



United States Air Force  
15th Air Base Wing  
Environmental Restoration Program

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## HISTORICAL REVIEW

Engineering Evaluation/Cost Analysis for  
Operable Unit 1 (Sites LF01, DP17, SD22,  
and DP06)

Bellows Air Force Station  
Oahu, Hawaii



September 25, 1998

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## Executive Summary

This Historical Review has been prepared as part of an Engineering Evaluation/Cost Analysis (EE/CA) of Operable Unit 1 (OU1) at Bellows Air Force Station (AFS), Oahu, Hawaii. The Bellows OU1 EE/CA project is being conducted to support Installation Restoration Program (IRP) activities managed by the 15th Air Base Wing (ABW) Civil Engineer Squadron/ Environmental Restoration Element (15 CES/CEVR) located at Hickam Air Force Base (AFB), Hawaii. This work is being performed through the Air Force Center for Environmental Excellence (AFCEE) under Delivery Order F41624-97-D-8019-0005.

OU1 comprises four IRP sites at Bellows AFS that are known or suspected to have been subject to the historical release of contaminants. The four sites, shown on Figure ES-1, are:

- Site LF01, Base Landfill
- Site DP17, Burn Disposal Site
- Site SD22, Abandoned Drums
- Site DP06, Multiple Drum Sites

The Bellows OU1 EE/CA also addresses the potential impact of these four sites on Waimanalo Stream (Figure ES-1).

The overall objective of the EE/CA is to provide sufficient information for the Air Force, the State of Hawaii Department of Health (HDOH), and the U.S. Environmental Protection Agency (EPA) to determine whether each site: (a) poses a potential risk to human health or the environment and requires a removal action; or (b) is eligible for No Further Remedial Action Planned (NFRAP) Category III documentation. This Historical Review supports the planning phase of the EE/CA process by bringing together in one reference document the available current and historical information on waste disposal activities at the four Bellows OU1 EE/CA sites.

The information sources used for this report include: historical documents, aerial and still photographs, and drawings; interviews with former Bellows AFS personnel and other knowledgeable persons; and previous reports prepared by other contractors.

### Bellows AFS Background Information

Bellows AFS occupies approximately 1,600 acres on the eastern coast of Oahu, Hawaii. The installation is located approximately 25 miles from Honolulu, on the eastern side of the Koolau Mountain Range. The installation is bordered by residential, recreational, and commercial land use areas to the north, west, and south, and Waimanalo Bay (the Pacific Ocean) to the east. The surface of the installation is dominated by cleared and leveled areas for runways, taxiways, and aprons that are now inactive; the unpaved areas are covered with vegetation.

Most of the installation is at an elevation of 25 feet or less above mean sea level (MSL). The installation's northern and western extents are characterized by hills and ridgelines up to approximately 400 feet above MSL. Groundwater beneath Bellows AFS generally flows east toward the ocean and is likely tidally influenced; due to its salinity, it is not a designated drinking water resource.

Few rare, threatened or endangered animal species inhabit Bellows AFS, and no rare, threatened, or endangered plant species have been identified at the installation. Sites LF01, DP17, and SD22 are located in areas having moderate probability of encountering unrecorded Native Hawaiian Resources; however, the probability is likely low at these specific sites due to historical excavation activities. Site DP06 is located in an area having a high probability of encountering unrecorded Native Hawaiian Resources.

Bellows AFS is currently used by the U.S. Air Force for military and civilian employee recreation activities, by the U.S. Marine Corps (USMC) and Hawaii Army National Guard (HIARNG) for training, and by the general public on a limited basis for recreation on weekends and holidays.

## **History of Waste Disposal at Bellows AFS**

Waste disposal at Bellows AFS can be divided into three distinct time periods: pre-World War II, World War II, and post-World War II. These periods correspond to the primary phases in the installation's history and are characterized by very different types and levels of waste disposal activity. The historical information sources generally do not define what types of refuse were disposed of at the various dump sites. Figure ES-2 summarizes the sites described below and shows their approximate locations.

Prior to World War II, as "Bellows Field," the installation's uses included agriculture, a landing field, military training, and a recreation area. Refuse was generally separated into two waste streams: food preparation waste, which was collected by island hog raisers and used as feed, and inorganic waste and brush from landscaping and site clearing, which was generally hauled to city and county dumps and burned. The installation's primary dump during this period was apparently the neighboring Waimanalo Plantation dump, which was reportedly covered when the installation boundary changed and the main runway (6-24) was constructed in 1942. The general location of this dump is believed to be beneath the westernmost portion of Runway 6-24, but its exact location has not been determined.

Bellows Field was greatly expanded during World War II. New runways were constructed, a staging area was established for transient aircraft, and numerous revetments for aircraft parking/repair and ordnance storage were constructed into hillsides on the installation. Waimanalo Stream was also rechanneled to its current alignment and the surrounding marshland filled. At least three new on-base dump sites were established and used during World War II: the first in the general area of Site DP17; the second at a former pier near the ocean end of Runway 3R-21; and

the third within the current location of Area of Concern (AOC) EA07 (Figure ES-2). At least two off-base dumps were also reportedly developed during the war.

Following the war, Bellows Field was transferred from the Army to the Air Force and redesignated Bellows Air Force Base (AFB), and later Bellows Air Force Station (AFS). The installation has since been used primarily for recreation (in the shoreline areas), military field training exercises, and as a communications relay complex. This complex was transferred to other Air Force and Navy installations in Hawaii in 1994. Several post-World War II drawings indicate that the dump site currently within the location of AOC EA07 continued to be used for refuse disposal through at least the late 1950s, and possibly as late as the early 1980s. The general locations of Sites LF01/DP17 and SD22 are also designated as “dump areas” on drawings from the 1950s and 1960s, but not on drawings after 1975. There is no historical information documenting waste disposal at Site DP06.

## **Waste Disposal at Bellows OU1 EE/CA Sites**

### **Site LF01**

Site LF01 is located in the west-central portion of Bellows AFS (Figure ES-1), within a former coral borrow area excavated during World War II. The results of an IRP Stage 1 Investigation at Site LF01 (HLA, 1992) indicate that the site was used for waste disposal. The materials encountered consisted of native soils with metal debris, glass, paper, foil, charcoal, and other debris. Low concentrations of total petroleum hydrocarbons (TPH) and polynuclear aromatic hydrocarbons (PAHs) were also detected in site soil, but no organics were detected in groundwater (HLA, 1992). Chemicals detected at concentrations exceeding current regulatory screening criteria included:

Soil: phenanthrene, arsenic, cadmium, iron, lead, lead, and thallium

Groundwater: cadmium, copper, lead, mercury, and nickel

Historical drawings label the general area of Site LF01 as a “dump area” in the 1950s and 1960s; the waste materials currently present at the site likely date from this period. Later drawings do not identify the site as a dump area and it is not currently used for waste disposal.

Hazardous materials from military shop operations during World War II were reportedly disposed of at Site LF01 between 1943 and 1946 (ES, 1984). Research conducted for this Historical Review, however, found no documentation of hazardous materials being disposed of specifically in Site LF01 during World War II. Reports of hazardous material disposal during World War II may refer to the other on- and off-base dump sites.

## Site DP17

Site DP17 is located immediately south of Site LF01 (Figure ES-1). The northern edge of Site DP17 overlaps the southern extent of Site LF01 and is referred to as Site DP17A; Site DP17A is located within the coral borrow pit that also encompasses Site LF01. Previous environmental assessments (EA, 1996) encountered waste materials in Site DP17A, including creosote-treated poles, electrical insulators, empty electrical power transformer casings, battery packs, and drums. In 1996, the drums and drum remnants were removed from Site DP17A (EA, 1996 and 1998). The analytical results of surface soil samples collected following drum removal indicate that the following chemicals exceeded current screening criteria: benzo(a)pyrene, phenanthrene, PCB (Aroclor) 1242, endosulfan II, endrin, endrin aldehyde, heptachlor epoxide, methoxychlor, arsenic, cadmium, and lead.

The location of Site DP17A within the coral borrow pit makes it likely that waste disposal occurred there sometime after quarrying operations ended in the mid- to late 1940s. The historical documents reviewed contain minimal information with respect to waste disposal in the remainder of Site DP17, although cleared areas are visible in 1942, 1943, and 1945 aerial photos and various roads or paths into the site are visible on photos from 1942 through 1985.

## Site SD22

Site SD22 is located immediately south of a former pursuit plane revetment (i.e., the south wall of the revetment was excavated and removed), approximately 200 feet northwest of Sites LF01 and DP17A (Figure ES-1). Site SD22 consists of a former drum disposal area. A 1993 Preliminary Assessment for underground storage tanks (USTs) (ES, 1993) encountered approximately 30 drums disposed of over the excavated south side of the revetment and onto the adjacent forest floor.

The drums' condition and markings reportedly suggested they originated during World War II; however, some drums had markings indicating post-World War II origins. No drums with liquid were found at the site (EA, 1996). The drums were removed in 1996 (EA, 1996 and 1998). The analytical results of shallow (approximately 1 foot below ground surface) soil samples collected following drum removal indicate that only arsenic exceeded its current screening criteria.

Use of the site as a disposal area likely did not occur until after excavation of the revetment. Historical drawings consistently show the revetment at the location of Site SD22 in place through 1957; drawings from 1966 through 1975 show that the revetment had been removed and identify the site as a "dump area." A 1981 drawing does not identify the site as a "dump area" and it is not currently used for waste disposal. It is therefore likely that the drums were dumped there between the late 1950s and late 1970s.

