TETRA TECH

Remedial Alternative Analysis

Hickam Communities Remedial Action Site
Joint Base Pearl Harbor-Hickam
Oʻahu, Hawaiʻi

June 7, 2012

complex world

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Remedial Alternative Analysis

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Joint Base Pearl Harbor-Hickam
O‘ahu, Hawai‘i

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June 7, 2012

2653505.0003.F02

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ACRONYMS AND ABBREVIATIONS

APRA	Analysis of Potential Removal Alternatives
ARAR	Applicable or Relevant and Appropriate Requirement
CFR	Code of Federal Regulations
COPC	chemical of potential concern
CSM	conceptual site model
CY	cubic yards
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DU	decision unit
EAL	environmental action level
ECR	excess cancer risk
EHE	Environmental Hazard Evaluation
EHMP	*Environmental Hazard Management Plan, Hickam Communities Remedial Action Site*
EPA	US Environmental Protection Agency
ESA	environmental site assessment
GRA	General Response Action
HAR	Hawai‘i Administrative Rules
HC	Hickam Communities LLC
HCH	Hickam Community Housing LLC
HDOH	Hawai‘i Department of Health
HHD	Historic Homes District
HHRE	human health risk evaluation
HHRE WP	*Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities*
HI	hazard index
HOMF	HC Office and Maintenance Facility
HQ	hazard quotient
HRS	Hawai‘i Revised Statute
JBPHH	Joint Base Pearl Harbor-Hickam
LUCID	*Land Use Controls Inventory Document*
mg/kg	milligram per kilogram
MI	multi-incremental
O&M	operations and maintenance
open areas	Open areas are defined as undeveloped land outside of the former building footprints and 3-foot building zones.
pesticide-impacted soil	Pesticide-impacted soil is defined as soil having organochlorine pesticide concentrations, specifically aldrin, chlordane, and dieldrin,

	exceeding the applicable site-specific risk criteria established for HC.
Program Manual	*Pesticide-Impacted Soil Investigation and Management Program Manual*
RAA	Remedial Alternatives Analysis
RAM	Response Action Memorandum
RAO	Remedial Action Objective
RAR	*Removal Action Report*
RCRA	Resource Conservation and Recovery Act
RI Report	*Remedial Investigation Report*
RO	Removal Action
SI	Site Investigation
TCLP	Toxicity Characteristic Leaching Procedure
technical chlordane	Technical chlordane (referred to as "chlordane") is a mixture of more than 140 related compounds. Major constituents of technical chlordane include alpha- and gamma-chlordane, chlordane, and heptachlor.
TGM	*Hawai'i Department of Health Technical Guidance Manual – Interim Final*
TBC	To-Be-Considered

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1.0 INTRODUCTION AND PURPOSE

This Remedial Alternative Analysis (RAA) has been prepared on behalf of Hickam Communities LLC (HC) to evaluate remedial alternatives for residual organochlorine pesticides in soil at the HC Remedial Action Site at Joint Base Pearl Harbor-Hickam (JBPHH), Oʻahu, Hawaiʻi (hereinafter the "Site"). The HC Remedial Action Site consists of the neighborhoods Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-1 (Figure 1-1). The analysis of remedial alternatives for the Site was implemented as part of the remedial action process that was conducted under the *Voluntary Agreement for Environmental Response Actions (Voluntary Agreement)* between the Hawaiʻi Department of Health (HDOH) and HC[1].

As part of the Department of Defense Military Family Housing Privatization Initiative, the US Air Force (USAF) selected Lend Lease Americas LLC (Lend Lease; legacy Actus Lend Lease LLC) to develop, design, and construct 1,182 new homes and to renovate 1,260 homes at JBPHH under a 50-year ground lease with the USAF. The project company, Hickam Community Housing LLC (HCH), was created in 2005 to manage the residential property under the 50-year ground lease. The project company is an affiliate of Lend Lease, and leases property at JBPHH from the USAF through the contract of the ground lease. The project company serves as the lessee and has certain responsibilities under the lease (development, property management and maintenance). As the lessee, the project company has overall responsibility for the project sites. The USAF, as lessor, maintains a review and coordination role for all activities conducted at the project sites. The dates of the ground lease are February 1, 2005 through July 31, 2057 for Construction Phase I housing and August 1, 2007 through July 31, 2057 for Construction Phase II housing. The project company HCH changed its name to HC in 2010.

