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SUPPORT AND UTILITY STRUCTURES AND FACILITIES (1917-1946): OVERVIEW, INVENTORY AND TREATMENT PLAN

R. Christopher Goodwin and Associates

May 31, 1995

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SUPPORT AND UTILITY STRUCTURES AND FACILITIES (1917 - 1946) OVERVIEW, INVENTORY, AND TREATMENT PLAN

FINAL REPORT

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EXECUTIVE SUMMARY

Description: The *Support and Utility Structures and Facilities (1917 - 1946) Overview, Inventory, and Treatment Plan* presents an historic context and treatment plan for support and utility properties constructed between 1917 and 1946 at military installations. From World War I to World War II, military installations underwent development and modernization that required extensive construction of support and utility facilities. Support and utility buildings and structures consist of: general storage, ordnance storage, fuel storage, water supply systems, sewage disposal systems, power and heating systems, and refuse disposal.

Purpose: The purpose of this project is to assist the Department of Defense with compliance with the National Historic Preservation Act (NHPA) of 1966, as amended. NHPA established the National Register of Historic Places, the national list of properties significant in American history, archeology, architecture, engineering, or culture. Section 110 of NHPA requires federal agencies to establish a program to identify, evaluate, and nominate to the National Register historic properties under their control or jurisdiction. Section 106 of NHPA requires federal agencies to consider the effects of their actions on historic properties; the first step in the Section 106 process is the identification of historic properties. The results of this project will assist DoD with fulfilling its responsibilities under NHPA through providing consistent and comprehensive information on a large segment of real property potentially eligible for the National Register.

Objectives and Results: The objective of this project was to develop a mechanism for the classification, evaluation, and treatment of support and utility buildings and structures constructed between 1917 and 1946. This project presents the following data in fulfillment of these objectives:

(1) an overview of the construction and historical associations of support and utility facilities;

(2) a classification system for support and utility buildings and structures;

(3) a partial inventory of the frequency and distribution of 35,077 current support and utility buildings and structures;

(4) a methodology for evaluating the significance of these facilities within a DoD-wide context; and,

(5) recommendations for the treatment of these properties.

Evaluation Recommendations: Individual examples of support and utility buildings or structures typically do not meet the National Register Criteria for Evaluation; however, support and utility buildings or structures may contribute to National Register historic districts. Supply depots and ordnance or ammunition depots may meet the National Register Criteria for Evaluation as historic districts if they have an important and specific association with military logistical support or ordnance storage in World War I or World War II and embody the distinctive characteristics of depot construction.

Application: The results of this project can assist DoD with the following actions at U.S. military installations in the Continental United States:

- Section 110 surveys to identify and evaluate historic properties; and,
- Section 106 review, including
- Consultation with the State Historic Preservation Officer (SHPO) and Advisory Council on Historic Preservation; or
- Developing a Programmatic Agreement.

This project is particularly relevant to pre-1946 supply or ordnance/ammunition depots.

Authority: This project was conducted in accordance with the National Historic Preservation Act of 1966, as amended. "Protection of Historic Properties" (36 CFR 800) also is applicable. This project also complies with OPNAVINST 5090.1B, Chapter 23, "Historic and Archeological Resources Protection," and Army Regulation 420-40 (the Army's new historic preservation regulation, AR 200-4, is in draft).

Project Background: This project was conducted as a demonstration project (Legacy Project No. 899) of the DoD Legacy Resource Management Program. R. Christopher Goodwin & Associates, Inc. completed this project on behalf of the U.S. Department of Navy, Atlantic Division, Naval Facilities Engineering Command. The Support and Utility Structures and Facilities Overview, Inventory, and Treatment Plan project was designed to fulfill the Legacy Program legislative objectives and to assist DoD in meeting its responsibilities under the National Historic Preservation Act of 1966, as amended.

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CHAPTER I

INTRODUCTION

Cultural Resource Management in the Department of Defense

The Department of Defense (DoD) manages 25 million acres within the United States. These lands contain a range of properties associated with the historical development of the military, as well as with many other facets of North American history and prehistory. Cultural resources are non-renewable resources that document the historical development of the nation; they include real property, personal property, records, and community resources.

Military cultural resource programs, including the identification, evaluation, and management of historic properties, are on-going functions within the respective services. Although Federal Preservation Officers for each service provide guidance in cultural resource management, responsibility for the majority of DoD cultural resource management duties falls upon individual installations, activities, and commands.

As installation-based cultural resource programs evolved, DoD recognized the complex historical inter-relationship of properties associated with the military services. Military construction typically was planned and executed as part of a national defense program. As a result, assessment of the historical significance of DoD properties requires comprehensive comparative data on the historical development of DoD construction. Such comparative data provides a basis for developing consistent management strategies for historic properties. Through the development of comprehensive historic context studies, DoD seeks to provide background and comparative information in a practical and cost-effective manner that is in the public interest.

Legislative Background

The National Historic Preservation Act (NHPA) of 1966, as amended, established the legislative basis for federal historic preservation programs. The implementing regulations are entitled "Protection of Historic Properties" (36 CFR 800).

The NHPA established the National Register of Historic Places, the national inventory of properties significant in American history, architecture, engineering, archeology, and culture. The National Register is continually updated to include significant properties that represent many facets of American history. DoD manages thousands of historic properties that are listed in or eligible for listing in the National Register.

Section 110 of NHPA requires federal agencies to identify, evaluate, and nominate to the National Register historic properties under their control or jurisdiction. Section 110 also requires federal agencies to consider the preservation of the cultural and historical values of historic properties under their control or jurisdiction (16 U.S.C. 470h-2). The Section 110 Guidelines, developed by the Advisory Council on Historic Preservation, direct federal agencies to establish historic contexts to identify and evaluate historic properties (53FR 4727-46).

Section 106 of NHPA requires federal agencies to take into account the effects their actions may have on properties listed in or eligible for listing in the National Register. Prior to the approval of an undertaking, DoD must allow the Advisory Council on Historic Preservation a reasonable opportunity to comment on the undertaking.

Project Description

The *Support and Utility Structures and Facilities (1917 - 1946) Overview, Inventory, and Treatment Plan* presents an historic context and treatment plan for support and utility properties constructed between 1917 and 1946 at military installations. The report examines the historical development of infrastructure and logistical support on military facilities from the beginning of World War I through the end of World War II. During that period, military installations underwent rapid development and modernization that required extensive construction of support and utility facilities.

The majority of DoD installations active prior to the end of World War II include pre-1946 support and utility facilities classified as permanent construction. Current DoD real property records list 35,077 properties currently categorized as support and utility buildings or structures constructed between 1917 and 1946. These properties are eligible for consideration for listing in the National Register, but evaluation of their significance was difficult due to the lack of consistent, comprehensive, DoD-wide information about their construction and historical associations. This report provides the comparative data necessary for DoD personnel to identify, evaluate, and manage historic properties that are support and utility facilities constructed between 1917 - 1946.

<u>Definition of Support and Utility Facilities</u>

This study covers specific categories of properties related by their *original function*. Two broad categories of properties were identified as support and utility facilities: (1) storage and (2) utility infrastructure. Storage properties were further subdivided into:

- general storage
- ordnance storage
- fuel storage

Utility infrastructure consists of:

- water supply systems
- sewage disposal systems
- power and heating systems
- refuse disposal

<u>Project Background</u>

This project was conducted as a demonstration project (Legacy Project No. 899) of the DoD Legacy Resource Management Program. The Legacy Program was created by the Department of Defense Appropriations Act, 1991 (P.L. 101-511). The purpose of the Legacy Program is:

> To better integrate the conservation of irreplaceable biological, cultural, and geophysical resources within the dynamic requirements of military missions. To achieve this goal, the Department of Defense will give high priority to inventorying, conserving, and restoring biological, cultural, and geophysical resources in a

comprehensive, cost-effective manner in partnership with federal, state, and local agencies and private groups (U.S. Department of Defense 1991:3).

The lessons and data derived from demonstration projects are designed to be incorporated into the DoD cultural resource management program, and then applied to the on-going mission of cultural resource stewardship.

R. Christopher Goodwin & Associates, Inc. completed this project on behalf of the U.S. Department of Navy, Atlantic Division, Naval Facilities Engineering Command. The Support and Utility Structures and Facilities Overview, Inventory, and Treatment Plan project was designed to fulfill the Legacy Program legislative objectives and to assist DoD in meeting its responsibilities under the National Historic Preservation Act of 1966, as amended.

Project Objectives

The purpose of this project was to develop a mechanism for the classification, evaluation, and treatment of support and utility buildings and structures. This purpose was accomplished by completing the following:

- an historical overview of military construction of support and utility facilities, 1917 - 1946;
- a classification system for support and utility buildings and structures constructed between 1917 and 1946;
- an inventory, listing frequency and distribution, of extant properties currently described in DoD real property inventories as support and utility buildings and structures constructed between 1917 and 1946;
- a methodology for evaluating the National Register eligibility of support and utility facilities constructed between 1917 and 1946;
- site visits to four active-duty installations to test the classification system and develop the evaluation methodology; and,
- a treatment plan that provides strategies for the treatment of support and utility buildings and structures constructed between 1917 and 1946.

The primary objective of this project is to assist DoD with compliance with Sections 110 and 106 of the National Historic Preservation Act of 1966, as amended. The results of this project will assist DoD cultural resource managers with fulfilling their NHPA responsibilities through:

- the synthesis and analysis of existing information related to these properties;
- the development of a consistent historic context that encompasses a large segment of similar DoD properties;
- the completion of a partial inventory of a large segment of DoD property; and,

- the establishment of a standard methodology for the identification and evaluation of a large segment of DoD property.

Report Organization

Chapter I presents an introduction to the project. Chapter II describes the project methodology. Chapters III - X provide historical background information and the classification system for support and utility buildings and structures. Chapter III presents an overview of military developments and construction between 1917 and 1946 that summarizes the background historic context. Chapters IV - X are each devoted to a specific type of support and utility property type; each of these chapters provides the technological background for the property type, describes the history of its development and construction at military installations, and presents a list of building types within each category. Chapter XI presents an analysis of the current DoD inventory of support and utility buildings and structures, and relates the current inventory to the classification system developed for this project. Chapter XII presents a methodology for evaluating these properties, and Chapter XIII presents recommendations for how to treat these properties in accordance with the National Historic Preservation Act of 1966, as amended.

Appendices A - D contain the reports for the installations selected for site visits for this project: Aberdeen Proving Ground, Kelly AFB, Naval Base Norfolk, and Marine Corps Development and Education Command, Quantico. Each site visit report provides a summary description of the installations, a description of the methodology used to identify the support and utility buildings and structures at the installations, the expected results of the survey, and the actual results of the survey. Appendix E contains the inventory that describes, the distribution of current support and utility facilities at DoD installations. Appendix F contains the Scope-of-Work for the project. Appendix G is the resumes of the key project personnel.

CHAPTER II

PROJECT METHODOLOGY

The research methodology utilized for this project combined three tasks: archival research, database analysis, and field investigation. This methodology was designed to accomplish the goals of the research design: (1) to develop an historic overview of utility and support buildings; (2) to classify building types; and (3) to anticipate the frequency and distribution of these resources.

Archival Research

Archival research was divided into two phases. Phase I research was designed to collect information on the general development and evolution of infrastructure, utilities, general storage, and ordnance storage. Phase II research focused on support and utility facilities construction by the military. The results of both phases of research were analyzed to develop topologies for the building types relevant to this study.

Secondary sources were reviewed at the Library of Congress, the Naval Historical Center, Command Historian's Office of the Naval Construction Battalion Center at Port Hueneme, the History Office of the U.S. Army Corps of Engineers, and the Library of the National Archives. In addition, periodical literature between 1917 and 1946 was reviewed to identify articles about the development of infrastructure technology. Publications, journal articles, and other secondary sources were sought that contained specific information on the military application of these technologies.

Previous historic contexts developed for military construction were reviewed to provide an overview of military construction and to identify any information relating specifically to support and utility buildings. The *National Historic Context for Department of Defense Installations, 1790 - 1940* (Draft: Cannan et al. 1993) provides a chronological overview, thematic studies, and property types for military construction between 1790 - 1940. The relevant contexts identified in this study are:

The Military and the Progressive Era, 1890-1918
- Development of Logistical Functions
- Wartime Cantonments
- World War I Army Aviation
- Logistical Support of the Fleet
- Personnel Support
- World War I Navy Construction

The Inter-War Years, 1918-1940
- Installation Improvement
- Training, Coastal Defense Schools and Logistics
- New Construction of Air Corps Installations
- Air Corps Logistical Support
- War Plans and the Shift to the Pacific
- Marine Corps Installations

The 1790 - 1940 historic context also defines the property types of general storage, ordnance storage, power plants/ electrical systems, and water and sewage systems. The *Historic Context for Department of Defense Facilities World War II Permanent Construction* (Draft: Hirrel et al. 1994) provides an historic context for permanent construction in the United States during World War II. The report develops the themes of military history, social history, architecture, and technology. The report identifies the primary installation types directly associated with military operations on the homefront: air fields and air stations; coastal fortifications; depots; hospitals; naval bases and stations; naval yards; research, development and testing; strategic communications; training; aircraft production and repair; Chemical Warfare Service installations; and ordnance works or plants. Support and utility buildings and structures are identified as component parts of these different types of installations.

Primary sources included drawing collections at the History Office of the U.S. Army Corps of Engineers at Fort Belvoir, Virginia; Department of Navy drawings in Record Group 71 at the Cartographic and Architectural Branch of the National Archives in College Park, Maryland; and, drawings located at the Naval Construction Battalion Center at Port Hueneme, California. Drawings were examined to classify types of infrastructure and storage buildings and to illustrate the evolution of building types between World War I and the end of World War II. Information collected from drawings included drawing subject, plan number, location of drawing, major construction materials, notable features, and dimensions.

The drawings at the History Office of the U.S. Army Corps of Engineers are organized numerically by drawing series; the collections includes drawings from 1917 through the 1970s. In the mid 1980s, the History Office prepared an index to the drawings. The index is keyed to subjects without reference to drawing date. To utilize this collection, researchers recorded all subject headings related to utility and support buildings and examined drawings included under these index headings.

The drawings that yielded the most information for buildings constructed between 1917 and 1946 were assigned three digit numbers and are contained currently in boxes 85-118 and 145-148. All drawings originally labeled with two digit or alphabetical sequences were developed after 1946. Drawings labeled 700, 800, 900-1100, or T.O. (theater of operations) are temporary mobilization building and were not examined as part of this study. In general, the Quartermaster Corps coded construction drawings numerically by building type and date. This organization greatly assisted the current investigation by illustrating the evolution of specific building types. In most cases, the drawings represent Quartermaster standard plans; few actual construction locations were recorded on the drawings. No assessment has been made of the completeness of the drawing collection in relation to Army construction. Not all support and utility building types were represented in the collections; few drawings date from World War II.

The Cartographic Branch of the National Archives maintains Department of Navy drawings from the nineteenth century through 1941 that were microfilmed during World War II. The drawings were organized by installation, except for fifteen microfilm reels that contain standard drawings. Each installation was assigned a file number. Within each installation file, drawings were grouped according to specific building type. Forty-five categories were established including sewers, water systems, heating systems, electric systems, power plants, magazines, miscellaneous buildings, Marine Corps construction, coaling plants, incinerators, and fuel storage. In addition to the microfilm records, the National Archives also maintains some flat files of architectural drawings.

Eight microfilm reels of standard drawings were examined. Drawings for utility and storage buildings were examined for each major category of active naval installations. The major categories of naval installations included: shipyard, air station, training station, radio station, supply depot, ammunition depot, fueling depot, operating base, and Marine Corps installation. Unique, special-purpose installations were not represented in the sample. After examining the sample installations, the results of the records search were reviewed to ensure that examples of all property types included in this study were represented. Where few examples of a specific building type were documented, additional microfilm reels that contained examples of under-represented property types were examined.

World War II drawings also were reviewed at the Naval Construction Battalion Center at Port Hueneme, California. The drawings were sampled according to the same methodology used for the pre-1941 records at the National Archives. All indices for standard drawings of utility and support structures were inspected and representative drawings were examined. In addition, drawings for one example of each major type of naval installation were reviewed. Particular emphasis was placed on locating examples of utility and support building types constructed during World War II. The World War II drawings located at Port Hueneme were organized using the same principles as at the National Archives. Each installation was assigned a number, and the building types located at the installation were grouped by category.

Database

To quantify extant military utility and support structures built between 1917 - 1946, real property databases were obtained from the Departments of Army, Air Force, and Navy. Current use classifications for each service branch were reviewed and appropriate "use categories" for utility and storage buildings selected, often in conjunction with military personnel. Real property information for selected use categories was requested in a computer database in ASCII format for use in a dBase III program. The purpose of this effort was to obtain an inventory of buildings and structures, built between 1917 and 1946, currently classified as utility and support structures for each service.

The Army provided a computerized database that included the location, category code, construction date, number of buildings constructed in each category code per year, and the current status of the structure. The Navy provided a computerized database that included location, category code, construction date, description, and square footage for Department of Navy properties including the Marine Corps. The Air Force supplied a paper printout of utility and support structures including the location, building number, category code, and construction date.

Record keeping systems vary among the services. The Army and Air Force databases record one use per building while the Navy database lists each use of a building as a separate record. As a result, the Navy database contains multiple records for many buildings. For example, a power house at Cherry Point Marine Corps Base is listed under eight different category codes. Where possible, the Navy database was edited to eliminate secondary building uses and thus, multiple records. In instances where the primary use was impossible to determine, multiple uses were retained in the database. As a result, subtotals of structures by use exceed the total number of buildings in the inventory. The current use data are very detailed. In some cases, identical buildings are classified differently; the two classifications differentiate between use by an installation or by a storage depot. The services do not maintain data indicating the original or historic uses of buildings in their current real property databases; such information must be gleaned from site-specific archival research.

Comparisons between current use classifications and the historic building topologies developed from archival records revealed that building have been reclassified as their uses have changed over time. Current databases cannot be used to predict the complete scope of DoD construction activity for a property type in a particular period since these databases reflect the current use and status of a structure. In general, water, sewage, and electrical utility buildings continue to serve their original function, and thus often retain their historic building use classifications. Discrepancies between historic and current uses often were found for general storage buildings. Many general storage buildings have been converted to other uses since their construction. Conversely, many buildings originally constructed for other uses have been converted to storage.

Thus, while the database provides a useful inventory of current real property constructed between 1917 and 1946 that are classified as support and utility structures, it is not an accurate summary of the property historically associated with the subject of this study. Instead, the database serves as a baseline guide and rough estimate of the frequency and distribution of the building types relevant to this study.

Field Survey

Four installations, one from each service, were chosen for on-site investigation and analysis: Aberdeen Proving Ground, Maryland; Kelly Air Force Base, Texas; Norfolk Naval Base, Virginia; and, Marine Corps Development and Education Command, Quantico, Virginia. Each installation was established about 1917 and expanded during the inter-war period and World War II. Archival research and real property databases indicated that these installations encompassed a wide range of examples of utility and support buildings constructed during the time period relevant to this study. In addition, a draft historic property inventory or a draft cultural resource management plan existed for each installation.

Three objectives were established for each site visit. The first objective was to field verify the building topologies developed during the archival research phase of work. The second objective was to compare historic building use with current use recorded in the real property databases to identify patterns of building change. The third objective was to assess the current appearance of the properties in order to develop guidelines for assessing the integrity of the support and utility structures.

Current maps and real property lists were obtained from the installations before each site visit. Historical building uses were identified from cultural resource inventories or other sources. Buildings were categorized according to the typology developed for this study: utility buildings (water, sewage, refuse disposal, and power) and storage (general, fuel, and ordnance). A windshield survey was conducted of all utility and support buildings identified from the installation real property lists. During this windshield survey, additional properties that fit the topologies also were identified. Representative buildings and structures that retained sufficient integrity to illustrate the property type or that were uncommon examples were selected for survey. Property locations were recorded on installation maps and property descriptions were recorded on standard survey forms (Figure 1). Properties also were documented photographically; two black and white photographs were taken of each surveyed property, except where site access was restricted. Survey teams also interviewed installation personnel knowledgeable about infrastructure and utilities to obtain further site-specific information about the construction, use, and operation of utility systems.

ARCHITECTURAL FIELD SURVEY

Building Number: Original Building No: Building Name:

Location: USGS Quad:

Construction Date: Architect:

City/County/State: Contractor:

Historic Use: Condition: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Present Use:

Rating/Treatment Category: ☐ I ☐ II ☐ III ☐ IV ☐ V

Property Type: Subtype: Styl. Inf.:

Hist. Function: ☐ Domestic ☐ Social ☐ Education ☐ Religion ☐ Recreation ☐ Industrial ☐ Medical ☐ Trans. ☐ Defense ☐ Govt.

Integrity: ☐ Location ☐ Design ☐ Setting ☐ Materials ☐ Workmanship ☐ Association ☐ Feeling

Historic Context:

Registration Status: ☐ listed ☐ not listed Eligibility Recommendation: ☐ eligible ☐ individual ☐ district ☐ not eligible

Construction Category: ☐ Permanent ☐ Semi-Permanent ☐ Temporary

Surveyor: Date Surveyed:

Photo Data: B&W Roll: Frame: Color Roll: Frame:

1. Location
___ original location
___ moved
___ building faces

2. Stories
___ specify #
___ basement

3. Construction
___ wood frame
___ brick
___ clay tile
___ concrete block
___ poured concrete
___ stone
___ composite masonry
___ specify other

4. Plan
___ rectangular
___ circular
___ square
___ irregular
___ L-shaped
___ U-shaped
___ H-shaped
___ T-shaped
___ specify other

5. Ground Floor
___ # x # of bays
___ symmetrical
___ asymmetrical

6. Upper Floors
___ # of bays
___ symmetrical
___ asymmetrical

7. Foundation Material
___ concrete slab
___ concrete pier
___ masonry wall
___ concrete wall
___ specify other

8. Exterior Wall Surface
___ stucco
___ brick
___ clay tile
___ stone
___ concrete block
___ wood siding
___ horizontal
___ vertical
___ wood shingles
___ synthetic shingles
___ synthetic siding
___ specify other

9. Roof Type
___ gable (front)
___ gable (side)
___ hipped
___ flat w/parapet
___ flat w/eaves
___ shed
___ monitor
___ specify other

10. Roof Description
___ clay tile
___ synthetic tile
___ metal standing seam
___ composition shingles
___ composition roll
___ slate shingles
___ # dormers
___ gable
___ other

___ exposed rafter ends
___ boxed eaves
___ ventilator
___ specify other

11. Doors/Entries
___ multiple entry (#)
___ recessed entry
___ single door
___ double door
___ portico entry
___ gable
___ arch
___ flat
___ entabl.
___ transom
___ sidelights
___ sliding track
___ overhead track
___ loading docks
___ specify other

12. Porches
___ # of bays
___ shed roof
___ hipped roof
___ gable roof
___ flat roof
___ inset
___ extension
___ arcade
___ balusters
___ brackets
___ porte cochere
___ specify other

13. Windows
___ wood sash
___ metal sash
___ single hung
___ double hung
___ fixed
___ casement
___ awning
___ hopper
___ pivot
___ # lights
___ specify other

14. Window Details
___ jack arched
___ round arched
___ lintels
___ sills
___ keystones
___ specify other

15. Chimneys
___ specify #
___ interior
___ exterior wall
___ stucco
___ hollow clay tile
___ brick
___ detached

16. Rear Elevation
___ windows
___ single door entry
___ double door entry
___ multiple door entry
___ loading dock
___ overhead track

Other:

Modifications/Alterations:

4/93

Figure 1. Standardized architectural field survey form developed by R. Christopher Goodwin & Associates, Inc.

CHAPTER III

BACKGROUND HISTORY OF MILITARY CONSTRUCTION, 1917 - 1946

The support and utility facilities and structures that are the subject of this study were built to serve the logistical and infrastructure needs of a growing, modern military. During the first half of this century, military supplies and logistics increased in complexity to support the growing breadth and size of military operations. The military devoted more resources towards developing storage facilities, particularly during wartime. During the same period, the government funded programs to improve the standards of living at military facilities, which housed larger populations than ever before. These improvements included utility systems comparable to those in civilian communities of the same period. Improved infrastructure also supplied electricity and other services to industrial military facilities that developed, produced, and repaired the increasingly mechanized means of modern warfare.

The following summary of military development and construction is drawn from two broad context studies funded by the Department of Defense, *National Historic Context for Department of Defense Installation, 1790 - 1940* (Draft: Cannan et al. 1993) and *Historic Context for Department of Defense Facilities World War II Permanent Construction* (Draft: Hirrel et al. 1994).

During the time period covered by this study, what later became the U.S. Air Force was part of the Department of Army, under various names, including Army Air Corps and later Army Air Force. Historical background information related to pre-1946 Air Force installations is included with the discussions of Army construction. Marine Corps facilities are included within the discussion of the Department of Navy.

World War I

The United States entry into World War I required a full-scale mobilization of national resources, including a conscription program and government management of war-related industries. The Americans contributed more than four million soldiers to the eventual Allied victory. In the years preceding the First World War, the services had embarked on a systematic program to improve military training, consolidate and upgrade installations, and adopt new technologies. During the war, extensive construction was undertaken of training camps and stations, and of depots for the storage and shipment of supplies and ordnance.

Navy

By the early twentieth century, new technologies had dramatically affected the Navy's operations and shore establishment. Heavily armored steel warships replaced old wooden ships. New weapons, the submarine and the aircraft, played an important role during World War I, foreshadowing their greater usefulness during World War II.

The nineteenth-century shore establishment of a few yards and stations unable to construct a modern warship grew into a multitude of bustling facilities, each capable of supporting the demands of a rapidly modernizing, ocean-going fleet. Shipyards were modernized to construct and repair steel warships. New research and development facilities opened to test ordnance and ship design. Old methods of instructing recruits on training ships were replaced with new training stations. Communication facilities, magazines, and coaling stations all added to the complexity of the shore establishment installations.

To meet the needs of the modernizing fleet, the Navy began to establish fuel oil depots in 1910 to supply the needs of submarines and destroyers. Its first fuel oil facilities were located on the East Coast at Key West, Charleston, Norfolk, and Narragansett Bay (U.S. Navy Department 1910:25). Another logistical requirement of the Navy was for ammunition storage facilities. To meet this need, the Ordnance Bureau expanded an existing set of naval magazines to serve the fleet. By 1915, the Navy operated six magazines on the East Coast, three of which were within the New York area. Facilities on the West Coast were located at Mare Island and Puget Sound (U.S. Navy Department 1915:312-313).

With the nation's entry into the First World War, the Navy's activities expanded with extraordinary rapidity. Expansion of the fleet also required expansion of the Navy shore establishment. The Navy, like the Army, conserved available resources through stringent economy measures. Wherever feasible, buildings were temporary, wooden buildings, not intended to last beyond the duration of the war. However, the heavy industrial functions of Navy shore facilities required more permanent construction than was necessary for other wartime military construction.

One of the most pressing wartime requirements was the construction of training installations to accommodate the influx of new sailors. The Navy planned a rapid expansion of existing training stations and the addition of training camps to existing Navy installations. These additions generally consisted of hastily constructed temporary barracks, designed to provide a minimum standard of shelter to recruits, and minimal infrastructure to ensure healthy living conditions (U.S. Navy Department 1921:41-73).

Ship repair and service facilities were not constructed so readily. The Navy began to plan for expansion of its yards in 1916. These plans called for new dry docks and supporting industrial facilities. As the United States entered the war, a massive construction program at existing Navy yards was initiated, at a final cost of over $210,643,000.00 (U.S. Navy Department 1921:160-161). Typical improvements included slips for building ships, machine shops, structural shops, cranes, and related industrial buildings. Unlike the training camps, shipyards required permanent construction.

In 1917, the term "operating base" entered the Navy's lexicon with the creation of the Norfolk Navy Base, a new type of installation and one of the most ambitious wartime projects. The new Norfolk Base was the rendezvous point for the Atlantic Fleet. It provided all logistical and personnel support functions, except ship construction and repair. Among the features included at the base were storage facilities, drill and training facilities, barracks for the enlisted personnel, and a large auditorium (Foss 1984:66-69).

The war also multiplied the activities of the Navy's Ordnance Department, which had responsibility for production of weapons and ammunition, storage of ammunition, and testing activities. Such activities required a proportionate increase in the facilities of the Ordnance Department, which was normally accomplished through the expansion of existing installations. Physical improvements were undertaken at the Navy's ammunition depots, the Naval Gun Factory in Washington, the Powder Factory in Indian Head, and the various torpedo stations. The buildings added to the ordnance activities were functional designs characterized by contemporary industrial design without references to historical styles. The Navy also constructed several new Ordnance Department installations. These additional facilities included a new proving ground at Dahlgren, Virginia, a mine depot at Yorktown, Virginia, and an armor and projectile factory in Charleston, West Virginia (U.S. Navy Department 1921:279-313).

To meet the storage and distribution requirements for its expanded fleet, the Navy also added to its warehouse capabilities. New warehouses were added to existing yards and stations; two new Fleet Supply Bases were established at Brooklyn, New York, and Norfolk, Virginia. Construction consisted of a combination of permanent and temporary buildings. The permanent buildings were generally multi-story warehouses, constructed from reinforced concrete, while the temporary buildings were wooden warehouses (U.S. Navy Department 1921:317-347).

The Navy's contribution to the Allied victory in World War I marked a significant milestone in the growth of the American Navy. Within a single generation, the United States emerged as one of the world's leading naval powers. Moreover, it accomplished this feat at a time when naval technology was changing rapidly. This time was noteworthy for its rapid growth and change for both the fleet and shore establishment. The history of navy installations reflects these changes, as the shore establishment acquired the sophistication to support a modern fleet.

Army

During the early twentieth century, the Army studied the lessons learned in the Spanish-American War of 1898, and instituted reforms to remedy problems related to the mobilization for that war, particularly in supply distribution and recruit housing. The War Department applied the lessons from the 1989 mobilization to the mobilization for World War I.

The Quartermaster Department underwent some important changes following the appearance of major logistical problems during the Spanish-American War. Several departments were consolidated into the Quartermaster Corps and the Quartermaster depot system was reorganized. Under the reorganization, the quartermasters of the various geographic departments were allocated a budget that could be spent by drawing supplies from the Quartermaster Department's general depots. These general depots were the wholesale purchasers and managers of selected equipment. The system of general depots was expanded until the Quartermaster Corps controlled 13 depots in World War I (Risch 1989:562, 590-592.)

In the Spanish-American War, the Army had established a series of encampments across the United States for training and housing recruits before their transport to Cuba. In its haste to establish the camps, the Army neglected to construct proper water and sewage facilities. This omission, when combined with the crowded living conditions, resulted in serious problems with sanitation and disease, including typhoid fever epidemics. After the war, two commissions were appointed to study the medical disasters of this war (Ashburn 1929:168-177).

In April 1917, the United States entered World War I, which had been devastating Europe since August 1914. For the Army, this war posed new problems that fully challenged its capabilities. The war introduced the wide-spread use of poison gas and indirect artillery, and new weapons, such as machine guns, airplanes, and tanks. War and Navy Department officials developed programs for coordinating America's industrial resources. Finally, the Army needed to induct and train more than two million soldiers as rapidly as possible.

Cantonment construction became a critical factor in the war effort. The Army's expansion depended on an ability to shelter soldiers while they were trained and organized. With the experiences of the Spanish-American War still in memory, senior officers wanted to ensure that the new cantonments contained adequate shelter and sanitary facilities. The War Department planned to construct 32 training camps by September 1, each capable of sheltering 40,000 soldiers. Responsibility for these camps was removed from the Quartermaster General and placed in a special "Cantonment Division," later called the "Construction Division," that reported directly to the Secretary of War (Risch 1989:605-609).

These camps were divided into two categories: (1) camps for the National Guard units that had been mobilized, and, (2) camps for the National Army, soldiers conscripted into the Army. Because the National Guard units were expected to be trained more quickly, the War Department decided to shelter the soldiers in tents, and to construct only the minimum number of wooden buildings. Even these modest requirements involved considerable construction effort, as the War Department built roads, storehouses, and administrative buildings. The Army also constructed water and sewage connections to avoid the sanitation problems of the Spanish-American War. The National Army cantonments were constructed using standard plans developed by the Construction Division for as temporary wooden-frame buildings (U.S. War Department 1918:64-65; Garner 1993:22-33).

The scale of the effort for these camps was enormous, especially considering that the Army long had been accustomed to small posts. The cantonments contained laundries, bakeries, kitchens, hospitals, cold storage facilities, utilities, theaters, and other buildings normally associated with a large city. Water and electricity often were drawn from nearby cities. A typical camp, Camp Grant at Rockford, Illinois, cost about $11,000,000.00 to house 45,000 men and 12,000 horses (Crowell 1919:541-545). The tight time schedules required some compromises on sanitation requirements. At Camp Lee, Virginia, the water pipes were constructed using wood staves, and leaked despite the best efforts of the builders. Sewage was poured directly into a local creek (Cannan et al. 1993:V.I 71).

In addition to the camps for line units, the War Department also constructed facilities to train soldiers in the technical branches. The Signal Corps required a training site near the major electronics manufacturers, and with sufficient real estate for students to practice communicating over a distance; it established Camp Alfred Vail near Monmouth, New Jersey, which was later renamed Ft. Monmouth. The Signal Corps, which at this time included the Army's nascent aviation program, also established 33 flying fields, 5 aviation supply depots, 3 general aviation depots, and 4 acceptance parks for receiving aircraft from manufacturers (Brown 1990:44-46). The Army created Camp Bragg, North Carolina, as a field artillery range, and it created another field artillery camp at Camp Knox, Kentucky. The Army expanded the School of Musketry into the Infantry School, and placed it at Camp Benning, near Columbus, Georgia. The Quartermaster Corps trained its soldiers at Camp Joseph F. Johnston, near Jacksonville, Florida, and at Camp Montgomery Meigs, in Washington, D.C. Camp Humphreys (later Ft. Belvoir), Virginia, became an engineer school, while Camp Eustis, at Williamsburg, Virginia, became a coastal artillery school (Crowell 1919:545).

These training camps did not mark the end of the construction needs of the war. The Army also required a multitude of support installations, including quartermaster, ordnance, and medical facilities. The quartermaster constructed a series of depots near the Atlantic ports, and interior depots, such as the ones at Chicago and at New Cumberland, Pennsylvania. The number of Army depots proved woefully insufficient for the requirements of World War I, and the Quartermaster Corps relied heavily on commercial warehouses and railroad cars to supplement their storage facilities. This situation led to the creation of a Warehousing Division within the Office of the Quartermaster General, with the responsibility for managing Quartermaster Depots (Risch 1989:629-630; 638). The largest construction project for the Ordnance Department was the construction of Aberdeen Proving Ground, with a sub-post at Edgewood Arsenal for preparing chemical munitions. The Ordnance Department also constructed new arsenals across the nation, including Raritan Arsenal, New Jersey, for holding munitions prior to shipment. Finally, the Army expanded medical facilities to care for war-related casualties and designated specific installations as general hospitals.

Inter-war Period

With the close of World War I, American interest in military affairs declined sharply. The war left an enormous debt that limited military expenditures. When the apparent prosperity of the 1920s ended in one of the worst depressions in U.S. history, the public correspondingly was unwilling to spend money on the military.

During the 1920s, international events seemed to support the belief that large armed forces would be unnecessary in the future. European nations formed the League of Nations in an effort to solve their disagreements peacefully. The Washington Naval Disarmament Conference of 1921 - 1922, followed by the London Naval Disarmament Conference of 1930, provided further confidence that future conflicts could be avoided through limiting Pacific fortifications and the ratio of capital ships. In the Kellog-Briand Pact, world powers outlawed war as an instrument of national policy. The rise of international tensions during the 1930s proved the hope for permanent peace to be illusory.

During this period, the services languished under restricted appropriations and slow growth, yet they also developed technologies and mobilization and operational plans that laid the groundwork for the massive World War II effort.

<u>Navy</u>

The history of the Navy during these years was dominated by international naval disarmament conferences, the growing threat of Japan, and the emergence of aircraft and submarines as formidable new weapons. Each of these trends affected naval installations. Even with the limitations of the naval disarmament conferences and the generally pacifist mood of the inter-war years, the Navy made some improvements in its facilities. The Navy focused its attention on the Pacific Ocean and on improvement of its installations on the West Coast and in Hawaii. Despite the traditional preference for surface warfare, the Navy incorporated aircraft and submarines into its system, and improved the capabilities of both weapons. When war returned during the 1940s, these improvements contributed significantly to the American war effort.

The Navy traditionally had concentrated in the Atlantic Ocean, with most of its facilities on the Atlantic or Gulf coasts. The possibility of war with Japan forced the Navy to shift its forces to the Pacific. In 1922, it divided the fleet into a Battle Fleet stationed in the Pacific, and a Scouting Fleet in the Atlantic. The next problem for the Navy was to find the shore facilities to support a Pacific fleet. The Navy began an expansion program for its Pacific bases; the three leading beneficiaries were San Diego, California; Bremerton, Washington; and Pearl Harbor, Hawaii. Improvements began slowly during the 1920s and accelerated during the 1930s.

Navy Department activity in the San Diego area began with a coaling station in 1901, and a communications station in 1906. A training facility and an air station were added during World War I. After the war, these facilities were retained and expanded to augment the Navy's presence in the Pacific. The coaling station was expanded into the Naval Supply Depot, and later the Naval Supply Center, complete with warehouses and piers. In 1920, the Navy activated a Naval Operating Base at San Diego, and in 1921, it established the Eleventh Naval District Headquarters at San Diego. Until the fleet was moved to Pearl Harbor in 1940, San Diego served as the principal operating base for the Pacific Fleet. The Navy also acquired a marshland area from the city of San Diego that it improved into a destroyer base. Like other Pacific Coast facilities, this destroyer base was improved steadily during the 1920s and 1930s by the addition of marine railways, dry docks, piers, and related facilities (Coletta 1985:553-584).

The deep channel at the Puget Sound Naval Shipyard in Bremerton made it an ideal site for a yard. Even before World War I, the yard was improved in response to the Japanese threat. During the inter-war years, the yard's importance increased in proportion to the potential for war with Japan. Even with the limited shipbuilding programs resulting from the disarmament conferences, Puget Sound received its share of projects (Coletta 1985:512-514).

Since its establishment as a coaling station at the beginning of the twentieth century, Pearl Harbor had been valued as an outpost against Japan. The Navy developed Pearl Harbor into a major repair and supply facility by dredging the channel, improving dry docks, creating a fuel oil depot, and otherwise adding to the base. Pearl Harbor also became the home of a submarine base and Navy airfields (Coletta 1985:431-463).

During the inter-war years, the military developed important new policies for ordnance storage. Following World War I, the military possessed large quantities of excess ammunition. In July 1926, lightning struck an ammunition magazine at the Lake Denmark Naval Ammunition Depot in New Jersey. The lightning caused an explosion within the magazine and a chain reaction of sympathetic explosions throughout the depot. The Lake Denmark Depot was destroyed, and the Army's adjacent Picatinny Arsenal and nearby towns were damaged heavily. As a result of investigations that followed the disaster, the Army and Navy adopted stringent new safety regulations for ammunition storage. The first ammunition depot to incorporate these new regulations in its design and construction was the Naval Ammunition Depot at Hawthorne, Nevada, the Navy's first large inland depot (U.S. Navy Department 1938:O3-O14).

As naval aviation slowly increased in importance, the number of installations supporting aviation increased proportionally. Pensacola, Florida, already had become the location for initial flight training of heavier-than-air aviators. Sailors learned aircraft maintenance and associated skills at the Great Lakes Naval Training Station, Illinois. The Anacostia Naval Air Station conducted testing and experimental work. Norfolk, San Diego, and Pearl Harbor stations were fleet aircraft bases, supporting their respective fleets.

During the inter-war years, the Marine Corps developed into the Fleet Marine Force that operated effectively during World War II and afterwards. As part of the Marine Corps' emphasis on functioning as an amphibious force in support of naval campaigns, the Marines maintained their installations at Parris Island, San Diego, and Quantico. Though a large number of marines remained assigned to Navy installations, on ships, or in foreign nations, the Marine Corps maintained distinct installations, primarily as training facilities.

Army

In many respects, the Army grew very slowly during the inter-war years. Because the nation did not foresee significant conflicts, the military operated under severe budget constraints until the late 1930s. During this era, the Army implemented some important administrative reforms and experimented with new technology on a limited scale. Despite the general lack of interest in the military, the Army undertook a coordinated effort to improve the design of deteriorating World War I cantonments. One of the most conspicuous achievements of the Army during these years was the physical improvement of its installations. With congressional authorization, the Army disposed of its unnecessary installations and constructed some of its most comfortable posts during this time. The Army survived these lean years until the Protective Mobilization phase that preceded U.S. involvement in World War II.

Army installations initially suffered from the neglect of the post-war years. Following the war, the Army had retained a significant number of its World War I cantonments. Lacking funds for proper maintenance, let alone improvement, the installations fell into disrepair. In 1926, Congress took the first step towards improving the condition of Army posts by enacting Public Law No. 45, which authorized the Secretary of War to dispose of 43 military installations, or portions thereof, and to deposit the money received from sales into a special fund designated the "Military Post Construction Fund" to towards construction at the remaining posts (Risch 1989:713).

In implementing this law, the Quartermaster Corps changed its emphasis from improving single buildings to wholesale installation planning. The Quartermaster General employed a group of distinguished architects, landscape architects, and planners, both uniformed and civilian, to apply the latest city planning techniques to Army posts. Remaining World War I cantonments particularly received the benefit of the new "garden city" and "city beautiful" movements in urban planning (Ford 1929:19-22). The Quartermaster Corps also decided to incorporate regional architecture in its standard designs. Generally, the Georgian or Colonial Revival style prevailed in the northeastern states, while Spanish Mission architecture was deemed most appropriate for the southern regions (Wheaton 1928:10-13).

During this wave of installation improvement, the Quartermaster devoted attention to the installation of modern utilities. One Quartermaster engineer wrote:

> For the comfort and health of troops quartered in army posts or camps, it is essential that not only the necessities of life be provided by the Quartermaster Corps but that the comforts to which our civilization and early training have accustomed us be here furnished substantially as they are supplied in the best and most progressive of our cities. In order to maintain the vigor and contentment of our troops in camps and barracks it is quite necessary that the "utilities" be provided, maintained and operated in an efficient manner, so that no unnecessary drudgery shall enter the daily life of the soldiers stationed in posts or camps (Chamberlain 1929:12).

During the economic depression of the 1930s, limited construction projects on Army posts continued. By using the Works Progress Administration (WPA) and Public Works Administration (PWA) programs to provide employment, the Army continued to improve its installations while other military funds were reduced.

The new posts allowed the Army to concentrate larger units at one installation, or to use larger training areas. Although small by late twentieth century standards, Army posts had increased to the point where some installations could house a brigade. One measure of the increase in size of the new posts was size of the new barracks building. A standard barracks constructed in 1928 housed four infantry companies, or about 400 soldiers. In 1894, an entire installation contained between 60 and 750 soldiers (Wheaton 1928:10).

The same conditions and legislative actions that affected other Army posts affected air fields. Army aviation received an additional boost through the Air Corps Act of 1926. Among other provisions, the law authorized additional men and aircraft. Although the new law did not mention new installations, the expansion of Army aviation implied new facilities. The Chief of the Air Corps proposed further development at 32 fields and construction of two other fields. Although the Air Corps' implementation of the plan fell short of its desires, the years from 1926 to 1932 marked some of the first permanent construction and physical improvements of aviation facilities (Brown 1990:73-89).

As Army aviation increased in operational autonomy, it also acquired greater control over its logistical support. Some aviation-related depots had existed since World War I, such as the Engine and Repair Depot in Montgomery, Alabama, which later became Maxwell AFB. With the special logistical requirements of aviation, the depot system expanded during the inter-war years. Despite overall reductions after World War I, the Air Corps maintained its separate depot system, and even added another depot at Sacramento, California, now McClellan AFB. Dayton, Ohio, had been important to Air Corps logistics since the creation of Fairfield Depot during World War I. Kelly Field became the San Antonio Intermediate Air Depot, later renamed Duncan Field (now Kelly AFB). In 1926, the Air Corps established a Materiel Division in McCook Field, also at Dayton. Upon completion of Wright Field in Dayton, the Materiel Division moved to the new field. Today, Wright-Patterson AFB contains both the former Wright Field and the Fairfield Depot (Brown 1990:78, 99, 44, 57).

World War II

World War II was a "war of resources," in which the effective marshalling of unprecedented amounts of resources played a decisive role in the defeat of the Axis forces. These resources included personnel, weapons, ammunition, food, transportation facilities, funding, and all the other items needed to sustain fighting forces. Mobilization of U.S. resources began in earnest after the fall of France in 1940. President Roosevelt implemented the Protective Mobilization Plan developed during the late 1930s; the plan called for the activation of National Guard units, the establishment of a peacetime Selective Service for the Army, strengthening the Navy, and development of an ammunition industry. One historian noted that,

> ... [T]he eighteen months of preparation before Pearl Harbor played a crucial, if not decisive, part in the outcome of the war. During this period the Military establishment of the United States was rehabilitated and the foundation laid for America's tremendous war production achievement. The greatest barrier to military preparedness at the time of the crisis of 1940 was the lack of capital facilities, and these required from several months to two years or even longer to create. To have delayed the construction of such facilities until the United States was actually involved in battle might have lost the war before it began (Smith 1959:437).

The Japanese attack upon Pearl Harbor in December ended the Protective Mobilization phase. During the first two years of war, defense construction continued at even greater rates than during the Protective Mobilization phase. Because the outcome of the war depended so much on the proper management of resources, particularly scarce labor and raw materials, military construction received considerable attention. New facilities were required to train and equip the new forces; additional facilities were required to produce, repair, store, and transport the vast amounts of required weapons, ammunition, and supplies.

The War and Navy Departments divided their construction programs into command and industrial construction. Command construction included all installations that operated in direct support of the military forces. Examples included training camps and stations, air bases, Navy yards and bases, storage and maintenance facilities, research and development facilities, medical facilities, and all other types of construction necessary for the actual operation of the forces. Industrial construction included facilities for producing explosives, ammunition, and other implements of war. Command facilities construction programs were characterized by a wide variety of building types and purposes. In keeping with wartime economy measures, the military used temporary construction wherever possible. Yet some command facilities unavoidably required permanent construction. In other cases, permanent construction presented long range advantages for use after the war, which outweighed its short term disadvantages. Industrial construction typically required permanent construction, though later waves of construction utilized temporary construction as possible.

Navy

Immediately after the fall of France, the Navy initiated a massive fleet and shore establishment build-up. During the eighteen months before Pearl Harbor, the Bureau of Ships transferred over $250 million to the Bureau of Yards and Docks to prepare shore facilities for the expanded fleet. Congress passed a bill calling for the establishment of a two-ocean Navy and increasing the existing force by 70 per cent (U.S. Navy Department 1947a V.I:1,171). The massive increase in fleet size demanded more shore facilities, while placing severe constraints on the availability of steel and other essential materials. Due to the constraints of time and material shortages, the Bureau ordered that all new naval building construction, except for structures whose function or intended post-war use required permanent construction, consist of temporary construction. Speed was the primary consideration in the construction of naval shore facilities, with cost or architectural planning ranking as secondary factors.

The Bureau of Yards and Docks recommended that shipbuilding facilities receive the construction highest priority. The Navy yard building construction program reached its peak on the East Coast in early 1943. Building construction continued at a significant pace at West Coast Navy yards until the end of the war. The total value of structures built for ship construction and repair purposes between 1 July 1940 and 31 December 1945 was $1,116,258,384.00 or 13.7 per cent of total building construction performed for the Navy shore establishment (Hirrel et al. 1994:47-50).

The Navy supported the fleet's vessels and ships crews at naval bases and stations. Navy bases played an increasingly important role in American mobilization. The Pacific Fleet was transferred to Pearl Harbor in 1940 to discourage further Japanese aggression. The newly created Atlantic Fleet established its headquarters at Naval Base Norfolk. The Norfolk Base also played an important role as the staging area for neutrality patrols on the East Coast. Naval operating bases provided anchorage facilities; replenished fuel, ammunition, and supplies; minor repair facilities; and recreational and hospital facilities for personnel. Examples of this type of installation included Naval Base Norfolk and the Naval Base Pearl Harbor. Naval operating bases had administrative control over activities such as Marine Corps barracks, training functions, naval air stations, and supply depots located within the installation's boundaries. Smaller bases were designed to handle specific types of vessels, such as destroyers or submarines. Examples include New London Submarine Base, Connecticut, and the San Diego Destroyer Base, California.

With American mobilization in 1940, construction of aviation facilities acquired a new urgency. German submarine activity in the Atlantic Ocean prompted the Navy to establish more bases for seaplane patrols of the Atlantic. By the end of June 1941, the Navy owned 13 East Coast stations, 10 Caribbean stations, 6 West Coast stations, 3 Alaskan stations, and 9 Pacific stations (U.S. Navy Department 1947a V.I:233-234). Despite these significant increases, America's entry into the war again required more bases. The Navy established a war time goal of 27,000 thousand aircraft, which required shore facility support, including training stations and bases for anti-submarine patrols.

The Marine Corps continued to employ its own aviation in close support of Marine Corps ground forces. The rapid expansion of Marine Corps aviation required a commensurate expansion of its air stations, which were used primarily to train aviators (U.S. Navy Department 1947a:V.1, 257-260).

The Navy Department developed an extensive system of supply depots for the receipt, storage, and issue of general supplies. At the beginning of the war, the Navy Department had only two operating supply depots, which were located in Norfolk and San Diego. Their proximity to the major bases on the Atlantic and Pacific coasts enabled these depots to support the fleet. The expanded operations of World War II required rapid expansion of the Navy's supply storage facilities.

In 1940, construction began on two supply depots located near major bases. These facilities were located in Bayonne, New Jersey, and Oakland, California. At the same time, the existing Norfolk and San Diego depots received funding for additional buildings. As the war progressed, the Navy established new supply depots along the coasts, and near the major naval installations (U.S. Navy Department 1947a V.I:291-301). In 1941, the Navy initiated a new approach to its distribution system, and began to select depot sites that were not adjacent to a specific port or base. These inland depots supported naval activities in particular regions (U.S. Department of Navy 1947a:V.1, 298-305).

The Navy Department also maintained an active research and development program during World War II. Its programs covered all aspects of naval development, including ship design, naval ordnance, aviation, and rocket development. Older installations, such as the Communications Laboratory in Anacostia, District of Columbia, or the Naval Proving Ground at Dahlgren, Virginia, were improved. Important new installations were established, including the Naval Ordnance Test Station Inyokern, California (better known as China Lake), White Oak Naval Ordnance Laboratory, Maryland, and the David Taylor Model Basin, Maryland.

The Army and Navy Munitions Board coordinated industrial production for both services and agreed that the Army would provide the Navy with explosives material and that the Navy would be responsible for loading and assembling its own finished artillery rounds. Thus, the Navy established fewer industrial plants than the Army, though the Navy did operate several ordnance plants, torpedo stations, ammunition depots, and a mine depot. To provide for the safe storage and efficient distribution of critical ammunition supplies, the Navy undertook a tremendous expansion of its ammunition depots, both through expanding existing installations and construction of new installations. Some Navy depots such as Hawthorne, Nevada; Crane, Illinois; McAlester, Oklahoma; and Hastings, Nebraska, included ammunition assembly lines, in addition to large numbers of ammunition storage facilities.

Army

The Protective Mobilization Plan of 1940 spurred an unprecedented wave of War Department construction. Among the most critical elements of the mobilization construction were the construction of training cantonments and the development of ammunition facilities. Responsibility for War Department construction within the United States was transferred from the Quartermaster Corps to the Corps of Engineers in December 1941.

The War Department hurriedly constructed training facilities for the millions of new recruits. For the most part, these camps consisted of temporary, wooden-frame buildings based on the "700 Series" and "800 Series" of standard plans developed by the Quartermaster Corps. During the initial phase of mobilization, some posts received funding for construction of facilities that were intended for permanent use. The U.S. entry into the war accentuated shortages of labor and raw materials, which greatly affected the construction standards, causing masonry and steel construction to give way to less durable construction whenever possible.

Industrial mobilization was a critical component of the war effort. The military of the 1930s lacked the materiel necessary to fight a sustained war, especially using the blitzkrieg tactics of World War II. In 1940, the United States lacked enough smokeless powder to supply even one day of fighting (Thomson and Mayo 1960:194-195). Even worse, the United States lacked the production capacity to produce munitions. In response to private industry's reluctance to invest in specialized military munitions plants, the government developed a national system of government-owned, contractor-operated ammunition production facilities. The War Department constructed 25 loading and component plants, 23 propellant/high explosives works, 13 small arms plants, and 13 chemical ordnance works (Voight 1947:passim). These facilities cost about three billion dollars in capital investment and employed almost a quarter million workers (Thomson and Mayo 1960:105). Most of these facilities were located in the interior of the country, away from large cities.

During the inter-war years, little had been done to address the military's potential storage needs. In response to the absence of these essential facilities, the Army established extensive depot systems to hold military materiel for long term storage, to provide supplies to units stationed in the United States, and to support the movement of materiel to units stationed overseas. Categories of supplies handled within the depot system ranged from large items such as tanks and artillery, to small items such as the individual repair parts for those machines. The Army also operated an extensive network of depots for the sole purpose of receiving, storing, and issuing general military supplies.

The scope of depot operations during World War II greatly exceeded anything within the military's previous experience. The Ordnance Department, Quartermaster Corps, and Air Corps operated the most extensive depot systems. The Signal Corps, Corps of Engineers, and Chemical Warfare Service operated smaller logistical systems. Ordnance Department depots were unique among the service depots. While other depots primarily consisted of facilities for the storage of inert materials, the primary mission of ordnance depots was the storage and distribution of explosive materials. Prior to 1940, ordnance depots were concentrated disproportionately near the East Coast; by 1942, the Army had developed an extensive system of ordnance depots throughout the nation to accommodate the influx of material from the new ordnance plants (Thomson and Mayo 1960:363, 384).

Full-scale plans for the general depots were not implemented until after the Japanese attack upon Pearl Harbor. When the United States entered World War II, Army planners estimated that the Army, excluding the Air Corps, possessed about half of the general storage space it would need to service the Army force expected to be raised by late 1942 (Fine and Remington 1989:481-482). Funding was plentiful after war was declared, and new depot facilities were erected nationwide. The Materiel Division of the Army Air Forces maintained the system of separate depots for aviation supplies. These depots stored aircraft and repair parts, plus performed extensive overhaul of engines and equipment (Walker and Wickam 1986:264-266).

Army air fields were another critical type of installation that received high construction priority. The Air Corps received an estimated 3.2 billion dollars for the construction and leasing of facilities (Fine and Remington 1989:703). In cooperation with the Quartermaster Corps Construction Branch, and later the Corps of Engineers, the Air Corps expanded from a handful of facilities in 1939 to a peak of 783 operational facilities by the war's end. Of these, 345 were main bases, 116 were sub-bases, and 322 were auxiliary fields (Mueller 1989:iii).

More than in previous conflicts, World War II demonstrated the importance of technological superiority. New or improved weapons provided a significant advantage. The extent of the research performed during World War II is indicated by the fact that seventy-five per cent of the ordnance equipment used by the Army either was replaced completely or radically improved (Hirrel et al. 1994:88). The government undertook complex research and development functions in specially designed buildings at installations across the country. For example, new weapons and equipment, including artillery, tanks, rockets, bombs, and trucks, were developed and tested at Aberdeen Proving Ground, Maryland. The Signal Corps developed communications and electronics at Ft. Monmouth, New Jersey.

From the first projects of the mobilization period to the final efforts at the close of the war, military construction within the United States played an essential role in the Allied victory. Given the limitations of time and material, the domestic construction programs of the Navy and War Departments were a remarkable achievement.

CHAPTER IV

GENERAL STORAGE

Between 1917 and 1946, the number of storage buildings on military installations increased tremendously, especially during World Wars I and II. The construction of storage buildings is related directly to logistical support for military activities, particularly training and combat. Supplying the modern military became increasingly complex as the military began to rely on mechanized weapons and to expand its mission beyond the continental United States. During both world wars, the amount of supplies and material required to fight each war increased dramatically. In addition, both wars were fought overseas and supplies were shipped long distances. The number of storage buildings correspondingly increased to handle increased amounts of material. During the inter-war period, the numbers of new storage buildings constructed remained small.

General storehouses were constructed at all military installations to house various supplies: personnel supplies, equipment, spare parts, machinery, lubricants, and oils. In some cases, storage structures were designed to store specific items. In other cases, generic building designs were used to store a wide variety of supplies. Storehouses varied in size and in construction materials, depending on their purpose and time of construction. Typical construction materials include concrete, brick, structural clay tile, corrugated metal, or wood. General storage buildings can be divided into two categories: installation storage and depot storage. Installation storage buildings include the many different types of buildings built to support a specific installation's activities. Depots are installations with the primary mission of storage and distribution of supplies within a region or for a branch of service. Supply depots typically are composed of complexes of large warehouses. Storage buildings discussed in this chapter were designed to hold non-explosive materials; ordnance storage is discussed in a separate chapter.

Naval General Storage

Historically, the Navy located general storage buildings at its shipyards to store ship building supplies and general provisions to outfit personnel and ships. In the early twentieth century, the demand for storage space outgrew available warehouse space.

World War I

On the eve of World War I, the Navy took advantage of the preparedness program to analyze and assess its storage needs. In 1916, personnel from the Bureau of Yards and Docks studied the merits of three popular types of fireproof construction: (1) structural steel frames with reinforced-concrete floor slabs; (2) reinforced-concrete column, girder, beam, and slab systems; and (3) reinforced-concrete column and flat-slab systems. After weighing the merits of each structural system, the Bureau of Yards and Docks chose reinforced-concrete column and flat-slab construction for permanent warehouses. The Bureau of Yards and Dock noted the following advantages of reinforced-concrete column and flat-slab construction: economy, speedy construction, floor headroom, and natural light. When combined with the reinforced-concrete column, girder, beam and slab, the structure was more fireproof than steel construction alone (U.S. Navy Department, Bureau of Yards and Docks 1921:317, 322).

Following the March 1917 Congressional appropriations, the Navy expanded its storage capacity by constructing several general storehouses. The typical naval general storehouse ranged from four to eleven stories in height and was capped by a flat roof (Figure 2). The structure comprised reinforced-concrete columns spaced every 20 to 21 feet to support concrete slabs, providing a four-way system of reinforcement. This reinforcement system was used in conjunction with design codes issued by the Joint Committee on Concrete and Reinforced Concrete of the Bureau of Yards and Docks. The area covered by these buildings generally was comparable to a city block. Concrete loading platforms were located along the long elevations of each building. The main floors were generally 4 feet above street level to facilitate loading material directly from railroad cars and trucks. The exterior walls consisted of the exposed concrete frame infilled with steel sash windows, with heavy wire glazing, and hollow brick spandrels below the sills (U.S. Navy Department, Bureau of Yards and Docks 1921:322, 327).

In 1917, the Navy awarded contracts to construct large, reinforced-concrete general storehouses at New York Shipyard and Brooklyn Supply Depot, New York; Boston Navy Yard, Massachusetts; Philadelphia Navy Yard, Pennsylvania; Mare Island Navy Yard, California; Puget Sound Navy Yard, Washington; Naval Submarine Base, New London, Connecticut; Hampton Roads Naval Operating Base, Virginia; Charleston Navy Yard, South Carolina; Pearl Harbor Navy Yard, Hawaii; and, Washington Navy Yard, D.C. The Medical Corps also constructed this type of general storehouse for their supplies in Brooklyn, New York, and Mare Island, California (U.S. Navy Department, Bureau of Yards and Docks 1921:317; U.S. Navy Department, Bureau of Yards and Docks *Bulletin 29* 1918:Table 2). The multi-story general storehouse utilized the restricted space available at naval shipyards most efficiently. In addition, these warehouses took advantage of existing infrastructure, such as heating, lighting, and docking.

While one general storehouse was constructed at each shipyard, storage space was still insufficient to meet wartime storage requirements. The Navy decided to stockpile supplies necessary for one to three years to meet the needs of U.S. and Allied forces. To store this amount of supplies, the Navy required greater storage capacity than ever before.

The Navy initiated a study to assess the nature of its purchased commodities, storage and distribution requirements, and shipping and transhipping methods. The object of the study was to develop efficient supply depots with a full complement of railroad facilities, modern water fronts, and up-to-date handling equipment. The Navy analyzed the storage capacity of its two most important East Coast shipyards: New York and Norfolk. Neither shipyard contained enough space for fleet storage. Due to the war emergency, the Navy selected South Brooklyn, New York, and Hampton Roads, Virginia, as the sites for two new fleet supply bases (U.S. Navy Department, Bureau of Yards and Docks 1921:338, 341). The Hampton Roads facility now is part of Norfolk Naval Base.

The two new depots exhibited the most elaborate World War I general storehouses. The Brooklyn depot was constructed on land owned by the Navy and on land leased from the city. It took advantage of existing railroads and piers. Buildings constructed at South Brooklyn (closed following World War I) included two, eight-story, permanent general storage buildings measuring 700 x 200 feet. The eight-story buildings were constructed of reinforced-concrete column and flat-slab design and included 2 passenger elevators, 21 freight elevators, and 3 automatic conveyors. These two buildings were among the largest buildings ever constructed by the Navy at that time. At Hampton Roads, Virginia, the Navy constructed two six-story permanent storehouses (U.S. Navy Department, Bureau of Yards and Docks 1921:341-345).

In addition to general storehouses, both supply depots were outfitted with other buildings and infrastructure. At South Brooklyn, the Navy constructed two semi-permanent warehouses, a permanent power plant, over ten miles of railroad track, two float bridges, a Marine Corps

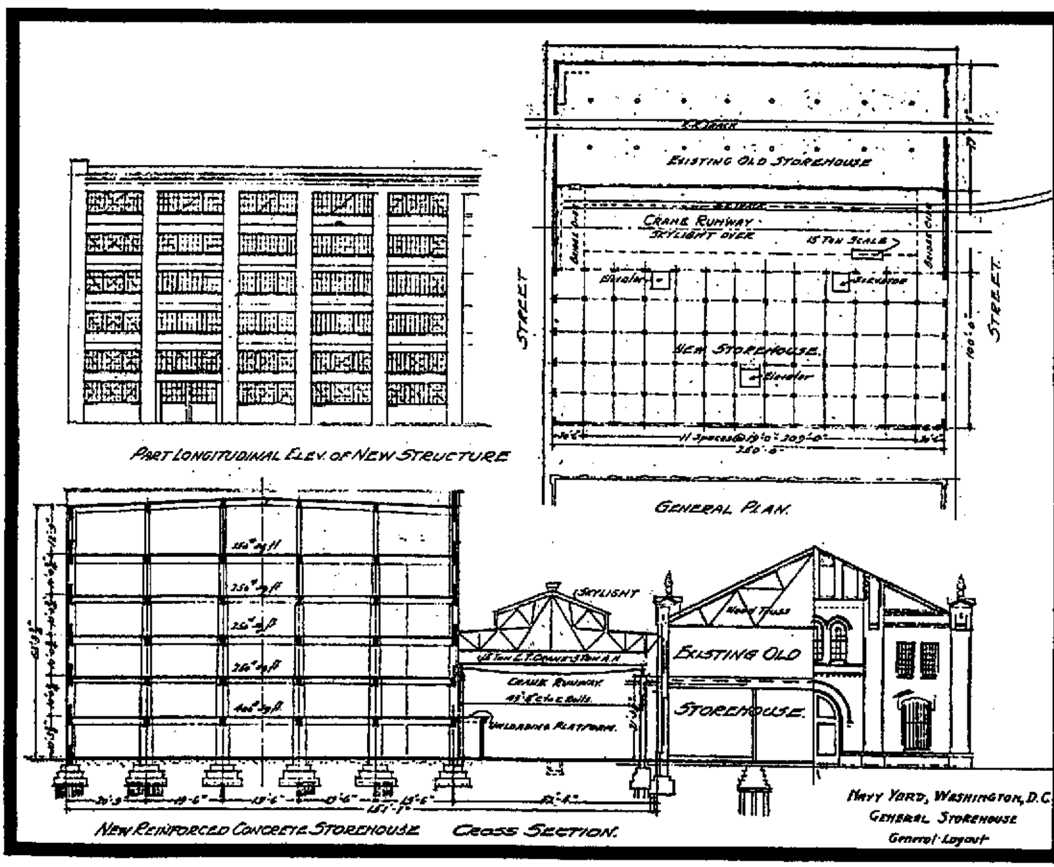


Figure 2. Plate showing cross section and partial elevation of general storehouse constructed at Washington Navy Yard, D.C. (U.S. Navy Department, Bureau of Yards and Docks, *Public Works of the Navy, Bulletin 23*, June 1916:22) Drawing depicts contrast between storehouse constructed before 1916 and storehouse constructed in 1916.

barracks, an office building, and a fire alarm system. At Hampton Roads, Virginia, the Navy constructed a cold storage building, seven large temporary warehouses, a one-story permanent warehouse, and a three-story aircraft storehouse. In addition, two merchandise piers, measuring 125 x 1,400 feet, were constructed at the supply depot for berthing, loading, and unloading supply ships and barges. The piers were constructed of creosote-coated timber and supported a transit shed measuring 67 x 1,192 feet. Auxiliary improvements to the installation included nine miles of railroad tracks, several miles of concrete and timber roads, sewers, water, and steam and electric distributing lines (U.S. Navy Department, Bureau of Yards and Docks 1921:341-347).

The Navy determined that some commodities were stored more efficiently on ground-floors rather than on upper floors of multi-story warehouses. Thus, the Navy also constructed one-story storage and transit buildings. Often the one-story buildings were considered temporary construction for the duration of the war emergency. This type of building was built of wooden frame on a concrete foundation and floor. In some cases, light-weight portable steel-frame buildings were constructed; this type of construction was useful if a particular building was unheated. At South Brooklyn, the Navy constructed two one-story, semi-permanent, wood-frame warehouses with hollow-tile walls that measured approximately 300 x 335 feet. At Hampton Roads, the Navy built seven temporary one-story storage buildings, as well as one-story transit sheds on the shipping piers. The Marine Corps built a one-story brick permanent storehouse at their main depot at Philadelphia (U.S. Navy Department, Bureau of Yards and Docks 1921:342, 328, 321, 344, 346; U.S. Navy Department, Bureau of Yards and Docks 1947b V.II, 316).

In addition to multi-story and one-story general storehouses, the Navy constructed specialized permanent storage buildings to meet specific requirements. Cold storage was required to store perishable items. The largest cold storage plant was constructed at Hampton Roads, Virginia (U.S. Navy Department, Bureau of Yards and Docks 1921:328-331).

The Navy designed a special one-story building to store bulky and heavy materials, salvage materials, materials turned in from ships, aircraft and aircraft parts, and boats. The one-story building featured a monitor roof that supported overhead cranes to move heavy materials (U.S. Navy Department, Bureau of Yards and Docks 1921:327, 331).

Naval shipyards also required special storage for industrial purposes. Specialized storage buildings were constructed for boat storage, metal storage, and lumber storage. Freight sheds and piers for receiving and shipping yard freight also were constructed. In some instances, the buildings appear similar to the general heavy materials storehouse type (U.S. Navy Department, Bureau of Yards and Docks 1921:327, 332, 337).

Between 1916 and 1919, the Navy constructed about 30 large permanent storage buildings and over 100 temporary and minor structures, providing a total of 15,000,000 square feet of storage (U.S. Navy Department, Bureau of Yards and Docks 1921:318).

Inter-war Period

Following World War I, most construction of storage buildings stopped. The Navy finished construction of permanent storage buildings at Hampton Roads, Virginia, to replace leased storage space (U.S. Navy Department, Bureau of Yards and Docks 1921:344). After the war, the Navy closed the fleet supply depot at South Brooklyn, New York, and established a new fleet supply depot at San Diego, California, to support the Pacific fleet. Two multi-story general storehouses were constructed at San Diego during the early 1920s (U.S. Navy Department, Bureau of Yards and Docks *Bulletin 35* 1925).

The Navy classified its storage buildings into the following types: general, medical, heavy materials, airplane, cold, inflammable, boat, dry-lumber, and temporary (U.S. Navy Department, Bureau of Yards and Docks 1938:K1-K8). In practice, several of the categories utilized the same building type. General and medical storage were similar and the heavy material type storehouse also was designed to store heavy materials, airplanes, and boats.

The general storehouse remained the same as during World War I: a multi-story building, ranging from 3 to 12 stories, constructed of reinforced concrete with flat slab floors. Flat slab construction with round columns was considered especially resistant to fire damage. Building height depended on available land area, required storage space, and foundation conditions. The Bureau of Yards and Docks recommended a rectangular plan as the simplest, but the U-shaped building plan afforded better natural lighting and ventilation and greater loading access. The U-shape and the hollow rectangular plans also allowed space for a courtyard bridge crane over tracks with loading platforms at various floors of both wings (U.S. Navy Department, Bureau of Yards and Docks 1938:K2-K3). The Navy continued to prefer the multi-story general storehouse where space was limited, particularly at naval shipyards. It also was used for medical supplies, fleet supplies, and general aviation supplies.

Even though the Bureau of Yards and Docks preferred multi-story general storage buildings, it acknowledged the advantages of one-story warehouses. The one-story building was particularly suited to store bulk materials at installations where ground space was not limited. The one-story building also was economical due to reduced handling costs through eliminating elevators (U.S. Navy Department, Bureau of Yards and Docks 1938:K2).

The design for heavy materials storage buildings featured a monitor roof to support a bridge crane. The building was one-story due to heavy floor and crane loads and had interior railroad tracks. This kind of building stored machinery, metals, ordnance, and bulky materials. This building form also was adapted to store aircraft and boats (U.S. Navy Department, Bureau of Yards and Docks 1938:K2-5; Q15-16).

The Bureau of Yards and Docks specifications allowed for temporary construction during emergencies. Temporary storage buildings were usually one-story, wood-frame buildings with concrete floors. The roofs were covered with composite roofing (U.S. Navy Department, Bureau of Yards and Docks 1938:K7).

Although the Navy defined these different categories of storage, it constructed few storage buildings during the inter-war years. During the 1930s, naval appropriations increased, allowing the Navy to construct some new permanent installations and to expand older installations. General storage buildings were included in the designs of new installations, such as at Alameda Naval Air Station in California. Shipyards included new storage buildings to support expanded shops and shipways. During the late 1930s, the Navy planned two additional supply depots, one at Oakland, California, and the other at Bayonne, New Jersey. The Navy constructed multi-story storage buildings at these two new depots beginning in 1940.

World War II

When the attack on Pearl Harbor precipitated U.S. entry into World War II, the Navy had two commissioned supply depots -- one at Norfolk, Virginia, and one at San Diego, California. The total square footage of covered storage space equalled 2,114,933 square feet. The supply depots at Oakland and Bayonne almost were completed; Oakland was commissioned one week after the attack on Pearl Harbor (U.S. Navy Department, Bureau of Yards and Docks 1947a 294).

By 1945, the Navy had 12 continental supply depots (Table 1) and over 50 special function depots, including fuel depots, landing-craft equipment depots, advance base supply depots, aviation supply annexes, and medical supply depots. On V-J day (15 August 1945), naval storage operations occupied a total of 144,207,169 square feet of covered storage. Thirty-five per cent of this storage space was located at supply depots; twenty-five per cent at navy yards; twelve per cent at naval air stations; and ten per cent at ordnance stations. The remaining storage space was located at miscellaneous naval facilities. In addition, the Navy also utilized a large amount of paved, open storage space for items that were unaffected by weather (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:291, 308).

The Navy continued to build multi-story, concrete-frame, general storage buildings to augment existing storage capacity at the coastal supply depots where land was at a premium. Between 1940 and 1945, the Navy completed multi-storied buildings at Bayonne, New Jersey; Oakland, California; Hampton Roads, Virginia (Figure 3, *top*); and San Diego, California (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:291-293, 298, 322).

One-story warehouses were constructed at installations where acreage permitted, particularly at large inland supply depots or installations that acquired additional land. Initially during World War II, the sizes of one-story warehouses varied based on the width of the steel-framing members (Figure 4). At Naval Base Charleston, South Carolina, the Navy constructed additional storage buildings when it acquired more acreage. The storehouses constructed during 1941 were one-story, metal-frame buildings clad with corrugated metal roofs and walls. When metal became a critical material, the Navy utilized wood-frame construction. Other materials used for storehouse construction at Naval Base Charleston included concrete block, poured concrete frames, and corrugated asbestos siding.

As the need for storage buildings increased, the Navy determined that one-story general storage buildings were more useful than multi-story buildings. The one-story design was better suited to the new packaging and handling technology of pallets and fork-lift trucks. Pallets, as standardized by the Navy's Bureau of Supplies and Accounts, consisted of four-foot square wooden platforms. The pallet, when loaded with packaged material, formed a four-foot cube of material that could be handled easily by a fork-lift truck and cargo sling. The Bureau of Yards and Docks designed a new standard for one-story storehouses to accommodate this change: a one-story building, measuring approximately 200 x 600 feet, that could store 300 carloads of palletized material (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:293).

The new standard was used widely at the inland supply depots that the Navy constructed to relieve pressure at coastal supply depots and industrial shipyards and to remove supplies out of potential coastal bombardment range. The new standard one-story storage buildings first appeared at the Navy's great inland storage depots of Mechanicsburg, Pennsylvania, and Clearfield, Utah (Figure 3, *bottom*). The new standard-size warehouse soon appeared at the other large inland depots and at annexes. The depot constructed at Stockton, California, completed in 1945 as an annex to Oakland, included only the new standard, one-story warehouses (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:293, 316).

The standard one-story warehouse was constructed using many types of building materials, depending on when construction occurred and which materials were in short supply. Design variations included adaptation to regional climates, inclusion of loading docks, and variations in roof forms. At Mechanicsburg, Pennsylvania, the first storehouses were constructed using a timber frame system with concrete floors directly on the ground without loading docks. Loading docks were incorporated later to assist handling shipments brought in by railroad or trucks. At Bayonne, New Jersey, one-story standard warehouses had barrel-arched concrete roofs. Other roof forms included monitor (Figure 5), segmental arch, and gable. By the end of

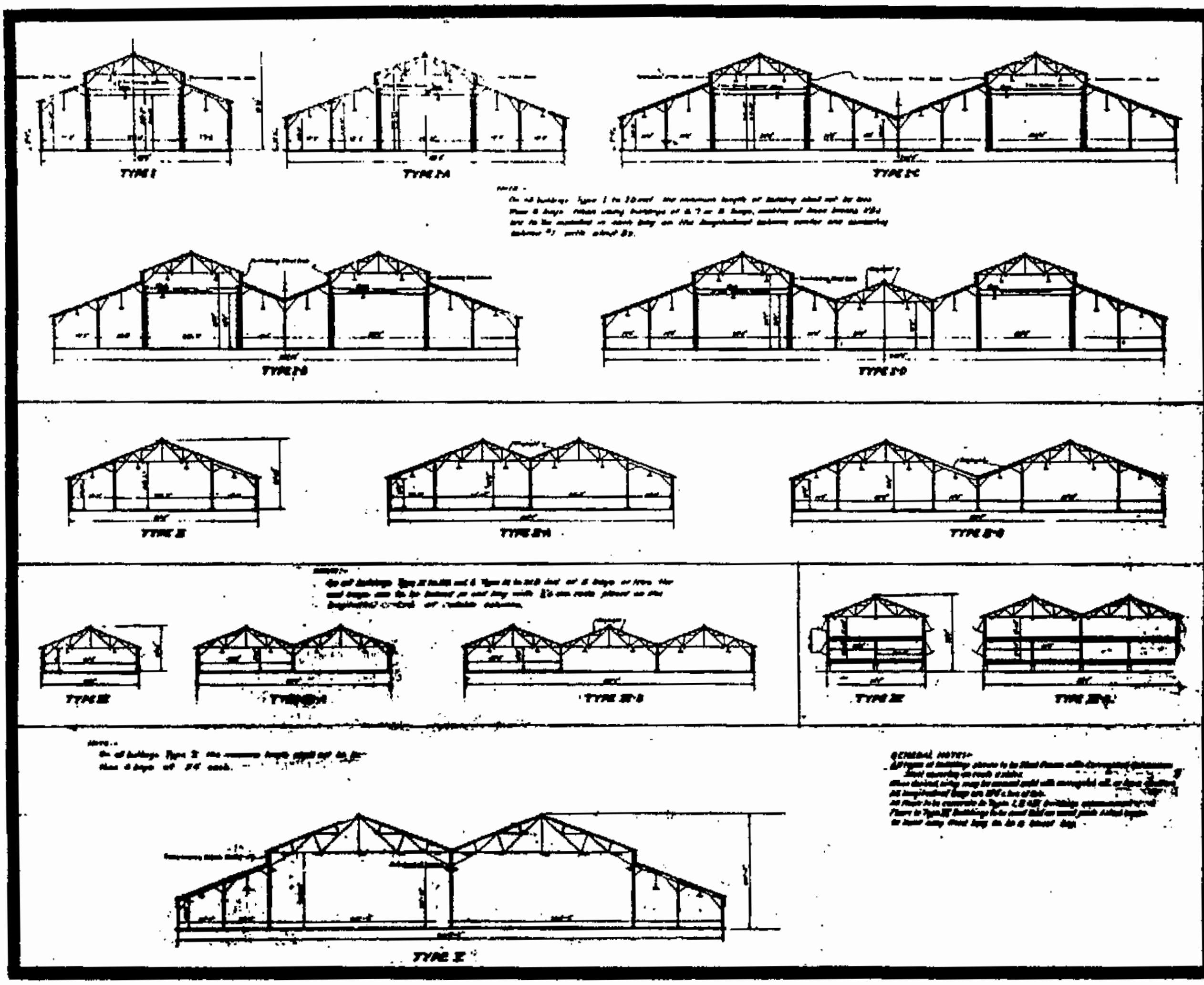


Figure 4. 1937 drawing of steel-frame, one-story warehouses (Drawing 124, 801, Reel 1293, Frame 716, Naval Construction Battalion Center, Port Hueneme, California)

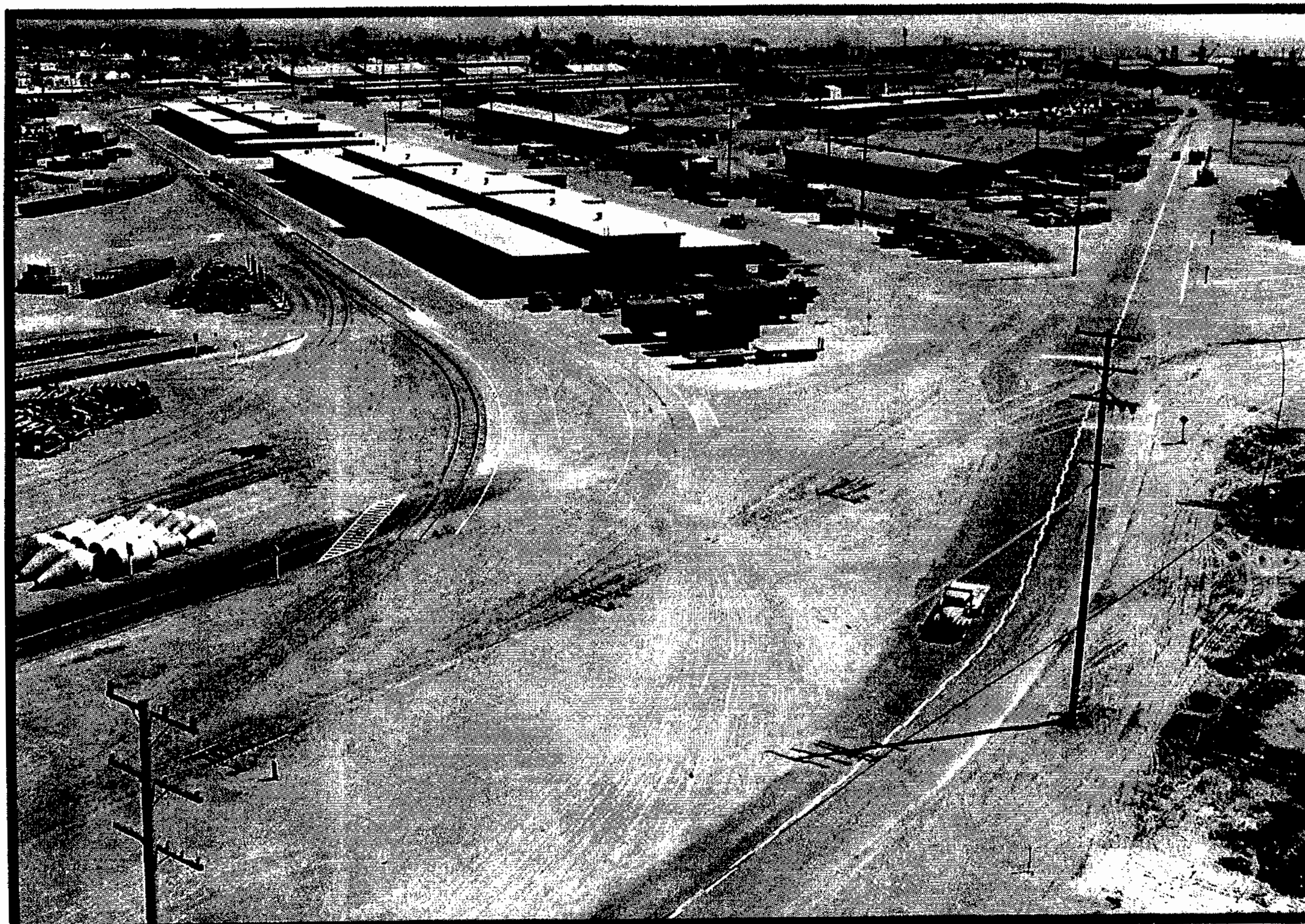


Figure 5. Standard World War II warehouse, Port Hueneme, California (Photo courtesy of U.S. Navy)

the war, the Navy resumed using steel-framing for its new standard storehouses constructed at the Stockton depot, since metal was no longer in critical short supply (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:310, 315, 316-317).

Naval Building Types

Multi-Story General Storehouses

The typical naval general storehouse was from two to eleven stories in height and utilized the restricted space available at naval shipyards most efficiently. The structure comprised reinforced-concrete columns spaced every 20 to 21 feet that supported concrete slabs; this structural system provided a four-way system of reinforcement. The ground floor generally was 15 feet high; upper floors were 10 feet 6 inches. Concrete loading platforms were located along the exterior elevations. The main floors were generally 4 feet above street level to facilitate loading material directly from railroad cars and trucks. The exterior walls consisted of an exposed concrete frame infilled with steel sash windows, heavy wire glazing, and hollow brick spandrels below the sills. Stairways and elevator shafts were located adjacent to outside walls in fireproof wells. Interior fire walls with automatic fire doors and automatic sprinkler systems also were provided (U.S. Navy Department, Bureau of Yards and Docks 1921:322, 327).

The Navy began to construct this type of general storehouse in 1917 during World War I (Figure 6, *top*). The Bureau of Yards and Docks recommended multi-story general storehouses for general storage buildings through World War II, particularly at coastal supply depots (Figure 6, *bottom*). The general storehouse type was constructed to store medical supplies, general aviation supplies, and fleet supplies.

Aircraft/Heavy Materials Storage

The design for aircraft/heavy materials storage buildings featured interior railroad tracks and a monitor roof to support a bridge crane. The height of this building type varied; one, two, and three-story examples have been identified. Building Z107 is a 1919 example of an aircraft storehouse located at Naval Base Norfolk (Figure 7, *top*). Building Z107 measures 168 x 935 feet. It has a steel frame, tile walls, steel sash windows, reinforced-concrete floors, and a flat, gypsum roof slab. A 10-ton crane located above the third story operated along an open aisle through the center of the building to move heavy parts directly from cars to loading platforms at the various floor levels (U. S. Navy Department, Bureau of Yards and Docks 1921:331-332).

During World War I, this type of storage building was constructed to store airplanes, aircraft parts, and other heavy materials. During the inter-war period, the Navy built a few heavy materials/aircraft storage buildings at shipyards and air stations. During World War II, the Navy erected heavy materials/aircraft storage buildings at supply depots, where they were used to store machinery, metals, ordnance, bulky materials, aircraft, and boats. During World War II, this type of building generally was constructed with a steel frame. The exterior walls were clad in brick or corrugated metal siding and featured the characteristic monitor roof (Figure 7, *bottom*).

One-Story General Storehouses

The one-story general storehouses were constructed in a variety of sizes and materials. Most storage buildings had multiple loading doors located along the long elevations to accommodate rail or truck traffic. Some storage buildings had more controlled access through loading doors in the narrow end. In some cases, loading doors were located in all four elevations.

During World War I, one-story storehouses often were built using temporary construction with wood framing and metal siding. Drawings for one-story storage buildings at Marine Corps bases and naval air stations depict buildings constructed of wood framing and clad with wood siding. Permanent one-story warehouses were constructed at yards and supply depots. At Naval Base Norfolk, Virginia, the Navy constructed one permanent, brick, one-story warehouse with loading doors along the long elevations and in each end (Figure 8, *top*) (U.S. Navy Department, Bureau of Yards and Docks 1921:327, 341-347).

During the inter-war period, the architectural design of general storehouses was similar to the design of the other permanent installation buildings. At Hawthorne AAP in Nevada, the one-story general storage building was constructed of concrete in a style similar to other permanent construction of the time period. During the 1930s, the Navy produced drawings of standard steel-frame, one-story buildings (Figure 4). During the early 1940s, examples of these steel-frame, metal-clad designs were constructed at yards and supply depots. Examples exist at Naval Base Charleston, South Carolina, and Naval Supply Annex, Naval Base Norfolk, Virginia. Other one-story buildings included long transit sheds that stored materials ready for shipment (Figure 8, *bottom*).

During World War II, the Navy developed a new standard general storehouse plan for a one-story building, measuring approximately 200 x 600 feet, that could store 300 carloads of palletized material (Figure 5). The standard-size one-story warehouse was constructed using many types of building materials, depending on where construction occurred and which materials were available. Framing materials included wood and steel. Drawings for the standard warehouses also depict buildings clad with mineral surfaced siding, concrete block, and corrugated asbestos siding (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:293, 310, 315; Drawings, Naval Construction Battalion Center, Port Hueneme, California).

<u>Cold Storage</u>

Cold storage buildings were first constructed during World War I, though in relatively few numbers and at few locations. The largest World War I cold storage/ice plant was constructed at Naval Base Norfolk, Virginia (now demolished). The building was a windowless, concrete-frame building that measured 118 x 263 feet. The main, 194-foot long part of the building was four stories high with a coil loft addition. Each of the lower floors was divided into six longitudinal insulated compartments. The inner compartment recorded temperatures of 30 degrees below zero (Fahrenheit). A one-story, lean-to addition housed the engine and compressor room, the freezing tanks for ice manufacture, and ice-storage space (U.S. Navy Department, Bureau of Yards and Docks 1921:328, 331). The Navy also constructed the same general design for large concrete cold storage buildings during World War II at coastal supply depots where perishable foods were collected. The four-story, concrete-frame, cold storage building constructed at Oakland Naval Supply Depot, California, is shown in Figure 9, *top*.

One-story cold storage buildings generally were constructed during the inter-war period at installations located in remote areas or where large numbers of personnel were stationed. At Hawthorne AAP in Nevada, cold storage was included in a multi-purpose building that also included a cafeteria and personnel support activities. At Naval Complex Pensacola, Florida, the one-story cold storage building was constructed of brick and ornamented with Georgian Colonial Revival motifs to complement the other buildings in the training area (Figure 9, *bottom*).

Where space was available at supply depots, the Navy constructed utilitarian one-story, cold storage buildings. The brick cold storage building constructed in 1943 at Fleet and Industrial Supply Center, Cheatham Annex, Virginia, measures 200 x 877 feet. It was constructed to hold meat, butter, and eggs. The low building features concrete loading docks located along both long elevations.

Inflammable Materials Storage Buildings

Specialized storage buildings also were constructed for inflammable materials, such as oils, paints, and dope. They generally are one-story buildings constructed of permanent materials, including brick and concrete. These types of buildings were constructed as needed and their size depended on the operations at a particular installation. At shipyards and air stations, inflammable material storage buildings can be large structures to contain the amounts of paints or lubricants used to maintain and operate ships or aircraft (Figure 10).