## Site DP06

Site DP06 is located in the southwest portion of the installation adjacent to Waimanalo Stream (Figure ES-1). The site was identified during reconnaissance for the 1993 UST PA (ES, 1993); its boundaries were defined by the visible extent of stressed vegetation and mounding of soil and concrete rubble.

An SI conducted at Site DP06 in 1996 included analysis of soil, groundwater, surface water, and sediment samples (EA, 1996). Chemicals detected at concentrations exceeding current screening criteria included:

Soil: methylene chloride, chrysene, di-n-octylphthalate, fluoranthene, PCB (Aroclor) 1254, and arsenic

Groundwater: lead (total), mercury (total and dissolved), nickel (total and dissolved), and zinc (total)

Surface water: zinc (total)

Sediment: antimony, arsenic, chromium, copper, and nickel

The history of waste disposal operations at Site DP06 is not documented. Tinker Road was completed through the site area in 1943. Tinker Road was the installation's primary roadway; it is therefore unlikely that a casual dump site would have developed while this section of the road was still in use. Aerial photographs do not show activity at the site before the 1960s, and deterioration of the bridge over Waimanalo Stream sometime before 1966 effectively left Site DP06 at the end of a dead-end road. Dumping at the site probably post-dates this event. Likely sources of materials dumped at the site include the demolition of World War II-era buildings, and possibly waste from post-World War II military or recreation activities.

## Waimanalo Stream

Waimanalo Stream crosses the center of the installation from southwest to northeast and discharges into Waimanalo Bay (Figure ES-1). The stream receives water from various sources west of Bellows AFS, including groundwater recharge, intermittent tributaries, drainage ditches in residential and agricultural areas, and ponds at the Olomana Golf Course (HDOH, March 1998). The stream also receives runoff and storm drainage from the installation. Waimanalo Stream is joined by Kahawai Stream along the installation's western boundary.

The stream was extensively rechanneled to its present alignment and the surrounding marshland filled during Bellows AFS expansion in the early 1940s. The stream mouth forms a coastal estuary, and the stream is tidally influenced. Water in the stream's lower reach is brackish due to flow from the ocean and recharge by groundwater.

No records indicate that refuse was disposed of in Waimanalo Stream; however, used oil, presumably motor oil, was reportedly applied to ditches and streams at the installation prior to World War II and possibly during the war in an effort to control mosquitoes. In addition, several secondary drainage ditches constructed during WWII discharged to Waimanalo Stream; these ditches carried runoff from the pursuit plane revetments area, runways/ taxiways, and an aircraft fuel dispensing area. Surface runoff also flows to the stream naturally as sheet flow from the higher elevations.

## **Pesticides and Herbicides**

Numerous historical documents discuss efforts to control insects at Bellows Field and throughout the Pacific theater during World War II. In addition to the use of used oil in the streams to control mosquitoes, pesticides included DDT (powder and sprayed solutions), dimethyl phthalate, aerosol pyrethrum, chloride of lime, and paradichlorobenzene.

A 1957 drawing identifies several areas of Bellows AFS for the application of herbicides, including the former pursuit plane revetments that border or include Sites LF01, DP17, and SD22. In addition, the Waimanalo Stream channel within Bellows AFS is managed as a floodway, and the stream banks are regularly sprayed with herbicide down to the water's edge to prevent vegetation from clogging the channel (HDOH, March 1998).

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## Acronyms and Abbreviations

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ABW	Air Base Wing
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AFS	Air Force Station
AOC	Area of Concern
bgs	below ground surface
CES	Civil Engineer Squadron
CEVR	Civil Engineer Squadron, Environmental Restoration Element
COE	U.S. Army Corps of Engineers
Det 1, 15 SPTG	U.S. Air Force, 15 ABW, Detachment 1, 15th Support Group
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EROS	Earth Resources Observation Systems
ft	feet
HIARNG	Hawaii Army National Guard
IRP	Installation Restoration Program
MSL	mean sea level
NARA	National Archives and Records Administration

NFRAP	No Further Remedial Action Planned
OU1	Operable Unit 1
PA	Preliminary Assessment
PAH	polynuclear aromatic hydrocarbons
PX	post exchange
RTE	rare, threatened, or endangered
TPH	total petroleum hydrocarbons
USAF	U.S. Air Force
USGS	U.S. Geological Survey
USMC	U.S. Marine Corps
UST	underground storage tank
WMR	Waimanalo Military Reservation

# 1.0 Introduction

This Historical Review has been prepared as part of an Engineering Evaluation/Cost Analysis (EE/CA) of Operable Unit 1 (OU1) at Bellows Air Force Station (AFS), Oahu, Hawaii. The Bellows OU1 EE/CA project is being conducted to support Installation Restoration Program (IRP) activities managed by the 15th Air Base Wing (ABW) Civil Engineer Squadron/ Environmental Restoration Element (15 CES/CEVR) located at Hickam Air Force Base (AFB), Hawaii. This work is being performed through the Air Force Center for Environmental Excellence (AFCEE) under Delivery Order F41624-97-D-8019-0005.

OU1 comprises four IRP sites at Bellows AFS that are known or suspected to have been subject to the historical release of contaminants. The four sites, shown on Figure 1-1, are:

Site LF01, Base Landfill

Site DP17, Burn Disposal Site

Site SD22, Abandoned Drums

\* Site DP06, Multiple Dump Sites

The Bellows OU1 EE/CA also addresses the potential impact of these four sites on Waimanalo Stream (Figure 1-1).

## 1.1 Purpose and Objectives

The overall objective of the EE/CA is to provide sufficient information for the U.S. Air Force (USAF), the State of Hawaii Department of Health (HDOH), and the U.S. Environmental Protection Agency (EPA) to determine whether each site: (a) poses a potential risk to human health or the environment and requires a removal action; or (b) is eligible for No Further Remedial Action Planned (NFRAP) Category III documentation. The EE/CA process identifies and focuses on the issues of greatest concern at a site, and the human and environmental receptors at greatest potential risk, in order to expedite decisionmaking. This Historical Review supports the planning phase of the EE/CA process by bringing together in one reference document the available historical information on waste disposal activities at the four Bellows OU1 EE/CA sites.

## 1.2 Scope of Work

The scope of this study was limited to Sites LF01, DP17, SD22, and DP06, and Waimanalo Stream. The study focuses on the known or likely dates of use and the possible materials disposed of at these sites. The research effort was also limited to locating information specific to these sites. Some information regarding the use of pesticides and herbicides at the installation was discovered during research; this information, while not specific to the Bellows AFS OU1 EE/CA sites, is included in this report (see Section 6).

This study included locating and reviewing primary historical information sources such as official U.S. Army and USAF documents, design drawings, and aerial photos. These sources were generally relied upon unless conflicting information, either in other historical sources or in reports by other contractors, was discovered; this report documents conflicting information, where identified. This report also consolidates the site-specific information compiled by other contractors.

A major focus of this research was the identification of new sources of information not cited in earlier studies. The repositories examined and types of materials reviewed are discussed in Section 2 and in Appendix A.

### **1.3 Limitations of this Report**

This Historical Review consolidates the available information regarding waste disposal at the four Bellows AFS OU1 EE/CA sites and Waimanalo Stream, but does not include independent verification of this information. The research effort did not include site field visits to verify discovered information.

The limited available information, particularly for the period after 1945, in some cases makes it difficult to identify specific waste disposal practices, locations, and dates with certainty. In many cases it was necessary to infer this information from indirect evidence such as topographic contours on historical survey drawings, official memoranda regarding U.S. Army waste disposal practices, and features observed on historical aerial photos. This report presents findings based on reasonable interpretation of the available information, and identifies uncertainties where they exist.

## 2.0 Information Resources

A variety of repositories were searched for aerial and still photographs, maps, plans, drawings, memos, and reports. Section 7 presents a complete list of reference material reviewed, organized by type of document. Appendix A details the research methods and the types of information located at each repository.

Research was conducted at the following repositories in Hawaii:

- U.S. Army Garrison Hawaii, Directorate of Public Works
- U.S. Army Museum at Fort DeRussy
- U.S. Army Corps of Engineers, Real Estate Directorate
- University of Hawaii, Hamilton Library
- 15 CES/CEVR
- 15 ABW, Headquarters History Office
- R.M. Towill Corporation, Honolulu
- CH2M HILL, Honolulu

Research was also conducted at the following U.S. mainland repositories:

- National Archives Records Administration, Washington D.C. (College Park, Maryland)
- Air Force Historical Research Agency, Maxwell AFB, Alabama
- U.S. Army Corps of Engineers History Office, Fort Belvoir, Virginia
- U.S. Geological Survey Earth Resources Observation Systems (EROS) Data Center, Sioux Falls, South Dakota

Copies of historical documents used for this report are archived in CH2M HILL's Honolulu office. Copies of historical drawings and aerial photos that help present the information discussed in this report are included in Appendix C (aerial photos) and Appendix D (drawings).

Where possible, interviews were conducted with former Bellows AFS personnel and other knowledgeable persons. Appendix B presents summaries of these interviews.