The RAA and was initially submitted to HDOH for review on December 28, 2011. Based on the comments received from HDOH in its letter dated February 3, 2012,[2] the RAA was revised to address the HDOH comments. The RAA was further revised based on comments received from HDOH in its letters dated April 16, 2012, May 25, 2012, and June 4, 2012.[3]

The RAA was developed based on in the following documents:

- *Interim Final Technical Guidance Manual for Implementation of the Hawaiʻi State Contingency Plan (TGM)*[4]*;*
- *Removal Action Report, Hickam Communities Remedial Action Site, Joint Base Pearl Harbor-Hickam, Oʻahu, Hawaiʻi (RAR)*[5];
- *Remedial Investigation Report, Hickam Communities Remedial Action Site, Joint Base Pearl Harbor-Hickam, Oʻahu, Hawaiʻi (RI Report;* the Environmental Hazard Evaluation is included as Appendix E*)*[6]; and
- *Draft Environmental Hazard Management Plan: Hickam Communities Remedial Action Site, Joint Base Pearl Harbor-Hickam, Oʻahu, Hawaiʻi (EHMP)*.[7]

[1] (HC 2011)
[2] (HDOH 2012a)
[3] (HDOH 2012c, 2012d, and 2012e)
[4] (HDOH 2009)
[5] (Tetra Tech 2012d)
[6] (Tetra Tech 2012c)
[7] (Tetra Tech 2012b)

The possibility that soil at JBPHH could be impacted by organochlorine pesticides was first identified during a Phase I Environmental Site Assessment (ESA) of the residential neighborhoods that was conducted 2004[8], and subsequently verified through investigations that also started in 2004[9]. The results of these investigations indicated that the impact to soil was primarily due to the organochlorine pesticides aldrin, technical chlordane (chlordane)[10], and dieldrin (Section 2.2). As a result, protocols were developed and implemented at HC for management of this soil during redevelopment. These protocols consisting of the following project plans:

- *Management Plan for Pesticide-Impacted Soils (MPPIS)* which was finalized for HC in 2006[11];
- *Pesticide-Impacted Soil Investigation and Management Program Manual, Hickam Communities Property, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i (Program Manual)*, which superseded the *MPPIS*[12]; and
- *Hickam Communities Resident Guide and Community Standards Handbook (Resident Guide)* which is provided to HC residents as attachment A to the Tenant Lease.[13]

Currently in development for the Site is the Draft *Land Use Controls Inventory Document, Hickam Communities Property, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i (LUCID)* which targets potential soil disturbing activities during maintenance of HC property over the 50-year ground lease[14].

1.1 Remedial Action

The remedial action process was initiated at the Site in July 2010 based on the discovery of a release caused by the improper handling of soil during redevelopment work that was not consistent with the accepted soil management practices at HC. As part of the remedial action process, a Site Investigation (SI) was initiated to evaluate organochlorine pesticide concentrations in the upper 1-foot of soil at three Site neighborhoods at the Site, Earhart I-2, Earhart I-3, and Onizuka II-1. The Hale Na Koa I-1 neighborhood was evaluated as a part of the remedial action and was determined not to require further action (Sections 2.2.2 and 2.2.3). The purpose of the SI was to further delineate the extent of soil impacted by organochlorine pesticides in these neighborhoods, and provide the information needed to develop an Environmental Hazard Evaluation (EHE) for the Site. The EHE is summarized in Section 4.0, and included in its entirety as Appendix E to the *RI Report*[15]. The results of the SI indicated that there was an immediate toxicity risk posed by detected organochlorine pesticide concentrations in soil at some of the sampled decision units (DUs) in the Earhart I-2 and Earhart I-3 neighborhoods, which initiated a Removal Action (RO) in September 2010 (Section 2.2.6). A complete chronology of the events preceding, and actions implemented during the remedial action is presented in detail in Section 2.2.