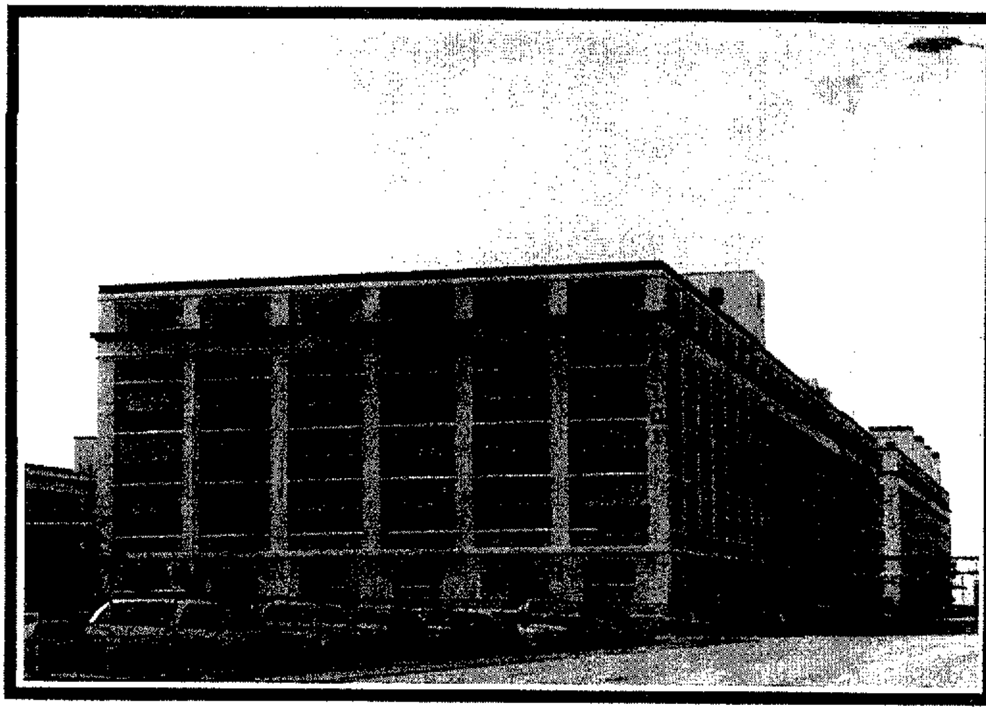
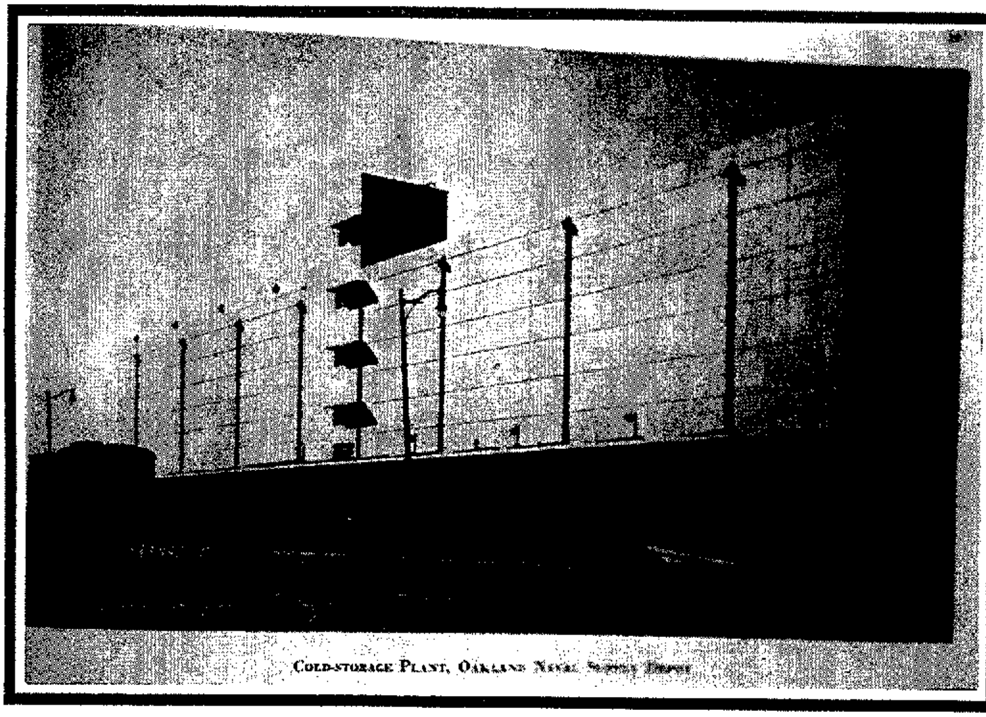


Figure 6. (*top*) 1919 six-story general storehouse (Building Z101, Naval Base Norfolk, Virginia)
(*bottom*) 1943 multiple story storehouse (Building W143, Naval Base Norfolk, Virginia)

Figure 7. (*top*) 1919 aviation supply storehouse (Building Z107, Naval Base Norfolk, Virginia)
(*bottom*) 1940 aircraft storehouse constructed at aviation depot (Building X136, Naval Base Norfolk, Virginia)

Figure 8. (*top*) 1919 one-story warehouse (Building Z105, Naval Base Norfolk, Virginia)
(*bottom*) 1945 transit warehouse (Building Z2, Naval Base Norfolk, Virginia)



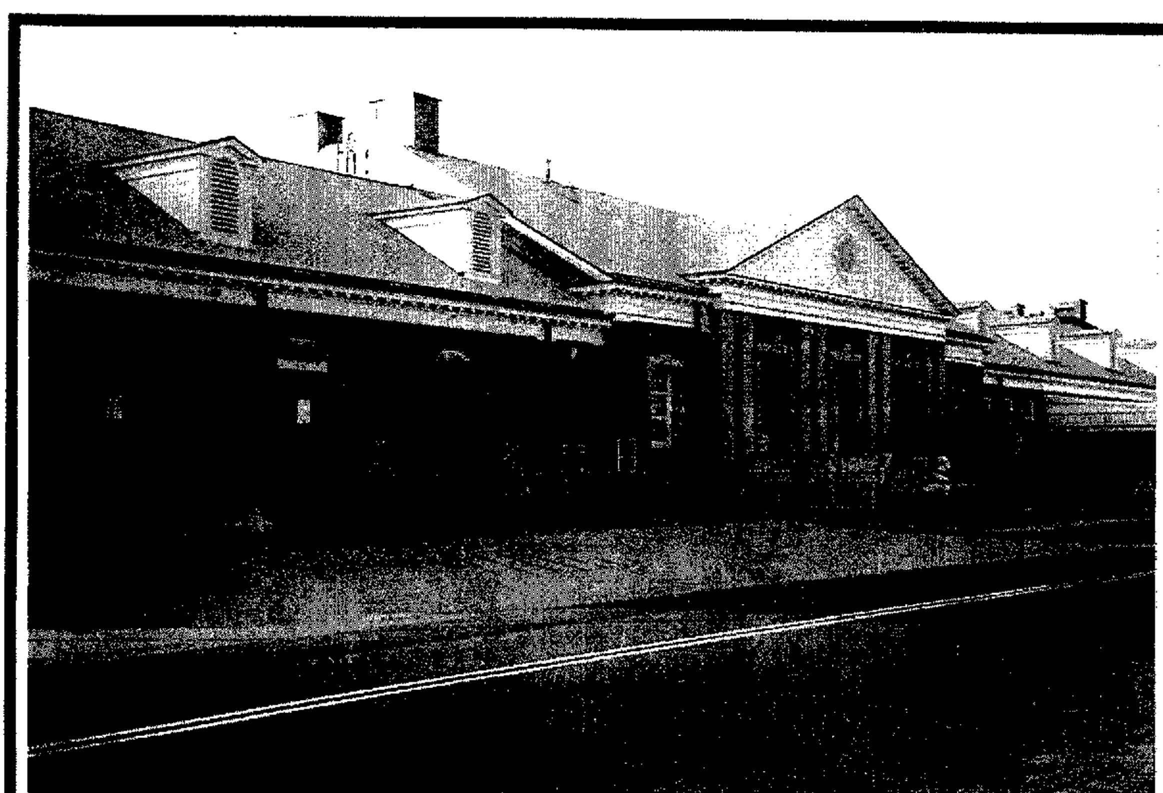
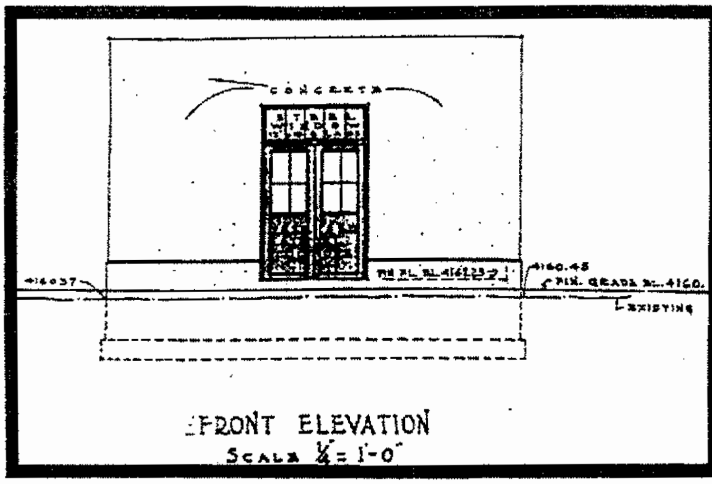


Figure 9. (*top*) World War II cold storage building constructed at Oakland Naval Supply Depot, California (Photo courtesy of U.S. Navy)
(*bottom*) 1942 cold storage building (Building 680, Naval Complex Pensacola, Florida)



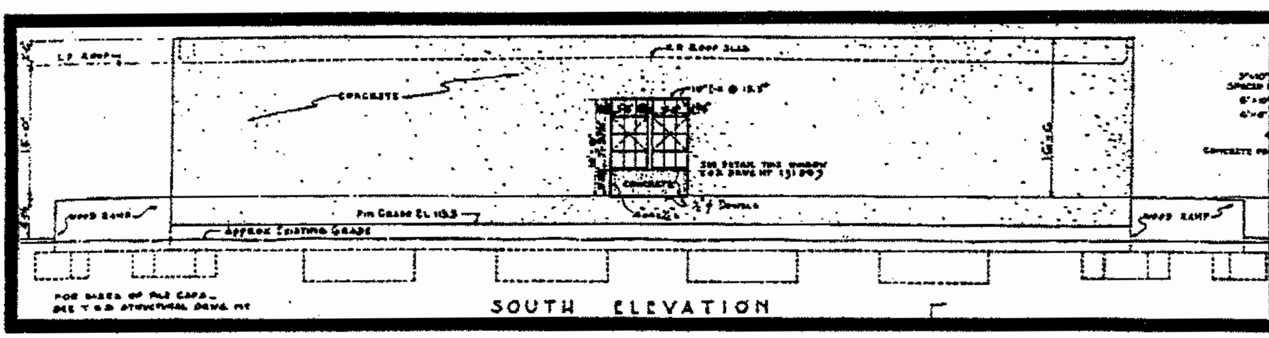


Figure 10. (*top*) 1930 drawing of paint storehouse, Hawthorne Ammunition Depot, Nevada (NARA, Cartographic Branch, RG 71, microfilm reel 1092)
(*middle*) 1939 drawing of paint and oil storehouse, Naval Air Station Alameda, California (NARA, Cartographic Branch, RG 71, microfilm reel 1048)
(*bottom*) 1942 paint and oil storehouse (Building SP83, Naval Base Norfolk, Virginia)

Army General Storage

The Army historically provided troops with necessary supplies, including food, clothing, and weapons. To control the distribution of supplies, the Army developed a dual storage system during the nineteenth century. Each permanent installation had one or two storehouses to store and distribute subsistence and other supplies to troops at the installation. In addition, the Quartermaster Corps developed central depots to store Quartermaster supplies for regional distribution. Access to transportation influenced the location of general depots. During the late nineteenth century, railroads replaced mule trains as the primary method of supply delivery. The spread of railroads increased the effectiveness of supply distribution from regional supply depots. Other technical services, including the Corps of Engineers and the Signal Corps, established their own supply systems to distribute equipment to their personnel. During the twentieth century, the amount of supplies required to outfit and support troops increased. The Quartermaster and other Army technical services required larger and more numerous warehouses, particularly during times of war.

World War I

As the United States entered World War I, the Army found that its storage facilities were inadequate to support the war effort. In November 1917, the Quartermaster Corps possessed less then 3 million square feet of storage space (Risch 1989:630). The wartime troop mobilization required corresponding increases in the supplies for those troops. Rapidly constructed training camps required hundreds of installation storehouses. Shipping terminals and depots were insufficient to handle the material needed to support a large expeditionary force. Docks and storage facilities for overseas shipments were dilapidated and handicapped by out-of-date technology to handle large quantities of goods (Nimmons 1919). In addition, the Army needed to transport new equipment that never had been used in battle, such as motorized vehicles, tanks, and aircraft. These items required specialized repair and supply depots.

The logistical organization during World War I suffered from lack of adequate storage facilities. Shipments of goods were delivered directly from factory production lines to the Army's eastern shipping terminals. The numerous shipments clogged the piers and prevented the ready assignment of priorities to the goods. Harried officials often organized shipments by what was available on the dock rather than by need.

The Army soon took steps to improve the distribution of supplies within the country and overseas. In early 1918, the government took control of the railroads. The Army began to construct new storage buildings and to lease commercial warehouses. The Army established secondary depots near the shipping terminals to free up space at the terminals. The depot system was reorganized into geographic zones, including specialized technical supplies organized along supply service lines. Depots supplied all camps, posts, and stations located in a specific geographical area (Risch 1953:326-327). By December 1918, the Army had over 64.5 million square feet of storage space (Risch 1989:702).

Towards the end of the war, the Construction Division of the Quartermaster Corps, which was charged with the design and construction of the mobilization facilities, began to plan for the return of men and material from overseas. On 23 August 1918, the Secretary of War authorized the funding to construct repair shops, warehouses, and other necessary facilities for salvage purposes at each of the National Army cantonments and National Guard camps (Risch 1989:705-706). Construction of wood-frame storage buildings continued during 1919.

Installation Storage. The Army's Quartermaster Corps required new storage buildings to supply troops at training camps. One or two Quartermaster storehouses could not hold all the supplies needed at the training cantonments. Multiple storehouses were required, each with access to rail siding. Warehouses constructed at Army cantonments during 1918 typically were one-story, long, narrow, wood-frame buildings with loading platforms along the side elevations to provide access to railroad cars and/or trucks. The Construction Division built 789 small storehouses at National Army cantonments alone (Crowell 1919:544).

One special type of storage that became widespread during World War I was the cold-storage building. Where possible, camps relied on cold-storage space obtained from the civilian community or refrigerated railroad cars; however, at some camps, it was necessary to build special refrigeration plants. These refrigeration plants had an ice-making capacity ranging from 6 to 35 tons daily. The ice consumption of American soldiers in the U.S. proved to be 2 3/4 pounds per man per day (Crowell 1919:544).

Supply Depots. At the beginning World War I, the Construction Division included Quartermaster storage depots in its extensive construction program. Between April 1917 and January 1919, the Construction Division constructed new storage facilities at seven expeditionary supply bases and nine interior depots. The expeditionary supply bases were located at: Brooklyn, New York; Boston, Massachusetts; Philadelphia, Pennsylvania; Norfolk, Virginia; Charleston, South Carolina; New Orleans, Louisiana; and, Port Newark, New Jersey. The interior depots were located at: Baltimore, Maryland; Chicago, Illinois; Columbus, Ohio; Jeffersonville, Indiana; New Cumberland, Pennsylvania; Philadelphia, Pennsylvania; Pittsburgh, Pennsylvania; Schenectady New York; and St. Louis, Missouri (Crowell 1919:562).

Two types of buildings appeared at Quartermaster supply depots: multi-story buildings and one-story buildings. The multi-story warehouses typically were built in urban areas, where available land was expensive and scarce. The buildings were fireproof with reinforced-concrete flat-slab construction. Multiple-storied warehouses were constructed at Brooklyn, New York; Boston, Massachusetts; Chicago, Illinois; and, St. Louis, Missouri (Nimmons 1919; Crowell 1919:554-556).

One-story warehouses were constructed of a variety of materials. At New Cumberland, warehouses were constructed of structural clay tile and brick walls on a concrete foundation (Building Technology Inc. *New Cumberland* 1984:15-16). At the depot at Charleston, South Carolina, six warehouses with a storage capacity of 1,152,000 square feet also were constructed of tile walls with concrete floors (Nimmons 1919). The Construction Division also built one-story warehouses with timber framing. These one-story buildings contained windows for natural lighting and sliding doors spaced in alternate 20-foot bays. These buildings were constructed with firewalls that extended from a concrete footing wall to about three feet above the roof (*Engineering News-Record* 1918:464).

Aviation Depots. At the beginning of World War I, the growth of aviation required not only recruit receptions centers and training fields, but also aviation general supply depots, aviation general repair depots, and acceptance parks for new aircraft. Aviation supply depots stored supplies, engines, and spare parts for distribution. Supply depots included: Americus, Georgia; Middletown, Pennsylvania; Richmond, Virginia; Fairfield Depot, Ohio; Little Rock Depot, Arkansas; San Antonio Depot, Texas; Morrison Depot, Virginia; and, Middletown Depot, Pennsylvania. Repair depots provided maintenance and overhaul of aircraft. Repair depots included: Indianapolis, Indiana; Montgomery, Alabama; and, Dallas, Texas (Brown 1990:44, 47, 50).

Aviation depots required special fireproof warehouses because of the flammable nature of the oil and other materials used by the Signal Corps (Crowell 1919:553). One example of an aviation depot was Fairfield Air Depot located outside of Dayton, Ohio, and now part of Wright-Patterson AFB. Established in June 1917, the first permanent building (Building 30001) completed was a one-story, U-shaped building that measured 262 x 825 feet. The U-shape allowed for the construction of a railroad spur through the center of the building. The roof covered the two wings and the railroad spur and contained storage space as well as offices. Six other buildings were completed during World War I including three steel storage hangars and a depot garage (Walker 1986:51-53).

Inter-war Period

Following the Armistice on 11 November 1918, the Army arranged for permanent storage of massive amounts of military material that was returned from Europe. While general construction projects were halted after the Armistice, the Army continued to build storage facilities. By December 1919, the Army owned more that 76.25 million square feet of storage space and rented more that 300 million square feet, the majority of which was open storage. The Army began a massive effort to salvage and sell surplus property, which effectively reduced its storage space requirements. Perishable goods and food stuffs were sold. The Army retained non-perishable items, such as tanks, automobiles, and aircraft parts for future use. Often this material was stored at existing Army arsenals. For example, at Rock Island Arsenal, the Army constructed eleven, flat-roofed, one-story, brick, vehicle warehouses, to store World War I equipment (Bouilly and Slattery n.d.:19). In 1922, the Army announced a policy requiring the use of on-hand equipment until the wartime supply was exhausted (Risch 1989:702, 711).

Installation Storage. The Army did not resume major construction projects until after the enactment of a nationwide Army construction program in 1926. The permanent construction program was initiated to address the poor housing conditions, particularly for enlisted and NCO personnel, reported at military installations throughout the United States. In 1929, Congress appropriated money to fund the construction of miscellaneous construction projects, including shops, warehouses, and magazines at specific installations (Risch 1989:714).

The permanent construction program had widespread impact on Army and Air Corps installations. Many installations retained after World War I were improved with permanent buildings during this period. Quartermaster Corps plans for new installations sought to provide both aesthetically pleasing layouts and practical utility and support areas. Though storage construction was not the primary purpose of the new building program, some World War I-era warehouse areas at installations were expanded through the addition of permanent masonry warehouses. Construction of storage buildings at this time focused on adequate installation storage; no new depots were constructed during the inter-war period. Some of the installations that received permanent construction between 1927 and 1940 include: Fort Belvoir, Virginia; Fort Benning, Georgia; Fort Bragg, North Carolina; Fort Devens, Massachusetts; Fort Knox, Kentucky; Fort Lewis, Washington; Fort Meade, Maryland; Fort McClellan, Alabama; Barksdale AFB, Louisiana; Bolling AFB, Washington, D.C.; Chanute AFB, Illinois; March AFB, California; Maxwell AFB, Alabama; Pope AFB, North Carolina; Randolph AFB, Texas; Scott AFB, Illinois; Selfridge ANG, Michigan; and, Wright-Patterson AFB, Ohio.

Supply Depots. During the 1920s, activity at general storage decreased. Activities were consolidated and the numbers of active depots decreased. The Army discontinued the geographical zone supply system instituted during World War I and reverted to a system of branch depots where supplies belonging to different technical branches were stored at different depots.

During the 1930s, activity at Army supply depots increased after the Quartermaster Corps became responsible for supplying the Civilian Conservation Corps. In 1940, the Quartermaster

Corps maintained 12 storage depots, totaling over 7.5 million square feet of storage space. This was enough storage capacity to maintain the inter-war employment level of Army personnel, since it was estimated that each serviceman required 17.5 square feet of storage. The supply depots included six general depots (San Francisco, California; San Antonio, Texas; Columbus, Ohio; New Cumberland, Pennsylvania; New York, New York; and, Schenectady, New York) and six Quartermaster depots (New Orleans, Louisiana; Chicago, Illinois; Washington, D.C.; Jeffersonville, Indiana; Philadelphia, Pennsylvania; and, Boston, Massachusetts) (Risch 1953:329, 331).

Aviation Depots. During the inter-war period, activity at aviation depots also decreased. By 1925, The number of aviation depots was reduced to three: Fairfield, Ohio; San Antonio, Texas; and, Middletown, Pennsylvania. In 1939, aviation depots numbered four: Middletown, Pennsylvania; Fairfield, Ohio; San Antonio, Texas; West Coast Depot, California (Brown 1990:70-71, 112-113).

World War II

Beginning in 1939, when President Roosevelt proclaimed a limited national emergency, the Quartermaster Corps planned the expansion of storage at installations and at existing depots.

Installation Storage. To supply increased numbers of recruits and trainees, the Army constructed numerous installation storehouses. For the most part, these warehouses were one-story, wood-frame, temporary mobilization buildings. Loading doors with loading platforms were located along the long elevations. In general, installation storage buildings were clustered in Quartermaster support areas with accessibility to road and railroad networks. Cold storage for perishable items often was located in the same support area. In most instances, cold storage buildings also were constructed from temporary mobilization plans.

Supply Depots. In 1940, the Quartermaster Corps began to expand its storage capacity at existing depots and to construct new depots. Locations of new depots was determined by their proximity to troop training installations, transportation, and commercial handling facilities. By December 1941, the Quartermaster Corps controlled 11.5 million square feet of storage space. Warehouse construction continued until 1943 when the Army Service Forces stopped all depot construction, unless such construction was required to maintain the efficiency of depot operations. By 1944, the Quartermaster Corps controlled eleven Armed Service Forces depots, ten Quartermaster depots, and eight sub-depots. By 1945, the Quartermaster's storage space totaled close to 75 million square feet including leased storage (Risch 1953:332-333, 334-335). Major Army depots are listed in Table 2.

In addition to Armed Service Forces supply depots and Quartermaster depots, other technical services also established supply depots. The Signal Corps established seven depots and the Corps of Engineers established seven depots (Table 2).

During World War II, the Army adopted the one-story storehouses for new construction at its general storage and specialized depots. World War II storehouses were long buildings with multiple loading doors and loading docks along side elevations. The loading docks and loading doors facilitated loading from trains and trucks. Often the depot complex was arranged so that one side allowed access to motor vehicles while the other side had railroad access. High ceilings and wide floor area allowed use of fork-lift equipment and stacking supplies on pallets (Risch 1953:333, 347-348).

Originally the buildings were constructed with structural steel framing. Critical shortages of steel during the early 1940s required the substitution of wooden and concrete framing. A

TABLE 2. WORLD WAR II ARMY SUPPLY DEPOTS

Original Name	Current Name	Location	Date Established	Type of Depot
Atlanta Army Depot	N/A	GA	1941	Army Service Forces
Belle Meade Army Depot	N/A	NJ	1941	Army Service Forces
Columbus Army Depot	Defense Construction Supply Center	OH	1918	Army Service Forces
Memphis Army Depot	Memphis Defense Depot	TN	1941	Army Service Forces
New Cumberland Army Depot	DDRE (New Cumberland)	PA	1918	Army Service Forces
Richmond Army Depot	Defense General Supply Center	VA	1941	Army Service Forces
Salt Lake City Army Depot	N/A	UT	1941	Army Service Forces
San Antonio Army Depot	N/A	TX	1918	Army Service Forces
Savannah Army Depot	N/A	GA	N/A	Army Service Forces
Schenectady Army Depot	N/A	NY	1918	Army Service Forces
Seattle Army Depot	N/A	WA	1941	Army Service Forces
Albany Engineer Depot	N/A	NY	N/A	Corps of Engineers
Granite City Engineer Depot	St. Louis Support Center	IL	1942	Corps of Engineers
Lathrop Engineer Depot	Sharpe Army Depot	CA	1942	Corps of Engineers
Marion Engineer Depot	N/A	OH	N/A	Corps of Engineers

Original Name	Current Name	Location	Date Established	Type of Depot
Pasco Engineer Depot	N/A	WA	N/A	Corps of Engineers
San Bernardino Engineer Depot	N/A	CA	N/A	Corps of Engineers
Sharonsville Engineer Depot	N/A	OH	N/A	Corps of Engineers
Boston Army Depot	N/A	MA	1918	Quartermaster
Charlotte Army Depot	N/A	NC	N/A	Quartermaster
Chicago Army Depot	N/A	IL	1918	Quartermaster
Fort Worth Army Depot	N/A	TX	1940	Quartermaster
Jeffersonville Army Depot	Jeffersonville Depot Activity	IN	1864	Quartermaster
Jersey City Army Depot	N/A	NJ	N/A	Quartermaster
Kansas City Army Depot	N/A	MO	N/A	Quartermaster
Oakland Army Depot	Oakland Army Base	CA	1941	Quartermaster
Philadelphia Army Depot	N/A	PA	N/A	Quartermaster
Washington Army Depot	N/A	DC	N/A	Quartermaster
Chicago Signal Depot	N/A	IL	N/A	Signal Corps
Dayton Signal Depot	N/A	OH	N/A	Signal Corps
Lexington Signal Depot	Lexington Army Depot	KY	1941	Signal Corps
Ogden Signal Depot	N/A	UT	N/A	Signal Corps
Philadelphia Signal Depot	N/A	PA	N/A	Signal Corps

Original Name	Current Name	Location	Date Established	Type of Depot
Sacramento Signal Depot	Defense Depot, Sacramento	CA	1942	Signal Corps
San Bernadino Signal Depot	N/A	CA	N/A	Signal Corps

SOURCE: Risch 1953:335; Hirrel et al. 1994.

description of six one-story storehouses measuring 180 x 960 feet was published in *Engineering News-Record* in 1942. The foundations and wall bases were poured concrete constructed without steel reinforcement; the walls were built of brick. The interior columns were concrete and the roofs were framed with wood trusses (*Engineering News-Record* 1942:204-206). As the war progressed, warehouses were constructed of structural clay tile or corrugated transite siding.

Aviation Depots. The number of aviation depots also increased during World War II (Table 3). Often aviation depots also served as repair depots. Storage capacity that had been adequate during the inter-war period suddenly became insufficient. New one-story warehouses were constructed at a rapid pace. At Fairfield Aviation Depot (Wright-Patterson AFB), Ohio, one-story brick storage buildings were constructed to augment existing World War I storage buildings. At Duncan Field (Kelly AFB), Texas, warehouses were constructed of wood frame with wood siding. In addition, open space was utilized for materials that were impermeable to weather.

Army Building Types

Multi-Story General Storehouses

Multi-story storehouses were constructed at Army supply bases during World War I. This type of fireproof warehouse was constructed of reinforced concrete using flat slab construction. At Brooklyn Army Supply Base in New York, two eight-story warehouses were constructed. One warehouse measured 200 x 960 feet, while the other measured 230 x 980 feet. Similar multi-storied warehouses were constructed at Boston, Massachusetts; Chicago, Illinois; and, St. Louis, Missouri. These permanent warehouses were fireproof and contained up-to-date technology (Nimmons 1919; Crowell 1919:554-556). Multi-storied storehouses were built where land was expensive, as in major cities or at ports. The Army did not construct this type of warehouse after World War I.

One-story Warehouses with Multiple Loading Doors Along Side Elevations

Between 1917 and 1946, one-story warehouses dominated storehouse construction. These storehouses are characterized with multiple loading doors along side elevations. Concrete loading platforms often were built along the long side elevations. Generally one side of the building was used to load and unload trucks, while the opposite side was used to load or unload railroad cars. The size of the warehouse depended on its purpose and the size of installation that it served. The buildings were constructed of all types of materials. During wartime emergencies, temporary wood-frame or steel buildings were constructed that were clad with wood or corrugated metal or transite siding. During World Wars I and II, long wood-frame storehouses were constructed with firewalls (Figure 11; Figure 12, *bottom*). Permanent warehouses were built of masonry materials, including brick, structural clay tile and concrete (Figure 12, *top*). The roofs typically were low-pitched gable roofs or monitor roofs, which allowed additional light into the building (Figure 13).

Heavy Materials Storehouses

This type of one-story storehouse is characterized by loading doors in the narrower end elevations rather than the long side elevations. This type of storehouse was built to store heavy materials, aircraft parts, or specialized supplies that did not require constant access. Interior cranes were installed along the long axis of the building to move the heavy supplies. This type of storehouse was built at Air Corps depots during World War I and World War II (Figure 14).

TABLE 3. WORLD WAR II AVIATION DEPOTS

Original Name	Current Name	Location	Date Established	Type of Depot
Fairfield Air Depot	Wright-Patterson AFB	OH	1918	Army Air Force
Galena Field	Fairchild AFB	WA	1942	Army Air Force
Midwest Air Depot	Tinker AFB	OK	1941	Army Air Force
Sacramento Air Depot	McClellan AFB	CA	1936	Army Air Force
Rome Air Depot	Griffiss AFB	NY	1942	Army Air Force
San Antonio Air Depot	Kelly AFB	TX	1917	Army Air Force
Robins Field	Robins AFB	GA	1941	Army Air Force
Little Rock Depot	Little Rock AFB	AR	1939	Army Air Force
Middletown Air Depot	N/A	PA	1918	Army Air Force
Mobile Depot	N/A	AL	1940	Army Air Force
Ogden Air Depot	Hill AFB	UT	1940	Army Air Force

SOURCE: Brown 1990:124-125; Mueller 1989.

Other heavy materials storehouses were constructed at storage depots and to meet specific installation requirements (Figure 15).

Quartermaster/Commissary Storehouse

The Quartermaster storehouse generally was a one- or two-story, gable-roof building constructed of brick, with standard-size windows and doors. This building type was the standard Quartermaster installation storehouse during the nineteenth century. It often contained storage and offices for the commissary and Quartermaster departments. During the wave of permanent construction during the inter-war period, one or two of these building types were often built at installation. The buildings may feature simplified detailing that reflects the architectural revival style selected for the main buildings of the cantonment. These buildings are smaller than the wartime warehouses. They usually are located in the Quartermaster support area set apart from the administrative and residential areas of the cantonment (Figure 16).

Air Corps Warehouse

The Air Corps warehouse is a one-story, rectangular, gable-roof building, typically constructed of brick, and characterized by bands of industrial steel sash windows (Figure 17). Entries are located on all four elevations. The Army constructed this building type at Air Corps installations during the inter-war period. With some variation of window and door openings, this building type also was constructed as maintenance and repair buildings at many installations. One variation of this warehouse type is the one-story tripled version often constructed at airfields.

Inflammable Materials Storage Buildings

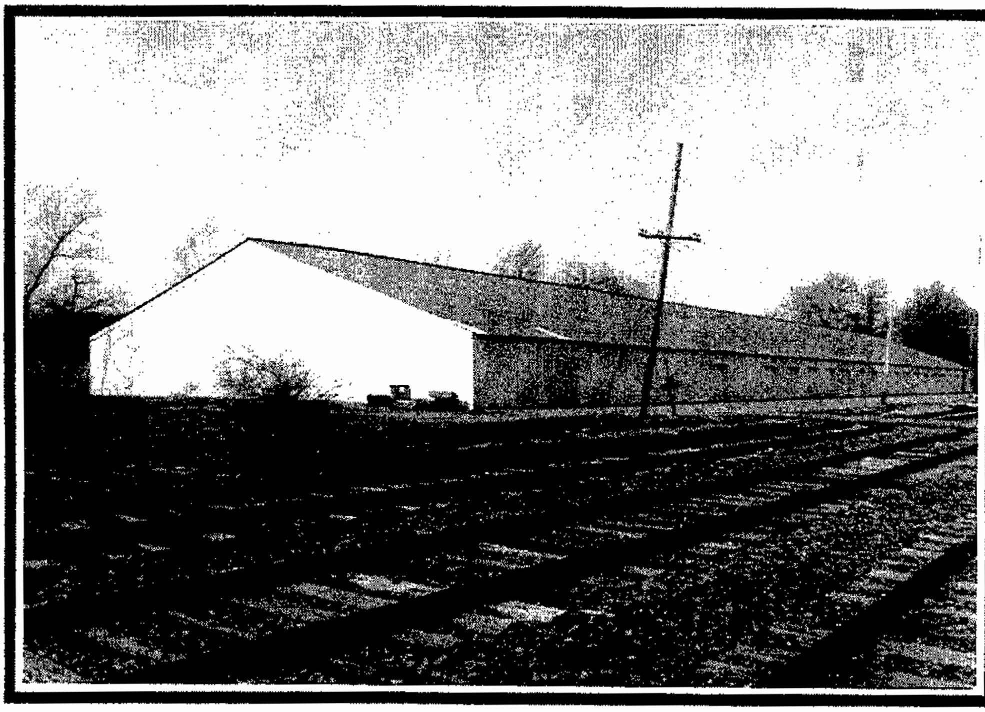
Inflammable materials storehouses generally are small one-story buildings that are used to store small amounts of inflammable materials, such as petroleum products (e.g., grease and lubricating oils), paints, dope, or other substances that were necessary in repair or maintenance activities. Between 1919 and throughout the 1930s, inflammable materials storehouses generally were constructed of masonry. They were located approximately 50 feet from the operations they supported. During World War II, the Army constructed metal frame buildings with corrugated metal siding to store inflammable materials. Often these buildings were located in installation support complexes such as quartermaster maintenance areas or, as at Aberdeen Proving Ground, in the test and shop area (Figure 18).

Oil House

A special building type constructed for one kind of inflammable material was the oil house. This storage building was one-story, generally constructed of permanent building materials. The main entrance was located in the front gable where drums of oil were loaded and unloaded. These buildings often were located near installation gasoline stations (Figure 19).

Cold Storage

Cold storage facilities first appeared on a widespread basis during World War I. They often were constructed as temporary mobilization buildings at training camps. During the inter-war period, the World War I cold storage buildings often were converted to permanent buildings; few new cold storage buildings were built during the inter-war period. On the eve of World War II, few installations included cold storage buildings. During World War II, the Army started a concerted effort to construct this building type using temporary mobilization plans. This building type is characterized by few window and door openings with loading platforms. No permanent examples of cold storage buildings were identified on site visits to Army or Air Force installations during this study.



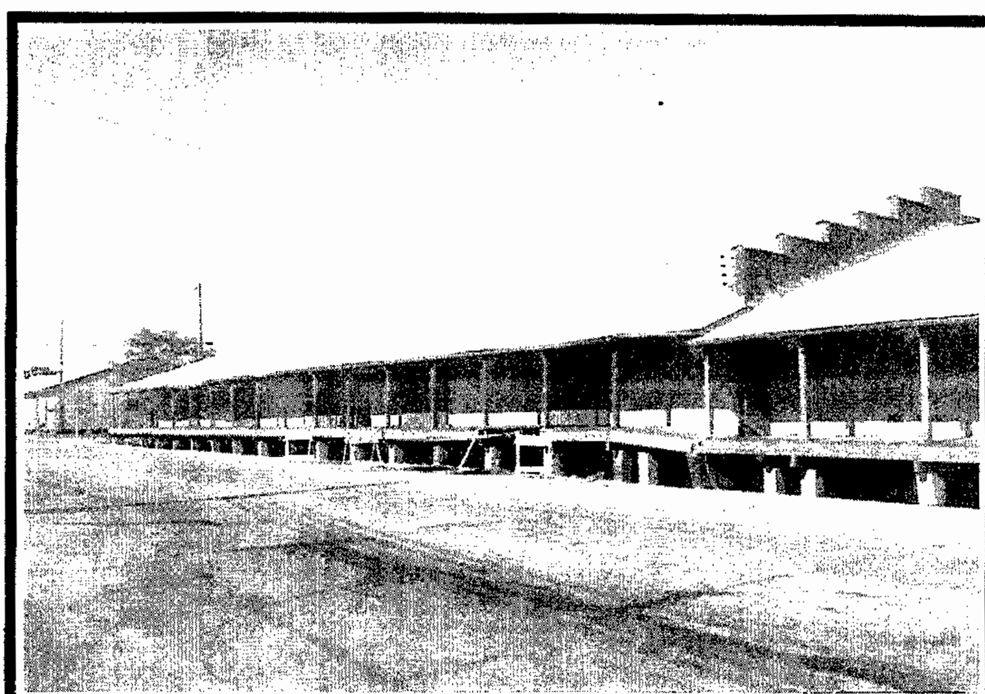
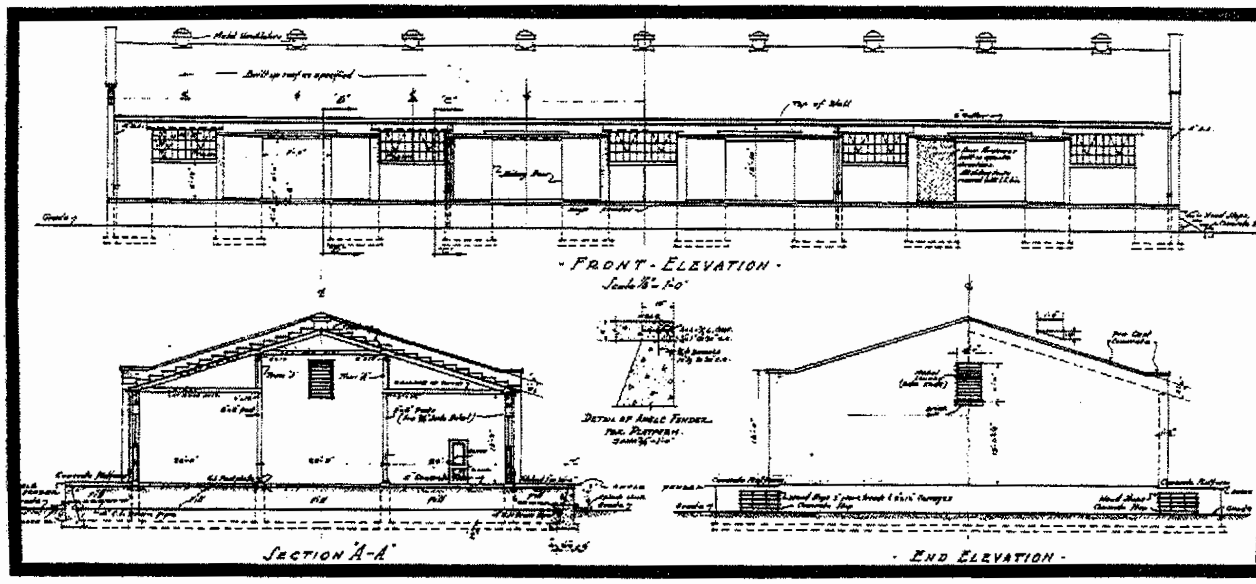


Figure 11. (*top*) 1918-1919 Field Service Storage (Building 530, Aberdeen Proving Ground, Maryland)
(*bottom*) 1919 installation storehouse (Building 61, Fort Knox, Kentucky)



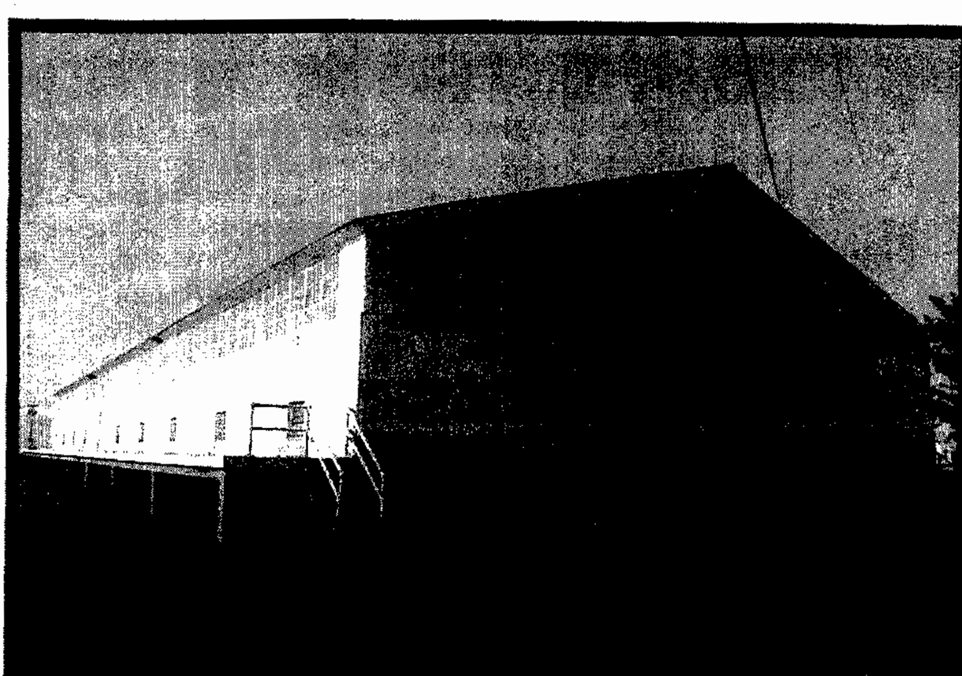


Figure 12. (*top*) 1933 Quartermaster warehouse (History Office, U.S. Army Corps of Engineers, OQMG Drawing 422-145, Box 88)
(*bottom*) 1941 general storehouse/inert storage (Building E5246, Aberdeen Proving Ground, Maryland)

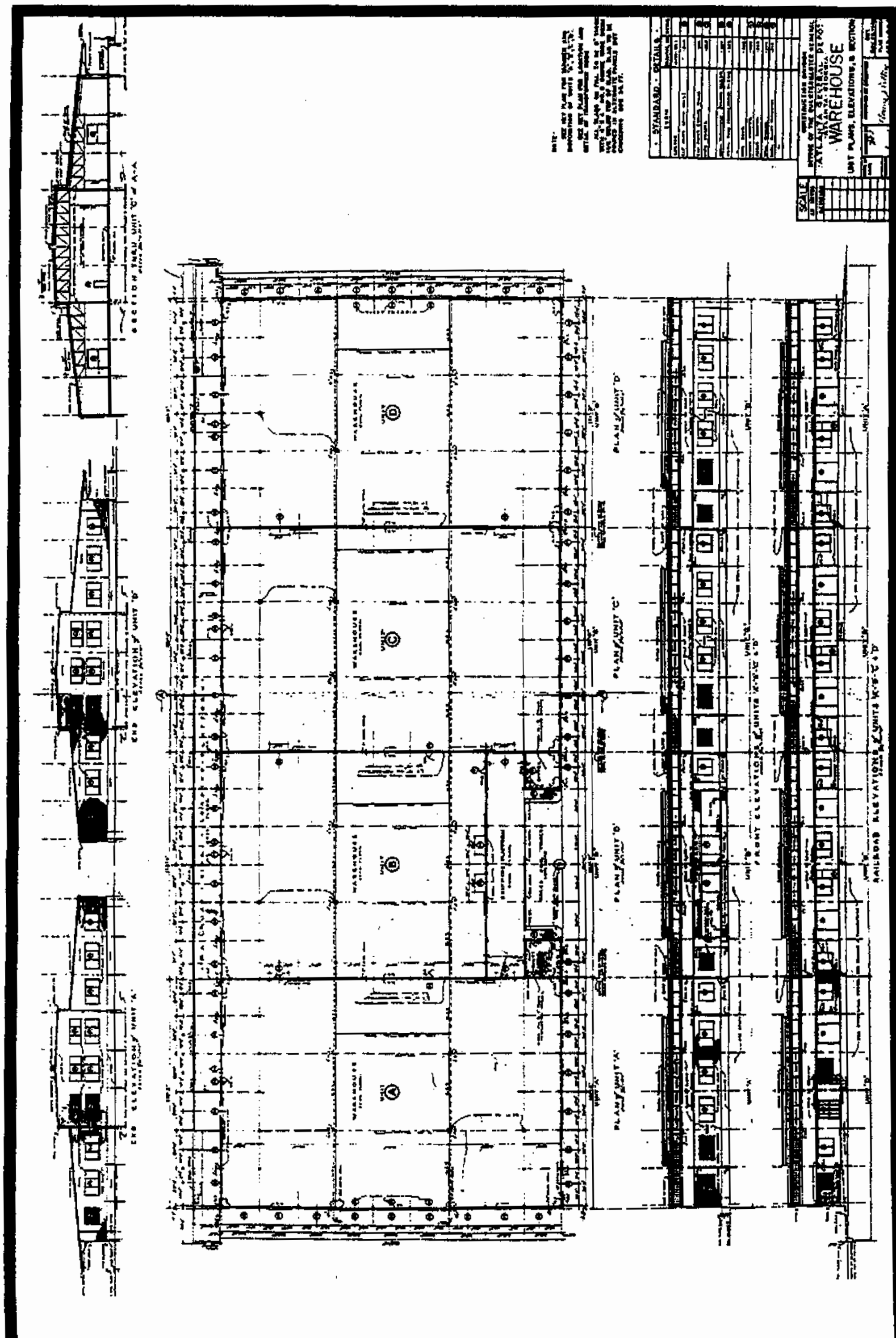


Figure 13. 1940 warehouse, Atlanta General Depot (History Office, U.S. Army Corps of Engineers, OQMG Drawing 422-296, Box 88)

Figure 14. (*top*) 1918 Air Corps Depot Headquarters and main storehouse (Building 30001, Wright-Patterson AFB, Ohio)
(*bottom*) 1941 Air Corps Depot warehouse (Building 30255, Wright-Patterson AFB, Ohio)

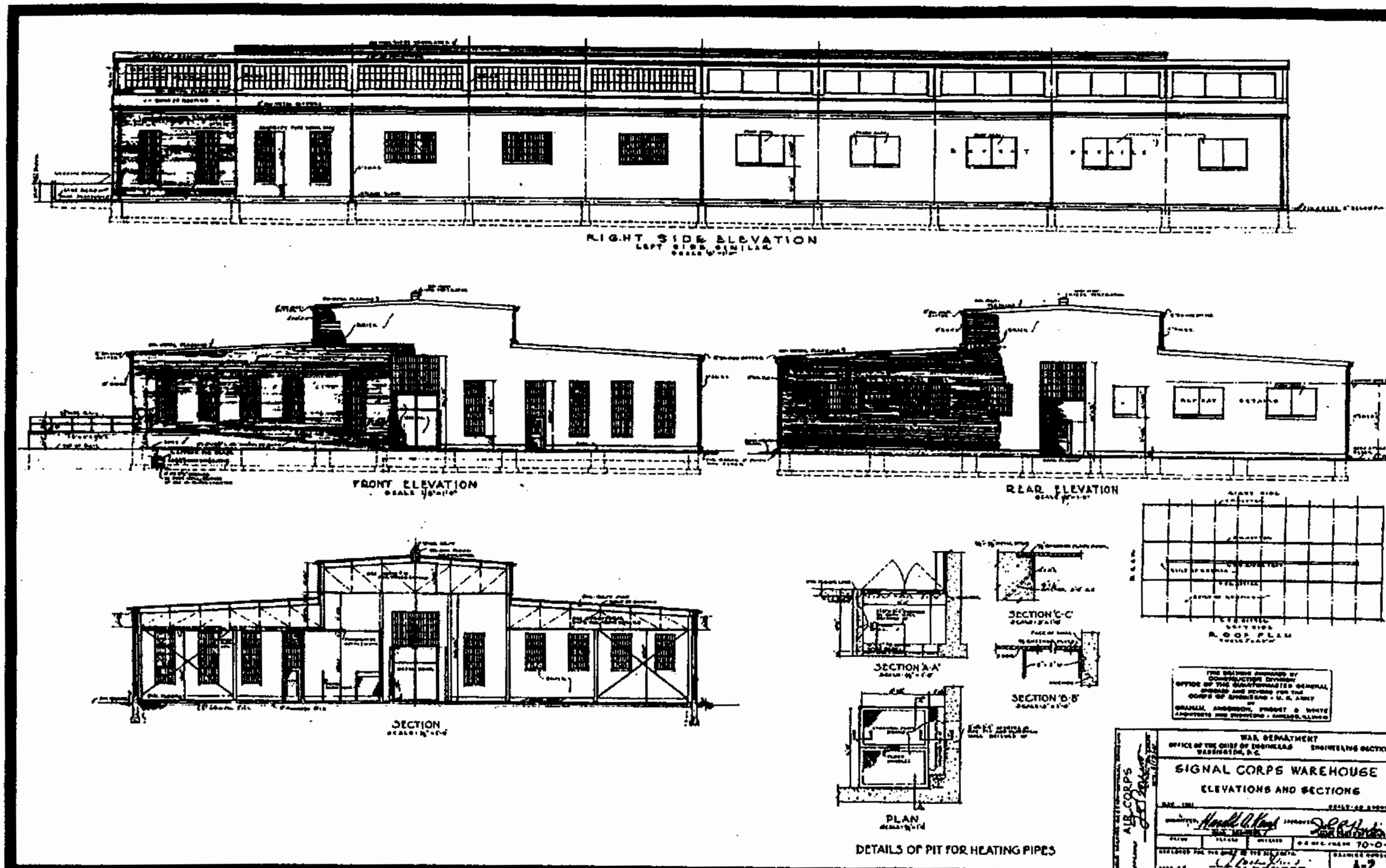


Figure 15. 1941 Signal Corps Warehouse (History Office, U.S. Army Corps of Engineers, OQMG Drawing 70-0-3.A-2, Box 146)

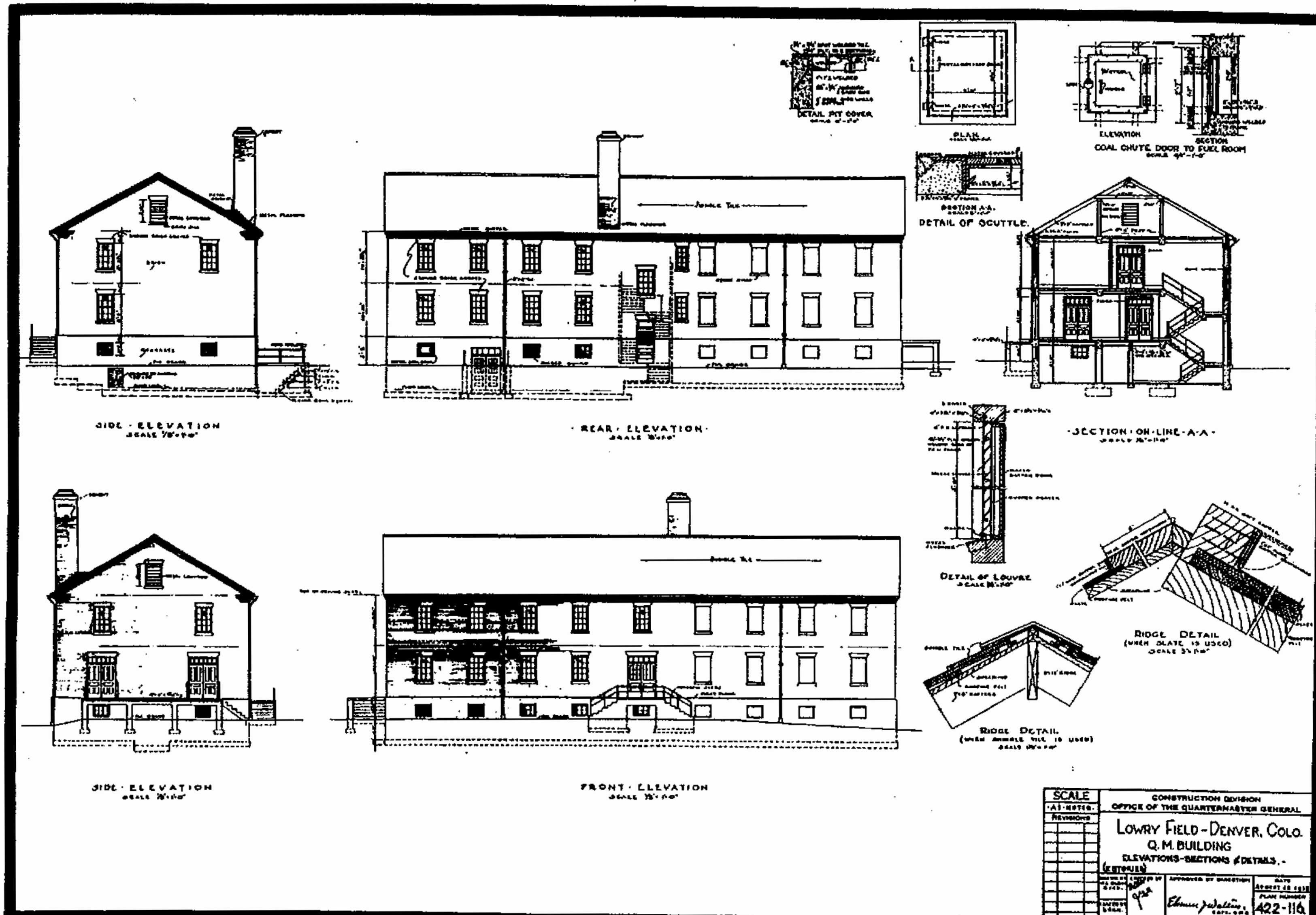


Figure 16. 1938 quartermaster storehouse (History Office, U.S. Army Corps of Engineers, OQMG Drawing 422-116, Box 88)

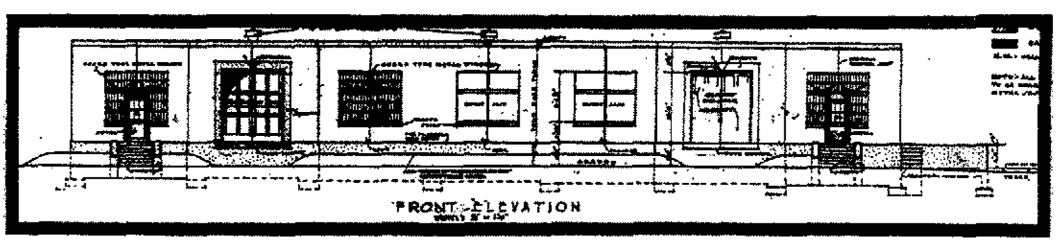


Figure 18. (*top*) 1934 inflammable materials storehouse (Building 531, Aberdeen Proving Ground, Maryland)
(*bottom*) 1941 paint, oil, and dope storage building (History Office, U.S. Army Corps of Engineers, OQMG Drawing 87-0-1.A-2, Box 147)

Figure 19. 1934 oil house (Building 342, Aberdeen Proving Ground, Maryland

CHAPTER V

ORDNANCE STORAGE

Military weapons, along with ammunition and related equipment, are defined as ordnance. The development, production, use, and storage of ordnance are directly related to the military's mission of defense. Storing ordnance requires specialized storage structures that generally are recognizable as separate building types from general storage. Ordnance storage buildings are further distinguished by the material they store. The design and construction of ordnance storage buildings over time was influenced strongly by the type of ordnance stored in the building. Explosives were divided into two categories: high explosives and propellants. High explosives, which exploded with greater force, were used to fill artillery shells or aerial bombs. Propellants were comparatively slow burning materials used to force the round out of the gun barrel, or to act as a rocket motor. Smokeless powder was the most common propellant.

During World War II, the military had three broad classifications of ordnance materials:

(1) most hazardous materials, including bulk high explosive, high explosive loaded in thin containers, such as aircraft bombs, and fuses and detonators;

(2) less hazardous materials such as smokeless powder, loaded but unfused projectiles and small-arms ammunition, which are more stable than the materials in the preceding group; and,

(3) inert materials, such as unloaded shells, cartridge cases, empty powder cans, and bag materials (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:328).

The Navy designed and constructed specific building types for each of the three classifications at its naval ammunition depots. The Army designed specific building types for the first two ordnance classifications. To store inert ordnance materials, the Army used general storage building types.

The organization of the military services, the development of ordnance technology, and level of military activity influenced construction of ordnance storage. Within the Department of Army, the Ordnance Department was responsible for the production, repair, testing, and storage of military weaponry. The Bureau of Ordnance was responsible for naval ordnance. The military developed a system of distributing ordnance from strategically located depots to installations or activities. This resulted in the construction of large numbers of identical ordnance storage buildings at ammunition storage depots, and small numbers of ordnance storage buildings at other installations to support specific missions. During the twentieth century, especially during wartime, the military required vast storage depots to hold the large amount of ammunition and explosives produced for modern warfare.

Naval Ordnance Storage

Historically, the Navy provided each ship with enough ammunition to fill its magazines and maintained reserve ammunition supplies on shore. During the nineteenth century, each naval shipyard had one or two buildings designated as ordnance magazines. In general, these buildings were one story with thick masonry walls to contain potential explosions.

As the Navy expanded and modernized its fleet during the mid and late nineteenth century, it required more ordnance storage structures. By 1915, the Navy operated six magazines, or ammunition storage depots, on the East Coast, three of which were within the New York area. Ordnance storage on the West Coast was located at Mare Island, California, and Puget Sound, Washington. (U.S. Navy Department 1915:312-313). The term magazine was used to mean both groups of and individual ordnance storage structures.

The Navy's magazine system evolved into a system of depots to store ammunition and outfit ships. Personnel at ammunition depots monitored the life of volatile ammunition, checked ammunition supplies, inspected ship ordnance, and replaced old stocks of ordnance. To prevent accidental explosions from damaging valuable shipyards and other ships, the Navy prohibited combat ships with full magazines from entering Navy yards. Early twentieth-century ammunition depots were located either on naval installations, such as Mare Island, California, or within 50 miles of major Navy yards (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:323).

World War I

Naval depots were classified into two types: (1) assembly and loading and (2) storage. The first type of depot contained buildings for assembling and loading ammunition, as well as storage buildings. Ammunition components were shipped to the depots, where laborers assembled the ammunition and prepared it for distribution. The second type of depot provided storage for both loaded ammunition and raw materials. Depots of the first type, ammunition assembly and loading, included: Hingham, Massachusetts; Iona Island, New York; Fort Mifflin, Pennsylvania; St. Juliens Creek, Virginia; Puget Sound, Washington; Mare Island, California; and Kuahua, Hawaii. Examples of the second type of ammunition depot (storage only) included: New London, Connecticut; Fort Lafayette, New York; Lake Denmark, New Jersey; Charleston, South Carolina; Olongapo, Philippine Islands; and Cavite, Philippine Islands. The Navy also established specialized depots to store torpedoes and mines. Mine and torpedo storage depots included Goat Island, Rhode Island, and Yorktown, Virginia (U.S. Navy Department, Bureau of Yards and Docks 1921:280, 283, 288).

Just prior to and during World War I, the Navy expanded both ammunition storage and assembly depots, concentrating its efforts primarily on the Atlantic seaboard because of its proximity to the European conflict. In order to accomplish the necessary construction within a tight schedule, the Bureau of Yards and Docks developed standard designs for different types of ordnance storage buildings based on the type of material it stored. Standard plans were developed for above-ground storage buildings, including ammunition storage, mine storage, torpedo storage, and inert storage. Above-ground storage was considered safe for all types of explosives and ordnance. In addition, the Bureau of Yards and Docks issued plans for subsurface storage buildings, although few were constructed.

While ammunition depots supplied most ammunition required by ships, Marine Corps installations and naval air stations required a small amount of ordnance storage on site for training and to equip aircraft. In 1918, the Bureau of Yards and Docks issued a magazine building design for air stations.

Inter-war Period

During World War I, the storage capacity of naval ammunition depots was extended beyond safety levels. After the war ended, the need to store ammunition returned from Europe further stretched available storage space at depots. In 1926, a severe electrical storm ignited a fire in one storage magazine at Lake Denmark Naval Ammunition Depot, New Jersey. The fire initiated a series of explosions that spread quickly throughout the depot. Fires burned for weeks at the installation, affecting every building and destroying many storage structures at Lake Denmark and at the Army's nearby Picatinny Arsenal (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:324).

The military responded to the disaster with a series of investigations into ammunition storage procedures. A joint Navy and Army board conducted the investigations and determined that storage procedures at Lake Denmark were recklessly inadequate. The investigation revealed that one magazine containing 1,691,000 pounds of TNT was located only 80 feet from another magazine containing 789,400 pounds of TNT. At the time of the explosion, Lake Denmark was one of several naval ammunition depots overcrowded with unused World War I munitions.

The official investigation resulted in new construction procedures and storage practices at both Navy and Army ordnance depots. Wider dispersal of ordnance storage buildings became a key feature of future depot construction. The amount of ammunition stored in a single storage unit was reduced considerably, while the space between storage units was increased. The revised Navy policy specified that single magazines contain less than 143,000 pounds of high explosives, and be located at least 500 feet apart (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:324; U.S. Navy Department, Bureau of Yards and Docks 1938:O3-O12).

As a result of the investigation, the Bureau of Yards and Docks issued new designs for ordnance storage structures. The new designs called for non-combustible construction materials that did not splinter. Reinforced concrete replaced structural clay tile. A new type of high-explosive magazine was devised; the new magazine was a low, arched structure constructed of reinforced concrete and covered with earth. This design directed the force of an explosion up instead of out (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:324; U.S. Navy Department, Bureau of Yards and Docks 1938:O3-O12). The new arched-type magazine was adopted by both the Navy and the Army. The Navy called the new design the arched-type high-explosive magazine; the Army called the new design the "igloo."

In addition, the Bureau of Yards and Docks increased lightning protection at ordnance depots (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:339). Any metal used in the construction of buildings storing explosive or flammable materials was required to be grounded. Each building was provided with an "umbrella of protection." Several grounded steel masts surrounding the building were joined beneath its surface by a heavy wire "girdle," providing extensive protection from lightning (U.S. Navy Department, Bureau of Yards and Docks 1938:O16-O19).

The Navy revised storage conditions at depots as space and budgetary constraints allowed. During the late 1920s, the Navy received minimal appropriations and could not institute a large construction campaign. At this time, the Navy maintained eight depots located near its shipyards: Hingham, Massachusetts; Iona Island, New York; Lake Denmark, New Jersey; Fort Mifflin, Pennsylvania; St. Juliens Creek, Virginia; Yorktown, Virginia; Puget Sound, Washington; and, Mare Island, California. However, few existing depots possessed sufficient land to allow the wide spacing between storage buildings required by the new policy. The first construction of the new arched-type magazine occurred at Yorktown, Virginia with the completion of 77 arched-type magazines (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:325).

Hawthorne Naval Ammunition Depot was the Navy's ninth ammunition depot and the first ammunition storage depot entirely planned and constructed after the Lake Denmark explosion. Located in the middle of a desert near Hawthorne, Nevada, the installation served Mare Island and Puget Sound Navy Yards by rail. Construction began at Hawthorne in 1928. The installation was commissioned in 1930 and contained 84 arched-type high-explosive magazines; 2 fuse and detonator magazines; a mine-filling plant; and, a personnel support area. The construction and design of Hawthorne reflected the Navy's revised storage policy. The magazines were designed according to the new capacity and spacing standards. Each magazine was spaced 600 feet from other magazines, and groups of magazines were separated by more space (Building Technology Inc., *Hawthorne*, 1984:32).

As illustrated in the construction of Hawthorne Naval Ammunition Depot, the Bureau of Yards and Docks continued to utilize three general types of ordnance storage structures during the 1930s. The three types were: (1) earth-covered structures for most hazardous materials; (2) above-ground magazines for less hazardous but still highly inflammable materials including smokeless powder, fixed and semi-fixed ammunition, small arms ammunition, and loaded projectiles; and, (3) storehouses for inert material. Though the Navy constructed few ordnance storage during the early and mid 1930s, the Bureau of Yards and Docks issued drawings for these three types of ordnance storage (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:339; U.S. Navy Department, Bureau of Yards and Docks 1938:O12; NARA, Cartographic Branch, RG 71, microfilm reel B7).

Naval air stations also required ordnance storage. Typical ammunition storage structures at naval air stations included: bomb sights storage, torpedo storage, bombtail storage, pyrotechnics storage, small arms storage, FS (a smoke agent) smokedrum storage, fuse and detonator storehouses, high-explosive magazines, and a war-head magazine. The number and size of the storage buildings varied depending on installation size and the number of aircraft assigned to the station (NARA, Cartographic Branch, RG 71, microfilm reel B7).

During the late 1930s, the U.S. Navy began to improve its forces in response to the international aggression and naval expansion that followed the expiration of naval limitation treaties. With this expansion came the demand for additional ammunition storage buildings, particularly on the West Coast. After 1938, the Navy expanded the Pacific fleet an additional 20 per cent. To accommodate storage needs for the enlarged fleet, the Navy constructed more than 100 new magazines of all types at three western depots: Puget Sound, Washington; Mare Island, California; and, Hawthorne, Nevada (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:325).

World War II

During the Protective Mobilization phase and World War II, the Navy established new ammunition depots and expanded existing depots to accommodate the increased needs for ammunition storage. The Navy utilized the standard plans for ordnance storage structures that were developed during the 1930s. The main types of ordnance storage structures remained earth-covered magazines, above-ground magazines, and inert storehouses. While the Navy utilized temporary construction wherever possible, ordnance storage structures were constructed of permanent materials to prevent and contain explosions. Inert storehouses were constructed using both temporary and permanent construction materials. When construction materials shortages became critical during World War II, inert storehouses often were constructed of timber frame and corrugated siding.

During World War II, the Navy enlarged the ammunition depot at Hawthorne, Nevada, and built three additional vast inland storage depots: Crane, Indiana; McAlester, Oklahoma; and Hastings, Nebraska. The inland storage depots were designed to supply regional coastal depots and transhipment points. Regional depots established during World War II included Charleston, South Carolina, and New Orleans, Louisiana. Earle, New Jersey, and, Port Chicago, California, were established as transhipment points. The Navy expanded older depots through acquiring additional nearby acreage. Cohasset, Massachusetts, and Puget Sound, Washington, were expanded using this method. A 1942 inventory of ordnance storage buildings located at principal naval ordnance stations is contained in Table 4.

Hawthorne Naval Ammunition Depot, one of the four inland depots, illustrates the three types of ordnance storage constructed during World War II. By the end of World War II, Hawthorne contained the following earth-covered magazines: 1,100 concrete arched-type, high-explosive magazines measuring 25 x 80 feet; 80 concrete, rectangular box fuse and detonator magazines measuring 25 x 20 feet; and, 400 reinforced concrete rectangular boxes measuring 50 x 100 feet. Above-ground concrete magazines were constructed to store smokeless powder. The installation also had 222 concrete inert material storehouses (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:339, 340; Building Technology Inc., *Hawthorne*, 1984:35-38). The other three inland ammunition depots contained the same building types.

During World War II, the Navy experimented with new designs of earth-covered magazines. The Bureau of Yards and Docks issued designs for a concrete rectangular box magazine that measured 50 x 100 that had concrete loading platforms. Other designs were proposed to save critical construction materials. Designers developed double- and triple-barrel vaulted magazines, which were comprised of two or three arched segments that shared common walls, foundations, and loading docks. Examples of multi-vaulted earth-covered magazines were built at the Naval Ammunition Depot, McAlester, Oklahoma.

The Corbetta beehive magazine also was developed to reduce material requirements and to simplify construction. Designed in 1942 by the Corbetta Construction Company of New York City, this structure consisted of an elliptical, dome-shaped magazine. The advantage of the Corbetta beehive was that it equaled the arched, earth-covered magazine in structural strength, but required only half the steel, one-third the copper, and two-thirds the concrete required by the standard type of magazine (MacLeay 1942:74-75; Fine and Remington 1972:333-334, 530-531). The Corbetta beehive magazine was constructed at the Naval Ammunition Depot, McAlester, Oklahoma (Komatsu 1990:16).

Naval Building Types

Above-Ground Storage

Until 1927, above-ground magazines were the primary structures for ordnance storage; such structures stored powder, shells, and fixed ammunition. After 1927, above-ground magazines stored ammunition classified as less hazardous, including smokeless powder, loaded but unfused projectiles, and small-arms ammunition.

Fixed Ammunition Magazines. In 1917, the Bureau of Yards and Docks issued a standard plan titled "Magazine Building, Shell House, Fixed Ammunition House." The plan depicted a one-story structure with a standard width of 50 feet and standard height of 14 feet from ground level to the roof framing. The building length was based on 10-foot bays and varied in length up to a maximum of 250 feet. The magazine was constructed of structural clay tile that supported a steel-truss roof clad with asbestos shingles. Windows, doors, and a concrete loading platform were

TABLE 4. 1942 CLASSIFICATION OF ORDNANCE STORAGE BUILDINGS AT PRINCIPAL NAVAL ORDNANCE STATIONS

Name	High Explo-sive	Smoke-less Powder	War-head	Black powder	Fuse & deto-nator	Fixed ammo	Projec-tile	Powder-projectile	Small Arms	Pyro-tech-nics	Smoke Drum	Inert store-houses	Unclas-sified	Key-port	Tor-pedo	Ord-nance Store-houses	Totals
Balboa NAD, CZ	44	2	2	–	10	2	–	–	3	2	–	1	–	4	–	-	70
Burns City NAD, IN	928	–	6	20	80	–	–	417	–	–	–	144	–	–	5	2	1,602
Charleston NAD, SC	56	–	1	2	16	–	–	30	–	4	1	3	–	–	–	-	113
Fallbrook NAD, CA	61	–	3	4	14	–	–	25	–	3	4	7	–	–	–	-	121
Ft. Mifflin NAD, PA	2	11	–	3	4	3	4	–	1	1	–	36	11	–	–	-	76
Hastings NAD, NE	476	–	–	–	–	–	–	231	–	–	–	70	–	–	–	-	777
Hawthorne NAD, NV	1,052	44	9	–	70	15	30	279	39	17	–	118	–	–	4	1	1,678
Hingham NAD, MA	—	–	–	10	–	–	2	–	–	1	1	4	43	–	–	-	61
Lake Denmark NAD, NJ	2	5	–	–	–	–	–	4	–	–	–	37	18	–	–	2	68
Lualualei NAD, HI	126	12	6	–	33	5	11	26	4	4	1	13	–	–	–	-	241
Mare Island NAD, CA	12	16	–	4	3	1	22	–	2	8	2	10	–	–	–	1	81
McAlester NAD, OK	476	–	–	–	–	–	–	23	–	–	–	70	–	–	–	-	569
New Orleans NAD, LA	20	14	1	–	4	6	3	–	–	–	1	2	–	–	–	-	51

Name	High Explosive	Smokeless Powder	Warhead	Black powder	Fuse & detonator	Fixed ammo	Projectile	Powder-projectile	Small Arms	Pyrotechnics	Smoke Drum	Inert storehouses	Unclassified	Keyport	Torpedo	Ordnance Storehouses	Totals
Puget Sound NAD, WA	5	5	–	2	2	1	3	–	1	2	–	2	7	100	–	-	130
St. Juliens NAD, VA	2	23	–	2	6	3	19	–	1	4	1	27	–	–	–	1	89
Vieques NAD, PR	30	2	–	–	4	5	2	–	4	2	2	3	–	–	–	-	54
West Loch NAD, HI	14	1	–	1	3	2	–	–	1	1	2	–	–	–	–	-	25
Coco Solo NM, CZ	22	1	2	–	9	2	–	–	4	2	2	2	1	–	–	-	47
Cohasset NM, MA	74	–	–	–	12	–	–	22	–	–	–	–	–	–	–	-	108
Indian Island NM, WA	58	–	2	–	16	1	–	–	2	1	3	4	–	–	1	-	88
Port Chicago NM, CA	50	–	–	–	–	–	–	–	–	–	–	9	–	–	–	-	59
Yorktown NMD, VA	98	–	7	–	8	–	–	–	–	–	–	4	–	–	–	-	117
TOTALS	3,608	136	39	48	294	46	96	1,057	62	52	20	566	80	104	10	7	6,225

Date: October 31, 1942
Source: Microfilm Drawing Reel 1290, Frame 187, Naval Construction Battalion, Port Hueneme, California

located along one long elevation. The buildings were oriented along railroad tracks to insure easy loading and unloading of ammunition (U.S. Navy Department, Bureau of Yards and Docks 1921:281-283) (Figure 20, *top*).

The structure was designed to protect stored explosives from heat outside of the building. Induction ventilators punctured the roof of the building in alternating bays to allow air circulation. At installations located south of Hampton Roads, Virginia, the Navy modified the design to accommodate the warmer climate. The ceilings were suspended from the lower chords of the roof trusses, and vents opened into the space directly under the roof. In addition, the Navy installed a lightning-protection system to guard against the effects of thunderstorms (U.S. Navy Department, Bureau of Yards and Docks 1921:281).

Within a year, the standard plan was modified. In 1918, the Navy issued a drawing entitled "Standard Magazine Building" using the same basic plan, but without windows (NARA, Cartographic Branch, RG 71, microfilm reel B7). In 1921, the Navy reported the construction of over 100 of this type of standard magazine at ammunition storage depots during World War I (U.S. Navy Department, Bureau of Yards and Docks 1921:281).

The design of fixed ammunition storage buildings was modified again following the 1926 explosion at the Lake Denmark Ammunition Depot, New Jersey. The Bureau of Yards and Docks replaced structural clay tile construction with reinforced concrete. The buildings generally had a concrete frame with concrete walls. A concrete loading platform was located along one long elevation. Throughout World War II, the Navy continued to construct fixed ammunition storage buildings at ammunition depots and installation magazine complexes (Figure 20, *bottom*).

<u>Depot Fuse and Detonator/Smokeless Powder/Small Arms/Pyrotechnics Magazines</u>. The fuse and detonator magazine originally was designed as a small version of the fixed ammunition magazine. This magazine type appeared primarily at large ammunition depots and installation magazine areas that were constructed for long-term storage. One 1918 example located at St. Juliens Creek Naval Annex, Virginia, is a one-story brick building that measures 86 x 25 feet. The foundation is concrete and the gable roof is clad with asbestos shingles (Figure 21, *top*).

After the 1926 Lake Denmark explosion, the Navy stored fuse and detonators in earth-covered structures. Yet, the Navy continued to build the former above-ground fuse and detonator magazine type to store smokeless powder, small arms, or pyrotechnics. In many cases, these buildings were concrete-frame buildings with concrete walls. Roofs were gabled and featured metal ventilators. Concrete loading platforms were located along one long elevation of the buildings (Figure 21, *bottom*).

<u>Installation Ready/Small Arms/Pyrotechnics Magazines</u>. The Navy issued a specific building design for ready/small arms magazines located at naval air stations and other types of installations that only required a small amount of ordnance. These buildings generally were small structures constructed of concrete and were intended only for temporary, short-term storage of ammunition. One example of a 1918 installation ready magazine is located at Naval Base Norfolk. The building measures 35 x 14 feet. It was constructed of concrete with a concrete floor. The hipped roof was clad in asbestos shingles (Figure 22, *top*).

During World War II, the buildings generally retained the same shape and had either a flat concrete roof or hipped roof. Installation ready magazines appeared as either one-bay buildings or multiple-bay buildings (Figure 22, *bottom*). In general, these buildings were utilitarian in design. In some cases, as at Moffett Naval Air Station, California, the buildings were finished in a fashion to reflect the prevailing architecture of the installation. The small, one-story installation ready magazine at Moffett had a red clay tile hipped roof and stuccoed exterior. Though located in an isolated area, the building's design reflected the Spanish Colonial Revival motifs of the main portion of the installation.

Mine Storage. During World War I, the Navy developed a specialized storage structure for use at naval mine depots to house 1,008 mines. The one-story building had a concrete foundation and floor, steel framing, and brick or structural clay tile walls. The roof was built-up on wood sheathing (Figure 23). In each building, mines were stored on steel-frame racks and moved mechanically by cranes that ran along tracks. Twenty mine storage structures were constructed during World War I. The locations included St. Juliens Creek, Virginia (6); U.S. Naval Torpedo Station, Rose Island, Rhode Island (2); New London, Connecticut (3); Hingham, Massachusetts (2); Weymouth, Massachusetts (2); Iona Island, New York (2); Pensacola, Florida (1); and Guantanamo, Cuba (1) (U.S. Navy Department, Bureau of Yards and Docks 1921:289; NARA, Cartographic Branch, RG 71, microfilm reel B7). No mine storage buildings constructed after World War I were identified.

Torpedo Storage. World War I torpedo storehouses resembled the standard fixed ammunition magazine with the addition of loading doors in the gable end elevations (Figure 24, *top*). As the war progressed, the Navy modified the design for torpedo storehouses to include improved methods for storing, handling, and overhauling torpedoes (U.S. Navy Department, Bureau of Yards and Docks 1921:286-287). For example, the 1918 designs for torpedo storehouses incorporated a monitor roof with a band of windows along the clerestory to provide additional light (NARA, Cartographic Branch, RG 71, microfilm reel 549). The monitor-roof design for torpedo storehouses remained in use through World War II (Figure 24, *bottom*). Torpedo storage was constructed at ammunition depots and naval air stations.

Warhead Magazines. The warhead magazine evolved as a separate building type. A 1920 drawing depicted a one-story structure with clay-tile walls that contained steel storage racks specifically designed to handle more than 200 war heads (Figure 25, *top*). Following the Lake Denmark explosion, warhead magazines were designed as earth-covered storage.

FS Smokedrum Storage. The FS smokedrum storehouse was constructed at both ammunition depots and naval air stations. FS is a chemical smoke agent that was stored in metal drums. The storehouse generally was a one-story building with a single access door. The drums were stored on metal racks installed in the interior. During World War II, the building was constructed with corrugated asbestos siding.

Earth-Covered Storage

Earth-covered storage was used to store the most hazardous materials, including bulk high explosives, high explosives loaded in thin containers, such as aircraft bombs, and fuses and detonators. Underground storage offered a greater measure of protection and a greater control over temperature than above-ground storage buildings. Temperature control and protection were essential considerations for safe storage of dangerously explosive material.

Subsurface Magazines. In 1917, the Navy issued a design for a reinforced-concrete, subsurface magazine for construction at Lake Denmark Naval Ammunition Depot, New Jersey. It was a rectangular thick concrete box with a metal-clad door that measured 15 x 20 feet. The subsurface magazine had a heavy concrete roof designed to contain possible explosions. The structure was built into the side of a hill (Figure 26, *top*) (U.S. Navy Department, Bureau of Yards and Docks 1921:282). These subsurface structures survived the 1926 explosion intact.

Rectangular Box Magazines. After the 1926 explosion at Lake Denmark Naval Ammunition Depot, the Navy redesigned its subsurface magazines for use at ammunition depots and installation magazine complexes. The heavy concrete roof was abandoned because of the danger flying pieces of concrete presented to adjacent buildings. The Navy concluded that constructing a roof heavy enough to contain an explosion was impractical. New roof designs were thinner and were covered with earth; this design directed the force of an explosion upward, instead of out towards other magazines. The new design also used less construction materials, and thus were more economical than the old, heavy concrete designs. Initially, the Navy constructed small boxes of 12 x 17 feet and 10 x 14 feet to store black powder and fuses and detonators (Figure 26, *middle*). During World War II, the Navy constructed large rectangular boxes that measured 100 x 50 feet to store smokeless powder, fixed ammunition, or small projectiles (Figure 26, *bottom*) (U.S. Navy Department, Bureau of Yards and Docks 1938:O13-14; Building Technology Inc., *McAlester*, 1984:29). The large rectangular box provided more efficient storage space than the arched-type magazine and still is constructed to store high explosives.

Arched-Type, High-Explosive Magazines. After the 1926 Lake Denmark explosion, the Navy introduced a new design for ordnance storage structures. Bulk explosives, high explosive loaded in thin containers, fuses, and detonators were stored in low, arched structures constructed of reinforced concrete and covered in earth. The general dimensions of the arched-type magazines were 25 x 40 feet, although the length could be as long as 80 feet. The Navy first constructed the arched-shape magazines at Yorktown, Virginia, and Hawthorne, Nevada (Figure 27, *top*).

The Navy constructed the earth-covered, arched-type high-explosive magazine during World War II at ammunition depots and installation magazine complexes (Figure 27, *bottom*). The structure stored many kinds of explosives. The spacing of the structures depended on the type of explosive stored and construction of earth-bermed, protective barricades. Another advantage of the earth-covering was protection from aerial observation.

During World War II, the Navy experimented with construction materials and designs to conserve critical materials. At the Marine Corps Development and Education Command, Quantico, Virginia, the magazines are basically Quonset huts covered with earth. The Navy also constructed double and triple arched-type magazines. The triple arched-type magazine was composed of three arched sections that shared common walls, foundations, and loading docks. In this design, three structures spaced approximately 12 feet apart were interconnected by a common concrete wall and loading platform. Each unit measured 26 feet-6 inches wide x 80 feet long. The concrete walls were 12 inches thick at the base, and tapered to 6 inches near the peak. A pair of double metal doors was centered on each vault (Building Technology Inc., *McAlester*, 1984).

Another variation were called "Keyport" magazines. As surveyed at Naval Base Norfolk, the Keyport magazine is a shallow, vaulted, concrete structure with paired metal doors over the opening. The magazines are located in a row of 15 adjoining magazines; the complex contained 12 rows. Each row of magazines faced an access road.

Corbetta Beehive Magazines. The Corbetta beehive magazine also was developed to reduce material requirements and to simplify the construction process. It was a circular, dome-shaped magazine that was as strong as the standard arched-type magazine, but required less construction material. The beehive magazine design became the standard for later magazine construction (Figure 28).

Warhead Magazines. During the 1940s, the Navy issued drawings for an earth-covered warhead magazine. Constructed of concrete, the buildings was rectangular with a gable roof (Figure 29).

Inert Storage

During World War I, the Navy developed special plans for storage buildings to house inert materials at naval ammunition depots. Inert materials included unloaded shells and non-flammable materials. The World War I standard magazine storehouse was generally two stories in height. The floor load requirements for the facility were less than those of the storehouses containing more volatile material. Lighter floor loads allowed greater flexibility in the construction and height of the building. Elevators frequently were installed between stories. Construction materials included brick and structural clay tile. Often repair and maintenance work was performed inside the inert storage building. Therefore, the buildings had windows and were equipped with heating and electrical lighting systems (U.S. Navy Department, Bureau of Yards and Docks 1921:282) (Figure 30, *top*). The Navy also constructed two-story inert storage buildings during World War II (NARA, Cartographic Branch, RG 71, microfilm reels B7, 63).

In 1918, the Bureau of Yards and Docks issued plans for a one-story standard storehouse for ammunition depots. This building was constructed of brick and measured 60 feet by a varied number of 20-foot bays; the storehouse could extent 200 feet. It contained three-ply metal-covered doors and steel-sash windows. The roof was a low-pitched gable with two lines of metal ventilators. As constructed at St. Juliens Creek Naval Annex, Virginia, this building had no windows, only loading doors along the side elevations (Figure 30, *bottom*).

During World War II, one-story inert storage buildings were constructed of brick, structural clay tile, or concrete. A standard plan for inert storehouses issued in 1941 depicted a one-story building measuring 50 feet wide with varying length dimensions. A concrete loading platform was located along the long elevation and the loading doors were sliding metal-clad doors. The loading elevation was punctuated with small pivot windows (Figure 31). The one-story inert storehouse became the most common type of inert storage building.

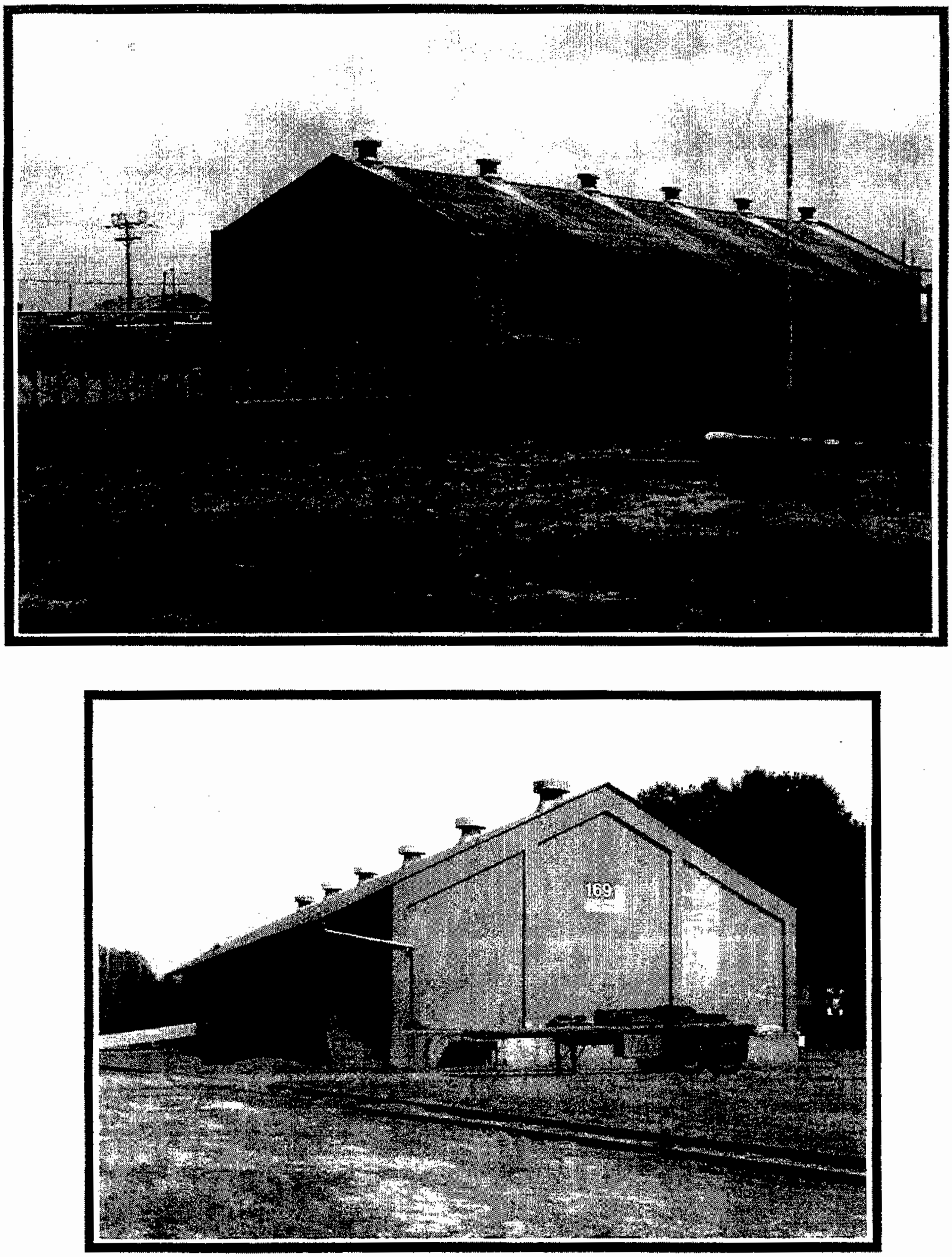


Figure 20. (*top*) 1918 standard magazine building, shell house, and fixed ammunition storage (Building 75, St. Juliens Creek Naval Annex, Virginia)
(*bottom*) 1942 fixed ammunition magazine (Building 169, St. Juliens Creek Naval Annex, Virginia)

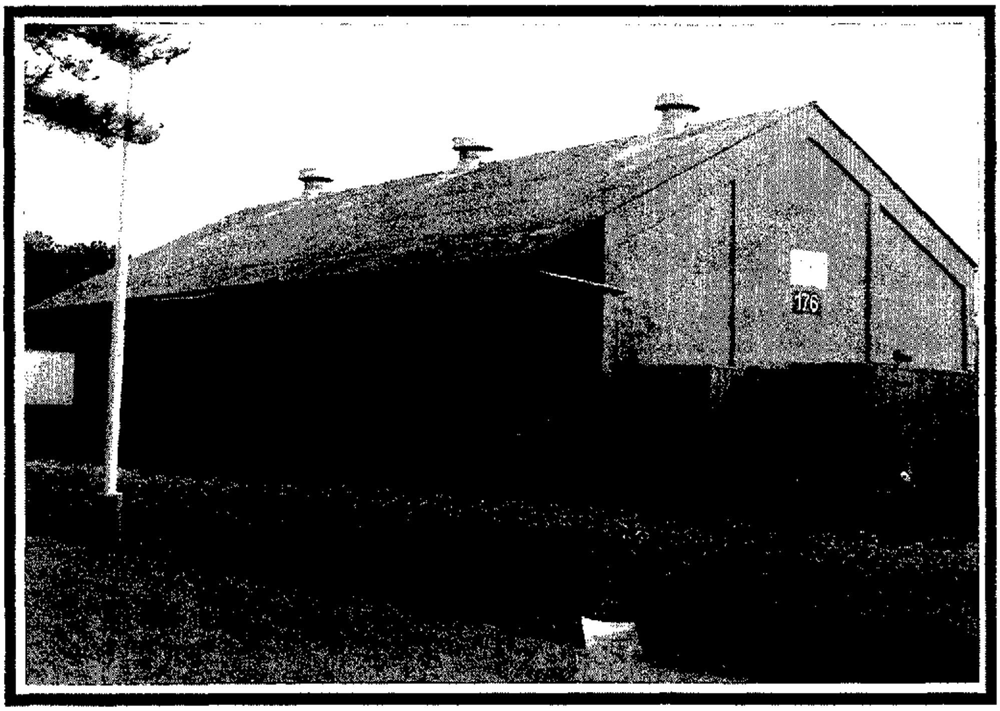
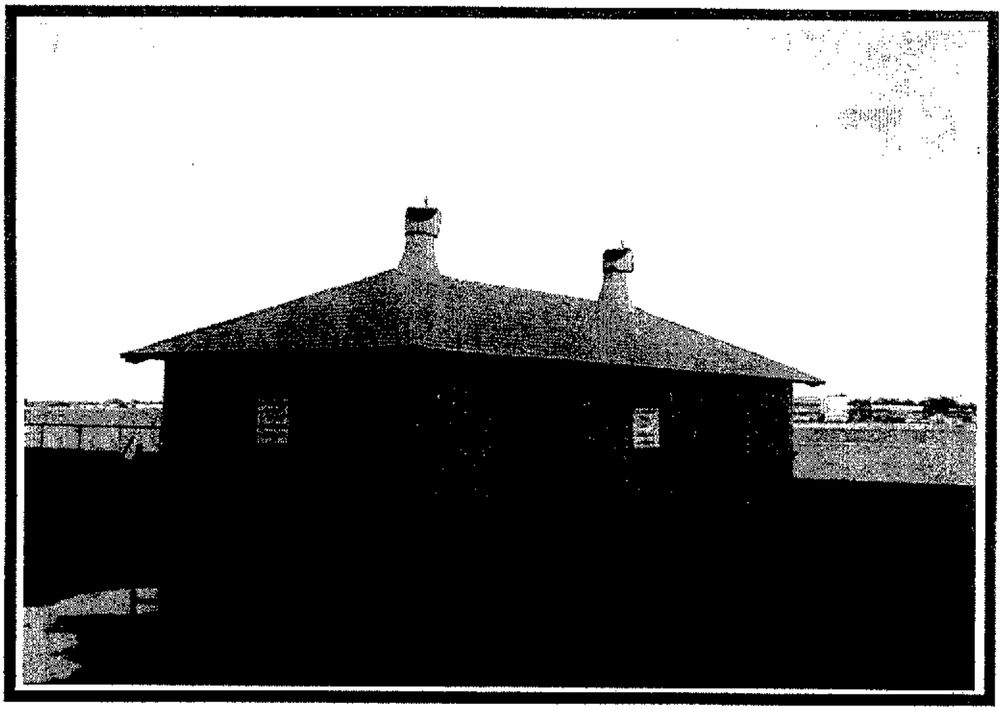


Figure 21. (*top*) 1918 fuse and primer storage building at (Building 83-Y, St. Juliens Creek Naval Annex, Virginia)
(*bottom*) 1942 magazine (Building 176, St. Juliens Creek Naval Annex, Virginia)



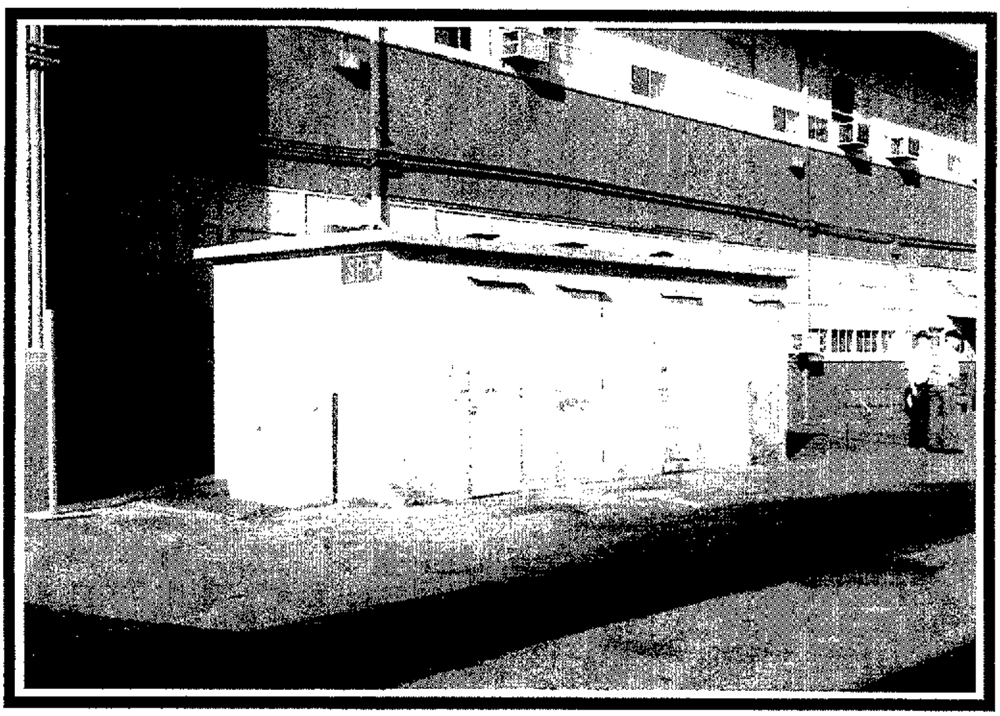


Figure 22. (*top*) World War I naval air station magazine (Building Y10, Naval Base Norfolk, Virginia)
(*bottom*) 1942 naval air station magazine (Building SP5, Naval Base Norfolk, Virginia)

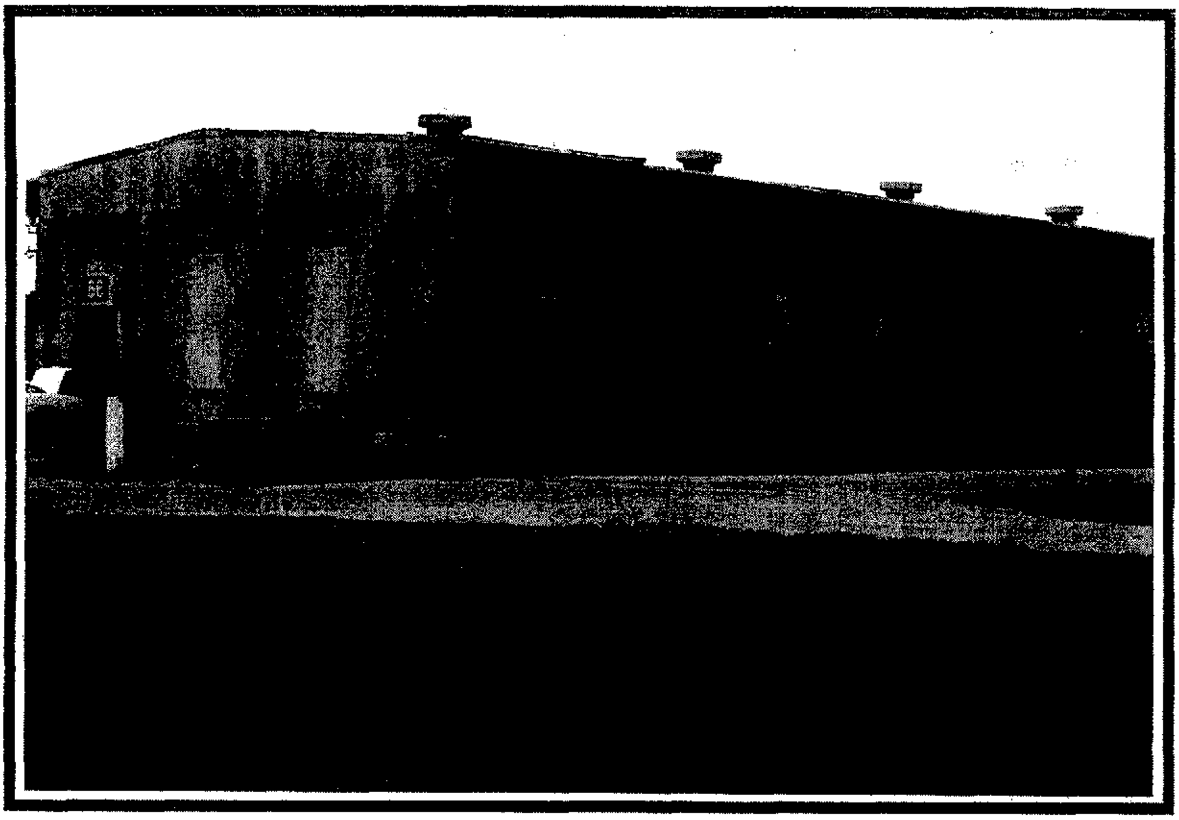
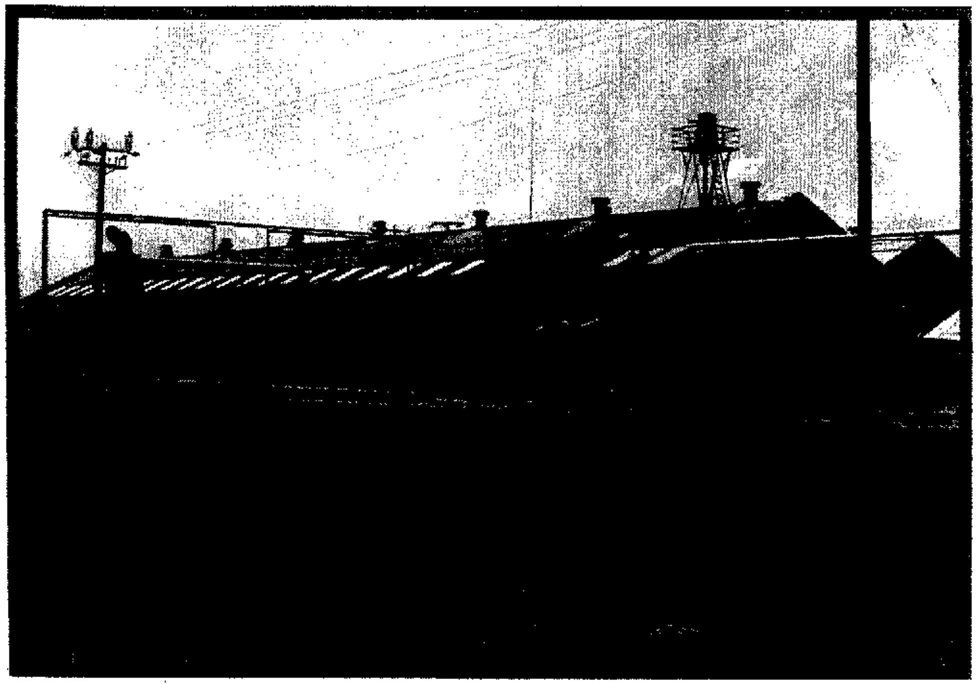


Figure 23. 1918 mine storage building (Building 64, St. Juliens Creek Naval Annex, Virginia)



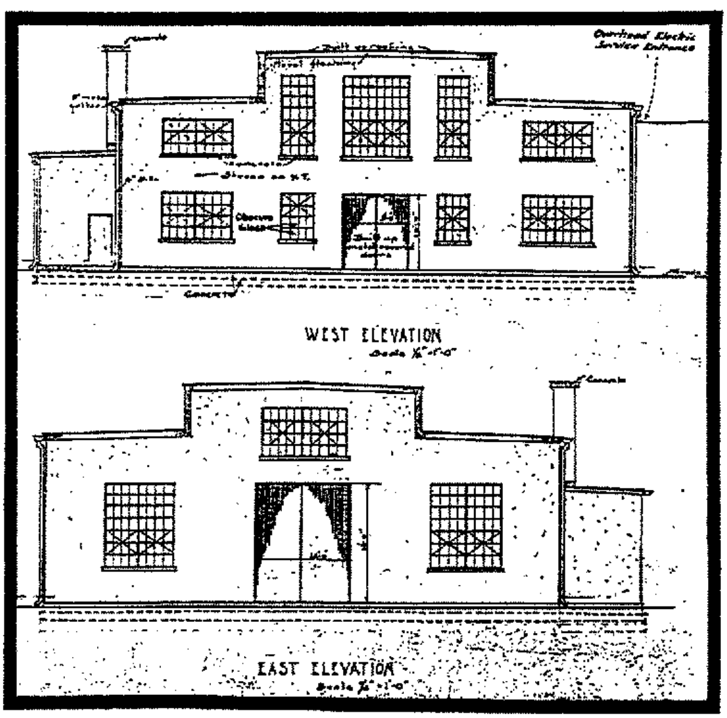
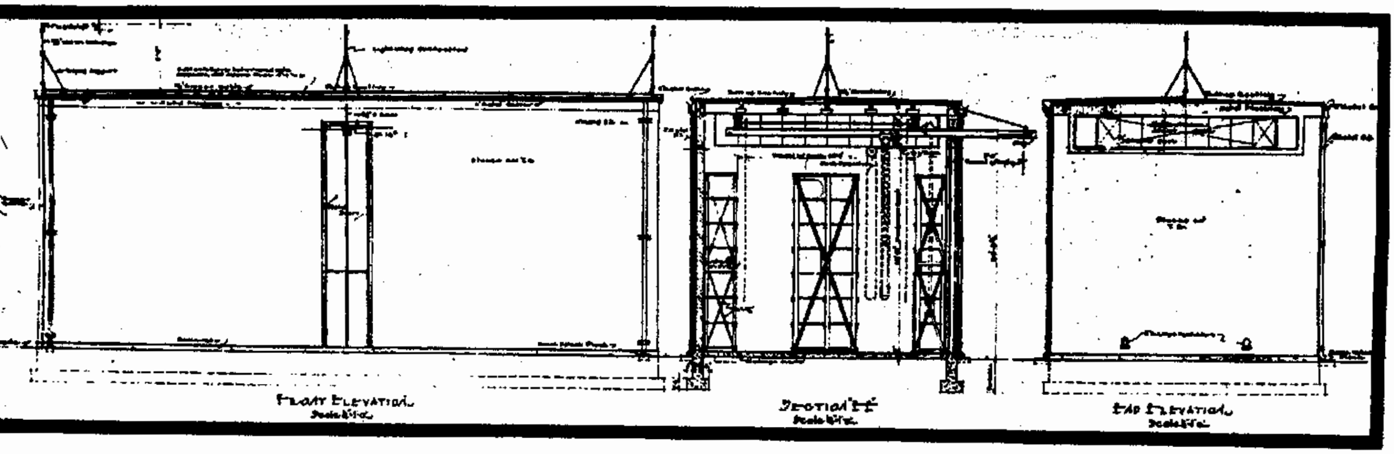


Figure 24. (*top*) 1918 torpedo warehouse (Building 68, St. Juliens Creek Naval Annex, Virginia)
(*bottom*) 1926 drawing of torpedo storehouse at Naval Destroyer Base, San Diego, California (NARA, Cartographic Branch, RG 71, microfilm reel 1059). This basic design was used through World War II.