Reports by other contractors that address one or more of the Bellows OU1 EE/CA sites were also reviewed. These reports include:

EA Engineering, Science, and Technology (EA). July 1996. *Draft Final Preliminary Assessment/Site Inspection Report, Bellows Air Force Station. Volume I of II: Preliminary Assessment Report.*

- \* EA. February 1998. *Draft Final: Multi-Drum Project Letter Report, Bellows Air Force Station, Hawaii.*

Engineering-Science (ES). September 1984. *Installation Restoration Program, Phase 1: Records Search, 15<sup>th</sup> ABW Satellite Installations, Hawaii.*

ES. June 1993. *IRP Draft Underground Storage Tank (UST) Preliminary Assessment for Hickam AFB, Bellows AFS, Palehua Solar Observatory, and Wake Island for Hickam AFB.*

Farrell, N. and R.L. Spear, Ph.D. February 1997. *Cultural Resources Management Plan (CRMP) for Bellows Air Force Station, Waimanalo, Ko'olaupoko, Island of O'ahu, Hawai'i. Volumes 1 and 2.*

Harding Lawson Associates (HLA). September 1992. *Installation Restoration Program Stage 1 Technical Report for Bellows Air Force Station, Hawaii.*

Applicable information from these reports has been included in this Historical Review.

## **3.0 Bellows Air Force Station Setting, Current Land Uses, and General History**

### **3.1 Setting**

Bellows AFS occupies approximately 1,600 acres on the eastern coast of Oahu, Hawaii (Figure 3-1). The installation is located approximately 25 miles from Honolulu, on the eastern side of the Koolau Mountain Range. The installation is bordered by residential, recreational, and commercial land use areas to the north, west, and south, and Waimanalo Bay (the Pacific Ocean) to the east. The surface of the installation is dominated by cleared and leveled areas for runways, taxiways, and aprons that are now inactive; the unpaved areas are covered with vegetation.

Bellows AFS is relatively flat throughout much of its central area; most of the installation is at an elevation of 25 feet or less above mean sea level (MSL). Groundwater beneath Bellows AFS generally flows east toward the ocean and is tidally influenced. Groundwater occurs at approximately 8 to 12 feet below ground surface (bgs) beneath most of the installation, but due to its salinity is not a designated drinking water resource. The nearest municipal water supply well is located approximately 1 mile west (upgradient) from Bellows AFS.

No rare, threatened, or endangered (RTE) plant species are known to occur on or near Bellows AFS (EA, 1997). Several RTE wildlife species have been observed or have the potential for occurrence at Bellows AFS; these include the black-necked stilt, Hawaiian duck, Hawaiian coot, Hawaiian short-eared owl, Hawaiian hoary bat, common moorhen, Newell's shearwater, green sea turtle, and Hawaiian monk seal (EA, 1997). There are no known occurrences of RTE invertebrate species on Bellows AFS (EA, 1997).

Sites LF01, DP17, and SD22 are located in areas predicted by the Cultural Resources Management Plan (SCS/CRMS, Inc., 1997) as having moderate probability of encountering unrecorded Native Hawaiian Resources; however, the probability is likely low at these specific sites due to historical excavation activities. Site DP06 is located in an area having a high probability of encountering unrecorded Native Hawaiian Resources.

### **3.2 Current Land Uses**

Figure 3-2 shows current Bellows AFS land uses. Bellows AFS is currently operated by the U.S. Air Force, 15 ABW, Detachment 1, 15th Support Group (Det 1, 15 SPTG) for military and civilian employee recreation activities. A staff housing area, supply and motor pool facilities, headquarters building, and base exchange are situated in the northwestern quarter of the installation near the main recreational area. Guardhouses are located at the main gate off Kalaniana'ole Highway at the town of Waimanalo and in the east-central portion of the installation along Tinker Road south of Waimanalo Stream.

Much of the installation is also used by the U.S. Marine Corps (USMC) and Hawaii Army National Guard (HIARNG) for field training exercises; the four Bellows OU1 EE/CA sites are located in the military training area. The beachfront areas south of Waimanalo Stream are open to the general public for recreation on weekends and holidays. In addition to the installation's military and recreational uses, civilian workers maintain and service sewer, electrical, and telephone utilities within rights-of-way leased from USAF.

Bellows AFS is most widely known as a rest and recreation center. The Bellows Recreation Center opened in 1942 to active-duty and retired members of the military. The Recreation Center facilities have been expanded considerably since World War II; current recreational facilities managed by USAF for overnight guests include cabins, camp sites, a beach club, an 18-hole miniature golf course and golf driving range, tennis courts, and three beachfront picnic pavilions north of Waimanalo Stream. On weekends and holidays the 54-acre central beach area between Waimanalo and Inoaole Streams and east of Tinker Road is open for use by the general public; this area is designated Bellows Field Beach Park. USMC uses this area for training on weekdays.

### 3.3 History

This section summarizes the general history of Bellows AFS; Sections 4 and 5, respectively, describe the installation's waste disposal practices and site-specific histories. The following summary was compiled from numerous sources; chief among these are the *Brief History of Bellows Air Force Station* (Anon, n.d.) provided by 15<sup>th</sup> ABW Historian's Office (15<sup>th</sup> ABW HO), and the *Cultural Resources Management Plan for Bellows Air Force Station* (SCS/CRMS, Inc., 1997). References to other documents are noted. Figure 3-3 presents a timeline and site plans highlighting the key events described below.

Bellows AFS was established in March 1917 as the Waimanalo Military Reservation (WMR) when the federal government set aside 1,510 acres for military purposes. Initially, WMR was used predominantly for pasture land and sugarcane cultivation. The military used the remainder of the reservation as an auxiliary landing field, a casual camp for air and ground training, and a gunnery and bombing range. By 1928 the military had created a landing field at WMR. The original runway, completed in January 1933, was 75 feet wide by 983 feet long and composed of coral rock with an oiled surface; the 1941 aerial photo in Appendix C shows the original runway. WMR was redesignated Bellows Field in August 1933, becoming a sub-post of Wheeler Field. Groups of U.S. Army air and ground forces used WMR for training and recreation, but few personnel were permanently stationed there. The Waimanalo Sugar Plantation leased 229 acres of WMR from 1923 until 1932 and again from 1938 to 1942.

An expansion program at Bellows Field was begun in 1941 as war in the Pacific became more likely. In March 1941, the 86<sup>th</sup> Observation Squadron (flying O-47Bs) and the 58<sup>th</sup> Bombardment Squadron (flying B-18s) were moved to Bellows Field from Wheeler Field. However, the Bombardment Squadron moved to Hickam Field a month later because its new A-20 aircraft were

too big for the facilities at Bellows. On July 22, 1941, Bellows Field was established as a separate permanent military post by General Order #42, Headquarters Hawaiian Department. A casual training camp was also established at Bellows Field in August 1941 to provide basic training for new recruits. By September the casual detachment included about 500 men.

Military activities at Bellows Field increased during World War II. Its runways were extended and a staging area was established for transient aircraft. Activities included aircraft repair and refurbishing at the Hawaii Air Sub-Depot, motor pool operations for aircraft ground equipment and general troop support, ordnance stockpiling for use in training missions, and base support operations. The aviation facilities on the north side of Waimanalo Stream were completed in 1943. They included two runways, repair revetments at the north end of runway 18-36, numerous slot revetments for smaller pursuit (fighter) planes at the south end of runway 3L-21R, and two taxiways connecting to the southern runways. During the mid-1940s, Bellows Field was responsible for providing support to two sub-installations: Kahuku Field, located at the extreme northern point of Oahu, and Kualoa Field, located just north of Kaneohe Bay along the windward coast of Oahu (Figure 3-1).

Following World War II, activity at Bellows Field shifted from the Army to other branches of the military. Bellows Field was the home of the Hawaii Air National Guard's 199<sup>th</sup> Fighter Squadron from 1946 to 1947. In April 1948 Bellows Field was transferred from the Army to the Air Force and redesignated Bellows Air Force Base (AFB), retroactive to March 1948, by Headquarters Pacific General Order No. 10. The base was placed on caretaker status in December 1948 and many of its buildings were reportedly "sold off or rented to private businesses for storage" (Harland Bartholomew and Associates, 1959, as cited in SCS/CRMS, Inc., 1997). In 1951, USMC began using the Bellows runways for air-to-ground training. The 1<sup>st</sup> Marine Brigade from nearby Kaneohe USMC Air Station began using Bellows as an amphibious, ground, and helicopter training area in 1958.

Upon the emergence of jet-powered aircraft, the runways at Bellows AFB were considered too short for practicable use as an air base. Air operations were moved to Hickam AFB and operations at Bellows AFB were dramatically reduced until a communications relay complex was constructed on base from 1956 to 1958, whereupon the base was renamed Bellows AFS. The communications complex headquarters building was constructed at the intersection of Runways 3R-21 and 12-30, with antennae located throughout the installation. The communications relay complex remained in operation until 1994, when its functions were transferred to other Air Force and Navy facilities in Hawaii. The antennae were all removed from the installation by 1995.

Two Nike missile batteries (3 and 4) were installed in the southern portion of the installation in 1960 and remained active until 1970, when this type of missile became obsolete. The missile batteries were constructed by the U.S. Army and operated by HIARNG. HIARNG established supply and maintenance companies on the former Nike missile site in 1970, and relocated the Hawaii Military Academy from Fort Ruger to its present location on Bellows AFS in 1987.

The Air Force released 77 acres at the southern end of the installation to the State of Hawaii in 1963; this area became part of the Waimanalo Bay State Recreation Area (Silva, 1981).