[8] (Tetra Tech 2005)
[9] (Tetra Tech 2004)
[10] Technical chlordane (referred to as "chlordane") is a mixture of more than 140 related compounds. Major constituents of technical chlordane include alpha- and gamma-chlordane, chlordane, and heptachlor.
[11] (Tetra Tech 2006c)
[12] (Tetra Tech 2009a and 2011d)
[13] (HC 2010)
[14] (Tetra Tech 2012a)
[15] (Tetra Tech 2012c)

1.2 Remedial Alternatives Analysis

The RAA was prepared by Tetra Tech after completion of the three ROs and the preparation of the *RAR* and *RI Report*. The scope of the *RAR* is to present the actions implemented under the RO at the Earhart I-2 and Earhart I-3 neighborhoods; its purpose is to document how the immediate risk posed by soil impacted by organochlorine pesticides was removed and managed. The scope of *RI Report* is for all four neighborhoods at the Site; its purpose is to identify environmental hazards associated with residual contaminant concentrations at the Site, and provide additional data to be used in identifying applicable and appropriate response action alternatives. Although the Hale Na Koa I-1 neighborhood was remediated prior to the initiation of the remedial action (Section 2.2.3), it is included in the scope of the remedial action at HC to address the remaining soil impacted by organochlorine pesticides at this neighborhood.

The primary purpose of this RAA is to provide a comparative evaluation of potential remedial strategies and alternatives that may be appropriate for addressing the environmental hazards remaining at the Site following the completion of the three ROs conducted from October 2010 through August 2011 at Earhart I-2 and Earhart I-3 neighborhoods at the Site. The principal considerations that the remedial action alternatives will be weighed against are effectiveness, implementability (i.e., technological and administrative feasibility), and cost. Based on these considerations, and the comparison of the remedial action alternatives, the preferred alternative will be identified, and a proposed remedy selected for the Site.

1.3 Process for Acceptance of the Final Remedy

The proposed remedy selected for the Site (which can consist of one or more remedial alternative) will be presented in the Draft Response Action Memorandum *(*RAM)[16], which will be available to the public for review and comment over a 30-day period. A public notice will be posted regarding availability for review of the Draft RAM and other key documents, a fact sheet, solicitation of verbal or written comments, and information on the public meeting, which will be held during the middle of the comment period.

The Final RAM will document the selected remedy for the Site as approved by HDOH HEER. Public comments will be addressed in a responsiveness summary in the Final RAM, and incorporated as changes to the selected remedy as appropriate.

1.4 Document Organization

This document follows the RAA format recommended in the HDOH *TGM*[17], with revisions and additions to accommodate this analysis. The report is organized into the following sections:

Section 1.0: Introduction and Purpose. Presents the Site, and outlines the RAA process.

Section 2.0: Background. Describes the Site characteristics, setting, history, and existing conditions. This section also discusses the chemicals of potential concern (COPCs), and presents conceptual site model (CSM) developed for the Site. The Site history includes a summary the events surrounding the release and the remedial action implemented at the Site.

[16] (Tetra Tech 2012e)
[17] (HDOH 2009)

Section 3.0: Magnitude and Extent of Contamination. This Section provides a discussion of the identification of the release, a summary of previous investigation leading up to the SI, and the subsequent RO conducted at the Site.

Section 4.0: Environmental Hazard Evaluation. This section summarizes the scope, development and findings of the *EHE.* The *EHE* identifies the potential hazards and receptors, and presents the risk criteria used to develop site-specific Environmental Action Levels (EALs) for the detected COPCs at the Site.

Section 5.0: Establishing Alternatives. This Section is critical to the RAA since it presents the parameters, specifically the Response Action Objectives (RAOs) and General Response Actions (GRAs), which are used to assess response action alternatives. In this Section, the possible response technologies for the Site will be identified and these parameters applied to select the proposed alternatives, which will be further analyzed in the following Section.