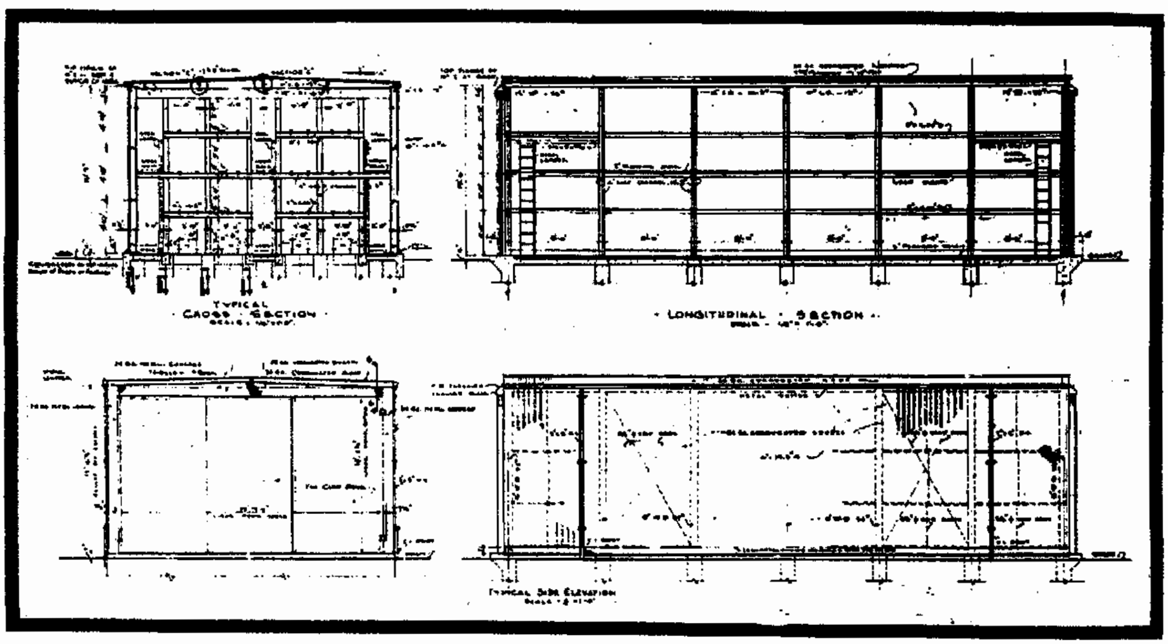
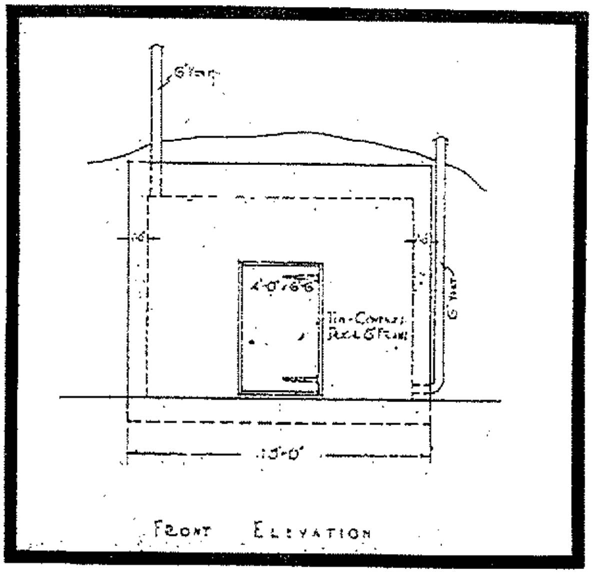


Figure 25. (*top*) 1920 warhead magazine (Drawing 88829, Reel 1290, Naval Construction Battalion Center, Port Hueneme, California)
(*bottom*) FS smokedrum storehouse (Drawing 179467, Reel 508, Naval Construction Battalion Center, Port Hueneme, California)



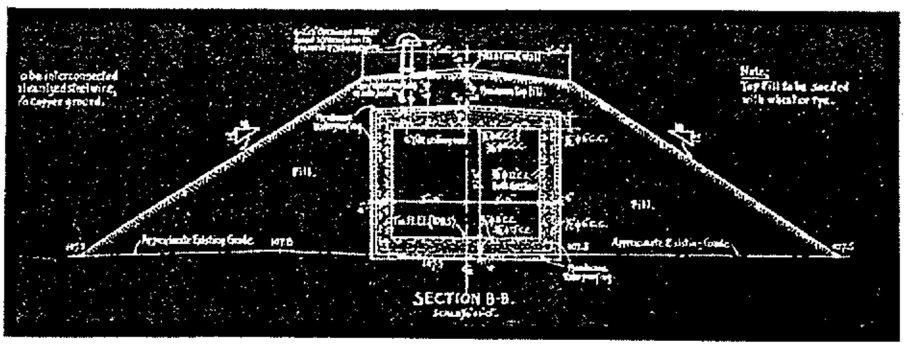


Figure 26. (*top*) 1917 sub-surface magazine at Lake Denmark NAD, New Jersey (NARA, Cartographic Branch, RG 71, microfilm reel 66)
(*middle*) Fuse magazine constructed at Iona Island, New York (NARA, Cartographic Branch, RG 71, microfilm reel 63)
(*bottom*) Earth-covered rectangular box storage at McAlester AAP, Oklahoma (Photo courtesy of U.S. Army)

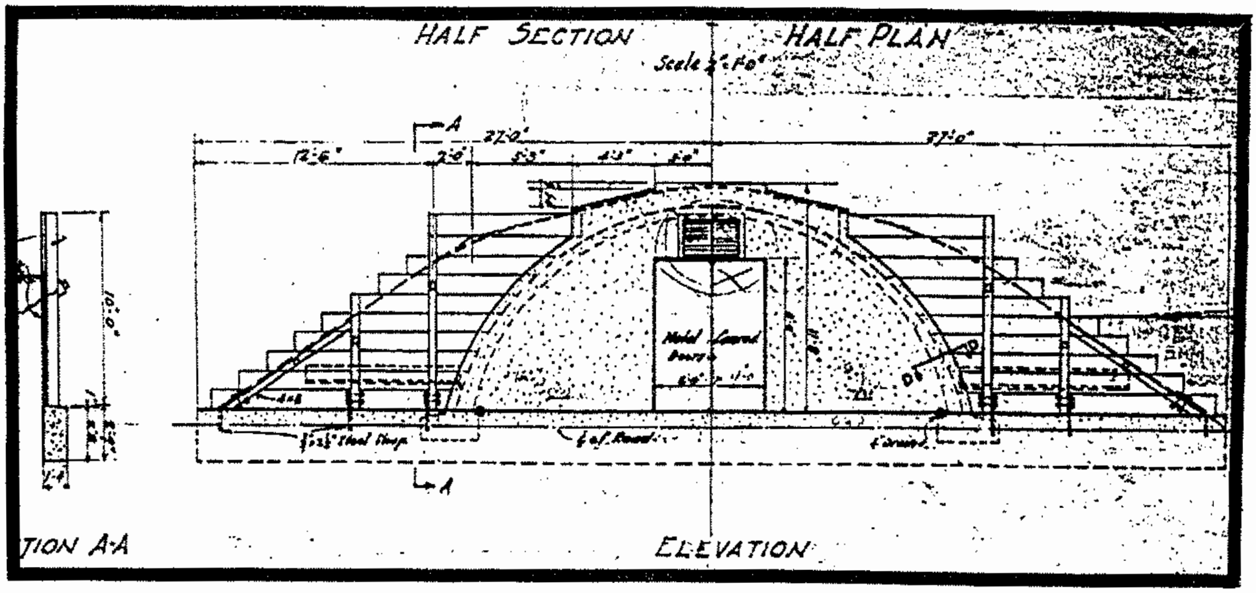


Figure 27. (*top*) 1927 arched-type high-explosive magazine constructed at Naval Mine Depot, Yorktown, Virginia (NARA, Cartographic Branch, RG 71, microfilm reel 549)
(*bottom*) 1945 arched-type high-explosive magazine (Building 251, St. Juliens Creek Naval Annex, Virginia)

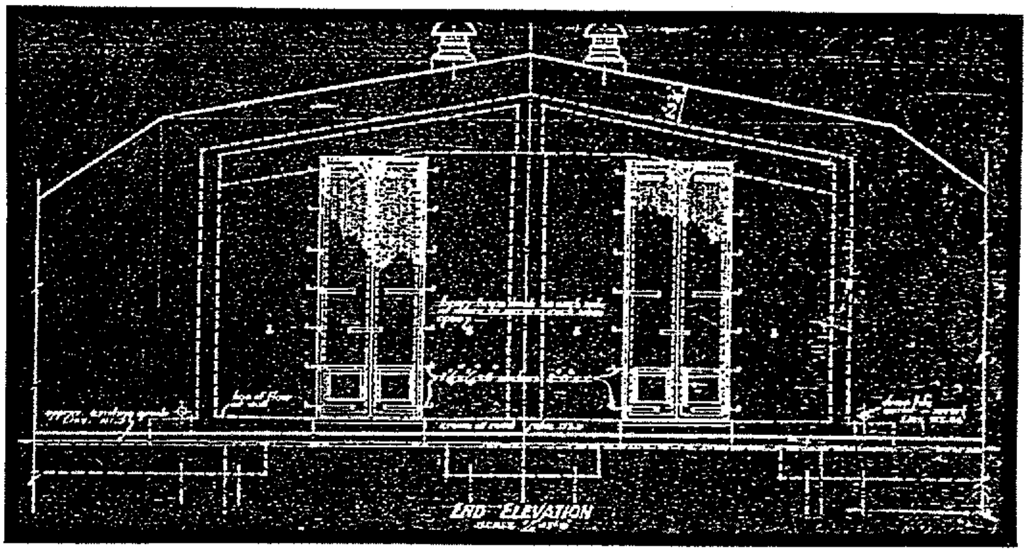
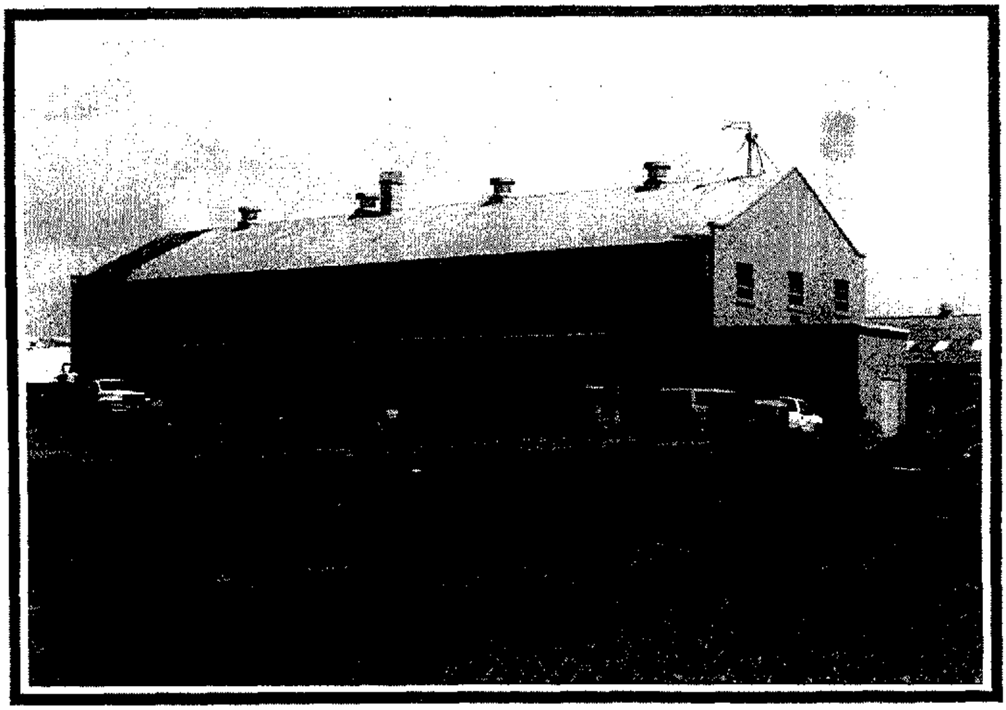


Figure 29. Warhead magazine constructed at Alameda NAS, California, 1940 (NARA, Cartographic Branch, RG 71, microfilm reel 1047)



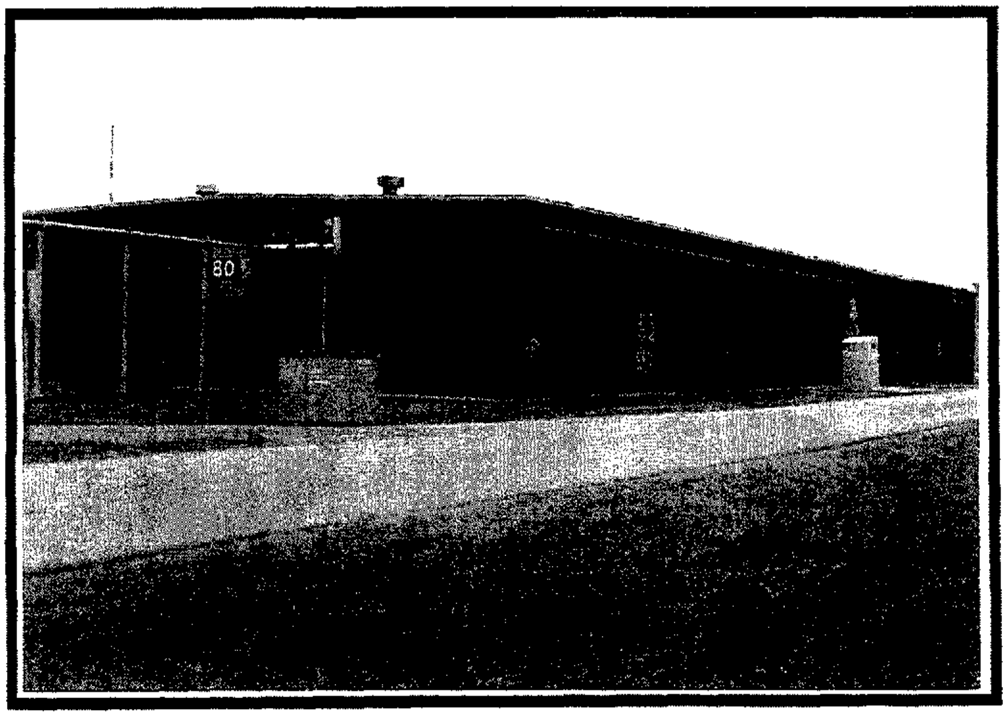


Figure 30. (*top*) 1918 standardized two-story storehouse for ammunition depots (Building 69, St. Juliens Creek Naval Annex, Virginia)
(*bottom*) 1918 standardized one-story storehouse for ammunition depots (Building 80, St. Juliens Creek Naval Annex, Virginia)

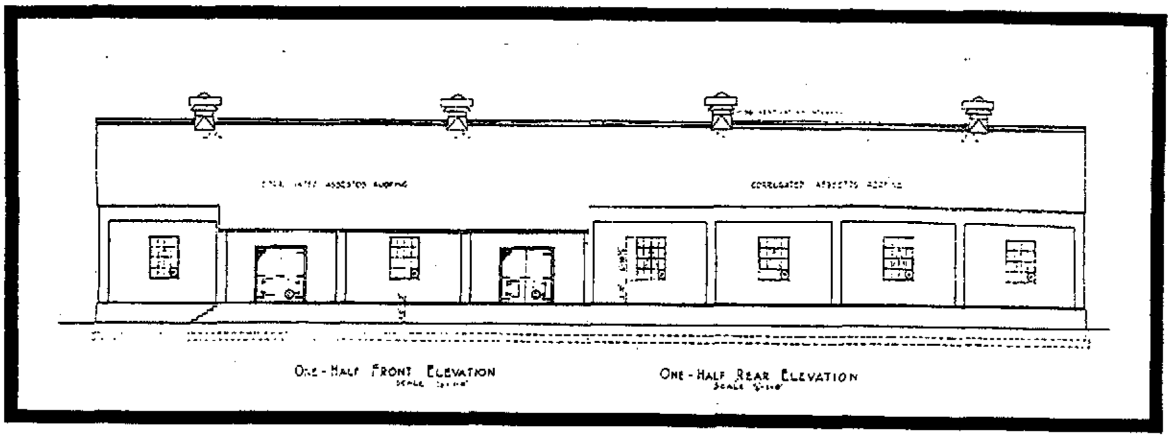


Figure 31. (*top*) 1941 Standardized design for inert storehouse (NARA, Cartographic Branch, RG 71, microfilm reel B7)

Army Ordnance Storage

Historically, Army troops transported ordnance supplies with them. At permanent encampments, one building generally served as the powder magazine for the unit. The magazine generally was a small, masonry building with thick walls to contain potential explosions.

During the nineteenth century, the Army developed a two-tier system of ordnance distribution. Installation magazine buildings were supplied with powder and ordnance from strategically-located arsenals. The term "arsenal" indicated two functions. Arsenals produced ordnance and also stored ordnance supplies until shipment; examples of production arsenals include Springfield Arsenal, Massachusetts; Watervliet Arsenal, New York; Rock Island Arsenal, Illinois; Picatinny Arsenal, New Jersey; and, Frankford Arsenal, Pennsylvania. In some cases, arsenals only served as ordnance storage depots; examples of such installations include West Point Arsenal, New York; New York Arsenal, New York; and, the Fort Leavenworth Ordnance Depot, Kansas. During the twentieth century, the Army expanded and improved its ordnance distribution system.

The number of ordnance buildings constructed at installations depended on the size of the installation and its mission. Production arsenals, artillery training installations, or ordnance testing installations often included large numbers of ordnance storage structures. At other installations, such as air fields, only a few ordnance structures were required.

World War I

When the United States entered the war in 1917, the Army was unprepared to wage a massive military campaign in Europe. Between 1917 and 1918, the Quartermaster Department constructed Aberdeen Proving Ground, Maryland, a large proving ground, and five large ammunition depots along the Atlantic Coast. The five ordnance depots were Raritan Arsenal, Metuchen, New Jersey; Curtis Bay, Maryland; Pig Point, Nansemond, Virginia; Charleston, South Carolina; and, Delaware, New Jersey (Thomson and Mayo 1960:353, 385). The Construction Division located the new depots near deep water to minimize handling of high explosives and far from inhabited areas to minimize impacts of potential explosions.

The largest of the new ordnance depots was Raritan Arsenal. A description of its construction reveals that the Army constructed above-ground magazines to store ordnance during World War I. By 1918, Raritan Arsenal contained 85 terra cotta tile magazines that stored shells, black powder, and miscellaneous items. In addition, 12 high-explosive magazines were constructed of sheet-metal; each magazine measured 26 x 42 feet. At the time of the Armistice in November 1918, 60 additional steel magazines were under construction to store smokeless powder (Crowell 1919:551-552).

During World War I, the Army also expanded ordnance storage capacity at existing installations. For example, at Picatinny Arsenal, 54 new ordnance storage buildings and a powder house were constructed (U.S. Department of Interior, National Park Service, HABS, 1985:24).

Inter-war Period

Following the end of the war in November 1918, War Department planners adopted a plan to improve the system of ordnance depots based on European combat experience. The plan recommended establishing reserve depots to store large stocks of ordnance supplies; establishing intermediate depots to store a three-month supply of ordnance; and, establishing area depots located at installations to store a one-month supply of ordnance. Due to severe budget constraints, the Army implemented the new plan slowly, using existing installations where possible.

Immediately following World War I, five production arsenals were converted to reserve depots: Frankford Arsenal, Pennsylvania; Springfield Arsenal, Massachusetts; Watertown Arsenal, Massachusetts; Watervliet Arsenal, New York; and, Rock Island Arsenal, Illinois. During the 1920s, two more reserve ordnance depots were constructed: Savanna Ordnance Depot, Illinois, and Ogden Ordnance Depot, Utah (Thomson and Mayo 1960:353). By 1929, the Army's ordnance depot system included 11 installations (Table 5).

The 1926 explosion at the Navy's Lake Denmark Ammunition Depot also affected Army ordnance storage practices. The Lake Denmark explosion spread to nearby Picatinny Arsenal, which suffered extensive damage from the explosions and subsequent fires. As a result of investigations that followed the disaster, the Army and Navy adopted stringent new safety regulations for ammunition storage. The most notable consequences of the Lake Denmark explosion were the development of a new type of ammunition magazine and the adoption of new quantity and distance requirements for ordnance storage. The Army adopted the barrel-vaulted magazine, known as the "igloo," to store high explosives. The structure was constructed of reinforced-concrete and earth-covered. The design and shape of the igloo directed the force of potential explosions upwards, rather than out toward adjacent magazines (Thomson and Mayo 1960:361). Lightning rods and extensive grounding of all metal prevented lightning from causing explosions. In addition, the Army recommended a dispersed plan of widely spaced and isolated igloos. The minimum width between barricaded igloos was 400 feet; between igloos without barricades, 800 feet (U.S. War Department, Ordnance Department 1941:26-27).

In 1929, the first igloos were completed at Savanna Ordnance Depot, Illinois; Benecia Arsenal, California; and Aberdeen Proving Ground, Maryland (Thomson and Mayo 1960:361). The igloo magazines at Aberdeen Proving Ground are recorded in real property records with a 1930 date of construction (Directorate of Public Works, Real Property Records, Aberdeen Proving Ground). At Savanna Ordnance Depot, 24 igloos were arranged in parallel rows along six roads and were spaced 400 feet from each other to minimize the potential for the spread of explosions (Building Technology Inc., *Savanna*, 1984:38). Igloo storage also was constructed at Army Air Corps installations including Selfridge Field, Michigan, and Langley Field, Virginia (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 110). From 1929 through World War II, the igloo was the Army's preferred structural design for high-explosive storage (U.S. War Department, Ordnance Department 1941:26-27). The Army continued to design non-igloo ordnance storage structures for storing other types of ordnance. During the 1930s, the Quartermaster Department issued a series of standard plans for ammunition magazines. The types of ordnance storage magazines included: standard post magazine, also for bulk high explosives, or primers and fuses; black powder magazine; standard ammunition magazine; bomb loading magazines; and, smokeless powder magazines. Despite these plans, the Army initiated little new construction at ordnance depots during the late 1920s and early 1930s. A few ordnance storage buildings were constructed at new or expanded installations that required the storage of small amounts of ordnance to fulfill their mission; for example, Air Corps installations typically included one or two bomb storage structures.

During the late 1930s, the War Department reorganized its ordnance storage system. The Army planned to reduce the number of eastern ordnance depots and to expand the number of western ordnance depots where the dry climate was more suitable for long-term storage. Geographic distribution was another important criterion for establishing new depots. Immediately after the passage of the Protective Mobilization legislation in 1940, the Army planned to locate one depot in each of the four corners of the country to support forces repelling attacks from any direction. The four locations selected were: Fort Wingate, New Mexico; Ravenna, Ohio; Umatilla,

TABLE 5. 1929 LIST OF ARMY RESERVE AND INTERMEDIATE AMMUNITION DEPOTS

Name	State	Date of Establishment	Type
Curtis Bay Ordnance Depot	MD	1918	Reserve
Delaware Ordnance Depot	NJ	1918	Reserve
Raritan Arsenal	NJ	1918	Reserve
Pig Point (Nansemond) Ordnance Depot	VA	1918	Reserve
Savanna Ordnance Depot	IL	1917	Reserve
Ogden Ordnance Depot	UT	1920	Reserve
Wingate General Ordnance Depot	NM	1870	Reserve
Augusta Ordnance Depot	GA	Unk.	Intermediate/Area
Benicia Arsenal	CA	1851	Intermediate/Area
Rock Island Arsenal	IL	1861	Intermediate/Area
San Antonio Arsenal	TX	1920	Intermediate/Area

Sources: Thomson and Mayo 1960:353-354; Ft. Sam Houston Museum 1990:43-47.

Oregon; and, Anniston, Alabama. Construction at these locations began in 1941 (Thomson and Mayo 1960:361-362; 366-367).

World War II

During World War II, the Army's ordnance requirements greatly expanded. Storage capacity available during 1940 was overtaxed by 1942. The Army rapidly expanded its ordnance depot system, adding 16 new ordnance depots by 1943.

To meet the overwhelming need for new facilities during World War II, the Army adopted a policy of temporary construction wherever possible. At ordnance depots, however, the Army generally utilized permanent construction materials, particularly for ordnance magazines and igloos. The first wave of ordnance depots planned and completed before 1942 were intended for use after the war and thus were constructed using permanent construction design and materials. These depots, termed the "Class A" included the four depots established in 1940, plus four additional depots: Milan, Tennessee; Seneca, New York; San Jacinto, Texas; and Red River, Texas.

The Ordnance Department constructed a second wave of eight depots, termed the "Class B" depots, after December 1941, to handle the ever-increasing supply of ordnance. Wherever feasible, the Ordnance Department located its depots near ordnance loading plants to reduce transportation costs. While permanent construction occurred within the explosives storage areas, administration and other non-explosives-storage structures were built utilizing temporary mobilization building plans and materials when possible. "Class B" depots included Sierra, Navajo, Letterkenny, Sioux, Black Hills, Tooele, Blue Grass, and Pueblo (Thomson and Mayo 1960:372-378) (Table 6).

The reinforced-concrete igloo was the most common structure constructed at ammunition depots during World War II. After January 1941, the Ordnance Department required concrete igloos for all types of ammunition except for small arms ammunition (Figure 32). While basic design and construction of the igloo remained the same as the early 1930s designs, minor design modifications were made as the construction of large numbers of igloos progressed. While the width of the igloo remained constant at 26 feet, the length of the igloos varied from 40, 60, to 80 feet. In addition, during construction of the Anniston depot, the construction of metal ventilators were added to the igloos design. This modification became part of the subsequent igloo standard plan (Thomson and Mayo 1960:366-368; History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 110; Building Technology Inc., *Anniston* 1984:19).

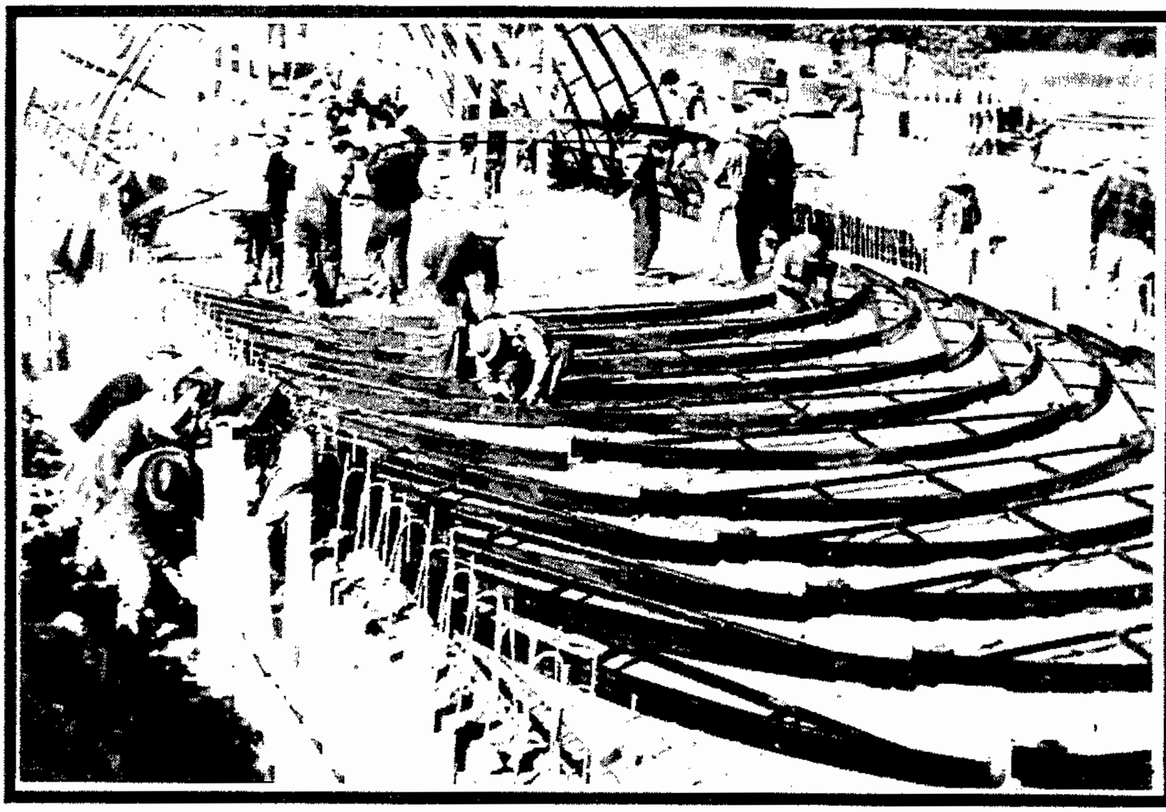
The large numbers of igloos constructed at ordnance depots followed a distinctive site plan. Igloos were located in blocks of 100, with a minimum distance of 1,400 feet between blocks. Within each block, magazines were separated by at least 400 feet. These minimum distance safety standards required that ordnance depots include considerable acreage, as well as extensive road and railroad networks to link the different areas within the depot (Thomson and Mayo 1960:368-369).

The Army also constructed above-ground magazines at ordnance production plants, ordnance depots, and chemical warfare depots. In 1941, the Ordnance Department published a safety manual that contained descriptions of the following types of above-ground magazines: explosives magazines, smokeless powder magazines, primer and fuse magazines, and ammunition magazines (U.S. War Department, Ordnance Department 1941:26-27). In general, these types of magazines were constructed of structural clay tile with concrete foundations. These buildings were arranged in rows with access to both railroad and road transportation networks. The

TABLE 6. WORLD WAR II ARMY ORDNANCE DEPOTS AND CHEMICAL WARFARE SERVICE DEPOTS

Original Name	Current Name	Location	Date Established	WWII Program Type
ORDNANCE DEPARTMENT DEPOTS				
Anniston Ordnance Depot	Anniston Army Depot	AL	1941	A
Benecia Arsenal	Benecia Arsenal	CA	1851	N/A
Black Hills Ordnance Depot	Black Hills Army Depot	SD	1942	B
Blue Grass Ordnance Depot	Lexington Blue Grass Depot Activity	KY	1941	B
Charleston Ordnance Depot	Charleston Army Depot	SC	1916	N/A
Curtis Bay Ordnance Depot	N/A	MD	1918	N/A
Delaware Ordnance Depot	N/A	NJ	1918	N/A
Letterkenny Ordnance Depot	Letterkenny Army Depot	PA	1942	B
Lima Army Tank Depot	Lima Army Tank Plant	OH	1942	N/A
Milan Ordnance Depot	Milan AAP	TN	1941	A
Nansemond Ordnance Depot	N/A	VA	1918	N/A
Navajo Ordnance Depot	Navajo Army Depot	AZ	1942	B
Ogden Ordnance Depot	Ogden Defense Depot	UT	1920	N/A
Portage Ordnance Depot	Ravenna AAP	OH	1940	A
Pueblo Ordnance Depot	Pueblo Army Depot	CO	1942	B
Raritan Arsenal	N/A	NJ	1918	N/A

Original Name	Current Name	Location	Date Established	WWII Program Type
Red River Ordnance Depot	Red River Army Depot	TX	1941	A
San Jacinto Ordnance Depot	N/A	TX	1941	A
Savanna Ordnance Depot	Savanna Army Depot Activity	IL	1917	N/A
Seneca Ordnance Depot	Seneca Army Depot	NY	1941	A
Sierra Ordnance Depot	Sierra Army Depot	CA	1942	B
Sioux Ordnance Depot	Sioux Army Depot	NE	1942	B
Tooele Ordnance Depot	Tooele Army Depot	UT	1942	B
Umatilla Ordnance Depot	Umatilla Army Depot	OR	1942	A
Wingate Ordnance Depot	Fort Wingate Army Depot	NM	1870	A
CHEMICAL WARFARE SERVICE DEPOTS				
Deseret Chemical Warfare Depot	Tooele Ordnance Depot	UT	1942	N/A
Eastern Chemical Warfare Depot	Edgewood Area, Aberdeen Proving Ground	MD	1940	N/A
Gulf Chemical Warfare Depot	Redstone Arsenal	AL	1941	N/A
Northeast Chemical Warfare Depot	Lake Ontario Arsenal	NY	1942	N/A
Midwest Chemical Warfare Depot	Pine Bluff Arsenal	AR	1941	N/A



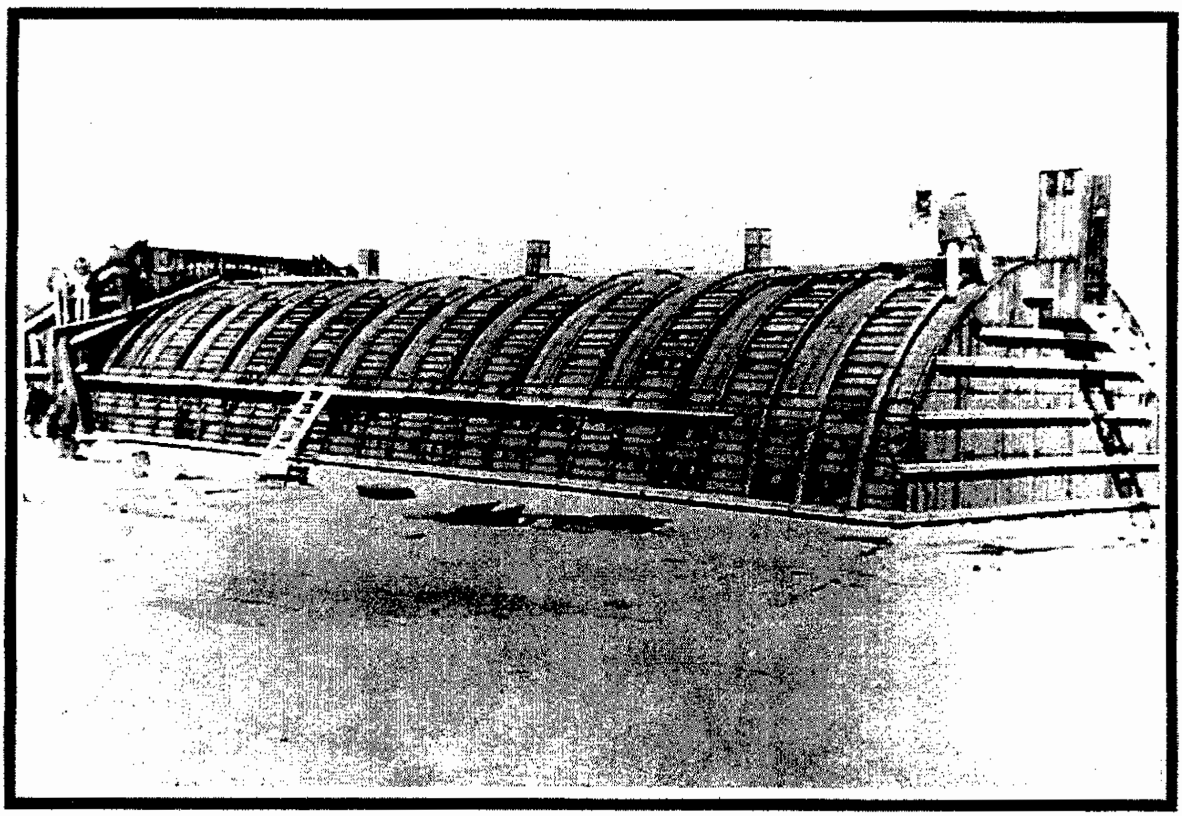


Figure 32. World War II construction of igloos at Red River Army Depot, Texas (Photo courtesy of U.S. Army)

structural clay tile magazine was the second most common type of ordnance storage building constructed during World War II.

Construction of igloos required an excessive quantity of steel, a critical war material. Between 1942 and 1943 engineers proposed an alternate design for munitions storage structures to reduce the amount of steel required for in each magazine. The design consisted of a circular, dome-shaped magazine, known as a "beehive." The new design proved to be equal to the igloo in structural strength, while using half the steel, one-third the copper and two-thirds the concrete required by the standard igloo (MacLeay 1943:74). The savings in construction materials was due to the shape of the magazine. The Corbetta Construction Company of New York City was the first company to construct the "beehive" storage igloos. Development of the beehive design, however, was undertaken after most ordnance depots already had been completed (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 112).

Other plans for storage magazines constructed during wartime included wood-frame storage buildings with extensive earth berms, "Richmond" magazines, and earth-covered steel structures. The "Richmond" magazine had a concrete foundation with brick or concrete block walls, and was surrounded by earth on three sides up to the roof line. This type of magazine was identified at ammunition plants such as Cornhusker, Kansas; Holston, Tennessee; and Newport, Indiana (Building Technology Inc., *Cornhusker* 1984:20; *Holston* 1984:25-28; *Newport* 1984:21,24; History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 112).

Other installations besides ordnance production plants and depots also required ordnance storage structures, notably installations involved with artillery training, ordnance testing, or aviation. For example, at Fort Knox, Kentucky, an armored forces training installation, a separate ammunition storage area was constructed during World War II that contained both above-ground and earth-covered storage. Earth-covered storage included reinforced-concrete igloos, arched steel magazines, and circular steel magazines. Above-ground storage included a structural clay tile magazine and a segregated magazine. At Aberdeen Proving Ground, Maryland, igloos and above-ground magazines were dispersed throughout the testing areas of the installation. At Army airfields, a few above-ground magazines generally were located near the hangars. If an installation required long-term storage, then groups of magazines were constructed in an isolated area (Grandine et al. 1994; History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 145).

Army Building Types

Above-Ground Storage

Powder Magazines. The standard black powder magazine was generally small in size, ranging from 8 x 8 feet to 20 x 24 feet, and was constructed for installation ammunition storage (Figure 33). The Quartermaster issued the first designs for a powder magazine during the nineteenth-century. The earliest designs of this building type depicted a stone or brick building with a gable roof and gable-end doorway. During the twentieth century, the building type was designed with a shed roof, often of concrete, and a central metal door (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 110). The powder magazine building type with the concrete shed-roof also stored dynamite and other high explosives as well as fuses and detonators.

Ammunition Magazines. The Quartermaster Department developed plans for larger ammunition storage structures in response to the expanding storage needs during World War I and attempted to standardize the construction. At Raritan Arsenal, New Jersey, the Army constructed 85 magazines that measured 51 x 218 feet. These magazines stored shell, black powder, and miscellaneous items (Crowell 1919:551-552). At Edgewood Arsenal, Maryland, the Army constructed rectangular, one-story structural clay tile magazines with monitor roofs (Figure 34, *top*).

During the 1930s, the Quartermaster Department issued plans for a standard ammunition magazine constructed of structural clay tile. It had pre-cast concrete lintels and sills, metal-clad wood loading doors (often sliding) in the long elevations, and a gable roof clad with fire retardant material. The building generally contained metal ventilators on the roof ridge and was protected by lightning rods. The magazines were 51 feet wide and of various lengths, including 78, 98, 118, and 218 feet long (Figure 34, *bottom*). During the 1930s, concrete loading docks along one side elevation became a characteristic feature for this type of building, particularly at ordnance production plants, ordnance depots, and chemical warfare depots (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 110).

Smokeless Powder Magazines. During the 1930s, the Quartermaster Department issued a standard plan for a smokeless powder magazine. It measured 37 x 110 feet and was constructed of structural clay tile walls with a gable roof clad with fire resistant material (Figure 35, *top*). Loading doors were located along the long elevations. During World War II, the Army constructed smokeless powder magazines with smaller dimensions, such as 51 x 78 feet or the size of explosives magazines described below (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 110).

Explosives/Primer and Fuse/Post Ordnance/Smokeless Powder Magazines. During World War I, the Army constructed metal-frame high-explosives magazines that measured 26 x 42 feet (Crowell 1919:551-552). This building type had a single entry in the gable end (Figure 35, *bottom*). In 1933, the Quartermaster Department issued a plan for a standard magazine for storage of bulk explosives or primers and fuses, or for use as a standard post ordnance magazine. The building was constructed of terra cotta tile and measured 27 x 43 feet.

The magazine had two design variations. One variation had a single entry in the gable end. Examples of this kind of magazine appeared at artillery and armored forces installations such as Fort McClellan, Alabama, and Fort Knox, Kentucky, and at Air Corps installations, such as Scott AFB, Illinois. The second variation contained multiple entries located along the long elevations. The second variation appeared at ordnance production plants, ordnance depots, and chemical warfare depots (Figure 36, *top*).

Segregated/Bomb Loading/Air Corps Magazines. This magazine generally was a small, masonry building with a shed roof (Figure 36, *bottom*). It was constructed in self-contained bays; each bay had one entry. The length of the building varied, depending on the number of compartments. Common lengths include two or six compartments. This type of magazine was constructed during the inter-war period and World War II at Air Corps installations and installation ordnance storage complexes.

Richmond Magazines. The "Richmond" magazine had a concrete foundation with brick or concrete block walls, without steel reinforcement. The roof was a slightly pitched gable roof. The magazine was surrounded by earth on three sides up to the roof line (Figure 37, *top*). The Army constructed "Richmond" magazines at World War II-era "Class B" ordnance depots and at ammunition plants such as Cornhusker, Kansas; Holston, Tennessee; and Newport, Indiana (Building Technology Inc., *Cornhusker* 1984:20; *Holston* 1984:25-28; *Newport* 1984:21,24; History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 112).

Earth-Covered Storage

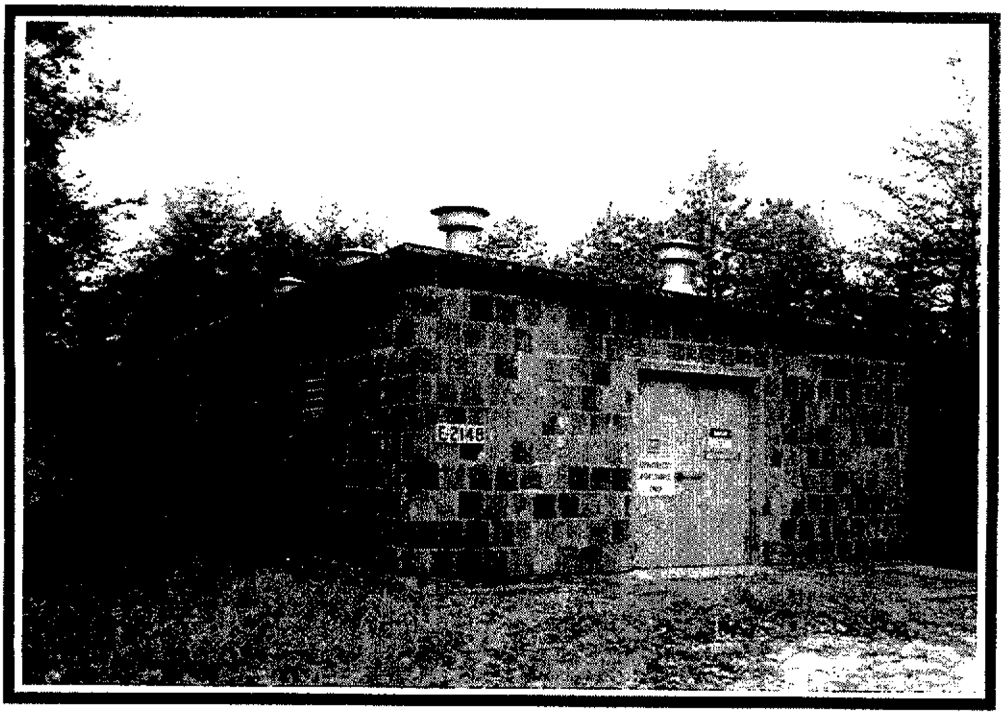
Igloos. The Army completed its first igloo magazines in 1929. This building type is similar to the Navy's arched-type magazine, and was used to store high explosives. The igloo magazine was a barrel-vaulted structure constructed of reinforced-concrete and earth-covered. The sides of the igloo were semicircular so that the weakest structural point was the roof. The igloo's shape directed the force of potential explosions upwards, rather than out toward adjacent magazines. The earth that covered the igloo was stabilized with grass. A metal door set in the center of the concrete wall protected the exposed end of the magazine and provided access into the igloo (Figure 37, *bottom*).

During World War II, the concrete igloo was the most common ordnance storage structure constructed, especially at ordnance storage depots. The size of the igloo varied. While the width of the igloo remained constant at 26 feet, the length of the igloos ranged from 40, 60, to 80 feet (Figure 38, *top*).

During World War II, some temporary igloos were constructed at small ammunition storage areas located on Army installations. At Fort Knox, Kentucky, the igloos were constructed of steel and covered with earth (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 110; U.S. Ordnance Department 1941:31).

Rectangular Boxes. During the 1930s, the Quartermaster Department issued a standard plan for an earth-covered, rectangular magazine that measured 8 x 10 feet. This structure was constructed of reinforced concrete and covered with earthen berms (Figure 38, *bottom*).

Corbetta Beehive Magazines. The Corbetta beehive magazine was developed to conserve critical construction materials and to simplify the construction process. It was a circular, domed structure constructed of reinforced concrete. The Corbetta beehive magazine was tested at the Naval Ammunition Depot, McAlester, Oklahoma (Komatsu 1990:16). It was constructed at several Army ordnance depots, including Volunteer Ammunition Depot, Tennessee (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 112) (Figure 28).



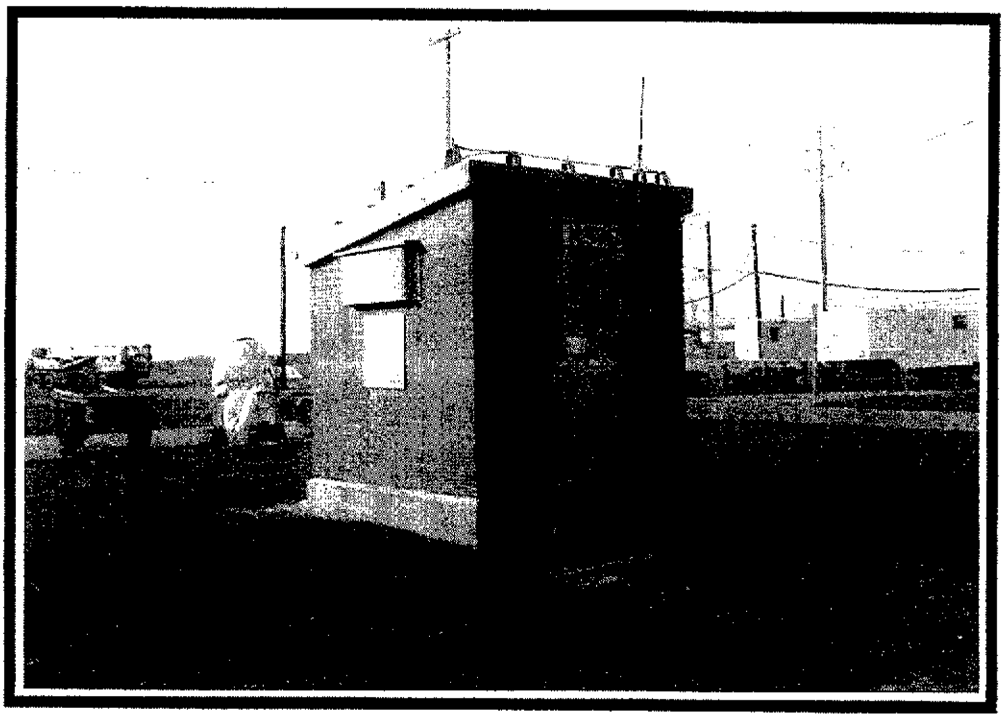
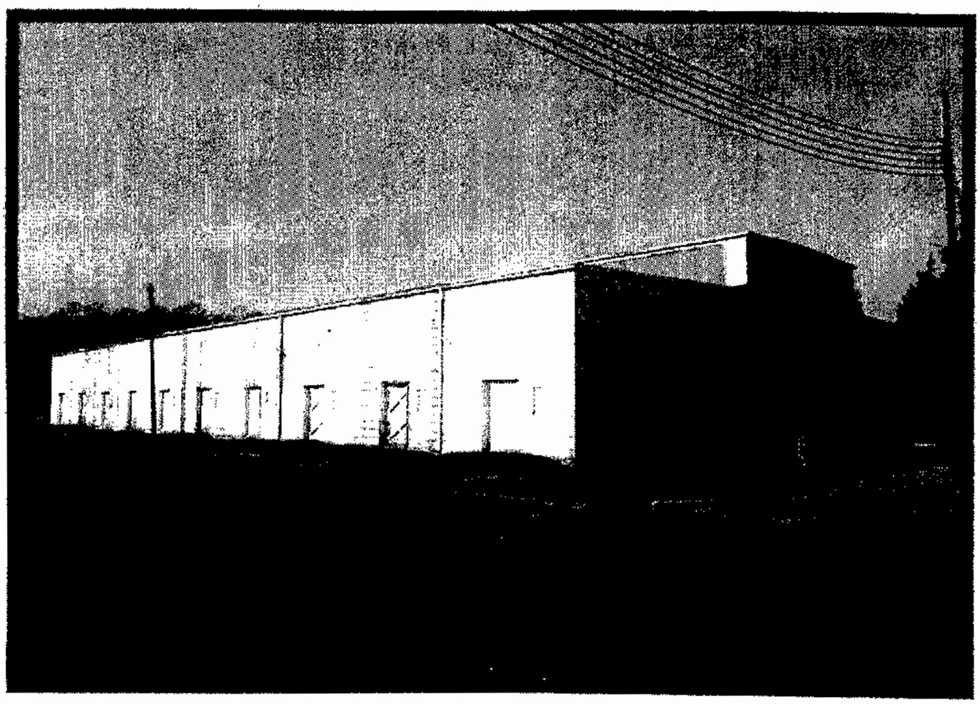


Figure 33. (*top*) 1919 high explosive magazine (Building E2148, Aberdeen Proving Ground, Maryland)
(*bottom*) 1934 high explosive magazine (Building M-376, Aberdeen Proving Ground, Maryland)



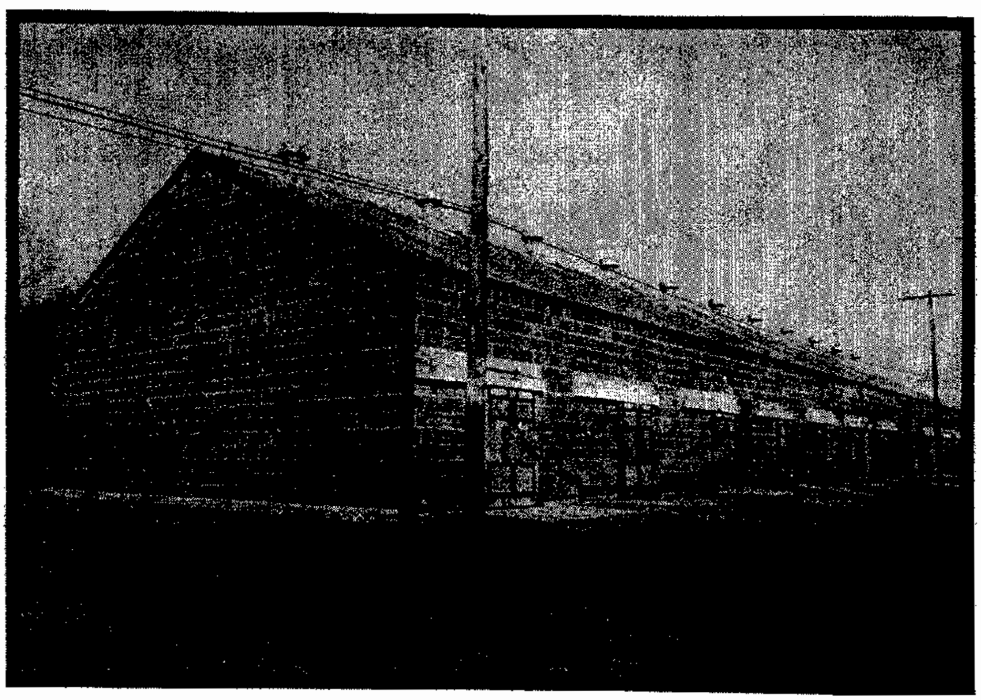
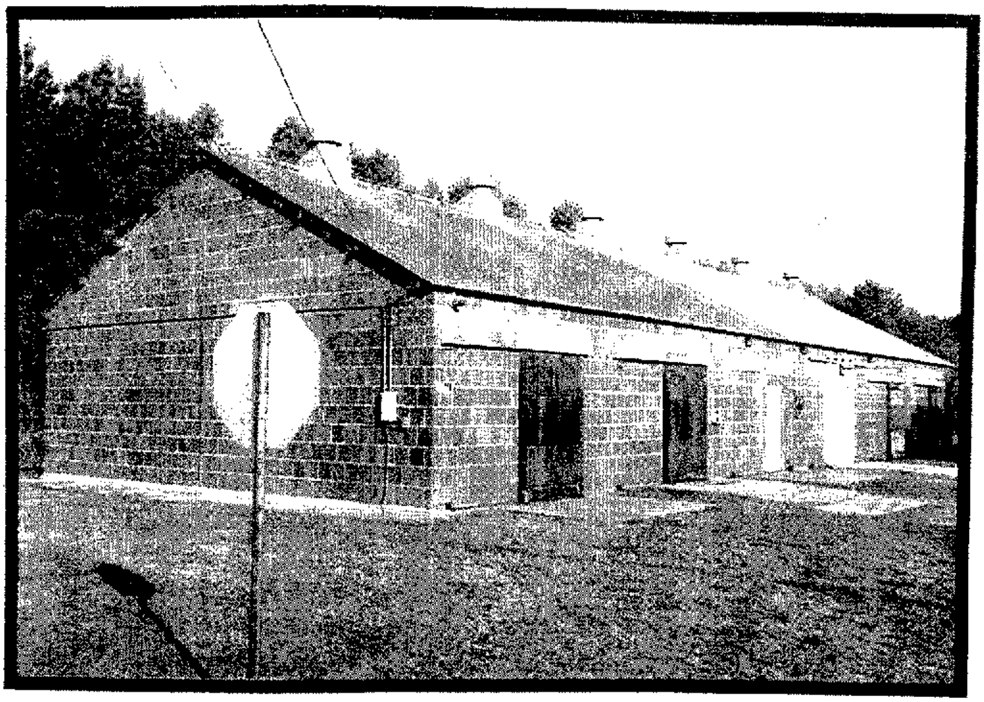


Figure 34. (*top*) 1918 ordnance magazine (Building E1930, Aberdeen Proving Ground, Maryland)
(*bottom*) 1941 ammunition magazine (Building E5892, Aberdeen Proving Ground, Maryland)



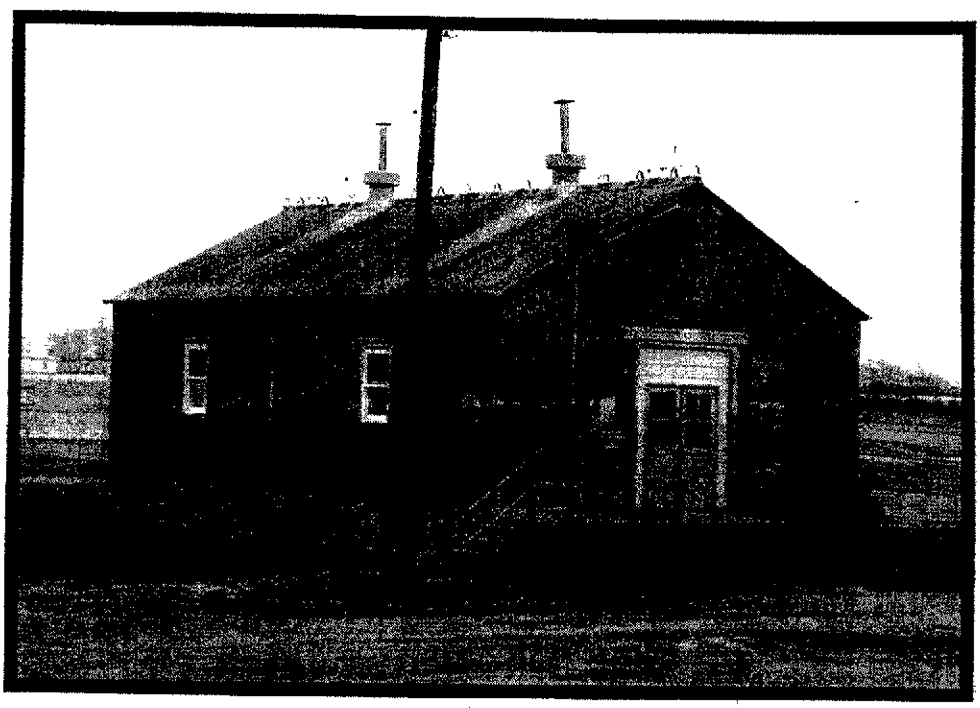
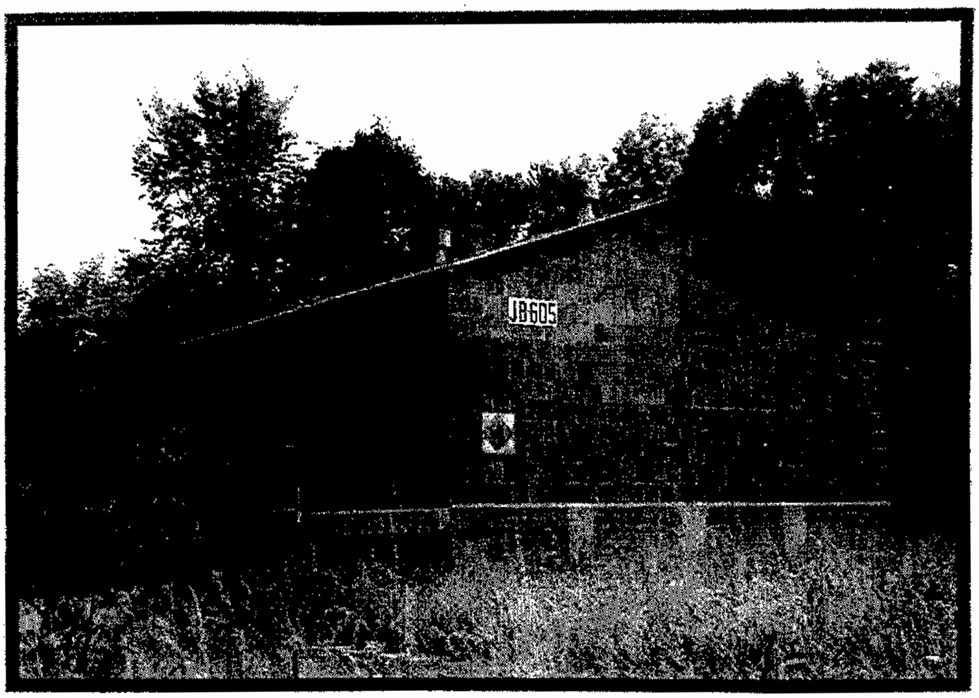


Figure 35. (*top*) 1941 standard smokeless powder magazine (E5844, Aberdeen Proving Ground, Maryland)
(*bottom*) 1934 explosive magazine (Building 435, Aberdeen Proving Ground, Maryland)



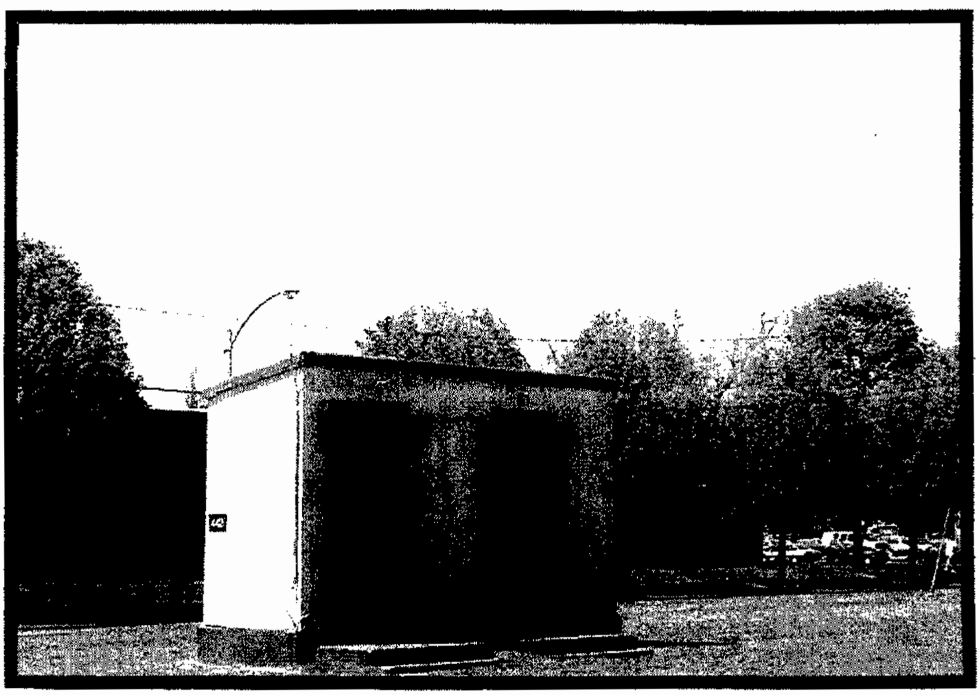
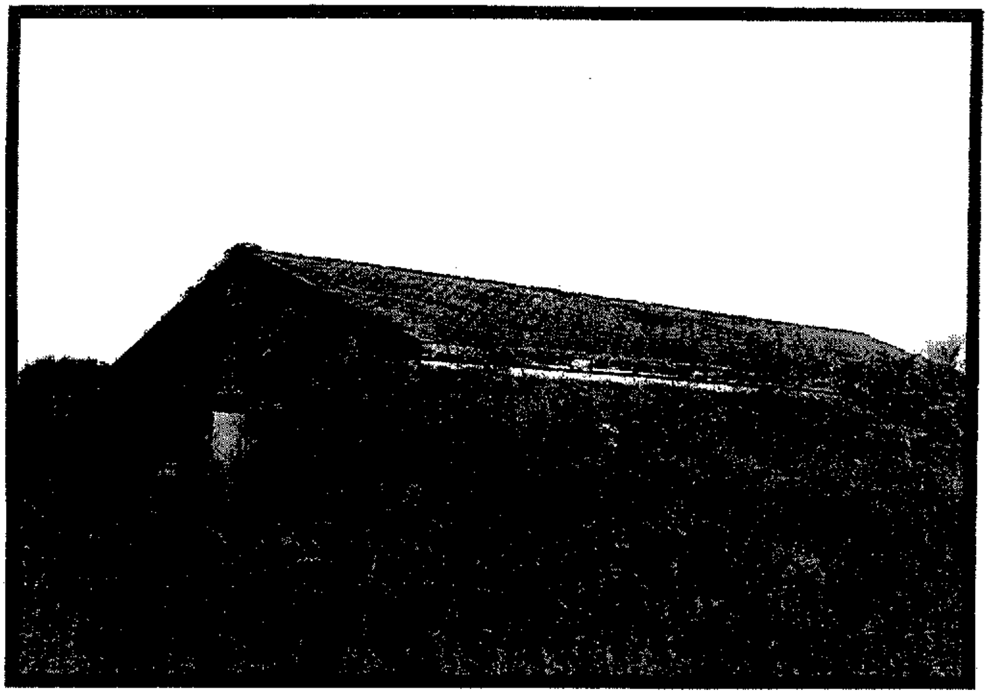


Figure 36. (*top*) World War II smokeless powder magazine (Building JB-605, Ravenna AAP, Ohio)
(*bottom*) 1942 Air Corps ammunition storage magazine (Building 442, Scott AFB, Illinois)



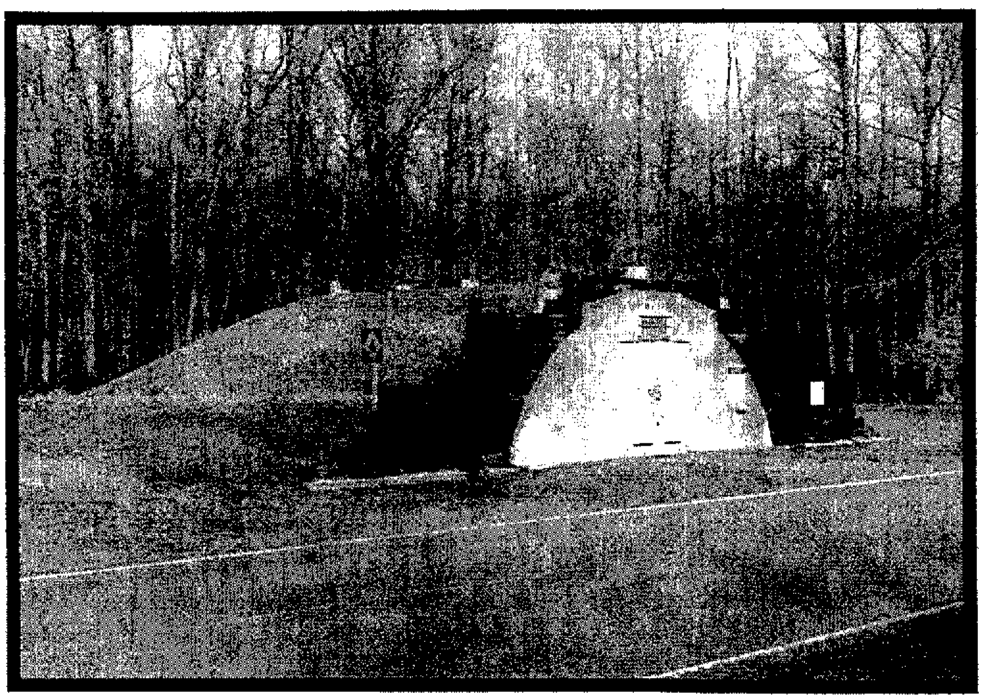
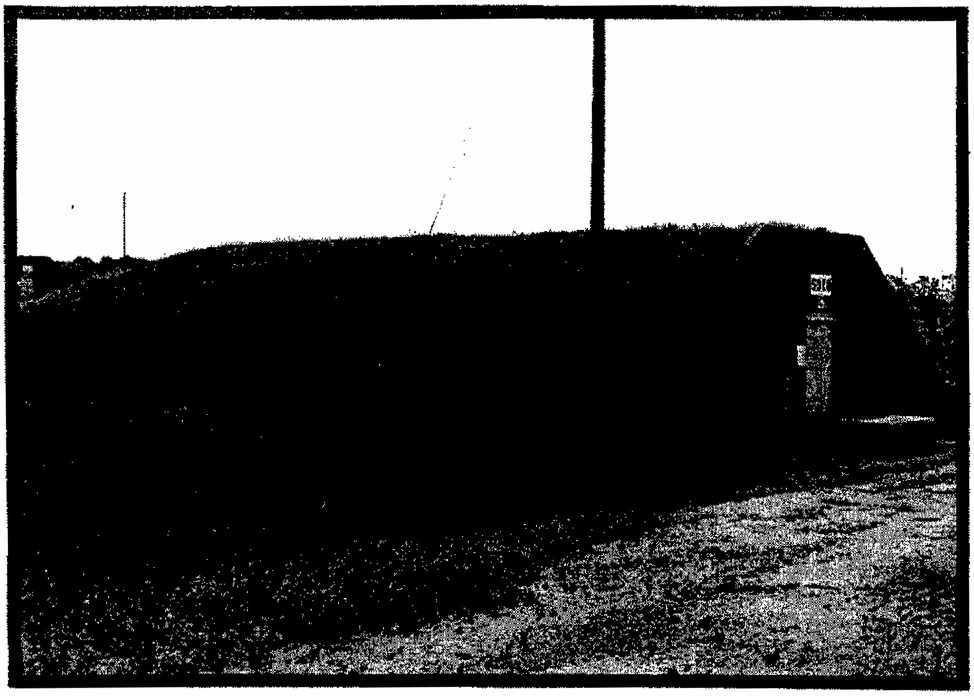


Figure 37. (*top*) World War II Richmond magazine, Indiana AAP, Indiana
(*bottom*) 1930 igloo (Building M-732, Aberdeen Proving Ground, Maryland)



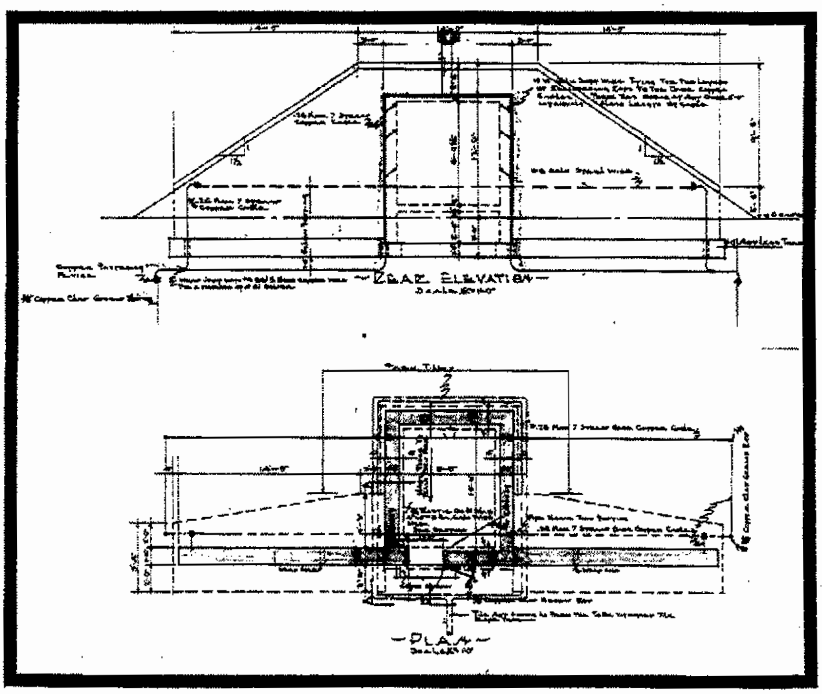


Figure 38. (*top*) 1941 igloo (Building 5018, Indiana AAP, Indiana)
(*bottom*) 1931 earth-covered magazine (History Office, U.S. Army Corps of Engineers, OQMG Drawing 652-287, Box 110)

CHAPTER VI

FUEL STORAGE

Fuel storage facilities were constructed to store coal and fuel oil. The military's increasing use of machinery and electric power equipment required stable supplies of fuels. Wood was the first fuel source used to power steam ships and locomotives. Coal replaced wood as the primary fuel source during the second half of the nineteenth century. Merchant ships began to experiment with fuel oil during the last decade of the nineteenth century. However, coal remained the dominant fuel source for the military through World War I. During the inter-war period, coal and fuel oil competed in the fuel source market. Fuel oil and gasoline were used to power aircraft, motor vehicles, and military ships. Coal remained the primary fuel source for power houses and boilers at military installations until World War II.

Naval Fuel Storage

The Navy required fuel for two functions: powering ships and supplying central power houses and boiler plants at shore installations. In both cases, the Navy initially relied on coal for fuel. Coal is a bulky substance that was stored outdoors in most cases. In some cases, shed-roofed structures were constructed to protect coal supplies. Coal needed to fuel central power plants was stored near the plant within easy distance of coal handling equipment.

During the 1880s, the Navy began to construct ships that relied on steam power rather than sails. Coal was the principal fuel source, and the Navy established coal depots at strategic coastal locations. Coaling stations included wharves to unload coal and fuel ships, open storage bunkers, a boiler house, a power house to provide steam power to coal handling equipment such as cranes, coal towers, and a system of dump cars. The Navy's largest coal depot on the Pacific Coast was established in 1904 at Tiburon, California (U.S. Navy Department, Bureau of Yards and Docks *Bulletin 7* 1911:12-19). Other coal depots included Melville, Rhode Island; Narragansett Bay, Rhode Island; San Diego, California; Key West, Florida; Pearl Harbor, Hawaii; and, the Panama Canal Zone.

The Navy experimented seriously with liquid fuel during the 1890s. In 1897, a torpedo boat was out-fitted with a steam system fueled by oil. Tests conducted during the first years of the twentieth century proved that oil-burning engines produced steam more rapidly and efficiently than coal-burning ones. In 1908, the Navy built its first large-scale, oil-burning steam plant in the monitor *Wyoming* (Alden 1972:224).

The new fuel source required that a new type of storage structure be constructed at strategic locations. In 1911, the Navy began to construct above-ground, steel fuel-oil storage tanks at Charleston Navy Yard, South Carolina; Norfolk Navy Yard, Virginia; Boston Navy Yard, Massachusetts; Key West, Florida; Melville, Rhode Island; San Diego, California; Puget Sound Navy Yard, Washington; Mare Island Navy Yard, California; Pearl Harbor, Hawaii; and, Cuba (Drawings, Reel 1299, Naval Construction Battalion Center, Port Hueneme, California). On the West Coast, the Navy used commercial oil storage facilities (U.S. Navy Department, Bureau of Yards and Docks *Bulletin 17* 1914:32-39). However, coal still remained the primary fuel for Navy ships through World War I.

Coal was the primary fuel source for central power houses and boiler plants at installations located in the East and Midwest. Storage bunkers were constructed as part of power houses or boiler plants to stockpile a 24-hour fuel supply. Additional coal supplies were stored in outdoor areas. The Navy constructed oil-fired power houses at the Mare Island and Puget Sound Navy Yards because of the availability of oil on the West Coast (U.S. Navy Department, Bureau of Yards and Docks 1921:255-277).

World War I

Fuel storage and distribution became critical during the war. The Navy required fuel supplies to operate its industrial plants and ships. The Navy was charged with transport operations of American troops and supplies to Europe. As part of transport operations, the Navy was responsible for fuel supplies. During World War I, fuel sources for ships included both coal and fuel oil. However, coal supplies remained most critical to naval planners. The Navy provided coal storage at points of troop and supply embarkation to refuel ships transporting supplies overseas (U.S. Navy Department, Bureau of Yards and Docks 1921:321). Coal also remained the primary fuel source for most naval power and heating plants during World War I.

During the winter of 1917-1918, a coal shortage crippled shipping on the East Coast. To avoid future problems during wartime, the Navy established five emergency coaling stations at critical ports to augment existing coaling stations. The new stations included: Boston, Massachusetts; New York, New York; Baltimore, Maryland; Hampton Roads, Virginia, and Charleston, South Carolina. These facilities generally were open areas that were serviced by a dock and ore-loading cranes.

Just prior to World War I, the Navy decided to increase its fuel-oil storage capacity along the coasts in response to the increased number of oil-fueled naval vessels. The Navy anticipated that oil-fueled ships would replace coal burners and incorporated technological changes into their training. At the naval training camp at Newport, Rhode Island, the new power plant was oil-fueled so that enlisted personnel could train using oil-burning equipment before ship assignment (U.S. Navy Department, Bureau of Yards and Docks 1921:263).

Construction of permanent fuel-oil storage facilities progressed during the war, even though such construction was not considered a wartime project. The Navy did not expect to use the storage during the war. The new storage structures were rectangular, reinforced-concrete tanks located underground. The tanks were equipped with special heaters to allow the oil to flow easily since the oil purchased from Mexican fields was a heavy grade. The Navy constructed concrete reservoirs at Guantanamo Bay, Cuba; Melville, Rhode Island; Puget Sound Navy Yard, Washington; San Diego, California; Pearl Harbor, Hawaii; and, Yorktown, Virginia (U.S. Navy Department, Bureau of Yards and Docks 1921:359-360).

The Navy constructed above-ground steel tanks to store oil at several installations. However, war time contingencies interrupted planning efforts. Fuel-oil and gasoline storage became critical in France during the war, so several steel tanks intended for use at U.S. Navy yards were shipped to Brest, France. Three steel tanks constructed at Norfolk Navy Yard, Virginia, were disassembled and shipped overseas before they were filled with oil. The fuel oil located at Brest supplied destroyers that protected the transport ships against submarine attack (U.S. Navy Department, Bureau of Yards and Docks 1921:359-361).

Inter-war Period

During the inter-war period, oil replaced coal as the primary fuel for powering ships. The Navy converted its pre-1918 coal depots to general fuel depots that eventually stored fuel oil exclusively. By the late 1930s, coal depots were obsolete.

During the inter-war period, the Navy classified its liquid fuels as fuel oil, diesel oil, and gasoline. Locations of fuel depots depended on fleet needs, availability of local fuel-oil supplies, and availability of commercial supplies. A fuel depot required fueling wharves, storage structures, and, if possible, a fire protection system. During the 1930s, the Navy recommended construction of steel tanks to store liquid fuels. The tanks were spaced to minimize the spread of fire (U.S. Navy Department, Bureau of Yards and Docks 1938:L1-L2).

The fuel depot at San Diego, California, illustrates the evolution of most fuel storage depots. San Diego originally was established as a coaling plant. During World War I, the coaling plant dominated the shoreline. One concrete oil storage reservoir was constructed at the plant. During the inter-war period, the number of fuel storage tanks increased and the coaling plant was disbanded. By World War II, the coaling plant was entirely replaced by fuel-oil storage tanks. Administration buildings were constructed on the location of the original coal yard.

The Navy required a variety of liquid fuels. Types of fuels needed included gasoline for aircraft; commercial-grade gasoline for trucks, automobiles, and boats; and, lubricating oils. The Bureau of Yards and Docks recommended construction of underground storage tanks at naval air stations that could be operated by remote-control pumps or compressed air. Capacities ranged from 20,000 to 30,000 gallons at patrol stations, to 120,000 to 130,000 gallons at fleet bases (U.S. Navy Department, Bureau of Yards and Docks 1938:Q17).

During the inter-war period, power and heating plants at naval installations continued to operate using fuels based on regional availability. The Navy continued to use coal at power plants on installations in the East and Midwest. The power plant constructed in 1928 at the Marine Corps Base, Quantico, Virginia, was the first system that used pulverized coal as fuel. Oil-burners continued in use at Mare Island, California; Puget Sound, Washington; and, Newport, Rhode Island. Gas was used at few installations during the late 1930s because of its high costs. Where used, the gas-fueled system was constructed for easy conversion to oil if the price of gas increased (U.S. Navy Department, Bureau of Yards and Docks 1938:D7-D8).

World War II

During World War II, the Navy expanded its liquid fuel depots. In 1941, stored fuel supplies included 3,500,000 barrels of fuel oil; slightly less than 200,000 barrels of diesel oil; and, 148,810 barrels of aviation gasoline. No excess commercial fuel storage was available. The Council on National Defense, organized in 1940, recommended that the military construct and fill reserve storage tanks with enough fuel oil to last through 100 days of war, an estimated 7,500,000 barrels (U. S. Navy Department, Bureau of Yards and Docks 1947a V.II:319).

In 1939, the Secretary of the Navy established the Fuel Storage Board to direct its fuel-storage expansion program. One of the board's first recommendations was that fuel-oil storage tanks be located underground to safeguard against air attack. The officers considered camouflage alone insufficient for protecting large tank farms, although camouflage might work for smaller storage plants. The board recommended that tanks be constructed of reinforced concrete and buried at least two feet underground. The Bureau of Yards and Docks prepared standard designs for a pre-stressed reinforced concrete tank meeting these specifications (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:318).

Tank storage facilities generally were constructed near navy yards, operating bases, or other major installations. Air stations were equipped with their own fuel storage facilities. A separate system of fuel-oil depots also was established (Table 7). The Navy recommended that all liquid fuel storage facilities include two pumping systems so that fuel could be accessed at all times. Fuel depot installations included boiler houses, electric transmission lines, pump houses, transformers, water supply, roads, railroads, piers, and moorings. Fuel depots generally were located near coastlines, although safety precautions required the construction of storage tanks a mile or more inland (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:319-320).

Naval Building Types

Underground Concrete Tanks

Underground fuel-oil storage were rectangular, reinforced-concrete tanks. The Navy constructed concrete reservoirs during World War I at Guantanamo Bay, Cuba; Melville, Rhode Island; Puget Sound Navy Yard, Washington; San Diego, California; Pearl Harbor, Hawaii; and, Yorktown, Virginia (U.S. Navy Department, Bureau of Yards and Docks 1921:359-360).

Underground storage tanks also were constructed during World War II (Figure 39). The Bureau of Yards and Docks prepared standard designs for a pre-stressed, reinforced-concrete tank. The tank featured a new design in which a concrete cylinder was compressed by steel tension rods tightened by turnbuckles. This construction eliminated the hairline cracks that appeared in reinforced concrete tanks and saved critical amounts of steel (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:318).

Steel Tanks

Above-ground steel riveted tanks were constructed throughout the time period included in this study, 1917 - 1946. The earliest designs for steel tanks date from 1910. These structures were cylindrical with rivetted exterior steel plates. Often the steel was set on a concrete foundation (Figure 40). The size of the tank was determined by the amount of oil that it was designed to hold. The largest tanks held 150,000 barrels of oil. During the 1930s, the Bureau of Yards and Docks determined that this size was too large for effective use and posed too great a fire hazard. The Navy recommended 100,000 barrels as the maximum size for fuel oil storage tanks and 5,350 barrels for gasoline storage (U.S. Navy Department, Bureau of Yards and Docks 1938:L4). During World War II, steel tanks also were placed underground as protection against possible air attack. Fuel storage tanks were constructed at fuel depots, navy yards, fleet supply centers, and naval aviation installations (Figure 41, *top*).