## 4.0 History of Refuse Disposal at Bellows Air Force Station

Research conducted for this report indicates a complicated history for waste disposal at Bellows AFS. Historical sources suggest that refuse was placed in at least six on-base dump sites and in two Army-developed dumps on the neighboring Waimanalo Plantation (one of which was originally on plantation property annexed by the installation during World War II). Refuse from the installation may also have been taken to two or more county-run dumps north of the installation, in Kanehoe and Kailua, and to an Army-run dump at Lanikai, but documentation of disposal at these sites is not conclusive.

Historical text documents (i.e., memos and correspondence) pertaining to waste disposal at Bellows AFS are available only for the period from 1941 through 1945; information on disposal activities before and after this period is limited to interpretation of historical drawings and aerial photos, and the results of field investigations. Most of the written record from the World War II era describes the disposed waste materials as “refuse,” which is defined as a combination of “garbage” and “rubbish.” The following definitions are given in a U.S. Army Corps of Engineers (COE) 1942 memo (COE, 29 May 1942):

“Garbage consists of organic waste, both animal and vegetable, and includes wastes resulting from preparation of, or dealing in meats, fruits, and vegetables.”

- \* “Rubbish consists of inorganic material which cannot be classified as garbage or ashes. It includes such things as paper, boxes, straw, old shoes and rags, bottles, crockery, tin cans and other like material. Banana stumps, palm leave, green and dry leaves, tree trimmings and grass are usually included under the term rubbish here, although part of this list may be classified as organic.”

It does not appear from other historical documents that this distinction between “garbage” and “rubbish” was consistently applied during actual disposal activities at Bellows AFS. The dump sites referenced in this section may potentially contain both types of waste. In addition, the historical documents do not mention the disposal of potentially hazardous industrial materials, such as used oil and solvents, that were presumably used at Bellows AFS for vehicle and aircraft refueling, maintenance, and other military purposes. It is therefore possible that the referenced dump sites may also have been used for disposal of industrial waste materials.

The following sections present a chronology for waste disposal at Bellows AFS divided into three distinct time periods: pre-World War II, World War II, and post-World War II. These periods are characterized by very different types and levels of waste disposal activity at the installation. Figure 4-1 shows the approximate locations of the sites described below.

## 4.1 Refuse Disposal Prior to World War II

**Figure 4-1, location (1):** Prior to World War II, all of the garbage from U.S. Army and Navy facilities on Oahu was collected by island hog raisers and used as feed. Rubbish was generally hauled to city and county dumps where it was burned. Prior to 1942, the primary dump used by Bellows Field was reportedly the Waimanalo Plantation dump. However, that dump was reportedly covered when the main runway (6-24) was constructed and extended westward in December 1941 (U.S. Army, January 19, 1943). The general location of this dump is believed to be beneath the westernmost portion of Runway 6-24 (see Figure 4-1, location 1), but its exact location has not been determined.

## 4.2 Refuse Disposal During World War II

By mid-1942, serious problems with refuse disposal had developed. The rapid increase in military personnel on the island resulted in a similar increase in refuse. Hog raisers could not use all of the garbage that was being generated. Further, they had trouble collecting the garbage they could use because of blackouts, gasoline rationing, tire restrictions, war regulations, and staff shortages. (COE, 29 May 1942). Like the hog raisers, however, the County had difficulty keeping enough personnel to handle the collection and disposal of rubbish after the war began. In addition, under blackout regulations, it was impossible to completely burn the rubbish since all fires had to be put out completely before dark (COE, 29 May 1942).

**Figure 4-1, location (2):** Bellows Field Information Sheet #19 (May 4, 1942; cited in *Brief History of Bellows Air Force Station* [Anon., n.d.]) states that “an area located just north of the coral quarry on the top of the hill” has been established as the “post dump,” and that all refuse will be hauled to this area for disposal. “The disposal of refuse in any other area than the above is prohibited.” A series of communications on waste disposal at Bellows Field dating from January 19 through April 2, 1943 also seems to reference this dump site (U.S. Army, 19 January 1943, with addenda). They describe an existing dump located near the top of “the coral formation hill near the scramble runways.” According to these communications, this 1942-43 dump site was used by both the Army and Waimanalo Plantation since the former plantation dump was covered by extension of Runway 6-24.

Figure 4-1, location 2 shows the probable approximate location of this dump site based on the historical documentation, and Figure 4-2 shows the topographic changes that have occurred in the area of Sites LF01 and DP17 since the early 1940s. A 1942 plan drawing for the pursuit dispersal area runway and taxiway (COE, September 1942) shows a “coral quarry” located at the south end of the pursuit plane revetments, just south of the 75-foot hill in Site DP17; this hill is still present. In addition, a January 1943 plan drawing (COE, January 1943) identifies the “old coral pit” in the same location as the “coral quarry” on the earlier drawing, and identifies a “new coral pit” (which encompasses Site LF01 and the northern edge of Site DP17) north of the 75-foot hill. In 1943 the “old” (southernmost) coral pit was converted into revetments for B-17s, and quarrying for coral fill

material continued at the “new” coral pit to the north. A north-south road or path between these two areas is visible on 1942, 1943, and 1945 aerial photos (Appendix C); cleared areas adjoin this road within the current location of Site DP17. The road and the clearings are largely revegetated in the 1950 aerial photo, but one former clearing is still visible as an apparent topographic depression in the 1963 aerial photo. This feature may correspond to the 1942-43 dump location described in the January 19 through April 2, 1943 Army memos (U.S. Army, 19 January 1943, with addenda).

**Figure 4-1, locations (3) and (4):** County-run dumps were used by Army units in the area of Bellows Field during World War II. In November 1942, the U.S. Engineer’s Office conducted a study to determine the volume of material being delivered to the county dumps from Army bases. The study showed that refuse was being delivered to two dumps near Bellows Field, at Kanehoe and Kailua (Figure 4-1, inset). A December 1943 report on military garbage disposal on Oahu notes that Army camps in the Waimanalo area were using the county dump at Kanehoe, and recommends the establishment of another dump at Kailua (U.S. Army Forces, 24 December 1943). While it is clear that Army installations in the Waimanalo area were using county dumps, no information regarding which, if any, county-run dumps were used specifically by Bellows Field was located as part of this study.

**Figure 4-1, location (5):** By early 1943, the “post dump” (Figure 4-1, location 2) was nearly full, and Bellows Field requested that the Department Engineer develop a project to establish a new dump at a site on the Waimanalo Plantation. This site, offered by the plantation manager, was approved and Work Order 600.118-E-105.0 was issued April 2, 1943 (U.S. Army, 19 January 1943, with addenda). That same Work Order number is found on a May 1943 plan drawing of the refuse dump access road prepared by War Emergency Construction, Hawaiian Department (COE, May 1943). Comparison of features on the May 1943 plan drawing with aerial photos and U.S. Geological Survey (USGS) quadrangle maps indicates that the dump site was likely located at the head of a small reservoir approximately 3,500 feet west-northwest of the western Tinker Road crossing of Waimanalo Stream (Figure 4-1, inset). This dump site appears to be on property currently owned by the State of Hawaii.

Bellows Field was probably using the Waimanalo Plantation dump by late 1943. An October 1943 memo on the disposal of non-edible wet garbage noted that the Waimanalo Plantation dump would not accept wet garbage and it would be necessary to haul it from the Waimanalo area to the Kaneohe dump or dispose of it locally (COE, 11 October 1943).

**Figure 4-1, location (6):** Another off-base dump may have been developed at Lanikai, north of Bellows Field (see Figure 4-1, inset). A Board of Officers was convened in December 1943 to evaluate the requirements for additional garbage disposal for military installations on the Island of Oahu. The Board concluded that current and future requirements for garbage disposal in the Pali, Fort Hase, Bellows Field, and Wainai area could be accommodated by one sanitary landfill to be located near Kailua. Their report also noted that the site offered suitable facilities for a rubbish and trash dump. However, an “Inter-Office Memorandum Slip” (COE, 23 December 1943) prepared

by the representative of the U.S. Engineer Office, Honolulu, who accompanied the Board on a field visit to the site, locates it at Lanikai.

**Figure 4-1, location (7):** A September 1945 request for relocation of the base dump (Office of the Commanding Officer, 5 September 1945) identifies an existing dump at the ocean end of Runway 3R-21 (see Figure 4-1, location 7) and notes that smoke and miscellaneous debris constitutes a fire hazard. It goes on to state that “the site now in use is completely filled and there is no additional area that could be utilized for trash disposal.” The Bellows Field General Plan (last update listed is May 1945) also identifies a “base dump” located just south of the ocean end of Runway 3R-21, near the end of the pier.

### 4.3 Refuse Disposal Since World War II

**Figure 4-1, location (8):** Comments on the September 1945 request for relocation of the base dump (Figure 4-1, location 7) identified the location of a proposed new dump as “on the leeward side of runway 3-R and...adjacent to an unused warehouse which is to be used for a salvage and reclamation building” (Figure 4-1, location 8). The proposed relocation was approved in October 1945. A January 1943 map shows a building at this site designated “QMC Salvage” (COE, January 1943). The Bellows Field General Plan (last update listed is May 1945) shows a “post dump” adjacent to the “QMC Salvage” warehouse, at the current location of Area of Concern (AOC) EA07. The “base dump” on the 1945 map appears to be the existing dump (Figure 4-1, location 7) described in the September 1945 request, and the “post dump” is likely the new location (location 8) identified in that request. The May 1945 map indicates that the new “post dump” may already have been in use prior to the September 1945 request for relocation.