Section 6.0: Detailed Analysis and Comparison of Retained Alternatives. Presents and conducts a comprehensive analysis of the retained alternatives for the Site, from the "No Action" option to and "Unrestricted Use" option (which would require the complete removal of all impacted media at the Site). This Section discusses how each of these alternatives would be implemented and will include the advantages and disadvantage of each alternative. Each alternative will then be scored based on the threshold criteria of effectiveness, implementability, and cost.

Section 7:0: Preferred Alternative. Presentation of the preferred remedy alternative and remedy proposed for the Site.

Section 8.0: References. Provides complete references for all correspondence, reports, communications, and maps cited in the RAA.

2.0 BACKGROUND

2.1 Site Description

The Site consists of military residential housing located within the Hickam Air Force Base (HAFB) section of JBPHH, which is an active military installation. Joint Base Pearl Harbor-Hickam is situated on approximately 2,700 acres of the Pearl Harbor coastal plain on the southern coast of O'ahu, approximately 8 miles west of downtown Honolulu, and adjacent to the Honolulu International Airport.

Hale Na Koa. The Hale Na Koa Village (Hale Na Koa) housing area (formerly known as "Capehart") encompasses approximately 85 acres on the central part of JBPHH, northwest of Earhart Village.[18] Hale Na Koa is Construction Phase I housing that consists of two project areas: the Hale Na Koa I-1 subphase of new multiplex units, and the other is Hale Na Koa Minor Renovations consisting of minor renovations of existing multiplex units,

Earhart Village. The Earhart Village (Earhart) housing area encompasses approximately 130 acres on the eastern portion of JBPHH[19]. Earhart consists of Construction Phase I housing in four subphases of new multiplex units, which are the Earhart I-1, Earhart I-2, Earhart I-3, and Earhart I-4 subphases. Earhart Village is the location for two of the neighborhoods at the Site, Earhart I-2 and Earhart I-3. These two neighborhoods are mostly delineated by Ohana Nui Circle, which is the outermost street that loops through Earhart Village.

Onizuka Village. The Onizuka Village (Onizuka) housing area encompasses approximately 74 acres in the central portion of JBPHH, west of Earhart Village. Onizuka consists of Construction Phase II housing in three subphases of new multiplex units, which are the Onizuka II-1, Onizuka II-2, and Onizuka II-3 subphases. The Onizuka II-1 neighborhood is the only one of these three that is part of the Site, and is located in the southwestern portion of Onizuka. The Onizuka II-1 neighborhood also includes the HC Office and Maintenance Facility (HOMF).

The location of these housing areas at JBPHH is shown in Figure 1-1.

2.1.1 Climate

The climate in the Honolulu area is mild to very warm, with dry to moderate humidity and northeasterly trade winds approximately 90 percent of the summer and 50 percent of the winter. There is very little diurnal or seasonal variation in temperature on O'ahu because of its tropical latitude, marine influence, and the prevailing northeasterly trade winds. The average daytime temperatures range between 22 and 27 degrees Celsius or 72 and 81 degrees Fahrenheit. The humidity varies between 58 and 90 percent.[20]

The average annual precipitation on HAFB is approximately 56 centimeters (22 inches). December is typically the wettest month of the year, and June is the driest.[21]

2.1.2 Soils/Geology

The JBPHH lies within on the coastal plain on the leeward side of the Ko'olau Range, immediately east of Pearl Harbor. The Pearl Harbor coastal plain is underlain by a succession of

[18] (Tetra Tech 2005)
[19] (Waller 2005)
[20] (USACE 1997)
[21] (HAFB 2006)

terrestrial alluvial and marine sedimentary layers.[22] As the island subsided over thousands of years, alluvial sediments interspersed with volcanic flows and volcanic ash were deposited on the margin of the island, building a reef platform. During periods of lower sea levels, the reef was exposed. This so-called caprock (because it caps the underlying volcanic rock, which contains the basal aquifer) contains strata of alluvium, lagoonal mud, beach sands, volcanic tuff, and corals. At depth, these strata overlay volcanic bedrock of the Honolulu volcanic series.