Pumping Stations

Fuel pumping stations are one-story buildings, generally constructed of permanent materials such as brick, concrete, or hollow clay tile (Figure 41, *bottom*). In general, pumping stations are utilitarian buildings with little architectural ornamentation. If a pumping station is located near a group of prominent buildings on an installation, it might be ornamented with elements reflecting the architectural character of an area.

TABLE 7. WORLD WAR II FUEL NAVY DEPOTS

Original Name	State	Date Established
Point Molate Fuel Depot	CA	1941
Middle and Orchard Point Fuel Depots	WA	1941
Yorktown Fuel Depot	VA	1917
Melville Fuel Depot	RI	1899
Richmond Fuel Depot	CA	1941
Craney Island Fuel Depot	VA	1936
Long Island Fuel Depot	ME	1942
Orient Heights Fuel Depot	MA	1942
San Pedro Fueling Annex	CA	1942
Cheatham Annex	VA	1942
Fuel Depot, Naval Operating Base, San Diego	CA	1904
Charleston Navy Yard	SC	1941

Source: U.S. Navy Department, Bureau of Yards and Docks 1947:318-322.

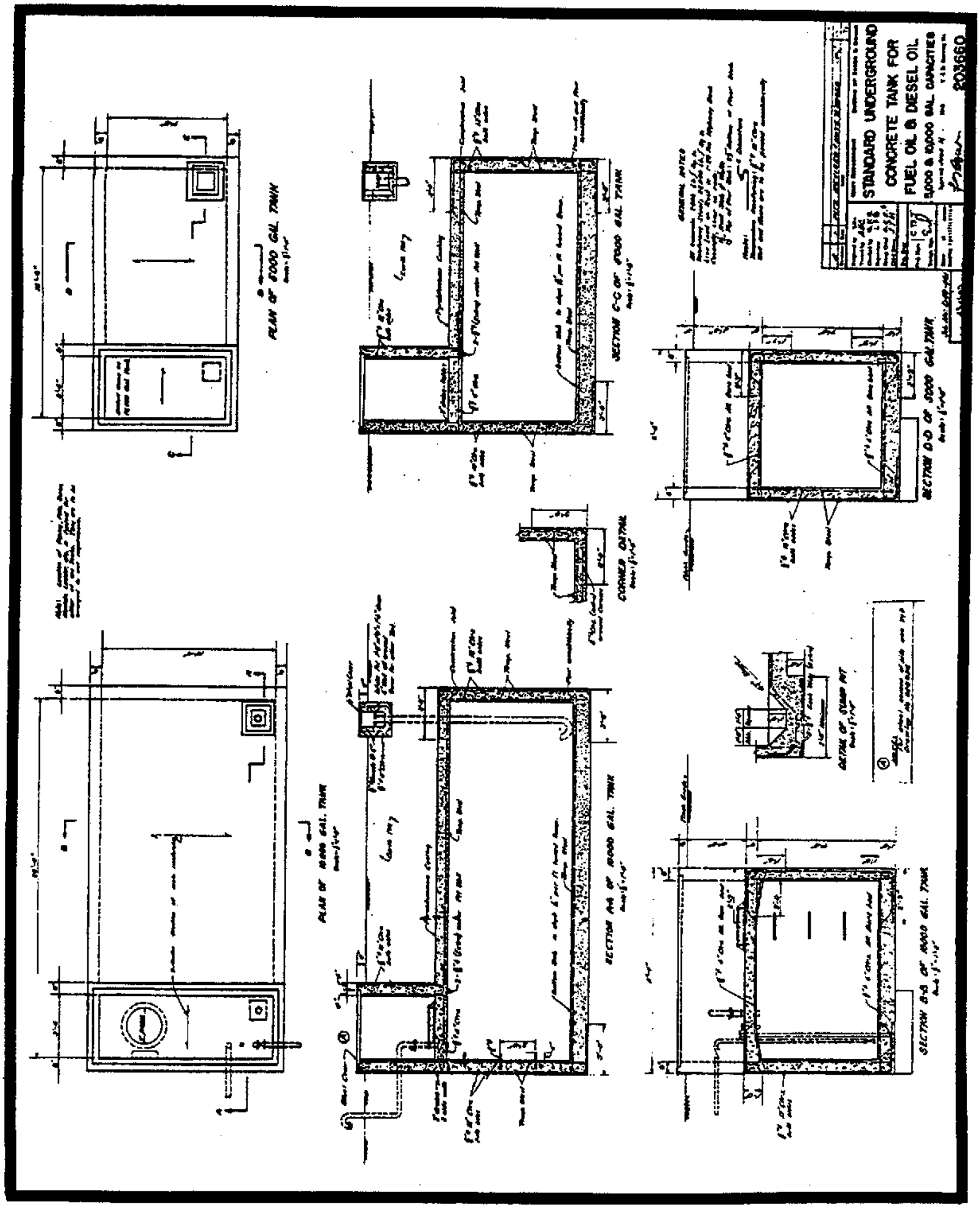


Figure 39. 1943 standard underground concrete tank for fuel oil and diesel oil (Drawing 203660, Naval Construction Battalion Center, Port Hueneme, California)

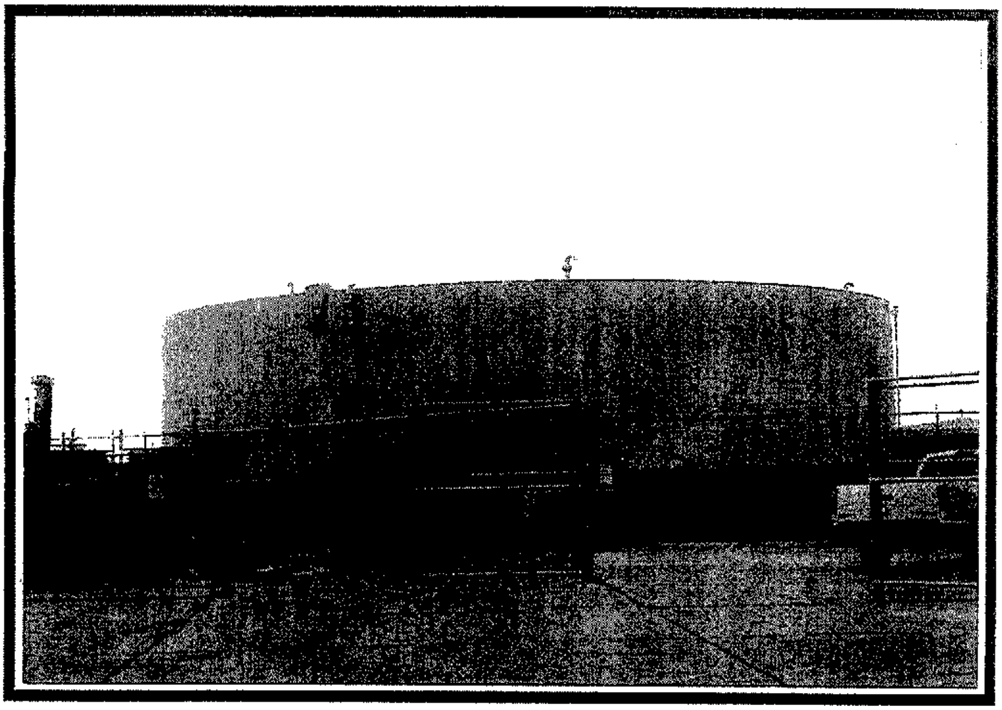
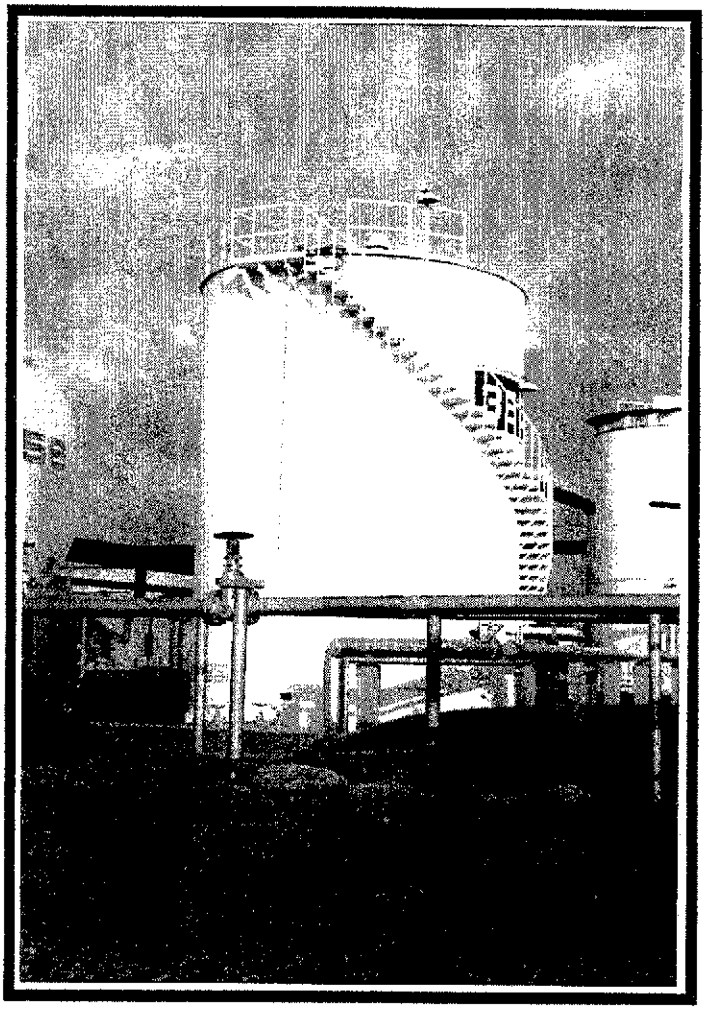


Figure 40. (*top*) 1922 diesel steel fuel oil storage tank (Building W110, Naval Base Norfolk, Virginia)
(*bottom*) 1940 aviation gasoline storage tank (Building 643, Naval Complex Pensacola, Florida)



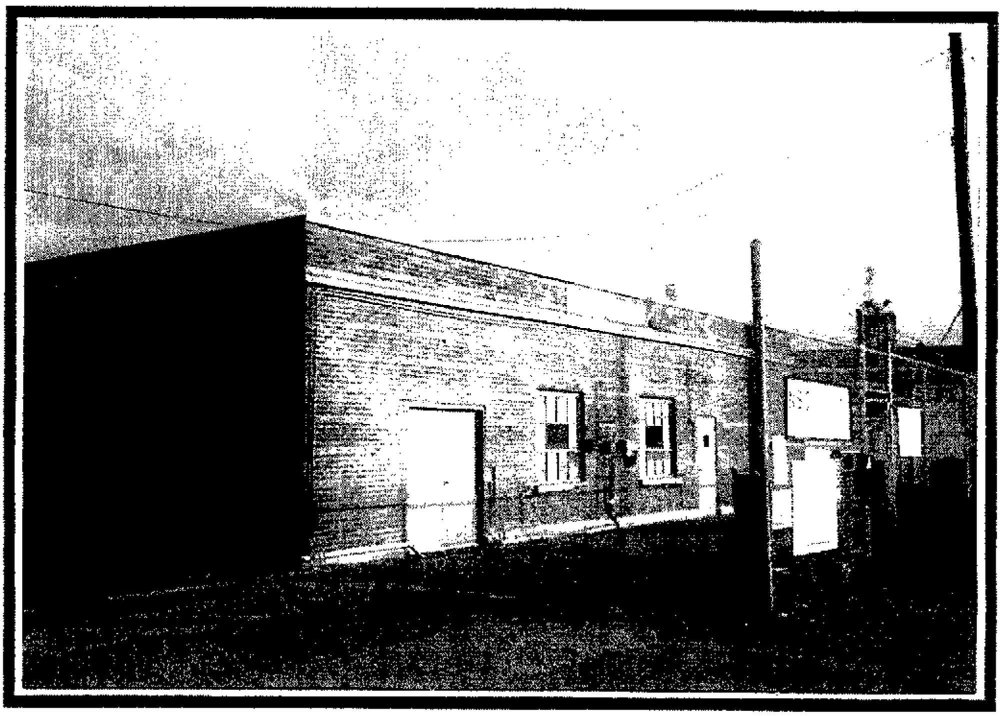


Figure 41. (*top*) 1923 aircraft fuel oil storage tanks (Building W360, Naval Base Norfolk, Virginia)
(*bottom*) 1931 fuel pump house (Building W69, Naval Base Norfolk, Virginia)

Army Fuel Storage

The Army primarily required fuel to support motor vehicles, aircraft, and power and heating plants. In general, heating and power plants at Army installations were coal fueled between World War I and World War II. Coal bunkers were constructed as part of power and heating plant buildings. Additional coal supplies were stored outdoors. Between 1917 and 1946, the construction of fuel-oil storage at installations was determined by the installation mission. Before World War II, the Army did not develop fuel storage depots.

World War I

World War I was the first U.S. war where fuel oil became a critical commodity due to the development of motor vehicles and aircraft as weapons of war. Motor vehicles and aircraft required steady gasoline or diesel oil fuel supplies. To support this equipment, the Army needed flexible fuel storage arrangements so that fuel supplies accompanied troop movements. In Europe, the Quartermaster Department, charged with handling American gasoline supplies, established a system of bulk gasoline distribution that utilized tank storage, railway tank cars, and motor truck tanks. Fuel was then pumped into cans that were transported with the vehicles (Risch 1989:660-662). This system was successful and required the construction of a number of new structures overseas, not in the continental United States.

Inter-war Period

During the inter-war period, the Quartermaster Corps designed gas stations to supply motor vehicles at installations. Air Corps installations were equipped with aviation fuel storage. In most cases, fuel-oil storage tanks were underground steel structures attached to pumping mechanisms to transfer the fuel (Figure 42). In some cases, the tanks were located above ground. Oil houses were constructed to contain lubricants and greases that were stored in drums.

World War II

During World War II, the need for fuel supplies increased greatly. The Council on National Defense, organized in 1940, recommended that the military construct and fill reserve storage tanks with enough fuel oil to last for 100 days of war, an estimated 7,500,000 barrels (315,000,000 gallons). The Army and the Navy shared the responsibility for fuel-oil storage (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:319).

The Army adapted the fuel-oil distribution systems used during World War I, i.e., tank cars, tank trucks, portable pipelines, and cans. During the war, the Army improved distribution equipment including larger tank trucks and improved pumping technology. To support the war effort abroad, the Army developed a centralized procurement system for petroleum products, excluding aircraft fuel. Petroleum products and equipment were procured and stored at five depots: Jersey City, New Jersey; Washington, D.C.; Oakland, California; Seattle, Washington; and Jeffersonville, Indiana (Risch 1953:143-144, 250).

Army Building Types

Underground Steel Tanks

Underground steel storage tanks were constructed during the inter-war period and World War II. The largest tanks were constructed for Army Air Corps installations. At Kelly AFB in Texas, for example, three separate underground fuel storage areas were constructed. The tank area constructed in 1922 comprised five 10,000 gallon and six 5,000 gallon fuel tanks. The tanks were horizontal steel cylinders buried underground. The fuel tanks were removed during the early 1990s (Don Ficklen, Environmental Management, Kelly AFB, personal communication). The majority of drawings identified at the History Office, U.S. Army Corps of Engineers depicted horizontal underground steel tank structures.

Above-Ground Storage

Above-ground steel rivetted tanks also were constructed by the Quartermaster Department. The Quartermaster Department first constructed steel tanks in Europe during World War I. The Quartermaster Department again prepared standard plans for steel tanks during World War II. The steel tank was described as a bolted steel tank for temporary bulk storage. Often, steel tanks were used to store small amount of fuel to power steam plants (Figure 43, *top*).

Pumping Stations

Fuel pumping stations are one-story buildings, generally constructed of permanent materials such as brick, concrete, or hollow clay tile. In general, pumping stations are utilitarian buildings with little architectural ornamentation. If a pumping station is located near a group of prominent buildings on an installation, it may be ornamented with elements reflecting the architectural character of an area. At Kelly AFB, the liquid fuel pump house is a one-story building with a geometrically ornamented roof parapet and molded corner pilasters (Figure 43, *bottom*).

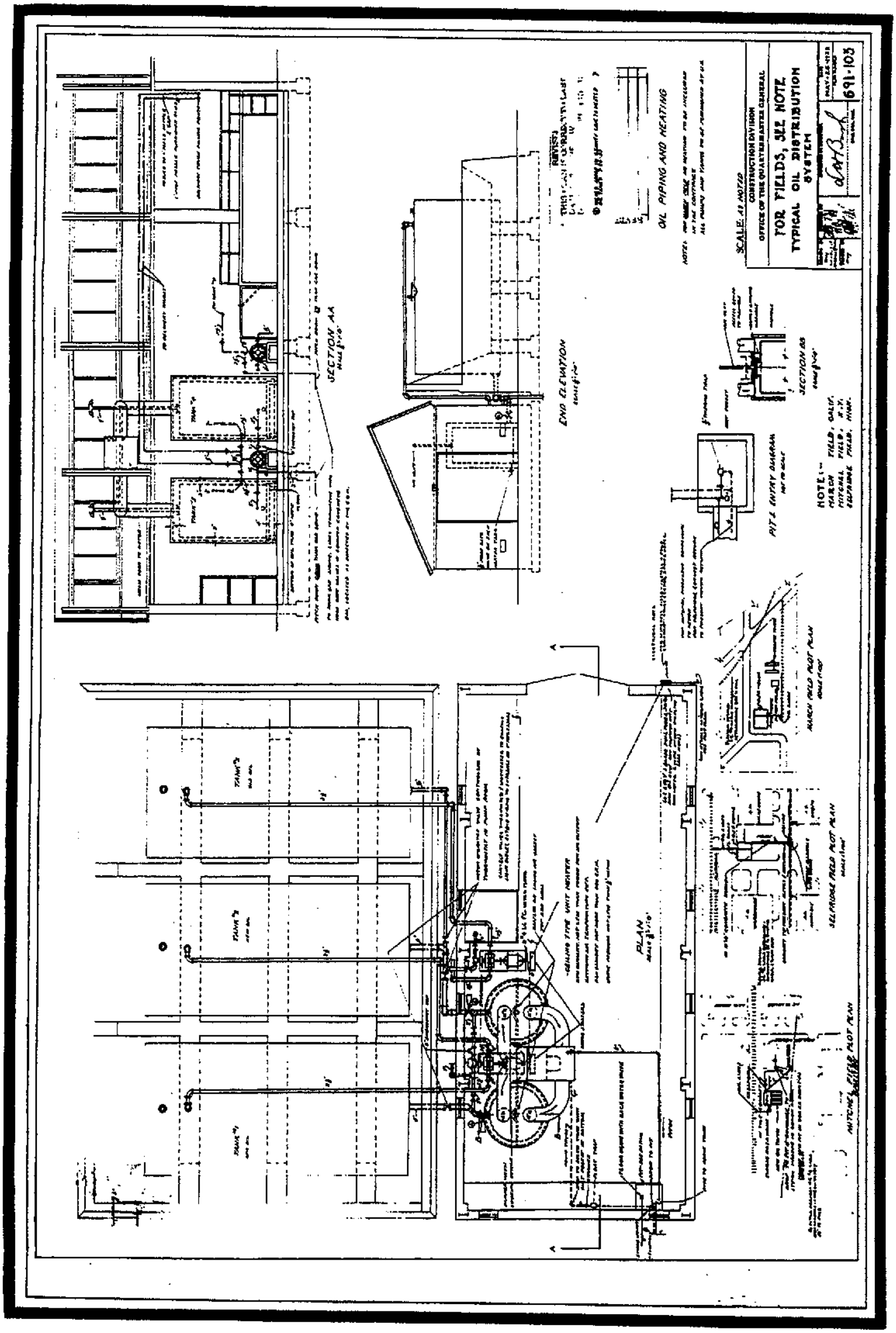


Figure 42. 1932 typical fuel oil distribution system (History Office, U.S. Army Corps of Engineers, OQMG Drawing 691-105, Box 116)

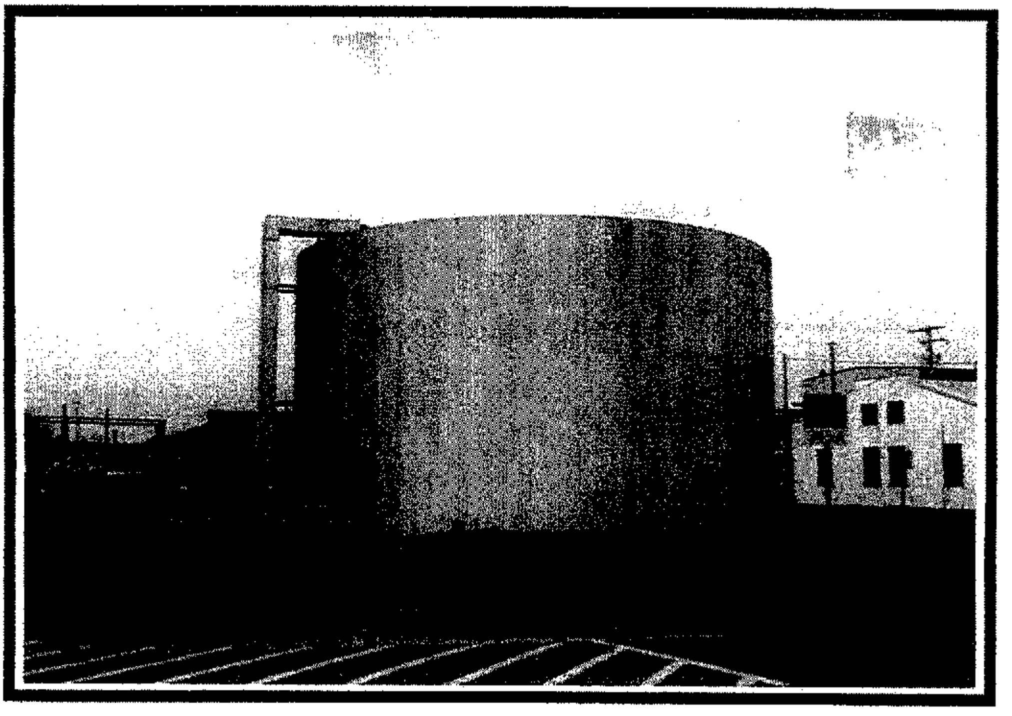


Figure 43. (*top*) Typical above-ground fuel-oil storage tank (Building 345-A, Aberdeen Proving Ground, Maryland, Maryland)
(*bottom*) 1937 liquid fuel pump building (Building 1618, Kelly AFB, Texas). This building served ten underground storage tanks, which have since been remediated.

CHAPTER VII

WATER SUPPLY SYSTEMS

Water supply systems provide and store clean, potable water. Water supply systems include four main elements: (1) water collection from a primary dependable source; (2) water distribution systems; (3) water treatment facilities; and, (4) storage facilities.

Water sources are either underground, such as artesian basins, or above-ground, such as rain water, springs, streams, lakes, and rivers. Water purity depends on the source. Historically, wells and lakes often contained purer water. Efforts were made to collect water as close to the original source as possible. The further from the source, the higher the potential for water pollution.

Collection systems are designed to tap or contain water. Examples of collection systems include wells to tap underground water sources and cisterns and roof catchments that collect above-ground water sources. Surface water collection often requires storage near collection points. In some cases, the collection system combines collection with storage functions. Storage reservoirs or dammed lakes often are constructed near the water source to ensure a dependable supply of water.

Distribution systems transport the water to its final destination. For large urban areas, water often is transported long distances through open or closed conduits, including culverts or aqueducts. Once at the final destination, the water is distributed to consumers. Historically, water was distributed at central points; users collected water from these central points for private use. Distribution systems expanded during the late nineteenth century when indoor plumbing was introduced widely into private residences.

Water treatment plants are used to purify drinking water supplies. Two techniques have been used since ancient times: sedimentation and filtration. Sedimentation is the process of storing water to allow large particles to filter out. Filtration is the process in which water seeps through sand and stones to remove impurities.

Twentieth-century water treatment techniques comprise a variety of processes, including: long-term storage; aeration; coagulation; sedimentation; softening; filtration; and, disinfection. Sedimentation and filtration remain the basis for all water treatment. Additional steps for water treatment reflect technological improvements to the basic purification methods.

Water supplies typically are stored in reservoirs or settling basins. Storage allows suspended bacteria and sediment to filter to the bottom of the reservoirs. Aeration is the process of mixing air with water, and is accomplished by contact bed or spray, cascade, multiple-tray, or air injection aerators. Aeration reduces odors and bad taste, and removes hardness and corrosiveness from the water. The addition of coagulants, such as aluminum sulphate, to water also causes the colloidal, color, and mineral particles to agglomerate into a floc that then settles out of the water. This process reduces the bacterial content and turbidity of water. The softening process reduces calcium and magnesium in the water. The process is carried out by either chemical precipitation or by ion exchange. The most common softening process is lime-soda softening. Lime-soda is added to water, causing calcium carbonate and magnesium hydroxide precipitation, followed by sedimentation (Williams 1978:1373).

Technological Evolution

Sedimentation and filtration techniques have been used to treat water supplies since ancient times. For sedimentation to be effective, water must sit for periods of time. Filtration was developed as an alternative method to quicken the purifying process. Modern methods of water filtration were developed during the nineteenth century. By the early 1900s, filtration of water through sand beds was the primary process of water treatment. Two methods of filtration evolved: (1) slow sand filtration, and (2) rapid sand filtration.

The principles of slow sand filtration were developed by the middle of the nineteenth century. In this method, water drained through beds of finely granulated sand to filter out suspended solids from the water. The process also removed manganese, bacteria, and turbidity. The purification process depended on biological organisms that lived on the top surface of the sand bed (Williams 1978:1373).

The use of the slow sand method of water filtration proved successful in England during the latter part of the nineteenth century. The use of the slow sand filtration process prevented the spread of cholera and typhoid fever in London. The slow sand filtration method of water treatment remained the unchallenged method of water treatment for the first several decades of the twentieth century. Though the principles of the treatment method itself did not change during this period, materials used in the construction of the filter mechanisms evolved. Concrete construction replaced brick and stone construction (Williams 1978:1373).

By the 1940s, fewer slow sand filters were being built for new treatment plants. Rapid sand filtration processed raw water at about 50 times the rate of the slow sand filter. Rapid sand filtration depended almost entirely on straining suspended solids out of the water through coarse sand filters. The process relied either on gravity filters or on pressure filters. In the gravity filter system, the water surface was at atmospheric pressure. In the pressure filter system, the system was enclosed in a boiler-type shell of wrought iron or steel. Nearly all of the earliest filters were built as small filtration units enclosed in a circular shell. Pressure filters generally were small in size, limited by the process itself. Gravity filters tended to be built in large, rectangular open tanks constructed of reinforced concrete.

The rapid sand filtration method, though much faster than the slow sand filtration method, did not produce as pure a drinking water supply as the slow sand filtration process. The coarser the sand, the more rapid the filtration process. However, the coarser sand left higher levels of bacteria in the water.

Rapid sand filtration techniques became popular after the adoption of aluminum sulphate as a coagulant to clarify the water before it passed through the sand filter. The two-step process resulted in a highly potable end product. Coagulation was first used in New Jersey in 1885 as a preliminary treatment to rapid sand filtration. By 1900, many American communities found the combination of the two processes as the most efficient means to filter drinking water. The coagulant was used first to remove numerous impurities in the water. The sand filtration system then retained fine suspended solids, including bacteria, just as the biological film did on the slow sand filter. By the mid-twentieth century, the two-step process that combined chemical coagulation of impurities followed by rapid sand filtration was the typical method of water treatment (Williams 1978:1375).

Additional improvements in water treatment technology were introduced during the early twentieth century. Throughout the first half of the twentieth century, aluminum sulphate was the most common chemical for coagulation prior to rapid sand filtration. Two other chemicals frequently used as coagulants were ferrous sulphate and ferric chloride. Sodium aluminate was introduced in conjunction with aluminum sulphate during the 1920s. During the 1920s and 1930s, different chemical combinations were used to create more effective coagulants to produce denser flocs that were filtered more easily from the water (Williams 1978:1373).

Settling basins reduced the amount of solid matter for removal by slow and fast sand filters. Settling tanks in the treatment of drinking water were used for years before the development of modern treatment methods. When coagulation became a common element of the water treatment process, settling or sedimentation tanks allowed the growth and settlement of chemical flocs. Tanks were built with paddles that provided slight turbulence, which helped the process of flocculation. Several different flocculation patents were granted during the early twentieth century. During the 1930s, developments occurred in the softening of flocs with the addition of different chemicals for either normal coagulation or lime softening.

In 1945, the microstrainer was introduced for the removal of algae from water. The microstrainer consisted of a rotating drum screen that carried a specially woven stainless steel wire mesh with apertures as small as 20mm. Microstrainers removed algae and other microparticles from water prior to the rapid sand filtration process (Williams 1978:1377).

The introduction of gaseous or liquid chlorine to disinfect water after filtration became relatively common after 1913 in the United States. At this time, mechanical chlorinators also were introduced for the precise measurement of the additive.

Navy/Marine Corps Application of Water Treatment Technology

Until the twentieth century, the Navy's shore installations did not house large numbers of permanent residents, and thus did not require large supplies of potable water. Water was collected from wells, nearby streams and rivers, and rain water. One important need for large supplies of water was fire prevention, but salt water was acceptable. Salt water fire prevention systems were constructed at shipyards, ammunition depots, and other naval installations.

When the Navy constructed central power houses, pure water was needed to avoid corrosion and to keep boilers functioning properly. Water filtration systems often were installed in power houses to purify water for boilers since water purity standards for boilers exceeded purity standards for domestic use (U.S. Navy Department, Bureau of Yards and Docks 1938:D2).

When the Navy constructed on-shore training stations during the twentieth century, potable water supplies for large populations of recruits were needed. At the Great Lakes Naval Training Station, the Navy completed a water filtration system in 1911. Water was pumped from Lake Michigan through an intake well and a suction well, and then passed through a filtration plant and was stored in a sedimentation basin. From there, water was distributed throughout the installation. The water filtration plant was located next to the power house (Hasbrouck Peterson Associates 1987:33; Drawing files, reel 680, frame 162, Naval Construction Battalion Center, Port Hueneme, California).

World War I

The Navy extensively expanded its shore installations during World War I. Where possible, the Navy preferred to utilize existing municipal water systems to supply the new and expanded installations. This proved successful for several naval training camps. At other camps, for example Coddington Point, Rhode Island, the Navy installed both a fresh water and a salt water system. The naval station at Newport, Rhode Island, received fresh drinking water from the city of Newport. Salt water drawn from the bay was used for bathing, toilets, and fire protection. At Great Lakes Naval Training Station, the water filtration and distribution system was expanded to accommodate 48,300 personnel (U.S. Navy Department, Bureau of Yards and Docks 1921:81-82, 91).

Other examples of World War I-era water supply systems were established at the Marine Corps bases at Quantico, Virginia, and Parris Island, South Carolina. At Quantico, the initial main water source was artesian wells. When wells proved inadequate, the Navy constructed a dam on Chopowamsic Creek. Water was pumped from the creek and filtered at a water filtration plant. The water filtration at the plant was accomplished by sedimentation, coagulation by alum and soda ash, rapid sand filtration, and the addition of chlorine and lime. The water was pumped to the installation four miles away. At Parris Island, water originally was pumped from wells. When wells showed a high level of salt, fresh water was transported to the installation by barge. The final solution to this problem was an underground pipe joining the water supply of nearby Port Royal (Navy Department, Bureau of Yards and Docks 1921:94; U.S. Navy Department, Bureau of Yards and Docks 1938:M11).

Inter-war Period and World War II

During the 1920s and 1930s, the Navy constructed permanent buildings at several temporary World War I installations and established new installations, notably air stations. In preparation for World War II, the Navy greatly expanded its shore establishment. During the late 1930s, the Navy continued its practice of supplying potable water from existing neighboring municipal or metropolitan water supplies. Water was piped onto the installation and stored in reservoirs. This method worked for installations located near large cities (U.S. Navy Department, Civil Engineer Corps 1945).

For bases not located near municipal water supplies, the Navy constructed ground wells or dams to secure water supplies. Water pumped from wells or streams was filtered through a filtration plant and stored in concrete reservoirs and/or elevated water storage tanks before distribution throughout the installation. A sampling of World War II water sources and storage structures on naval installations is contained in Table 8.

Naval Building Types

Water Treatment Plants

The Navy constructed water filtration plants only as needed. In general, the buildings are masonry buildings with a utilitarian appearance. Only one water treatment plant was identified during the site visits: Building 1303 at the Marine Corps Development and Education Command, Quantico, Virginia. Building 1303 is a one-story brick building, originally constructed in 1918. Since its initial construction, the building has received several additions and equipment upgrades in response to increasing demands for water.

Reservoirs

The Navy generally constructed rectangular concrete reservoirs to store potable water supplies (Figure 44, *top*). These reservoirs were constructed both underground and above-ground; above-ground reservoirs often were surrounded by earthen berms. During World War II, concrete blocks, wood, and metal also were used to construct water reservoirs.

TABLE 8. SAMPLE OF WATER SUPPLY AND SEWAGE TREATMENT SYSTEMS AT U.S. NAVY FACILITIES IN 1947

Name	Date Established	Water Source	Water Storage	Sewage Disposal
Alameda Naval Air Station, CA	1938	Municipal and 2 wells	5 concrete reservoirs; 3 elevated steel tanks	Digester sedimentation tanks and sludge beds
Bayonne Naval Supply Depot, NJ	1941	Municipal	None listed	Sewage disposal plant shared with naval annex
Charleston Navy Yard, SC	1901	Municipal	1 elevated steel tank; 1 underground concrete reservoir	Direct into Cooper River
Chelsea Naval Hospital, MA	1836	Municipal	Elevated water tank	Municipal
Chollas Heights Radio Station, CA	1914	Municipal with Navy pumping plant	1 elevated steel tank; 1 concrete reservoir	Imhoff tank
Corpus Christi Naval Air Station, TX	1938	Municipal	3 concrete reservoirs; 1 elevated steel tank	Trickling filter disposal system
Crane Naval Ammunition Depot, IN	1940	Springs through filter system	1 natural lake; 2 underground concrete clearwells; 5 elevated steel tanks; 1 wood tank; 1 concrete tank	Biofiltration plant; Imhoff settling system, activated sludge type
Dahlgren Proving Ground, VA	1918	Wells	None listed	Activated Sludge Digester
Great Lakes Naval Training Center, IL	1911	Lake Michigan, normal filter	1 steel tank; 2 concrete tanks; 1 wood tank	2 sewage disposal plants

Name	Date Established	Water Source	Water Storage	Sewage Disposal
Hawthorne Naval Ammunition Depot, NV	1929	Wells	3 concrete and earth-filled reservoirs; 8 elevated steel tanks	2 Imhoff tanks; 2 digestion tanks; 2 sludge beds; 20 effluent tanks; 49 septic tanks
Lake Denmark Naval Ammunition Depot, NJ	1892	Wells	5 concrete reservoirs; 2 basins; 1 cistern; 2 standpipes	2 disposal plants
Lakehurst Naval Air Station, NJ	1921	8 Wells	3 elevated steel tanks; 1 concrete reservoir for fire protection	Primary and secondary treatment
Mare Island Navy Yard, CA	1853	Municipal	2 concrete reservoirs; 3 steel reservoirs	Direct into bay
Marine Corps Base, Quantico, VA	1917	Chopowamsic Creek	2 dams; 3 reservoirs; 2 elevated tanks	Disposal system with settling tanks, dosing tanks, filters, digesters, sludge drying beds
Moffett Naval Air Station, CA	1931	Municipal	1 elevated steel tank; 1 concrete reservoir	Imhoff tanks and sludge beds
Norfolk Naval Station, VA	1917	Municipal	7 concrete reservoirs; 1 elevated tank	Municipal
Norfolk Navy Yard, VA	1801	Municipal	4 elevated tanks; 6 concrete reservoirs	Direct
Oakland Naval Supply Depot, CA	1940	Municipal	None listed	Direct into bay
Pensacola Naval Air Station, FL	1914	Wells	6 concrete reservoirs; 2 elevated steel tanks	Direct into bay

Name	Date Established	Water Source	Water Storage	Sewage Disposal
Port Hueneme Advance Base Depot, CA	1942	Wells	2 wood elevated tanks	3 Imhoff tanks; 23 septic tanks
Puget Sound Navy Yard, WA	1891	Municipal with standby well	3 steel tanks	Direct into sound
St. Juliens Creek Naval Ammunition Depot, VA	1897	Municipal	Elevated tank for fire fighting	Effluent discharged to river
San Diego Naval Supply Depot, CA	1922	Municipal	None listed	Municipal
Stockton Naval Supply Annex, CA	1943	Municipal	None listed	Imhoff tank
U.S. Naval Academy, MD	1845	Wells	1 concrete reservoir	Municipal
Yorktown Naval Mine Warfare School, VA	1917	Spring-fed pond	1 concrete reservoir; 2 elevated steel tanks	Filtration and chlorination and discharge to river
Yorktown Naval Mine Depot, VA	1917	Municipal	2 concrete reservoirs; 5 elevated steel and wood tanks	Septic tanks; sand and rock filters; Imhoff tanks; biofilter and chlorination

Source: U.S. Navy Department, Bureau of Yards and Docks, *Data Book*, 1947:Vol II.

Elevated Water Storage Tanks

Elevated water storage tanks generally were constructed of steel. Steel plates were rivetted to form the tank. The elevated tank was supported by a steel frame (Figure 44, *bottom*). In general, the size of the tank increased between World War I and World War II to supply the increasing population of naval installations. The World War I-era tank has a cylindrical shape with a conical roof. The World War II-era tank has a wider diameter and lower roof profile. During World War II, poured concrete frames also were used to support elevated tanks in an effort to conserve steel.

Pumping/Meter Building

This building type is generally a one-story building that contains pumping, valve, or metering equipment. It generally is constructed of permanent materials, including brick or concrete (Figure 45).

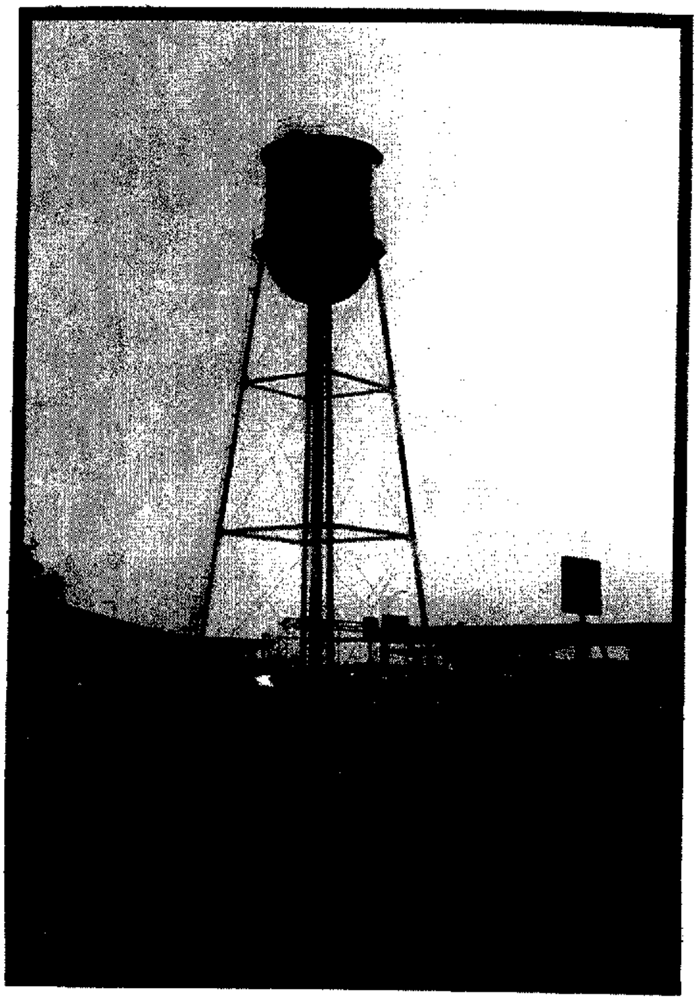


Figure 44. (*top*) 1926 reservoir for potable water (Building 365, Naval Complex Pensacola, Florida)
(*bottom*) 1919 elevated water storage tank (Building P17, Naval Base Norfolk, Virginia)

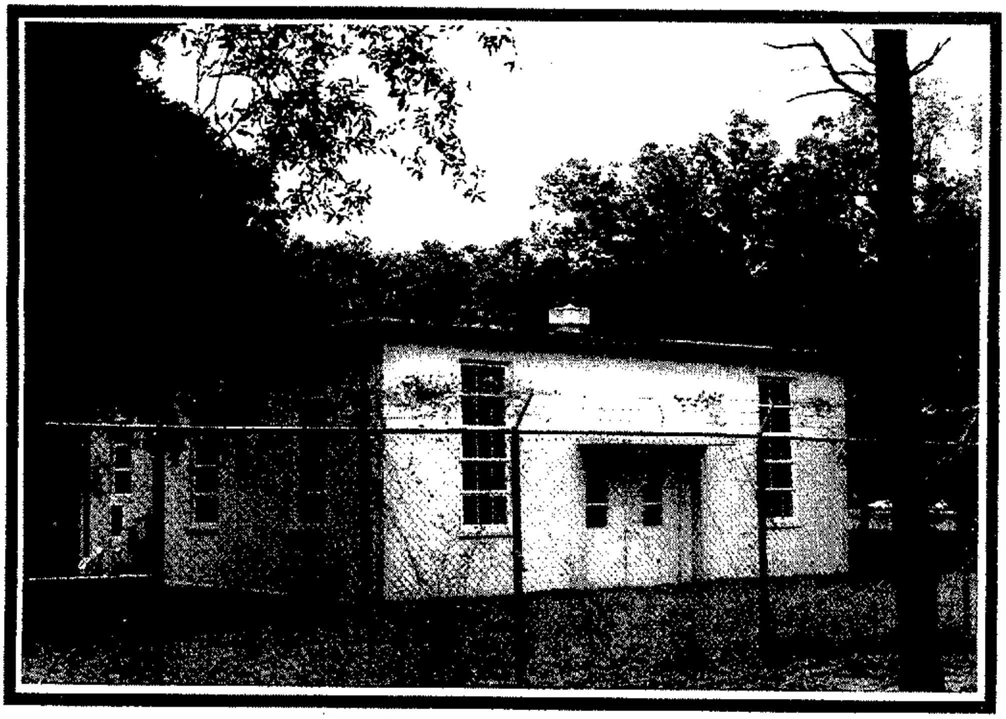


Figure 45. 1942 water pumping station and substation (Building 706, Naval Complex Pensacola, Florida)

Army/Air Corps Application of Water Treatment Technology

The Army became aware of the importance of a safe water supply during the Civil War when impure drinking water contributed to massive outbreaks of typhoid fever. When the Army consolidated its troops in larger and more permanent installations during the 1880s and 1890s, the Quartermaster Department included plans for water supply systems. During the 1880s, the Army included indoor plumbing in housing. By 1892, all but 130 company barracks contained indoor plumbing. By 1896, the Quartermaster Department's annual budget for water supply, plumbing, sewage, and drainage exceeded $250,000 (Clary 1983:14, 21-22). Construction included water storage reservoirs, water towers and tanks, pumping stations, and distribution systems at new and expanded posts. During the late nineteenth century, the Quartermaster primarily was concerned with maintaining a steady water supply and a workable distribution system. Before World War I, the primary testing procedures for water purity were visual inspection of water supplies.

World War I

During World War I, the Army constructed approximately 46 mobilization training installations. The new installations often were the size of a small city, accommodating in some cases a population of 45,000. Each installation required a safe and secure water supply as well as sewers, electrical power, and other utilities. The Construction Division of the Quartermaster Corps estimated that each trainee required a water supply of 55 gallons per man per day, a capacity of 2,250,000 gallons of water daily for each cantonment (Crowell 1919:543).

Where possible, the Army utilized water drawn from nearby municipal water mains. However, in many cases, the Army was forced to develop separate water supplies. In these cases, water was drawn from local streams or rivers or from wells, then stored in reservoirs and filtered. Filter houses became common features of Army installations during World War I. At the filter houses, water quality was tested; if necessary, the water was disinfected using chlorine. Water quality testing reduced the number of recruits hospitalized because of water-borne diseases (Crowell 1919:543, 535). The water was distributed by a system of centrifugal pumps and gravity tanks. Each cantonment contained miles of underground wooden water mains through which water was piped to each barracks. The water pressure was sufficient for personal use and for fire fighting (Crowell 1919:541, 536).

Several cantonments provide examples of a World War I training cantonment water supply system. At Camp Grant, in Rockford, Illinois, the water was drawn from six wells drilled 175 feet deep. The cantonment had 38 miles of underground water mains and reservoir tanks stored up to 550,000 gallons (Crowell 1919:541). At Aberdeen Proving Ground, Maryland, the Army also relied on water pumped from wells. The water was purified through a filter house and stored in a square, concrete reservoir with a hipped roof.

At Edgewood Arsenal, Maryland, the Army constructed two independent water supplies: a salt water supply pumped from the Bush River for fire prevention and a fresh water supply pumped from a local stream located off the installation (U.S. Department of Interior, National Park Service, HABS 1982). On the stream, the Army constructed a permanent dam, a pumping station, and a pipe line. The water was pumped to an enclosed concrete and metal reservoir that had a storage capacity of 1,750 gallons. The water was distributed on the installation through underground cast-iron water lines (U.S. War Department, Construction Division 1919c:29-30). Pressure in the system was maintained through elevated water storage tanks.

Inter-war Period

The Army continued to construct water supply systems to supply its new Army and Army Air Corps installations during the nationwide Army permanent construction program that started after 1926. During this construction program, the Army achieved a high degree of standardization in its installation planning and construction. Utilities, including installation water supplies, received a high priority in the planning process. Planners estimated that the normal daily per capita water consumption at permanent posts was between 100 and 200 gallons (Engle 1937:20).

The same trends evident during World War I continued during this period. Where possible, the Army tapped into existing municipal water supply systems to supply installations. In these cases, the Army's primary concern was with storage and distribution systems. Reservoirs and elevated storage tanks or standpipes were constructed to store sufficient supplies of water and to increase pressure for the distribution system. Water distribution pipes typically were cast iron, replacing the wood piping installed during World War I (Engle 1937:23).

In cases of large, isolated installations, the Army constructed its own dams, pumping stations, and water filtration systems to insure adequate supplies of drinking water. The Army preferred rapid sand filtration systems that operated either by gravity or by pressure filters (Engle 1937:21). The buildings constructed to contain these systems were either utilitarian or elaborate structures, depending on the location of the building. Where water filtration plants were located near or within the main post area, these buildings often exhibited remarkable architectural detailing. When located near the water source, away from the main post, these buildings were utilitarian structures, lacking architectural distinction.

The Army widely utilized chemical treatments during this time period. Chlorination was a widespread technique, used when water supplies required sterilization. Other chemicals used in water treatment included alum, sodium aluminate, lime, soda ash, caustic soda, activated carbon, copper sulfate, and ammonia. At each installation, the treatment depended on the chemical composition of the water source (Engle 1937:21).

The methods of water treatment at Army installations did not differ from municipal treatment plants. Water treatment was under the control of personnel trained in applying and controlling water treatment methods. The treated water supply was monitored and tested to maintain purity standards (Engle 1937:22).

World War II

During the Protective Mobilization phase and during World War II, the Army again constructed mobilization cantonments to train new recruits. The new cantonments required extensive construction of water supply systems to meet the demands of increased numbers of recruits. Expansion often required new sources of water, either located on an installation or outside of its boundaries. During wartime, speed and scarce materials were constant concerns. Therefore, the Army constructed utilitarian water supply buildings (Figure 46).

At Aberdeen Proving Ground, for example, ground wells no longer provided adequate water supplies. The Army acquired property near Deer Creek, approximately nine miles northwest of the installation, to expand its water supply. Water was pumped from Deer Creek to a water treatment facility four miles away. The Chapel Hill Water Treatment Plant comprises sedimentary basins, a filter building, and a clearwell. Water is then pumped five miles to Aberdeen Proving Ground.

At Edgewood Arsenal, water supplies were expanded through the construction of wells on the installation and the expansion of the off-post water supply. During World War II, the Army constructed a reinforced concrete dam that provided a large open reservoir. Water was then piped to a separate water treatment area, then pumped to the installation.

To store and distribute water supplies on installations, the Army relied on rivetted-steel, elevated water storage tanks. Often one tank served several temporary cantonments. Elevated water storage tanks served as effective storage structures and maintained sufficient water pressure. During this time period, the Army also expanded its numbers of concrete underground reservoirs.

Army Building Types

Water Treatment Plants

Water treatment plants typically are constructed of permanent materials, including brick and concrete. During World War I, the water filtration plant typically was a two-story, utilitarian building that often contained wooden filtration tanks. During the inter-war period and World War II, the water treatment plant was either two stories or composed of a two or three-story section and a long one-story section (Figure 47, *top*). The water treatment building generally contained circular steel tanks that held media for the filtration process. After filtering, water was stored in an enclosed concrete clearwell before final distribution. During the inter-war period, these buildings sometimes featured architectural detailing that complemented the main architectural design of the installations (Figure 47, *bottom*). During wartimes, these buildings often were utilitarian structures (Figure 48, *top*).

Reservoirs

The Army employed two types of reservoirs: open and enclosed. Open reservoirs often are lakes restrained by dams. Enclosed reservoirs can be underground or above-ground structures. Reservoirs constructed during World War I often were square or rectangular reinforced-concrete structures (Figure 47, *top*). In many cases, these reservoirs were above ground, with earthen berms. During World War II, concrete block was used to construct water reservoirs. During World War II, the Army also experimented with circular above-ground water tanks constructed of prestressed concrete or steel. These tanks rested directly on the ground.

Elevated Water Storage Tanks

Elevated water storage tanks generally were constructed of steel. The tank was constructed of rivetted steel plates and supported by a steel frame. The World War I-era tank has a cylindrical shape with a conical roof. The World War II tank has a wider diameter and lower roof profile (Figure 48, *bottom*). In general, water tanks constructed during World War II were larger than earlier water tanks. During World War II, concrete frames were constructed to support new water towers in an effort to conserve steel. During the inter-war period, water storage standpipes and tanks sometimes displayed elaborate architectural ornamentation. In two instances, notably Randolph AFB, Texas, and Barksdale AFB, Louisiana, the water towers were elaborate, architectural focal points on the installations (Figure 49, *top*).

Pump Houses/Stations

Pump houses or pumping stations were constructed to shelter pumping equipment located above water wells of used in distribution systems. Pump houses and stations generally are one-story structures constructed of permanent materials. Architectural detailing on pumping stations was determined by the location of the structure. During the inter-war era, if the structure was located in a cantonment area, the building often exhibited materials and design compatible with nearby construction (Figure 49, *bottom*). If located in an isolated part of the installation, the pumping station generally was of utilitarian design.

Dams

The Army constructed two types of dams: embankment and masonry dams. Embankment dams were built of earth or rock, usually of compacted or dumped fills. Large masonry dams generally were constructed of concrete and are either gravity supported, arch supported, or buttressed.

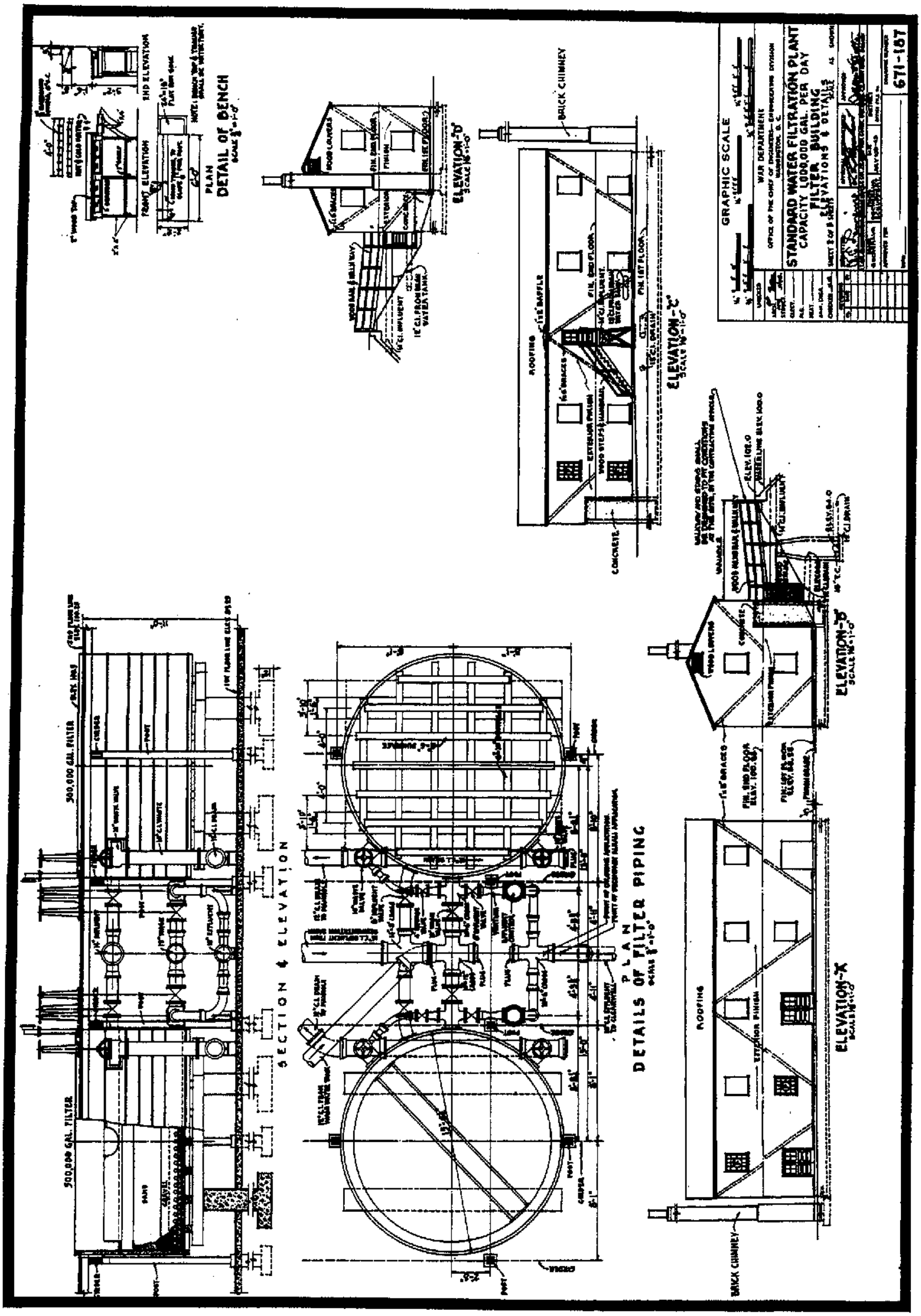


Figure 46. 1943 standard water filtration plant (History Office, U.S. Army Corps of Engineers, OQMG Plan 671-187, Box 115)

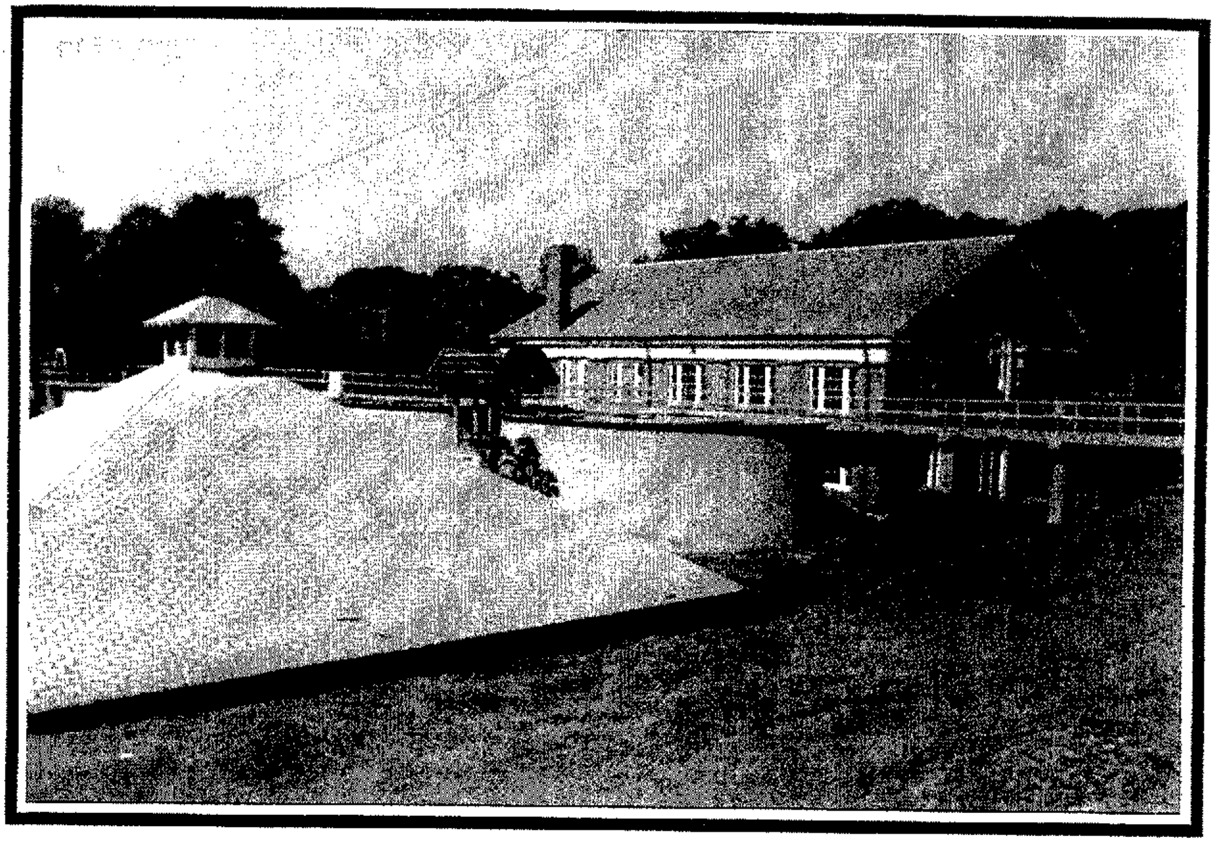
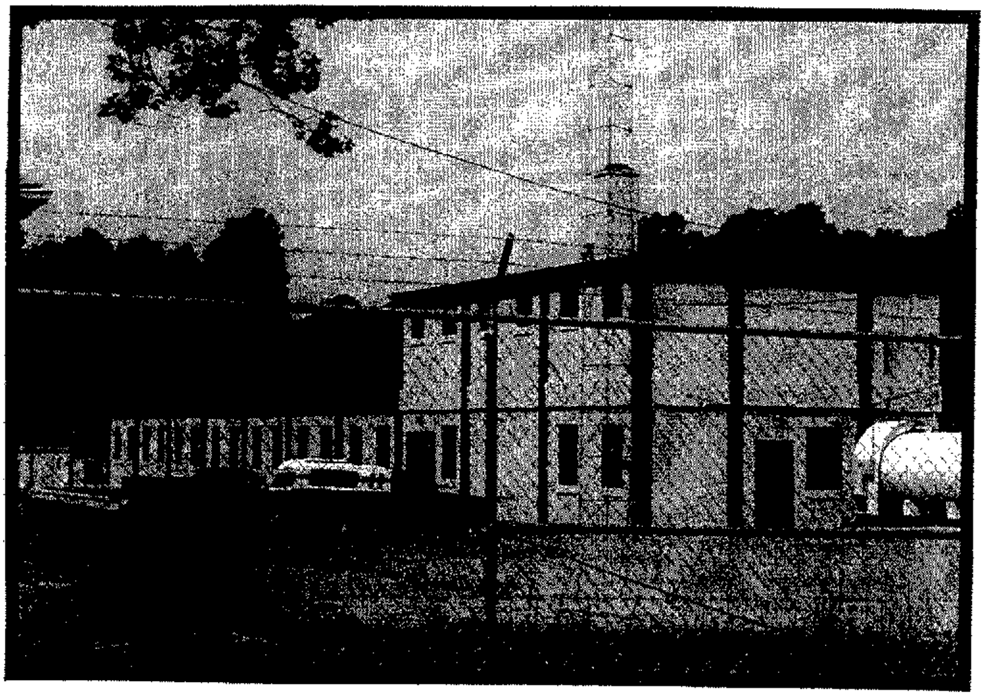


Figure 47. (*top*) 1918 covered reservoir (Building 252, Aberdeen Proving Ground, Maryland) and 1934 water treatment plant (Building 250, Aberdeen Proving Ground)
(*bottom*) 1938 water treatment plant (Building 1205, Fort Knox, Kentucky)



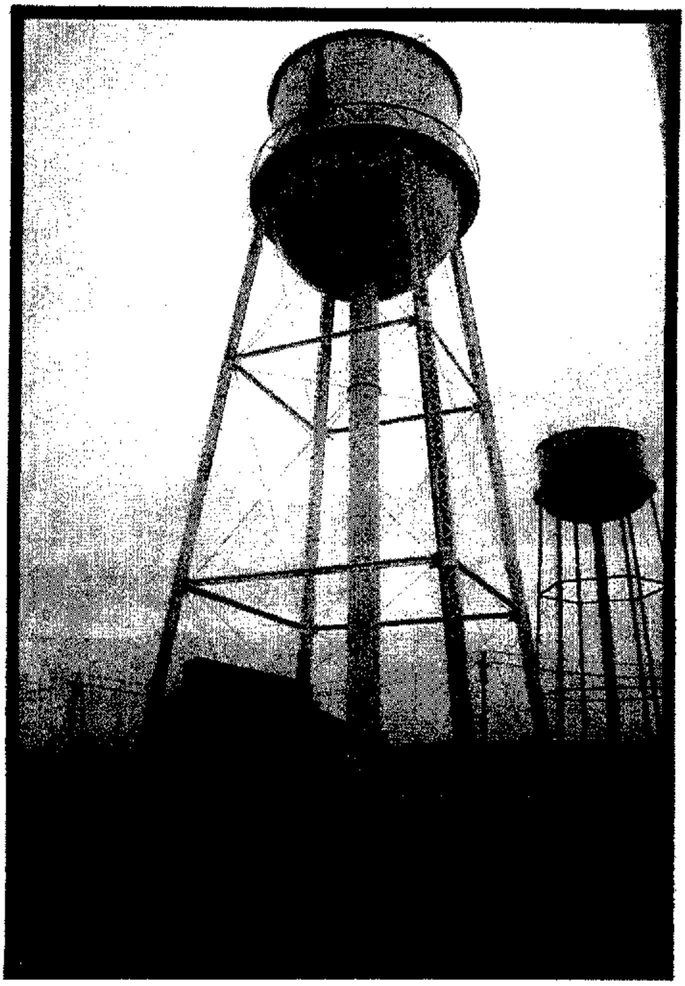
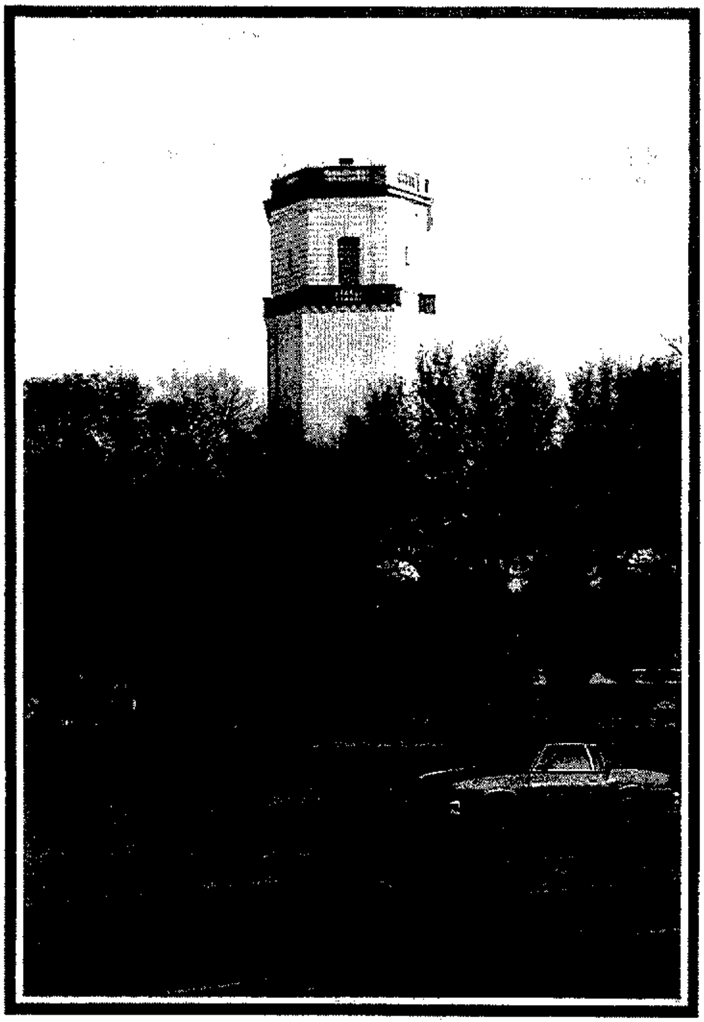


Figure 48. (*top*) 1943 water treatment plant (Building 3009, Fort Knox, Kentucky)
(*bottom*) 1918 and 1940s water towers at Edgewood Arsenal, Aberdeen Proving Ground, Maryland



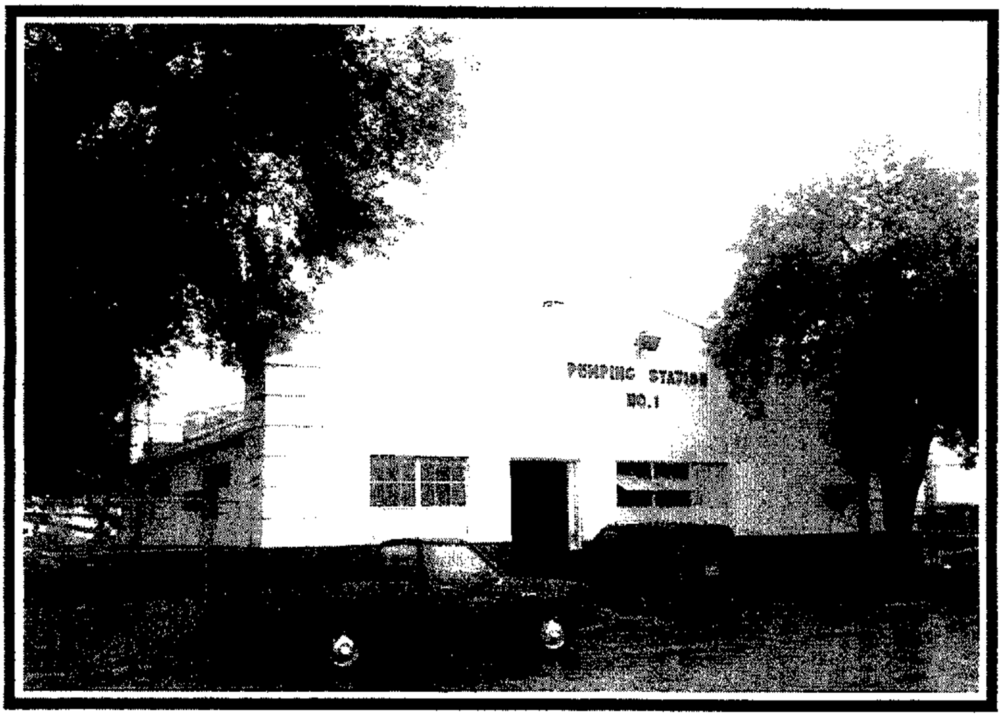


Figure 49. (*top*) 1934 water standpipe at Barksdale AFB, Louisiana
(*bottom*) 1942 water well with pump house (Building 314, Kelly AFB, Texas)

CHAPTER VIII

SEWAGE DISPOSAL SYSTEMS

Sewage disposal systems are designed to collect and treat water before returning the water to the environment. Sewage systems handle two types of water: storm water and waste water generated by industrial and domestic use. One system usually handles both types of water. Communities create two types of waste water: domestic and industrial. Domestic waste includes water and sewage from dwellings as well as waste from businesses and office buildings. Industrial waste water is produced during industrial operations.

Three levels of sewage treatment exist: primary, secondary, and tertiary. Primary treatment removes the heaviest solid materials from sewage through processes of screening and settling. Primary treatment removes approximately 30 per cent of organic wastes. Secondary treatment removes approximately 85 to 90 per cent of solids and oxygen-consuming wastes after primary treatment. Secondary treatment relies on biological activity and includes trickling filter and activated sludge processes. Tertiary treatment follows primary and secondary treatment and includes chemical treatment, microscopic screening, or radiation treatment. The evolution of sewage treatment reflects the growing awareness of water pollution levels and increased sophistication in applying various treatment techniques.

Technological Evolution

In early methods of sewage disposal, waste was deposited in pits, cesspools, privies, or latrines. These methods took advantage of the natural process that occurred as the sewage settled, waste water filtered through the ground, and bacteria removed or stabilized polluting matter. In nineteenth-century England, sewage was dumped onto agricultural property, known as sewage farms. This practice provided fertilizer for crops and filtered waste water.

The development of septic tank systems was based on these earlier practices. With this method, sewage enters an underground steel or concrete tank through pipes. The heavy particles settle to the bottom of the tank. The effluent water passes through a leaching field where bacteria break down the remaining organic material. Bacteria digest sludge left in the tank and convert it into a gas. Periodically, the sludge is pumped out of the tank. This system is acceptable for residences, rural areas, and isolated institutions.

A larger version of the septic tank process is the Imhoff tank developed by Karl Imhoff and introduced in the United States in 1907. The Imhoff tank is a vertical structure, comprising two chambers, which allows settling and digestion processes to occur separately. Sewage settles in the upper chamber and sludge drops to the bottom chamber where digestion occurs. The Imhoff tank became a popular method for primary sewage treatment and also was adapted in combination with secondary sewage treatment methods (McGraw-Hill 1992 9:31-32).

During the Industrial Revolution, cities experienced unprecedented population and industrial growth, as large numbers of people migrated to industrial centers. Growing urban populations overtaxed septic systems and sewage farms. To rid cities of sewage, it was dumped into nearby streams and rivers. While this removed sewage from the immediate area and allowed natural processes eventually to purify wastes, it also polluted water supply sources. The discovery of the link between untreated sewage and waste water to illness and epidemics provided an impetus to develop better sanitation systems.

Subsequent sewage treatment techniques simulated purification methods accomplished naturally by rivers and streams. It was observed that moderate amounts of organic wastes discharged into a watercourse underwent a natural purification process. Sewage and other wastes were diluted as they entered another body of water. As sewage travelled over a water course, it mixed with air, interacted with biological organisms, and filtered through rocks and sand. Sewage treatment plants often are described as compressed rivers, because the plant accomplishes in a few hours and in a small area what a river accomplishes in several days over the course of several miles.

To simulate natural purification processes, waste water flow was exposed to air and biological filtering systems were developed. Biological filtering was accomplished in large tanks filled with stones measuring from three to eight inches in diameter. The tanks were filled and the waste water settled in the spaces between the stones. After several hours, the tanks were drained, leaving much of the organic matter trapped in the bacterial growths on the stones.

Improvements to biological filters included trickling filter method of sewage treatment. In this method, waste water was allowed to settle, which removed the heaviest matter. Then rotating pumps poured waste water over large, shallow, stone-filled tanks. The waste water flowed through the crevices between the stones, and drained to the bottom of the tank. Pumps were operated on intermittent cycles to oxidate the bacterial growths. Typically, several tanks operated simultaneously. Each tank was rotated on a "fill and draw basis," and operated at separate stages in the process. Trickling filter sewage treatment systems became widespread by the mid-twentieth century.

Between 1912 and 1915, the British developed a more efficient method of sewage treatment, the activated sludge method. In this method, compressed air was released into a waste water tank to circulate sludge, thus the term "activated sludge." The circulation of sludge within the tank created greater biological activity than the trickling filter process. The combination of organisms carried in the circulated sludge, oxygen supplied in the compressed air, and food supplied by the settled waste water entering the aeration tanks, produced cleaner waters than the trickling filter process alone. The activated sludge process occurred in tanks or in oxidation ponds or lagoons.

Chemical precipitation methods also were developed to treat sewage. Initially, chemicals were introduced to reduce the amount of particles in the effluent so that the effluent could be treated on land. In modem sewage treatment, chemicals are used to control the quality sterilization of the final effluent. Widespread use of chemicals became prevalent after the mid-twentieth century.

Navy/Marine Corps Application of Sewage Treatment Technology

Between 1917 and 1946, the Navy's standard sewage disposal practice was to discharge sewage directly into the nearest body of water. This was the cheapest and simplest method since most Navy installations were located near water. In cases where sewage disposal was located near shellfish beds, ships' berths, residences, or bathing beaches, the Navy recommended some form of treatment and disinfection prior to discharge (U.S. Navy Department, Bureau of Yards and Docks 1938:M13).

During the early twentieth century, the Navy constructed underground sewer lines at most of its installations. However, no sewage treatment was provided and the sewers led directly to the nearest large body of water. The earliest identified sewage treatment system constructed by the Navy was located at Great Lakes Naval Training Station, Illinois. The Navy started construction on the new training station for 1,500 enlisted recruits in 1904. A one-story, brick sewage disposal plant was among the original buildings completed in 1911 (Hasbrouck Peterson Associates 1987:30).

The Navy monitored the development of municipal and Army sewage treatment plants. During World War I, the Navy constructed a sewage treatment plant at the Naval Training Camp in Gulfport, Mississippi. The camp had two main sewer lines, one serving the main portion of the camp and the other serving the hospital. The disposal plant utilized a septic system with a sludge chamber where sewage was treated chemically with a solution of chloride of lime. The effluent passed through a screen and was disinfected with calcium hypochlorite (Figure 50) (U.S. Navy Department, Bureau of Yards and Docks, 1921:84-85).

During World War I and the early 1920s, the Bureau of Yards and Docks collected drawings of standard sewage tanks designed by the Army's Construction Division (Drawing files, Reel 1263, Naval Construction Battalion Center, Port Hueneme, California). Reviews of articles on municipal sewage treatment appeared in publications of the Bureau of Yards and Docks during the 1930s (U.S. Navy Department, Bureau of Yards and Docks, *Bureau News Memorandum*).

In 1935, the Navy compiled a list of sewage disposal at 141 yards and stations. Sixty-three installations discharged sewage directly into nearby bodies of water. Thirty-four installations had septic tanks. Eighteen installations discharged sewage into municipal sewage systems, and eight used a combination of municipal sewers and direct discharge. Other methods included cesspools (12); settling basins (2); and, local open culverts (1). Only three installations treated sewage: Submarine Base, New London, Connecticut; Great Lakes Naval Training Station, Illinois; and, Sand Point Naval Air Station, Washington. The New London Submarine Base had an Imhoff tank. The plant at Great Lakes Naval Training Station, Illinois, (constructed 1911) had digestion and sedimentation tanks. The plant at Sand Point Naval Air Station, Washington (constructed 1928), had an Imhoff tank, sprinkler filter, sludge bed, and dosing tank (Drawings files, Reel 1263, Frames 512-523, Naval Construction Battalion Center, Port Hueneme, California; U.S. Navy Department, Bureau of Yards and Docks 1938:M19-M20).

As the Navy developed its shore establishment, improved sewage treatment became part of the standard infrastructure requirements. In 1938, the Bureau of Yards and Docks described the following sewage treatment methods as acceptable for naval installations: dilution; septic tanks and Imhoff tanks for primary treatment; and, subsurface irrigation beds, contact beds, and filter beds for secondary treatment following sedimentation in septic tanks or as primary treatment for small installations (U.S. Navy Department, Bureau of Yards and Docks 1938:M19-M20).

Construction at new installations and improvements at older installations during the late 1930s and early 1940s often included new sewage treatment plants. New plants were constructed at Great Lakes Naval Training Station, Illinois (1936); Marine Corps Base, Quantico, Virginia (1939); Alameda Naval Air Station, California (1939); Dahlgren Naval Proving Ground, Virginia (1941); and Moffett Naval Air Station, California (1943). The 1939 sewage treatment plant at Quantico included sludge digestion tanks, trickling filters, primary and secondary settling tanks, and a sludge drying bed (Figure 51) (NARA, Cartographic Branch RG 71, microfilm reels 574; Drawings No. 317951 and Reel 502, Naval Construction Battalion Center, Port Hueneme, California). In 1940, the Bureau of Yards and Docks issued a "Standard sewage disposal plant" plan that included an Imhoff tank and an aerating tank (Drawings No. 137,403 and 137,404, Naval Construction Battalion Center, Port Hueneme, California).

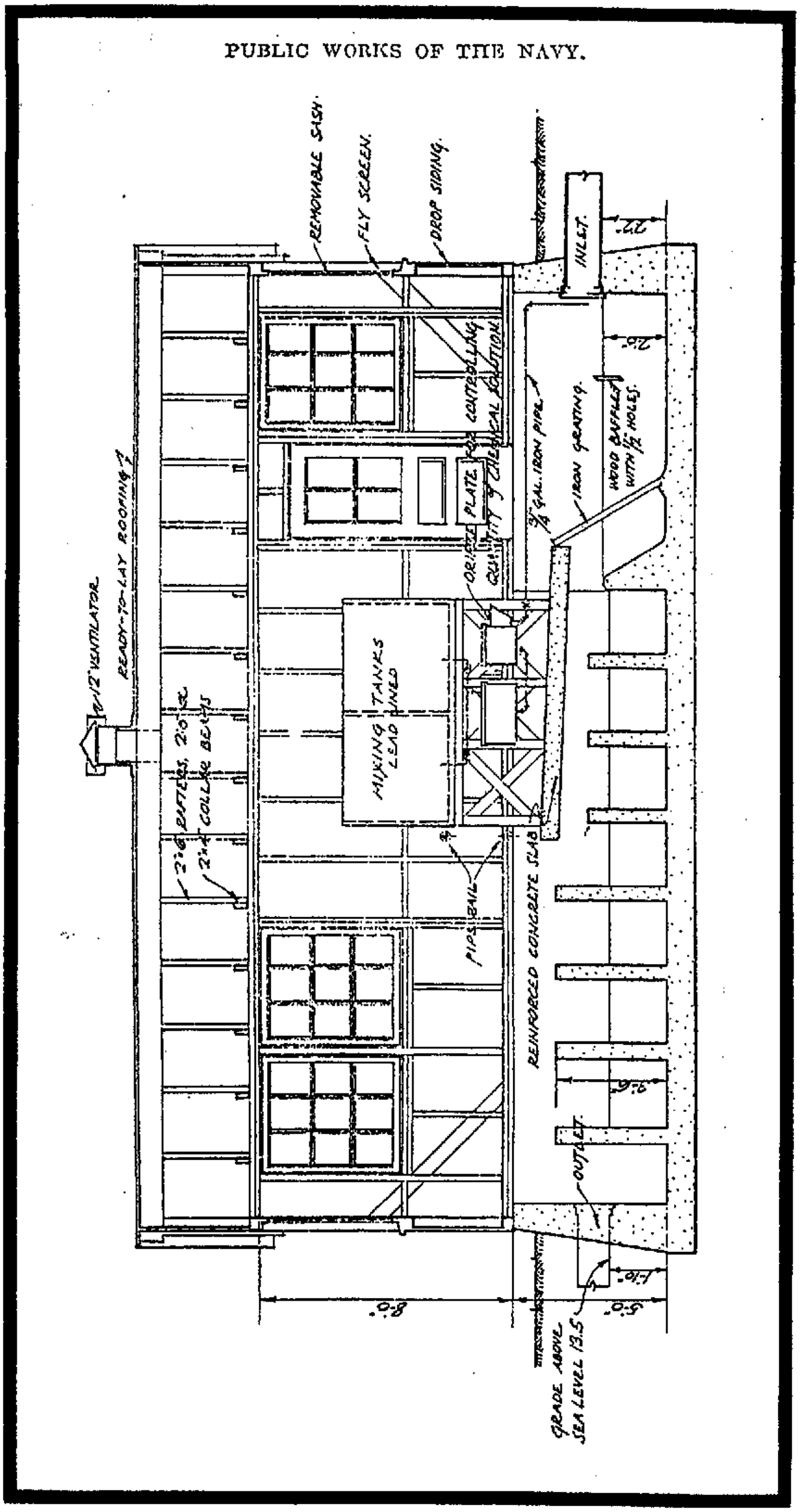


Figure 50. Sewage disposal plant at U.S. naval training camp, Gulfport, Mississippi (U.S. Navy, Bureau of Yards and Docks, *Public Works of the Navy Bulletin 31* 1920:86)

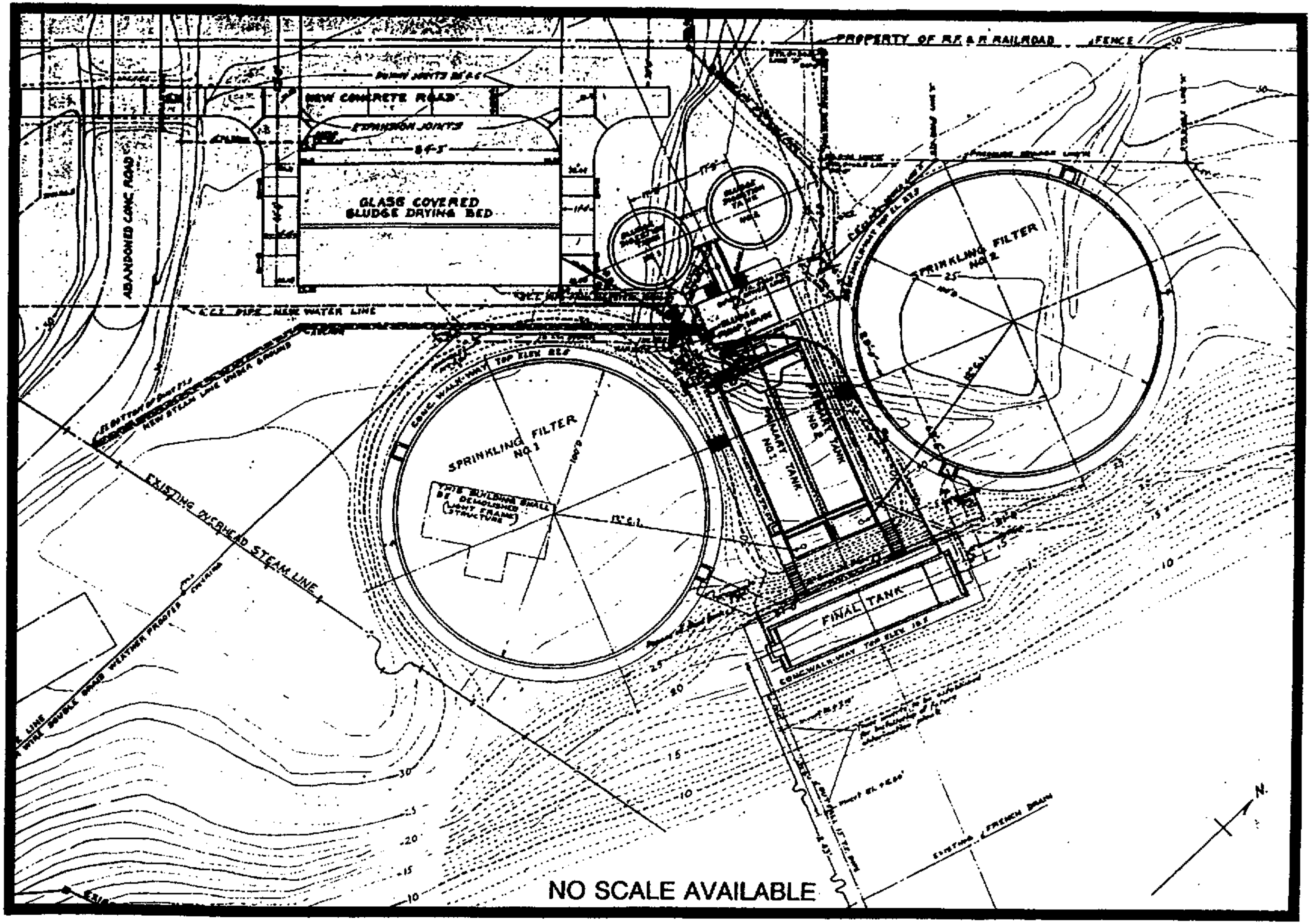


Figure 51. 1939 drawing of sewage disposal system, Marine Corps Development and Education Command, Quantico, Virginia (NARA, Cartographic Branch, RG 71, microfilm reel 574)

After the U.S. declaration of war, the Navy limited construction to conserve labor and materials. In 1942, the Bureau of Yards and Docks issued a policy allowing the construction only of primary sewage disposal plants unless exceptional circumstances warranted additional waste water treatment. In 1946, 25 naval installations were included in a study of military sewage treatment plants. The study found 6 activated sludge systems; 12 trickling filters; 2 primary treatment systems; 3 contact aeration system; 1 oxidation pond; and 1 sand filter (Committee on Sanitary Engineering 1946 811-813).

By 1946, the Navy prepared training documents for its Civil Engineering Officers that described sewage treatment. At the primary level of sewage treatment, the sewage was screened for large solids, and placed in sedimentation tanks. The most common tanks were septic tanks, Imhoff tanks, and mechanically cleaned sedimentation tanks with separate sludge digesters. Secondary treatment included biochemical aeration of effluent after removal of solids. Sand filtration and chlorination were considered tertiary treatment (U.S. Navy Department, Civil Engineer Corps, 1945, upgrade 1946:6).

Naval Building Types

Settling Tanks/Trickling Filters

Settling tanks and trickling filters generally are open structures constructed of concrete. Primary and secondary settling tanks generally are rectangular. These structures hold waste water to allow large particles to settle out of the water. Trickling filters are either rectangular with stationary piping or circular with rotating piping. Trickling filters are filled with media, generally stones, through which the waste water is filtered to oxidize bacterial growths (Figure 52, *top*).

Digesters

Digesters are masonry structures where sludge left from the filtering process is broken down by bacterial processes. The digesters are one-story, roofed structures that have a footprint of connected adjoining circles.

Control Houses

In general, sewage treatment plants also had control houses and small storage buildings located in the sewage disposal area to allow personnel to monitor the sewage treatment processes, to provide quality control, and to store chemicals used in treatment. These buildings generally were one-story buildings constructed of permanent materials with little ornamentation (Figure 52, *top*).

Pumping Stations

Pumping stations were constructed to pump sewage to and through the sewage treatment plant and to pump effluent to its final destination. Sewage pumping stations generally were either partially buried in the ground or one-story. These structures generally were constructed of permanent materials including brick, concrete, or concrete block. Generally utilitarian structures with no ornamentation, these buildings might exhibit some ornamentation if they were located near areas of high building density (Figure 52, *bottom*).

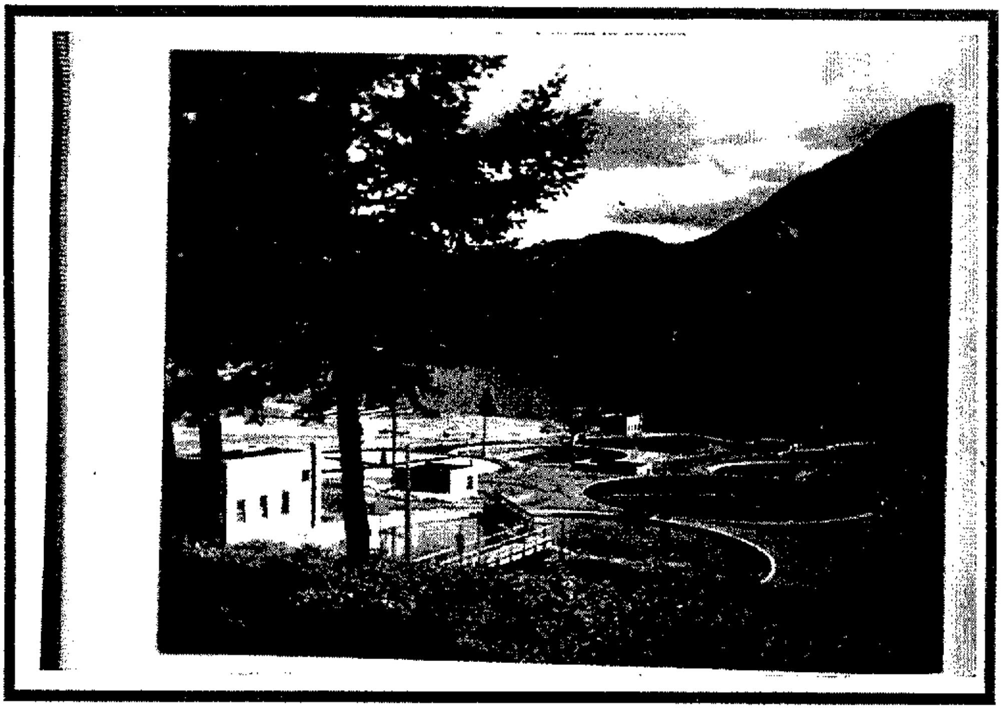


Figure 52. (*top*) Overview of trickling filter sewage treatment plant at Farragut, Idaho (Photo courtesy of U.S. Navy)
(*bottom*) 1940 sewage lift station (Building 645, Naval Complex Pensacola, Florida)

Army/Air Corps Application of Sewage Treatment Technology

During World War I, the Army constructed a total of 46 temporary training installations, including 16 Army cantonments, 16 National Guard camps, and 14 specialized training camps (Crowell 1919:546-547). During this massive mobilization program, the Army emphasized clean water supplies. In addition to clean water supplies, the Army began to organize sewage disposal systems to avoid polluting installation drinking water and to protect the health of the troops. The mobilization cantonments included construction of underground tile, cast iron, or concrete pipes. Where possible, the camp or cantonment sewage system was connected to nearby municipal sewage systems.

World War I sewage disposal utilized three methods: dilution, septic tank systems, and biological oxidation. Biological oxidation was the rarest method of sewage treatment; it was used at selected aviation fields. Dilution was the most common method when an installation was located near a running body of water and dilution did not pollute neighboring water supplies (Committee on Sanitary Engineering 1946:794). In this case, the camp or cantonment sewage system generally carried sewage to the nearest body of water. This was the case during construction of Aberdeen Proving Ground, Maryland, where the underground sewer lines emptied directly into the Chesapeake Bay and Swan Creek.

When sewage treatment facilities were installed during World War I, the Army constructed septic tank systems. In 1918, the Construction Division issued a drawing of a sewage disposal plant (Figure 53). In this plan, sewage first settled in a septic tank. The effluent then passed through a filter bed and was released through the outfall sewer into nearby water bodies. Sludge that accumulated in the septic tank was pumped to a sludge drying bed (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 115). Other septic tank systems included installation of Imhoff tanks.

The Army continued to install septic tank sewage disposal plants at its permanent installations during the inter-war period. The 1933 sewage disposal plant constructed at Fort Knox, Kentucky, included intake chamber, settling (septic) tanks, filter beds, and sludge beds (Suitland Federal Records Center, RG 77, Completion Reports, Fort Knox).

When the War Department began to plan for emergency mobilization in 1940, sewage treatment was one of the problems encountered in constructing mobilization training cantonments. An Engineering Board was appointed to prepare recommendations for sewage disposal plants. The constraints for selecting sewage treatment options included security to public health, sufficient treatment to prevent a serious nuisance, economy, and speed of design and construction (Committee on Sanitary Engineering 1946:800).