Several post-World War II drawings indicate that the “post dump” adjacent to the Quartermaster’s salvage warehouse (Figure 4-1, location 8) continued to be used for refuse disposal through at least the late 1950s. This location is labeled “dump area” on maps from 1945 through 1957, and its location is outlined (but not labeled) on maps from 1966 through 1981. The only indication of specific refuse contents is on a December 1955 drawing (Figure 4-3) that specifies the site as a “disposal area for brush” cleared from Waimanalo Stream and other installation drainage ditches.

**Figure 4-1, location (9):** This area, which includes Site SD22, appears to have been used as a dump site by 1966 and through at least 1975. Historical maps consistently show the revetments at SD22 in place through June 1957, although an area between two pursuit plane revetments just south of Site SD22 is labeled “coral pit” on the 1955 drawing (Figure 4-3). An August 1966 map no longer shows revetments at this location and labels the location of site SD22 as a “dump area.” Maps dated May 1969 (Figure 4-3) and December 1975 also identify the site as a “dump area.”

**Figure 4-1, location (10):** The northernmost of the two World War II-era coral borrow pits, bounded by the pursuit plane revetments (Figure 4-1, location 10), is shown on the 1955 drawing (Figure 4-3) as “borrow area for boulders;” this area includes Site LF01. A 1957 map specifies that “surplus fill” from “rough clearing and grading” of various areas is to be dumped in this borrow

area (Office of the Installations Engineer, 6 May 1957). By 1969 this borrow area is labeled “trash dump area” (Figure 4-3) and heavy vehicle haul routes are shown leading to it (Office of the Base Civil Engineer, 2 May 1969). This coral borrow area is not labeled as a dump area on maps after 1969. A Bellows AFS civilian employee who began working at the installation in June 1945 stated that the Fire Department conducted controlled burns at the landfill once a week (see Appendix B, Kubota interview), although it is not certain whether this interviewee was referring specifically to Site LF01.

**Figure 4-1, location (11):** The May 1969 map also shows a “dump area for asphaltic concrete and coral” in the northeast portion of Bellows AFS, immediately west of Runway 3L-21 (Figure 4-1, location 11; and Figure 4-3). This site is not labeled as a dump area on later maps.

## 5.0 Historical Development of Bellows AFS OU1 EE/CA Sites and Waimanalo Stream

The following sections present the available information about the historical development and waste disposal activities at Sites LF01, DP17, SD22 and DP06, and Waimanalo Stream. In order to identify site-specific chemicals of potential concern (COPCs) that may have resulted from historical disposal activities, the analytical results of previous environmental investigations are compared to current regulatory screening criteria, which include:

- \* Soil: EPA Region IX Preliminary Remediation Goals (PRGs) for industrial site use scenarios, and HDOH Soil Action Levels (SALs) calculated using the Tier 1 approach
- Groundwater: HDOH Tier 1 action levels for protection of groundwater that is not a drinking water source
- Surface water: marine chronic Ambient Water Quality Criteria (AWQC)
- Sediment: National Oceanic and Atmospheric Administration (NOAA) effects-range-low (ERL) and effects-range-median (ERM) sediment screening values (SSVs)

These screening criteria will be used in evaluating the Bellows OU1 EE/CA analytical data.

### 5.1 Site LF01

Site LF01 is located in the west-central portion of Bellows AFS, as shown on Figure 5-1. Based on geophysical and soil boring data collected during the IRP Phase II Stage 1 investigation of Site LF01 (Harding Lawson Associates [HLA], 1992), the landfill area reportedly occupies approximately 48,000 square feet and is approximately 10 feet deep. A report summarizing the results of a Preliminary Assessment/Site Inspection (PA/SI) of other IRP Sites and AOCs at Bellows AFS in 1996 (EA Engineering, Sciences, Technology, Inc. [EA], July 1996), excluding Site LF01, illustrates the boundary of Site LF01 as extending further north. The PA/SI, however, did not include characterization of Site LF01 and the report provides no supporting documentation to account for the larger extent of the site. Waimanalo Stream is located approximately 700 feet southeast of Site LF01.

Site LF01 is located within a former coral borrow area excavated during Bellows AFS expansion (see Section 4.2, and the 1945 aerial photo in Appendix C). As shown on Figure 4-2, this borrow area was originally a coral outcrop reaching to 110 feet above MSL. The current topography of Site LF01 itself slopes gently downward from approximately 25 feet above MSL to the base of the excavation at approximately 10 feet above MSL. The surrounding topography consists of the former pursuit plane revetments to the west, a ridge approximately 30 feet above MSL to the east,

a relatively flat area at approximately 10 feet above MSL to the north, and a hill approximately 75 feet above MSL to the south (within Site DP17).

Refuse was reportedly disposed of at Site LF01 from the early 1940s to the mid-1970s (HLA, 1992). The 1942, 1943, and 1945 aerial photos (Appendix C) show extensive clearing and excavation throughout the coral borrow area, which includes Site LF01. Aerial photos from 1950 and 1963 indicate some revegetation of the excavation by 1950 and nearly complete revegetation by the early 1960s. The May 1957 drawing (Appendix D) indicates that the northern part of Site LF01 may have been used for dumping “rough clearing and grading surplus fill” as part of general base maintenance. A road or path leading to the general area of Site LF01 from the east is visible in aerial photos from 1963 through 1985 (Appendix C); this road appears to be almost entirely overgrown in a 1992 aerial photo (Appendix C). The 1969 drawing (Figure 4-3) labels the borrow area, including Site LF01, as “trash dump area” and heavy vehicle haul routes are shown leading to it. Later drawings do not identify the site as a dump area and it is not currently used for waste disposal.

An IRP Phase I literature and records search conducted for Site LF01 (Engineering-Science [ES], September 1984) reported that drummed hazardous materials from industrial shops active during World War II may have been deposited in a pit within the “installation landfill” between 1943 and 1946. These materials reportedly included oil, solvent, paint thinner, and acids. An attachment to a 1944 document titled *Organizational History, 47<sup>th</sup> Fighter Squadron* (Anonymous, July 1944) shows a photo lab and aircraft maintenance/repair facilities located at the north end of the revetment area. Shop operations ceased in 1946, and hazardous materials generated at Bellows AFS were reportedly transported offsite for disposal (ES, 1984). The ES report, however, presented no documentation of hazardous waste disposal at Site LF01, and research conducted for this Historical Review found no documentation of hazardous materials being disposed of specifically in Site LF01 during World War II. The area encompassing Site LF01 was extensively quarried for coral fill during the war, as shown in Figure 4-2, making simultaneous refuse disposal and quarry operations at this site unlikely. Aerial photos show the site as an active quarry through 1945 and only sparsely revegetated by 1950 (Appendix C). In addition, historical documents indicate that the first “post dump” established in 1942 was nearly full by early 1943, necessitating the establishment of other dump sites elsewhere on the installation and on Waimanalo Plantation (see Section 4.2). It is possible that hazardous materials generated during World War II were disposed of in the 1942-43 “post dump,” or in the later “base dump” or “post dump” sites established elsewhere on the installation (see Section 4.2), although no specific documentation of such disposal was found.

Historical drawings from the late 1950s through the late 1960s do identify the general area of Site LF01 as a “dump area,” and the results of the IRP Phase II Stage I field investigation of Site LF01 (HLA, 1992) confirm that the site was used for waste disposal. A former Bellows AFS civilian employee who began working at the installation in June 1945 reported that controlled burns were conducted at “the landfill” once a week, although it is not certain whether the area referred to included Site LF01 (Appendix B, Kubota interview).

The geophysical survey conducted for the IRP Phase II Stage I investigation indicated that the landfill contains subsurface metallic debris (HLA, 1992). The materials encountered in soil borings within the landfill area as identified by the geophysical survey consisted of native soils with metal debris, glass, paper, foil, charcoal, and other debris. Low concentrations of total petroleum hydrocarbons (TPH) and polynuclear aromatic hydrocarbons (PAHs) were detected in site soil, but no organics other than bis(2-ethylhexyl)phthalate, concluded to be a laboratory contaminant, were detected in groundwater (HLA, 1992). Chemicals detected at concentrations exceeding current screening criteria included:

Soil: phenanthrene, arsenic, cadmium, iron, lead, lead, and thallium

Groundwater: cadmium, copper, lead, mercury, and nickel

While field investigation results confirm that Site LF01 was used for waste disposal, the location of this site does not correspond to the first “post dump” referenced in historical documents from World War II, and the site appears to have been an active quarry area from 1942 through at least 1945. By 1945, other on- and off-base dump sites had been established. Therefore, Site LF01 cannot be considered the installation’s primary landfill during World War II and reports of hazardous material disposal may refer to the other dump sites. Based on the evidence presented in historical drawings, the waste materials currently present at the site likely date from the 1950s and 1960s.

## 5.2 Site DP17

Site DP17 is located immediately south of Site LF01 (Figure 5-1); the northern edge of Site DP17 overlaps the southern extent of Site LF01, and a dirt road leading to Site LF01 serves as a portion of the eastern border of Site DP17. Site DP17 as delineated by EA (1996) encompasses approximately 6 acres (250,000 square feet) that are densely vegetated. The site includes the 75-foot hill between the historical coral borrow areas and portions of Revetments 25, 29, and 30.

