrete loose, or spalling may be caused by poor quality materials. 
Slab cracks. Slab cracks divide the slab into 2 or more pieces. They can be caused by thermal stresses, poor subgrade support, or heavy loadings. They are sometimes related to slabs with joints spaced too widely. Slabs with a length-to-width ratio greater than 1.25 are more likely to develop mid-slab cracks. 
D-cracks. D-cracks or disintegration cracking, develop when the aggregate is able to absorb moisture. This causes the aggregate to break apart under freeze-thaw action which leads to deterioration. Usually, it starts at the bottom of the slab and moves upward. Fine cracking and a dark discoloration adjacent to the joint often indicate a D-cracking problem. 

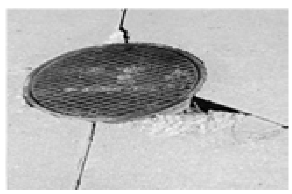
Corner cracks. Usually these cracks are within a foot or two of the slab corner and are caused by insufficient soil support or concentrated stress due to temperature-related slab movement. The corner breaks under traffic loading. They may begin as hairline cracks.



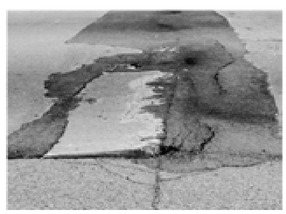
Meander cracks. Some pavement cracks appear to wander randomly. They may cross a slab diagonally or meander in a random manner. Meander cracks may be caused by settlement due to unstable subsoil or drainage problems. Frost heave and spring thaw can also cause them.



Manhole and inlet cracks. The pavement adjacent to a light can, manhole, or storm sewer inlet often cannot accommodate normal pavement movement due to frost heaving and temperature changes.



Blowups. Concrete slabs may push up or be crushed at a joint. Often caused by expansion of the concrete where incompressible materials (sand, debris, etc.) have infiltrated into poorly sealed joints.



(Ref: FAA Pub AC 150/5320-17)

Table A7.47. Troubleshooting Asphalt Concrete Pavement

Problem	Symptom	Test	Potential Cause
Low asphalt content	Dry appearance Stiff mix Uncoated aggregate Brown color	Extraction	Mix design Faulty scales or metering
High asphalt content	Shiny appearance Mix slumps in truck	Extraction	Mix design Faulty scales and metering
Improper gradation	Course appearance Fine appearance Dry appearance Shiny appearance	Sieve analysis	Faulty scales Cold feed setting Segregation during handling Change in gradation delivered to plant Mix design
Grade	Birdbaths	Survey	Not using stringline or stringline not set properly
Smoothness	Birdbaths and/or rough ride	Straightedge	Stopping and starting paver Quick starts and stops with rollers Parking rollers on finished surface Underlying surface is uneven Excessive manual operation of thickness control on paver
Roller checking	Hairline cracks	Visual	Mix too hot Excessive rolling with steel wheel roller Too much tack coat Dirty existing surface Too many fines in mix
Improper bond to underlying layer	Hairline cracks	Inspection of cores	Too much tack Not enough tack Dirty existing surface Bad tack material

(Ref: ETL 09-2)

Table A7.48. Common U.S. to Metric Conversions

Length		
U.S. Unit	**Metric Equivalent**	
Inch	2.5400	Centimeters
Inch	25.4001	Millimeters
Feet	0.3048	Meters
Mile	1.6093	Kilometers
Area		
Square inch	6.4516	Square centimeters
Square feet	0.0929	Square meters
Pressure		
Pounds per square inch	0.0700	Kilogram-force per square centimeters
Volume		
Gallon (liquid)	3.7854	Liters
Gallon (dry)	4.4048	Liters
Cubic feet	0.0283	Cubic meters
Cubic inch	16.3870	Cubic centimeters
Mass (Weight)		
Pound	0.4536	Kilograms
Temperature		
Degrees 100 (F)	37.7777	Degrees (C)
Degrees 72 (F)	22.2222	Degrees (C)
Degrees 32 (F)	0.0000	Degrees (C)
Degrees 0 (F)	17.7777	Degrees (C)
Angle		
Degrees (angular)	17.7778	Mils

Table A7.49. Fractions of an Inch

Inch	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2
Cm	0.16	0.32	0.48	0.64	0.79	0.95	1.11	1.27
Inch	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
Cm	1.43	1.59	1.75	1.91	2.06	2.22	2.38	2.54

Table A7.50. Common Metric to U.S. Conversions

Length		
Metric Unit	**U.S. Equivalent**	
Centimeter	0.3937	Inches
Millimeter	0.0393	Inches
Meter	3.2808	Feet
Kilometer	0.6213	Miles
Area		
Square centimeter	0.1550	Square inches
Square meter	10.7639	Square feet
Pressure		
Kilogram-force per square centimeter	14.2233	Pounds per square inch
Volume		
Liter	0.2642	Gallons (liquid)
Liter	0.2270	Gallons (dry)
Cubic meter	35.3146	Cubic feet
Cubic centimeter	0.0610	Cubic inches
Mass (Weight)		
Kilogram	2.2046	Pounds
Temperature		
Degrees 0 (C)	32.0	Degrees (F)
Degrees 15 (C)	59.0	Degrees (F)
Degrees 30 (C)	86.0	Degrees (F)
Degrees 45 (C)	113.0	Degrees (F)
Angle		
Mil	0.0562	Degrees (angular)

Table A7.51. Units of Centimeters

Cm	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
Inch	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.31	0.35	0.39

Table A7.52. Metric Equivalents (Distance)

One unit (below) equals →	mm	cm	m	km
Millimeters (mm)	1	0.1	0.001	0.000001
Centimeters (cm)	10	1	0.01	0.00001
Meters (m)	1,000	100	1	0.001
Kilometers (km)	1,000,000	100,000	1,000	1

Table A7.53. Metric Equivalents (Weight)

One unit (below) equals →	g	kg	Metric ton
Grams (g)	1	0.001	0.000001
Kilograms (kg)	1,000	1	0.001
Metric tons	1,000,000	1,000	1