The Army policies established for sewage treatment practices depended on the size of the installation and the location and condition of the water bodies receiving the effluent. The lowest amount of partial treatment of sewage was sedimentation tanks and chlorination. For camps where higher levels of treatment were required, the Army used activated sludge process, trickling filters, or multi-stage high-capacity filters (Committee on Sanitary Engineering 1946:803) (Figure 54).

Army policy was to locate sewage treatment plants as far away as possible from residential and administrative areas, depending on the topography and the location of the discharge stream. The plants also were located in areas where they would not interfere with military operations, particularly artillery ranges (Committee on Sanitary Engineering 1946:804). At Aberdeen Proving Ground, Maryland, the sewage treatment plant is located just northeast of the administrative area, close to Swan Creek. The Army selected the site of the sewage disposal plant because of the location of the artillery ranges.

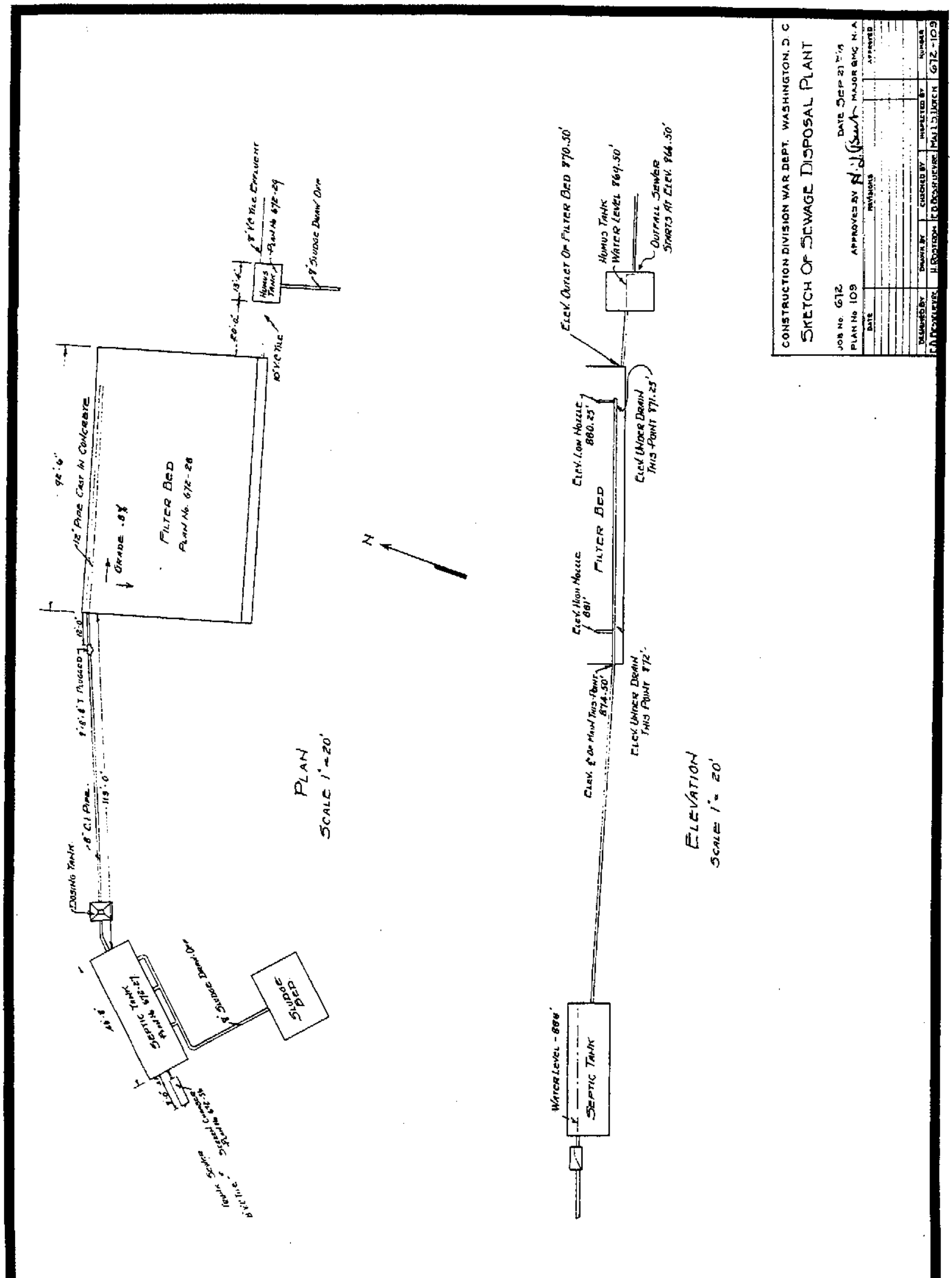


Figure 53. 1918 sewage layout (History Office, U.S. Army Corps of Engineers, OQMG Drawing 672-109, Box 115)

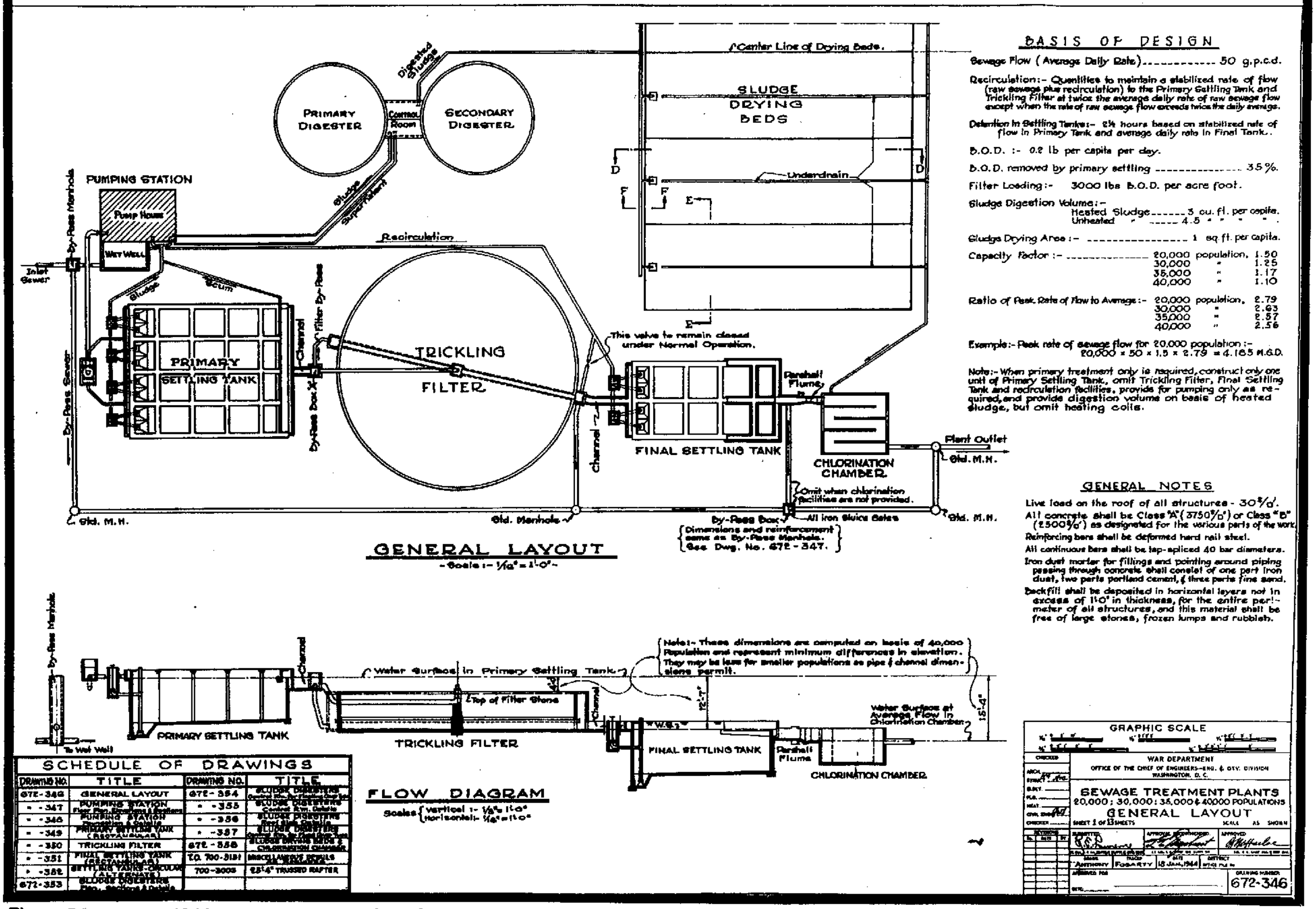


Figure 54. 1944 sewage treatment plants for 20,000, 30,000, 35,000, and 40,000 population (History Office, U.S. Army Corps of Engineers, OQMG Drawing 672-346, Box 115)

The number of sewage works constructed by the Army during World War II provided a rare opportunity to study sewage treatment operations and compare various processes. In 1945, the Committee on Sanitary Engineering performed a survey of Army and Navy sewage treatment practices. The study included 108 Army and Air Corps sewage treatment plants. The sewage treatment processes represented in the survey included: 10 activated sludge systems, 16 primary systems, 66 trickling filter systems, 2 trickling filter and activated sludge systems, 12 contact aeration systems, 1 oxidation pond, and 1 contact aeration and oxidation pond system (Committee on Sanitary Engineering 1946:811-813).

Army Building Types

Settling Tanks/Trickling Filters

Settling tanks and trickling filters generally are open structures constructed of concrete. Primary and secondary settling tanks generally are rectangular. These structures hold waste water to allow large particles to settle out of the water. Trickling filters are either rectangular with stationary piping or circular with rotating piping. Trickling filters are filled with media, generally stones, through which the waste water is filtered to oxidize bacterial growths (Figure 52, *top*).

Digesters

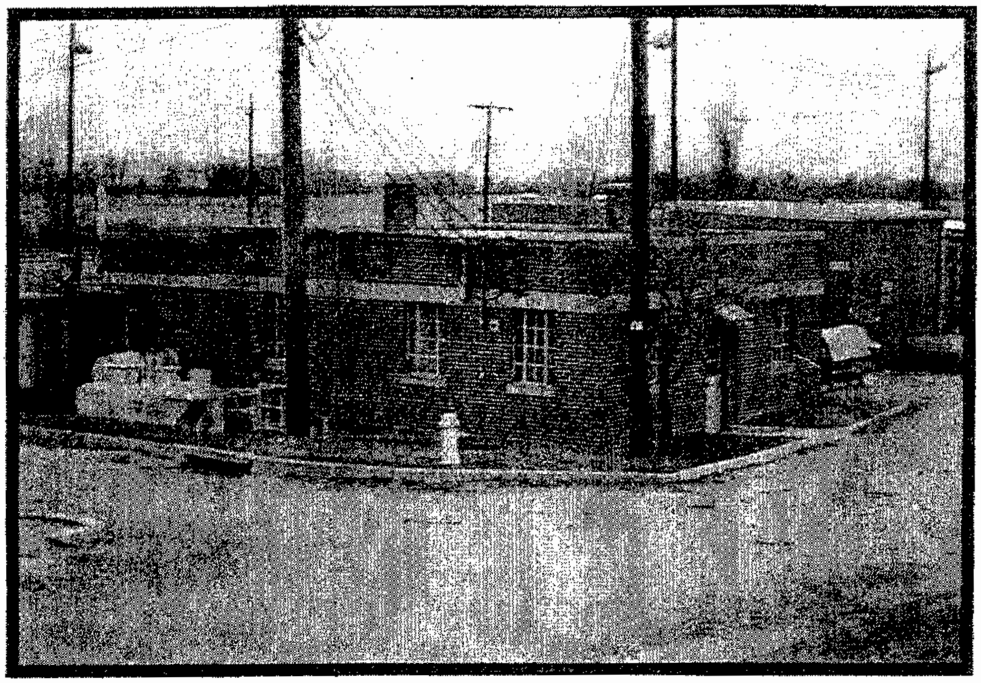
Digesters are masonry structures where sludge left from the filtering process is broken down by bacterial processes. The digesters are one-story, roofed structures that have a footprint of connected adjoining circles (Figure 55, *bottom*).

Control Houses

In general, sewage treatment plants also had control houses and small storage buildings located in the sewage disposal area to allow personnel to monitor the sewage treatment processes, to provide quality control, and to store chemicals used in treatment. These buildings generally were one-story buildings constructed of permanent materials with little ornamentation (Figure 55, *top*).

Pumping Stations

Pumping stations were constructed to pump sewage to and through the sewage treatment plant and to pump effluent to its final destination. Sewage pumping stations generally were either partially buried in the ground or one-story. These structures generally were constructed of permanent materials including brick, concrete, or concrete block (Figure 56). Generally utilitarian structures with no ornamentation, these buildings might exhibit some ornamentation if they were located near areas of high building density.



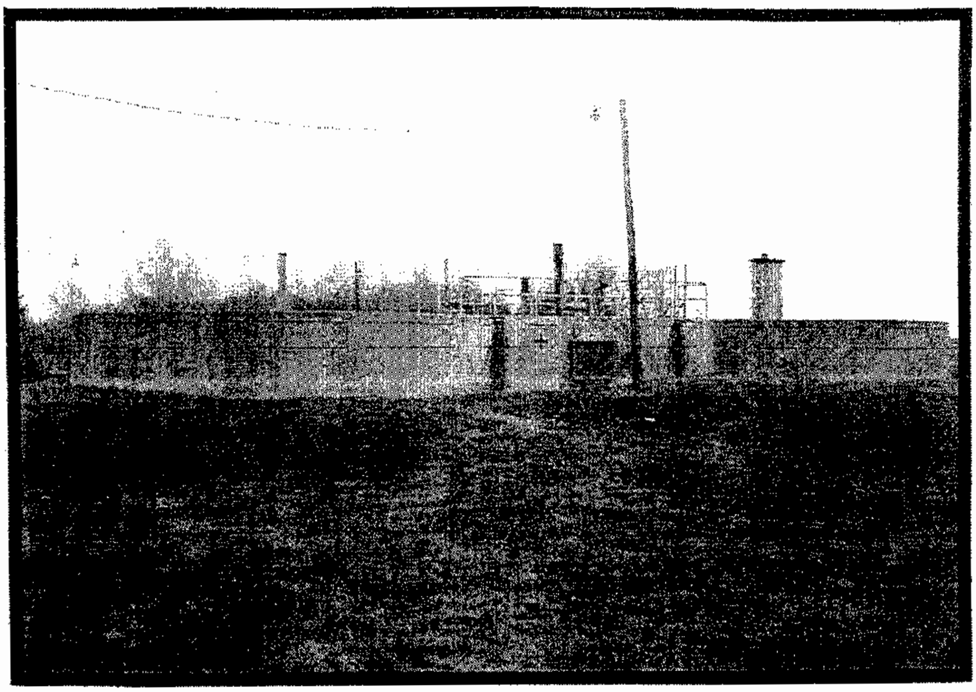


Figure 55. (*top*) 1941 sewage treatment plant control house (Building 398, Aberdeen Proving Ground, Maryland)
(*bottom*) 1945 digesters at sewage Treatment Plant (Building 399, Aberdeen Proving Ground)

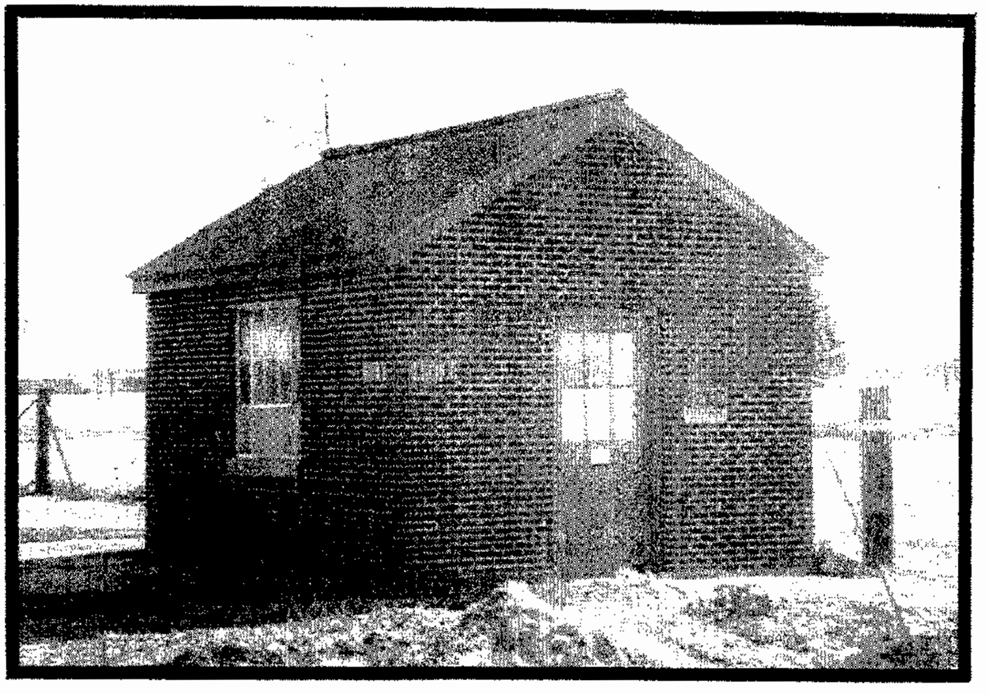


Figure 56. 1941 sewage pump station (Building E5296, Aberdeen Proving Ground Maryland)

CHAPTER IX

POWER AND HEATING SYSTEMS

Power and heating plants and their associated distribution systems on military installations provided power, heat, and electricity. Power plants provided power for industrial production, while heating plants provided heat to residential and office buildings. Power plants, whether coal or oil fueled, operated in the same way: water was converted into steam that, in turn, was used to heat buildings or to power generators that converted steam into mechanical power or electrical power. Power and heating technology developed during the last half of the nineteenth century and is related directly to industrial development.

The military adopted power and heating technology by the end of the nineteenth century. The Navy constructed large central power plants to support manufacturing activities at shipyards; central power plants provided electricity, steam heating, and compressed air. The Army built power plants primarily to heat cantonments composed of barracks, residences, and administrative buildings. In general, the Army did not produce its own electrical power, but purchased it from local utility companies.

The distinctions between central power plants and heating plants have changed over time. The term "central power plant" originally indicated that the building included electrical generating equipment. However, by World War II central power plants constructed during the inter-war period no longer included primary electrical generation equipment. By this time, most naval installations purchased electric power from local utilities. Currently, the Army, Air Force, Navy, and Marine Corps purchase the bulk of electric power from local utility companies. Many original power plants, where in service, currently are categorized as heating plants although they may possess auxiliary or stand-by generators.

Technological Evolution

Electric Power

During the last quarter of the nineteenth century, steam engines were developed to generate mechanical power to operate a variety of machinery and equipment. Steam engines became popular in mills and factories following the Civil War. Dynamos, the first practical cost-efficient electric generators, were produced in Europe during the 1870s. Inventors used dynamos to explore commercial uses for electricity; one of the early uses was for lighting. During the mid 1870s, Charles Brush developed an electric arc lighting system to replace outdoor gas lighting. Brush installed his first arc lighting system in San Francisco in 1879, where he built a central electric station that powered 22 electric arc lamps (Marcus and Segal 1989:143-144).

During the late 1870s, the first commercially successful incandescent light bulb was developed and marketed. In 1882, the Edison Electric Illuminating Company constructed a central power plant in New York City that served as the heart of an electrification system. The system included underground conduits and insulated wiring. The central power station used steam engines to power generators. Innovations in this power plant included water-tube boilers, direct-current Jumbo generators, mechanical coal and ash handling devices, direct-connected prime movers, parallel operation, forced draft, and ventilated windings (Webster 1930:359; Orrok 1930:324).

The earliest power plants generated direct current (DC). In 1888, George Westinghouse began to experiment with alternating current (AC) motors. Alternating current could be transmitted longer distances with less cost than DC. By 1892, Westinghouse adapted an AC motor for power generation and transmission machinery. Early electric customers chose between alternating and direct current. By 1900, electrical substations contained equipment to transfer AC to DC and vice versa (Marcus and Segal 1989:156).

While improvements were being made in the installation and commercialization of electric power, efforts also were undertaken to improve electrical generation equipment. During the late nineteenth century, electrical generators were powered by two principal types of engines: reciprocating steam engines and turbine steam engines. Between 1893 and 1903, the most popular engine was the reciprocating steam engine. After about 1905, the use of steam turbine engines became more widespread, although both types of engines existed until about World War I (Orrok 1930:324-325).

After generators were improved, efforts were undertaken to increase boiler efficiency. Boilers heated water to provide steam to power the equipment that generated electricity. Boilers increased in size and water capacity. Fuel efficiency in combustion and water evaporation also were improved (Orrok 1930:325). The 1890s central power plants generally contained one or more horizontal tubular boilers that were enclosed by brick walls. The most popular boiler manufacturers were Heine, Babcock & Wilcock, Campbell & Zell and Atman Taylor (Boomhower 1944a:74).

Coal was the principal energy source for power plants during the late nineteenth and early twentieth centuries. Coal-fired boilers required space below the firing floor to accommodate ash hoppers, wind boxes, sifting hoppers, ash removal equipment, and portions of the coal conveying machinery. Automatic stokers appeared before 1900 and were in general use by 1910. The chain-grate and the overfeed types of fuel conveyers appeared first, but were replaced by the underfeed system by 1910 (Orrok 1930:325). Pulverized coal was introduced as a fuel for steam turbines during the 1920s. Gasoline and diesel fuels were introduced in 1895, particularly for small engines (*Mechanical Engineering* 1930:584). Oil became a competing fuel in steam plants following World War I (Hubbard 1923:143).

Another challenge of electrification was transmission of electric current. Transmission of electric current over wire lines began in the United States during the 1890s. In 1891, a 10 kilovolt line operated. By 1896, an 11 kilovolt, three-phase line transmitted electrical energy generated in Niagara Falls to Buffalo, New York. Transmission lines increased their voltage to successively higher levels. In 1936, the highest kilovolt transmission lines began operation in the United States between the Hoover Dam and Los Angeles, California (McGraw-Hill 1992 V.6:43).

District Heating

With the rise of electric power generation came the question of what to do with the exhaust steam from the engines used to drive electric generators. The disposal of the exhaust steam led to the birth of district heating. District heating systems distributed heat, usually in the form of steam or hot water, from a central source. Early district heating systems utilized thermal energy generated from electric power generation.

The first successful district heating system was established by Birdsill Holly, a hydraulic engineer from Lockport, New York, in 1877. Holly installed a boiler in the basement of his house and heated the dwelling by steam pipes extending from the boiler. Once the system was established, Holly successfully extended it to the residence of a neighbor almost 500 feet away. This experiment also was successful and Holly organized the Holly Steam Combination Company in Lockport, New York (Broders 1981:13).

The news of Holly's success spread quickly throughout the Northeast; and, by 1890, district heating systems were installed in numerous small cities and towns in New York. By the beginning of the twentieth century, many cities in the northeastern United States, especially industrial communities, installed district heating systems. Other northern and midwestern cities soon built district heating systems.

Philadelphia established that city's first district heating system in 1887. During this period, many of the city's electric utility companies merged with the four district heating concerns that were recently established in the city. Most electric companies were located within central business and industrial areas. The companies marketed steam generated by electricity production as a heat source and sold steam to electric customers (Broders 1981:13-15).

By the end of the nineteenth century, power and heating utilities operated joint utility companies. The process of utilizing the exhaust steam from steam engines used to drive electrical generators was called cogeneration. Both electricity and thermal energy were produced simultaneously from a single power source. Electrical generators continued to be the principal energy source for district heating well into the twentieth century. In addition to power companies, many industrial and commercial power customers also operated individual steam-driven electric generators; the excess steam was used as heat (Broders 1981:13-18).

During the 1920s, advancements made in the technology of electricity production reduced the efficiency of cogeneration systems. Changes in furnaces designed to generate electricity eliminated the exhaust steam utilized for district heating. At the same time, electric current transmission over high-tension lines improved dramatically. This improvement permitted the construction of large electric power plants removed from population centers. During the 1920s, district heating was effective only within a 15 mile radius of the steam source. The distance between modern electric power plants and population centers prohibited the distribution of thermal energy through district heating networks. These advances in technology implemented in new plants reduced the cost of electricity production and distribution. As a consequence, smaller, less modern neighborhood electrical-generating plants, which also provided steam for district heating, were forced to restructure their services (Broders 1981:13-18).

Some of the smaller, urban power companies competing with the more modern power companies left the electrical generating business and became distributors of thermal energy in district heating systems. These companies raised the price of steam, making the business profitable. The first commercial plants devoted solely to thermal energy production for use in district heating networks appeared during the late 1920s. In 1927, the Willow Steam Plant in Philadelphia was opened. The plant operated with three boilers and provided steam for district heating only; it did not generate electricity (Broders 1981:16).

During the 1920s, small cogeneration district heating and electric power generation plants powered by steam turbines were established. Like earlier cogeneration facilities, these plants utilized the exhaust steam created by the small power plants for district heating purposes. Steam turbines were small in size, and unsuited for major urban use. Steam turbine cogeneration facilities efficiently served small, contained communities, such as office complexes, factories, college campuses, and military installations where exhaust steam heated adjacent buildings.

Numerous small district heating networks flourished during the 1920s and 1930s. District heating remained popular until the wide availability of oil and natural gas. With these plentiful and cheap fuel sources, consumers turned to individual building heating systems (Broders 1981:13-18).

Navy/Marine Corps Power and Heating Systems

During the late nineteenth and early twentieth centuries, the Navy installed power-generating equipment at its naval yards. The construction of power-generating plants at Navy yards accompanied the development of the modern Navy at the end of the nineteenth century. In 1883, the Navy began construction of three "protected" steel cruisers. The transition from wooden to steel ships required greater industrial capacity at navy yards. In 1898, the Navy initiated a nationwide construction program to improve and to expand its shore facilities. The program included the addition of new shipbuilding, maintenance, storage, and industrial facilities at existing naval yards and stations, as well as the creation of new installations.

Initially, shop buildings were outfitted with individual power plants for operating shop machinery. In 1904, in an effort to consolidate the management of power generation, the Navy assigned the Bureau of Yards and Docks with the responsibility to administer Navy power plants and distribution systems (U.S. Navy Department, Bureau of Yards and Docks 1921:18). The Naval Act of 27 April 1904 was enacted to promote economies of scale, to avoid repetitive power services, and to standardize the design and equipment for all naval power plants.

Between 1904 and 1914, the Navy invested heavily in the construction of central power plants at naval shipyards and training stations. Central power plants and distribution systems typically provided electrical power, steam heat, compressed air (high and low pressure), hydraulic power, and gas (illuminating, hydrogen and acetylene) to the entire installation. The size of the power plant depended on the needs of the installation. For example, the 1907 central power plant at the Charleston Navy Yard contained two 625-kilovolt-ampere turbo-alternators and four 350-horsepower boilers (Figure 57). The Navy generally used AC steam turbine generators. Only a few naval power plants generated DC power: Portsmouth Navy Yard, Maine; Washington Navy Yard, Washington, D.C.; and, Newport Torpedo Station, Rhode Island (U.S. Navy Department, Bureau of Yards and Docks 1921:255-277). At the Washington Navy Yard, the power plant contained vertical and horizontal steam engines.

Fuel used in the power plants reflected regional markets. Coal was the preferred fuel in the East and Midwest. Oil-fired plants were constructed at Mare Island and Puget Sound Navy Yards. Both coal and oil required specialized storage. Coal generally was transported by rail, ship, or barge and was stored in open piles or under covered shelters. Oil was stored in underground and above-ground tanks.

Central power plants constructed by the Navy before 1914 typically were grand industrial buildings with classically-inspired designs sited in prominent locations. They symbolized the Navy's growing industrial strength and were built in permanent materials to harmonize with the architectural character of the installation. At Great Lakes Naval Training Station, Illinois, noted architect Jarvis Hunt designed the exterior of the power plant, as well as the other station buildings. Naval engineers designed the interior machinery and plan (Hasbrouck and Peterson Associates 1987:118). The central power and heating plant included electrical generating equipment, water pumping equipment, refrigerating plant, and machine shop, all operated by a single boiler plant (U.S. Navy Department, Bureau of Yards and Docks, *Bulletin 5*, 1913:17-35).

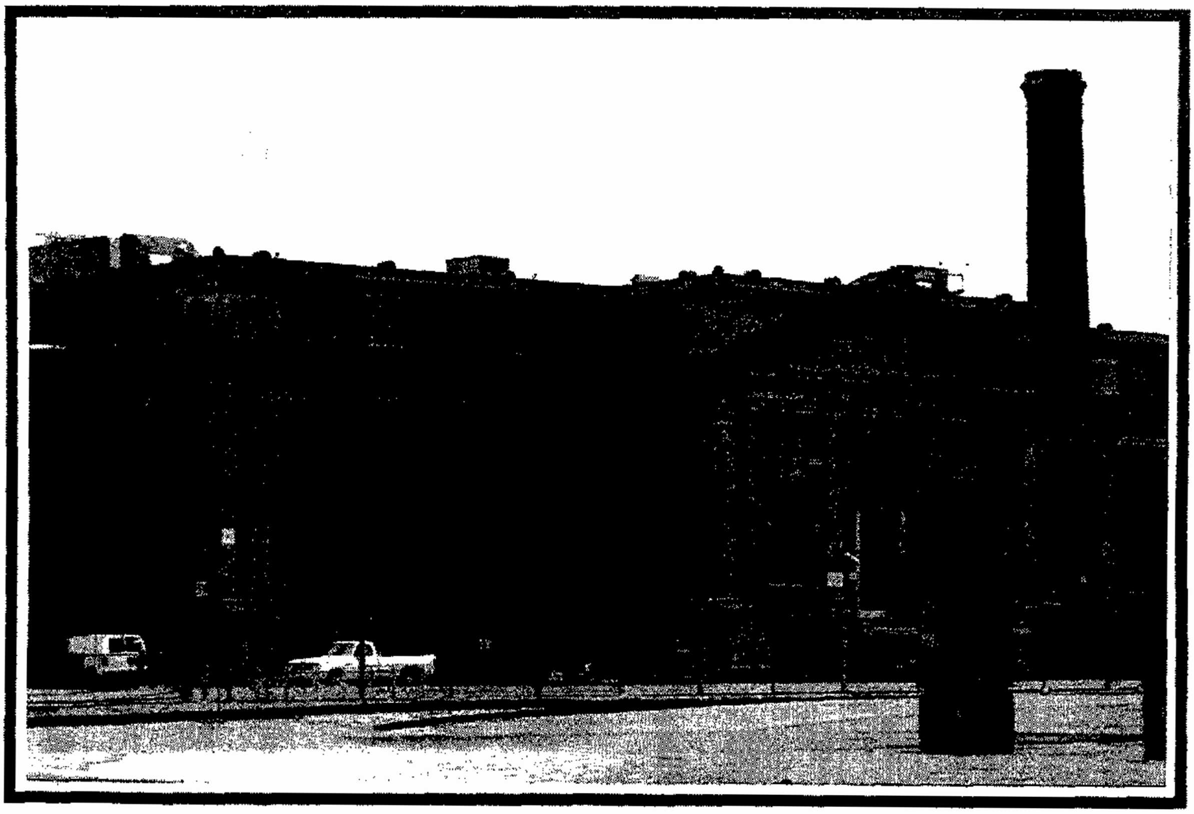


Figure 57. 1907 central power house (Building 32, Naval Base Charleston, South Carolina)

World War I

After the beginning of World War I in 1914 in Europe, the Navy realized that naval shore facilities would require expansion if the United States entered the conflict. The power-plant section of the Bureau of Yards and Docks was charged with the design and construction of new plants, extending existing plants, and upgrading existing machinery. Mr. L. W. Bates, a civilian, led the power-plant section of the Bureau of Yards and Dock; other staff included three aids, five clerical assistants, and sixty draftsmen. During the war years, private engineering firms and consultants augmented the Navy's small staff of electrical and mechanical draftsmen. The Bureau of Yards and Docks awarded approximately 140 public works contracts to upgrade power plants, equipment, and other components between April 6, 1917 and November 11, 1918 (U.S. Navy Department, Bureau of Yards and Docks 1921:255).

The two largest and most important power plants constructed by the Bureau of Yards and Docks during World War I were the central plants at the Norfolk and Philadelphia Navy Yards, which were identical in design (Figure 58). The two plants were equipped with the most modern equipment and contained high-efficiency power generating systems. The Bureau of Yards and Docks shipbuilding and yard development section designed the buildings while the power plant section prepared the plans and specifications for the machinery. Machinery included 11,250 kilovolt-ampere turbo-generators, reciprocating air compressors, and turbo-compressors. The boiler equipment consisted of twelve 600-horsepower water-tube boilers equipped with superheaters, mechanical stokers, forced and induced draft apparatus, soot blowers, balanced draft regulators, draft gauges, and automatic flue gas analyzers and meters. Two rows of boilers lined a firing aisle. The equipment was capable of operating at 300 per cent of rating, providing a maximum capacity of 21,600 horsepower. The buildings were designed to accommodate additional boilers. Coal was delivered to the plants on railroad cars; the coal was transferred from the cars to outside ground storage, then to the power plant bunkers. To remove ash from the plants, the buildings were designed to allow standard-gauge railroad cars to enter the building and receive loads from the stoker ash pits. The Norfolk and Philadelphia power houses were designed without interior columns; side-wall columns supported the elevated bunkers and roof. Although this design increased the cost of construction, it provided unobstructed interior spaces for the boilers. Window spans were considerably greater than normal industrial design to provide natural light to the interior (U.S. Navy Department, Bureau of Yards and Docks 1921:255-259).

The power plant machinery at most other Navy yards was upgraded without building expansions. At Charleston Navy Yard, South Carolina, more powerful turbo-generators and air compressor equipment were installed during World War I. In some instances, shipyards augmented their power supply by purchasing power from local public utilities. Electric power was transferred through transmission lines and regulated through a yard substation. At the Naval Aircraft Factory at the Philadelphia Navy Yard, the shipyard power plant could not accommodate the increased demands for power. The Navy constructed a separate boiler plant to provide heat and energy for the factory. Until the new boiler plant was completed, the factory purchased electricity from the local public utility, and a brick substation was constructed to regulate the flow of electricity to the installation. At the New York Navy Yard, a substation was constructed that converted DC from the public utility to AC for the yard (U.S. Navy Department, Bureau of Yards and Docks 1921:270-277).

The Navy also secured power supplies at mine filling plants and ordnance depots to meet the power needs of the small scale industrial activities at these installations. At Yorktown Mine Depot, Virginia, the Navy initially powered the depot by electricity purchased from the local utility and transported through transmission lines. Permanent plans for the installation included a small, one-story power plant that was completed immediately after the war (U.S. Navy Department, Bureau of Yards and Docks 1921:289).

Power sources varied at other naval stations and shore installations. Where possible, the Navy purchased electric power from local utilities for training, air, and Marine Corps stations. These stations were not involved in manufacturing or repair work and demand was limited to building services and personnel activities.

The Navy constructed central heating plants at three training stations (Cloyne Field at Newport Training Center, Rhode Island; Pelham Park, New York; and Hampton Roads, Virginia). Before the permanent heating plant at Hampton Roads was completed, the Navy proposed adding electrical generating capabilities. However, funding prevented these improvements (U.S. Navy Department, Bureau of Yards and Docks 1921:263-264; 402). Small district heating systems were constructed for discrete groups of buildings such as barracks and hospitals. Two boiler houses were constructed at the Marine Corps Base, Quantico, Virginia, for the hospital and barracks during World War I (NARA, Cartographic Branch, RG 71, microfilm reel 575). Central heating plants also were constructed at mine and ordnance depots.

Coal remained the primary fuel source for most naval power and heating plants. However, at the navy yards at Mare Island, California, and Puget Sound, Washington, the power plants utilized fuel oil instead of coal. The only other oil-fueled central power plants were located at the naval training camp at Newport, Rhode Island, and at New Orleans. The Newport power plant used oil fuel so that enlisted personnel could be trained using oil-burning equipment before being assigned to ships (U.S. Navy Department, Bureau of Yards and Docks 1921:273, 263).

Inter-war Period

The Navy's need for power and heating plants declined dramatically following World War I. During this period, naval shipyards relied on the power plants constructed and improved during the war. At new installations, the Navy constructed cogeneration plants that produced electricity as well as heat. Cogeneration plants were constructed at Naval Proving Grounds, Dahlgren, Virginia, and Alameda Naval Air Station, California.

Technological improvements in the transmission of electric current greatly reduced the need for each naval installation to install its own electrical generating power house. These improvements encouraged the Navy to purchase electricity from local utility companies. The Navy installed overhead and underground transmission lines. At the installation, electricity was distributed through substations, switching stations, and transformers. The equipment housed in these buildings regulated electrical flow and voltage between the source and the consumer.

Substations connected generators, controlled voltage levels, or connected alternate sources of power. Switching stations provided connections for various levels of voltage. Transformers were used to increase alternating current to high voltages for long-distance power transmission to minimize drops in voltage and to convert voltage for consumer use. Industrial establishments required high and medium voltages, whereas light industry and residential use required medium and low voltages. Transformers generated varying amounts of heat; oil, air, or pyranol were commonly used to cool enclosed transformers to avoid circuit failure.

Improved transmission lines assisted with the construction of Hawthorne Naval Ammunition Depot, Nevada, begun in 1929. Hawthorne was a vast, inland ammunition depot in an isolated location. Electricity was provided from a 54-mile, 3-wire, high-tension line that crossed a mountain range and was routed to a substation of the local utility (U.S. Navy Department, Bureau of Yards and Docks 1947:340). A boiler plant was constructed to supply heat at the installation (NARA, Cartographic Branch, RG 71, microfilm reel 1089).

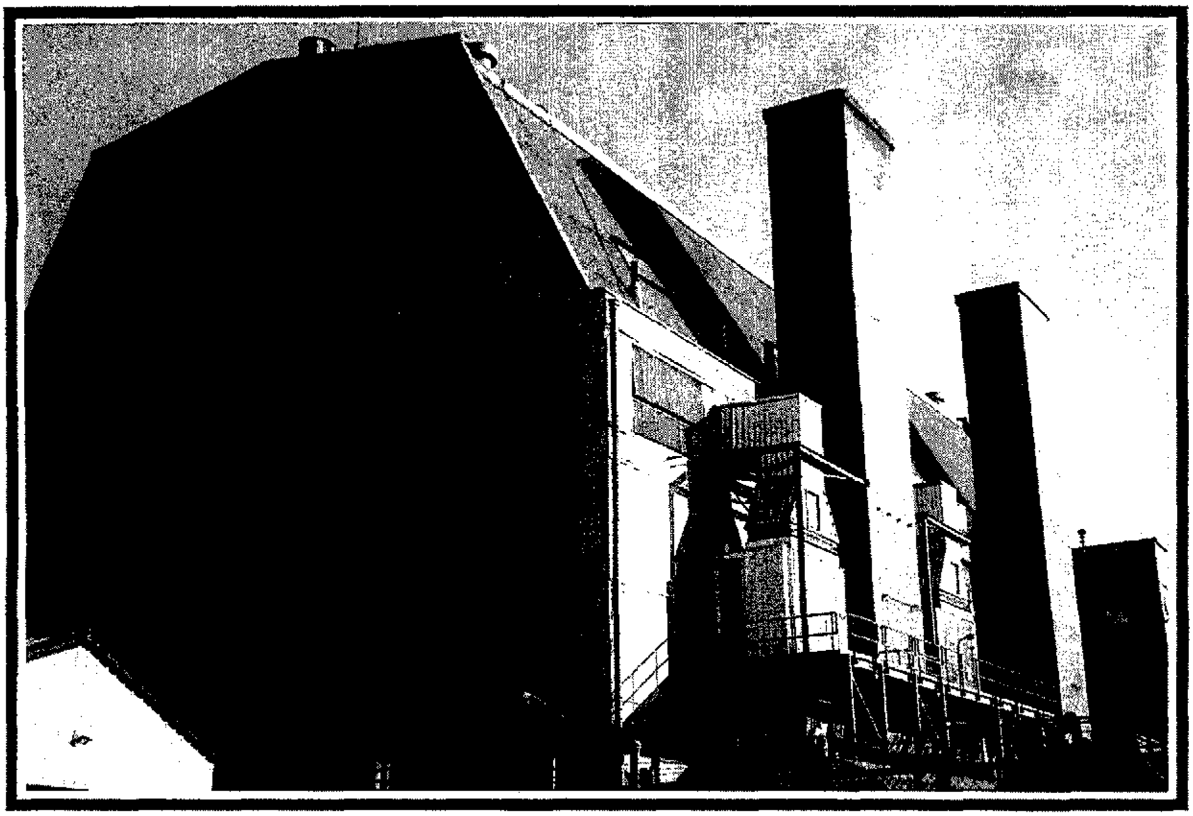


Figure 58. 1919 power plant (Building 23, Philadelphia Naval Base, Pennsylvania)

To heat buildings, the Navy either constructed central boiler plants for groups of buildings or installed boilers in individual buildings. At Moffett Naval Air Station, California, the Navy constructed a central steam heating plant (Building 10) that served ten buildings; the plant was located in the central administrative area. In addition, individual barracks and quarters contained gas-fired boilers.

During the inter-war period, the basic technology of steam plants remained essentially the same as during World War I. Technological improvements focused on increased efficiency in fuel-handling, fuel consumption, boiler pressures, and power or steam heat distribution. While coal was the dominant fuel source before and during World War I, a critical coal shortage during the war shifted attention to the potential for oil. During the 1920s, oil began to compete successfully with coal as a fuel. Each type of fuel had its own challenges in use and storage.

Coal was bulky to load, unload, store, and transport. Transporting coal required a system of belt conveyors, scrappers, or overhead grab buckets. Reserves of coal were stored in outdoor pile and spontaneous combustion was a hazard to stockpiled coal reserves. As a result, coal was piled in thin layers and each layer was packed firmly with a steam roller to prevent air circulation to the interior of the coal pile and thus reduce the hazard of spontaneous combustion. In addition, coal burning produced ash and discharged soot, creating disposal and pollution problems (Boomhower 1944b:71).

In contrast, oil was pumped directly to the combustion chamber of the furnace from large storage tanks. Oil-fired furnaces were smaller in size then their coal-fired counterparts, though the boiler systems were identical. While oil-fired power plants were comparatively more expensive to operate due to the higher price of oil, they did not have the storage and disposal problems associated with coal-fired plants (Boomhower 1944b:71).

World War II

During the late 1930s, the Navy undertook its first significant expansion since World War I and began to modernize its shore installations. As part of these improvements, the Navy reassessed its policies on electric power. In December 1939, the Navy proposed that each naval installation maintain two sources of power to provide a backup electrical system in case of power failure. The new policy recommended that Navy yards and industrial stations with on-site primary electrical generating capabilities establish connections to local utility companies through transmission lines and transformers. The policy also recommended equipping naval stations that purchased electric power from private companies with stand-by generators (U.S. Navy Department, *Bureau News Memorandum #214*, 1939:B174-B175).

The 1939 policy was implemented during World War II. Navy yards upgraded their power generation equipment to accommodate increased industrial activity. In some cases, new power plants were constructed to provide power to the main shipyard and nearby annexes; in other cases, new boilers and turbines were installed in existing power plants. At the New York Navy Yard, an entire new building and plant was constructed for $8 million. At Charleston Navy Yard, new boilers were installed in the central power plant and three existing turbo-generators were upgraded (U.S. Navy Department, Bureau of Yards and Docks 1947a V.II:191-192).

The primary power source at most non-industrial stations, including air stations, training stations, operating bases, storage depots, radio station, and Marine Corps bases, was electricity purchased from local utilities. By the end of World War II, local electric companies were the primary power source even at installations where central power houses were constructed during the inter-war period. Navy generators provided a backup electric power system. This pattern was followed at the Naval Air Station, Alameda, California; Naval Air Station, Corpus Christi, Texas; Naval Station Norfolk, Virginia; Marine Corps Base, Quantico, Virginia; Hawthorne Naval Ammunition Depot, Nevada; Naval Proving Grounds, Dahlgren, Virginia; and, Yorktown Mine Depot, Virginia (U.S. Navy Department, Bureau of Yards and Docks, *Data Book* 1947b:V.II).

During World War II, substations, transformers, and switching stations proliferated. The Bureau of Yards and Docks made increasing use of self-contained unit substations. The unit substation used three-phase power transformers and vertical lift metal-clad switchgear for high voltage circuits; it was a self-contained unit clad in a metal box. The unit substation had several advantages. It was manufactured and assembled at the factory, and thus simply required site installation. It was portable and had no exposed parts, so that the unit substation was suited to indoor or outdoor locations. If the unit was cooled by a non-inflammable cooling medium, it could be installed indoors without a special vault. The adoption of the unit substation eliminated the need for substation buildings. The unit could be installed outdoors on a concrete pad or in an existing building (U.S. Navy Department, *Bureau News Memorandum #223*, 1940:F1430-F1432).

The Navy continued to heat its installations through a combination of central heating plants and building boilers. New naval stations often included several central heating plants and numerous individual building boilers. Small heating plants were used to heat specialized functions such as hospitals, laundries, and small groups of buildings, such as a Marine Corps barracks complex located at a Navy yard.

Naval Building Types

Central Power and Heating Plants

Before 1914, the Navy constructed large central power plants at industrial yards. These buildings typically were monumental industrial buildings situated in prominent locations. Generally constructed of masonry, the power plants were designed to harmonize with the prevailing architectural style of the installation. Some designs are attributable to noted architects. At Great Lakes Naval Training Station, Illinois, noted architect Jarvis Hunt designed the exterior of the power plant, while naval engineers designed the interior machinery and layout (Hasbrouck and Peterson Associates 1987:118).

During World War I, few new central power and heating plants were constructed. Instead, the Navy chose to upgrade equipment in their plants. The two exceptions were massive utilitarian industrial structures constructed of steel and concrete completed at Norfolk and Philadelphia Navy Yards.

During the inter-war period, the Navy constructed power and heating plants at newly established installations. The type and size of the buildings depended on the size and energy requirements of an installation. Central power and heating plants generally were two-stories and constructed of similar permanent materials as other buildings on an installation. They often had tall industrial sash windows for lighting and classically-inspired architectural ornamentation. In general, the central heating plant buildings occupied prominent locations on the installations. Where an installation had different activities located over a wide geographical area, each area might have a separate heating plant. At some depots, the central power or heating plants were one-story buildings (Figure 59).

During World War II, central power and heating plants were constructed of permanent materials. The buildings were functional with little architectural ornamentation. The number of window openings was reduced to a minimum, creating large expanses of blank wall space (Figure 60).

In general, the Navy continually upgraded equipment in the power houses and heating plants to meet current energy and heating requirements. The general pattern established during World War I was to replace and upgrade equipment in an existing central power house or heating plant rather than build a new one. In fact, equipment may have been replaced two or three times.

Substations/Distribution Transformers/Switching Stations

Substations, distribution transformers, and switching stations housed equipment to regulate the flow and voltage of electricity to various sections of an installation. In general, these one-story buildings were constructed of permanent materials, typically brick or concrete. These buildings usually included a single door and few windows (Figure 61). Currently, many of these buildings are being replaced by self-contained transformer units located on concrete pads.

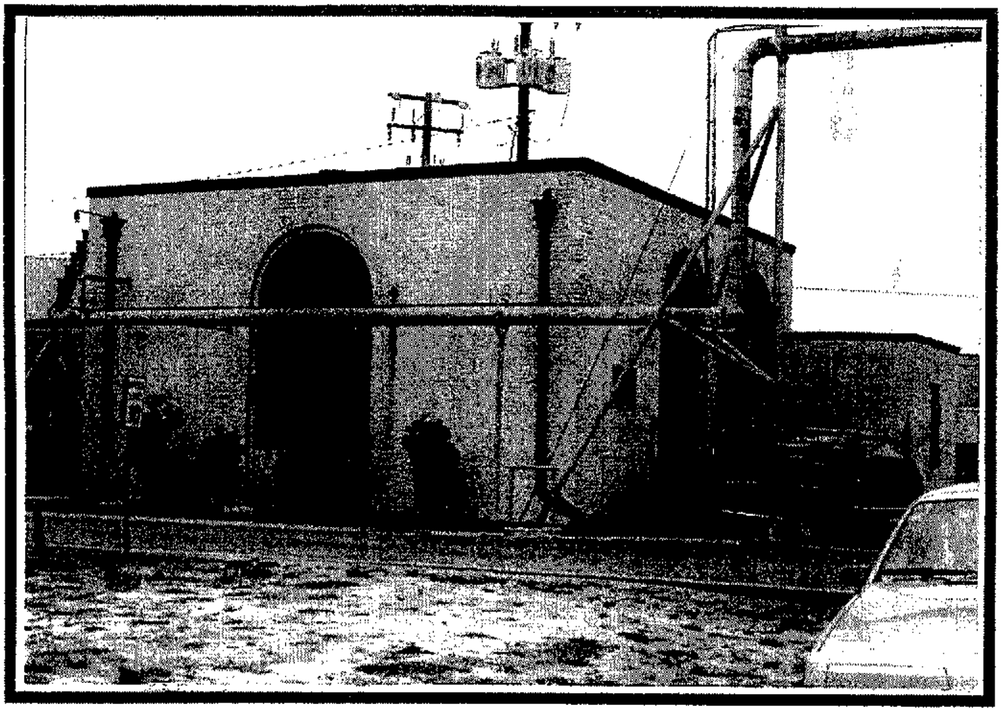


Figure 59. (*top*) 1919 central power house (Building 90, St. Juliens Creek Naval Annex, Virginia)
(*bottom*) 1929 power house (Building 2012, Marine Corps Development and Education Command, Quantico, Virginia)

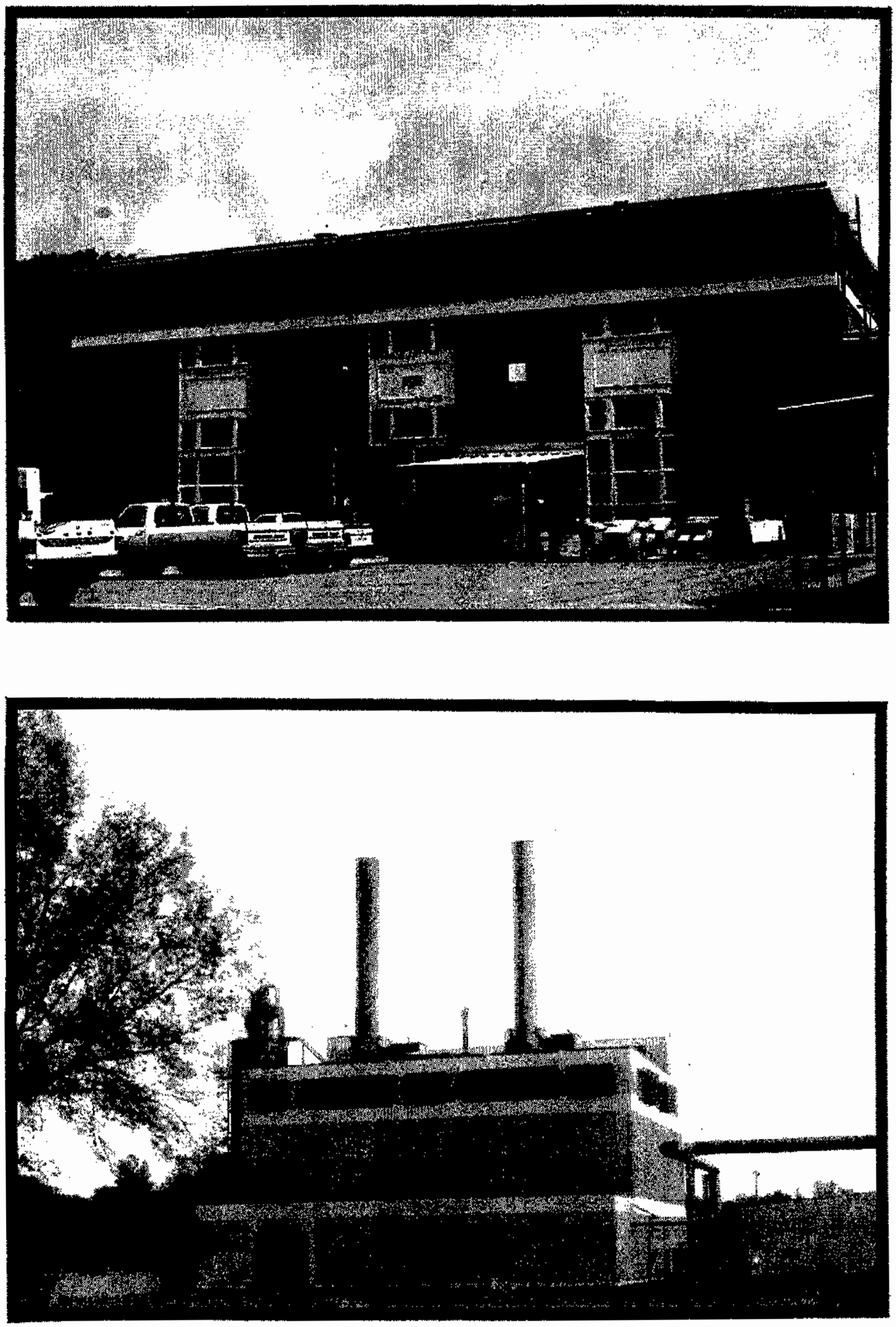
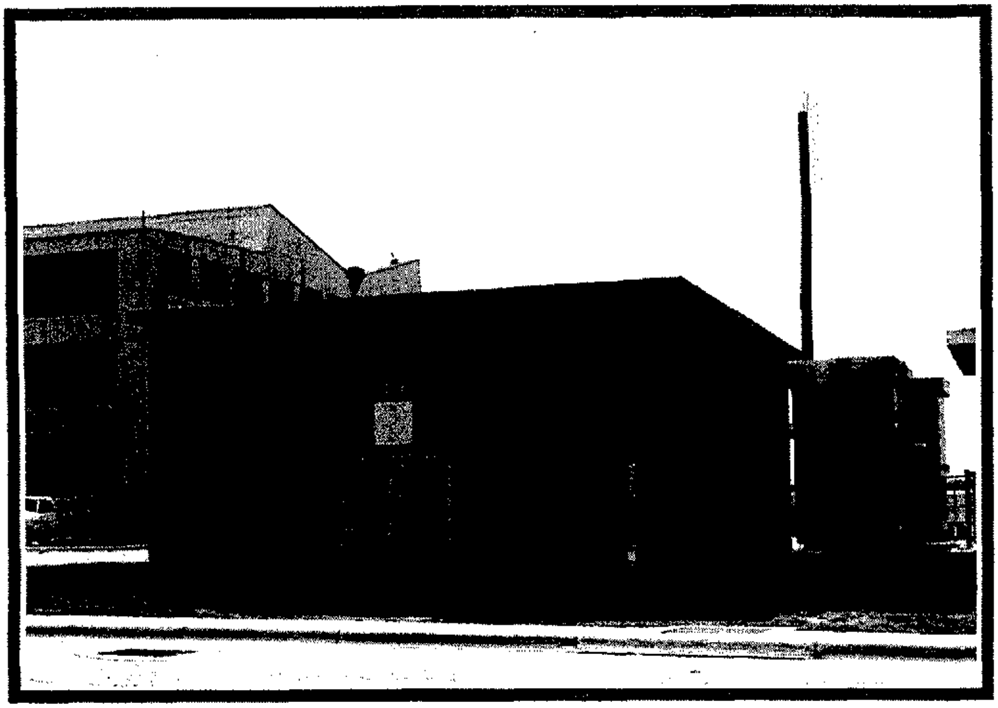


Figure 60. (*top*) 1942 heating plant (Building 458, Naval Complex Pensacola, Florida)
(*bottom*) 1943 steam heating plant (Building SP85, Naval Base Norfolk, Virginia)



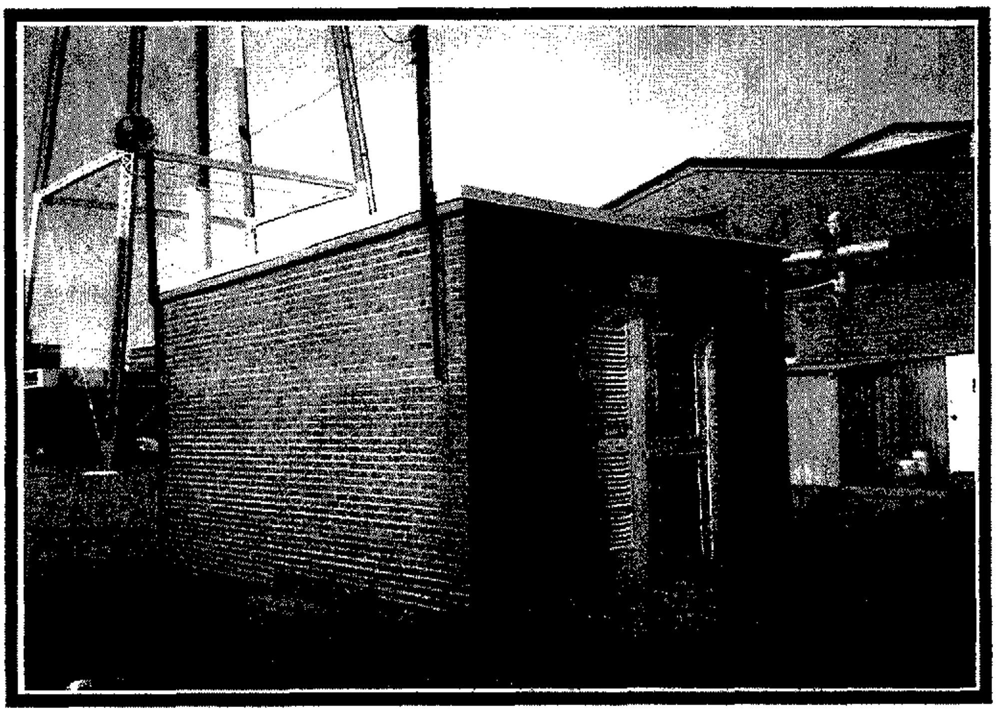


Figure 61. (*top*) 1921 substation (Building 317, Substation #3, Naval Complex Pensacola, Florida)
(*bottom*) 1942 distribution transformer building (Building P63, Naval Base Norfolk, Virginia)

Army/Army Air Corps Power and Heating Systems

In general, the Army maintained heating and electrical generation as two separate systems and did not adopt the civilian technology combining electrical generation and steam heating. Steam heating plants are more common on Army and Air Corps installations than electrical generation facilities.

During the late nineteenth century, the Army consolidated its troops on larger installations. The Army constructed permanent buildings and made conscious efforts to improve living standards on posts. During the 1880s and 1890s, the Quartermaster Department experimented with steam heating systems. The Army built both central steam heating plants for entire installations and separate building boilers. By 1892, a quarter of the Army's barracks were heated by steam or hot air. During the same period, the Army experimented with electric lighting; electricity was introduced into barracks in 1891 (Clary 1983:34).

By 1904, Quartermaster personnel were expected to have a thorough knowledge of hot air, steam, and hot water heating systems for both building boilers and for central heating plants. While five paragraphs of instructions explained the Quartermaster responsibilities concerning heating systems, only one paragraph of instructions was devoted to electricity. At installations with electricity, Quartermaster personnel were expected to be knowledgeable about the care of generators, transformers, rheostats, ammeters, and wattmeters (U.S. War Department, Quartermaster Department 1904:16-17). The Quartermaster Department does not appear to have issued standard plans for boiler houses and power plants before 1918; the indices of Quartermaster standard plans do not include boiler houses or power plants (NARA, Cartographic Branch, RG 77, Index to standard plans).

Before World War I, the Army only required a steady source of power for its manufacturing arsenals. For example, at Watervliet Arsenal, New York, the main gun shop included a boiler that produced the power for the shop. At Rock Island Arsenal, Illinois, a hydroelectric plant on the installation produced power for the arsenal (Building Technology Inc., *Watervliet,* 1984:77-78; Building Technology Inc., *Rock Island,* 1985:45-50,58).

World War I

During World War I, the Army established standard practices for supplying heat and electricity at its installations. Manufacturing installations were the only facilities where the Army built power plants. At most installations, the Army typically purchased electricity from local utilities.

At Edgewood Arsenal, Maryland, a World War I chemical weapons manufacturing facility, the Army generated electricity as an integral service of the installation. The central power plant at Edgewood Arsenal, completed in 1918, provided electricity, steam heat, and compressed air for the central industrial area. The plant's electricity also was used to light the hospital and permanent barracks. The plant's original equipment included eight coal-fired water tube boilers, and two electric generators and air compressors. To supplement the installation's internal power production, Edgewood Arsenal was connected to the local power utility through a high tension transmission line (U.S. War Department, Construction Division 1919a:28).

The majority of Army installations during this period were training camps, where protected power supplies were not as critical to the mission as at a manufacturing facility. The Army purchased electricity from local utility companies for its training cantonments and distributed the electricity by above-ground transmission lines. For example, at Aberdeen Proving Ground, Maryland, the main electricity source was the local utility company; emergency power generating equipment was part of the central steam heating plant.

The Army used stoves to heat barracks and other buildings at its temporary training cantonments (Rowan 1927:22). At permanent installations, the Army constructed central and district heating plants. At Aberdeen Proving Ground, the central heating plant provided steam heat to 62 buildings in the administrative and testing areas. At Edgewood Arsenal, separate district heating plants were constructed to heat permanent barracks and the hospital. In many cases, post hospitals were heated by separate heating plants.

Small oil- or coal-fueled power plants were constructed to provide electricity for specific tasks. Drawings indicate that the Army constructed small power houses to provide electricity for laundries and hospitals (History Office, U.S, Army Corps of Engineers, Quartermaster drawings, Box 108).

Inter-war Period

During its nationwide construction program begun during the late 1920s, the Army continued its earlier practices. The Army continued to rely on commercial utilities for electricity at most posts. Improvements to high-power transmission lines expanded the Army's ability to purchase electricity from local electrical utility companies (Rowan 1927:22). Overhead and underground transmission lines distributed electricity within the installation. Substations and transformers adjusted the electric current.

The Army employed three methods of supplying heat to its permanent installations: building boilers, central heating plants, or district heating plants. Individual building boilers was the most prevalent method of supplying heat. This method proved most efficient on installations where buildings were scattered over large tracts.

At installations where buildings were located in compact plans, the Army typically constructed central or district heating plants. Central heating plants were large buildings that provide heat for an entire installation. At permanent Air Corps installations, buildings often were clustered to maximize space for the flying field; thus, the Army often constructed central heating plants at Air Corps installations. In these cases, due to its location in the main cantonment, the heating plant often exhibited architectural detailing compatible with the architectural character of the surrounding buildings.

District heating plants were used for distinct complexes within an installation. The district heating plant also was suited to building complexes removed from the main development area. For example, post hospitals or residential areas often included district heating plants. At Fort Knox, Kentucky, when the officer housing area was expanded in 1938 through the addition of 10 field officers' quarters and 61 company officers' quarters, the Army proposed the construction of a coal-fired district heating plant (Suitland Federal Records Center, RG 77, Completion Reports, Fort Knox). District heating plants often supplied heat for small adjunct air fields. Educational complexes, such as the Ordnance School located at Aberdeen Proving Ground, also were heated through a district heating plant. District heating plants often exhibited architectural design that complemented the major buildings in the complex.

World War II

During the massive mobilization for World War II, the Army relied on standard plans for most of its wartime construction to conserve materials and time. The Army standardized its electrical systems to a greater degree than previously. The primary factors in selecting an electrical system for an installation were site conditions and application. These factors determined the amount of electricity required and the general layout of the electrical distribution systems.

Most Army installations were located close to large electric utility production stations and private utility companies provided a transmission line to a government-built high-voltage substation. From the substation, electricity was distributed throughout the installation.

The most common type of substation used during World War II comprised electrical equipment mounted on a concrete platform. Small buildings containing monitoring equipment often were constructed near the concrete pad. Most substations were constructed of metal, but during the last years of the war the Army sometimes built wood superstructures over substation equipment. Metal-clad switches and rubber insulators protected the hardware of the high voltage substations from the weather. Smaller metal transformers located throughout the installation further refined the electrical voltage for use in individual buildings (Tugby 1944:78-79; *Power Plant Engineer* 1942:68-73).

Electrical power was distributed throughout an installation via overhead wire systems. During World War II, the Army preferred overhead wire systems to underground systems due to their flexibility, economy, and adaptability. Overhead wires could be repaired easily and constructed quickly. The overhead system also offered the advantage of easier material salvage after the war (Tugby 1944:78-79).

At installations where distances made overhead wire systems uneconomical or where a dependable power source was required, the Army installed electrical generating equipment. Stand-by electric generators often were constructed at Army ordnance plants, air fields, and other installations where interruption of power would hamper operations. Auxiliary electrical generating equipment was either coal- or oil-fueled. During World War II, oil began to replace coal as the primary fuel, particularly at inland ordnance plants.

Heating plants also were constructed at new installations. District heating remained a common method for heating groups of buildings located closely together. Heating plants often were constructed to support the central administration area of ammunition plants. Otherwise, individual boilers were used to heat buildings.

During World War II, power and central heating plants were designed to meet wartime defense measures. The early threats of air attack led to the use of "blackout" designs. In place of windows, architects substituted recessed brick panels in the curtain walls that could be converted to regular window bays after the war. Power plants were difficult to conceal because of their size and prominent smoke stacks. Shorter smoke stacks were constructed during the war to eliminate hazards to aircraft and to manipulate the image of the building as camouflage protection against air raids. Induced draft fans made shorter smoke stacks possible (Kahn 1944:96). At the start of the mobilization, the Army constructed boiler plants in masonry, but later in the war wood-frame construction was adopted to preserve scarce building materials.

Army Building Types

Central Power and Heating Plants

Central power and heating plants generally are large masonry structures often with tall masonry or metal chimney stacks. The buildings typically appear from the exterior as multi-story buildings. The interior space is undivided to accommodate large boilers; a mezzanine provides access to the upper levels of the boilers. The earliest power and central heating plants were coal fired and included coal hoppers for coal storage. During World War II, the increased use of oil eliminated the need for coal hoppers. Central power and heating plants often are located centrally on an installation (Figure 62).

Common modifications to central power and heating plants included the removal of smoke stacks following the conversion to oil. Equipment may also have been modified. Equipment in central power and heating plants constructed before World War II usually were upgraded during the war. Central power or heating plants in limited service during the last fifty years may contain original intact equipment. Where a boiler system has been in constant use since World War II, it is probable that the equipment has been, or is scheduled for, modification.

Stand-by Generator Buildings

Stand-by generators were constructed primarily during World War II as backup power systems. In some cases, stand-by generators were part of central heating plants. In other cases, separate buildings were constructed to house these generators. Generator buildings generally are one-story, utilitarian structures located in shop or support areas. One auxiliary diesel-fueled generator plant was surveyed at Aberdeen Proving Ground, Maryland. Building 318, constructed in the shop area, was used to charge batteries and contained two electric generators as an auxiliary/stand-by power supply. The building is constructed of prefabricated, synthetic panel, exterior walls with a transite skirt at the foundation (Figure 63, *bottom*).

District Heating Plants/Boiler Plants

The typical district heating plant or boiler plant is a small, one-story masonry structure. In general, the design and construction of district heating plants reflects the design of surrounding buildings. If the boiler plant supported a complex of architecturally prominent buildings, the plant often was designed with architectural elements that complemented the main buildings. If the plant served utilitarian structures, it typically was constructed according to a utilitarian design with little or no architectural ornamentation (Figure 63, *top*).

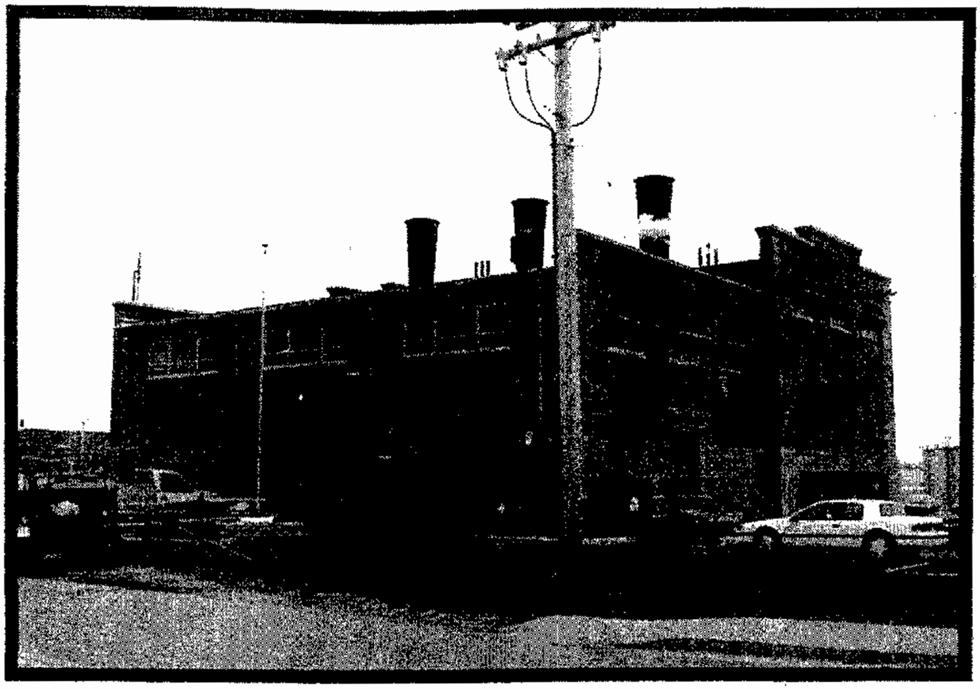
One major modification to boiler plants often is the removal of original tall smoke stacks. This is particularly noticeable in cases where the original masonry smokestacks for coal-fired boilers have been replaced by metal flues.

Substations

During the inter-war period, the Army enclosed substations in small, one-story, masonry buildings (Figure 64, *top*). During World War II, substations consisted of electrical equipment mounted on concrete pads. In general, electrical substation equipment continually has been upgraded and no longer reflects the technology of earlier time periods.

Distribution Transformer Buildings

Distribution transformer buildings appear during the 1930s phase of permanent Army construction. They are most common in permanent housing areas and distinct building complexes, such as Army air fields. Distribution transformer buildings were one-story buildings, often designed to complement the architecture of the surrounding area. Two designs of distribution transformer buildings are identifiable. One design has a metal door in the front gable end; the other design has a door opening in the side elevation (Figure 64, *bottom*).



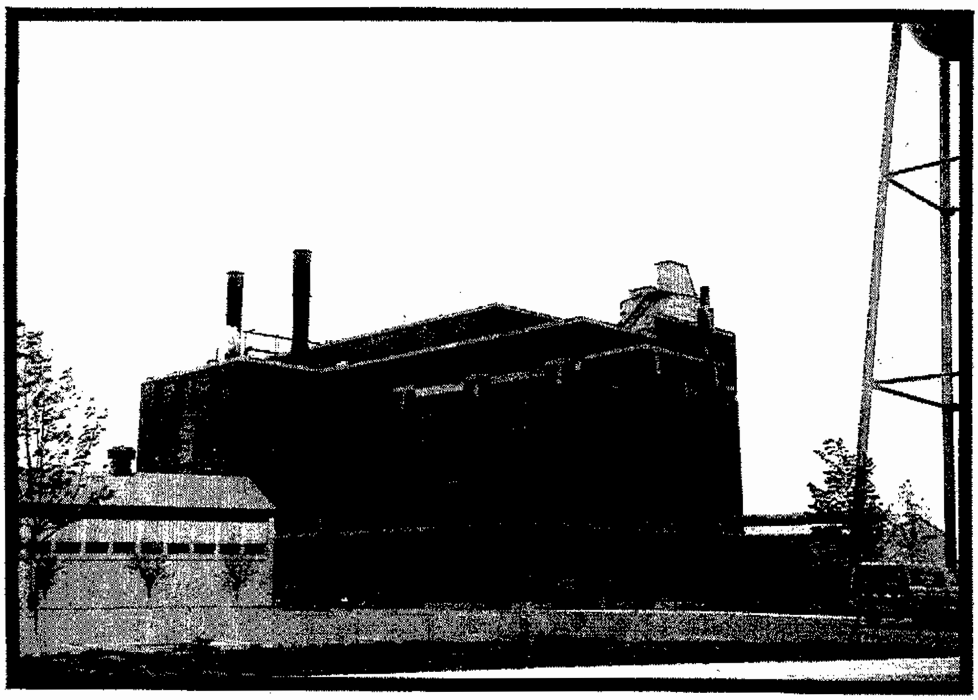
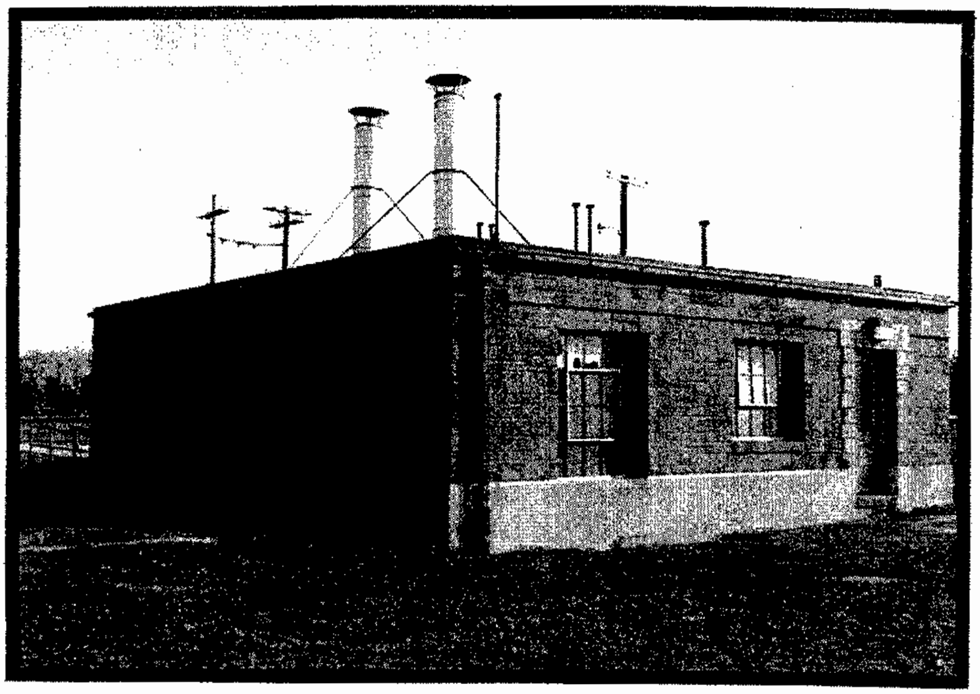


Figure 62. (*top*) 1918 central heating plant (Building 345, Aberdeen Proving Ground, Maryland)
(*bottom*) 1937 central heating plant (Building 30170, Wright Patterson AFB, Ohio)



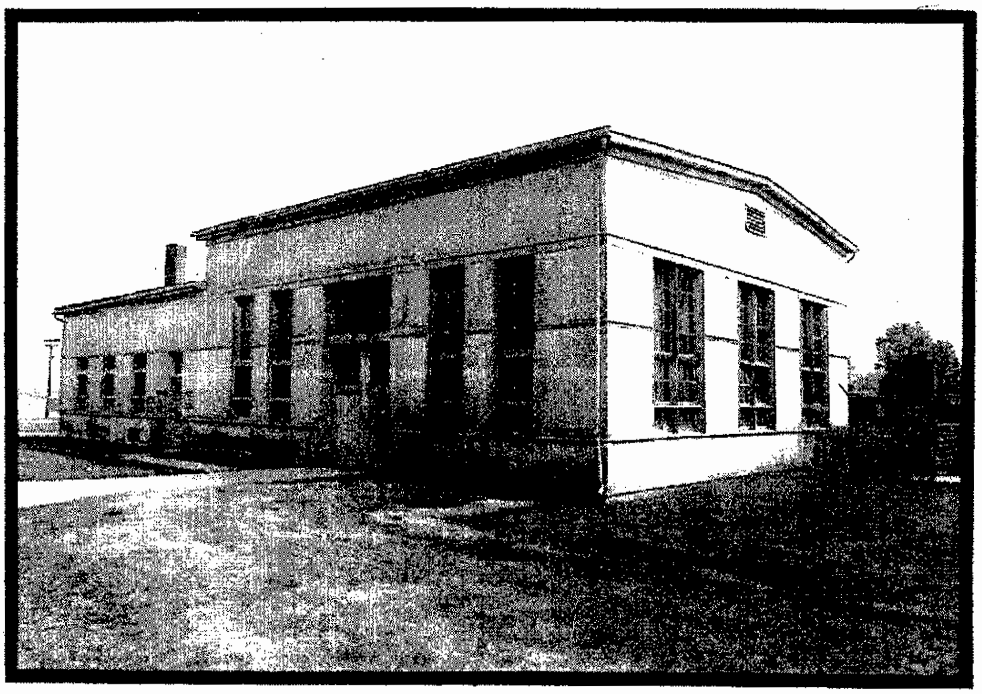


Figure 63. (*top*) 1941 district heating plant (Building 3062, Aberdeen Proving Ground, Maryland)
(*bottom*) 1943 auxiliary generator building (Building 318, Aberdeen Proving Ground, Maryland)

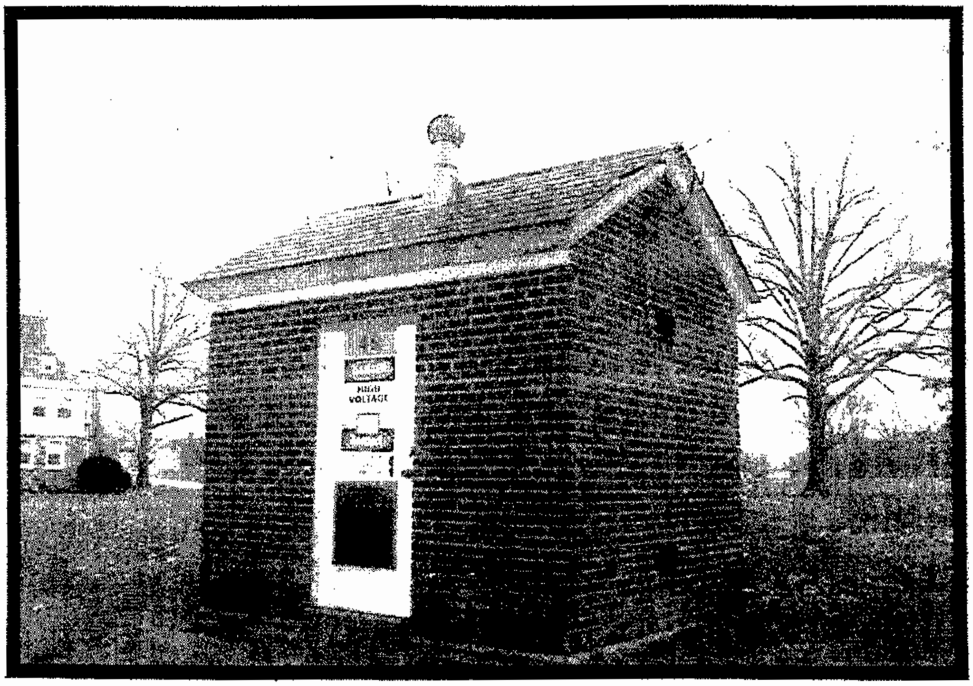


Figure 64. (*top*) 1923 electrical substation (Building 7, Scott AFB, Illinois)
(*bottom*) 1935 brick distribution transformer building (Building 46, Aberdeen Proving Ground, Maryland)

CHAPTER X

REFUSE DISPOSAL

Industrial, commercial, and domestic activity produces solid wastes that people have disposed of in various ways over time. Refuse is classified into three categories: (1) garbage, (2) rubbish, and (3) trash. Garbage is a mixture of solid wastes that result from food preparation and primarily contains vegetable matter. Only a small percentage of the refuse produced in the United States is classified as garbage. Rubbish is a mixture of combustible materials composed primarily of paper and light plastics. Trash includes all other solid wastes. It consists predominantly of noncombustible materials and yard and garden trimmings (Fife 1966:93). Communities manage solid waste through the development and operation of refuse disposal systems that dispose of community refuse in a healthy and economic manner according to the standards of the time. As military installations developed and knowledge about the connection between health and refuse disposal grew, the military developed better means of refuse disposal.

Technological Evolution

Management of solid wastes generally relied upon methods that salvaged as much of the waste as economically possible, and reduced the remainder through burning or compaction. Solid wastes were disposed using a variety of methods: dumping on land or in water, feeding animals, or burning.

The most popular method of refuse removal was dumping. Most cities and towns disposed of community wastes by dumping refuse in lakes, streams, and fields. During the nineteenth century, public health officials demanded the removal of refuse dumps from populated areas. Land dumping continued to be the most common method of refuse disposal until the middle of the 1910s.

During the late nineteenth century, refuse disposal in the United States was primitive. In the last quarter of the nineteenth century, only 43 per cent of American cities provided any sort of municipal waste collection and disposal (Melosi 1981:152). Two methods of waste disposal gradually supplanted dumping: incineration and reduction. These two technologies remained popular until World War I.

Reduction is the process of compacting solid waste to decrease its volume. Machines shred, hammer, and pulverize the refuse into small particles.

Incineration is the process of burning combustible waste at high temperature to produce an inert residue. Burning originally was done in open areas or pits. During the late nineteenth century, European inventors developed a special incineration furnace that controlled the burning process. The incinerator included a furnace where combustible refuse was charged and ignited, a secondary combustion chamber where high-temperature burning completed the combustion process, and flues and chimneys to provide an exhaust system.

In 1885, the Army installed the first refuse incinerator. This system was imported from Europe and located in the United States at Governors Island in the harbor of New York City (Fife 1966:95). At the beginning of the twentieth century, approximately 32 per cent of American cities utilized incineration to dispose of refuse. Another 13.5 per cent of American cities relied on reduction; 32 percent on land dumps; and, 13.5 percent on farm use (Melosi 1981:163).

While proponents claimed that incineration provided the most sanitary and economic means of refuse disposal, American engineers were unhappy with the most commonly-used incinerators, which were European imports. Operators complained that existing incinerators did not compete effectively with dumping practices because of inefficient fuel use. By 1910, many engineers claimed that new technology made incinerators more efficient. By 1914, approximately 300 incineration plants operated in the United States and Canada; 88 of these plants were constructed between 1908 and 1914. In 1916, 43 per cent of American cities used incineration (Melosi 1981:163;170-175).

The improved incinerator plants frequently included space for unloading and storing refuse for short periods of time to permit uniform charging of the furnaces. As the technology improved, the heat generated by the incinerators was sometimes used to generate steam for industrial processes, space heating, or power generation. Incineration was especially practical for small communities such as large commercial establishments or military installations.

Between 1910 and 1920, the percentage of American cities providing municipal waste collection and disposal rose to approximately 90 per cent (Melosi 1981:152). However, during the first two decades of the twentieth century, no single method of refuse disposal was preferred by the majority of American communities. Both incineration and reduction were promoted as the most efficient means of waste disposal.

During World War I, other refuse disposal methods included recycling materials and swine feeding. Popular in the United States until the 1890s, swine feeding was adopted during the war as a way to increase food production. Swine feeding continued in the Northeast as a method of refuse disposal until the 1930s. The practice became less popular when the federal government passed laws requiring that garbage fed to hogs be cooked to prevent the spread of disease. Sites for hog feeding became increasingly difficult to locate within a reasonable distance from highly populated areas.

As American society became more affluent following World War I, the problem of refuse disposal increased in magnitude and complexity. The dramatic rise in the number of automobiles, as well as the growth of the chemical and electrical industries during the 1920s, transformed the economy. The appearance of a variety of consumer products and diverse disposable packaging, changed the nature of refuse (Melosi 1981:190).

After World War I, refuse disposal methods remained varied. In 1924, 29 per cent of American cities used incineration; 2 per cent reduction; 38 per cent farm use; 17 per cent land dumping; and 14 per cent relied upon other methods (Melosi 1981:163). Both reduction and incineration facilities continued to operate during the 1920s, although reduction never regained its pre-World War I popularity.

Many coastal communities dumped refuse at sea during the early twentieth century. The problems presented by this method of disposal became evident quickly as trash washed back on shore. After the first half of the twentieth century laws were passed that generally precluded the direct disposal of waste in bodies of water.

Incineration continued to be a practical method of refuse disposal until World War II. However, during the 1930s, the use of sanitary landfills increased in popularity, and the number of incinerators declined significantly. Since World War II, the sanitary landfill has remained the primary method of refuse disposal, particularly with rising concerns about air pollution from incineration.

Naval/Marine Corps Application of Refuse Disposal Technology

The Navy's use of refuse disposal technology followed civilian patterns. The Navy recognized the importance of refuse disposal to avoid health hazards. The Navy disposed of garbage by dumping, sanitary filling, burning, and hog feeding. Trash usually was salvaged or burned (U.S. Navy Department, Civil Engineer Corps 1945). Review of the Navy's archival records did not locate any plans of or references to reduction plants.

After incineration was introduced in the United States in 1885, the Navy gradually adopted this technology for naval installations. In 1905, a crematory with the capacity to burn five to seven tons of garbage was constructed at the New York Navy Yard. The Morse-Boulger Destructor Company of New York provided the equipment and the building designs (NARA, Cartographic Branch, RG 71, microfilm reel 59).

In 1913, the Navy reported a problem with the crematory at the Norfolk Navy Yard. In 1912, the old crematory had been replaced. The furnaces were removed from the old crematory and the plant was closed. Just after the new crematory was completed, cracks developed in its stack, and the yard closed the new plant. The lack of a crematory at the shipyard formed a menace to the health of shipyard workers. The Navy solved the problem by using the Army's open pit furnace method of incineration. This method disposed of 2 tons of animal and vegetable matter per day (U.S. Navy Department, Bureau of Yards and Docks, *Bulletin 13*, June 1913:35-36).

Another example of a crematory was built at the Naval Training Station at Newport, Rhode Island. The incinerator contained concrete floors and walls lined with enameled brick. Garbage was dumped onto the upper fire-clay grates of the incinerator through two openings in the top of the furnace. The draft from coal fires on lower grates located at each end of the furnace, passed over the garbage, and another grate. Exhaust exited the system through the flue, which was partly below the furnace and led back to the chimney (U.S. Navy Department, Bureau of Yards and Docks, *Bulletin 14*, June 1914).

Between 1917 and 1946, incinerators were constructed at many types of naval installations including training stations, hospitals, air stations, supply depots, ammunition depots, and Marine Corps installations. During the late 1930s and throughout World War II, incinerators were a typical building type constructed at most installations.

Naval Building Types

Incinerators

Incinerators generally are two-story, rectangular buildings (Figure 65). The first floor often is partially below ground and houses the furnace. This level generally is constructed of permanent materials, typically concrete. The refuse is unloaded and prepared for incineration on the upper level. The exterior of the upper story of the buildings could be constructed of brick, concrete, or corrugated metal. The choice of material depended on the location of the incinerator and its capacity. Incinerator buildings could be windowless or feature industrial steel sash or double-hung sash windows. A prominent feature of the incinerator building is its tall smokestack. The size of installation incinerators depended on the number of personnel stationed at the installation. The

Navy estimated that one person generated one-half pound of garbage and one-and-one-half pounds of refuse per day (U.S. Navy Department, Bureau of Yards and Docks 1938: T17-19).

Between 1917 and 1946, incineration technology remained the same. The incinerator was composed of a furnace, charging and combustion chambers with interior walls lined with fire brick, and a chimney stack. The refuse entered the furnace from the upper level and was burned by fires fueled by wood, coal, or oil. Large incinerators had mechanical stoking equipment; small incinerators were hand stoked. The Bureau of Yards and Docks recommended the installation of hot water coils to harness the heat generated to produce hot water and steam. At some installations, incinerators were connected to the power plant so that the two processes could share the same chimney stack (U.S. Navy Department, Bureau of Yards and Docks 1938: T17-19). Hawthorne Ammunition Depot in Nevada included an example of this combined building type.

Early incinerators were small buildings. The 1905 incinerator designed for the New York Navy Yard measured 26 by 29 feet. Its capacity was between five to seven tons of garbage. The incinerator constructed at Quantico during the 1920s measured 28 by 28 feet. The largest Navy incinerator of the era was constructed in 1938 at the New York Navy Yard. It measured 72 by 42 feet and had a capacity of 76 tons (NARA, Cartographic Branch, RG 71, microfilm reels 59, 60). Incinerators typically were located away from personnel structures; if the installation had limited land, then the incinerator might be attached to the power house.

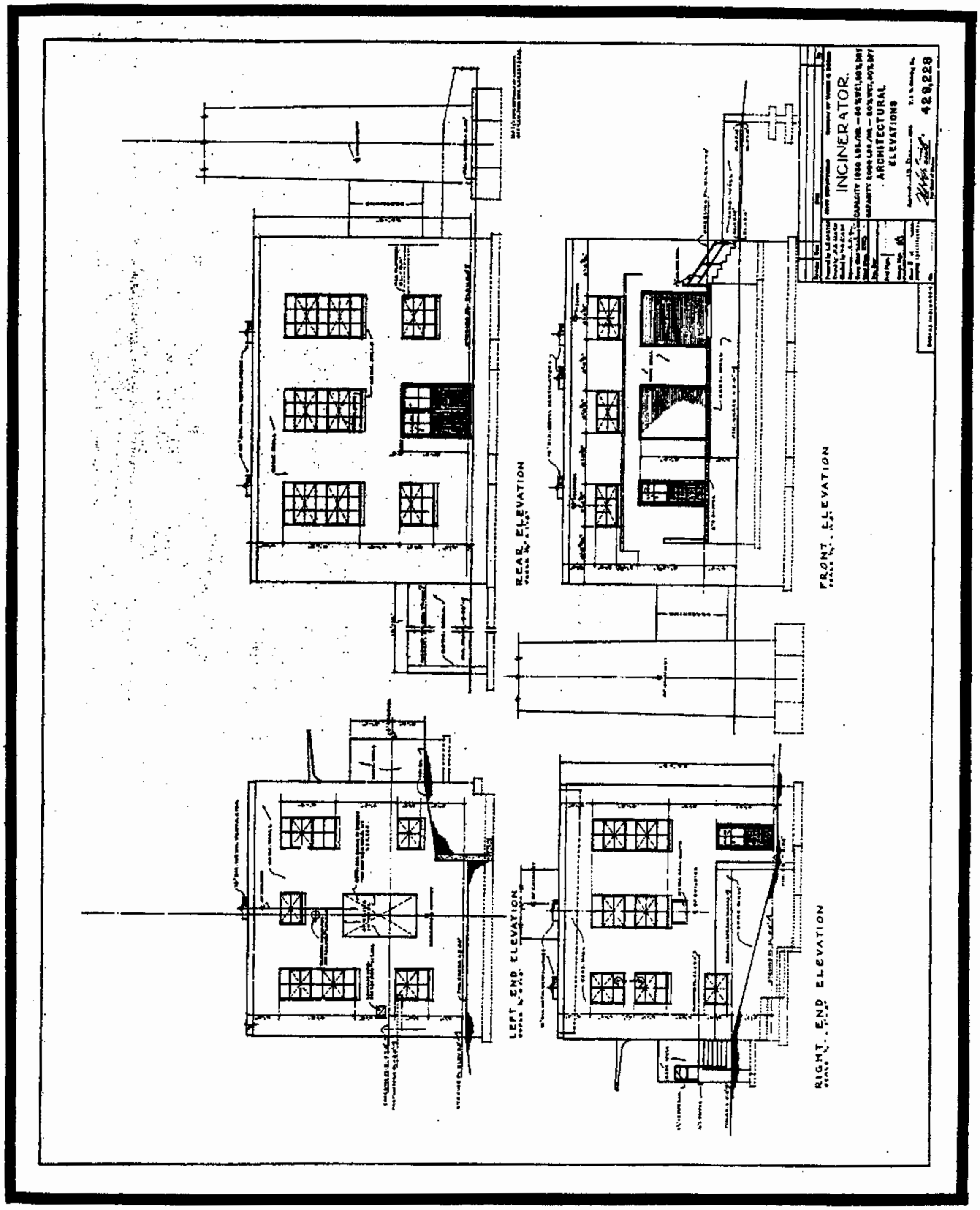


Figure 65. 1946 standard incinerator (Drawing 429,228, Reel 1299, Naval Construction Battalion Center, Port Hueneme, California)

Army/Air Corps Application of Refuse Disposal Technology

During the nineteenth century, the Army typically disposed of refuse through burning in open pits. As the Army improved living standards for its personnel during the late nineteenth century, waste control methods also were improved. In 1885, the Army installed and operated the first refuse incinerator (no longer extant) in the United States at Governors Island, New York. The incinerator, which was imported from Europe, was a single refractory-lined chamber with a stationary grate. Refuse was loaded into the furnace through a top opening, and stoked by hand. The incinerator did not include a means to collect fly ash or an exhaust system (Fife 1966:95).