The northern portion of the site, designated Site DP17, Subsite A (DP17A), is located within and just east of the coral borrow area; the steep cliff that forms the southern edge of the borrow pit also forms the boundary between Sites DP17 and DP17A. Materials reportedly present in Site DP17A include creosote-treated poles, electrical insulators, empty electrical power transformer casings, battery packs, and empty drums and drum remnants near the cliff walls (EA, 1996 and 1998).

In 1996, approximately 47 drums and drum remnants were removed from Site DP17A (EA, 1996 and 1998). The analytical results of surface soil samples collected following drum removal indicate that the following chemicals exceeded current screening criteria: benzo(a)pyrene, phenanthrene, PCB (Aroclor) 1242, endosulfan II, endrin, endrin aldehyde, heptachlor epoxide, methoxychlor, arsenic, cadmium, and lead.

None of the historical drawings reviewed indicate that Site DP17 was used for waste disposal; however, historical aerial photographs (Appendix C) do provide some evidence for the possible

period of use. The site appears to be in a natural condition in a 1940 photograph. The 1943 and 1945 photographs show the revetments south, west, and north of the site completed and much of the area they enclosed excavated to below the tops of the revetments. The excavated area (the “new” coral borrow pit) appears to include Site DP17A. As noted in Section 4.2, clearings and an adjoining north-south road or path visible in the 1942 and 1943 aerial photos may correspond to the on-base dump that was established by May 1942 and nearly full by early 1943. The 1945 photograph shows a road entering Site DP17 from the east. That road is visible in the 1950 photograph, although it seems to be partially overgrown, suggesting that it was receiving little use. However, much of the area north of the east-west road is cleared and access to Site DP17 may have been possible from other roads. The east-west road is visible in several later photographs (1963, 1969, 1974, 1975, and 1985), as is a small clearing. The clearing appears to be in the northern part of Site DP17, although part of it may extend into Site LF01. By 1992, both the clearing and road were overgrown.

Major construction at Bellows AFS, and the associated excavation of the coral borrow pit, appear to have been largely completed by 1945. The northern portion of Site DP17, including the small clearing noted above, appears to be within the excavated area in the 1945 aerial photo; therefore, use of Site DP17A for disposal probably did not begin until after borrow pit excavation ended. The east-west road appears to be little used in the 1950 photograph; however, it is clearly being used in the photographs between 1963 and 1985 and that use may correspond with use of Site DP17 or DP17A for disposal. It should be noted that no aerial photos were located for the period between 1950 and 1963 or 1985 and 1992, hence the possible period of use is uncertain.

### **5.3 Site SD22**

Site SD22 (Figure 5-2) is located immediately south of Revetment 35 (i.e., the south wall of the revetment was excavated and removed), approximately 200 feet northwest of Sites LF01 and DP17A. Site SD22 consists of a former drum disposal area; approximately 30 drums were disposed of over the excavated south side of former Revetment 35 and onto the forest floor adjacent to the revetment. The estimated site area is approximately 10,000 square feet. The immediate surrounding area is heavily vegetated second-growth forest and shrubland. The base elevation of Revetment 35 is approximately 28 feet above MSL; Site SD22 slopes downward from the revetment toward Site LF01 to an elevation of approximately 20 feet above MSL. The site is located approximately 1,100 feet northwest of Waimanalo Stream.

Site SD22 was identified during a 1993 PA for underground storage tanks (USTs) at Air Force installations in Hawaii (ES, 1993). The 1994/1995 PA site reconnaissance (EA, 1996) noted that the drums were rusted and the conditions and markings suggested they originated during World War II; however, some drums were labeled “Jet Fuel,” and “No Parking” was painted on several others, indicating that at least some of the drums post-dated World War II and others were used for traffic control purposes. One steel drum with a plastic inner liner was labeled “AFFF-Fire Fighting Agent.” A second drum with a similar plastic liner was located within 2 feet of the AFFF drum. No

drums with liquid were found at the site (EA, 1996). The drums were removed in 1996 (EA, 1996 and 1998). The analytical results of shallow (approximately 1 foot below ground surface) soil samples collected following drum removal indicate that only arsenic exceeded its current screening criteria.

Site SD22 is located in an area of pursuit plane revetments constructed in 1942 and used throughout World War II. Use of the site as a disposal area likely did not occur until after removal of the revetments. As noted in Section 4.3, historical drawings consistently show the revetments in place through June 1957; however, drawings from 1966, 1969 (Figure 4-3), and 1975 show that the revetments at the location of Site SD22 had been removed and identify the general area of the site as a “dump area.” These drawings suggest that dumping at site SD22 began some time between 1957 and 1966 and may have continued through the mid-1970s. It is therefore unlikely that the drums recovered at the site date to World War II. Given the period during which the site was probably used, it is more likely that the material dumped there came from the Nike missile battery, the communications facility, or the recreation area.

## 5.4 Site DP06

Site DP06 is located in the southwest portion of the installation adjacent to Waimanalo Stream (Figure 5-3). A narrow dirt road (Tinker Road) and the Communications Area fence along the stream border the site’s northern edge; the fence and the original alignment of Tinker Road (“Old Tinker Road”) form the western border. The site is bordered to the south and east by shrub forest and grassland. The installation boundary and the Olomana Golf Course are located immediately west of Waimanalo Stream.

The area was identified during the site reconnaissance for the 1993 UST PA (ES, 1993) and subsequently designated as an IRP site by 15 CES/CEVR. The site boundary was defined by the visible extent of stressed vegetation and mounding of soil and concrete rubble. The estimated site area is 6,000 square feet (EA, 1996). The site has a general slope of approximately 20 percent to the west toward Waimanalo Stream; the stream is approximately 40 ft north and 130 ft west of Site DP06. Site DP06 ranges in elevation from approximately 5 to 10 feet above MSL.

An SI conducted at Site DP06 in 1996 included analysis of soil, groundwater, surface water, and sediment samples. Chemicals detected at concentrations exceeding current screening criteria included:

Soil: methylene chloride, chrysene, di-n-octylphthalate, fluoranthene, PCB (Aroclor) 1254, and arsenic

Groundwater: lead (total), mercury (total and dissolved), nickel (total and dissolved), and zinc (total)

Surface water: zinc (total)

Sediment: antimony, arsenic, chromium, copper, and nickel

The history of waste disposal operations at Site DP06 is not documented on historical documents. The mounds of rubble reported at the site may have been wastes composed largely of construction and demolition debris from the 1960s (EA, 1996). However, due to the long period of inactivity and the lack of documentation regarding the operational history, the wastes disposed and the waste quantities are not known (EA, 1996).

Historical drawings and aerial photographs provide some evidence of the possible period of use for Site DP06. These sources indicate that Tinker Road was completed through the site area in 1943. Tinker Road circled the base and was the primary roadway connecting its various areas. Given the importance of Tinker Road, it seems unlikely that a casual dump site would have developed while this section of the road was still in use.

Tinker Road originally crossed Waimanalo Stream at the site, as shown on Figure 5-4. By the mid-1950s the bridge across the stream had deteriorated; it is shown as “unsafe” on the 1955 drawing (Figure 4-3). Later drawings and aerial photos show the bridge gone by 1966 (see Appendix D, August 1966 drawing). Drawings after 1966 do not show an alternate alignment of Tinker Road crossing the stream, but aerial photos from 1974 and 1985 indicate a road or path turning east from Tinker Road approximately 350 feet south of the stream and extending south of Site DP06 to the northern end of Runway 12-30. The 1969 drawing (Figure 4-3) indicates that the abandoned runways and taxiways were being used as roadways by this time. The loss of the bridge effectively left Site DP06 at the end of a dead-end road. Dumping at the site probably post-dates this event, although aerial photographs show no obvious signs of dumping.

The dead-end section of Tinker Road and the path to the south of Site DP06 appear to be well used in later aerial photographs (1969, 1975, and 1985). By 1992, a new alignment of Tinker Road is visible along the south bank of Waimanalo Stream and Site DP06 and the former path to the south appear overgrown with vegetation.

While historical maps and aerial photographs do not provide direct evidence of the use of DP06, they do suggest that use of the site for dumping probably did not begin before the late 1950s. Consequently, materials dumped at the site almost certainly did not come from World War II operations. More likely sources would be demolition of World War II-era buildings, operations at the communications facility, the Nike missile batteries, Marine training exercises, and the recreation areas.

## 5.5 Waimanalo Stream

Three streams flow into or through Bellows AFS: Waimanalo, Kahawai, and Inoaole Streams. As shown on Figure 5-4, each stream originates in the Koolau Mountains and flows east to Bellows AFS.

Waimanalo Stream, originating furthest west, is a perennial stream. The main stem of the stream is approximately 3 miles long and originates in the cliff valleys of the Koolau Mountains approximately 2 miles west of the installation (Figure 5-4). The headwaters comprise areas of groundwater input at the base of the cliffs. Small tributary channels merge with the main stem in the upper reaches; these tributaries are dry or nearly dry under most weather conditions (HDOH, March 1998). Land uses west of Bellows AFS, near the stream channel, include pasture lands, nurseries, rural housing, moderate-density neighborhoods, and the Olomana Golf Course. A number of ditches that provide stormwater drainage from these areas enter the stream west of the installation, and groundwater recharges the stream from several small perennial springs west of Kalaniana'ole Highway (HDOH, March 1998). Waimanalo Stream discharges into Waimanalo Bay and has a total drainage area of 2.6 square miles (USGS, 1993).