In 1902 and 1904, the Quartermaster Corps issued standard plans for crematories (NARA, Cartographic Branch, RG 77, Standard plans). According to the extant drawings, the plans were not revised many times; the absence of revisions typically indicates that the plans were not used often. Quartermaster personnel were assigned the responsibilities for the operation of crematories. In 1904, Quartermaster personnel were instructed to operate crematories efficiently within the capacity of the equipment and to watch the grate bars and stack carefully (U.S. War Department, Quartermaster Department 1904:17). Between 1918 and 1946, the Quartermaster Department issued additional drawings for incinerators (History Office, U.S. Army Corps of Engineers, Quartermaster drawings, Box 86).

During World War I, the Army built cantonments across the country to house and train recruits. These cantonments consisted primarily of temporary, wooden buildings. Fire prevention was a major concern in these wooden cantonments (Crowell 1919:535-536). Because of the fire risks associated with open pit burning, most temporary cantonments included a masonry incinerator building. Another building that sometimes was associated with incinerator buildings was the garbage can washing building where personnel washed garbage cans, generally using water heated by the incineration process.

Between 1917 and 1946, incinerators were constructed at most Army installations. During the late 1930s and throughout World War II, incinerators were a typical building type constructed at most installations.

Army Building Types

Incinerators

Incinerators generally are two-story, rectangular buildings. The first floor often is partially below ground and houses the furnace. The basement walls generally are constructed of permanent materials such as poured reinforced concrete or masonry block. The first floor can also be constructed of permanent materials such as brick. More common is a steel-frame structural system clad with corrugated metal siding. The building often has a gable roof clad with corrugated metal. Metal sash windows and metal doors often are incorporated into the building. A prominent feature of the incinerator building was the smokestack that released heat into the atmosphere from the furnaces located in the basement. Incinerators used natural or forced draft fans to aid in the burning process. Raised concrete loading platforms often are part of the structure (Figure 66).

In 1942, standard plans developed by the Corps of Engineers specified the use of a wood superstructure for the incinerator building. These substitutions were in response to the shortage of critical materials during the war.

The size of the incinerator depended on the number of persons served. Incinerator capacities ranged from one-half ton to thirty-three tons per eight hours. Incinerator operation was the same regardless of size. Refuse was unloaded onto a concrete raised platform from trucks. Refuse then was moved to the enclosed first floor, known as the charging room. The refuse was collected here until firing. During firing, the refuse was shoveled into brick-lined combustion chambers. The incinerators were oil-fueled. The waste was fired and finished using oil; the material was allowed to burn naturally when possible. Smoke stack temperatures were maintained above 225° C during burning (U.S. Army Environmental Hygiene Agency 1989:815). Ash was removed from the incinerator from the basement level through large sliding doors located on the rear elevation.

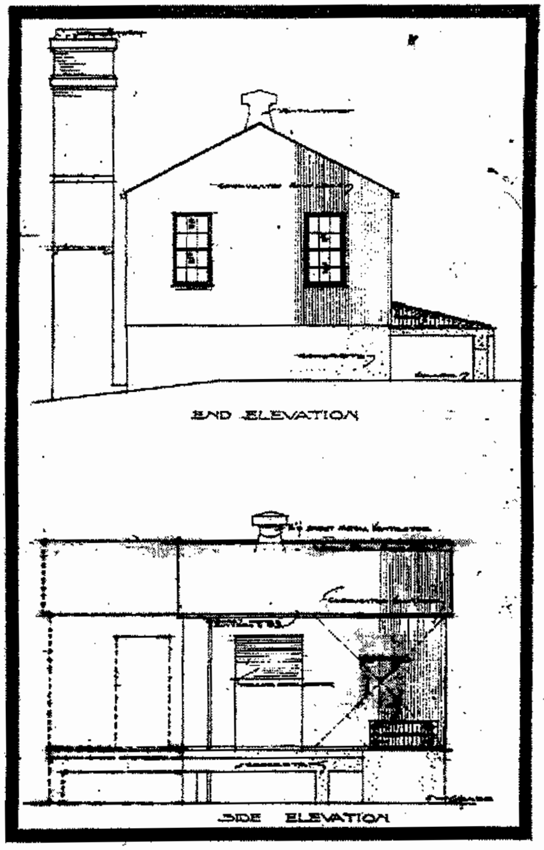


Figure 66. (*top*) 1919 three-ton capacity incinerator plant (History Office, U.S. Army Corps of Engineers, OQMG Drawing 414.43-148, Box 86)
(*bottom*) 1941 incinerators (Buildings 5010 and 5011, Aberdeen Proving Ground)

CHAPTER XI

CURRENT INVENTORY OF SUPPORT AND UTILITY BUILDINGS AND STRUCTURES

The numbers of buildings and structures constructed between 1917 and 1946 currently classified as support and utility buildings are summarized in Table 9. The classifications are based on the *current use* of buildings or structures as recorded in 1994 real property inventories of the Army, Air Force, Navy, and Marine Corps. The total number of buildings currently classified as support and utility buildings is 35,077. The Army's inventory contains the most support and utility buildings (24,378), followed by the Navy (8,375). Ordnance storage represent the most numerous support buildings (23,389). General storage buildings total 6,808, and utilities total 4,880.

This investigation revealed that the most support and utility buildings were constructed during World War II (1940-1945). The peak construction years for the Navy, Marine Corps, and Air Force were 1942 and 1943. The Army's peak construction years were 1941 and 1942 (Figures 67, 68, and 69).

Each service has developed a system of category codes that identify property use. The Department of Navy and the Department of Army have five-digit classification codes; the Air Force uses six-digit classification codes. The tables included in this chapter present tallies of the number of buildings and structures within each category code organized according to the general classifications of general storage, ordnance storage, and utilities.

The Department of Defense (DoD) has demonstrated exceptional resourcefulness in managing its building inventory and has been extremely inventive in adaptive reuse. Therefore, the current use building and structure classifications do not necessarily reflect original building use. Field investigations revealed that often an examination of original drawings combined with building survey was the only reliable method of determining the original use and thus the original inventory of utility and support buildings and structures at an installation.

The building typologies for support and utility structures developed for this project are based on *original use* as identified through archival research and field survey. The typologies are described in Chapters IV - X. The identification of a building's *original use* is important because *original use* establishes a property's historical associations and defines the parameters for assessing historical integrity. Association with significant historic contexts and integrity are the key factors assessing National Register eligibility. Guidance on evaluating the National Register eligibility is found in Chapter XII.

Despite DoD's practice of adapting buildings for new uses, analysis of the current real property inventory provides preliminary data for quantifying the identification and management of this class of buildings. An analysis of DoD's inventory of 1917-1946 general storage, ordnance storage, and utility buildings and structures follows. Tables listing the distribution of support and utility buildings by installation are contained in Appendix E.

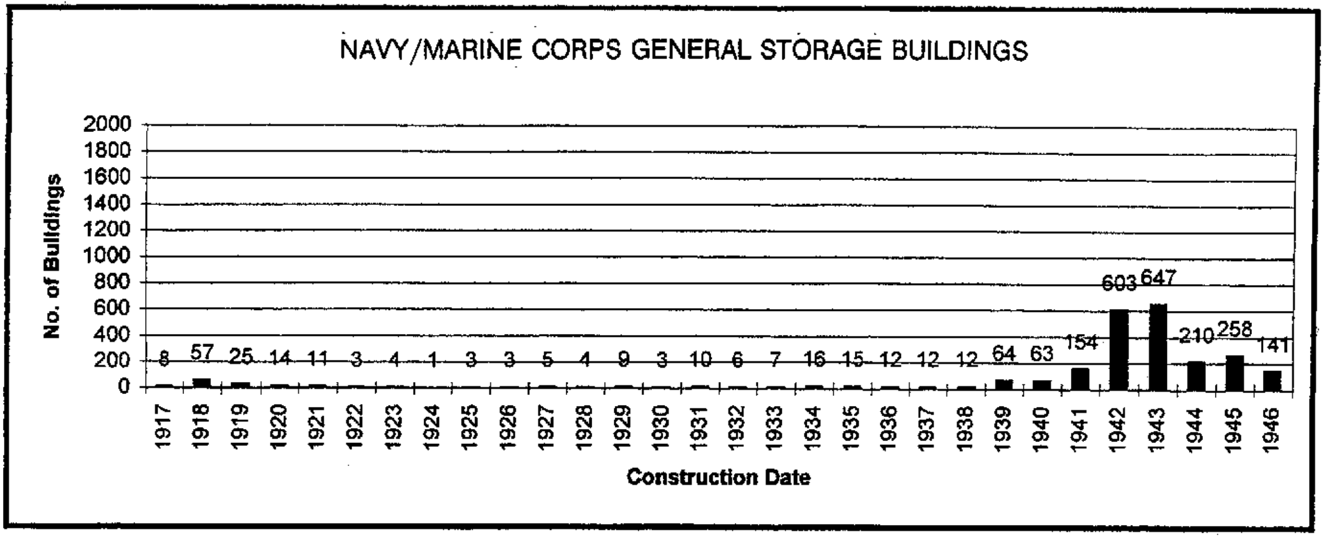
General Storage

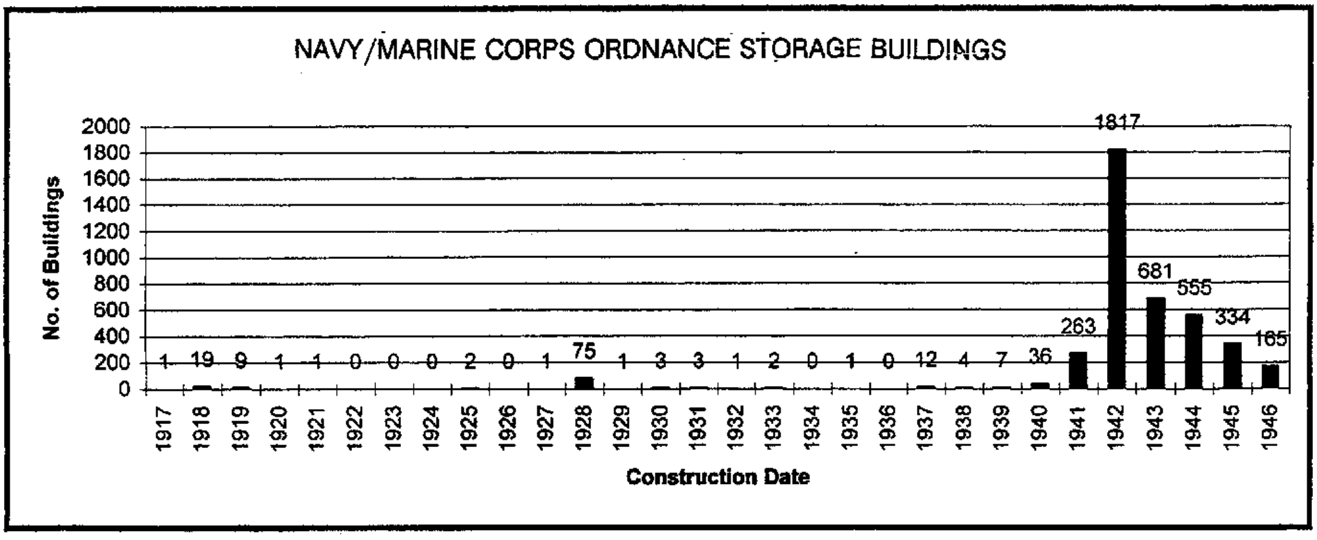
A total of 6,808 buildings currently are classified as general storage (Tables 10, 11, and 12). Of the categories of buildings included in this study, general storage buildings are the most

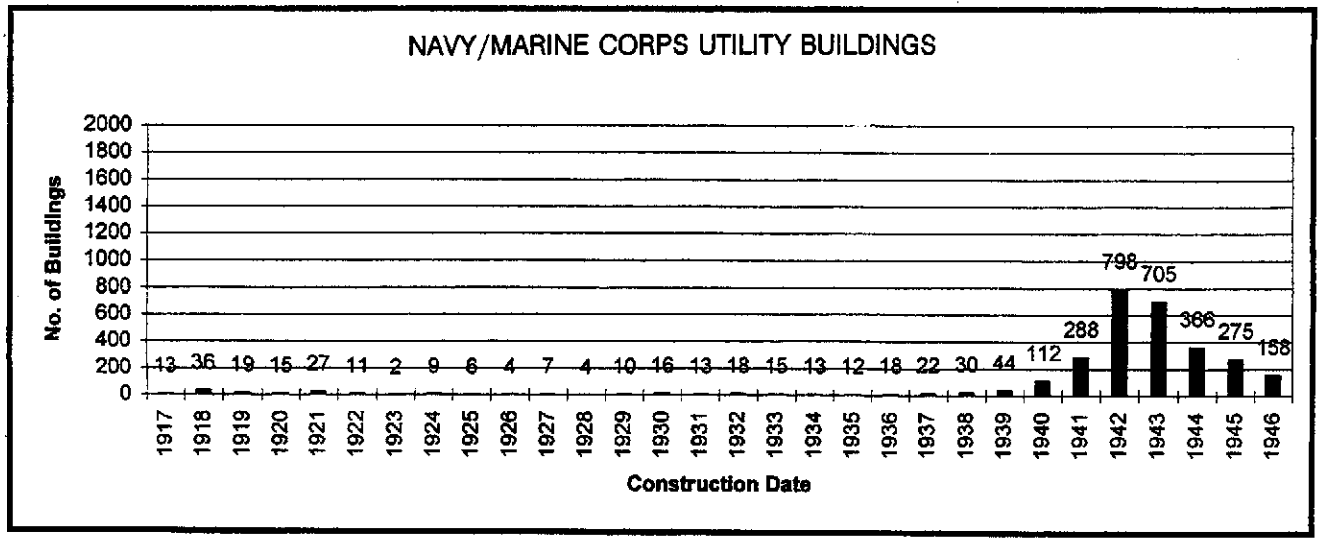
TABLE 9. SUMMARY OF PROPERTIES CURRENTLY CLASSIFIED AS SUPPORT AND UTILITY BUILDINGS AND STRUCTURES IN DoD INVENTORY, 1917-1946

	Army	Air Force	Navy	Marine Corps	Totals
General Storage	3,812	616	1,835	545	6,808
Ordnance Storage	19,186	209	3,881	113	23,389
Utilities	1,380	456	2,659	385	4,880
Totals	24,378	1,281	8,375	1,043	35,077

Source: 1994 Real Property Inventories, Departments of Army, Navy, and Air Force

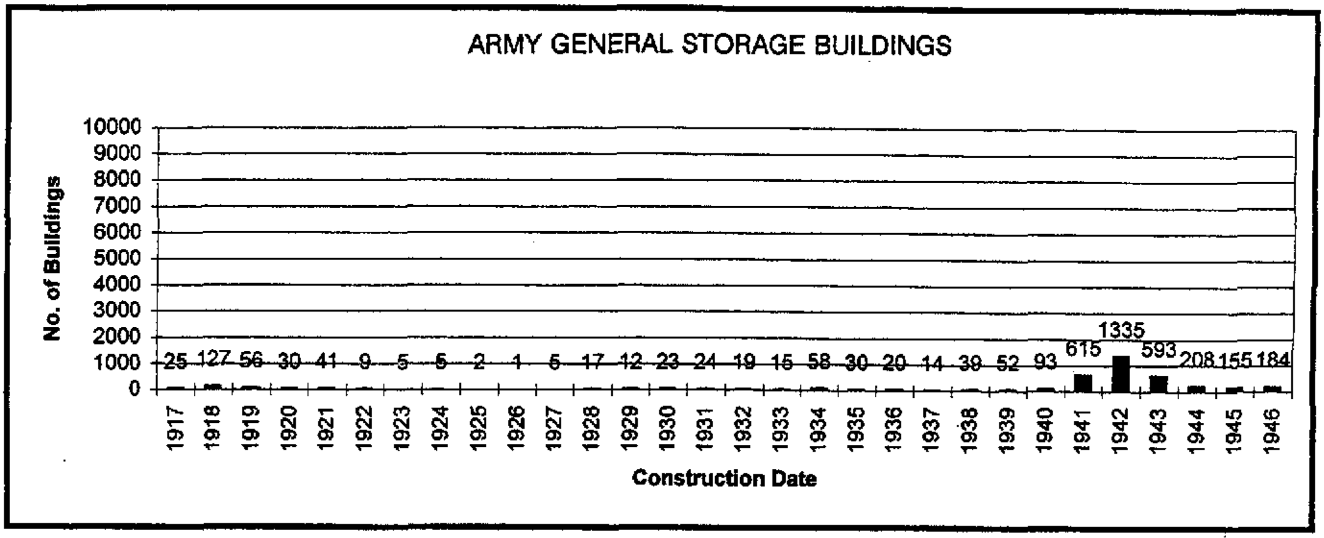


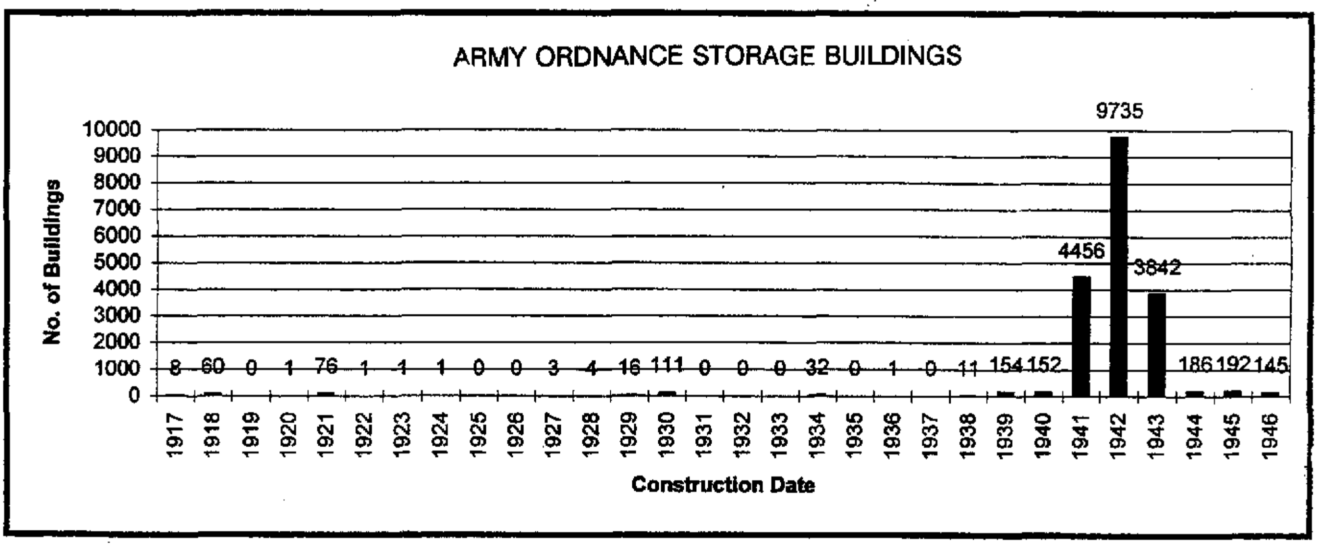


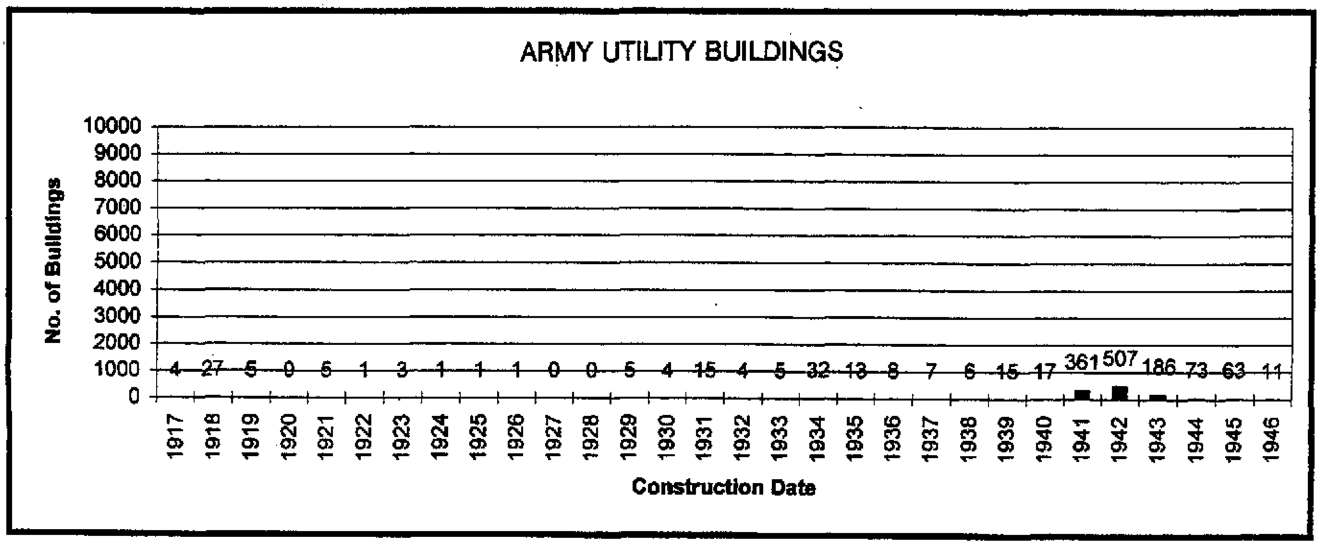


SOURCE: 1994 REAL PROPERTY INVENTORY, U.S. NAVY

Figure 67. Frequency of Construction of Navy/Marine Corps Support and Utility Buildings by Date

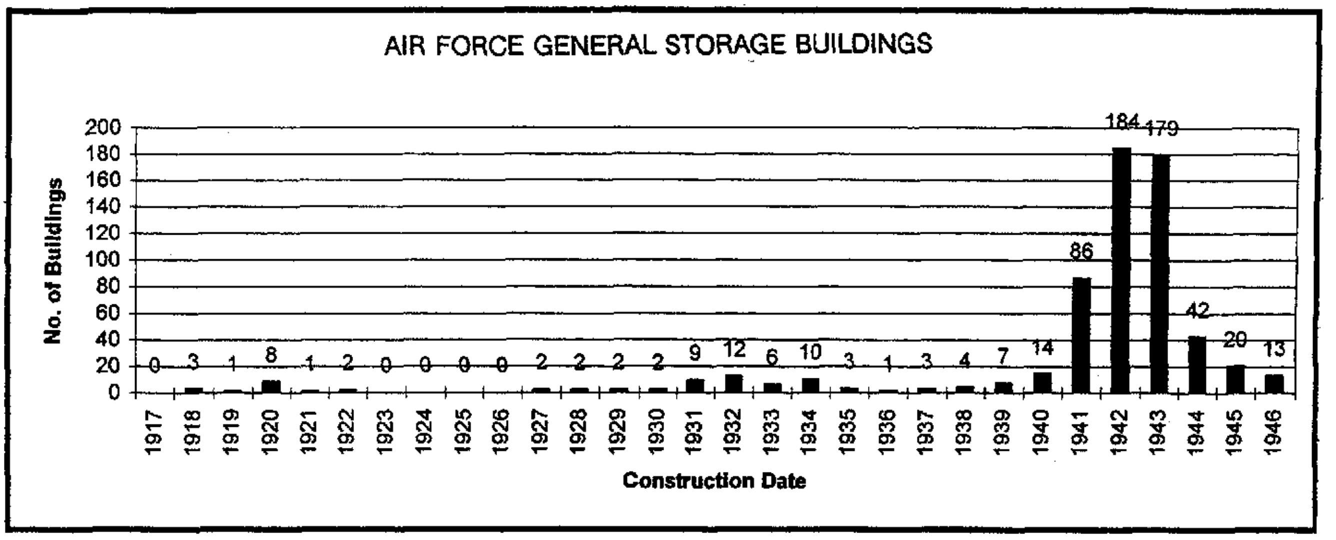


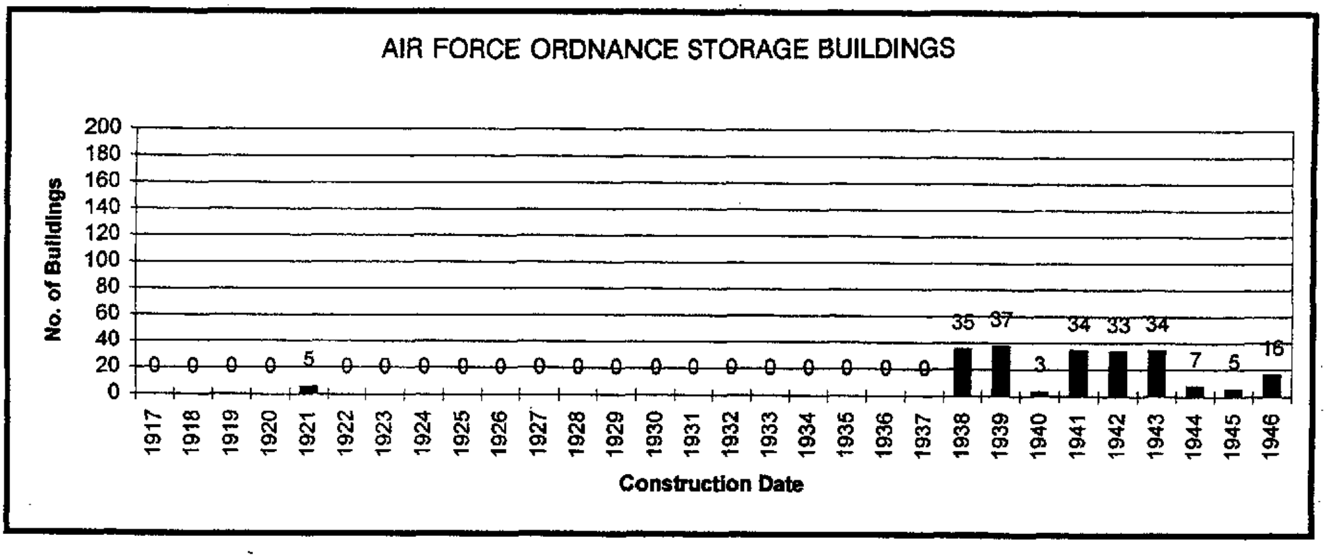


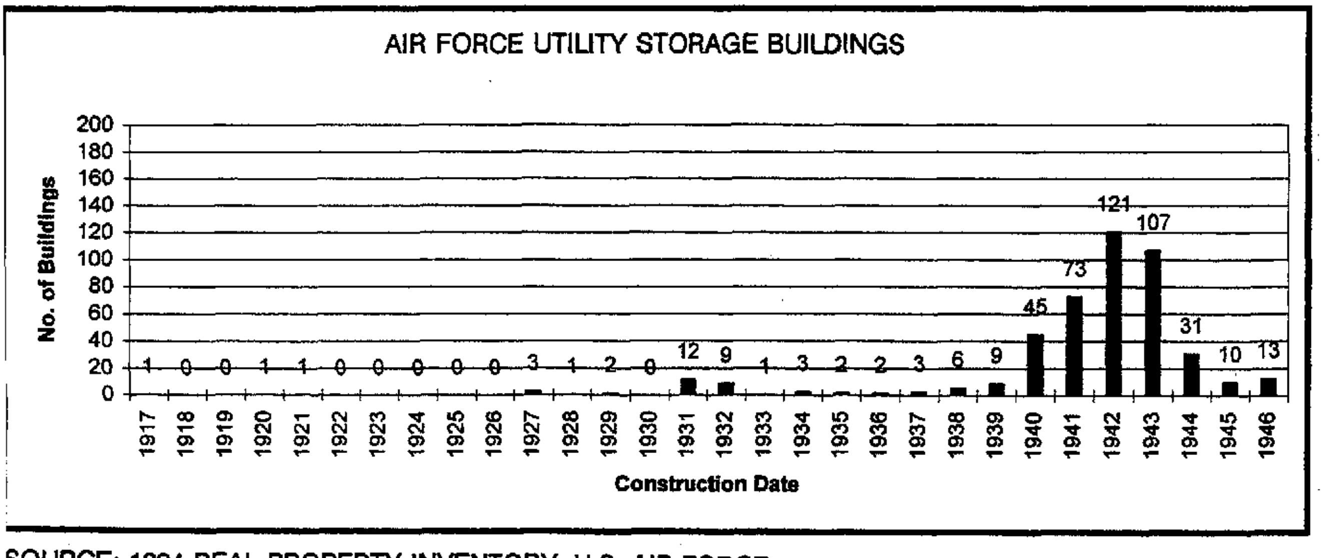


SOURCE: 1994 REAL PROPERTY INVENTORY, U.S. ARMY

Figure 68. Frequency of Construction of Army Support and Utility Buildings by Date







SOURCE: 1994 REAL PROPERTY INVENTORY, U.S. AIR FORCE

Figure 69. Frequency of Construction of Air Force Support and Utility Buildings by Date

TABLE 10. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS FUEL STORAGE AND GENERAL STORAGE CONSTRUCTED BETWEEN 1917 - 1946 IN NAVY AND MARINE CORPS INVENTORY

Category Code	Description	Navy Frequency	Marine Corps Frequency
FUEL STORAGE			
12110	Aircraft Direct Fueling Station	-	-
12120	Aircraft Truck Fueling Facility	14	4
12130	Aircraft Defueling Facility	-	-
12210	Marine Corps Fueling Facility	5	-
12220	Marine Corps Small Craft Fueling Facility	5	1
12310	Filling Station	43	7
12315	Filling Station Building	8	3
12420	Drum/Can Ready Fuel Storage	10	-
12430	Aircraft Ready Fuel Storage	105	33
12440	Small Craft Ready Fuel Storage	16	14
12450	Vehicle Fuel Storage	91	23
12465	Activity Heating Fuel Storage	9	1
12470	Surge Storage	1	-
12520	Shed/Shelter for Miscellaneous POL Pipeline Facilities	140	-
12610	Drum and Can Loading Facility	1	-
12630	Tank Truck/Tank Car Loading Facility	20	4
12640	Tank Truck/Tank Car Unloading Facility	3	1
82160	Distillate Heating Fuel Oil Storage	94	24
82161	Residual Heating Fuel Oil Storage	25	9
82320	Gas Storage Tanks	3	4
	TOTAL	593	118

Category Code	Description	Navy Frequency	Marine Corps Frequency
GENERAL STORAGE			
43110	Cold Storage Warehouse	19	3
44110	General Warehouse-Navy	865	17
44111	General Purpose Warehouse-Marine Corps	3	35
44112	Storage for Marine Corps Air or Ground Organic Units	5	308
44113	Specific Purpose Warehouse, Marine Corps Logistics Support Base	2	20
44114	Specific Purpose Warehouse, Marine Corps SASSY Management Unit	-	1
44120	Controlled Humidity Warehouse	40	1
44130	Hazardous and Flammable Storehouse	193	25
44135	General Storage Shed	91	14
44140	Underground Storage	1	-
44170	Disposal-Salvage-Scrap Building	23	3
	TOTAL	1,242	427

Source: 1994 Real Property Inventory, Department of Navy

TABLE 11. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS GENERAL STORAGE CONSTRUCTED BETWEEN 1917 - 1946 IN ARMY INVENTORY*

Category Code	Description	Frequency
COLD STORAGE		
42410	Cold Storage Battery	2
43110	Cold Storage Warehouse	2
43210	Cold Storage Warehouse	36
43211	Cold Storage I & R Warehouse	3
43220	Meat Cut Plant	3
43230	Refrigerator Warehouse-Perishables	2
	TOTAL	48
GENERAL STORAGE		
44110	General Purpose Warehouse	633
44130	Controlled Humidity Warehouse	133
44150	Inflammable Material Storehouse	30
44160	RADA Storage Warehouse	1
44180	Open Warehouse Facility	19
44181	Vehicle Storage Facility	32
44190	Other	1
44210	Air Conditioned Parts Storage Building	4
44212	Air Conditioned Parts and Table of Organization Equipment Storage	1
44215	Oxygen Storage Facility	1
44217	Acetyl Storage Facility	3
44219	Steel Storage Facility	4
44220	General Purpose Warehouse	1,073
44221	Target Storage	17
44222	Storage Shed	96

Category Code	Description	Frequency
44223	Arms Building	12
44224	Deploy Storage Building	1
44225	Medical Supply Warehouse	17
44226	Supply/Maintenance Warehouse	10
44228	ISECT Storage Facility	11
44230	Controlled Humidity Warehouse	38
44240	Inflammable Material Storehouse	319
44245	Air Conditioned Inflammable Storage	0
44250	Underground Storage Facility	10
44260	Transit Shed	13
44261	Lumber and Paint Shed, Facility Engineer	23
44262	Vehicle Storage	71
44270	General Storehouse	933
44271	General Storage, Family Housing	14
44275	Facility Engineer Storehouse	158
44276	Structural Material Handling Equipment	5
44280	Open Warehouse	2
44285	Salvage and Surplus Property Storage	53
44286	Division Breakdown Building	2
44290	Other	24
	TOTAL	3,764

Source: 1994 Real Property Inventory, U.S. Army.

* Fuel Storage Structures were not contained in database supplied by U.S. Army.

TABLE 12. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS GENERAL STORAGE AND FUEL STORAGE CONSTRUCTED BETWEEN 1917 - 1946 IN AIR FORCE INVENTORY

Category Code	Description	Frequency
FUEL STORAGE		
125977	Pump Station, Liquid Fuel	23
GENERAL STORAGE		
141387	Film Storage	-
141782	Air Freight Terminal	1
141787	Consolidation/ Containerization Point	-
141821	Material Processing Depot	-
159353	Warehouse Transit Cargo	-
171472	Range Supplies & Equipment Storage	-
171473	Range Target Storage & Repair	-
219946	Base Engineer Covered Storage	135
219947	Base Engineer Storage Shed	40
319995	Research Equipment Storage	6
432283	Cold Storage Base	6
441257	Hazardous Storage Depot	8
441628	Shed Supplies and Equipment Depot	8
441758	Warehousing Supplies and Equipment Depot	44
442257	Hazardous Storage Base	34
442258	Storage Liquid Oxygen	6
442515	Medical Storage	10
442628	Base Supplies and Equipment	21
442758	Warehousing Supplies and Equipment Base	159
442765	Warehousing Troop Subsistence	4
442768	Warehousing Forms and Publications Equipment Base	20
442769	Housing Support Storage Facility	38

Category Code	Description	Frequency
740397	Exchange Central Warehouse	3
740387	Exchange Retail Warehouse	14
740672	MWR Supply and Non-Appropriated Fund Central Storage	35
	TOTAL	616

Source: 1994 Real Property Inventory, U.S. Air Force. The Real Property Inventory did not include structures.

likely to have been modified for adaptive reuse. Current use classifications of general storage buildings often do not reflect the original use of the buildings. Archival research and site investigations identified general storage buildings that were converted to other uses and reclassified in real property inventories according to new use. In addition, many buildings currently classified as general storage originally were constructed for a variety of other purposes. To evaluate this class of buildings the identification of original building uses is imperative.

The site survey at Aberdeen Proving Ground, Maryland, illustrated the challenge created by changes in classification from original use to current use for general storage buildings. At Edgewood Area, five identical ordnance storage buildings were constructed in 1918. Three buildings currently are classified as general storage buildings while two buildings are classified in categories not included in this study. The same pattern of reuse and reclassification was identified for above-ground magazines constructed during World War II at Edgewood Area. Of the 18 buildings originally constructed as above-ground magazines, all 18 buildings currently are classified as general storage.

Data collected during other site visits revealed similar reclassification patterns for storage buildings. Site visits to Naval Base Norfolk, Virginia, and at Marine Corps Development and Education Command, Quantico, Virginia, revealed that many multi-story storage buildings were adapted to administrative uses. The identification of general storage buildings depended heavily on archival research and on-site survey.

Fuel Storage

Only the Department of Navy included fuel storage structures in their real property inventory (593 for Navy and 118 for Marine Corps). Information collected during the four site visits revealed that efforts are underway to remove underground storage tanks throughout DoD to comply with environmental regulations. The number of fuel storage facilities in the DoD inventory has decreased since the real property database was obtained for this study. For example, information collected during the site visit at Marine Corps Development and Education Command, Quantico, indicated that all underground fuel storage tanks have been removed. Similar efforts to remove underground fuel storage tanks were noted at Kelly Air Force Base, Texas.

Ordnance Storage

Ordnance storage, totaling 23,389 buildings and structures, represents the largest single classification of utility and support structures (Tables 13, 14, and 15). Of these, 18,768 buildings are classified as igloos (Army/Air Force terminology) or high explosive magazines (Navy/Marine Corps terminology). Another 835 buildings are classified as fuse and detonator magazines. The concrete arched-type magazines generally are classified as igloos or high-explosive magazines. Rectangular box magazines also are included in the counts for high-explosive, and fuse and detonator magazines. The original Navy designation of arched-type magazines as high-explosive magazines has been retained in Army real property records for former naval installations that have been transferred to the Army, such as Hawthorne AAP, Nevada.

Current classifications of above-ground ordnance storage buildings also differs from historical classifications. For the Department of the Navy, above-ground magazines classified under the ordnance category codes include: inert storehouse, ready magazine, smokedrum storehouse, small arms/pyrotechnics magazines, or smokeless powder projectile magazines (Table 13). These classifications originally were developed to identify specific historic building

TABLE 13. FREQUENCY OF PROPERTIES CURRENTLY CLASSIFIED AS ORDNANCE STORAGE STRUCTURES CONSTRUCTED BETWEEN 1917 - 1946 IN NAVY AND MARINE CORPS INVENTORY

Category Code	Description	Navy Frequency	Marine Corps Frequency
42112	Fuse & Detonator Magazine	360	26
42122	High Explosive Magazine	1,908	48
42132	Inert Storehouse	333	11
42135	Ready Magazine	89	-
42142	Smokedrum Storehouse	1	5
42148	Small Arms/Pyrotechnics Magazine	232	19
42152	Smokeless Powder Projectile Magazine	824	4
42162	Special Weapons Magazine	23	-
42172*	Missile Magazine	111	-
	TOTAL	3,881	113

Source: 1994 Real Property Inventory, U.S. Navy.

* The dates of construction for some structures with this code pre-date missiles, therefore, these structures probably are other types of magazines that have been adapted to missile storage.

TABLE 14. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS ORDNANCE STORAGE STRUCTURES CONSTRUCTED BETWEEN 1917 - 1946 IN ARMY INVENTORY

Category Code	Description	Frequency
42110	Fuse & Detonator Magazine-Bulk	377
42120	High Explosive Magazine-Bulk	1,555
42150	Smokeless Powder Magazine	421
42160	Special Weapons Magazine-Bulk	73
42170	GM Magazine-Bulk	8
42180	Igloo Storage-Bulk	11,998
42181	Storehouse	31
42182	Small Arms Magazine	31
42183	General Purpose Magazine	257
42184	Ammo Hut	5
42190	Other	2
42210	Fuse Detonator Magazine	72
42215	High Explosive Magazine	983
42225	Smokedrum Storehouse	15
42230	Small Arms/Pyrotechnics Magazine	73
42231	Storehouse	88
42235	Ready Magazine	325
42240	Fixed Ammo Magazine	129
42250	Special Weapons Magazine	11
42260	GM Magazine	4
42280	Igloo Storage	2,145
42281	Ammo Hut	10
42283	General Purpose Magazine	549
42285	Unit Small Arms Storage	1
42286	Arms Storage	4
42290	Other	19
	TOTAL	19,186

Source: 1994 Real Property Inventory, U.S. Army.

TABLE 15. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS ORDNANCE STORAGE STRUCTURES CONSTRUCTED BETWEEN 1917 - 1946 IN AIR FORCE INVENTORY

Category Code	Description	Frequency
422253	Storage-Multi-Cubicle Magazine	-
422256	Storage-Rocket Check Out and Assembly	2
422257	Storage-Segregated Magazine	27
422258	Storage-Magazine Above Ground Type A, B, & C	33
422259	Storage-Missile Facility	-
422264	Storage-Igloo	131
422265	Storage-Spare Inert	16
422271	Storage-Module Barricaded	-
422273	Storage-Igloo Steel Arch Underpass	-
422275	Ancillary Explosives Facility	-
	TOTAL	209

Source: 1994 Real Property Inventory, U.S. Air Force.

types. Current classifications do not necessarily denote historic building types. In addition, the number of categories for ordnance storage facilities has decreased between 1942 and 1994.

For the Army, above-ground ordnance storage buildings can be recorded in any of the current use classifications for ordnance storage aside from igloos (Table 14). The Army's current category code classifications differentiates between depot storage (421--) and installation storage (422--). In general, small arms magazines, general purpose magazines, smokeless powder magazines, ready magazines, and inert storehouses probably are included within current classifications of above-ground storage buildings. However, many of the above-ground magazines currently serve as general storage.

Utilities

Buildings and structures numbering 4,880 currently are classified as utilities. In general, there is a close correlation between current use classifications for utility buildings and their original uses (Tables 16, 17, and 18). Utility buildings typically were retained in service and expanded or upgraded to contain modern equipment. When upgrading was no longer possible, the buildings were left vacant or scheduled for demolition. In some cases, information obtained from site visits identified more pre-1946 utility buildings than were recorded on current real property lists. In these cases, the original utility buildings were vacant, reclassified to other uses, or dropped from the real property inventory lists.

In general, utility systems were designed to meet specific installation requirements. The range and number of utility building and structure types located on installations reflect site-specific requirements. The building typologies developed in this study apply to power/heating, water supply, waste treatment, and refuse disposal systems.

Power and heating plants with their attendant distribution systems are likely to be found at every installation. Heating plants are more numerous than electric power plants. Between 1918 and 1946, especially during wartime, military policy required installations to maintain an independent power supply as well as a backup supply. At most Navy installations, this policy resulted in the construction of a central power plant with stand-by connection to the local power company. At most Army installations, the pattern was reversed; the local utility company provided the primary electric power supply, with stand-by generators at the Army installation. In most cases, one large steam heating plant at the installation was equipped with stand-by generators. The most numerous power structures on most installations are substations and distribution transformers.

The other utilities systems (water, sewage, and refuse) also reflect site-specific requirements. Sewage and water supply systems often were designed to take advantage of the services of neighboring communities. This was particularly true for Navy installations; Army installations tended to establish independent water supplies and to construct sewage treatment plants. The majority of the water and sewage related utility buildings found at installation are buildings and structures associated with distribution, such as pump houses, reservoirs, and elevated water storage tanks.

Utility buildings and structures classified as miscellaneous in real property records include compressed air plants, ice plants, utility vaults, and valve houses. The Navy has the largest number of miscellaneous utility buildings and structures; many are related to technical functions undertaken at shipyards.

TABLE 16. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS UTILITY BUILDINGS AND STRUCTURES CONSTRUCTED BETWEEN 1917 - 1946 IN NAVY AND MARINES CORPS INVENTORY

Category Code	Description	Navy Frequency	Marine Corps Frequency
ELECTRIC POWER/HEATING			
81109	Electric Power Plant	14	-
81110	Electric Power Plant-Diesel	7	1
81125	Electric Power Plant-Steam	6	1
81145	Electric Power Plant-Gas Turbine	-	-
81159	Stand-by Generator Building	49	4
81160	Stand-by Generator Plant	50	4
81209	Electric Distribution Building/Shelter	322	7
81212	Transformer Station less than 500 KV	271	39
81310	Switching/Substation Building/Shelter	113	2
81320	Substation more than 499 KV	118	26
81330	Switching Station for Sectional Distribution Circuits	29	3
	TOTAL	979	87
HEATING/COOLING			
82109	Heating Plant Building	150	16
82112	Surge Storage	26	4
82122	Fossil Fuel Heating Plant-Medium	94	19
82150	Non-Nuclear Steam Plant	18	1
82209	Steam/Heat Building/Shelter	20	1
82309	Gas Generating Building	-	-
82310	Gas Generating Plant	1	-
82315	Gas Meter Shed/Shelter	14	-
82610	Refrigeration/Air Conditioning Plant Building	4	-
82620	Chilled Water Plant, 25 to 100 Tons	-	-

Category Code	Description	Navy Frequency	Marine Corps Frequency
82625	Chilled Water Plant over 100 Tons	1	-
82630	Air Conditioning Plant, 25 to 100 Tons	-	-
82640	Air Conditioning Plant over 100 Tons	5	-
82710	Air Conditioning Valve House/Shed/Shelter	-	-
	TOTAL	333	41
SEWAGE AND INDUSTRIAL WASTE-TREATMENT AND DISPOSAL			
83109	Combined Sewage and Industrial Waste Treatment Building	29	30
83110	Combined Sewage and Industrial Waste Treatment Plant	74	4
83111	Ballast Contamination Skimmer	2	-
83114	Industrial Waste Treatment Building	-	-
83115	Industrial Waste Treatment Facility	2	-
83116	Runoff/Oil Separator	5	-
83130	Septic Tank/Drain Field	54	23
83141	Hazardous Waste Storage and Transfer Facility	26	13
83229	Sewage Pumping Station Shed/Shelter	114	17
83230	Sewage/Industrial Waste Pumping Station	60	9
83309	Incinerator Building and Incinerator	13	-
83310	Incinerator-Exterior	2	-
83315	Sanitary/Cut-fill disposal area	-	-
83320	Solid Waste Grinder Building	-	-
83321	Solid Waste Grinder-Nongalley	-	-
83330	Solid Waste Stand-Nongalley	1	1
83340	Garbage House	10	4
	TOTAL	392	101
WATER SUPPLY			
84109	Water Treatment Facility Building	86	30
84110	Water Treatment Facilities	50	10

Category Code	Description	Navy Frequency	Marine Corps Frequency
84120	Supply Mains and Pumping Facilities (Pretreatment Only)	20	-
84130	Elevated Potable Water Storage Tank	63	12
84140	Ground Level Potable Water Storage Tank	115	22
84150	Wells-Potable Water	109	34
84151	Reservoir-Potable Water	32	8
84152	Water Catchment Area	-	-
84209	Water Distribution Building/Shelter, Potable	134	20
84215	Pumping Stations, Potable	35	7
84320	Fire Protection Pumping Station	27	-
84330	Fire Protection Water Tank	26	-
84335	Fire Protection Reservoir	7	1
84340	Fire Protection Water Well	69	-
84350	Fire Protection Valve House	22	-
84410	Water Supply Storage Building, Nonpotable	3	1
84420	Wells, Nonpotable	6	1
84430	Supply Pumping Station, Nonpotable Water	3	1
84440	Storage Tanks, Nonpotable Water	19	-
84510	Pipeline Building-Nonpotable Water	7	-
84450	Reservoirs, Nonpotable Water	2	4
84530	Booster Pump Station, Nonpotable Water	2	1
	TOTAL	837	151
MISCELLANEOUS			
86041	Railroad Scalehouse	5	-
87115	Storm Water Pumping Station	4	-
87125	Dyke/Dam	12	-
87220	Guard and Watch Towers	7	-
89010	Acetylene Plant	2	-
89011	Acetylene Distribution System	4	-

Category Code	Description	Navy Frequency	Marine Corps Frequency
89015	Nitrogen Plant	-	-
89020	Compressed Air Plant	25	1
89025	Carbon Dioxide Plant	2	2
89027	Icemaking Plant	-	1
89030	Industrial Oxygen Plant	2	-
89042	Air Conditioning Plant (5 to 25 Tons)	3	-
89045	Valve House or Other Shed/Shelter	38	1
89077	Utility System Storage	17	-
	TOTAL	118	5

Source: 1994 Real Property Inventory, Department of Navy.

TABLE 17. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS UTILITY BUILDINGS AND STRUCTURES CONSTRUCTED BETWEEN 1917 - 1946 IN ARMY INVENTORY

Category Code	Description	Frequency
ELECTRIC POWER/HEATING		
81110	Power Plant Building-Fossil	3
81150	Uninterrupted System Facility	1
81160	Standby Generator	27
81170	Power Plant Building-Hydraulic	1
81180	Power Plant Building-Other	5
81190	Other	1
81261	Distribution Transformer Building	105
81280	Power Distribution Building	0
81321	Substation Building	36
81351	Switch Station Building	35
81360	Transformers	1
	TOTAL	215
HEATING/COOLING		
82110	Heating Plant Coal	24
82115	High Pressure Boiler Plant Building	16
82116	Heat Plant Building	77
82120	Heat Plant-Oil	117
82130	Heat Plant-Gas	56
82150	Steam Plant-Power	15
82180	Other Heat Plant Building	4
82190	Other	4
82230	Heat Distribution Station	93
82310	Gas Generation Plant	1
82311	Heat Gas Generation Building	4
82380	Other Heat/Gas Building	1

Category Code	Description	Frequency
82420	Gas Distribution Station	16
82610	Air Condition Plant	3
82615	Air Condition Plant Building	0
82623	Refrigeration Plant Building	1
82634	Mechanical Ventilation Plant Building	1
	TOTAL	433
SEWAGE/WASTE TREATMENT		
83114	Sewage/Waste Treatment Plant Building	82
83128	Effluent Containment Facility	3
83140	Industrial Waste Treatment	16
83190	Other	1
83231	Sewage Pump Station Building	118
83280	Sewage Collection Building	1
83311	Incinerator Building	24
83312	Refuse Collection Building	3
83320	Recycling Facility	5
	TOTAL	253
WATER TREATMENT		
84111	Water Treatment Building	32
84123	Pressure Containment Valve	13
84125	Filter Plant Facility	8
84131	Water Well with Pump Station	140
84132	Water Well & Pump Building	40
84141	Pump Station	41
84142	Water Pump Station Building	50
84150	Chlorinator Building	16
84190	Other	3
84220	Water Pump-Potable	27
84310	Fire Protection Pump Station	9
84461	Fire Protection Pond Building	1

Category Code	Description	Frequency
84470	Well Non-Potable with Pump Station	4
84471	Water Well Building	2
84480	Water Supply Building-Other	3
84520	Water Pump-Non-potable	20
84580	Water Distribution Building	1
	TOTAL	410
MISCELLANEOUS UTILITIES		
89015	Environment Test Facility	6
89017	Inert Gas Facility	1
89023	Compressed Air Plant Building	53
89046	Combination AC-HT Building	2
89050	Ice Plant	2
89080	Other Miscellaneous Plant Building	5
	TOTAL	69

Source: 1994 Real Property Inventory, U.S. Army.

TABLE 18. FREQUENCY OF PROPERTIES CURRENTLY CATEGORIZED AS UTILITY BUILDINGS AND STRUCTURES CONSTRUCTED BETWEEN 1917 - 1946 IN AIR FORCE INVENTORY

Category Code	Description	Frequency
ELECTRIC POWER		
811144	Total Energy Plant Building	-
811145	Prime/Stand-by Electric Power Generation Plant	-
811147	Emergency Electric Power Generation Plant	-
811149	Electric Power Station Building	19
813228	Electric Switching Station	21
813231	Electric Substation	3
	TOTAL	40
HEATING/COOLING		
821113	Heating from Central Plant	-
821115	Heating Plant 750/3500 mb	-
821116	Heating Plant over 3500 mb	-
821117	Heating Facility Building	44
821155	Steam Plant Industrial	-
821156	Steam Facility Building	11
822248	Hot Water Pump Station	-
822268	Condensate Return Pump Station	4
823243	Gas Compressor	-
823248	Gas Vaporizer	-
824462	Gas Meter Facility	20
824468	Gas Valve Facility	5
826122	Air Conditioning Plants 25 to 100 Tons	-
826123	Air Condition Plant over 100 Tons	-
	TOTAL	84
SEWAGE/INDUSTRIAL WASTE		
831155	Industrial Waste Treatment and Disposal	-
831157	Industrial Waster Fuel Spill Collection	-
831165	Sewage Treatment and Disposal	-

Category Code	Description	Frequency
831168	Waste Treatment Facility Building	30
831169	Sewage Septic Tank	-
831173	Demolition and Burning Facility	-
832267	Pump Station Sanitary Sewage	54
833354	Solid Waste Disposal Facility	2
833356	Solid Waste Repository	1
	TOTAL	87
WATER/WATER TREATMENT		
841162	Commercial Water Supply	-
841165	Water Supply Treatment	-
841166	Water Well	-
841169	Water Supply Building	111
841423	Water Storage Dam	-
841425	Water Storage Reservoir	-
841427	Water Tank Storage	-
842249	Water Pump Station	78
843316	Water Fire Pumping Station	7
843319	Fire Protection Water Storage	-
844367	Water Supply Storage (Non-Potable)	-
844368	Water Supply (Non-Potable)	-
845362	Water Supply (Non-Potable) Building	4
	TOTAL	200
MISCELLANEOUS		
871185	Storm Drainage Pump Station	3
890136	Compressed Air Plant	2
890187	Utility Vault	38
890123	Air Conditioning Plant Building	2
	TOTAL	45

Source: 1994 Real Property Inventory, U.S. Air Force.

Current real property records probably under-report the historical numbers of utility buildings. During site visits, wells, sewage treatment plants, and incinerators were noted that are closed and no longer recorded in current real property lists. In particular, incinerators systematically have been abandoned in favor of sanitary landfill operations. At Naval Base Norfolk, a number of transformer distribution buildings were being replaced systematically; these structures are not recorded on the real property inventory.

CHAPTER XII

RECOMMENDATIONS FOR EVALUATION

This section of the report presents a methodology for evaluating the National Register eligibility of support and utility facilities constructed between 1917 and 1946 at Department of Defense (DoD) installations. The evaluation methodology was developed in accordance with the National Historic Preservation Act of 1966, as amended, and its implementing regulations and guidelines, including "Protection of Historic Properties" (36 CFR 800), the Section 110 Guidelines (53 FR 4727-46), and the Secretary of the Interior's "Standards and Guidelines for Archeology and Historic Preservation."

National Register Criteria for Evaluation

The National Register is the nation's official list of historic properties. The Secretary of the Interior maintains the National Register, which is administered by the National Park Service. Federal agencies, including the Department of Defense, are required to consider the effects of their actions on properties that are eligible for listing in the National Register. Federal agencies also are required to identify, evaluate, and nominate properties eligible for inclusion in the National Register.

The Department of the Interior has developed regulations outlining the procedures for listing properties in the National Register (36 CFR 60). These regulations define the National Register Criteria for Evaluation (36 CFR 60.4), which provide a basis for selecting properties for inclusion in the National Register (Table 19). The National Park Service has developed guidance for the application of the criteria, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* (U.S. Department of the Interior 1991). For a property to be eligible for the National Register, it must meet one of the criteria by (1) being associated with an important historic context and (2) retaining historic integrity sufficient to convey its significance (U.S. Department of the Interior 1991:3).

Methodology for Evaluating Properties

Evaluating property for its eligibility is a four-step process: (1) Categorize the property; (2) Determine what historic contexts the property represents; (3) Determine whether the property is significant under the National Register criteria; and, (4) Determine whether the property retains integrity (U.S. Department of the Interior 1991:3). The process is summarized in Table 20 and explained in detail below.

1. Categorize the Property

The National Register includes several different categories of real property that can be considered for listing in the National Register. The following definitions are taken from National Register Bulletin 15, with examples relevant to support and utility facilities provided as illustrations:

TABLE 19. NATIONAL REGISTER CRITERIA FOR EVALUATION

The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

(a) That are associated with the events that have made a significant contribution to the broad patterns of our history; or

(b) That are associated with the lives of persons significant in our past; or

(c) That embody the distinctive characteristics of a type, period, or method of construction or that represent a significant and distinguishable entity whose components may lack individual distinction; or

(d) That have yielded, or may be likely to yield, information important in prehistory or history.

TABLE 20. METHODOLOGY FOR EVALUATING SUPPORT AND UTILITY FACILITIES (1917 - 1946)

1. Categorize the Property.

- Is it a building, structure, or district?
  If it is a building or structure, is it part of a district or is it isolated?
- How does it fit into the classification system developed for support and utility facilities?
  - Storage
    - General Storage
    - Ordnance Storage
    - Fuel Storage
  - Utilities
    - Water Supply Systems
    - Sewage Disposal Systems
    - Power and Heating Systems
    - Refuse Disposal Systems

2. Determine What Historic Context the Property Represents.

3. Determine Whether the Property is Significant under the National Register Criteria.

- Criterion A: Association with Events
- Criterion C: Design/Construction

4. Determine Whether the Property Retains Integrity

- *Building*: A building is created principally to shelter any form of human activity. "Building" also may refer to an historically and functionally related complex, such as a courthouse and jail or a house and barn.

  Examples: warehouse; power plant

- *Structure*: Structures are functional constructions made usually for purposes other than creating human shelter.

  Examples: ammunition storage magazine; water tower

- *Object*: Objects are properties that are primarily artistic in nature or are relatively small in scale and simply constructed. Although it may be, by nature or design, movable, an object is associated with a specific setting or environment. No "objects" were identified as support and utility facilities.

- *Site*: A site is the location of a significant event, a prehistoric or historic occupation or activity, or a building or structure, whether standing, ruined, or vanished, where the location itself possesses historic, cultural, or archeological value regardless of the value of any existing structure. This category of property is rarely relevant to support and utility facilities.

- *District*: A district possesses a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development (U.S. Department of the Interior 1991:4-5).

  Examples: depot; cantonment; main base; housing area

Defining the boundaries of historic districts is more complex than defining the boundaries of a building. A district is a definable geographic area characterized by shared relationships among the properties within the district. Other points to note about the selection of historic district boundaries include:

- A district can include features that lack individual distinction, if the district as a whole is significant;

- A district may contain properties that do not contribute to the district's significance;

- District boundaries are based on the historical and physical associations among the properties, which do not necessarily coincide with current installation boundaries or activity jurisdictions; and,

- A district usually consists of a contiguous area, but may consist of two or more separate areas if the space between the areas is not related to the significance of the district and visual continuity is not a factor in the significance (U.S. Department of the Interior 1991:5-6).

(2) Determine What Historic Contexts the Property Represents

The second step in the evaluation methodology is to identify what historic context the property represents. An historic context provides an organizational framework to assist with understanding the broad patterns of history. The three elements of an historic context are time, geographic area, and theme. Evaluating a property within its historic context provides an understanding of its relative importance within history. A key component in establishing the relevant historic context for property on a military installation is to determine the primary mission, or purpose, of the installation during the relevant time frame.

Chapter III of this report provides a synthesis of historic contexts previously compiled for U.S. military development and construction during World War I, the inter-war period, and World War II. This summary context emphasizes the role of logistical support and the development of modern infrastructure at U.S. military installations. Chapters IV - X provide specific historic contexts for support and utility facilities, organized by function. These contexts describe the development of infrastructure technology relevant to each type of property and the role it played at military installations between 1917 and 1946. These chapters provide information to assist in determining the appropriate historic contexts.

(3) Determine Whether the Property is Significant Under the National Register Criteria

Criterion A: Association with Events. The first criterion of the National Register recognizes properties associated with events important in the broad patterns of United States history. These events can be of two types: (1) specific events or (2) patterns of events that occurred over time.

The military has played an important role in U.S. history, and the World Wars that frame the time period of this study (1917 - 1946) certainly were significant events that influenced the nation. However, not all military construction built during these important periods of time is necessarily significant. For a property to meet Criterion A, the property must have an important and specific association with the event (U.S. Department of the Interior 1991:12). To determine if a property is significant under Criterion A:

1. Determine the nature of the property, including date of construction, type of construction, and function(s) during 1917 - 1946;

2. Determine if the property is associated specifically with the mission of the installation during its period of significance; and,

3. Evaluate the property's history to determine whether it is associated with the historic context in an important way (U.S. Department of the Interior 1991:12).

Criterion C: Design/Construction. To be eligible for listing in the National Register under Criterion C, properties must meet at least one of the following four requirements: (1) embody distinctive characteristics of a type, period, or method of construction; (2) represent the work of a master; (3) possess high artistic value; or (4) represent a significant and distinguishable entity whose components may lack individual distinction. The first and fourth of these requirements are the most relevant to military construction.

National Register Bulletin 15 defines "distinctive characteristics" as "the physical features or traits that commonly recur" in properties; "type, period, or method of construction" is defined as "the way certain properties are related to one another by cultural tradition or function, by dates of construction or style, or by choice or availability of materials and technology" (U.S. Department of the Interior 1991:18). Properties are eligible for listing in the National Register if they are important examples, within an historic context, of design and construction of a particular time. This facet of Criterion C can apply to buildings, structures, objects, or districts.

"Significant and distinguishable entities" refers to historic properties that contain a collection of components that may lack individual distinction but form a significant and distinguishable whole. This section of Criterion C applies only to districts. Military installations are composed of component parts that often were interrelated physically, functionally, and aesthetically. *Properties that individually may not be eligible for listing in the National Register may be eligible as part of an historic district.*

To determine if a property is an important example of the distinctive characteristics of a type, period, or method of construction or as a significant and distinguishable district:

1. Determine the category of the property, including date of construction, type of construction, historic appearance, and function(s) during 1917 - 1946;

2. Determine if the property represents a type, period and method of construction;

3. Compare the property with the other examples of the property type and determine if it possesses the distinctive characteristics of the type; and,

4. Evaluate the property's design and construction to determine if it is an important example of its type, period and method of construction.

(4) Determine Whether the Property Retains Integrity

To meet the National Register Criteria for Evaluation, a property, in addition to possessing significance within an historic context, must have integrity. Integrity is the ability of a property to convey its significance through the retention of the property's essential physical characteristics from its period of significance. The National Register Criteria for Evaluation list seven aspects of integrity: location, design, setting, materials, workmanship, feeling, and association. A property eligible for the National Register must possess at least several of these aspects of integrity. The assessment of a property's integrity is rooted in its significance; the reasons why a property is important first must be established, then the qualities necessary to convey that significance can be identified.

To assess historical integrity:

1. Determine the essential physical features that must be present for a property to represent its significance;

2. Determine whether the essential physical features are sufficiently visible to convey their significance;

3. Compare the property with similar properties if the physical features necessary to convey the significance are not well-defined; and,

4. Determine, based on the property's significance, which aspects of integrity are particularly important to the property in question and if they are intact (U.S. Department of the Interior 1991:45).

Properties significant for their associations with important historical events (Criterion A) must retain the key physical features of the relevant property type from their period of significance in order to be eligible for the National Register. Properties significant for their design and construction (Criterion C) must retain the physical features that are the essential elements of the type, period, or method of construction that the property represents to be eligible for the National Register. To qualify for listing as an historic district, the majority of the properties in the district must possess integrity.

Industrial and technical properties typically receive continual alterations in response to technological improvements. These properties still may possess integrity if they retain sufficient features to convey their important associations during the property's period of significance.

Application of Evaluation Criteria

Information Needed to Evaluate Properties

To evaluate support and utility facilities at DoD installations, the following information is needed:

(1) location of the property;

(2) date of construction;

(3) historic appearance of the property;

(4) function of the particular buildings or structures at the time of its construction and its use prior to 1946;

(5) the primary mission of the installation between 1917- 1946; and,

(6) site-specific installation history.

Historic Districts vs. Individual Buildings or Structures

Military installations consist of properties in definable areas that were constructed for related activities directly associated with or in support of the primary missions of the installation. When conducting the identification and evaluation of historic properties on military installations, groups of buildings and structures, such as the cantonment or main base area, should be examined to determine if they meet the National Register Criteria for Evaluation as historic districts. Support and utility buildings and structures may be contributing properties in an historic district, even if the support and utility facilities lack individual distinction, and would not qualify for individual listing in the National Register. Support and utility buildings located in prominent sites within a cantonment or main base area often were designed to be compatible with the surrounding buildings. In some instances, support and utility buildings, for example power plants at industrial facilities, may possess a strong historical association with the district. Concentrations of support buildings and structures, notably storage facilities at depots, also may be considered as historic districts. To qualify as contributing properties within an historic district, support and utility properties must:

(1) possess a physical or historical relationship to the other contributing properties in the historic district; and,

(2) retain integrity from the historic district's period of significance.

Isolated, individual examples of support and utility buildings or structures typically are not good representatives of the important themes associated with military installations and their construction. Isolated support and utility facilities without a strong physical link to the other properties they supported usually do not convey the historical importance of the installation activity or its role in the overall development of U.S. military. Thus, isolated, individual support or utility facilities rarely possess important and specific associations with events (Criterion A). Isolated examples also seldom represent distinctive characteristics of a type, period, or method of construction (Criterion C).

The following sections provide guidance on the application of the evaluation methodology to each type of support and utility facility identified in this study. Guidance is provided for evaluating support and utility facilities as:

1. individual or separate buildings or structures;
2. contributing properties in historic districts; and,
3. historic districts themselves.

<u>Storage</u>

As military supplies and logistics increased in complexity to support the growing breadth and size of military operations, the military devoted more attention to the efficient storage of supplies. Prior to World War I, each installation needed only a few, small storage facilities; even depots, installations with the primary mission of storage, included a relative handful of storage facilities. During World War I, the Army erected large warehouse districts to handle supplies, while the Navy developed fleet supply bases and depots to coordinate the flow of supplies. During the inter-war period, few general storage facilities were constructed. During this same period, the military developed important new policies for ordnance storage that affected its design and construction. The logistical requirements of supplying a multi-front war during World War II dwarfed anything in the previous military experience. Vast storage depots were constructed to receive, store, and issue general supplies and ordnance.

<u>General Storage.</u> As individual buildings, general storage buildings rarely have important and specific associations with an historical event or pattern of events. Storage buildings are typically found at all installations, where they support the primary mission of the installation, such as training or industrial production. Storage buildings may contribute to an historic district if they are part of the concentration of properties that compose the historic district and retain integrity from the district's period of significance.

A complex of storage buildings built during wartime at a supply depot is associated with the theme of military logistical support for either World War I or II, or both. The military constructed storage depots during wartime to store goods and equipment for shipment to overseas theaters of war. General storage buildings are an important property type at supply depots, where the primary mission of the installation was to receive, store, and distribute supplies. While no one supply depot made the difference in the outcome of World War I or World War II, the cumulative effect of these facilities was the effective distribution of critical supplies to armed forces at distant fronts. During World War I, the Navy developed a new type of installation, the naval operating base, specifically to supply the fleet. During World War II, which was characterized as a war of resources, the role of logistical support was particularly important. A supply depot must have an important and specific association with wartime logistical support to meet Criterion A. Supply depots from World War I and from World War II also may illustrate distinctive types of wartime mobilization construction (Criterion C). To possess integrity as a representative example of a supply depot, a property should maintain the character-defining features of a supply depot from the period(s) of significance. These include the organization and layout of the depot, the number, location, design, and construction materials of the warehouses, and the roads, piers, and/or rail lines that provided the depot's essential transportation network.

Ordnance Storage. As individual structures, ordnance storage structures rarely have important and specific associations with an historical event or pattern of events. Single examples or small groups of ordnance storage structures may be found on many types of installations, such as air stations, artillery training posts, or ordnance research and testing facilities. The ordnance storage structures were constructed to support the primary mission of the installation. Above-ground ordnance storage buildings sometimes were located near other buildings, such as near an airfield or a testing range; in those cases, individual ordnance storage facilities may be considered as contributing buildings in an historic district. However, isolated examples of installation ordnance storage are not near enough to the main areas of an installation to be included in a main base or cantonment historic district and do not possess important and specific associations with the historical mission of non-depot installations to qualify as historic districts on their own merits.

Ordnance depots (Army) or ammunition depots (Navy) were installations constructed specifically for the safe storage and distribution of military ordnance. These installations primarily are associated with the theme of military ordnance storage. During the inter-war period, the military developed specific requirements for the safer design and construction of ordnance storage facilities. World War II ordnance depots, in particular, represent these new design standards. Ordnance storage structures are an important property type at ordnance or ammunition depots, where the primary mission of the installation was to receive, store, and distribute ordnance. As with supply depots, no one ordnance storage facility made the difference in the outcome of World War I or World War II, but the cumulative effect of these facilities was the safe storage of ammunition critical to armed forces at distant fronts. This was particularly notable during World War II, which was characterized as a war of resources. An ordnance depot must have an important and specific association with either the development of new ordnance storage standards or an important, specific association with wartime ordnance storage to meet Criterion A. Ordnance and ammunition depots from the inter-war and World War II periods may illustrate a distinctive type of construction (Criterion C). Naval ammunition depots during World Wars I and II also served as ammunition loading plants, in which case they should be evaluated within the context of manufacturing plants.

To possess integrity as a representative example of an ordnance or ammunition depot, a property should maintain the character-defining features of a depot, as a whole, from the period(s) of significance. These include the organization and layout of the depot, the number, location, design, and materials of the ordnance storage structures, and the roads and rail lines that provided the depot's essential transportation network.

Fuel Storage. Fuel storage facilities may be located near concentrations of other buildings, or in isolated locations. For example, a few fuel storage facilities typically are located near the pier area of naval bases and near the flight line at airfields and air stations. In these cases, if the surrounding properties qualify for listing as an historic district, the fuel storage facilities may be considered as contributing properties for their supporting function if they retain integrity from the historic district's period of significance. However, fuel storage facilities lack individual distinction and do not have an important and specific association with an historic event or patterns of events. They also do not represent a distinctive type, period, or method of construction. Thus, individual examples or groups of fuel storage facilities that are not contributing properties in historic districts do not meet the National Register Criteria for Evaluation.

Utilities

During the military's construction efforts during and after World War I, increased attention was paid to providing modern infrastructure at military installations. The modern infrastructure was built for two purposes. First, power plants provided energy for industrial purposes at arsenals, shipyards, and ordnance plants. Second, the improved infrastructure was part of an effort to improve the standards of living at military installations by providing the same public services typically found in civilian communities of comparable size. The military did not originate infrastructure technology, but followed the lead of civilian communities and industries in the application of modern utilities. Utilities built to produce energy for an installation's mission-related activities have a stronger association with the relative significance of the installation than do generic utilities built to provide ordinary water, sewer, heat, and trash disposal services.

Most individual examples of utility infrastructure at military installations do not represent important themes associated with military installations and their construction. These facilities were built to support the primary functions of the installation, and typically qualify for listing in the National Register only as contributing elements to historic districts. Unlike storage buildings and structures, utilities were not built in concentrations sufficient to constitute an historic district by themselves. The location of utilities in relation to the main area of the installation affects their ability to be considered as part of an historic district. Isolated utilities without important associations to historical events or that are not representative of distinctive design or construction are not eligible for the National Register.

Water supply systems. Water supply system properties may contribute to an historic district if they are related physically or aesthetically to the historic district. Isolated water supply systems and their attendant facilities are not significant under Criterion A. In one identified instance, a water treatment plant embodied the distinctive characteristics of a particular period of construction (Criterion C). In this instance, a 1938 water treatment plant at Ft. Knox, Kentucky, was designed in the Art Deco architectural style that typified many federally-funded public works projects of the 1930s (Figure 47). It is located near, though not within the main cantonment. In contrast, a 1943 water treatment plant built at Ft. Knox is located at a distance from the main cantonment and does not possess architectural significance (Figure 48).

Sewage disposal systems. Sewage treatment plants typically are located apart from the main cantonment or base. Sewage disposal systems at military installations lack individual distinction and do not have an important and specific association with an historic event or patterns of events. They also do not represent a distinctive type, period, or method of construction. Therefore, as a category of properties, they do not meet the National Register Criteria of Evaluation.

Power and heating systems. Power plants have a direct historical association with industrial installations, such as shipyards, arsenals, and ordnance plants, where they supplied the power for the industrial operations of these installations. In these cases, the power plant is often a prominent building located near the heart of the industrial area. At these type of installations, the power plant may be a key contributing building to an historic district if it retains integrity from the historic district's period of significance.

Heating plants were part of the wave of infrastructure that was installed at military installations to improve standards of living. As such, they do not have an important and specific association with an historic event or with the purpose of the installation. In cases where the heating plant is part of a complex of buildings or located within the main installation area, it should be assessed for its potential as a contributing element to an historic district. Distinct areas within an installation, such as hospitals, often were equipped with district heating plants. Isolated, individual heating plants do not possess individual significance unless they reflect a particular period, type, or method of construction.

Refuse disposal. Refuse disposal facilities typically were located apart from the main cantonment or base. Refuse disposal facilities at military installations lack individual distinction and do not have an important and specific association with an historic event or patterns of events. They also do not represent a distinctive type, period, or method of construction. Therefore, as a category of properties, they do not meet the National Register Criteria of Evaluation.

CHAPTER XIII

TREATMENT PLAN

This section of the report presents recommendations for the treatment of support and utility facilities constructed between 1917 and 1946 at Department of Defense (DoD) installations that are eligible for listing in the National Register of Historic Places. These recommendations were developed in accordance with the National Historic Preservation Act of 1966, as amended, and its implementing regulations and guidelines, including "Protection of Historic Properties" (36 CFR 800), and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation.

Treatment of Historic Properties

The National Historic Preservation Act (NHPA) of 1966, as amended, and DoD regulations require that the Department of Defense incorporate the consideration of historic properties in the project planning process. The process used by federal agencies to meet this responsibility is commonly called "the Section 106 process." Historic properties are those properties that are included in or are eligible for inclusion in the National Register (36 CFR 800.2(e)). Thus, properties that do not meet the National Register Criteria for Evaluation are not subject to the full Section 106 process.

NHPA and its implementing regulations recognize that preservation of historic properties, while a preferred option, may not be a feasible alternative. Responsible management of cultural resources requires the development of treatment strategies tailored to the significance of the historic property to mitigate any adverse effect that a federal action may have on the property. Once properties under DoD jurisdiction are identified and evaluated, DoD can develop appropriate treatment strategies for those properties that DoD determines meet the National Register Criteria for Evaluation.

Summary of Treatment Options

The Secretary of the Interior's Standards for the Treatment of Historic Properties identifies treatments for historic properties including preservation, rehabilitation, restoration, and reconstruction. Only preservation and rehabilitation are applicable to the support and utility facilities documented in this study. Preservation is the maintenance and repair of a property's existing historic materials and design as it evolved over time. Rehabilitation is the process of making an efficient compatible use for a property possible through repair, alterations, and additions, while still preserving the significant portions of the property.

Documentation can be used to mitigate the effects of demolition or substantial alteration of an historic property through preserving information about that property. Section 110(b) of NHPA requires federal agencies to record historic properties that will be demolished or substantially altered by federal actions. Documentation includes photographic and written documentation, and oral and video histories. The Secretary of the Interior's Standards for Architectural and Engineering Documentation identify standards for recording historic structures. Documentation often includes drawings or plans, photographs, written text, and maps. This type of documentation typically follows the standards established by the Historic American Buildings Survey and Historic American Engineering Record (HABS/HAER), which is administered by the National Park Service. In selecting an appropriate level and type of documentation, it is essential to define why and how a property is significant in order to ensure that the documentation captures the historical associations that make a property significant and the qualities of the property that convey its significance. Federal agencies determine if documentation is needed and the appropriate level and type of documentation in consultation with the State Historic Preservation Officer (SHPO).

Programmatic Agreements

Programmatic Agreements (PA) enable federal agencies to streamline the Section 106 process by allowing programs with similar and repetitive or nationwide effects on historic properties to be reviewed as a whole rather than as a series of individual reviews. Under Programmatic Agreements, an agency can achieve compliance with the Section 106 process for an entire program, instead of for each individual project or for each property affected. Federal agencies develop Programmatic Agreements in consultation with the Advisory Council on Historic Preservation, and with the SHPO of the relevant state(s). When the Programmatic Agreement covers a national program, the Advisory Council invites the National Conference of State Historic Preservation Officers to participate as a consulting party.

DoD has successfully utilized this approach for programs that resulted in repetitive actions at similar historic properties on multiple installations. Examples of previous Programmatic Agreements relevant to this study of support and utility buildings include:

- a 1986 PA to document World War II temporary buildings, prior to their demolition under the Military Construction Authorization Bill for 1983;
- a 1993 PA concerning a program to cease maintenance, excess, and dispose of World War II-era Army Materiel Command installations.

The PA for World War II temporary buildings stated that World War II temporary buildings may meet the National Register Criteria for Evaluation, and stipulated extensive documentation of the historic context for this type of construction and documentation of one example of all major building types. The Department of the Army completed their responsibilities under the World War II temporary buildings Programmatic Agreement in 1993 (November 16, 1993 letter from Lewis Walker, Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health) to Robert Bush, Executive Director, Advisory Council on Historic Preservation). The Department of Navy also has completed their responsibilities under this PA (Druscilla Null, Advisory Council on Historic Preservation, personal communication). General storage buildings are the only category of support and utility buildings likely to have been built according to temporary construction plans. The demolition of World War II temporary support buildings under the Congressional order does not require initiation of the Section 106 process. However, if a DoD undertaking involves other actions in addition to the demolition of World War II temporary buildings, Section 106 consultation is required.

The PA for Modified Caretaker Activities for Army Materiel Command (AMC) properties adopted a comprehensive, program-wide approach to installation cultural resources management. Rather than conducting extensive inventory, evaluation, and documentation and implementing PAs at each installation, AMC determined that all of their World War II facilities were potentially eligible for the National Register and pro-actively proposed to mitigate the adverse effects of their program to dispose of these properties. The PA was developed in consultation between the Department of the Army, Advisory Council, and SHPOs in the particular states. The PA stipulated that the documentation would include: (1) preparation of a thematic context for the World War II Ordnance Department mobilization; (2) archival-quality photographs of archetypal production lines and major non-production buildings or structures; and (3) preservation of records and consultation with the Center for Military History on the possible preservation of historic equipment. This approach provided consistent recordation of the properties' significance without requiring extensive and costly individual inventory, evaluation, nomination, and documentation. Undertakings that affect support and utility buildings and structures at AMC installations covered by this PA do not require additional review under the Section 106 process.

Treatment Plan

The selection of the appropriate treatment for historic properties depends upon the significance of the historic property and the requirements of the federal agency program.

Depots

Supply depots and ordnance/ammunition depots may meet the criteria of the National Register of Historic Places. Base realignment or closure may affect these properties. Older ordnance storage structures often are smaller than required for modern ordnance and cannot accommodate mechanized loading. A program to demolish or excess these properties would have an adverse effect on a potentially eligible class of properties. If DoD, a service branch, or command, initiates a program that would potentially affect pre-1946 depots, this group of properties is a good candidate for a programmatic agreement. Storage buildings and structures typically are repetitive buildings that are relatively easy to identify and categorize. A programmatic agreement similar to the Programmatic Agreement for AMC World War II installations may be an appropriate mechanism for complying with DoD's Section 106 responsibilities if a program is initiated that will adversely affect depots. The historic contexts developed in previous studies may be used as the background historic contexts for the documentation.

Active-duty supply and ordnance/ammunition depots are listed in Chapters IV and V. Appendix E includes tables that describe the distribution of storage buildings and structures at DoD installations.

Support and Utility Buildings and Structures at Other Types of Installations

Contributing Properties in Historic Districts. Preservation is the preferred treatment for support and utility buildings and structures that are contributing properties in historic districts. Adapting the property for a compatible use in a manner that retains the property's character-defining features of the property and does not adversely affect the historic district is also a recommended treatment.

In instances where preservation or rehabilitation are not feasible, documentation may be an appropriate treatment to mitigate the adverse effects to the historic property. The level and type of documentation depends on the relationship of the property to the historic district. For properties that lack individual distinction, fulfilled a minor, support function in relation to the district's historical significance, and are not an important factor in the district's physical setting or character, the following documentation may be appropriate: current photographs of the principal exterior views of the property; photographs of the property's setting and relationship to the historic district; location map; information on the date of construction and functions of the property; and, relevant portions from Chapters III - X of this report that provide information on the historic context and property type. For properties that are directly related to the significance of the historic district or that are major elements of the district's physical setting or character, the following documentation, in addition to the above-listed documentation, may be appropriate: original plans or drawings, either of the specific property or standard plans, that depict the significant features, including mechanical systems, where relevant; and a narrative discussion of the property's relationship to the historic context of the historic district.

Isolated examples. Isolated individual or groups of support and utility buildings and structures that are not related directly to the primary mission of the installation rarely are eligible for the National Register, and thus do not require the development of a treatment plan to mitigate possible adverse effect to these properties in the future.

Application of this Study

The following recommendations provide guidance on the application of this study in DoD's on-going cultural resource management program.

Department of Defense

1. Notify commanders of this study and its application to their efforts to comply with the National Historic Preservation Act of 1966, as amended:

    - Section 110(a)(1): Assuming responsibility for preservation;
    - Section 110(a)(2): Locating, inventorying, and nominating properties to the National Register;
    - Section 110(b): Documenting historic properties adversely affected by federal undertakings; and,
    - Section 106: Considering the effects of federal undertakings on historic properties.

2. Coordinate with the Keeper of the National Register of Historic Places. Seek agreement on the appropriate historic contexts for evaluating support and utility properties, and the methodology described in this report.

3. Notify State Historic Preservation Officers (SHPO) of this study, and its application to the identification, evaluation, and treatment of support and utility properties at DoD installations.

Service or Major Command

1. Determine if the agency plans to undertake a program that may affect National Register-eligible support and utility facilities at multiple depots. If so, initiate consultation with the Advisory Council on Historic Preservation to develop a Programmatic Agreement to take into account the effect the action(s) may have on historic properties.

Installation or Activity

1. Identify and evaluate support and utility buildings and structures. Determine if they meet the National Register Criteria for Evaluation applying the methodology presented in this report.

2. Notify SHPO of determinations of eligibility. Provide the SHPO with the following information: relevant sections of this report and site-specific data.

3. Incorporate data from this report into installation Cultural Resource Management Plan (CRMP), Historic Preservation Plan (HPP), or Historical and Archeological Resources Protection (HARP) Plan.

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APPENDIX A

ABERDEEN PROVING GROUND, MARYLAND, SITE VISIT SUMMARY

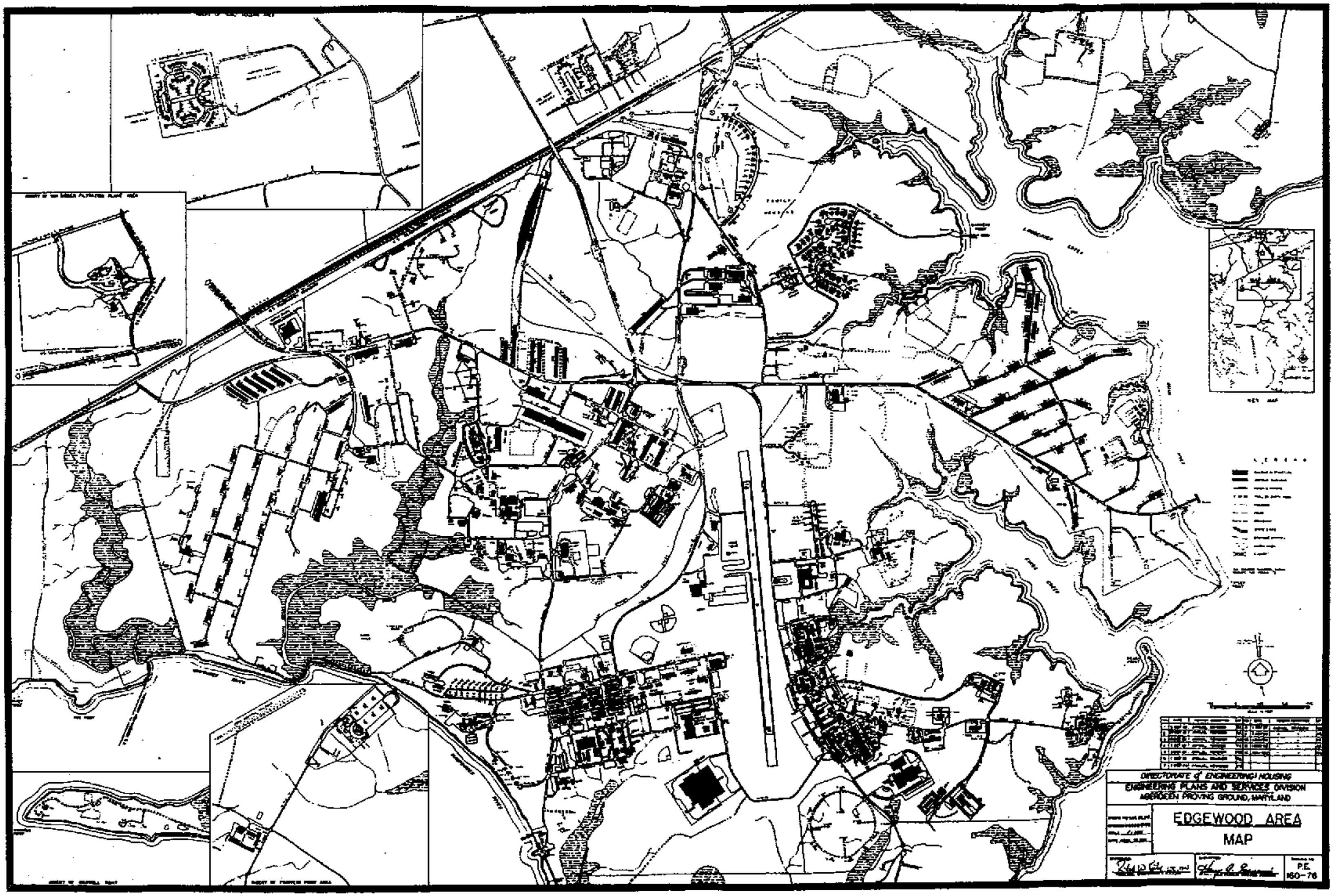

Figure A-2 Map of Edgewood Area, Aberdeen Proving Ground, Maryland

The main portion of the installation occupied the northern portion of Bush Neck. The Main Front was established as the main firing range and projectiles were aimed south of the main installation. The headquarters building, major shops, and storage buildings were located just north of the main front. The hospital and barracks occupied Plumb Point.

Activity at the installation slowed during the Inter-war years in response to the limited funds. Some research and development activity continued during this period, including the development of the 105mm howitzer. Work also resumed on the development of powder, projectiles, bombs, and other artillery. During the 1930s, a permanent housing area was established on Plumb Point; permanent brick buildings were constructed along the Main Front; and, permanent buildings were added to the administrative and shop area. A small airfield, Phillips Field, was located southeast of the Main Front. A new educational complex was located west of the administrative area and the Main Front.

With the approach of World War II, the Army established other proving grounds to keep pace with increased wartime production. Throughout the war, Aberdeen Proving Ground served as the Army's principal ordnance research and testing facility. The Main Front served as the operational core of the facility where the central testing mission was implemented. Ordnance Department personnel continued to perform acceptance testing and research, development, and testing for new weapons designs. Research was conducted on ammunition, armor, aviation armament, ballistic research, rockets, and automotive engines. In November 1943, Aberdeen Proving Ground was recognized as the Ordnance Research Center. During the war, the number of buildings increased and utility systems were expanded. Waste removal systems included incinerators and a sewage treatment plant. As additional complexes were located beyond the range of the steam lines of the main power plant, the Army constructed additional district heating plants.

Building Types

<u>Storage-General</u>

Aberdeen Proving Ground contains many types of storage buildings, both general and specialized. Aberdeen Proving Ground has two defined storage areas. Other storage buildings are distributed throughout the installation to support specific activities. Tracking original-use storage buildings was difficult. In several cases, buildings are identified on the Army real property inventory by tenant activity, though the main function of the building is to store equipment or supplies. In other cases, the current use classifications reflect the adaptive reuse of buildings not originally constructed for storage.

The historic storehouse area was located in the center of the administrative area. Two early storehouses are Buildings 320 and 321. Constructed in 1918, both buildings are long one-story brick buildings with multiple loading doors located along the side elevations. Building 320 was constructed for the Ordnance Department; Building 321 was constructed for the Quartermaster and Commissary Departments.

The largest group of general storage buildings contains Buildings 501, 502, 503, 504, 505, 506, 507, 509, 510, and 530. These long one-story buildings with multiple loading doors located along the side elevations were constructed in 1919 as field service warehouses to store material after World War I. The buildings are located near railroad sidings east of the Main Front.

Inflammable material storehouses are small one-story buildings that stored small amounts of inflammable materials, such as petroleum products (e.g., grease and lubricating oils), paints or other substances that were necessary in shop, repair, or maintenance activities. During the 1930s, inflammable materials storehouses typically were constructed of masonry. Building 531 was constructed in 1934 as an oil house for the plate range. During World War II, the inflammable materials storehouses often were metal frame buildings with corrugated metal siding (Building 312), located to support shop and maintenance complexes. They provided a separate, secure place to contain potential fire damage from inflammable materials.

A specific building type was constructed for one kind of inflammable material. Oil storage buildings were one-story buildings with front gables. Building 341, a brick oil house constructed in 1934, and Building 337, an oil house and gas station completed in 1942 are examples of this type of storage building.

One specialized type of storage building is the heavy materials storage building (Building 342, 1934). This tall and long one-story building had large sliding doors on either end of the building. It probably had an interior crane to move heavy materials; currently the building serves as a print shop.

Other specialized storage buildings identified at Aberdeen Proving Ground include storage for mobile artillery and lumber. Mobile artillery storage buildings are one-story brick buildings characterized by multiple door openings along the side elevations. They store mobile artillery and are garages similar to gun sheds. The lumber storage building (Building 336) is a long, brick building with a clipped gable roof along the side elevation. One half of the length of the building is used as garage storage and is enclosed with wood doors. The other half of the building is open along the side elevation for lumber storage.

Aberdeen Proving Ground has one cold storage building (Building 4025). This building was constructed as a temporary building from 700 series plans. It was located in a group of temporary mobilization Quartermaster warehouses. Since its construction, the building has been remodeled into a permanent building.

Storage-Ordnance

Aberdeen Proving Ground has many types of ordnance storage. These buildings are located throughout the installation to support test missions. In general, there are two types of ordnance storage structures: above-ground and earth-covered. Examples of both types of storage are extant at Aberdeen Proving Ground.