Kahawai Stream is a perennial stream that originates southeast of Waimanalo Stream; it flows along the installation's western boundary for approximately 2,000 feet and empties into Waimanalo Stream approximately 1,000 feet south (upstream) of site DP06 (Figure 5-4). Inoaole Stream is also a perennial stream, and extends across the southeastern portion of the installation with a total drainage area of 1.21 square miles (USGS, 1993). Inoaole Stream discharges into Waimanalo Bay; however, beach sand deposited at the stream mouth prevents direct discharge from this stream to the bay except under high stream flow and/or high surf conditions.

Within Bellows AFS, Waimanalo Stream has homogenous stream depths that average approximately 1.7 feet. The sediment is fine to sandy in composition; the lower reaches exhibit sandy sediments due to the tidal action from Waimanalo Bay, and the mid and upper reaches exhibit fine (silts, clays) sediments due to the low flow conditions. There is a high percentage of suspended sediments in the stream water. The stream mouth forms a coastal estuary; scattered mangroves, which require saline water, grow along the banks of Waimanalo Stream, indicating that the stream is brackish and is subject to tidal influence (EA, July 1996). Much of the riparian zone is roadways, grasses, and mangroves. The stream mouth is a nursery for juvenile fish species.

Surface water runoff from the installation drains to Waimanalo Stream, either as sheet flow from the higher elevations or through shallow drainage ditches that empty into the streams. In addition, Kahawai Stream flows through more densely populated residential and commercial areas south of Bellows AFS before emptying into Waimanalo Stream, although specific inputs to Kahawai Stream are unknown. Waimanalo Stream, the shoreline, and the land extending ½ mile north and up to ¼ mile south of the stream are also within a 100-year flood zone, with base flood elevations of 6 to 8 ft above MSL. The Waimanalo Stream channel within Bellows AFS is managed as a floodway, and the stream banks are regularly sprayed with herbicide down to the water's edge to prevent vegetation from clogging the channel (HDOH, March 1998).

Waimanalo Stream was rechanneled during World War II to accommodate runway construction/expansion. Figure 5-5 shows the original stream channel and surrounding marshland superimposed onto current site topography; the January 1943 and May 1945 drawings,

respectively, in Appendix D show the planned and executed rechanneling and general installation drainage improvements. A 30-foot-wide channel was excavated to depths up to approximately 2 feet below MSL, and coral from the borrow areas was used to create the side slopes and fill much of the adjacent marshland. The coastal marsh area was filled and the stream mouth realigned approximately 1,000 feet north in order to accommodate the eastern end of Runway 3R-21. Stone jetties were constructed to flank the new stream mouth; the remains of these jetties are still present.

No records indicate that refuse was disposed of in Waimanalo Stream; however, a *Special Sanitary Report* prepared by the Bellows Field Camp Surgeon (U.S. Army, January 22, 1941) states that used oil, presumably motor oil, was regularly applied to ditches and streams at the installation in an effort to control mosquitoes. In addition, several secondary drainage ditches constructed during WWII discharged to Waimanalo Stream (Figure 5-5 and the May 1945 drawing in Appendix D). These ditches carried runoff from the pursuit plane revetments area, runways/taxiways, and an aircraft fuel dispensing area. The 1955 drawing (Figure 4-3) specifies “clearing and snagging” of brush from the stream along the installation’s western boundary and west of Runway 36-18. This drawing also proposes re-excavation of the stream mouth.

Periodic water quality monitoring studies have been conducted on the upper reaches of Waimanalo Stream (University of Hawaii, December 1996; HDOH, March 1998). These studies have focused primarily on nutrient loading and the effect of non-point-source contamination to the watershed, and have reported Waimanalo Stream to be “moderately impaired” based on habitat quality and high nutrient loading.

Within Bellows AFS, two surface water and two sediment samples were collected from Waimanalo Stream as part of the SI of Site DP06 (EA, 1996). Section 5.4 summarizes the results of this investigation.

## 6.0 Pesticides and Herbicides

This section presents information regarding the use of pesticides and herbicides at Bellows AFS that is either potentially relevant to more than one Bellows AFS OU1 EE/CA site or not directly relevant to the current study but potentially relevant to other 15 CES/CEVR environmental studies.

Numerous documents examined for this project discuss efforts to control insects at Bellows Field and throughout the Pacific theater during World War II. As noted in Section 5.5, a report by the Bellows Field Camp Surgeon (U.S. Army, January 22, 1941) states that used oil was regularly applied to ditches and streams in the installation in an effort to control mosquitoes. The general use of pesticides is addressed in a 1944 document titled *Report on Observations in Southwest Pacific and Pacific Ocean Areas* (Dill, 1944). The report states that DDT powder in individual 2-ounce cans was widely used by soldiers to control lice and bed bugs. In addition, individual soldiers also impregnated their clothing with dimethyl phthalate, which provided protection against a typhus-bearing mite. An interesting section states:

“The Aerosol dispenser, charged with freon containing pyrethrum, has attained a high place in the affections of soldiers...It is widely used in transport airplanes, in mess halls, offices, and hospitals. Since the production of this (measured in insect killing capacity) is very small as compared with that of DDT, attention should be directed towards increasing facilities for hand spraying DDT solutions. This was coming into use throughout the Pacific, though hindered by a shortage of DDT and sprayers and the fears of some medical officers that spraying DDT in mess halls might poison the food.” (Dill, 1944)

In addressing control of flies around latrines, the report notes the traditional methods were use of chloride of lime, diesel oil, and burning diesel oil, but that paradichlorobenzene had become popular. The report recommended hand spraying of DDT. Exhibit 1 attached to the report contains comments on protection against insects from various locations in the Pacific. A comment from Hickam Field states that barracks were sprayed with a solution of pyrethrum in kerosene and with DDT in kerosene.

Evidence of herbicide use at Bellows AFS is provided by a May 1957 drawing (Appendix D). The drawing identifies several areas for the application of herbicides, including the former pursuit plane revetments that border or include Sites LF01, DP17, and SD22. A note on the drawing specifies the application of “herbicides, either C.M.U., or Karmex W. or approved equal herbicide.”

As noted in Section 5.5, the Waimanalo Stream channel within Bellows AFS is managed as a floodway, and the stream banks are regularly sprayed with herbicide down to the water’s edge to prevent vegetation from clogging the channel (HDOH, March 1998).

## 7.0 References

The materials reviewed during research for this report are presented below by type of document: historical text documents, historical drawings, and environmental reports and historical studies.

### 7.1 Historical Text Documents

#### (numbered for cross-reference to Figure 4-1)

1. Anonymous. n.d. *Brief History of Bellows Air Force Station*. On file, Office of Historian, 15<sup>th</sup> Air Base Wing, Hickam AFB, Honolulu.
2. Anonymous. July 1944. *Organizational History, 47<sup>th</sup> Fighter Squadron, APO 951, 15<sup>th</sup> Fighter Group, VII Fighter Command, Seventh Air Force, 1 July 1944 – 31 July 1944*.
3. Dill, D.B. October-December, 1944. *Report on Observations in Southwest Pacific and Pacific Ocean Areas*.
4. Headquarters Central Pacific Base Command. 30 April 1945. *Construction of Munitions Reconditioning Shop*. (NARA: RG 338 635. Motor Repair and Maintenance. Box G-424).
5. Office of the Commanding Officer, APO 951. Headquarters Army Air Base. 5 September 1945. *Relocation of Dump at APO 951*. Memorandum to Commanding General VI Air Service Area Command. (NARA: RG 338, Box G-428).
6. U.S. Air Force. Headquarters, Central Pacific Area. 16 January 1944. *Request for construction of additional painting facilities*. (NARA: RG 338. 635 Motor Repair and Maintenance. Box G-424).
7. U.S. Army. Air Officer. 19 January 1943. *Incineration and Waste Disposal, Bellows Field*. (NARA: RG 338, Box G-428).
8. U.S. Army. Air Officer. 26 January 1942. *Decontamination Stations*. (NARA: RG 338. 660.4 Gasproofed Fortifications, Vol. IV. Box G-438).
9. U.S. Army. Bellows Field. 4 May 1942. *Bellows Field Information Sheet #19*.
10. U.S. Army. Headquarters. 36<sup>th</sup> Anti-aircraft Artillery Group, Office of the Commanding Officer. 8 October 1945. *Removal of Fire Control Equipment and Armaments from Roof Positions*. Memorandum to Commanding Officer, 70<sup>th</sup> AAA Brigade. (NARA: RG 338 Box G-428).
11. U.S. Army. Headquarters Bellows Field. 14 March 1942. *Sewage Disposal*. Memorandum to Commanding Officer, 7<sup>th</sup> Air Force Base Command, Hickam Field. (NARA: RG 338. 671 Sewers Vol. II. G-458).

12. U.S. Army. Headquarters Central Pacific Base Command, Office of the Commanding General. 19 October 1945. *Grease in Schofield Sewage*. Memorandum to Commanding General, Army Port and Service Command, APO 455. (NARA: RG 338. 671 Sewers, Vol. III. Box G-458).
13. U.S. Army. Station Dispensary, Bellows Field, T.H. 22 January 1941. *Special Sanitary Report*. Memorandum to Commanding General, Hickam Field, T.H. (NARA: RG 338. 6861E, Box G-486).
14. U.S. Army Corps of Engineers (COE). District Engineer. 6 November 1942. *Check on Garbage & Trash Disposal on City & County Incinerators & Dumps*. (NARA: RG 338. Box G-428).
15. COE. District Engineer. 27 August 1943. *Ltr fr Goder Incinerator Corporation, Chicago, dated 15 July 1943*. (NARA: RG 338, Box G-428).
16. COE. District Engineer. 11 October 1943. *Disposal of non-edible wet garbage from camps on Oahu*. Memorandum to Commanding Officer, Army Port and Service Command, APO 455. (NARA: RG 338, Box G-428).
17. COE. District Engineer. 18 November 1943. *Garbage Disposal*. (NARA: RG 338, Box No. G. 428).
18. COE. Headquarters Hawaiian Department. 6 June 1943. *Storage of C.W.S. Equipment*. (NARA: RG 338. 633 Storehouses Vol. V. Box G-416).
19. COE. Headquarters Hawaiian Department. Office of the Department Engineer, Fort Shafter, Territory of Hawaii. 29 May 1942. *Refuse Collection and Disposal*. Memorandum to G-4, Headquarters Fort Shafter, T.H. Ref, no. Engr. 720. (NARA: RG 338, Box G-428).
20. COE. Headquarter Engineer Depot. 4 January 1944. *Supplies for Searchlight Maintenance*. (NARA: RG 338. 470.3. Box G-343).
21. COE. U.S. Engineer Office. 23 December 1943. *Garbage Disposal Sites*. Inter-Office Memorandum Slip. (NARA: RG 338. Box G-299).
22. COE. U.S. Engineer Office, Honolulu, T.H. 1943. *Manual for Sewage Treatment Plant Operators. 2<sup>nd</sup> Edition*. (NARA: RG 338. 671 Sewers Vol. III. Box G-458).
23. COE. U.S. Engineer Office, Honolulu, T.H. *Destruction Chamber in Joint Army & Navy Command Post*. (NARA: RG338. Box G-428).
24. U.S. Army Forces. Headquarters Central Pacific Area, APO 958. 24 December 1943. *Proceedings of a Board of Officers Relating to Requirements for Additional Garbage Disposal for Military Installations on the Island of Oahu*. (NARA: RG 338, Box G-229).

25. U.S. Army Forces. Headquarters Central Pacific Area. Office of the Assistant Chief of Staff for Military Intelligence. n.d. *Disposition of garbage and swill contract between the U.S.E.D., and the Division of Refuse Collection and Disposal, City & County of Honolulu. Unauthorized disclosure of classified information resulting from above contractual operation.* Memorandum for the Officer in Charge. (NARA: RG 338, Box G-229).

26. U.S. Navy. Office of the Administrative Commander, Fifth Amphibious Force, Pacific Fleet, San Francisco, California. *Waimanalo A.T.B., Revision in Sewage Disposal Facilities – Request for.* Memorandum to Commanding General, Central Pacific Area. (NARA: RG 338. 671 Sewers Vol. II. Box G-458).

## 7.2 Historical Drawings

### (in chronological order)

COE. U.S. Engineer Office. Original Date missing, First Revision 15 September 1942. *Pursuit Dispersal Area, Runway and Taxiway, Bellows Field.* File No. F-72/78. Drawer 156.

COE. U.S. Engineer Office, Honolulu, T.H. January 1943. *Storm Drainage, Bellows Field.* File No. 118/17, Sheet 1 of 2. Drawer 156.

COE. U.S. Engineer Office, Honolulu, T.H. May 1943. *Bellows Field, Oahu, T. H. Waimanalo Plantation Refuse Dump Access Road, Plan Profile and Typical Section.* File No. F-118/60, Sheet 1 of 1. Drawer 156.

COE. U.S. Engineer Office, Honolulu, T.H. 15<sup>th</sup> Air Base Wing Civil Engineer Squadron/Environmental Restoration Element (15 CES/CERV. October 1944. *Honolulu Harbor to Hickam Field. Existing and Contemplated Improvements General Plan.* File No. F-161/108.

Office of the Base Engineer. Bellows Air Field. 19 May 1945 (last revision). *General Plan: Combined Utilities.* File No. not legible, Sheet 1 of 1.

Office of the Installations Engineer, 6486<sup>th</sup> Air Base Wing, Hickam Air Force Base, Oahu T.H. 13 December 1955. *Clearing and Snagging Drainage Ditches. Bellows Air Force Base.* Drawing No. H100/1111, Sheet 1 of 1. Drawer 158.

Office of the Installations Engineer, 6486<sup>th</sup> Air Base Wing, Hickam Air Force Base, Oahu T.H. 6 May 1957. *Ground Maintenance, AACS Site – Area #2. Bellows A.F.B. HIC 373-7(A),* Sheet 2 of 2. Drawer 158.

Office of the Installations Engineer, 6486<sup>th</sup> Air Base Wing, Hickam Air Force Base, Oahu T.H. June 1957. *Service Hydrants and Water Valves, Bellows Field.* HIC 391-7(P). Drawer 158.

Office of the Base Civil Engineer. Pacific Air Force Base Command, Hickam Air Force Base, Hawaii. 4 August 1966. *Water Distribution System, Bellows Air Force Station*. Drawing No. 90/93, Sheet 1 of 1. Drawer 158.

Office of the Base Civil Engineer. Headquarters 6486<sup>th</sup> Air Base Wing (PACAF) Hickam Air Force Base, Hawaii. 2 May 1969. *Install Fire Hydrants Bellows Air Force Station, Hawaii*. Drawing No. 90/103, Sheet 1 of 7. Drawer 158.

Office of the Base Civil Engineer. Headquarters 15<sup>th</sup> Air Base Wing (PACAF), Hickam Air Force Base, Hawaii. 24 December 1975. *Refuse Collection, Bellows Air Force Station*. Drawing No. 90/145, Sheet 1 of 1. Drawer 158.

Office of the Base Civil Engineer. Headquarters 15<sup>th</sup> Air Base Wing (PACAF), Hickam Air Force Base, Hawaii. 10 April 1981. *Refuse Collection, Bellows Air Force Station*. Drawing No. 90/172, Sheet 1 of 1. Drawer 158.

### **7.3 Environmental Reports and Historical Studies**

Arakaki, L.R. and J.R. Kuborn. 1991. *7 December 1941: The Air Force Story*. Pacific Air Forces Office of History: Hickam Air Force Base, Hawaii.

EA Engineering, Sciences, Technology, Inc. (EA). February 1998. *Draft Final: Multi-Drum Project Letter Report, Bellows Air Force Station, Hawaii*. Prepared for AFCEE/ERD, Brooks Air Force Base, Texas and 15 CES/CEVR, Hickam Air Force Base, Honolulu, Hawaii.

EA. January 1997. *Preliminary Draft: Integrated Natural Resources Management Plan for Hickam AFB, Oahu, Bellows AFS, Oahu, Hickam POL Pipeline, Oahu, Kaala AFS, Oahu, Kaena Point STS, Oahu, Kokee AFS, Kauai, Palehua Solar Observatory, Oahu ((15<sup>th</sup> Air Base Wing Installations)*. Prepared for AFCEE/ERD, Brooks Air Force Base, Texas and 15 CES/CEVR, Hickam Air Force Base, Honolulu, Hawaii.

EA. July 1996. *Draft Final: Preliminary Assessment/Site Inspection Report, Bellows Air Force Station. Volume I of II: Preliminary Assessment Report*. Prepared for AFCEE/ERD, Brooks Air Force Base, Texas and 15 CES/CEVR, Hickam Air Force Base, Honolulu, Hawaii.

Engineering-Science (ES). June 1993. *IRP Draft Underground Storage Tank (UST) Preliminary Assessment for Hickam AFB, Bellows AFS, Palehua Solar Observatory, and Wake Island for Hickam AFB*.

ES. September 1984. *Installation Restoration Program, Phase 1: Records Search, 15<sup>th</sup> ABW Satellite Installations, Hawaii*. Prepared for U.S. Air Force, AFESC/DEV, Tyndall AFB, Florida and HQ PACAF/DEEV, Hickam AFB, Hawaii.

Harding Lawson Associates. September 1992. *Final: Installation Restoration Program Stage 1 Technical Report for Bellows Air Force Station, Hawaii*. Prepared for Headquarters Pacific Air Forces, Directorate of Programs and Environmental Planning, Hickam Air Force Base, Hawaii and AFCEE/ERD, Brooks Air Force Base, Texas.

Hawaii Department of Health (HDOH). March 1998. *Biological Assessment and Habitat Characterization of Waimanalo Stream: Establishing Environmental Goals and a TMDL for Watershed Management*. Stream Bioassessment Program, Environmental Planning Office, HDOH.

SCS/CRMS, Inc. February 1997. *Preliminary Draft Report: Cultural Resources Management Plan (CRMP) for Bellows Air Force Station, Waimanalo, Ko'olaupoko, Island of O'ahu, Hawai'i*. Volumes 1 and 2. Prepared for U.S. Army Corps of Engineers, Pacific Ocean Division, Fort Shafter, Hawaii.

Silva, Carol. 1981. "Historical Documentary Research," Appendix A in *Archaeological Reconnaissance Survey of Proposed Additional Marine Corps Training Areas, Bellows Air Force Station, Oahu, Hawaii* prepared by Paul H. Rosendahl, Ph.D. of Archaeological Research Associates (ARA), Kurtistown, Hawaii for Commander, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor. ARA Report 29-020781.