Seventeen powder magazines, including Buildings 375 and 376 (constructed in 1934), were identified at Aberdeen Proving Ground; they measured approximately 8 x 8 feet or 10 x 12 feet. The powder magazines are small one-story cubes, constructed of masonry, with a single door in the front. The buildings are constructed of brick or concrete with concrete shed roofs that exhibit lightning protection. This building type is the direct descendant of the small gable-roofed black powder magazine found at nineteenth-century frontier posts. Powder magazines are located throughout the testing areas of the Aberdeen Proving Ground.

Two segregated magazines were identified at Aberdeen Proving Ground (Buildings 655 and 657, 1941-1942). These buildings have a shed roofs with multiple entries along the front elevation. Constructed of a concrete frame, the walls are infilled with brick. A variation of this type is a concrete-framed, shed-roofed building with a single entry in the end elevation. Buildings 706, 707, 708, 735, and 741 (constructed in 1943) are examples of this type.

Four post ordnance storage buildings were identified during the site visit, represented by Buildings 440, 441, and 442 (constructed in 1918-1919) and Building 435 (constructed 1934).

These buildings are one-story with gable roofs and a single entry in the gable end. Building 435 a structural clay tile building built from Quartermaster standard drawing 652-297 labeled a standard magazine for bulk high explosives, primer and fuze, or standard post ordnance magazine. Buildings 440-442 are clad with corrugated metal siding.

One example of a standard ammunition magazine is Building 742, constructed in 1934. This building was constructed from structural clay tile from Quartermaster plans 652-297, 652-305, and 6265-13A, 5480. Its three primary openings are located along the side elevations rather than in the front gable end. The dimensions of this building are approximately 138 x 51 feet. The 51-foot width became standard for structural clay tile magazines constructed during the inter-war period and throughout World War II.

Aberdeen Proving Ground has 15 earth-covered, reinforced concrete igloos completed in 1930. These igloos are among the first igloos completed after the 1926 explosion of the Lake Denmark Naval Ammunition Depot. Each igloo measures 26 x 42 feet.

In 1943, five earth-covered rectangular boxes were constructed at Aberdeen Proving Ground. These structures measured 12 x 10 and 18 x 22 feet were constructed in 1943.

Water Supply

The earliest water supply building at Aberdeen Proving Ground was Building 252, a square, covered, concrete reservoir constructed in 1918. This building is located at the western end of the Main Front and forms the core of the on-installation water supply.

Plans reveal that there was a water filtration plant at Aberdeen Proving Ground during World War I, but it is no longer extant. In 1934, Building 250 was constructed to house the water filtration equipment. It is a two-story, Colonial Revival building with a Palladian window in the front gable end. Nearby are two pairs of steel-tanks used for water storage. This water filtration plant treated water pumped from the ground by nearby water wells. In 1942, a concrete block water reservoir (Building 253) was constructed to store filtered water. Two World War II-era water wells are located nearby.

During World War II, Aberdeen Proving Ground acquired property near Deer Creek, approximately nine miles northwest of installation, to expand its water supply. Water is pumped from Deer Creek to a water treatment plant located four miles away. The Chapel Hill Water Treatment Plant comprises sedimentary basins, a filter building, and a clearwell. Water is pumped five miles to Aberdeen Proving Ground.

Two elevated water storage tanks are located on Aberdeen Proving Ground. Building 99, constructed in 1934, is a steel frame, steel tank elevated tower constructed northeast of the Headquarters building and east of the 1930s housing area. The second elevated water tower (Building 2230, 1941) served the water distribution needs of Camp Rodman, a World War II temporary camp constructed as part of the Ordnance School.

One building was constructed as a water pump station with a separate metal storage tank. It was located near the original Phillips Airfield, an enclave that comprised a barracks building, district heating plant, a garage, and a hangar.

Sewage Treatment

The Army constructed a sewer system for Aberdeen Proving Ground when it was established. The underground sewer lines carried sewage directly to the Chesapeake Bay and Swan Creek. During World War II, a primary sewage treatment plant was established east of the administration area. The complex served the main post, main housing area, and the Ordnance School. The 1940s sewage treatment plant comprised primary settling tanks (Building 417, 1941), a wet well and pump house (Building 398, 1941), two sludge digesters (Building 399, 1945), and sludge drying beds. The primary settling tanks and the sludge digesters are poured concrete structures. The wet well and pump house is a one-story brick building. In 1983, the sewage treatment plant was improved to conform to modern standards. The system was reconfigured; for example, Building 417 is now the final settling tank.

Most of the sewer system operated on gravity. Where gravity operation was interrupted by terrain, lift stations (called sewage pumping stations in real property inventory category codes) were constructed to force sewage through the mains. Aberdeen Proving Ground has seven sewage pumping stations that date from World War II. These pumping stations are located throughout the installation. The buildings are one-story buildings, constructed of masonry (concrete block or brick), with gable roofs. Materials were chosen to reflect nearby construction.

Power and Heating Plants

Building 345 was constructed as the original heating and power plant. The coal-fired brick plant had the capability to generate electricity, compressed air, and steam heating. The brick structure occupies a central position on the installation and serves the Main Front testing area and the administrative/shop area. Equipment in Building 345 was removed and replaced during World War II. In 1994, the World War II-era equipment was removed and replaced with modern boilers that provide steam heat to 62 buildings in the immediate vicinity. The central power plant remained coal-fired until the 1950s, when it was converted to oil. Two steel oil storage tanks constructed in 1953 are located near the building.

An auxiliary diesel-fueled generator plant (Building 318) was constructed in the shop area. This plant was used to charge batteries and contained two electric generators as an auxiliary/stand-by power supply. This building, constructed in 1943, has prefabricated synthetic board exterior walls with a transite skirt at the foundation.

Aberdeen Proving Ground has 13 district heating plants constructed between the 1918 and 1946. The typical district heating plant is a small, one-story, masonry structure. In general, the exterior design and materials reflected surrounding construction. Two boiler plants (Building 3062 at the U.S. Army Ordnance School, 1940, and Building 455 at the original Phillips Airfield, 1935) were constructed as part of complexes and exhibit construction materials and architectural style that complement the main buildings of the complex. Other district heating plants are utilitarian in appearance and constructed of concrete or concrete block. For example, eight boiler plants are identical and were constructed to heat educational buildings constructed for Camp Rodman in 1941. The concrete-block boiler plants are located between two educational buildings and form three-building complexes.

One major modification to district heating plants is the removal of original smoke stacks. In most cases, the district heating plants originally were coal fueled. During the 1950s, many of the plants were converted to oil and the smokestacks were removed.

In addition to district heating plants, some buildings were constructed with their own furnaces. The 1930s permanent residences and barracks were equipped with individual heating plants in each building and were not served by the central power plant.

The primary electricity source was the local utility company through transmission lines, substations, and distribution transformers. During permanent construction in the 1930s, the electrical needs of the housing area were served by seven distribution transformer buildings that were placed throughout the housing area (Buildings 6, 19, 46, 51, 59, 85, 108 in 1935; Building 2022 in 1941). The distribution transformer buildings were designed to complement the architecture of the housing area. The same materials, i.e., stone and slate, were used in the construction of these small buildings.

Two designs of distribution transformer buildings are represented at Aberdeen Proving Ground. One design has a metal door in the front gable-end; the other design has a door opening in the side. Two distribution transformer buildings were constructed during World War II (Buildings 1061 and 1081). These buildings distributed electricity to specific areas of the installation. Building 1061 served the World War II airfield.

During World War II, outdoor substations were established at Aberdeen Proving Ground. Concrete pads were placed throughout the installation and equipment was installed on them (Buildings 123, 333). The equipment continually has been renewed, but the original date of the construction of the concrete pad is reported in the real property records. In the case of Building 333, drawings indicate that the one-story, brick substation building was constructed in 1957.

<u>Refuse</u>

Aberdeen Proving Ground has two incinerators (Buildings 5010 and 5011, scheduled for demolition) that were constructed in 1941. The two buildings are located south of a Quartermaster warehouse area of one-story World War II temporary warehouses. The two incinerators are separated by a road that served as the unloading point for trash. The two buildings each have poured, reinforced-concrete foundations and exposed basement with a steel-frame building sided with corrugated metal at the first floor level. Each building has a gable roof clad with corrugated metal siding and a large detached smokestack.

Historically, refuse was unloaded onto the raised platforms from trucks. The refuse was shoveled into the incinerator through a hole in the floor. The incinerator compartments were located in the basement. The incinerator was oil-fired at the beginning of a session and at the end; otherwise, the garbage was allowed to burn naturally. Ash was removed from the incinerator from the basement level through a large sliding metal door located on the rear elevation.

Historical Background: Edgewood Arsenal

Edgewood Arsenal, Maryland, was established in 1918 as the only U.S. chemical weapons production installation (Figure A-2). Located on property originally acquired for Aberdeen Proving Ground, Edgewood's chemical production plants were designed to produce chlorine, mustard gas, chlorpicrin, and phosgene. Because it was a chemical production plant, the installation was constructed with its own power generating equipment, secondary power supply, and an extensive water supply system, both for potable water and for fire protection. The production plants required storage, both general and ordnance, to accommodate raw materials and finished products.

Following World War I, Edgewood Arsenal remained a permanent installation; however, the level of activity was reduced and many production lines were closed. The Chemical Warfare Service was established as a separate entity from the Ordnance Department under the National Defense Act of 1920.

During the inter-war period, Edgewood Arsenal was designated the headquarters for research, production, and training for the newly created Chemical Weapons Service. This branch was established to develop methods of protection against enemy chemicals and to employ offensive chemicals. The Chemical Warfare School, which trained both Army and Navy personnel, was relocated to the installation in 1922 to train chemical warfare specialists.

With the approach of World War II, the Army's interest in chemical warfare revived. Beginning in 1939, the service renewed its development of toxic agents, protective gear against these agents, and chemical weapons at Edgewood Arsenal. At the beginning of the Protective Mobilization period, existing chemical production facilities at Edgewood Arsenal were renovated. Between 1939 and 1941, the production plants were placed on stand-by status in preparation for major activity. Immediately following the mobilization phase, permanent construction activity at Edgewood Arsenal concentrated on buildings for production, assembly, storage, and shipment of chemical weapons. New chemical, industrial, and shell-loading plants were constructed to produce toxic chemicals weapons. Additional mixing, storage, and support buildings were added to Edgewood Arsenal's World War I-era phosgene plant, the pilot plant, the cyanide plant, and the mustard gas plant. Two new pilot plants also were constructed: the Adamsite Pilot Plant and the Impregnite Plant.

During the late 1930s, Edgewood Arsenal was designated the Eastern Chemical Depot. Permanent warehouses were constructed and transportation access was expanded. Rows of above-ground magazines were located along railroad lines both for the depot and to support increased manufacturing activities at the installation. The new storage areas encircled Edgewood Arsenal's industrial core.

Building Types

<u>Storage-General</u>

The identification of general storage buildings at Edgewood Arsenal was based primarily on original uses determined from original drawings and historic real property records. Current use classifications now categorize many ordnance storage buildings as general storage buildings.

General storage buildings were constructed at Edgewood Arsenal to store inert materials for production plants and specialized materials for specific activities. During World War I, storage buildings generally were disbursed throughout the installation. During World War II, general storage buildings were clustered at three main locations at the installation.

The oldest general storage building located at Edgewood Arsenal was Building E1890, constructed in 1918 for the inert storage of empty shells. It is one-story and measures approximately 100 x 700 feet. Its walls are clad with corrugated metal and asbestos siding. Originally, the building had loading doors located along the long elevations for access to railroad tracks.

During World War II, the number of general storage buildings increased. In 1942, eight structural clay tile general warehouses were completed at Edgewood Arsenal. Similar to World War II standard ordnance magazines, these buildings are five-bays long (240 feet) with five sliding loading doors. Construction drawings identified these buildings as general storehouses. These buildings were located at the western edge of the Eastern Chemical Depot. Longer structural clay tile (496 feet) buildings also were constructed. These buildings were located in the industrial area to store materials required for the industrial plants.

Other designs of general storage buildings were identified at Edgewood Arsenal, reflecting the changes in construction materials and their availability. Two groups of general storage buildings (represented by Buildings E2194-E2198 and E5026-E5027), completed in 1941, were constructed of concrete with bands of steel-sash windows along the eave line. The buildings have multiple loading doors with concrete platforms located along their long elevations. One storage group is located north of the industrial area to support industrial production; the other group was constructed for the Eastern Chemical Depot located east of the industrial area.

By 1945, general storage buildings were constructed of metal frame with corrugated transite exterior walls. Buildings E5910-E5915 illustrate this method of construction. The buildings have no window openings; multiple loading doors with concrete platforms are located along their long elevations.

A few small buildings at Edgewood Arsenal are classified as inflammable storage buildings. Building E1936 was constructed in 1918. It is a one-story building constructed of structural clay tile with a gable roof.

Storage-Ordnance

Examples of ordnance storage at Edgewood Arsenal include above-ground and earth-covered buildings. Seven World War I ordnance storage buildings remain from World War I. The majority of ordnance storage buildings were constructed during World War II. The western storage area served the shell loading plants. The eastern ordnance storage area was the Eastern Chemical Depot. No Corbetta Beehive magazines were identified.

The World War I magazine area was located north of the industrial area. The area comprised ten above-ground ammunition magazines located in four rows spaced 100 feet apart and linked through railroad lines (U.S. War Department, Construction Division 1919b:109-115). The 1918 magazines (Buildings E1930, E1932, E1942, E1950, and E1958) measure approximately 100 x 202 feet. They are constructed of structural clay tile and have monitor roofs. Currently the five buildings are classified as general purpose warehouses.

Two above-ground powder magazines (Buildings E2148 and E2150) are located in an isolated area east of the magazine area. Constructed in 1919, these buildings are small one-story structures, constructed of structural clay tile. They have shed roofs and a single door in the front elevation.

During World War II, the number of ordnance storage buildings at Edgewood Arsenal increased substantially, primarily through the addition of ammunition magazines and smokeless powder magazines. Constructed in structural clay tile from standard plans, the ammunition storage buildings varied in length, from six, ten, or eleven bays. Edgewood Arsenal has 14 six-bay magazines (represented by Buildings E5844-E5848) and 23 ten-bay magazines (represented by Buildings E5884-E5896). The exterior doors, located along the long elevations, are sliding wood doors sheathed with metal. Metal ventilators line the roof line of each magazine; the number of ventilators generally equals the number of door openings.

Smokeless powder magazines at Edgewood Arsenal are two-bay buildings constructed of structural clay tile. Seven smokeless powder magazines (represented by Buildings E5868-E5870) are located in the ordnance storage area west of the industrial area.

In addition, four four-bay magazines are located at Edgewood Arsenal. These four buildings, completed in 1943, have wood frames and structural clay walls. These buildings were completed under the constraints imposed by construction material shortages.

A special type of magazine is represented by three buildings (Buildings E2630, E5864, E5866) constructed at Edgewood Arsenal to store white phosphorus chemical munitions. These buildings are structural clay tile with six loading doors along the sides. They have stepped firewalls that define and isolate each bay of the building.

No earth-covered storage structures were constructed at Edgewood Arsenal until 1941. Construction of igloos and rectangular boxes were disbursed throughout the installation. In 1941, six concrete igloos, measuring approximate 26 x 40 feet, were constructed. In 1943, 13 arched corrugated metal igloos, measuring approximately 11 x 20 feet, were constructed. In addition, two earth-covered rectangular boxes, measuring approximately 10 x 12 feet, were identified at Edgewood Arsenal.

Water Supply

During World War I, Edgewood Arsenal had two independent water supplies: a salt water supply pumped from the Bush River and a fresh water supply pumped from Winters Run augmented by installation wells (U.S. Department of Interior, Historic American Buildings Survey 1982). At a location along Winters Run, the Army constructed a permanent dam and a pumping station. Water was pumped from the stream into two settling tanks. In the tanks, it was treated with a coagulating solution to remove organic matter. Water was then decanted through mechanical filters and pumped to a distributing reservoir. At the pumping station, water was treated with chlorine. The water traveled through a pipe line to a reservoir (Building E6150). The enclosed reservoir had a concrete foundation, metal walls and a 1,750 gallon storage capacity. Earth was bermed around the structure. Nearby was a valve house (Building E6151) constructed of structural clay tile walls. The water was pumped to the installation and distributed through cast-iron water lines (U.S. War Department, Construction Division 1919c:29-30).

During World War II, the fresh water supply along Winters Run was expanded. A large open reservoir was established when the reinforced concrete Atkisson Dam (Building E6000) was completed in 1942. A gate house (Building E6001) was located near the dam. The water was piped to the Van Bibber water treatment area. A chemical storehouse (Building E6105) was added to the treatment area. The water was pumped to Edgewood Arsenal.

During World War II, ground water was tapped through the construction of nine water wells with pumping houses in 1941. The wells are scattered throughout the installation. The water was pumped to Building E5236 (1941) for treatment. This concrete building is detailed with scored bands at the eave level. The stepped parapet roof is incised with the date of completion. The building is composed of two height levels: a two-story section and a one-story wing. During the 1980s, the State of Maryland declared the water wells contaminated and the water treatment plant was shut down.

Eight elevated water storage tanks are located on Edgewood Arsenal; one dates from 1918 and seven date from World War II (1941-1942). All of the tanks are steel supported by steel frames. The major difference between the 1918 tank and the World War II tanks is size and capacity. The World War II elevated water storage tanks are visibly larger. The tanks are located throughout the installation; four are located in the industrial area; two, in residential areas; and, two, in storage areas. Currently only three of the elevated water storage tanks provide potable water. The other five are used to control water supplies to district heating plants or for fire protection.

Sewage Treatment

During World War I, septic tanks placed in various locations throughout the installation handled sewage. Three septic tanks were constructed for the permanent barracks area of Edgewood Arsenal. The largest tank was constructed for the permanent barracks buildings. The tank measured 18 x 77 feet and was constructed of 12" reinforced-concrete walls. It was located near the Gunpowder River. A small septic tank was constructed to serve the officers' quarters; it measured 7 x 21 feet. The third septic tank was constructed at the rear of the bakery, heating plant, and laundry. It measured 18 x 9 feet. Effluent from each tank flowed to the Gunpowder River. Septic tanks also were constructed for the base hospital area (U.S. War Department, Construction Division 1919c:28-30).

The Army constructed a primary sewage treatment plant at Edgewood Arsenal in 1942. The plant was located east of the main industrial area in an isolated area on the south bank of the Bush River. Sewage entered the system through a diversion chamber (Building E3952) through a comminutor and parshall flume (Building E3950). Building E3953 was the primary sedimentation tanks. The effluent was pumped through to the Chesapeake Bay. The sludge was pumped (Building E3853 pump house) to concrete sludge digester tanks (Buildings E3851 and E3852), then to sludge drying beds.

Most of the sewer system operated through gravity. Where gravity was interrupted by terrain, lift stations (called sewage pumping stations in category codes) were constructed that forced the sewage through the mains. Edgewood Arsenal has three lift stations that date from World War II. They are scattered throughout the installation. The buildings are one-story buildings, constructed of masonry, mostly brick with gable roofs. Materials were chosen to complement nearby construction.

Power and Heating Plants

Completed in 1918, Building E5126 was the central power plant for the installation; it provided electricity, steam heat, and compressed air and remained the primary source of electricity through World War II. During World War I, electricity generated from Building E5126 was used to operate the industrial plant and to light the hospital and permanent barracks areas. Original equipment included eight coal-fired water tube boilers. The original boilers were replaced in 1941 with five oil-fired boilers, which the building still contains today. The building originally contained two electric generators and air compressors. The generators and air compressors were removed 15 to 20 years ago. Building E5126 retained electrical generating capabilities until this equipment was removed. The generators were sold to a South American company. The air compressors were scrapped (Bob Blake, Chief Boiler Operator, Edgewood Area, personal communication). The original smokestacks were removed and replaced with two brick stacks in 1941. Two diesel oil steel storage tanks were added to the complex in 1946 (Buildings E5162 and E5163).

In addition to the central power plant, Edgewood Arsenal also had a backup electrical power system during World War I. The installation was connected to the local power utility through a high tension transmission line (U.S. War Department, Construction Division 1919a:28). This connection augmented the electricity supply.

As manufacturing operations increased during World War II, the electrical capacities were expanded. The Army constructed four outdoor substations in the industrial areas of Edgewood Arsenal. The electrical equipment for the substations was installed on concrete pads. Currently, the Army owns the concrete pad, but the equipment is maintained by the local utility company. The equipment continually has been renewed, though the original World War II construction date of the concrete pad is recorded in the Army's real property records.

The central power plant (Building E5126) also provided steam heat for the industrial core of the installation. Clusters of buildings located outside the industrial core required their own district heating plants. At Edgewood Arsenal, the living areas were located north and south of the industrial area. Located south of the industrial area, Building E4160 was constructed to heat the permanent barracks area; Building E4651 heated the original officers' quarters and mess (Building E4650). Located north of the industrial area, Building E1574 was constructed to heat the original base hospital.

As the During World War II, four additional district heating plants were constructed to serve expanded industrial production plants. Each boiler building is designed differently. Two boilers (Buildings E3312 and E3148) were constructed to heat the eastern section of the installation as laboratories and test facilities expanded to that area during World War II. Building E3312 is the second largest boiler plant at Edgewood Arsenal. A two-story building, it is constructed of concrete block with metal-frame, three-light, pivot windows. It originally was constructed as an oil-fueled system. Building E3148 was constructed as a stand-by district heating plant.

Two other district heating plants are located west of the industrial core. Building E5330 was constructed as an auxiliary steam heating system and is used most often during winter. It is a massive concrete building without window openings that has the height of a three-story building. Building E5828 was constructed to heat the shell loading plant located west of Canal Creek.

Refuse

Edgewood Arsenal has two incinerators. Building E5292 was constructed in 1918; Building E5294 was constructed in 1943. Both buildings display similar design. Each building is constructed with a raised concrete basement that housed the incineration equipment. The upper part of each building received the refuse, which was then pushed through the floor into the incinerators and burned. Each building has a smokestack. The differences between the two buildings are size and materials. Building E5292 is constructed entirely of concrete; Building E5294 is constructed of brick above the concrete basement. These buildings were identified as incinerators through historical records. Building E5292 currently is used as a practice building for firemen; Building E5294 is used for storage.

APPENDIX B

KELLY AIR FORCE BASE, TEXAS, SITE VISIT SUMMARY

APPENDIX B

KELLY AIR FORCE BASE, TEXAS, SITE VISIT SUMMARY

Kelly Air Force Base comprises over 1,000 acres and is located in Bexar County near San Antonio, Texas (Figures B-1 and B-2). This installation was chosen for a site visit because it was established during World War I. Since its establishment, Kelly Air Force Base has served as both a flying field and an aviation depot.

Methodology

Prior to the site visit, Kelly Air Force Base Environmental Management Office provided a list of pre-1947 buildings, which contained original building uses. The list of historic uses was compared against use classifications found in the 1994 Air Force Real Property Inventory. Comparison of the two lists revealed that current use classifications were unreliable in identifying original use. Field investigations were limited to buildings originally built as utility and support structures as recorded by the Environmental Management Office. Interviews also were conducted with personnel knowledgeable about water treatment, electrical distribution, sewage treatment, and fuel storage.

Expected Results

The 1994 Air Force Real Property Inventory indicated that current classifications of support and utility buildings include 48 general storage buildings, no ordnance storage buildings, and 11 utility buildings and structures. It was anticipated that permanent World War II storage buildings constructed for the aviation depot would illustrate patterns of standardization of storage construction.

Results

On-site research included survey of 38 buildings, including 21 general storage buildings, 1 ordnance storage building, and 16 utility buildings and structures. Kelly AFB maintains separate water supply and heating plants. Power, sewage, and refuse disposal are connected with municipal services. The identification of a sewage treatment plant was not anticipated. However, the plant no longer operates and the structures do not appear on the real property records.

Depot activities have resulted in the construction of large groups of warehouses. However, these warehouses illustrated World War II temporary mobilization structures rather than permanent warehouse construction. Few masonry storage buildings built between 1917 and 1946 exist at Kelly AFB.

Kelly Air Force Base developed in three different areas. Two areas are contiguous: Kelly Field #2 and Duncan Field. Kelly and Duncan Field historically remained under control of the Air Corps. The third area, Camp Normoyle, was developed as an Army motor corps supply depot that supported activities throughout the Eighth Corps District. Camp Normoyle is physically separate from the main part of Kelly AFB.

Historical Background: Kelly and Duncan Fields

In 1917, the Army established two aviation training flying fields, Kelly Field No. 1 and Kelly Field No. 2, on the site that eventually became Kelly Air Force Base (Figure B-1). By September 1917, the San Antonio Air Depot was moved from downtown San Antonio, Texas, to Kelly Field No. 1. At the end of the war, Kelly Field No. 1 remained a supply depot; in 1921, an aviation repair depot was added to the supply depot. In 1925, the air intermediate depot was named Duncan Field. Kelly Field No. 2 became an advanced flying training center. The two uses co-existed until World War II.

World War I buildings at Kelly AFB were wood-frame construction. Immediately after the war, military appropriations were cut drastically. Few buildings were constructed between 1920 and 1926 except for a group of wood-frame officer bungalows. After the passage of the Air Corps Act of 1926 and Public Law 45, appropriations for military construction increased. Beginning in the 1930s, permanent buildings were constructed at Duncan Field, including new Moderne hangars. By 1940, permanent buildings were constructed for the flying field, located north of Duncan Field between Duncan and Billy Mitchell Roads.

During World War II, both the advanced training field and the supply depot were expanded. By 1943, training activities were moved to a new location and the entire installation was converted to the supply depot. Kelly and Duncan Fields were merged into Kelly Field.

Building Types

Storage-General

Storage buildings at Kelly AFB include storehouses constructed at the supply and repair depot located at Duncan Field and smaller storehouses constructed for installation support at Kelly Field #2.

Duncan Field became a depot during World War I. During the war, depot activities were contained in one large building that measured 270 by 830 feet (no longer extant). The advantage of Duncan Field was its access to a major railroad line that defines the eastern boundary of the main installation. After the end of the war, storage buildings were expanded to accommodate war material that was returned from Europe. Approximately six metal-frame hangars were erected on the installation for use as storage; three of these structures (Buildings 50, 53, and 78) remain.

No examples of general depot storage buildings were constructed at Kelly AFB during the inter-war period. During World War II, one-story storage buildings with multiple loading doors along side elevations were constructed at the supply depot. The buildings reflect the availability of construction materials, and included: wood-frame and wood-sided temporary mobilization buildings (Buildings 169, 170, and 172); metal or wood-frame and metal-sided buildings (Buildings 57, 58, 80, and 912); and, concrete-frame buildings with structural clay tile walls (Building 171). In addition, storage capacities were augmented through Butler buildings (Buildings 80, 1589, and 1590).

After the flying training field closed in 1943, depot activities expanded onto acreage north of the flying field. Six large wood-frame warehouses and six large covered storage sheds were constructed. The storage area is laid out in a strict grid pattern and has both railroad and truck access. Roadways form the outer boundaries of the area and provide a central boulevard dividing enclosed storage from originally open shed storage. Railroad tracks are located between the two lines of storage buildings. The warehouses (Buildings 1550, 1552, 1560, 1562, and 1572) possess

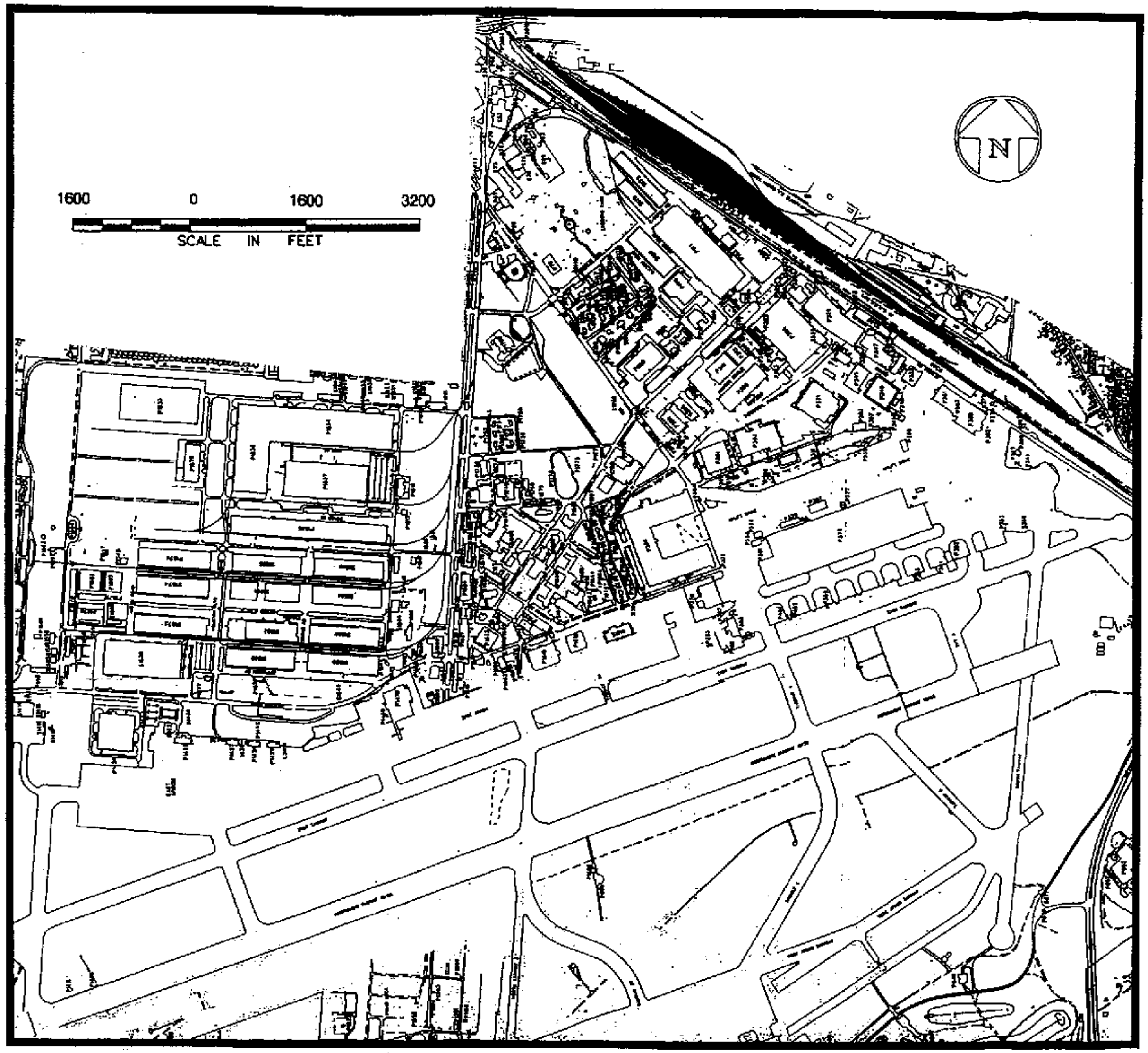

Figure B-1 Map of Kelly AFB, Texas

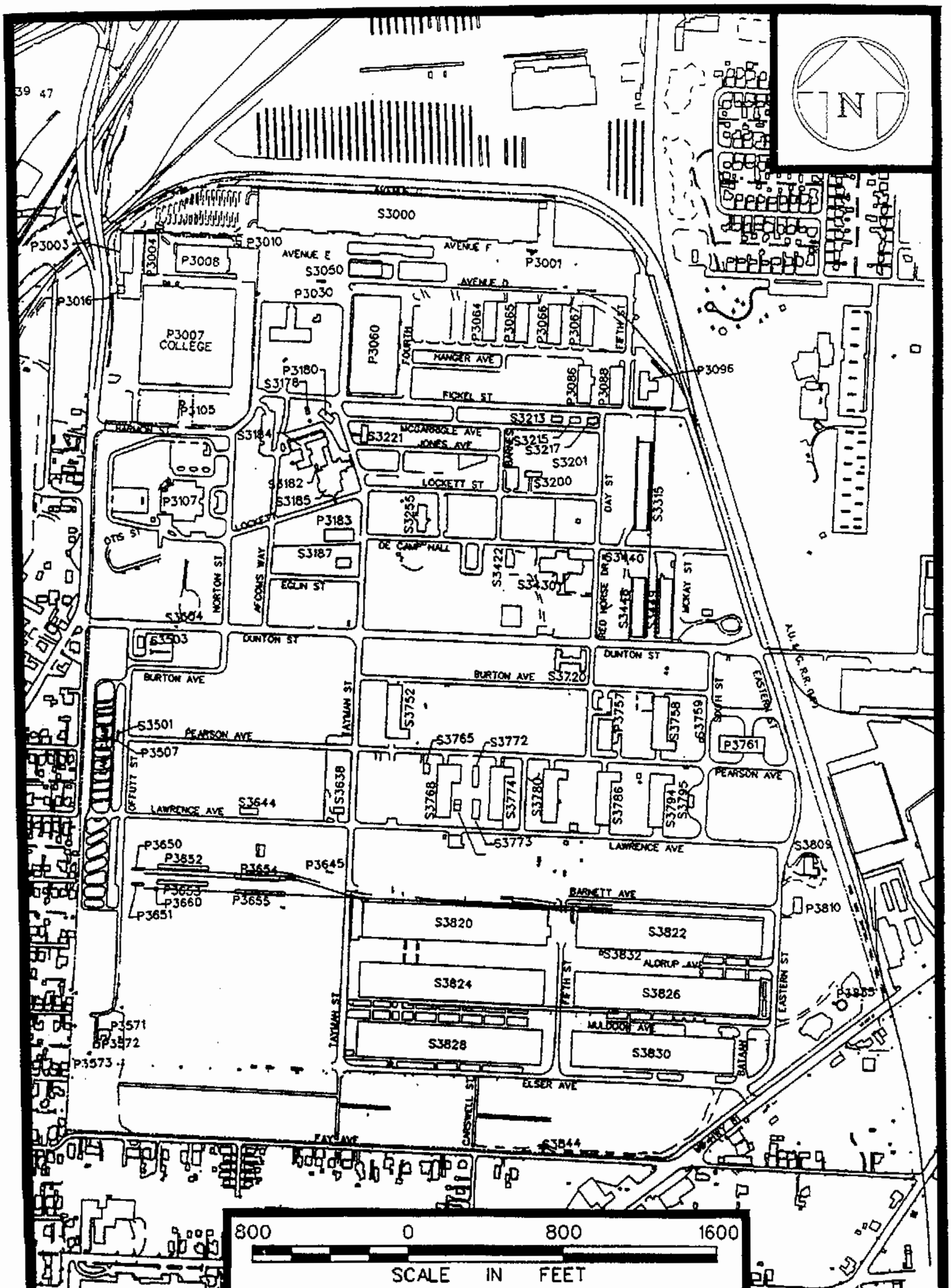

Figure B-2 Map of East Kelly AFB, formerly Camp Normoyle, Texas concrete loading platforms and interior firewalls. The wood-frame open storage sheds (Buildings 1554, 1556, 1564, 1566, 1574, and 1576) originally had gable roofs. They stood on concrete slab floors. In 1946, these buildings were enclosed with structural clay tile and wood sheathing.

Inflammable materials storage also was constructed as part of the depot. These storage buildings included an oil reclamation building (Building 184), dope storage (Building 321), and a paint/oil/dope storage building (Buildings 183 and 87). Buildings 184 and 321 were completed during the early 1930s. Both buildings are concrete frame structures with clay tile walls. Building 183, completed in 1942, is a cast concrete structure. Building 87, completed in 1945, is a concrete frame structure with clay tile walls.

Storage buildings also were constructed for activities located at Kelly Field #2, during its use as an advanced flying training center. In 1940, one warehouse was constructed for the Quartermaster Department (Building 1626) and two warehouses were constructed for the Signal Corps (Buildings 1632 and 1635). All three buildings are one-story, rectangular buildings constructed with concrete frames infilled with structural clay tile. The buildings originally had concrete loading docks along their long elevations with multiple loading doors. During World War II, storage capacity was augmented through construction of temporary wood-frame mobilization storehouses (represented by Building 1500).

Kelly AFB also had three fuel tank farms to store aircraft and motor vehicle fuel. The typical tank farm contained underground horizontal metal tanks. The only above-ground structure was a fuel pumping station. One fuel pumping station identified during this site visit is Building 1618, a one-story stuccoed concrete building located near the flightline. Building 1618 was constructed in 1937 to pump fuel from 13 underground steel fuel tanks. All underground fuel storage tanks constructed at Kelly AFB before 1946 have been removed.

Storage-Ordnance

One ordnance storage building was identified. Building 1609 was constructed in 1942 for bombsight storage. This one-story building is a typical example of a segregated magazine. The building has a concrete foundation, concrete walls, and a concrete shed roof. Two metal doors appear on the front facade. It is located near the World War II - era hangars.

Water Supply

The installation is supplied with water from artesian wells located throughout the installation. Each well has a corresponding pump house. There is no central water purification building; the water is treated chemically at each well. Three water pump houses are located in the vicinity of major areas of architectural density (Buildings 141, 314, and 1638). The earliest well (Building 141) was dug in 1906 and pre-dates the establishment of the installation. It is located in the office bungalow area. In 1940, a stuccoed clay-tile pump house was constructed that replaced the former wood-frame building. All three buildings reflect, in simpler versions, the Moderne style architecture constructed during the late 1930s at Kelly AFB. Pump house No. 1 (Building 314) has a prominent location on the flightline of Duncan Field. Building 1638 has a prominent location in the cantonment area of Kelly Field #2 (Dana Ulanoff, Civil Engineer, and Pat Garcio, Civil Engineering Water Department, Kelly AFB, personal communication).

A fourth well and pump house (Building 1044) identified at Kelly is located in a remote part of the installation. It is a utilitarian masonry structure with no architectural detailing.

Kelly AFB has six elevated water storage tanks that provide pressure to the water distribution system. Two elevated water storage tanks date between 1917 and 1946. Building 1577, completed in 1943, is a steel tank supported on a poured concrete structure. Building 879, completed in 1946, is a tank supported by a steel framework.

Sewage Treatment

During World War II, a sewage treatment plant was constructed at Duncan Field. No information was obtained describing sewage disposal before World War II. The World War II sewage disposal plant comprised a bar screen, a concrete grit chamber, three concrete clarifiers (primary, intermediate, and final), two sets of Imhoff tanks, dosing tank, square fixed nozzle trickling filters, concrete digesters, and sludge beds. Buildings at the plant included: a control house (Building 619), a chemical storehouse (Building 628), and a sludge pumping station. The effluent was discharged into the local creek. The treatment process was described as a "classic Hays process" (Bobby Howell, Environmental Management, Kelly AFB, personal communication). In 1956, sanitary sewage was converted to the city sewage system. The plant was reopened in 1958 as an industrial waste plant.

Power and Heating Plants

Two district heating plants were identified at Kelly AFB. Building 322 was completed in 1933 and Building 328 was completed in 1942. Both buildings are located along the flightline of Duncan Field and supplied steam heat to the shops and hangars. Originally both buildings had smoke stacks, which suggests they were coal fueled.

Currently, the installation purchases electrical power from the local utility company. No records indicate that power generating equipment was located at the installation. Building 328, completed in 1944, is a switching station and contains relays and breakers, but no transformers and regulators. The equipment on the concrete pad is maintained by the local utility company and post-dates 1946.

Refuse

No examples of incinerators constructed before 1947 were identified at Kelly AFB.

Historical Background: Camp Normoyle (East Kelly)

Camp Normoyle (Figure B-2) was established in 1918 as a maintenance depot for the Army's Motor Transport Corps. It served a geographical area west of the Mississippi River and south of Kansas. After World War I, the Army stored motor vehicles and parts at Camp Normoyle. During the inter-war period, the camp supported military activities within the Eighth Corps Area headquartered at Fort Sam Houston.

Between 1939 and 1943, the Army expanded the camp, adding 159 acres to the installation and numerous temporary mobilization buildings. When jurisdiction over motor vehicles was transferred from the Quartermaster Department to the Ordnance Department in 1942, Camp Normoyle was classified as an ordnance training installation. In late 1943, the Ordnance Department transferred supply activities to Red River Ordnance Depot, and the Army Air Forces occupied storage buildings at Camp Normoyle. In 1945, the installation was renamed "East Kelly Field."

Building Types

Storage-General

Storage buildings at Camp Normoyle were constructed during the early 1920s and during World War II. The 1920 storage buildings comprise six identical metal-frame buildings patterned on a prevalent World War I metal-frame hangar design (Buildings 3064-3067, 3086, and 3088). The metal-frame hangar was designed to be portable and could be adapted for many uses, in this case storage.

During World War II, variously-sized, one-story, wood-frame mobilization storage buildings were constructed at the installation. Most of the storage buildings have access to railroad tracks that form the eastern boundary of the installation. The railroad lines have spur lines to the main storage areas.

The largest warehouse (Building 3000) extends a quarter mile in length. The wood-frame building is clad in horizontal wood siding; clay tile firewalls divide the length of the building. A monitor roof provides natural light to the building. Concrete loading platforms are located along the side elevations where the loading doors are grouped under a projecting marquis.

Smaller wood-frame, one-story storage buildings were located along the eastern edge of the installation. These buildings have smaller proportions and fewer storage sections, but contain the characteristic firewalls, concrete loading platforms, and multiple loading doors located along the long elevations.

The southern portion of the installation is the location of the original open storage areas. One section of this area contains outdoor concrete loading platforms and an open storage shed. Large covered storage sheds (Buildings 3820, 3822, 3824, 3826, 3828, and 3830) were constructed east of the open storage area. These one-story, wood-frame buildings originally had gable roofs, but no wall sheathing. They stood on concrete slab floors. In 1946, these buildings were enclosed with structural clay tile and wood sheathing.

Storage-Ordnance

No examples of ordnance storage were identified at East Kelly.

Water Supply

The installation is supplied with water from artesian wells. The earliest well (Building 3010) was dug in 1919. Water was pumped into a steel elevated storage tank (Building 3105) supported by a steel framework. During World War II, a second elevated storage tank was constructed (Building 3835). This steel tank is supported on a poured concrete structure.

Sewage Treatment

Sewage from Camp Normoyle was discharged into the city sewage system. One sewage pumping station (Building 3440) exists from World War II. The exterior building is wood-frame temporary mobilization building.

Power and Heating Plants

In 1919, the installation was equipped with a separate power station (no longer extant). No extant examples of power or heating plants constructed before 1947 were identified at East Kelly.

Refuse

No examples of pre-1946 incinerators were identified at East Kelly.

APPENDIX C

NORFOLK NAVAL BASE, NORFOLK, VIRGINIA, SITE VISIT SUMMARY

APPENDIX C

NAVAL BASE NORFOLK, VIRGINIA, SITE VISIT SUMMARY

Naval Base Norfolk, comprising approximately 4,600 acres, is located near Hampton Roads, Virginia (Figure C-1). The installation, established in 1917, is organized geographically around five major activities: a naval station, a naval supply center, a naval training station, a naval air station, and a public works center. Each activity historically occupied its own discrete area, except for the Public Works Center which currently maintains utilities and housing. Naval Base Norfolk was chosen as a site visit because of the historic range of activities it has hosted throughout the period of this study. It was anticipated that the evolution of a variety of building types could be identified at the installation.

Methodology

Before the site visit, the Public Works Center supplied current maps and a current real property list. The list was analyzed to identify current utility and support buildings located at the Naval Base Norfolk. The buildings were located on the facility maps. The draft *Cultural Resources Survey Naval Base Norfolk* (Onyx Group 1994) was reviewed to determine original building uses. Buildings that originally were support and utility structures, but did not appear as such on the current real property lists, were added to the survey maps.

Site investigation included survey and photography of representative examples of utility and support structures. Buildings that retained integrity were selected for survey. For repetitive building types, one example was selected for survey. The survey team was escorted through the naval magazine, but not allowed to photograph the buildings. In addition, personnel knowledgeable about electrical utilities were interviewed.

Expected Results

The 1994 Navy real property inventory listed 338 properties classified as utility and support at the Naval Base Norfolk. The list included 38 general storage buildings, 39 ordnance storage buildings, and 261 utility buildings. Archival research indicated that Naval Base Norfolk contained examples of utility and support structures from World War I through World War II, particularly storage buildings. Archival research also indicated that the installation contained few examples of sewage, water treatment, or electrical building types since these services were purchased from the local utility companies. Examples of heating plants, cold storage buildings, a 1940s incinerator, and ordnance storage were anticipated at the installation.

Results

A wide variety of storage and electrical utility structures on the installation were identified. Fifty-six buildings and structures, including 37 general storage buildings, 11 ordnance storage buildings, and 8 utility buildings, were documented. Electrical buildings and steam heating plants were more numerous than expected. As anticipated, there were few sewage and water treatment buildings. The incinerator and cold storage buildings are no longer extant. The naval magazine contained examples of earth-covered concrete magazines and above-ground storage structures.

Historical Background: Naval Base Norfolk

Naval Base Norfolk, Virginia, was established in 1917 in response to the entry of the United States into World War I. The installation was established to alleviate crowded fleet support and supply activities located at the Norfolk Navy Yard. The Navy acquired the site of the 1907 Jamestown Exposition for its fleet supply and support base. The installation was founded as an operating base, a new type of naval installation and one of the most ambitious World War I construction projects. The Navy built permanent and temporary storage buildings, including large multi-story concrete-frame warehouses. In addition to fleet supply activities, a training station and hospital complex were established east of the supply area. Most of the initial structures were wood-frame mobilization buildings. In 1917, work began on a naval air station for seaplanes. During World War I, the Navy expanded the property through dredging and draining the area.

During the inter-war period, the Navy continued to reclaim land. At the end of the 1930s, permanent construction of the naval training station was undertaken.

During World War II, the Naval Base Norfolk grew tremendously. The seaplane area was expanded and a new land plane area was constructed. The Navy constructed a naval magazine to support the air station. New multi-story warehouses were constructed for the supply depot, and an annex with 12 one-story warehouses and open storage space was constructed. In addition to the supply depot, special storage areas were constructed for aviation and nets. A brick naval hospital complex was constructed south of the original installation.

Building Types

Storage-General

Naval Base Norfolk exhibits a variety of types of storage structures. The numerous storage buildings illustrate both the capacity required for the supply depot and the specific storage needs for each activity on the installation.

The largest numbers of storage buildings were constructed for the supply depot, currently known as the Fleet and Industrial Supply Center (FISC). Between 1917 and 1920, the Navy constructed a variety of storage building types, including multi-story general warehouses (Buildings Z101 and Z103); aircraft storehouse (Building Z107); one-story warehouse (Building Z105); two transit sheds (Piers 2 and 3); a cold storage building; and, temporary storehouse (Building Y102).

The World War I general warehouses (Buildings Z101 and Z103) are concrete-frame, six-story buildings. The aircraft storehouse (Building Z107) is a three-story, steel-frame building with a monitor roof. The building originally had a railroad track that ran into the center building bay with a crane that operated above the third story (U.S. Navy, Bureau of Yards and Docks 1921:331-332). Building Z105 is a brick one-story warehouse with a monitor roof and loading docks along the long elevations. The one-story warehouse form was repeated in the warehouses constructed on the merchandizing piers. The cold storage and ice manufacturing plant was a four-story, concrete-frame building with no windows (U.S. Navy, Bureau of Yards and Docks 1921:328-331). The cold storage building is no longer extant. Temporary storage buildings (Building Y102) generally were constructed of wood frame on a concrete floor (U.S. Navy, Bureau of Yards and Docks 1921:328).

Storage buildings for other installation activities varied in design depending on the size of the activity and the location of the building. The training station has few extant storage buildings from the World War I and the inter-war periods. Building E13 (1918) was constructed

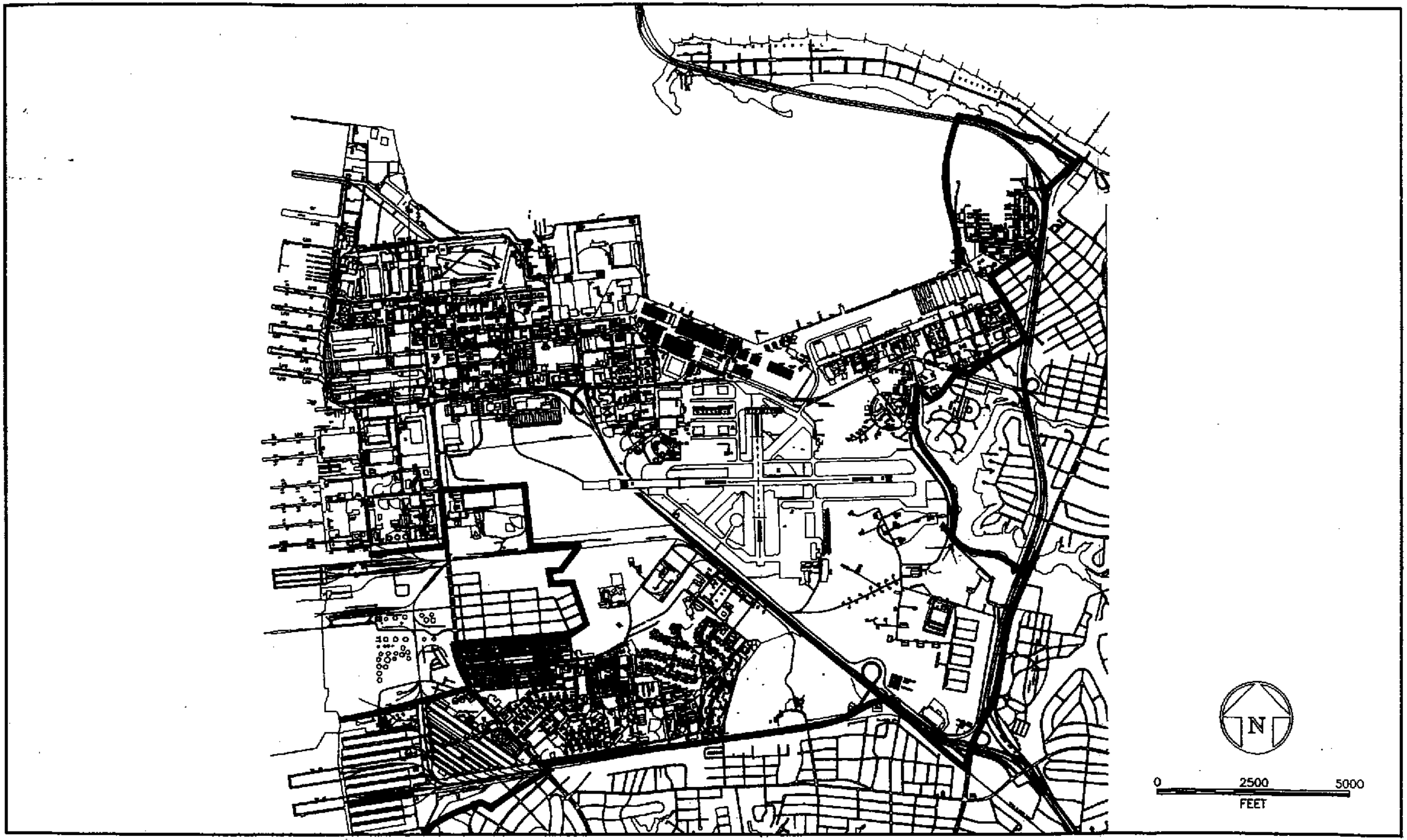

Figure C-1 Map of Naval Base Norfolk, Virginia as the commissary receiving depot. It resembles a train depot, with its hipped roof and dormers ornamented with jigsaw decoration. A wood loading dock is located along the south elevation. Building X353 was constructed in 1920 as a warehouse for the medical department. It is a two-story brick building with industrial sash windows; it reflects the construction materials of the other training station buildings.

During World War II, the Navy expanded the storage capacity of the naval base. Storage building design followed the patterns established during World War I. Concrete-frame, multi-story warehouses were constructed as general storehouses. Often these storage buildings have freight elevator shafts incorporated into the exterior design. Examples of this type include Buildings W143 and Z133 constructed for the supply depot; Building X132 constructed for the aviation supply depot; and, Buildings V53 and V29 constructed for the seaplane area.

Aircraft storage buildings also retained the same basic form established during World War I. These buildings generally were multi-story, steel-frame buildings with wide gabled monitor roofs that supported overhead cranes to move parts. These kinds of buildings appeared in two locations on the installation. Building V52 was constructed at the seaplane area, and Buildings X134 and X136 were constructed at the aviation supply depot located north of Dillingham Boulevard. Building V47 in the seaplane area illustrates the same monitor roof type in a metal-frame, one-story building completed in 1941.

One-story storage buildings are the most numerous building type constructed during World War II at Naval Base Norfolk. These buildings were either wood-frame or metal-frame buildings. The varied roof types included segmental-arch, barrel-arch, or monitor roofs. In some cases, the Navy constructed double or triple versions of these one-story warehouses to provide increased storage space. World War II buildings that illustrate the one-story, monitor-roofed storehouse include transit sheds Z2, W4, and W3 (1942-1943), located on the piers; Building X137 located in the aviation supply area; and, Buildings SDA202, SDA203, and SDA213 located in the Supply Depot Annex several miles south of the installation. Buildings W131, W127, and W128 illustrate double and triple versions of the single monitor roof storage building. Arched or segmental-arched, one-story storage buildings are represented by Buildings SP86-SP89 located in the seaplane area.

In some cases, one-story warehouses also were constructed of permanent materials, primarily brick. Building LP26 is a brick example of a one-story storage building with triple segmental-arched roof with monitors and firewalls. It was used to store spare aviation parts. Building Z216 is a concrete one-story warehouse.

A variety of structures were constructed to store inflammable materials, such as paints, oils, and dope. In some cases, the buildings were constructed of metal frame with corrugated metal siding (Building V17, 1922). In other cases, the buildings were constructed of brick or concrete. Building SP83, a large paint and oil storehouse, is a concrete-frame building with brick walls that has a double segmental-arched roof with projecting firewalls. It is located in a relatively isolated area near the railroad tracks. Building Z194 is an example of a concrete inflammable material storehouse.

Storage structures also were constructed to support specific activities. Storage constructed to support the naval training station included a one-story, brick building with concrete coping (Building L31). A one-story, brick squadron storehouse (Building SP9) was constructed in the seaplane area.

Naval Base Norfolk contains a variety of above-ground and underground steel tanks used for short-term fuel storage and to supply immediate fueling needs. Long-term fuel storage is not located on the installation proper. During World War I, the Naval Fuel Depot, Yorktown, had the largest long-term fuel storage capacity. During the inter-war period, Craney Island, located approximately four miles southwest of the base, was developed as a major, long-term fuel storage installation. Currently, Naval Base Norfolk is connected to Craney Island via a pipeline.

The first fuel tank storage area established on the base was located near the piers. It contained various sizes of fuel tanks to store diesel fuel, aviation fuel, and gasoline. Two large, circular, above-ground rivetted steel tanks (W67 and W68) were constructed in 1922. By 1931, two additional steel tanks were constructed (W109 and W110). In 1923, two tall, circular tanks (W360 and W361) were constructed to store airplane fuel. A third group of horizontal above-ground steel tanks (W356 and W359) were constructed in 1923 to store gasoline. In addition, a one-story, brick, fuel pump house (W69) was constructed in 1931 to pump fuel from the various tanks.

During World War II, additional fuel storage facilities were constructed to store aviation fuel. Two fuel storage areas were constructed at the Naval Air Station; one area to support seaplanes and one area to support land planes. Both areas are located apart from the flightlines. Both fuel storage areas are located below-ground and are covered by grassy knolls.

Storage-Ordnance

Naval Base Norfolk exhibits a variety of types of ordnance storage structures constructed between 1917 and 1945. Before World War II, the base included only above-ground storage. Buildings W104 and W105 are long metal-frame buildings with corrugated metal siding. These buildings originally were constructed as part of the supply depot to store mines for the fleet, according to historic maps of the base.

Building V10 is an example of a World War I installation ready/small arms magazine/pyrotechnics magazine; it is located in the seaplane area. The building is a small poured-concrete structure with a hipped roof. During the 1940s, four-bay and two-bay versions of installation ready magazines were constructed at the corners of aircraft hangar. These magazines stored ammunition on a short-term basis. Examples of these magazines are Buildings V4A, LP10, LP11, SP5, and SP7.

During World War II, a naval magazine was constructed to provide intermediate ammunition storage for the naval air station. The naval magazine contains both above-ground and earth-covered storage. The ammunition storage area is isolated from the developed areas of the installation; it is located in the southeast corner of the installation, south of the aircraft runway. The structures are widely dispersed as a precaution against the spread of accidental explosions.

The naval magazine contains three types of earth-covered storage structures: arched-type high explosive magazines; Keyport magazines; and, two sizes of rectangular box magazines. The arched-type high explosive magazine is represented by Building NM24. Constructed of concrete, this magazine has a detached blast shield. Forklifts are used to load the larger magazines.

The Keyport magazine is a shallow vaulted concrete structure with paired metal doors over the main opening. The magazines are grouped in numbers of 12 rows; each row has 15 adjoining magazines. The naval magazine has three groups of keyport magazines (NM35, NM36, and NM47).

Two designs of rectangular box magazines are located in the naval magazine area. The larger of the two measures approximately 50 x 100 feet and has a concrete loading platform with two sets of double metal doors and glass block window openings. Buildings NM29, NM30, NM31, and NM32 are examples of the larger rectangular boxes. The smaller rectangular box is represented by NM11. It is composed of two parts: a concrete magazine with an attached blast shield. The earth berm encircles three-quarters of the entire structure with one narrow entry that allows only manual loading and unloading.

Above-ground magazines are constructed of concrete frames with poured concrete walls and corrugated-metal gable roofs. The numbers of bays of the magazines vary: three bays (NM27 and NM26); four bays (NM7); and, two-bays (NM9).

Two types of inert storage buildings are located at the naval magazine. One type is metal-frame clad with corrugated metal siding with a corrugated metal gable roof (Building NM170). It has four metal overhead doors along the long elevation with a concrete loading dock. A second type of inert storage building is a brick building (Building NM45) with a central metal roll door, two windows, and a flat roof.

Water Supply

Historically, Naval Base Norfolk has procured its water supply from the local municipality. By the end of World War II, the naval station possessed one elevated water storage tank and seven concrete water storage reservoirs (U.S. Navy, Bureau of Yards and Docks 1947b, V.II:336-338). Real property records indicate that an elevated steel water storage tank (P17) was constructed in 1918-1919 to hold the water supply needed for the main steam plant. During World War II, elevated water towers were constructed to meet expanding needs for potable water for growing populations at the various naval activities. In some cases, steel tanks were supported by a steel frame (V148). In other cases, the steel water tank was supported on a poured concrete frame (SP84).

Sewage Treatment

When the installation was constructed during World War I, underground sewer lines were installed. However, no sewage treatment was employed other than natural diffusion of sewage into the nearby river and bay. By the end of World War II, the naval base was connected to the local municipal sewage system. A brick sewage pumping station belonging to the municipal sewage system is located directly outside Gate 1 of the naval base. The real property records indicate that a few sewage lift pumping stations were constructed during World War II. However, no property types related to sewage disposal were located or surveyed during this site visit.

Power and Heating Plants

During World War I, three steam heating plants were constructed at Naval Base Norfolk: one for the main training station; one temporary boiler plant; and, one for East Camp (location unknown). The current real property inventory lists three steam heating plants dating from World War II.

The original location of the main boiler plant is near the current location of Building P1. Maps dated 1918, 1921, and 1938 depict a boiler plant, a pump house, and a reservoir. A photograph labeled "Boiler Plant for industrial section of Naval Operating Base, Hampton Roads, Va." appears in a 1921 publication (U.S. Navy, Bureau of Yards and Docks 1921:266). In 1921, a new permanent boiler house was constructed on Piersey Street near the center of the industrial area that supported the naval training center. Originally designed to provide steam heat, the Navy considered including electrical generators in the building. However, generators were not installed because of funding constraints (U.S. Navy Bureau of Yards and Docks 1921:264-265). During World War II, the building was altered and expanded substantially. Two turbo auxiliary generators were installed in the building.

Building P1 is a brick structure with tall window openings. Building P1 appears on the current real property database with a construction date of 1941. The current equipment in the building is a combination of 1940s boilers that have been retubed and new boilers. The newest boiler was installed during the late 1970s when a new addition was constructed. The auxiliary generators were removed from the building and replaced by external generating equipment (Dave Midgett, Utilities, Naval Base Norfolk, personal communication).

During World War II, the Navy constructed two other steam heating plants: Buildings SP85 (1943) and NH200 (1941). Both of these plants served discrete areas of the installation. Building NH200 provided steam heat for the naval hospital. Building SP85 provided steam heat for the seaplane area. Both of these buildings are utilitarian in appearance with little architectural ornamentation.

Between 1917 and 1945, electricity was purchased from the local utility company. Electricity was distributed throughout the installation through a system of 5 kilovolt substations, distribution transformer stations, and switching stations. All the property types associated with electrical distribution date from World War II; no structures were identified that were associated with the electrical distribution system prior to 1940. In 1945, Naval Base Norfolk possessed 109 transformers with the capacity of AC 26,800 kva and 760 transformers, AC 39,947 kva (U.S. Navy, Bureau of Yards and Docks 1947b, V.II:336-338).

The largest electrical stations on the installation are the 5 kilovolt substations that reduce 11500 volts to 4160 volts. These buildings are concrete structures with metal access doors. Examples of substations include Buildings P62 and X358.

Distribution transformer stations reduce the voltage from 4160 volts to building usage levels. Distribution transformers are small buildings constructed either of concrete or brick and located throughout the installation. The type of construction material depends on the location of the utility building. Concrete is used in functional or industrial areas, while brick is used in residential areas. Examples include Buildings Y182, X26, and KM1.

The smallest electric utility buildings are the switching stations. The only extant pre-1946 switching station is located at the naval hospital complex. Building NH37 is a small brick building with a concrete pad foundation, flat roof, and a single metal access door (Dave Midgett, Utilities, Naval Base Norfolk, personal communication).

The 1940s electrical distribution system currently is being upgraded with new equipment. Switching stations and distribution transformer stations are being replaced with modern equipment in plastic containers (D27). Often the equipment is installed on the 1940s concrete pad. Wherever new equipment fits into existing buildings, the buildings are retained. If the equipment does not fit, the buildings will be removed (Dave Midgett, Utilities, Naval Base Norfolk, personal communication).

Refuse

Incineration was the common method for disposing of waste at the installation. A 1918 base map depicts an incinerator. Archival drawings depict another incinerator constructed during World War II. Neither of these incinerators are extant. The current operating incinerator was constructed during the 1990s.

APPENDIX D

MARINE CORPS DEVELOPMENT AND EDUCATION COMMAND, QUANTICO, VIRGINIA, SITE VISIT SUMMARY

APPENDIX D

MARINE CORPS DEVELOPMENT AND EDUCATION COMMAND, QUANTICO, VIRGINIA, SITE VISIT SUMMARY

The Marine Corps Development and Education Command, Quantico comprises a site of approximately 100 square miles in Prince William, Stafford, and Facquier Counties, Virginia. The developed area of the installation is near the town of Quantico, in Prince William County (Figure D-1). The installation was selected as part of this current investigation as a representative example of a Marine Corps training installation. The installation illustrates the typical twentieth-century military construction pattern. It was founded during World War I, received permanent construction during the late 1920s and 1930s, and was expanded during World War II.

Methodology

Prior to the site visit, the Department of Planning provided a list of utility and support buildings. This list was compared with a "Listing and Assignment of Buildings and Structures" of the base obtained through U.S. Navy, Atlantic Division from U.S. Army Corps of Engineers Construction Engineering and Research Laboratory. This list also was compared with the Quantico portion of the 1994 real property database obtained from the Department of Navy. The Department of Planning property list was compared with the historic real property cards maintained by the Department of Planning. None of the current or archival records identified additional utility and support buildings or structures other than those identified in the list supplied by the Department of Planning. Telephone and on-site interviews were conducted with installation personnel knowledgeable about the utility systems located on the installation.

Expected Results

The 1994 Department of Navy real property inventory database indicated that the Marine Corps Development and Education Command, Quantico, had jurisdiction over 55 storage buildings, including 30 general storage buildings, 1 cold storage building, 1 shed, 5 hazardous storage buildings, and 18 fuel storage buildings constructed before 1946. Seventeen ordnance storage buildings were listed in the database, including 1 fuse and detonator magazine, 5 high explosive magazines, and 11 small arms magazines. The database indicated a total of 34 utility buildings and structures: 4 related to electrical, 5 related to heating and cooling, 7 related to sewage, 1 incinerator, 16 related to water, and 1 miscellaneous utility building. Archival research indicated that, by 1947, the installation had an up-to-date water supply system and sewage treatment plant. Drawings located during archival research also indicated that a central heating plant and ammunition storage area existed on the installation.

Results

The Marine Corps Development and Education Command, Quantico has four general areas of development: the main cantonment and training area, two aviation fields (Turner and Brown Airfields), and a naval hospital complex. For the purposes of this study, the field survey did not include Turner Field or the naval hospital complex. Turner Field was inaccessible due to security restrictions. In general, each area contains separate heating supply, sewage and waste treatment, and storage buildings. Other utilities were shared, including electrical power distribution and water supply. Fifty-five buildings were documented during the survey, including 11 related

Separate storage buildings were constructed at Brown Airfield, located the southern end of the main construction area of the installation. Building 2125 is a corrugated metal, one-story warehouse constructed in 1939. Building 2121, constructed in 1945, is a multi-story, permanent brick warehouse.

Turner Airfield originally had underground fuel storage tanks. However, during the last five years, the Navy made a concerted effort to remove old underground fuel storage tanks and to upgrade fuel storage to meet environmental regulations.

Small storage buildings were dispersed around the installation to meet specific needs. The small storage buildings currently are classified as storage sheds; it is not known if any of these structures were originally classified as inflammable materials storage. Building 5108, constructed in 1935, is an example of a corrugated metal-sided structure recorded as inflammable materials storage. Building 5107 (constructed 1920), a duplicate of Building 5108, is recorded as a general storehouse. Two other similar metal-sided buildings (Buildings 662 and 664) are storehouses that support the sewage treatment plant.

Building 3013 is classified as inflammable storage and is located near the main supply area. It is comprised of two sections. Both sections are wood-frame and three walls are wood sided. One elevation of each section is open with wood cross-bracing and screens. Building 2139 also is classified as a storage shed. It is located near Turner Airfield near a former well building (Building 2018). Building 2139 is a one-story, small square building with a flat roof; its design is characteristic of an ammunition or inflammable storage building rather than of a general storage shed.

Storage-Ordnance

Ordnance storage was identified in two areas of the installation. Three ammunition buildings (Buildings 2118, 2119, and 2120) are associated with Brown Airfield and the aviation history of the installation. All three buildings currently are classified as general storage buildings. Building 2118, constructed in 1942, is a one-story, concrete-frame small arms magazine with a concrete loading platform. Building 2119 was originally a pyrotechnics magazine with concrete foundation and walls capped with corrugated asbestos roof. Building 2120 is a metal frame building with corrugated metal walls; it has the characteristic features of an FS smokedrum storehouse.

The second ammunition storage area is located west of I-95 on land purchased in 1942 and named "Guadalcanal Area." The additional land provided space for artillery firing training conducted by the Marine Corps Ordnance School, which was established in April 1942 to train personnel in all aspects of firing and upkeep of Marine Corps artillery. The ammunition storage area comprises earth-covered arched metal structures (described as quonset huts covered with earth) with concrete fronts with metal doors. Three sets of magazines are triplets (Buildings 3150-3152, 3154-3156, and 3195-3197); two sets of magazines are singles (Buildings 3157 and 3159). Building 3158 is a chemical magazine with a concrete block front. Two buildings (Buildings 3194 and 3149) are above-ground, metal-frame structures. The ammunition storage structures are deteriorated and are too small to accommodate mechanical handling by forklifts. The installation is considering demolition of these facilities.

Water Supply

The earliest water supply system was installed in 1918. The system comprised a dam with filter, pumping station, and two concrete reservoirs that contained 20,000 and 30,000 gallon storage capacity. In 1930, storage capacity was expanded to 2,000,000 gallons through the construction of a water tank, reservoir, wells, and pump houses (Drawing index for Marine Corps Base, Quantico, Naval Construction Battalion, Port Hueneme, California). By 1947, the supply system contained two dams (Buildings 1701 and 1310), one 2-million gallon reservoir (Breckinridge Reservoir), two elevated water storage tanks (Buildings 1705 and 1706), and one 420,000 gallon reservoir (Building 1702).

A 1918 drawing illustrates the filtration system of the earliest water treatment plant. The water initially was held in a sedimentation tank. It passed through one filter where it was chemically treated, then a second filter. After the filtration process, water was held in the clearwell before distribution (NARA, Cartographic Branch, Record Group 71, microfilm reel 574).

The water filtration complex is located near Chopowamsic Creek. Building 1303 is recorded as a water filtration plant constructed in 1918. The building is a one-story, L-shaped brick building. The building contains the pumps, the filtration system, stand-by generators, and a clearwell in the basement. It is not clear how much of the building, if any, dates to 1918. The water filtration system appears to have been upgraded substantially during the 1950s with the addition of new pumping equipment, pressurized filters, and a new clarifier (Building 1315). Building 1314, a metal-frame, one-story building, also was constructed in 1953 and is attached to Building 1303. The complex also contains a small, one-story, shed-roofed, rectangular storage building (Building 1307), probably originally constructed for chemical storage. During the 1930s, a general storage shed with a two-vehicle garage (Building 1305) and an elevated water tank (Building 1316) were added to the complex.

The current water supply is drawn from surface water. The largest reservoir is Breckinridge Dam (1702), constructed in 1937. Water is pumped to the water treatment plant where it is chemically treated, clarified, pressure filtered, and stored in a clearwell before distribution.

Between 1917 and 1946, the installation supplemented the surface water supply through wells. Buildings 2016 and 2018 are one-story, brick pump houses constructed in 1931. During World War I, pump houses were wood-frame structures. Building 2017, constructed in 1931, is an example of a poured concrete well cover that is mostly below ground. Building 27140, constructed in 1944, is an example of a brick well cover located mostly below ground. The wells are abandoned.

Water distribution around the main post was accomplished through covered ground reservoirs and elevated water tanks. Many of the pre-World War II ground reservoirs were wood. During the late 1920s and the 1930s, metal elevated water towers (Buildings 1705 and 1706) were added to the system. A one-story brick pump house (Building 2030) was located at the base of Building 1706. A concrete reservoir (Building 1702) replaced earlier wooden reservoirs. Building 1702 is listed on the real property record with a construction date of 1944, although a 1930 drawing depicts the reservoir (NARA, Cartographic Branch, Record Group 71, microfilm reel 574).

Sewage Treatment

During World War I, the camp contained both latrines and bathhouses as part of initial camp construction (Lapp et al. 1991:14). By 1929, the installation sewage system comprised septic tanks, sewage ejector, and catch basin (Drawing index for Quantico Marine Corps Base, Naval Construction Battalion, Port Hueneme, California). In a 1935 survey of sewage treatment practices, the Marine Corps Base at Quantico was not listed as one of three installations that treated sewage.

In 1939, plans were developed for a sewage treatment plant; construction was completed during 1940. The 1940 sewage disposal plant included one rectangular open concrete primary settling tank (Building 2072), two circular concrete trickling filters (Buildings 2070 and 2071), and one rectangular open concrete final settling tank (Building 2073). Sludge from the settling tanks and trickling filters was pumped to the pair of joined circular concrete sludge digesters (Building 2036) by the sludge pump house (Building 2037). Sludge was then pumped to the sludge drying beds originally located west of the Building (2036). The entire system was arranged symmetrically and designed to take advantage of the sloping topography. The final settling tank was located the bottom of the slope. Walkways and stairs linked all the initial parts of the plant. The system was improved in 1944 with addition of chlorination plant and drum storage. In 1947, the sewage treatment plant contained settling tanks, dosing tanks, filters, digesters, and sludge drying beds (U.S. Navy, Bureau of Yards and Docks V.II 1947b:241).

Three sewage pumping stations were distributed around the installation. Building 2038, constructed in 1940, is a poured concrete structure that is mostly underground.

The sewage treatment plant served most of the main post. However, other sewage treatment facilities were constructed for other areas located far from the plant. In 1945, Brown Airfield was equipped with two Imhoff tanks (Building 5121) to handle the immediate area.

Power and Heating

Throughout its history, the Marine Corps base at Quantico has purchased power from the local power utility company. The local utility company established a substation north of Building 2012. Electrical distribution was by overhead wires and distribution transformers. No distribution transformer buildings were identified as part of the on-site survey. In the last three years, the electrical distribution system has been upgraded. The current transformers generally are self-contained units mounted on concrete pads. Building 5146 was identified on the real property list as an electrical distribution building dating from 1917. The facility currently is comprised of modern units. In 1947, the Navy's inventory of installation utilities listed the Virginia Electric & Power Company as the main source for electric power at Quantico, along with stand-by generators (two AC 300kw and one 240 kw) (U.S. Navy, Bureau of Yards and Docks V.II 1947b:241).

Building 2012 is the central heating plant that currently provides steam heating to buildings located in the main area, the airfield, and the hospital. Originally Brown Airfield and the hospital were heated by separate district heating plants. Building 2113 served Brown Airfield. After the steam heating system was integrated, the two smaller district heating plants were mothballed.

Building 2012, a large brick building, was constructed in 1929 as a central power plant. The central power plant originally had 150 hp boilers fueled by coal. In 1931, foundations for new boilers were constructed. In 1938, two 820 hp boilers were installed. In 1929, the power plant had air compressors. Archival research indicates that the Navy used the term "central power plant" to designate electricity generating capacity. Interviews with installation personnel indicated that Building 2012 only provided steam heating, although the system included stand-by diesel generators to operate the boiler plant.

The plant was coal-fueled and included an interior coal hopper. Coal handling equipment was installed on the exterior of the building. Open coal storage was located on either side of the building and was transferred to the coal bunker in the building through a system of conveyor belts and chutes. The alternate fuel source originally was oil which was stored near the plant and could be pumped to the plant by the heat fuel oil plant (Building 2028).

The equipment in the building currently consists of six boilers. Boilers 1 and 2 are combustion engine water tube types built in 1938. Boilers 3, 4, and 5 were installed in 1994 and are fueled with natural gas with oil fuel backup. Boiler 6 was installed in 1944. It was fueled with coal, but is currently inactive.

Steam was distributed through the installation through underground and above ground steam pipes. Where needed, the pressure along the steam lines was controlled by steam pump houses. Buildings 3142 and 3143 are examples of steam pump buildings constructed in 1945. Both buildings are one-story, brick structures.

The housing areas relied on natural gas for heating, cooking, and hot water. Building 2352 is an example of a one-story brick gas meter building.

Refuse

In 1919, an incinerator was constructed at Quantico (Index of Drawings for Marine Corps Base, Quantico, Naval Construction Battalion, Port Hueneme, California). By 1921, construction of a brick incinerator (Building 663) was completed. The incinerator is one story with an exposed basement. The exposed basement is constructed of concrete and the first floor is constructed of brick. The first floor level was the charging room, while the furnace was located in the basement. The road encircles the building. One story is visible on the east elevation where the garbage was unloaded across a concrete loading platform. A detached smoke stack was located on the west facade; it has been demolished. The incinerator operated until the 1960s when it was closed (Bob Fritz, Director of Utilities, personal communication). The building is currently abandoned. Current refuse is disposed in a sanitary landfill.

APPENDIX E

DISTRIBUTION OF CURRENT USE CLASSIFICATIONS OF UTILITY AND SUPPORT BUILDINGS AND STRUCTURES TABLES AT ACTIVE DUTY INSTALLATIONS GENERATED FROM 1994 REAL PROPERTY INVENTORY

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Butte MT NRF	--	--	--	--	--	--
Camp Pendleton CA NAVHOSP	--	--	--	--	--	--
Cecil Field FL NAS	1	--	--	--	1	1
Charleston SC FISC	18	--	--	1	--	--
Charleston SC NAVHOSP	--	--	--	--	--	--
Charleston SC NS	--	--	--	--	--	--
Charleston SC NSY	5	--	--	--	--	--
Charleston SC NWS	20	--	--	1	4	--
Charleston SC POMFLANT	--	--	--	--	--	--
Chase Field TX NAS	1	--	1	--	1	--
Cheltenham MD NCU WASH	1	--	--	--	--	--
Cherry Point NC NH	--	1	--	--	--	--
China Lake CA NAWCWPNSDIV	10	--	1	--	1	--
Concord CA NWS	5	--	1	1	2	--
Coronado CA NAVPHIBASE	--	--	--	--	--	--
Corpus Christi TX NAS	9	--	--	--	25	--
Crane IN NAVSURFWARCENDIV	53	--	--	--	21	2
Dahlgren VA NAVPASURSYS	--	--	--	4	--	--

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Dahlgren VA NSWCTR DIV	8	--	--	--	2	--
Dallas TX NAS	2	2	--	--	1	--
Dallas TX NWIRP	3	--	--	1	2	--
Dam Neck VA FCTCLANT	--	--	--	--	1	--
Davisville RI NCBC	31	--	--	--	--	1
Earle NJ NWS	5	--	--	1	1	--
El Centro CA NAF	7	--	--	--	3	--
Fallon NV NAS	--	--	--	--	--	2
Fort Monroe VA NSWCTF	1	--	--	--	--	--
Ft. Lauderdale FL NSWCDET	1	--	--	--	--	--
Glenview IL NAS	1	2	--	--	2	2
Great Lakes IL NTC	--	--	--	2	1	4
Great Lakes IL PWC	--	--	--	--	--	--
Groton CT SUPSHIP	8	--	--	--	--	--
Gulfport MS NCBC	1	--	--	--	--	--
Indian Head MD NSWCTRDIV	12	--	--	2	6	3
Indianapolis IN NAWCACDIV	1	--	--	--	2	1
Jacksonville FL FISC	--	--	--	--	--	--

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Jacksonville FL NAS	21	--	1	2	6	1
Jacksonville FL NMCRC	2	--	--	--	--	--
Jacksonville FL PWC	2	--	--	--	1	3
Key West FL NAS	5	--	--	--	--	1
Key West FL NAVMEDCLINIC	--	--	--	1	--	1
Keyport WA NUWC DIV	3	--	1	--	4	--
Kingsville TX NAS	2	--	--	--	--	--
Kittery ME Portsmouth NSY	14	--	2	--	--	2
Lakehurst NJ NAWC ACFTDIV	7	--	--	--	2	3
Lewes DE NAVRESFAC	1	--	--	--	--	--
Little Creek VA NAVPHIBSE	1	--	--	--	--	--
Long Beach CA NS	2	--	--	2	--	--
Long Beach CA NSY	4	--	--	--	1	--
McClennan TX NIROP	7	--	--	4	--	--
Mechanicsburg PA SPCC	38	--	1	2	--	--
Memphis TN NAS	2	2	--	1	--	5
Minneapolis MN NIROP	1	--	--	--	--	6
Miramar CA NAS	10	1	--	1	--	--

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Moffett Field CA NAS	2	--	--	--	1	2
Monterey CA NPGS	--	--	--	--	--	--
New London CT NSB	8	--	--	--	2	--
New Orleans LA NSA	5	1	--	--	--	--
New York NY NAVSTA	3	--	--	1	4	--
Newport RI NAVHOSP	1	--	1	--	--	--
Newport RI NETC	8	--	--	1	1	1
Newport RI NUSWCTR DIV	2	--	1	--	--	--
Norfolk VA FISC	24	--	1	--	1	--
Norfolk VA LANTFLTHQSPACT	--	--	--	--	1	--
Norfolk VA NAS	5	--	--	--	--	--
Norfolk VA NAVADMCOM AFSC	1	--	--	--	--	--
Norfolk VA NCTAMS LANT	--	--	--	--	1	--
Norfolk VA NS	2	--	--	--	--	--
Norfolk VA PWC	2	--	--	1	--	2
North Island CA NAS	22	--	1	3	--	1
Oakland CA FISC	53	--	--	6	2	--
Oakland CA NH	--	--	--	1	--	--

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Oceana VA NAS	2	--	--	--	--	--
Orlando FL NAVHOSP	--	--	--	--	1	--
Orlando FL NTC	12	--	--	--	--	1
Panama City FL NSWCCSTSYS	--	--	--	--	--	3
Patuxent River MD AWCADV	4	--	--	--	--	8
Pensacola FL NAS	4	--	1	--	--	2
Pensacola FL NETPDC	2	--	--	--	--	--
Pensacola FL NTTC	--	--	--	--	--	--
Pensacola FL PWC	--	--	--	--	--	8
Philadelphia PA ASO	7	--	--	--	1	2
Philadelphia PA NAVHOSP	--	--	--	--	1	--
Philadelphia PA NAVSTA	6	1	--	--	1	--
Philadelphia PA NDAMCONTC	--	--	--	--	--	--
Philadelphia PA NODIVNFEC	3	--	--	--	--	--
Philadelphia PA NSWCSSES	--	--	--	--	1	--
Philadelphia PA NSY	9	--	1	4	1	2
Pittsfield MA NIROP	--	--	--	--	--	--
Point Mugu CA NAVAIRWPNSST	1	--	--	--	--	2

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Pomona CA NIROP	--	--	--	--	--	--
Port Hueneme CA CIVENGLAB	--	--	--	--	--	--
Port Hueneme CA Naval Construction Battalion Center	26	--	--	1	9	--
Portsmouth VA Norfolk NSY	17	--	--	11	16	--
Puget Sound WA NS	6	--	--	--	1	--
Quantico VA NAVMEDCLINIC	--	--	--	--	--	--
Rochester NY NIROP	1	--	--	--	--	--
Rocket Center WVA ABL MNR	22	--	--	--	--	--
Sacramento CA AROJET-GEN	--	--	--	--	1	--
San Bruno CA WESTDIV NFEC	--	--	--	--	--	--
San Diego CA FASWTC PAC	--	--	--	--	--	--
San Diego CA FLT&INDSUPCT	33	--	2	2	1	--
San Diego CA NCCOSCRDTEDV	--	--	--	--	--	--
San Diego CA NCOMPTELSTA	1	--	--	--	--	--
San Diego CA NFECMD SWDIV	--	--	--	--	--	--
San Diego CA NS	7	--	--	--	--	4
San Diego CA NSB	--	--	--	--	1	--

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
San Diego CA NTC	11	--	1	2	4	--
San Diego CA PWC	2	--	--	--	2	4
San Diego CA SIMA	1	--	--	--	--	--
San Francisco CA PWC	3	--	--	--	1	2
Scotia NY NAVADMINU	1	--	--	--	--	--
Seal Beach CA NWS	7	--	--	2	4	--
Seattle WA NRC	--	--	--	--	--	--
Silver Spring MD NSWCD WOAK	2	--	--	--	--	1
Silverdale WA STRATWEPFAC	--	--	--	--	--	--
Skaggs Island CA NSGA	--	--	--	2	--	--
South Weymouth MA NAS	1	--	--	--	--	--
St. Inigoes MD NAVELEXSYS	--	--	--	--	--	--
St. Paul MN NIROP	4	--	--	--	--	--
Stockton CA NCS	33	--	--	5	5	--
Tacoma WA NMCRC	--	--	--	--	--	--
Treasure Island CA NAVSTA	28	--	--	1	1	1
Trenton NJ NAWC ACFTDIV	1	--	--	--	1	
Vallejo CA Mare Island NSY	25	--	--	1	6	1

Name	General Warehouse (44110)	General Purpose and Specific Purpose Warehouse (44111, 44112 44113, 44114)	Cold Storage (44135)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12---, 82160, 82161, 82320)
Warminster PA NAWC ACFTDV	2	--	--	1	1	3
Washington DC ENGFLDACT CHES	--	--	--	--	--	--
Washington DC COMNAVDIST	1	--	--	--	--	1
Washington DC NAVOBSY	2	--	--	--	--	1
Washington DC NAVSECSTA	1	--	--	--	--	--
Washington DC NRL	4	--	--	--	--	1
Washington DC PWC	2	--	--	1	2	14
Whidbey Island WA NAS	2	--	--	--	1	1
Whiting Field FL NAS	--	--	--	1	1	11
Williamsburg VA FISC CA	29	--	--	--	--	2
Williamsburg VA NTAEAF	4	--	--	--	--	--
Willow Grove PA NAS	1	--	--	--	--	--
Winter Harbor ME NSGA	--	--	--	--	--	--
Yorktown VA NWS	4	--	--	--	1	--
TOTALS	865	10	19	91	193	122

Source: 1994 Real Property Inventory, U.S. Navy

TABLE E-2. DISTRIBUTION OF NAVY PERMANENT ORDNANCE STORAGE CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Alameda CA NAS	1	4	3	13	--
Alexandria VA NAVPETOFF	--	--	--	1	--
Annapolis MD NAVACAD	--	1	4	1	--
Bainbridge MD NTC	--	1	--	4	--
Baltimore MD NRC	--	--	--	--	--
Bangor WA NAVSUBASE	--	--	--	--	--
Bethesda MD NATNAVMEDCOM	--	--	--	--	--
Bethesda MD NSWCCARDEROCK	--	1	--	--	--
Bethpage NY NWIRP	--	--	--	--	--
Bremerton Puget Sound WA NSY	--	--	--	--	--
Bremerton Puget Sound WA FISC	--	--	--	--	--
Bremerton WA NAVHOSP	--	--	--	--	--
Brooklyn NY NMCRC	--	--	--	--	--
Brunswick ME NAS	--	2	1	3	--
Butte MT NRF	--	--	--	--	--
Camp Pendleton CA NAVHOSP	--	--	--	--	--
Cecil Field FL NAS	--	3	1	--	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Charleston SC FISC	--	--	--	--	--
Charleston SC NAVHOSP	--	--	--	--	--
Charleston SC NS	--	--	--	2	--
Charleston SC NSY	--	--	--	--	--
Charleston SC NWS	17	33	14	26	47
Charleston SC POMFLANT	--	--	--	--	3
Chase Field TX NAS	--	--	1	--	--
Cheltenham MD NCU WASH	--	--	--	--	--
Cherry Point NC NH	--	--	--	--	--
China Lake CA NAWCWPNSDIV	3	38	1	5	4
Concord CA NWS	47	66	8	24	64
Coronado CA NAVPHIBASE	--	--	--	--	--
Corpus Christi TX NAS	1	1	--	7	--
Crane IN NAVSURFWARCENDIV	113	1,054	159	17	456
Dahlgren VA NAVPASURSYS	--	--	--	--	--
Dahlgren VA NSWCTR DIV	--	3	2	--	13
Dallas TX NAS	--	--	--	--	--
Dallas TX NWIRP	--	--	--	--	--
Dam Neck VA FCTCLANT	--	--	3	3	2
Davisville RI NCBC	--	2	--	1	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Earle NJ NWS	30	147	17	--	52
El Centro CA NAF	1	4	1	1	--
Fallon NV NAS	--	--	--	--	--
Fort Monroe VA NSWCTF	--	--	--	--	--
Ft. Lauderdale FL NSWCDET	--	1	--	2	--
Glenview IL NAS	--	--	2	--	--
Great Lakes IL NTC	--	--	--	1	--
Great Lakes IL PWC	--	--	--	--	--
Groton CT SUPSHIP	--	--	--	--	--
Gulfport MS NCBC	--	--	--	3	--
Indian Head MD NSWCTRDIV	3	10	7	2	38
Indianapolis IN NAWCACDIV	--	--	--	--	--
Jacksonville FL FISC	--	--	--	--	--
Jacksonville FL NAS	8	22	2	8	--
Jacksonville FL NMCRC	--	--	--	--	--
Jacksonville FL PWC	--	--	--	--	--
Key West FL NAS	4	12	7	--	2
Key West FL NAVMEDCLINIC	--	--	--	--	--
Keyport WA NUWC DIV	--	--	14	--	73
Kingsville TX NAS	--	--	--	--	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Kittery ME Portsmouth NSY	--	--	1	1	--
Lakehurst NJ NAWC ACFTDIV	1	1	--	3	--
Lewes DE NAVRESFAC	--	--	--	--	--
Little Creek VA NAVPHIBSE	--	--	1	1	--
Long Beach CA NS	--	--	--	--	--
Long Beach CA NSY	--	--	--	--	--
McClennan TX NIROP	--	118	--	--	--
Mechanicsburg PA SPCC	--	--	--	--	--
Memphis TN NAS	--	--	1	2	--
Minneapolis MN NIROP	--	--	--	--	--
Miramar CA NAS	--	--	1	7	--
Moffett Field CA NAS	1	4	1	2	--
Monterey CA NPGS	--	--	--	--	--
New London CT NSB	10	53	--	--	--
New Orleans LA NSA	--	--	--	--	--
New York NY NAVSTA	--	--	--	--	--
Newport RI NAVHOSP	--	--	--	--	--
Newport RI NETC	--	--	--	--	--
Newport RI NUSWCTR DIV	--	--	--	--	--
Norfolk VA FISC	--	--	--	--	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Norfolk VA LANTFLTHQSPACT	--	--	--	--	--
Norfolk VA NAS	17	11	4	5	2
Norfolk VA NAVADMCOM AFSC	--	--	--	--	--
Norfolk VA NCTAMS LANT	--	--	--	--	--
Norfolk VA NS	--	--	--	--	--
Norfolk VA PWC	--	--	--	--	--
North Island CA NAS	1	11	4	2	--
Oakland CA FISC	--	--	--	--	--
Oakland CA NH	--	--	--	--	--
Oceana VA NAS	--	--	--	--	--
Orlando FL NAVHOSP	--	--	--	--	--
Orlando FL NTC	--	--	--	--	--
Panama City FL NSWCCSTSYS	--	--	--	--	--
Patuxent River MD AWCADV	--	1	2	3	1
Pensacola FL NAS	1	3	1	4	--
Pensacola FL NETPDC	--	--	--	--	--
Pensacola FL NTTC	--	--	--	--	--
Pensacola FL PWC	--	--	--	--	--
Philadelphia PA ASO	--	--	--	--	--
Philadelphia PA NAVHOSP	--	--	--	--	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Philadelphia PA NAVSTA	--	--	--	--	--
Philadelphia PA NDAMCONTC	--	--	--	--	--
Philadelphia PA NODIVNFEC	--	--	--	--	--
Philadelphia PA NSWCSSES	--	--	--	--	--
Philadelphia PA NSY	--	--	--	--	--
Pittsfield MA NIROP	--	--	--	--	--
Point Mugu CA NAVAIRWPNSST	2	11	--	1	--
Pomona CA NIROP	--	--	--	--	--
Port Hueneme CA CIVENGLAB	--	--	--	--	--
Port Hueneme CA Naval Construction Battalion Center	--	--	--	--	--
Portsmouth VA Norfolk NSY	--	--	--	--	--
Puget Sound WA NS	--	--	--	--	--
Quantico VA NAVMEDCLINIC	--	--	--	--	--
Rochester NY NIROP	--	--	--	--	--
Rocket Center WVA ABL MNR	--	6	--	--	--
Sacramento CA AROJET-GEN	--	--	--	--	--
San Bruno CA WESTDIV NFEC	--	--	--	--	--
San Diego CA FASWTC PAC	--	--	--	--	--
San Diego CA FLT&INDSUPCT	--	--	1	--	--
San Diego CA NCCOSCRDTEDV	1	--	--	--	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
San Diego CA NCOMPTELSTA	--	--	--	--	--
San Diego CA NFECMD SWDIV	--	--	--	--	--
San Diego CA NS	--	--	--	--	--
San Diego CA NSB	--	--	--	--	--
San Diego CA NTC	--	--	--	--	--
San Diego CA PWC	--	--	--	--	--
San Diego CA SIMA	--	--	--	--	--
San Francisco CA PWC	--	--	--	--	--
Scotia NY NAVADMINU	--	--	--	--	--
Seal Beach CA NWS	60	149	29	51	66
Seattle WA NRC	--	--	--	--	--
Silver Spring MD NSWCD WOAK	1	5	--	--	--
Silverdale WA STRATWEPFAC	11	--	4	--	--
Skaggs Island CA NSGA	--	--	--	--	--
South Weymouth MA NAS	--	1	--	--	1
St. Inigoes MD NAVELEXSYS	--	--	--	--	--
St. Paul MN NIROP	--	--	--	--	--
Stockton CA NCS	--	--	--	--	--
Tacoma WA NMCRC	--	--	--	--	--
Treasure Island CA NAVSTA	--	--	--	--	--

Name	Fuse and Detonator (42112)	High Explosive (42122)	Inert (42132)	Small Arms (42148)	Smokeless Powder (42152)
Trenton NJ NAWC ACFTDIV	--	--	--	--	--
Vallejo CA Mare Island NSY	--	5	1	11	--
Warminster PA NAWC ACFTDV	--	--	1	--	--
Washington DC ENGFLDACT CHES	--	--	--	--	--
Washington DC COMNAVDIST	--	--	--	--	--
Washington DC NAVOBSY	--	--	--	--	--
Washington DC NAVSECSTA	--	--	--	--	--
Washington DC NRL	--	--	--	2	--
Washington DC PWC	--	--	--	--	--
Whidbey Island WA NAS	3	17	3	--	--
Whiting Field FL NAS	--	--	--	1	--
Williamsburg VA FISC CA	--	--	--	--	--
Williamsburg VA NTAEAF	--	--	--	--	--
Willow Grove PA NAS	--	--	--	2	--
Winter Harbor ME NSGA	--	--	--	--	--
Yorktown VA NWS	23	107	31	10	--
TOTALS	360	1,908	333	232	824

Source: 1994 Real Property Inventory, U.S. Navy

TABLE E-3. DISTRIBUTION OF NAVY PERMANENT UTILITIES CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Alameda CA NAS	3	--	--	--	2	2
Alexandria VA NAVPETOFF	2	1	2	--	4	--
Annapolis MD NAVACAD	14	3	9	--	3	--
Bainbridge MD NTC	1	5	23	2	6	--
Baltimore MD NRC	--	--	--	--	--	--
Bangor WA NAVSUBASE	8	--	9	--	12	--
Bethesda MD NATNAVMEDCOM	--	--	--	--	1	--
Bethesda MD NSWCCARDEROCK	5	3	3	--	10	1
Bethpage NY NWIRP	--	2	1	--	4	--
Bremerton Puget Sound WA NSY	42	2	2	1	2	2
Bremerton Puget Sound WA FISC	6	2	2	--	11	--
Bremerton WA NAVHOSP	--	--	--	--	--	--
Brooklyn NY NMCRC	--	--	--	--	--	--
Brunswick ME NAS	--	--	1	--	2	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Butte MT NRF	1	--	--	--	--	--
Camp Pendleton CA NAVHOSP	--	--	--	--	--	--
Cecil Field FL NAS	--	--	2	--	--	--
Charleston SC FISC	2	--	--	--	1	--
Charleston SC NAVHOSP	--	--	--	--	--	--
Charleston SC NS	--	--	--	--	--	--
Charleston SC NSY	18	--	--	--	9	2
Charleston SC NWS	1	4	1	--	5	--
Charleston SC POMFLANT	--	--	--	--	--	--
Chase Field TX NAS	--	--	3	--	2	--
Cheltenham MD NCU WASH	2	1	--	--	2	2
Cherry Point NC NH	--	--	--	--	--	--
China Lake CA NAWCWPNSDIV	12	14	3	--	37	--
Concord CA NWS	1	--	--	--	7	--
Coronado CA NAVPHIBASE	--	--	--	--	--	1
Corpus Christi TX NAS	7	4	13	--	5	5
Crane IN NAVSURFWARCENDIV	14	16	10	--	14	23
Dahlgren VA NAVPASURSYS	--	--	--	--	--	--
Dahlgren VA NSWCTR DIV	3	10	3	--	7	2

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Dallas TX NAS	2	--	1	1	8	--
Dallas TX NWIRP	2	3	3	--	7	1
Dam Neck VA FCTCLANT	--	1	--	--	--	--
Davisville RI NCBC	1	17	1	--	--	--
Earle NJ NWS	9	3	8	--	16	--
El Centro CA NAF	6	--	6	1	13	--
Fallon NV NAS	--	--	--	--	--	--
Fort Monroe VA NSWCTF	--	--	--	--	--	--
Ft. Lauderdale FL NSWCDET	2	--	--	--	--	--
Glenview IL NAS	5	2	--	--	1	1
Great Lakes IL NTC	--	--	--	--	--	--
Great Lakes IL PWC	5	6	2	1	2	1
Groton CT SUPSHIP	--	--	--	--	--	--
Gulfport MS NCBC	1	--	4	--	4	--
Indian Head MD NSWCTRDIV	8	2	5	--	15	1
Indianapolis IN NAWCACDIV	2	3	--	--	2	1
Jacksonville FL FISC	--	--	--	--	1	--
Jacksonville FL NAS	1	1	14	2	13	3
Jacksonville FL NMCRC	--	--	--	--	--	--
Jacksonville FL PWC	14	8	10	--	34	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Key West FL NAS	17	3	4	1	89	1
Key West FL NAVMEDCLINIC	--	1	--	--	--	--
Keyport WA NUWC DIV	34	1	4	--	6	--
Kingsville TX NAS	3	--	--	--	3	--
Kittery ME Portsmouth NSY	5	--	--	--	2	1
Lakehurst NJ NAWC ACFTDIV	50	2	5	--	19	2
Lewes DE NAVRESFAC	--	--	--	--	--	--
Little Creek VA NAVPHIBSE	1	--	1	--	--	--
Long Beach CA NS	1	2	1	--	--	--
Long Beach CA NSY	28	2	5	--	3	1
McClennan TX NIROP	1	2	1	--	15	--
Mechanicsburg PA SPCC	2	9	8	1	6	--
Memphis TN NAS	1	4	4	--	5	--
Minneapolis MN NIROP	--	--	--	--	6	--
Miramar CA NAS	--	--	--	--	5	--
Moffett Field CA NAS	5	5	1	1	9	1
Monterey CA NPGS	1	--	--	--	1	--
New London CT NSB	3	1	6	--	2	1
New Orleans LA NSA	4	1	--	--	--	--
New York NY NAVSTA	4	--	1	--	2	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Newport RI NAVHOSP	1	--	--	--	--	--
Newport RI NETC	26	7	1	--	15	2
Newport RI NUSWCTR DIV	3	1	--	--	5	2
Norfolk VA FISC	24	1	5	--	5	--
Norfolk VA LANTFLTHQSPACT	3	--	--	--	--	--
Norfolk VA NAS	5	2	2	--	--	--
Norfolk VA NAVADMCOM AFSC	--	--	--	--	--	--
Norfolk VA NCTAMS LANT	10	--	1	--	3	1
Norfolk VA NS	--	--	1	--	--	1
Norfolk VA PWC	146	21	10	--	37	1
North Island CA NAS	5	1	1	--	9	2
Oakland CA FISC	--	--	1	--	--	--
Oakland CA NH	--	--	--	--	2	--
Oceana VA NAS	--	--	--	--	--	--
Orlando FL NAVHOSP	--	--	--	--	--	--
Orlando FL NTC	--	1	2	--	1	--
Panama City FL NSWCCSTSYS	2	--	--	--	7	--
Patuxent River MD AWCADV	3	19	21	1	63	--
Pensacola FL NAS	8	1	--	1	--	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Pensacola FL NETPDC	--	--	--	--	3	--
Pensacola FL NTTC	--	--	--	--	--	--
Pensacola FL PWC	44	10	8	--	19	--
Philadelphia PA ASO	21	1	--	--	--	--
Philadelphia PA NAVHOSP	3	2	1	--	2	--
Philadelphia PA NAVSTA	--	1	--	--	--	--
Philadelphia PA NDAMCONTC	--	1	--	--	1	--
Philadelphia PA NODIVNFEC	3	1	--	--	--	--
Philadelphia PA NSWCSSES	2	--	--	--	1	--
Philadelphia PA NSY	23	4	2	1	19	2
Pittsfield MA NIROP	--	1	--	--	--	--
Point Mugu CA NAVAIRWPNSST	7	--	4	--	4	--
Pomona CA NIROP	--	--	--	--	1	--
Port Hueneme CA CIVENGLAB	--	--	1	--	--	--
Port Hueneme CA Naval Construction Battalion Center	2	8	5	--	12	--
Portsmouth VA Norfolk NSY	5	4	2	1	2	2
Puget Sound WA NS	4	2	6	--	2	--
Quantico VA NAVMEDCLINIC	1	2	--	1	--	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Rochester NY NIROP	--	--	--	--	--	--
Rocket Center WVA ABL MNR	--	--	--	--	2	--
Sacramento CA AROJET-GEN	--	--	--	--	--	--
San Bruno CA WESTDIV NFEC	--	--	--	--	1	--
San Diego CA FASWTC PAC	--	--	--	--	--	--
San Diego CA FLT&INDSUPCT	1	--	--	--	--	2
San Diego CA NCCOSCRDTEDV	--	--	--	--	1	--
San Diego CA NCOMPTELSTA	--	--	1	--	1	--
San Diego CA NFECMD SWDIV	1	--	--	--	--	--
San Diego CA NS	--	--	--	--	3	--
San Diego CA NSB	--	1	--	--	--	--
San Diego CA NTC	1	--	--	--	--	1
San Diego CA PWC	40	12	11	--	50	1
San Diego CA SIMA	--	--	--	--	--	--
San Francisco CA PWC	61	18	31	--	29	--
Scotia NY NAVADMINU	--	--	--	--	--	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Seal Beach CA NWS	44	11	7	3	24	2
Seattle WA NRC	3	1	--	--	--	--
Silver Spring MD NSWCD WOAK	4	2	--	--	--	--
Silverdale WA STRATWEPFAC	--	--	--	--	--	--
Skaggs Island CA NSGA	2	--	1	--	1	2
South Weymouth MA NAS	2	3	1	--	2	--
St. Inigoes MD NAVELEXSYS	--	--	1	--	1	--
St. Paul MN NIROP	2	2	--	--	1	--
Stockton CA NCS	1	2	3	--	3	1
Tacoma WA NMCRC	--	1	--	--	--	1
Treasure Island CA NAVSTA	13	1	--	--	4	--
Trenton NJ NAWC ACFTDIV	1	--	--	--	2	--
Vallejo CA Mare Island NSY	22	3	4	1	6	10
Warminster PA NAWC ACFTDV	3	1	14	--	10	1
Washington DC ENGFLDACT CHES	1	--	--	--	--	--
Washington DC COMNAVDIST	1	1	4	--	--	--
Washington DC NAVOBSY	--	1	--	--	--	--

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- + 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Washington DC NAVSECSTA	2	--	--	--	--	--
Washington DC NRL	5	4	--	--	3	--
Washington DC PWC	23	12	4	1	1	--
Whidbey Island WA NAS	7	1	1	--	10	--
Whiting Field FL NAS	2	2	10	3	7	1
Williamsburg VA FISC CA	2	2	4	--	7	--
Williamsburg VA NTAEAF	--	--	--	--	1	--
Willow Grove PA NAS	6	3	3	1	9	1
Winter Harbor ME NSGA	1	--	--	--	--	--
Yorktown VA NWS	17	12	10	1	10	2
TOTALS	979	333	366	26	837	93

Source: 1994 Real Property Inventory, U.S. Navy

Name	General Storage (44110)	Marine Corps Storage (44111, 44112, 44113, 44114)	Cold Storage (43110)	Shed (44135)	Hazardous Storage (44130)	Fuel Storage (12--, 82160, 82161, 82320)
Arlington VA HQMC	--	1	--	--	--	--
Barstow CA MCLB	--	24	--	--	2	1
Beaufort SC MCAS	--	6	--	--	--	1
Camp Elmore VA MCCD	--	2	--	1	1	--
Camp Lejeune NC MCB	4	142	1	6	2	12
Camp Pendleton CA MCAS	--	--	--	--	--	--
Camp Pendleton CA MCB	--	88	--	--	3	11
Cherry Point MCAS	6	11	1	1	1	31
El Toro CA MCAS	5	4	--	1	8	32
Garden City NY MCDIST	1	--	--	--	--	--
Parris Island SC MCRD	--	24	--	1	1	8
Quantico VA MCCOMBDEV CMD	1	29	1	1	5	18
San Diego CA MCRD	--	16	--	3	1	--
Tustin CA MCAS	--	13	--	--	1	--
Washington DC MCBKS	--	1	--	--	--	1
Yuma AZ MCAS	--	3	--	--	--	3
TOTAL	17	364	3	14	25	118

Source: 1994 Real Property Inventory, U.S. Navy

TABLE E-5. DISTRIBUTION OF MARINE CORPS PERMANENT ORDNANCE STORAGE CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Fuse & Detonator Magazines (42112)	High Explosive Magazines (42112)	Inert Storage (42132)	Small Arms Magazines (42148)	Smokeless Powder Magazines (42152)
Arlington VA HQMC	--	--	--	--	--
Barstow CA MCLB	--	--	--	--	--
Beaufort SC MCAS	--	--	--	--	--
Camp Elmore VA MCCD	--	--	--	--	--
Camp Lejeune NC MCB	13	16	--	7	4
Camp Pendleton CA MCAS	--	--	--	--	--
Camp Pendleton CA MCB	--	--	--	--	--
Cherry Point NC1 MCAS	9	22	3	--	--
El Toro CA MCAS	--	--	7	--	--
Garden City NY MCDIST	--	--	--	--	--
Parris Island SC MCRD	3	4	1	1	--
Quantico VA MCCOMBDEV CMD	1	5	--	11	--
San Diego CA MCRD	--	--	--	--	--
Tustin CA MCAS	--	--	--	--	--
Washington DC MCBKS	--	--	--	--	--
Yuma AZ MCAS	--	1	--	--	--
TOTALS	26	48	11	19	4

Source: 1994 Real Property Inventory, U.S. Navy

Name	Electrical (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Incinerators (833--)	Water (84---)	Miscellaneous (89---)
Arlington VA HQMC	--	--	--	--	--	--
Barstow CA MCLB	6	3	--	--	16	--
Beaufort SC MCAS	--	--	--	--	3	--
Camp Elmore VA MCCD	--	--	--	--	--	--
Camp Lejeune NC MCB	42	24	40	--	41	2
Camp Pendleton CA MCAS	--	--	--	--	--	--
Camp Pendleton CA MCB	18	2	16	1	26	--
Cherry Point MCAS	9	1	27	--	26	--
El Toro CA MCAS	--	1	1	--	7	2
Garden City NY MCDIST	--	--	--	--	--	--
Parris Island SC MCRD	3	2	3	3	10	--
Quantico VA MCCOMBDEV CMD	4	5	7	1	16	1
San Diego CA MCRD	1	--	--	--	--	--
Tustin CA MCAS	4	3	1	--	2	--
Washington DC MCBKS	--	--	--	--	--	--
Yuma AZ MCAS	--	--	1	--	4	--
TOTALS	87	41	96	5	151	5

Source: 1994 Real Property Inventory, U.S. Navy

TABLE E-7. DISTRIBUTION OF ARMY PERMANENT STORAGE BUILDINGS CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
1sg Adam S. Brandt USARC, MD	--	1	--	--	--	--	--
Aberdeen Proving Ground, MD	1	122	--	33	9	2	4
Adelphi Blossom PT Test Area, MD	--	--	--	--	--	--	--
AFRC Douglas, UT	--	5	--	--	2	1	4
AFRC Los Alamitos, CA	1	18	--	--	--	--	--
Alabama AAP, AL	--	19	--	3	--	1	2
Anniston Army Depot, AL	--	12	31	1	11	2	--
Army Materials Technology Lab, MA	--	1	--	--	--	--	1
Badger AAP, WI	--	59	--	7	--	--	7
Big Bethel Reservoir, VA	--	--	--	--	--	--	--
Blue Grass Activity-LBAD, KY	--	16	--	1	1	--	--
Bonneville Camp, WA	1	3	--	--	--	--	1

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Cameron Station, VA	--	7	--	--	--	--	--
Camp Bullis, TX	--	4	--	--	1	--	--
Camp Peary Erie Army Depot, OH	--	5	--	--	--	--	--
Camp Stanley Storage Activity, TX	--	6	--	2	3	5	--
Carlisle Barracks, PA	--	5	--	--	3	--	--
Charles Melvin Price Support Center, IL	--	7	4	1	--	--	--
Columbus Support Facility, OH	--	--	--	--	--	--	--
Coosa River Storage Annex, AL	--	--	--	--	--	--	--
Cornhusker AAP, NE	--	12	--	8	--	2	--
Defense Construction Support Center, OH	--	15	11	2	--	--	14
DEF Depot Memphis, TN	1	26	--	1	--	--	--
DEF Depot Ogden, UT	--	34	--	5	2	--	--
DEF DISTR REG E New Cumberland, PA	--	18	1	2	1	1	--
DEF DIST REG WEST Sharpe Site, CA	--	11	2	3	--	1	--

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
DEF DISTR REG WEST, Tracy, CA	--	13	--	--	--	--	--
Defense General Supply Center, VA	--	21	1	7	1	--	--
Defense Personnel Support Center, PA	--	12	--	1	--	--	--
Defense Mapping Agency, VA	--	1	--	1	--	--	--
Detroit Arsenal, MI	--	1	--	--	--	--	--
Detroit Arsenal Tank Plant, MI	--	--	--	--	--	--	--
Dugway Proving Ground, UT	--	1	--	1	--	1	--
Fitzsimons Army Medical Center, CO	1	15	--	1	8	1	3
Fort Baker East, CA	--	1	--	3	--	--	--
Fort Belvoir, VA	--	29	--	5	1	--	--
Fort Benjamin Harrison, IN	--	15	--	3	2	--	--
Fort Benning, GA	2	29	--	2	1	--	--
Fort Bliss, TX	1	53	--	6	--	--	1
Fort Bliss-AAA Ranges, TX	--	--	--	--	--	--	--

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Fort Bragg, NC	1	12	--	--	1	1	--
Fort Campbell, KY	--	--	--	--	--	--	--
Fort Carson, CO	--	2	--	1	--	--	1
Fort Chaffee, AR	--	--	--	1	--	--	--
Fort Detrick, MD	--	4	--	--	2	--	--
Fort Devens, MA	1	2	--	4	1	--	--
Fort Devens Training Annex Sudbury, MA	--	--	--	--	--	--	--
Fort Dix, NJ	--	32	--	--	--	--	--
Fort Drum, NY	2	40	--	1	--	--	--
Fort Eustis, VA	--	5	--	--	--	--	--
Fort George G. Meade, MD	1	28	--	1	5	--	1
Fort Gillem, GA	--	34	2	2	--	1	1
Fort Gordon, GA	--	1	--	--	--	--	--
Fort Hamilton, NY	--	--	--	--	--	--	2
Fort Huachuca, AZ	1	8	--	--	6	--	--
Fort Hunter Liggett, CA	--	2	--	--	--	--	--
Fort Indiantown Gap, PA	1	6	--	--	1	--	--
Fort Jackson, SC	1	3	1	--	1	--	--

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Fort Knox, KY	1	45	--	7	9	1	--
Fort Leavenworth, KS	--	7	--	4	4	1	1
Fort Lee, VA	1	1	--	1	--	--	--
Fort Leonard Wood, MO	3	25	--	--	--	--	--
Fort Lewis, WA	2	50	--	--	--	1	1
Fort McClellan, AL	2	6	1	--	--	--	2
Fort McCoy, WI	--	1	--	1	--	--	--
Fort McPherson, GA	--	7	--	--	--	--	--
Fort Missoula, MT	--	--	--	--	--	--	--
Fort Monroe, VA	--	6	--	1	--	--	--
Fort Myer, VA	--	5	--	--	--	--	---
Fort Monmouth, NJ	--	5	--	--	1	--	--
Fort Monmouth Fort Charles Wood Area, NJ	--	11	--	--	--	--	--
Fort Monmouth-Evans Area, NJ	--	4	--	--	--	2	--
Fort Ord, CA	1	31	--	1	--	--	--
Fort Pickett, VA	--	--	--	--	--	--	--
Fort Polk, LA	--	1	--	--	--	--	--
Fort Riley, KS	2	20	--	2	1	--	--

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Fort Ritchie, MD	--	3	1	--	--	--	--
Fort Rucker, AL	--	2	--	3	--	--	--
Fort Sam Houston, TX	2	25	--	2	5	4	--
Fort Sill, OK	1	38	--	3	2	--	--
Fort Sheridan, IL	--	4	--	2	1	--	4
Fort Stewart, GA	1	2	--	--	--	--	--
Fort Story, VA	1	18	--	--	--	--	--
Fort Totten, NY	--	--	--	--	--	1	--
Fort Wingate Depot Activity, NM	--	10	--	--	--	--	1
Hamilton Army Airfield, CA	1	6	--	1	--	--	--
Hawthorne AAP, NV	2	200	--	19	5	--	--
Holabird DEF Investigation Facility, MD	--	2	--	--	--	--	--
Holston AAP, TN	--	4	--	--	--	--	1
Hunter Army Airfield, GA	--	5	--	9	--	--	--
Indiana AAP, IN	--	96	--	4	--	--	--
Iowa AAP, IO	--	44	--	5	2	--	1
Jefferson Proving Ground, IN	--	12	--	1	1	1	2

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Joliet AAP Elwood, IL	--	29	--	6	2	--	--
Joliet AAP Kankakee, IL	--	9	--	1	--	1	1
Kansas AAP, KS	--	27	--	3	1	4	--
Lake City AAP, MO	--	12	--	--	--	--	--
Letterkenny Army Depot, PA	--	15	18	1	--	1	--
Lexington-Blue Grass Army Depot, KY	1	8	4	3	3	--	--
Lima Army Tank Plant, OH	--	1	--	--	--	--	--
Lone Star AAP, TX	--	25	--	2	--	--	--
Longhorn AAP, TX	--	8	--	1	--	3	1
Louisiana AAP, LA	--	33	1	4	--	1	1
McAlester AAP, OK	--	135	--	23	6	4	--
MG Leif J. Sverdrup USARC/AMSA, MO	--	--	--	--	--	--	--
Milan AAP, TN	--	45	2	14	--	--	1
Military Ocean Terminal, Bayonne, NJ	1	17	--	--	--	1	1
Navajo Depot Activity, AZ	--	11	--	2	1	--	1

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
New Orleans Army Base, LA	--	--	--	--	--	--	--
Newport AAP, IN	--	30	--	1	1	--	1
NG Atterbury Res Forces Training, IN	--	--	--	--	--	--	--
NG Byrd Field, VA	--	--	--	--	--	--	--
NG Camp Ashland, NE	--	4	--	--	--	1	--
NG Camp Clark, MO	1	21	--	1	--	--	--
NG Camp Edwards, MA	4	9	--	--	1	18	--
NG Camp Gruber, OK	1	2	--	--	--	--	--
NG Camp Mc Cain, MS	--	--	--	--	1	--	--
NG Camp Roberts, CA	1	1	--	2	--	--	--
NG Camp Williams, UT	--	--	--	--	--	--	--
NG Custer Res Forces Training Area, MI	--	8	--	--	--	--	--
NG Ethan Allen AFB, VT	--	9	--	--	--	--	--
NG Fort Allen, VT	--	5	--	1	--	--	--
NG Fort Missoula, MT	--	1	--	1	--	--	2
NG Fort William Henry Harrison, MT	--	--	--	--	--	--	1
NG George Wright, WA	--	--	--	--	--	--	5

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
NG Hammer Field, CA	--	9	--	--	--	--	--
NG Hastings, NE	--	2	--	1	--	--	--
NG Mead, NE	--	1	--	--	--	--	--
NG New Castle, DE	--	3	--	1	1	--	--
NG Smyrna Training Center, TN	--	--	--	1	--	--	--
NTC and Fort Irwin, CA	--	--	--	--	--	--	--
Oakland Army Base, CA	--	13	--	--	--	--	1
Pedricktown Support Facility, NJ	--	2	--	--	3	--	--
Pentagon, VA	--	--	--	--	--	--	--
Picatinny Arsenal, NJ	--	69	--	25	8	2	1
Pine Bluff Arsenal, AR	--	69	1	17	--	--	--
Presidio of Monterey, CA	--	1	--	--	--	--	1
Presidio of San Francisco, CA	--	3	--	6	1	6	1
Pueblo Depot Activity, CO	--	22	--	--	3	3	1
Radford AAP, VA	1	56	2	--	--	3	--
Radford AAP, New River, VA	--	--	--	--	--	--	1

Name	Cold Storage (424-- & 43---)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Ravenna AAP, OH	--	36	23	6	1	--	1
Red River Army Depot, TX	--	22	11	1	2	--	5
Redstone Arsenal, AL	--	88	--	6	8	10	--
Rock Island Arsenal, IL	1	15	--	4	2	--	--
Rocky Mountain Arsenal, CO	--	16	--	5	--	1	1
Sacramento Army Depot, CA	--	5	--	--	1	--	--
Savanna Depot Activity, IL	--	17	--	7	2	1	3
Seneca Army Depot, NY	--	25	6	1	--	--	--
Sierra Army Depot, CA	--	29	47	2	2	--	--
Skaneateles Wet Site, NY	--	3	--	--	--	--	--
St. Louis AAP, MO	--	5	--	--	--	--	--
St. Charles USARC, MO	--	--	--	2	--	--	1
Stewart Annex, NY	--	11	--	--	--	1	1
Stratford Army Eng Plant, CT	--	2	--	2	--	--	--
Sunflower AAP, KS	--	63	--	6	--	2	--
Tacony Warehouse Site, PA	--	2	--	--	--	--	--

Name	Cold Storage (424– & 43—)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Tarheel Army Missile Plant, NC	--	1	--	--	--	--	--
Tooele Army Depot, UT	--	24	--	3	5	1	8
Tooele Army Depot RR Maintenance, UT	--	--	--	1	--	--	--
Tooele Army Depot South Area, UT	--	7	--	--	1	--	2
Twin Cities AAP, MN	--	5	--	7	--	--	--
Umatillo Depot Activity, OR	--	43	--	2	1	--	4
U.S. Army Garrison-Selfridge, MI	--	--	--	--	3	1	--
USARC Des Moines, IO	--	1	--	--	--	--	--
USARC Fac Woolworth St., NE	--	1	--	--	--	--	--
USARC Fort Lawton, WA	--	1	--	--	--	--	--
USARC Hingham Cohasset, MA	--	2	--	--	--	--	--
USDB Lompoc, CA	--	--	--	--	--	--	--
Vancouver Barracks, WA	--	2	--	--	--	--	--
Vint Hill Farms Station, VA	--	3	--	--	--	--	--

Name	Cold Storage (424-- & 43—)	General Purpose (44220, 44110, & 44270)	Controlled Humidity (44130 & 44230)	Inflammable Material (44150 & 44240)	Facilities Engineer Storehouse (44275)	Sheds (44222)	Vehicle Storage (44181 & 44262)
Volunteer AAP, TN	--	2	--	--	--	3	--
Walter Reed AMC, DC	--	2	--	--	2	--	--
Walter Reed AMC, Forest Glen, MD	--	--	--	--	1	--	--
Watervliet Arsenal, NY	--	4	1	--	--	1	--
West Point Military Reservation, NY	1	12	--	2	1	--	1
White Sands Missile Range, NM	--	3	--	--	--	--	--
TOTALS	48	2,639	171	349	158	96	103

Source: 1994 Real Property Inventory, U.S. Army

TABLE E-8. DISTRIBUTION OF PERMANENT ARMY ORDNANCE STORAGE CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
1sg Adam S. Brandt USARC, MD	--	--	--	--	--	--
Aberdeen Proving Ground, MD	27	32	3	--	25	--
Adelphi Blossom PT Test Area, MD	--	--	2	--	--	--
AFRC Douglas, UT	--	--	--	--	--	--
AFRC Los Alamitos, CA	--	--	--	--	--	7
Alabama AAP, AL	--	--	--	--	--	--
Anniston Army Depot, AL	699	--	--	--	--	--
Army Materials Technology Lab, MA	--	--	--	--	--	--
Badger AAP, WI	--	22	1	--	4	98
Big Bethel Reservoir, VA	--	--	--	--	--	--
Blue grass Activity-LBAD, KY	801	--	--	12	1	--
Bonneville Camp, WA	--	--	--	--	--	--
Cameron Station, VA	--	--	--	--	--	--
Camp Bullis, TX	--	--	--	--	8	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Camp Peary Erie Army Depot, OH	--	--	--	--	--	--
Camp Stanley Storage Activity, TX	120	--	--	--	--	5
Carlisle Barracks, PA	--	--	--	--	--	--
Charles Melvin Price Support Center, IL	--	--	--	--	--	--
Columbus Support Facility, OH	--	--	--	--	--	--
Coosa River Storage Annex, AL	136	--	--	--	--	--
Cornhusker AAP, NE	--	117	--	--	--	102
Defense Construction Support Center, OH	--	--	--	--	--	--
DEF Depot Memphis, TN	--	--	--	--	--	--
DEF Depot Ogden, UT	10	--	--	--	1	--
DEF DISTR REG E New Cumberland, PA	--	--	--	--	--	--
DEF DIST REG WEST Sharpe Site, CA	--	--	--	--	--	--
DEF DISTR REG WEST, Tracy, CA	--	--	--	--	--	--
Defense General Supply Center, VA	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Defense Personnel Support Center, PA	--	--	--	--	--	--
Defense Mapping Agency, VA	--	--	--	--	--	--
Detroit Arsenal, MI	--	--	--	--	--	--
Detroit Arsenal Tank Plant, MI	--	--	--	--	--	--
Dugway Proving Ground, UT	4	--	--	--	--	15
Fitzsimons Army Medical Center, CO	--	--	--	--	--	--
Fort Baker East, CA	--	--	--	--	--	--
Fort Belvoir, VA	--	5	2	--	2	--
Fort Benjamin Harrison, IN	--	--	--	--	--	--
Fort Benning, GA	9	--	--	--	--	--
Fort Bliss-AAA Ranges, TX	4	--	--	--	--	--
Fort Bragg, NC	--	--	--	--	--	--
Fort Campbell, KY	--	--	--	--	--	--
Fort Carson, CO	--	--	--	--	--	--
Fort Chaffee, AR	--	23	--	--	--	--
Fort Detrick, MD	--	--	--	--	--	--
Fort Devens, MA	--	--	--	--	12	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Fort Devens Training Annex Sudbury, MA	50	--	--	--	--	--
Fort Dix, NJ	--	2	1	--	--	1
Fort Drum, NY	--	3	--	--	--	--
Fort Eustis, VA	--	--	--	--	--	--
Fort George G. Meade, MD	--	--	--	--	--	--
Fort Gillem, GA	6	--	--	--	--	--
Fort Gordon, GA	20	--	--	--	--	--
Fort Hamilton, NY	--	--	--	--	--	--
Fort Huachuca, AZ	--	13	--	--	--	--
Fort Hunter Liggett, CA	--	--	--	--	--	--
Fort Indiantown Gap, PA	--	--	--	--	--	--
Fort Jackson, SC	--	6	--	--	--	--
Fort Knox, KY	1	19	5	--	--	--
Fort Leavenworth, KS	--	--	--	--	--	--
Fort Lee, VA	--	--	--	--	--	--
Fort Leonard Wood, MO	--	--	--	--	--	--
Fort Lewis, WA	--	--	--	--	--	--
Fort McClellan, AL	--	16	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Fort McCoy, WI	--	--	--	--	--	--
Fort McPherson, GA	--	--	--	--	--	--
Fort Missoula, MT	--	---	--	--	--	--
Fort Monroe, VA	--	--	--	--	--	--
Fort Myer, VA	--	--	--	--	5	--
Fort Monmouth, NJ	--	--	--	--	3	--
Fort Monmouth-Charles Wood Area, NJ	--	--	--	--	--	--
Fort Monmouth-Evans Area, NJ	--	--	--	--	--	--
Fort Ord, CA	--	1	1	--	--	1
Fort Pickett, VA	--	--	--	--	--	--
Fort Polk, LA	--	--	--	--	--	--
Fort Riley, KS	--	2	--	--	--	--
Fort Ritchie, MD	--	--	--	--	--	--
Fort Rucker, AL	14	--	--	--	--	--
Fort Sam Houston, TX	3	--	--	--	--	--
Fort Sill, OK	1	1	1	--	--	4
Fort Sheridan, IL	--	--	---	--	3	--
Fort Stewart, GA	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Fort Story, VA	--	--	--	--	--	--
Fort Totten, NY	--	--	--	--	--	--
Fort Wingate Depot Activity, NM	651	--	--	--	--	13
Hamilton Army Airfield, CA	--	--	--	--	--	--
Hawthorne AAP, NV	--	1481	108	237	3	1
Holabird DEF Investigation Facility, MD	--	--	--	--	--	--
Holston AAP, TN	--	141	--	--	--	--
Hunter Army Airfield, GA	--	--	--	--	--	1
Indiana AAP, IN	154	20	--	--	--	164
Iowa AAP, IO	270	33	--	--	33	31
Jefferson Proving Ground, IN	12	--	4	--	--	3
Joliet AAP Elwood, IL	263	48	13	--	--	10
Joliet AAP Kankakee, IL	129	--	--	--	--	--
Kansas AAP, KS	187	2	--	--	15	--
Lake City AAP, MO	2	38	--	--	--	36
Letterkenny Army Depot, PA	802	--	--	--	--	6
Lexington-Blue Grass Army Depot, KY	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Lima Army Tank Plant, OH	--	--	--	--	--	--
Lone Star AAP, TX	200	--	--	--	--	--
Longhorn AAP, TX	--	--	--	--	--	--
Louisiana AAP, LA	147	--	1	--	43	--
McAlester AAP, OK	1036	134	113	1	19	--
MG Leif J. Sverdrup USARC/AMSA, MO	--	--	--	--	--	--
Milan AAP, TN	875	24	--	--	57	--
Military Ocean Terminal, Bayonne, NJ	--	--	--	--	--	--
Navajo Depot Activity, AZ	781	1	--	--	--	--
New Orleans Army Base, LA	--	--	--	--	--	--
Newport AAP, IN	--	52	--	--	--	--
NG Atterbury Res Forces Training, IN	14	--	--	--	--	--
NG Byrd Field, VA	4	--	--	--	--	--
NG Camp Ashland, NE	--	--	--	--	--	--
NG Camp Carroll ATS	--	--	--	--	--	--
NG Camp Clark, MO	--	--	--	--	1	--
NG Camp Edwards, MA	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
NG Camp Mc Cain, MS	--	--	--	--	--	--
NG Camp Roberts, CA	--	--	--	--	--	--
NG Custer Res Forces Training Area, MI	--	3	3	--	--	--
NG Ethan Allen AFB, VT	--	--	--	--	--	--
NG Fort Allen, VT	--	--	--	--	--	--
NG Fort Missoula, MT	--	--	--	--	--	--
NG Fort William Henry Harrison, MT	--	--	--	--	--	--
NG George Wright, WA	--	--	--	--	--	--
NG Hammer Field, CA	--	--	--	--	--	1
NG Hastings, NE	--	--	100	--	--	--
NG Mead, NE	--	20	--	--	--	--
NG New Castle, DE	--	--	--	--	--	--
NG Smyrna Training Center, TN	--	--	--	--	--	--
NTC and Fort Irwin, CA	--	--	--	--	--	--
Oakland Army Base, CA	--	--	--	--	--	--
Pedricktown Support Facility, NJ	--	--	--	--	--	--
Pentagon, VA	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Picatinny Arsenal, NJ	30	14	13	--	7	53
Pine Bluff Arsenal, AR	223	6	77	7	--	9
Presidio of Monterey, CA	--	--	--	--	--	--
Presidio of San Francisco, CA	--	--	--	--	--	--
Pueblo Depot Activity, CO	800	1	--	2	--	--
Radford AAP, VA	3	--	--	75	--	--
Radford AAP, New River, VA	89	--	--	59	1	--
Ravenna AAP, OH	690	--	--	--	64	73
Red River Army Depot, TX	702	14	--	1	--	--
Redstone Arsenal, AL	393	18	--	--	--	--
Rock Island Arsenal, IL	--	--	--	--	--	4
Rocky Mountain Arsenal, CO	6	1	--	--	--	24
Sacramento Army Depot, CA	--	--	--	--	--	--
Savanna Depot Activity, IL	406	30	--	26	--	100
Seneca Army Depot, NY	502	--	--	--	--	9
Sierra Army Depot, CA	753	--	--	--	--	12
Skaneateles Wet Site, NY	--	--	--	--	--	--
St. Louis AAP, MO	--	--	--	--	--	--
St. Charles USARC, MO	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Stewart Annex, NY	--	--	--	--	--	--
Stratford Army Eng Plant, CT	--	--	--	--	--	--
Sunflower AAP, KS	--	95	--	--	--	--
Tacony Warehouse Site, PA	--	--	--	--	--	--
Tarheel Army Missile Plant, NC	--	--	--	--	--	--
Tooele Army Depot, UT	799	2	--	--	--	8
Tooele Army Depot RR Maintenance, UT	--	--	--	--	--	--
Tooele Army Depot South Area, UT	140	--	--	--	--	--
Twin Cities AAP, MN	2	37	--	--	18	1
Umatillo Depot Activity, OR	971	--	--	1	--	14
U.S. Army Garrison-Selfridge, MI	--	--	--	--	--	--
USARC Des Moines Fort, IO	--	--	--	--	--	--
USARC Fac Woolworth St., NE	--	--	--	--	--	--
USARC Fort Lawton, WA	--	--	--	--	--	--
USARC Hingham Cohasset, MA	--	--	--	--	--	--
USDB Lompoc, CA	--	--	--	--	--	--
Vancouver Barracks, WA	--	--	--	--	--	--

Name	Igloos (42180 & 42280)	High Explosive Magazines (42120 & 42215)	Fuse & Detonator Magazines (42110 & 42210)	Smokeless Powder Magazines (42150)	Ready Magazines (42235)	General Purpose Magazines (42183 & 42283)
Vint Hill Farms Station, VA	--	--	--	--	--	--
Volunteer AAP, TN	200	--	--	--	--	--
Walter Reed AMC, DC	--	--	--	--	--	--
Walter Reed AMC, Forest Glen, MD	--	--	--	--	--	--
Watervliet Arsenal, NY	--	--	--	--	--	--
West Point Military Reservation, NY	--	3	1	--	--	--
White Sands Missile Range, NM	--	--	--	--	--	--
TOTALS	14,143	2,538	449	421	325	806

Source: 1994 Real Property Inventory, U.S. Army

TABLE E-9. DISTRIBUTION OF ARMY PERMANENT UTILITIES CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
1sg Adam S. Brandt USARC, MD	--	--	--	--	--	--
Aberdeen Proving Ground, MD	14	22	16	2	17	1
Adelphi Blossom PT Test Area, MD	1	--	--	--	--	--
AFRC Douglas, UT	--	--	--	--	--	--
AFRC Los Alamitos, CA	--	--	--	--	3	--
Alabama AAP, AL	--	--	1	--	1	--
Anniston Army Depot, AL	1	9	2	1	1	1
Army Materials Technology Lab, MA	--	1	--	--	1	--
Badger AAP, WI	1	86	10	1	5	4
Big Bethel Reservoir, VA	--	--	--	--	2	--
Blue grass Activity-LBAD, KY	--	3	2	--	2	--
Bonneville Camp, WA	--	--	--	--	--	--
Cameron Station, VA	--	1	1	--	--	--
Camp Bullis, TX	--	--	1	--	2	--
Camp Peary Erie Army Depot, OH	--	--	--	--	--	--
Camp Stanley Storage Activity, TX	--	3	--	1	1	--

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
Fort Indiantown Gap, PA	--	2	2	--	--	--
Fort Jackson, SC	--	--	--	--	--	--
Fort Knox, KY	14	5	2	--	2	--
Fort Leavenworth, KS	27	9	1	--	4	--
Fort Lee, VA	--	--	--	--	2	--
Fort Leonard Wood, MO	--	--	--	--	2	--
Fort Lewis, WA	--	6	--	--	3	--
Fort McClellan, AL	--	1	1	--	--	--
Fort McCoy, WI	1	3	1	--	16	--
Fort McPherson, GA	--	1	--	--	1	--
Fort Missoula, MT	1	--	--	--	2	--
Fort Monroe, VA	2	--	5	--	1	--
Fort Myer, VA	--	--	--	--	1	--
Fort Monmouth, NJ	2	--	5	1	2	1
Fort Monmouth-Charles Wood Area, NJ	--	1	1	--	--	--
Fort Monmouth-Evans Area, NJ	10	8	1	--	--	--
Fort Ord, CA	--	1	3	1	1	--
Fort Pickett, VA	1	1	2	3	3	--
Fort Polk, LA	--	5	3	--	3	--
Fort Riley, KS	--	1	3	--	5	--

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
Fort Ritchie, MD	--	1	--	--	3	--
Fort Rucker, AL	--	--	2	--	8	--
Fort Sam Houston, TX	--	--	--	--	2	1
Fort Sill, OK	4	2	1	--	1	--
Fort Sheridan, IL	2	--	--	--	1	--
Fort Stewart, GA	1	1	3	--	1	--
Fort Story, VA	--	--	1	--	--	--
Fort Totten, NY	2	--	--	--	--	--
Fort Wingate Depot Activity, NM	2	3	1	--	--	--
Hamilton Army Airfield, CA	--	--	--	--	--	2
Hawthorne AAP, NV	5	11	1	--	6	2
Holabird DEF Investigation Facility, MD	--	--	--	--	--	--
Holston AAP, TN	2	5	--	--	7	--
Hunter Army Airfield, GA	--	1	--	--	2	--
Indiana AAP, IN	--	3	6	--	20	--
Iowa AAP, IO	--	6	2	1	3	6
Jefferson Proving Ground, IN	42	4	1	--	4	--
Joliet AAP Elwood, IL	7	13	6	--	8	1
Joliet AAP Kankakee, IL	--	4	5	--	27	--
Kansas AAP, KS	--	11	2	1	2	9

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
Lake City AAP, MO	--	5	2	2	11	5
Letterkenny Army Depot, PA	--	4	--	1	--	2
Lexington-Blue Grass Army Depot, KY	--	1	1	--	1	--
Lima Army Tank Plant, OH	--	--	1	--	2	--
Lone Star AAP, TX	--	6	1	--	1	--
Longhorn AAP, TX	--	2	4	--	3	1
Louisiana AAP, LA	--	15	12	--	2	3
McAlester AAP, OK	--	12	2	1	13	5
MG Leif J. Sverdrup USARC/AMSA, MO	--	--	--	--	--	--
Milan AAP, TN	1	6	--	--	9	4
Military Ocean Terminal, Bayonne, NJ	2	2	1	--	3	--
Navajo Depot Activity, AZ	2	5	1	--	2	--
New Orleans Army Base, LA	--	--	--	--	--	--
Newport AAP, IN	6	1	1	--	4	--
NG Atterbury Res Forces Training, IN	--	--	--	--	--	--
NG Byrd Field, VA	--	--	--	--	--	--
NG Camp Ashland, NE	--	--	--	--	--	--
NG Camp Clark, MO	--	--	--	--	1	--
NG Camp Edwards, MA	--	1	--	--	--	--
NG Camp Gruber, OK	--	--	--	--	--	--

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
NG Camp Mc Cain, MS	--	--	--	--	--	--
NG Camp Roberts, CA	--	--	--	--	--	--
NG Camp Williams, UT	--	--	--	--	1	--
NG Custer Res Forces Training Area, MI	--	--	--	--	--	--
NG Ethan Allen AFB, VT	--	--	--	--	--	--
NG Fort Allen, VT	--	--	--	--	--	--
NG Fort Missoula, MT	--	--	--	--	--	--
NG Fort William Henry Harrison, MT	--	--	--	--	--	--
NG George Wright, WA	--	--	--	--	--	--
NG Hammer Field, CA	--	--	--	--	--	--
NG Hastings, NE	--	--	--	--	1	--
NG Mead, NE	--	--	--	--	--	--
NG New Castle, DE	--	--	--	--	1	--
NG Smyrna Training Center, TN	--	--	--	--	--	--
NTC and Fort Irwin, CA	--	--	--	--	4	--
Oakland Army Base, CA	--	1	3	--	--	--
Pedricktown Support Facility, NJ	--	1	--	--	--	--
Pentagon, VA	--	--	1	--	--	--
Picatinny Arsenal, NJ	--	4	8	--	8	--
Pine Bluff Arsenal, AR	--	4	2	1	7	--

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
Presidio of Monterey, CA	2	--	--	--	1	--
Presidio of San Francisco, CA	--	--	1	1	4	1
Pueblo Depot Activity, CO	--	4	2	--	10	--
Radford AAP, VA	3	2	6	4	3	2
Radford AAP, New River, VA	--	1	1	--	--	--
Ravenna AAP, OH	3	11	9	--	12	1
Red River Army Depot, TX	--	5	5	--	3	--
Redstone Arsenal, AL	--	10	3	--	2	1
Rock Island Arsenal, IL	1	3	1	--	1	1
Rocky Mountain Arsenal, CO	4	2	2	1	2	--
Sacramento Army Depot, CA	--	1	1	--	1	--
Savanna Depot Activity, IL	2	4	3	--	3	3
Seneca Army Depot, NY	1	4	2	--	2	--
Sierra Army Depot, CA	--	5	--	--	4	--
Skaneateles Wet Site, NY	--	--	--	--	--	--
St. Louis AAP, MO	--	--	--	--	--	--
St. Charles USARC, MO	--	3	--	--	--	--
Stewart Annex, NY	1	1	--	--	2	--
Stratford Army Eng Plant, CT	3	2	--	--	1	--
Sunflower AAP, KS	1	4	5	--	13	--

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
Tacony Warehouse Site, PA	--	--	--	--	--	--
Tarheel Army Missile Plant, NC	--	1	--	--	--	--
Tooele Army Depot, UT	3	7	--	--	3	3
Tooele Army Depot RR Maintenance, UT	--	--	--	--	--	--
Tooele Army Depot South Area, UT	--	1	--	--	2	--
Twin Cities AAP, MN	--	5	2	--	6	--
Umatillo Depot Activity, OR	1	2	--	--	3	--
U.S. Army Garrison-Selfridge, MI	7	1	--	--	1	--
USARC Des Moines, IO	--	--	--	--	1	--
USARC Fac Woolworth St., NE	--	--	--	--	--	--
USARC Fort Lawton, WA	--	--	--	1	--	--
USARC Hingham Cohasset, MA	--	2	--	--	1	--
USDB Lompoc, CA	--	1	1	--	--	--
Vancouver Barracks, WA	--	--	--	--	--	--
Vint Hill Farms Station, VA	2	--	1	--	1	--
Volunteer AAP, TN	--	2	1	--	3	--
Walter Reed AMC, DC	--	--	--	--	--	--
Walter Reed AMC, Forest Glen, MD	--	--	--	--	--	--
Watervliet Arsenal, NY	1	1	--	--	--	--
West Point Military Reservation, NY	1	--	--	--	4	--

Name	Electrical (81---)	Heating/Cooling (82---)	Sewage (831-- + 832--)	Incinerator Waste (833--)	Water (84---)	Miscellaneous (89---)
White Sands Missile Range, NM	--	--	--	--	--	--
TOTALS	215	433	221	32	410	69

Source: 1994 Real Property Inventory, U.S. Army

TABLE E-10. DISTRIBUTION OF AIR FORCE PERMANENT GENERAL STORAGE BUILDINGS CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
AF Plant 03, OK	--	--	1	1	--
AF Plant 04, TX	--	3	--	--	--
AF Plant 06, GA	--	--	--	--	--
AF Plant 59, NY	--	--	--	--	--
AF Plant 85, OH	--	1	2	--	--
Alpena County REG APT, HI	--	1	--	--	1
Altus AFB, OK	--	--	--	--	--
Andrews AFB, MD	--	--	1	1	8
Atlantic City IAP, NJ	--	--	1	2	1
Bangor IAP, ME	--	--	--	--	--
Barksdale AFB, LA	--	3	--	--	1
Beale AFB, CA	--	--	--	--	1
Bergstrom AFB, TX	--	--	--	--	1
Birmingham APT, AL	--	1	--	--	--
Boise ATM, ID	--	2	--	--	--
Bolling AFB, DC	--	2	--	--	6

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Brooks AFB, TX	--	--	--	--	--
Camp Blanding Training ANG, FL	--	--	--	--	2
Cannon AFB, NM	--	--	--	--	--
Carswell AFB, TX	--	1	--	--	--
Castle AFB, CA	1	2	--	--	--
Castle Housing Annex, CA	--	--	--	--	--
Canute AFB, IL	--	1	--	--	2
Camp Pendleton Traning ANG, VA	--	2	--	--	--
Columbus AFB, MS	--	--	--	--	--
Cove Gardens Family Housing, FL	--	--	--	1	--
Camp Perry, OH	--	--	--	--	2
Dallas NAS, TX	--	--	--	--	--
Davis-Monthan AFB, AZ	--	1	1	--	1
Dobbins AFB, GA	--	--	--	--	--
Dyess, AFB, TX	--	--	--	--	--
Edwards AFB, CA	--	--	--	--	1
Elgin AFB, FL	--	--	--	--	1
Elgin #3 AAF, FL	--	--	--	--	--
Elgin #6 AAF, FL	--	3	--	--	--
Elgin #9 AAF, FL	--	--	--	--	1

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Ellington Field, TX	--	1	--	--	--
Ellsworth AFB, SD	--	1	--	--	--
FE Warren, WY TX	1	8	1	--	2
Fairchild AFB, WA	--	3	1	--	1
Fairchild SWG-Airway Heights, WA	--	--	--	--	--
Fairchild WSS-Airway Heights, WA	--	--	--	--	--
Fort Macarthur, CA	--	1	--	--	--
Fourth Cliff Recreational Area, MA	--	--	--	--	--
Ft. Indiantown Gap AGS, PA	--	2	1	--	--
Ft. Wayne IAP, IN	--	--	--	1	--
Gentile DEC, OH	--	2	--	--	--
George AFB, CA	--	6	--	--	2
Goodfellow AFB, TX	1	3	--	--	2
Great Bend RBS, NY	--	1	--	--	--
Griffiss AFB, NY	--	4	--	--	2
Griffiss COM, NY	--	--	--	--	--
Grissom AFB, TX	--	--	--	--	3
Hancock ANG Field, NY	--	--	--	--	--
Harrisburg IAP, PA	--	1	--	--	--
Hastings BHG, NE	--	--	--	--	1

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Hawthorne RBS, NV	--	--	--	--	--
Hector IAP ANG, ND	--	--	--	--	--
Hill AFB, UT	--	7	--	--	4
Hollowman AFB, NM	--	--	--	--	--
Indian Springs AAF, NV	--	--	--	--	--
Ipswich TST, MA	--	--	--	1	--
Jefferson Barracks AGS, MO	--	1	--	--	--
Jefferson WRG, IN	--	--	--	--	--
Joe Floss Field, SD	--	--	--	--	--
Keesler AFB, MS	--	--	--	--	1
Kessler 01 Training, MS	--	--	--	--	--
Kelly AFB, TX	--	36	4	5	3
Key Field, MS	--	--	--	--	--
Kirtland, NM	--	--	1	1	1
Klamath Falls IAP, OR	--	1	--	--	--
Lackland AFB, TX	--	--	--	--	2
Lambert/St. Louis IAP, MO	--	--	--	--	--
Langley AFB, VA	--	1	--	--	3
Laughlin AFB, TX	--	--	--	--	1
Little Mountain TST, UT	--	--	--	--	--

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Little Rock AFB, AR	--	2	--	1	1
Los Angeles AFB, CA	--	--	1	--	--
Lowry AFB, CO	--	2	2	--	1
Luke AFB, AZ	--	--	--	--	2
MacDill AFB, FL	--	3	--	--	6
MacDill-Avon Park, FL	--	--	--	--	1
Malmstrom AFB, MT	--	--	--	--	--
March AFB, CA	--	1	--	--	7
March WSS-Home Gardens, CA	--	--	--	--	--
March WSS-Perris, CA	--	--	--	--	--
Mather AFB, CA	--	--	--	--	6
Maxwell AFB, AL	1	2	--	--	6
Maxwell Gunter ANG Training, AL	--	1	--	--	4
McChord AFB, WA	--	--	--	1	5
McClellan AFB, CA	--	6	--	1	6
McEntire AGB, SC	--	--	--	--	--
McGuire AFB, NJ	--	--	1	1	3
Minneapolis/St. Paul IAP, MN	--	1	1	--	--
Montgomery AGS, AL	--	1	1	--	--
Moody AFB, GA	--	2	--	--	--

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Mountain Home, ID	1	--	3	--	4
Mukilteo DFP, WA	--	--	--	--	1
Myrtle Beach AFB, SC	--	--	--	--	--
Nashville Metro APT, TN	--	--	--	--	1
Nellis AFB, NV	--	1	--	--	2
New Castle County APT, DE	--	--	--	--	--
Norton AFB, CA	--	17	2	--	4
Offutt AFB, NE	--	--	--	--	2
Ohare RTC, IL	--	--	--	--	--
Ontario ANG IAP, CA	--	--	--	--	--
Otis AGB, MA	--	--	--	--	3
Patrick AFB, FL	1	3	4	1	4
Pillar Point AFS, CA	--	--	--	1	--
Pittsburgh ARSIAP, PA	--	--	--	--	--
Plattsburgh AFB, NY	--	--	--	--	3
Pope AFB, NC	--	1	--	--	3
Portland IAP, OR	--	4	--	--	1
Quonset State APT, RI	--	--	1	--	2
Randolph AFB, TX	--	4	1	--	1
Reese AFB, TX	--	3	--	--	2

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Richmond Byrd Field IAP, VA	--	--	--	--	--
Rickenbacker AGB, OH	--	--	1	--	2
Robins AFB, GA	--	9	1	--	3
Rosecrans Memorial APT, MO	--	--	--	--	--
Roslyn AGS, NY	--	--	--	--	--
Sacremento DOC, CA	--	--	--	--	--
Salt Lake City IAP, UT	--	3	--	--	--
Savannah IAP, GA	--	5	--	--	--
Scott AFB, IL	--	1	--	--	7
Scott RRL, IL	--	--	--	--	--
Selfridge AGB, MI	--	5	2	--	3
Seymour Johnson AFB, NC	--	--	--	--	--
Shaw AFB, SC	--	--	1	--	--
Sheppard AFB, TX	--	2	--	1	3
Smoky Hill WRG, KS	--	--	--	--	--
St. Louis AFS, MO	--	--	--	--	--
St. Louis STG, MO	--	2	1	--	--
Tinker AFB, OK	--	2	2	--	4
Travis AFB, CA	--	--	--	--	--
Travis 0---WSS, CA	--	--	--	--	--

Name	Cold Storage (432283)	Warehousing (441758 & 442758)	Hazardouse Storage (441257 & 442257)	Base Supplies (442628)	Base Engineer (219946 & 219947)
Tyndall AFB, FL	--	2	--	1	5
USAF Academy, CO	--	--	--	--	1
Vance AFB, OK	--	5	--	--	2
Vandenberg AFB, CA	--	--	--	--	--
W.K. Kellogg APT, MI	--	--	--	--	--
Warren Grove WRG, NJ	--	--	--	--	--
Westover AFB, MA	--	2	2	--	1
Whiteman AFB, MO	--	--	--	--	--
Williams AFB, AZ	--	--	--	--	1
Wright-Patterson AFB, OH	--	10	1	--	5
Wurtsmith AFB, MI	--	--	--	--	--
TOTALS	6	203	42	21	175

Source: 1994 Real Property Inventory, U.S. Air Force

TABLE E-11. DISTRIBUTION OF AIR FORCE PERMANENT ORDNANCE STORAGE CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
AF Plant 03, OK	--	--	--	--	--
AF Plant 04, TX	--	--	--	--	--
AF Plant 06, GA	--	--	--	--	--
AF Plant 59, NY	--	--	--	--	--
AF Plant 85, OH	--	--	--	--	--
Alpena County REG APT, MI	--	--	--	--	--
Altus AFB, OK	--	--	--	--	--
Andrews AFB, MD	--	--	--	--	--
Atlantic City IAP, NJ	--	--	--	--	--
Bangor IAP, ME	--	--	--	--	--
Barksdale AFB, LA	2	1	--	--	--
Beale AFB, CA	--	--	--	--	--
Bergstrom AFB, TX	--	--	--	--	--
Birmingham APT, AL	--	--	--	1	--
Bolling AFB, DC	--	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Brooks AFB, TX	--	--	--	--	--
Camp Blanding Training ANG, FL	--	--	--	--	--
Cannon AFB, NM	--	2	1	--	--
Carswell AFB, TX	--	--	--	--	--
Castle AFB, CA	--	--	--	--	--
Castle Housing Annex, CA	--	--	--	--	--
Canute AFB, IL	--	--	--	--	--
Camp Pendleton Training ANG, VA	--	--	--	--	--
Columbus AFB, MS	--	--	--	--	--
Cove Gardens Family Housing, FL	--	--	--	--	--
Camp Perry, OH	--	--	--	--	--
Dallas NAS, TX	--	--	--	--	--
Davis-Monthan AFB, AZ	--	--	--	--	--
Dobbins AFB, GA	--	--	--	--	--
Dyess AFB, TX	--	--	--	--	--
Edwards AFB, CA	--	1	--	1	1
Eglin AFB, FL	7	--	--	2	1
Eglin #3 AAF, FL	--	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Eglin #6 AAF, FL	--	--	--	--	--
Eglin #9 AAF, FL	--	--	--	--	--
Ellington Field, TX	--	--	--	--	--
Ellsworth AFB, SD	--	--	--	--	--
FE Warren, WY TX	--	--	--	--	--
Fairchild AFB, WA	--	--	--	--	--
Fairchild SWG-Airway Heights, WA	--	--	--	--	--
Fairchild WSS-Airway Heights, WA	--	--	--	--	--
Fort Macarthur, CA	--	--	--	--	--
Fourth Cliff Recreational Area, MA	--	--	--	--	--
Ft. Indiantown Gap AGS, PA	--	--	--	--	--
Ft. Wayne IAP, IN	--	--	--	--	--
Gentile DEC, OH	--	--	--	--	--
George AFB, CA	--	1	1	1	--
Goodfellow AFB, TX	--	--	--	--	--
Great Bend RBS, NY	--	--	--	--	--
Griffiss AFB, NY	--	--	--	1	--
Griffiss COM, NY	--	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Grissom AFB, TX	--	--	--	--	--
Hancock ANG Field, NY	--	--	1	--	--
Harrisburg IAP, PA	--	--	2	--	--
Hastings BHG, NE	--	--	--	--	--
Hawthorne RBS, NV	--	--	--	--	--
Hector IAP ANG, ND	--	--	--	--	--
Hill AFB, UT	77	5	15	7	--
Hollowman AFB, NM	--	1	1	--	--
Indian Springs AAF, NV	--	--	--	--	--
Ipswich TST, MA	--	--	--	--	--
Jefferson Barracks AGS, MO	--	--	--	--	--
Jefferson WRG, IN	--	--	--	--	--
Joe Floss Field, SD	--	--	--	--	--
Keesler AFB, MS	--	--	--	4	--
Kessler 01 Training, MS	--	--	--	--	--
Kegelman AAF, OK	--	--	--	--	--
Kelly AFB, TX	--	--	--	--	--
Key Field, MS	--	--	--	--	--
Kirtland, NM	17	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Klamath Falls IAP, OR	--	--	--	--	--
Lackland AFB, TX	--	--	--	--	--
Lambert/St. Louis IAP, MO	--	--	--	--	--
Langley AFB, VA	--	2	3	--	--
Laughlin AFB, TX	--	--	--	--	--
Lewis B. Wilson APT, GA	--	--	--	--	--
Little Mountain TST, UT	--	--	--	--	--
Little Rock AFB, AR	--	--	--	--	--
Los Angeles AFB, CA	--	--	--	--	--
Lowry AFB, CO	--	--	1	2	--
Luke AFB, AZ	--	--	--	--	--
MacDill AFB, FL	--	--	--	1	--
DacDill-Avon Park, FL	--	--	--	1	--
Malmstrom AFB, MT	--	--	--	--	--
Mansfield Lahm APT, OH	--	--	--	--	--
March AFB, CA	--	--	--	--	--
March WSS-Home Gardens, CA	--	--	--	--	--
March WSS-Perris, CA	--	--	--	--	--
Mather AFB, CA	--	--	1	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Maxwell AFB, AL	--	--	2	--	--
Maxwell Gunter ANG Training, AL	--	--	--	--	--
McChord AFB, WA	12	2	--	2	--
McClellan AFB, CA	2	--	--	--	--
McEntire AGB, SC	--	--	--	--	--
McGuire AFB, NJ	--	--	--	--	--
Minneapolis/St. Paul IAP, MN	--	--	--	--	--
Montgomery AGS, AL	--	--	--	--	--
Moody AFB, GA	--	--	--	--	--
Mountain Home, ID	--	--	--	--	--
Mukilteo DFP, WA	--	--	--	--	--
Myrtle Beach AFB, SC	3	--	--	--	--
Nashville Metro APT, TN	--	--	--	--	--
Nellis AFB, NV	1	--	--	--	--
New Castle County APT, DE	--	--	--	--	--
Norton AFB, CA	--	--	--	--	--
Offutt AFB, NE	--	--	--	--	--
Ohare RTC, IL	--	--	--	--	--
Ontario ANG IAP, CA	--	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Otis AGB, MA	--	--	--	--	--
Patrick AFB, FL	5	1	3	1	--
Pillar Point AFS, CA	--	--	--	--	--
Pittsburgh ARS IAP, PA	--	--	--	--	--
Plattsburgh AFB, NY	--	--	--	--	--
Pope AFB, NC	--	--	--	--	--
Portland IAP, OR	--	--	--	--	--
Quonset State APT, RI	--	--	--	--	--
Randolph AFB, TX	--	--	--	--	--
Reese AFB, TX	--	--	--	--	--
Richmond Byrd Field IAP, VA	--	--	--	--	--
Rickenbacker AGB, OH	--	--	--	--	--
Robins AFB, GA	--	--	1	--	--
Rosecrans Memorial APT, MO	--	--	--	--	--
Roslyn AGS, NY	--	--	--	--	--
Sacramento DOC, CA	--	--	--	--	--
Salt Lake City IAP, UT	--	--	--	--	--
Savannah IAP, GA	--	--	--	--	--
Scott AFB, IL	--	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Scott RRL, IL	--	--	--	--	--
Selfridge AGB, MI	--	--	--	--	--
Seymour Johnson AFB, NC	--	--	--	--	--
Shaw AFB, SC	--	--	--	--	--
Sheppard AFB, TX	--	--	--	--	--
Smoky Hill WRG, KS	--	--	1	--	--
St. Louis AFS, MO	--	--	--	--	--
St. Louis STG, MO	--	--	--	--	--
Tinker AFB, OK	--	--	--	--	----
Travis AFB, CA	--	--	--	--	--
Travis 0---WSS, CA	--	--	--	--	--
Tyndall AFB, FL	--	--	--	--	--
USAF Academy, CO	--	--	--	--	--
Vance AFB, OK	--	--	--	--	--
Vandenberg AFB, CA	3	--	--	--	--
W.K. Kellogg APT, MI	--	--	--	--	--
Warren Grove WRG, NJ	1	--	--	--	--
Westover AFB, MA	--	--	--	3	--
Whiteman AFB, MO	--	--	--	--	--
Williams AFB, AZ	1	--	--	--	--

NAME	IGLOO (422264)	INERT (422265)	ABOVE-GROUND MAGAZINE (422258)	SEGREGATED MAGAZINES (422257)	ROCKET STORAGE (422256)
Wright-Patterson AFB, OH	--	--	--	--	--
Wurtsmith AFB, MI	--	--	--	--	--
TOTALS	131	16	33	27	2

Source: 1994 Real Property Inventory, U.S. Air Force

TABLE E-12. DISTRIBUTION OF AIR FORCE PERMANENT UTILITIES CONSTRUCTED BETWEEN 1917 - 1946 AT ACTIVE-DUTY INSTALLATIONS

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
AF Plant 03, OK	--	1	--	--	--	--
AF Plant 04, TX	--	2	--	--	2	1
AF Plant 06, GA	--	1	1	--	2	1
AF Plant 59, NY	--	--	--	--	1	--
AF Plant 85, OH	--	2	--	--	2	--
Alpena County REG APT, MI	--	1	1	--	1	--
Altus AFB, OK	--	--	--	--	--	--
Andrews AFB, MD	1	2	3	--	1	--
Atlantic City IAP, NJ	--	1	--	--	--	--
Bangor IAP, ME	--	--	--	--	--	--
Barksdale AFB, LA	--	2	1	1	3	--
Beale AFB, CA	--	--	--	--	2	--
Bergstrom AFB, TX	1	--	1	--	1	--
Birmingham APT, AL	--	--	--	--	--	--
Bolling AFB, DC	1	1	1	--	--	--
Brooks AFB, TX	--	--	--	--	1	--

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
Camp Blanding Training ANG, FL	--	--	--	--	--	--
Cannon AFB, NM	--	--	--	--	--	--
Carswell AFB, TX	--	--	--	--	1	--
Castle AFB, CA	--	1	--	--	--	--
Castle Housing Annex, CA	--	--	1	--	--	--
Canute AFB, IL	1	1	4	--	7	3
Camp Pendleton Traning ANG, VA	--	--	--	--	--	--
Columbus AFB, MS	--	--	--	--	3	--
Cove Gardens Family Housing, FL	--	--	--	--	--	--
Camp Perry, OH	--	--	--	--	--	--
Dallas NAS, TX	--	--	--	--	--	--
Davis-Monthan AFB, AZ	--	--	--	--	1	--
Dobbins AFB, GA	--	--	--	--	--	--
Dyess AFB, TX	--	--	--	--	--	1
Edwards AFB, CA	1	1	2	1	5	1
Elgin AFB, FL	--	--	2	--	3	--
Elgin #3 AAF, FL	--	--	--	--	5	--
Elgin #6 AAF, FL	--	--	--	--	1	--
Elgin #9 AAF, FL	--	--	--	--	--	--

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
Ellington Field, TX	--	--	--	--	--	--
Ellsworth AFB, SD	--	1	1	--	1	--
FE Warren, WY TX	--	1	--	--	--	--
Fairchild AFB, WA	--	1	--	--	--	--
Fairchild SWG-Airway Heights, WA	--	--	1	--	--	--
Fairchild WSS-Airway Heights, WA	--	--	--	--	2	--
Fort Macarthur, CA	--	--	--	--	--	--
Fourth Cliff Recreational Area, MA	--	--	--	--	1	--
Ft. Indiantown Gap AGS, PA	--	--	--	--	--	--
Ft. Wayne IAP, IN	--	--	--	--	--	--
Gentile DEC, OH	--	2	1	--	2	--
George AFB, CA	--	--	2	--	2	1
Goodfellow AFB, TX	--	--	--	--	1	--
Great Bend RBS, NY	--	--	--	--	--	--
Griffiss AFB, NY	1	--	2	--	3	--
Griffiss COM, NY	--	--	--	--	--	--
Grissom AFB, TX	--	--	--	1	3	--
Hancock ANG Field, NY	--	--	--	--	--	--
Harrisburg IAP, PA	--	--	--	--	--	--

Name	Electried (61---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
Hastings BHG, NE	--	--	--	--	--	--
Hawthorne RBS, NV	--	--	--	--	--	--
Hector IAP ANG, ND	--	--	--	--	--	--
Hill AFB, UT	5	5	1	--	6	4
Hollowman AFB, NM	--	--	--	--	--	--
Indian Springs AAF, NV	--	--	--	--	2	--
Ipswich TST, MA	--	--	--	--	--	--
Jefferson Barracks AGS, MO	--	--	--	--	--	--
Jefferson WRG, IN	--	--	--	--	--	--
Joe Floss Field, SD	--	1	--	--	--	--
Keesler AFB, MS	--	6	2	--	5	--
Kessler 01 Training, MS	--	--	1	--	--	--
Kegelman AAF, OK	--	--	--	--	--	--
Kelly AFB, TX	1	1	1	--	6	2
Key Field, MS	--	1	--	--	--	--
Kirtland, NM	--	--	--	--	--	--
Klamath Falls IAP, OR	--	1	--	--	--	--
Lackland AFB, TX	--	--	--	--	1	--
Lambert/St. Louis IAP, MO	--	--	--	--	1	--
Langley AFB, VA	3	1	7	--	--	11

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
Laughlin AFB, TX	--	--	--	--	--	--
Lewis B. Wilson APT, GA	--	--	--	--	--	--
Little Mountain TST, UT	--	1	--	--	--	--
Little Rock AFB, AR	--	--	--	--	--	--
Los Angeles AFB, CA	--	--	--	--	--	--
Lowry AFB, CO	1	1	--	--	--	--
Luke AFB, AZ	--	--	--	--	2	--
MacDill AFB, FL	--	1	2	--	2	--
DacDill-Avon Park, FL	--	--	--	--	--	--
Malmstrom AFB, MT	--	2	--	--	--	--
Mansfield Lahm APT, OH	--	--	--	--	--	--
March AFB, CA	2	--	3	--	7	--
March WSS-Home Gardens, CA	--	--	--	--	2	--
March WSS-Perris, CA	--	--	--	--	2	--
Mather AFB, CA	--	1	2	--	1	1
Maxwell AFB, AL	--	1	--	--	2	--
Maxwell Gunter ANG Training, AL	--	1	--	--	1	--
McChord AFB, WA	2	1	2	--	5	--
McClellan AFB, CA	1	3	2	--	6	--

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
McEntire AGB, SC	--	--	--	--	3	--
McGuire AFB, NJ	--	1	1	--	--	--
Minneapolis/St. Paul IAP, MN	1	1	--	--	1	--
Montgomery AGS, AL	--	--	--	--	--	--
Moody AFB, GA	--	2	3	--	2	1
Mountain Home, ID	--	--	3	--	1	--
Mukilteo DFP, WA	--	--	--	--	--	--
Myrtle Beach AFB, SC	--	--	--	--	--	--
Nashville Metro APT, TN	--	--	--	--	--	--
Nellis AFB, NV	--	--	--	--	1	--
New Castle County APT, DE	--	--	--	--	--	--
Norton AFB, CA	--	1	--	--	4	--
Offutt AFB, NE	--	2	--	--	1	--
Ohare RTC, IL	--	--	--	--	1	--
Ontario ANG IAP, CA	--	--	--	--	--	--
Otis AGB, MA	--	--	5	--	2	--
Patrick AFB, FL	--	1	--	--	3	6
Pillar Point AFS, CA	--	--	--	--	--	--
Pittburg ARS IAP, PA	--	--	--	--	--	--
Plattsburgh AFB, NY	--	--	--	--	--	--

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
Pope AFB, NC	--	--	--	--	--	--
Portland IAP, OR	--	--	--	--	--	--
Quonset State APT, RI	--	--	--	--	--	--
Randolph AFB, TX	1	--	1	--	2	--
Reese AFB, TX	--	--	2	--	2	--
Richmond Byrd Field IAP, VA	--	--	--	--	--	--
Rickenbacker AGB, OH	--	--	--	--	1	--
Robins AFB, GA	--	1	--	--	5	--
Rosecrans Memorial APT, MO	--	--	--	--	1	--
Roslyn AGS, NY	--	--	--	--	--	--
Sacramento DOC, CA	--	--	--	--	1	--
Salt Lake City IAP, UT	--	--	--	--	--	--
Savannah IAP, GA	--	--	--	--	--	--
Scott AFB, IL	--	4	2	--	1	1
Scott RRL, IL	--	--	--	--	1	--
Selfridge AGB, MI	9	3	1	--	1	--
Seymour Johnson AFB, NC	--	1	--	--	--	--
Shaw AFB, SC	--	--	2	--	--	--
Sheppard AFB, TX	--	3	2	--	1	1
Smoky Hill WRG, KS	--	--	--	--	--	--

Name	Electried (81---)	Heating/ Cooling (82---)	Sewage (831-- & 832--)	Refuse (833--)	Water (84---)	Miscellaneous (89---)
St. Louis AFS, MO	--	--	--	--	--	--
St. Louis STG, MO	--	--	--	--	--	--
Tinker AFB, OK	--	2	3	--	21	--
Travis AFB, CA	--	--	3	--	--	--
Travis 01-WSS, CA	--	--	--	--	1	--
Tyndall AFB, FL	2	--	3	--	2	--
USAF Academy, CO	--	--	--	--	--	--
Vance AFB, OK	--	--	1	--	1	--
Vandenberg AFB, CA	--	--	1	--	4	--
W.K. Kellogg APT, MI	--	1	--	--	2	--
Warren Grove WRG, NJ	--	--	--	--	--	--
Westover AFB, MA	1	1	--	--	1	1
Whiteman AFB, MO	--	--	--	--	3	1
Williams AFB, AZ	2	--	3	--	1	--
Wright-Patterson AFB, OH	3	10	--	1	20	5
Wurtsmith AFB, MI	--	--	1	--	1	--
TOTALS	40	84	84	3	200	42

Source: 1994 Real Property Inventory, U.S. Air Force

APPENDIX F

SCOPE OF WORK

SCOPE OF WORK
CONTRACT N62470-92-D-8965
DELIVERY ORDER

LEGACY PROJECT NO. 899
DEPARTMENT OF DEFENSE
SUPPORT AND UTILITY STRUCTURES AND FACILITIES
OVERVIEW, INVENTORY, AND TREATMENT PLAN
1917 - 1946

1. INTRODUCTION

1.1 LOCATION: Military Installations, Continental United States

1.2 PURPOSE: This statement of work is designed to obtain the professional services, labor, materials, and equipment necessary to: (a) complete an overview, (b) develop a classification system, (c) complete a partial inventory, and (d) develop a treatment plan for support and utility structures and facilities on military installations in the continental United States. The support and utility buildings and structures such as warehouses, magazines, heating plants, sewage treatment plants, etc. tend to be problematic in isolation, but could be eligible for listing in the National Register of Historic Places as individual structures or as contributing buildings or structures within a district. In order to effectively evaluate these types of facilities, a Department of Defense (DoD) wide perspective is required. The goals of this study are to develop a mechanism by which these categories of buildings and structures can be classified, their significance evaluated, and appropriate treatments undertaken.

1.3 AUTHORITY: This program is being conducted in accordance with Public Law 91-190, the National Environmental Policy Act of 1969; Public Law 93-291, Preservation of Historic and Archeological Data, amending Public Law 96-523; and the National Historic Preservation Act of 1966, as amended by Public Law 94-43. Also applicable is OPNAVINST 5090.1A, Chapter 20, "Historic and Archeological Resources Protection", and 36 CFR 800, "Protection of Historic Properties".

2. GENERAL: Military installations operative between 1917 and 1946 underwent rapid development in all aspects of operations, testing, supply, and housing. To support the major growth patterns associated with World War I and World War II, many support and utility structures and facilities were constructed. These are in most cases listed as permanent construction and are extant on most operating installations. Some of the support and utility real property assets are located in cantonment areas or main bases, while others are located apart from the major built areas of installations. These structures and facilities because of their age could be eligible for listing in the National Register of Historic Places, but because it is difficult in many cases to ascertain their significance, they pose a unique management problem.

To begin to effectively deal with the issue of support and utility structures and facilities on military installations, this study has been initiated under the Department of Defense Legacy Resource Management Program. Its goals are to develop: (a) a mechanism by which buildings and structures can be classified; (b) criteria for evaluating the significance of the facilities within a DoD wide context; and (c) management options for treatment of these resources. To do so, theme and contexts statements developed elsewhere will need to be reviewed and data gaps identified, particularly as they relate to these mundane types of facilities. Utilizing these contexts, the categories of mundane buildings will be evaluated for their potential significance. In the course of the evaluation, one or two bases for each service will be inventoried and evaluated to develop a mechanism for evaluation.

3. PROFESSIONAL STANDARDS AND ETHICS: The Contractor's professional employees shall adhere to the highest research standards and ethics of the profession.

3.1 RESEARCH STANDARDS: For the purposes of this delivery order, the Contracting Officer will accept as minimal guidelines any set of research standards promulgated by any recognized national or regional professional society or organization acceptable to the Contractor. The Government considers as minimal guidelines a set of standards similar to those published by the National Park Service in the Federal Register on January 28, 1977 (36 CFR 66), or those published as Appendix C in the Airlie House Report (McGimsey and Davis 1977). The contractor should also be familiar with "Treatment of Archeological Properties" (Advisory Council on Historic Preservation 1980).

3.2 ETHICS: The Contracting Officer will accept as minimal guidelines any set of professional ethics promulgated by any recognized national or regional professional society or organization appropriate to cultural resources investigations and acceptable to the Contractor.

4. PROGRAM SCHEDULE

4.1 WORK PLAN AND OUTLINE: The contractor shall submit to the government a work plan to complete work under this delivery order as well as an outline for the report. The work plan shall set forth the goals, methods, and rationale to complete the tasking. The outline shall cover major chapter headings proposed for the report as well as section or topic headings for each chapter. These shall be submitted within one hundred and thirty (130) calendar days of issuance of this delivery order . Ten copies of the work plan and outlines shall be submitted to LANTDIV.

4.2 The Government will review the work plan and outline within sixty (60) calendar days of receipt.

4.3 The first progress report for this contract is due within thirty (30) calendar days after the issuance of this delivery order. Subsequent progress reports are due every thirty (30) calendar days thereafter until completion of all delivery orders.

4.4 DRAFT TECHNICAL SYNTHESIS REPORT: The draft Technical Synthesis Report is due within three hundred (300) calendar days of the issuance of this delivery order.

4.5 The Government will review the draft Technical Synthesis Report within sixty (60) calendar days of receipt of draft.

4.7 TECHNICAL SYNTHESIS REPORT: The final Technical Synthesis Report is due within forty-five (45) calendar days of receipt of Government review comments for the draft Technical Synthesis Report.

4.8 DRAFT DATA COMPENDIUM AND PHOTOGRAPHIC NOTEBOOK: The Data Compendium and Photographic Notebook are due thirty (30) calendar days of the Government's acceptance of the final Technical Synthesis Report.

4.9 The Government will review the Data Compendium and Photographic Notebook within thirty (30) calendar days of receipt.

4.10 DATA COMPENDIUM AND PHOTOGRAPHIC NOTEBOOK: The final Data Compendium and Photographic Notebook are due within thirty (30) calendar days of receipt of Government comments.

5. SUMMARY OF TASKS: The work to be performed under this delivery order consists of the following:

5.1 ARCHIVAL RESEARCH AND RECORDS SEARCH: The consultant shall undertake archival or background research, to include review of the historic contexts statements developed under the Legacy Resource Management Program, prior to any field surveys. Where historic contexts statements are not available or underdeveloped, the contractor shall develop relevant context statements. The contractor shall additionally review extant architectural survey reports developed for military installations to note the methodology used to evaluate these facilities to date.

5.2 CLASSIFICATION OF BUILDINGS: The consultant shall develop a typology for mundane buildings that can be used to classify them so that they may be evaluated for eligibility. The buildings from 1917-1946 that are support and utility structures will be the topic of this study, frequencies of each category as well as distribution will be obtained through government property records. This data will be presented in matrix format.

5.3 DOCUMENTATION OF REPRESENTATIVE TYPES: The consultant shall document representative types defined in task 5.2 above. To accomplish this task, the consultant shall complete an architectural survey of mundane building types at minimally one installation from each service. The consultant shall document on appropriate forms all pertinent data regarding each structure/building examined for this study area At least two photographic views shall accompany each survey form. To take photographs at the various military installations, it may be necessary for the contractor to obtain a photographic pass and notify the base in advance of arrival to ensure base personnel are available as escorts.

5.3 The contractor shall meet with the LANTDIV archeologist and other DoD personnel after the survey but prior to submitting the draft Technical Synthesis Report to go over their findings. Maps and other appropriate information regarding district definition and eligibility status of structures/buildings will be reviewed at this meeting.

6. REPORTS: The contractor's performance under this contract will be evaluated on the quality, adequacy, and completeness or reports submitted. Five classes of reports are required under this delivery order.

6.1 **Monthly Progress Report:** The Monthly Progress Report is a brief summary of the work accomplished each month. The contractor's principal investigator shall be the author of the Monthly Progress Report.

6.2 **Work Plan and Outline**: The Work Plan and outline are brief documents that outline the rationale, goals, and methods for completing the tasking in this delivery order as well as proposed presentation.

6.3 **Draft Technical Synthesis Report**: The draft report shall be a polished product and an accurate representation of the final report. The draft report shall be an essentially complete document that only requires editorial, drafting, or cartographic revisions to be a publishable quality monograph.

6.4 **Technical Synthesis Report**: The final report shall incorporate review comments submitted to the Contractor. If there is a disagreement regarding comments, the contractor will meet with the Government to resolve differences. If the disagreement cannot be resolved, the Government comments will be incorporated. The report shall include the following:

1. *Executive Summary*: a brief synopsis, suitable for publication in an abstract journal summarizing the findings, conclusions, and recommendations of the report.

2. *Table of Contents*

3. *Introduction*: shall include a statement of purpose for the investigation and the means by which the goals of the investigation were met.

4. *Contextual Setting*

5. *Results of the Investigation*: synthesis, integration, and interpretation of all data collected. This should include: Classification of buildings, documentation of property types, general assessment of eligibility, and management options for treatment.

6. *References Cited*

7. *Appendices*: which shall include all site forms, non-sensitive maps, and other information gathered during the investigation.

6.5 **Data Compendium and Photographic Notebook:** The data compendium and photographic notebook shall contain all of the data collected for the project and will include all site or architectural forms, background data not included in the report, notes, drawings, and originals of all maps. The photographic notebook shall contain one copy of each photograph with an accompanying negative that were taken during the project. Each photograph and negative shall indicate building number, location, date of photograph and any other relevant information gathered during the course of the investigation. The data compendium and photographic notebook may be submitted in a three ring, loose leaf notebook format.

7. REPORT FORMAT

7.1 Monthly Progress Report: This report shall be submitted in letter format, normally not to exceed two pages in length for each delivery order, and shall be accompanied by a cover letter.

7.2 Work Plan with Outline: This document shall be submitted in extended letter format and shall be no longer than ten (10) pages in length.

7.3 **Draft Technical Synthesis Report:** The draft report shall be submitted in bound form. This document will be double-spaced and may be dot-matrix printed. Five copies of the draft report shall be submitted. Photographs, plates, drawings, and other graphic material shall appear in the same size, format, and general location in the draft report as they will appear in the final report.

7.4 **Technical Synthesis Report:** The Technical synthesis Report shall be a publishable quality monograph that shall conform to general practice in the profession. The document shall conform to the style guide of the American Anthropological Association, or some other nationally recognized style guide that is appropriate for archeological or architectural reports. The text shall be typed or printed single spaced in a one or two column format. Twenty five (25) copies of the Technical Synthesis Report shall be submitted to the Government.

7.4.1 The contractor shall submit the original of the final Technical Synthesis Report, letter quality typescript, and ready for reproduction by photo-optical copying on 8.5 by 11 inch paper (except for those pages that may be 8.5 by 17, 22, or 34 inch fold out figures) with a binding edge of one inch.

7.4.2 All hand prepared pages such as maps and drawings shall be professionally drafted. maps shall be drawn on vellum and shall have a legend that is clear and readable, including such information as the scale, north indication, and symbol identification. The features to be illustrated such as site locations must stand our clearly against the other features on the map. All maps shall have a half inch border and a binding edge of one inch. The original(s) must be submitted.

7.4.3 Photographs shall be original black and white positive prints or half-tones. A caption shall be typed for each photograph and properly mounted.

7.4.4 Sensitive maps and information will be contained in the Data Compendium and will not be included as part of the report unless the data are in an appendix and are removable.

7.5 **Dissemination of Data:** The contractor will not disseminate the data collected under this delivery order without the express consent of LANTDIV.

8. **OTHER CONSIDERATIONS:**

8.1 **Ownership of Data and Materials:** Title to all data recovered or generated under this solicitation is vested in the U.S. Government.

8.2 **Security:** Since the materials and data generated under this solicitation are the property of the Government and since the contractor will be acting as an agent of the Government, the contractor shall continually provide for the secure safekeeping of the data, or any other material in their custody.

8.3 **Publicity:** During the terms of this delivery order, the contractor and employees and sub-consultants shall not release for publication any sketch, photograph, report, account, or any other material of any nature pertaining to the work for which services are performed under the terms of this delivery order unless written permission is obtained from the Contracting Officer.

8.4 **Inspection and Coordination:** The Contracting Officer or his authorized representative may at all reasonable times inspect or otherwise evaluate the work being performed under this contract and the premises on which it is being performed. All inspections and evaluations will be performed in such a manner as will not unduly delay progress of work. It is necessary that close coordination between the contractor and LANTDIV's archeologist be maintained throughout the life of the contract to ensure its satisfactory completion. Any communication with the contractor of a directional nature will be made in written form by the Contracting Officer or his authorized representative.

8.5 **Notice to the Government of Delays:** In the event the contractor encounters difficulty in meeting performance requirements, or when he anticipates difficulty in complying with the contract delivery schedule or data, or whenever the contractor has knowledge that any actual or potential situation is delaying or threatening to delay the timely performance of this delivery order, the contractor shall immediately notify the Contracting Officer in writing, giving pertinent details; provided, however, that this data shall be informational only in character and that this provision shall not be construed as a waiver by the Government of any delivery schedule, of data, or of any rights or remedies provided by law or under this delivery order.

APPENDIX G

RESUMES OF KEY PERSONNEL

DEBORAH K. CANNAN, B.A.

PROJECT MANAGER

Ms. Deborah K. Cannan, B.A., Project Manager, was graduated from the University of Virginia in 1985 with a Bachelor of Arts degree in architectural history. While at UVA, Ms. Cannan served as Assistant to the Editor of Modulus, the University of Virginia Architectural Review, and completed an internship at the Octagon Museum in Washington, D.C. Ms. Cannan has served as Architectural Historian with the Fairfax County Office of Comprehensive Planning and as a private preservation consultant in Virginia and Washington, D.C. Her projects included intensive and reconnaissance architectural surveys, National Register of Historic Places nominations, local historic district designation, and historic district design guidelines. She is a past member of the Advisory Board of the Preservation Alliance of Virginia.

Since joining R. Christopher Goodwin & Associates, Inc., Ms. Cannan has been project manager on numerous investigations involving the identification, evaluation, nomination, and management of cultural resources. Recent projects have included a Cultural Resource Management Plan for historic properties located within Fort Detrick, Maryland; the documentation, and evaluation of the Routzahn Farm, Frederick County, Maryland, and architectural survey and evaluation of the Potomac Palisades, Arlington County, Virginia. Ms. Cannan also conducted historical research and architectural survey for the Moorefield Flood Control Project in Hardy County, West Virginia, and completed architectural survey in Gettysburg, Pennsylvania.

Ms. Cannan also served as project manager for the development of the Nationwide Historic Context for the evaluation of historic properties located on Department of Defense installations, and for the development of the World War II Permanent Construction Historic Context. Ms. Cannan also directed the intensive architectural survey of Charleston Naval Base and Fort Knox as a demonstration project for the DoD Legacy Resource Management Program. Ms. Cannan authored the *Handbook for Historic Military Quarters* and scripted a training video, "Cultural Resources in the DoD," on behalf of the Department of Defense.

KATHRYN M. KURANDA, M. ARCH. HIST.

VICE PRESIDENT - ARCHITECTURAL SERVICES, MID-ATLANTIC REGIONAL OFFICE

Ms. Kathryn M. Kuranda, M. Arch. Hist., Vice-President - Architectural Services, directs the architectural history and history programs of R. Christopher Goodwin & Associates, Inc. A graduate of Dickinson College and of the University of Virginia, Ms. Kuranda's professional qualifications exceed those established by the Secretary of the Interior in the field of architectural history. Ms. Kuranda possesses particular expertise in nineteenth and twentieth century vernacular architecture. She also is a court-qualified architectural historian

Prior to joining Goodwin & Associates, Inc., as the architectural historian with the Nevada State Historic Preservation Office where she coordinated the state's program for built resources including: Survey and Inventory Activities; the Historic Preservation Tax Program; Review and Compliance; Public Education; and, Technical Assistance.

Ms. Kuranda has been responsible for the successful execution of numerous HABS/HAER projects. These include residential, commercial and industrial sites in the Mid-Atlantic , Northeastern, Western, and Southern states.

Since joining Goodwin & Associates, Inc., Ms. Kuranda has directed over 50 identification, evaluation, planning, and management projects for built resources. Ms. Kuranda, has directed the development of historic contexts for the Army Materiel Command's World War II Facilities; for Resources Associated with the Navy's Guided Missile Program, 1946-1989; and for Department of Defense Installation, 1790-1940. HABS/HAER recordation projects include eight industrial complexes on the site of Oriole Park at Camden Yards, Baltimore; 3 buildings on the site of the Maryland Library for the Blind and Physically Handicapped, Baltimore; and the Canal Street Car Barns, New Orleans. She has designed and implemented evaluation and impact studies for the Montgomery County Resource Recovery Facility at Dickerson, Maryland, and for historic properties in the vicinity of the Baltimore Gas & Electric Company pipeline corridors in Maryland.

KATHERINE GRANDINE, M.A.

PROJECT MANAGER

Ms. Katherine E. Grandine, M.A., Project Manager and Historian, received a Master of Arts degre in American Civilization with Emphasis on Historic Preservation in 1983 from the George Washingtc University, Washington, D.C. She has been professionally active in the field of historic preservation sinc 1981. Her project experience includes historic research, architectural surveys, in Washington, D.C Maryland, and Virginia, Historic American Buildings Survey documentation, National Register of Histor Places nominations, local landmark and historic district nominations, and survey of historically significai family housing for the Department of Defense. She has particular expertise in data management for histori properties including the Integrated Preservation Software developed by the National Park Service.

Since joining Goodwin & Associates, Inc., Ms. Grandine has served as an historic preservatio specialist in the development of the National Historic Context for DoD Installations from 1790 to 1940 an performed reconnaissance-level and intensive-level architectural surveys at Aberdeen Proving Grounc Maryland; Charleston Naval Base, South Carolina; Fort Knox, Kentucky; Carlisle Barracks, Pennsylvania; anc FISC, Cheatham Annex, Virginia. She has conducted literature searches for Phase I surveys, including fc the C & D Canal project in Maryland and Delaware, and architectural surveys in Virginia, including th Potomac Palisades area in Arlington. She has managed architectural survey and evaluation projects, writte National Register nominations for individual properties and historic districts, co-authored a cultural resourc management plan and numerous technical reports, and provided historic background research for a variet of cultural resources projects. She also has managed architectural survey databases and prepared exhib panels and an informational brochure for Aberdeen Proving Ground, Maryland.