Most of JBPHH soils are mapped as fill, comprising material dredged from the ocean or hauled in from elsewhere. In addition to the fill, there are five naturally occurring soil types present (Māmala stony silt clay loam, Makalapa clay, Kea'au stony clay, Jaucus sand, and coral outcrop) that are associated with the coastal plain and coral reef substratum over which the base lies. The fill and naturally occurring soil types are considered poor for vegetation growth, and high-maintenance landscaping areas usually contain topsoil fill from off-base sources. The erosion potential for the JBPHH soils is generally slight to moderate, with the exception of Jaucus sand, which is highly erodible.

2.1.3 Surface Water

There are no natural lakes, rivers, or streams in the Earhart Village housing areas, but Manuwai Canal, which provides storm drainage for the eastern third of JBPHH, flows next to the southern boundary of the Earhart Village housing area. The Manuwai Canal empties into Māmala Bay to the south.

The housing areas are not in the area on JBPHH designated as a potential flood inundation zone. The housing areas use a storm drainage system that collects surface water and sends it to a series of canals that eventually empty to Māmala Bay. The sedimentary deposits are intermittent with the volcanic basalts that make up the land mass of the Hawaiian Islands.

No wetlands are present on the Earhart Village housing area properties. The Manuwai Canal, which flows next to the southern boundary of the Earhart Village housing area, has been classified by the National Wetland Inventory as an estuarine, open water, subtidal inundation, and excavated wetland.[23]

2.1.4 Groundwater

There are two groundwater aquifers below JBPHH. Most of the installation is underlain by a brackish aquifer that is not suitable for commercial or residential use or for recreation. General groundwater flow in the area is toward the Pacific Ocean to the south. A small portion of the base is underlain by a protected freshwater aquifer and has stringent requirements for water quality protection. Potable water is supplied to the HAFB part of JBPHH from Navy storage tanks outside the base.[24]

2.2 Historic Land Use and Previous Investigations

The Site is part of HC leased property located within the boundary of JBPHH, formerly HAFB. The Site has been used for military purposes for more than 50 years. Development of the base began in 1928, when the War Department identified the area to improve air defenses for Hawaiian territories.[25] Prior to acquisition by the War Department, the area that now contains

[22] (USAF 2002)
[23] (USAF 2002)
[24] (USAF1998)
[25] (Waller 2005)

HAFB was used for agriculture and fish ponds.[26] In 1935, approximately 2,225 acres of brush and sugar cane fields were developed into Hickam Field and the Base was activated in 1938. Hickam Field became HAFB in 1948, which merged with Naval Base Pearl Harbor in 2010 to form JBPHH. The Hickam Field Officer Quarters (part of the Historic Homes District [HHD]) were constructed between 1939 and 1947.[27]

The property currently occupied by the Hale Na Koa and Earhart Village housing areas was utilized for agricultural purposes, primarily the cultivation of sugarcane. The property occupied by the Hale Na Koa housing area was acquired in 1935 and developed for residential purposes and as an open area to support aviation activity. The open area was later developed for residential purposes. A former motor pool also was been situated on the northern portion of the former Capehart housing area; the specific dates of its operation are not known.[28] The Fort Kamehameha housing area (part of the HHD) was acquired by USAF in March of 1993. Constructed in 1917, they are the oldest units at JBPHH. In addition to their historical significance as the earliest remaining military family housing units established on the island, Fort Kamehameha is archaeologically significant as pre and post-contact remains have been recovered within the area. With the exception of the HHD, most of the original housing at the Site was constructed in the 1950s through the 1970s. The Earhart Village housing property was acquired in two phases (1942 and 1968) and developed for residential purposes. Onizuka Village was originally constructed in 1975, overlaying what was once part of the airfield.[29]

2.2.1 Pesticide-Impacted Soil Management

In buildings constructed at military installations from the 1940s to the 1980s, organochlorine pesticides were routinely applied to soil under and around the perimeter of building foundations to control subterranean termites. Although use of organochlorine pesticides was banned by the US Environmental Protection Agency (EPA) by the late-1980s, because these pesticides are persistent in the environment, residual concentrations can still be present in the soil beneath building foundations, and subsequently exposed when the buildings are demolished to prepare for construction of new housing, or during renovation of existing homes. Since any pesticide-impacted soil detected at HC would require management during demolition, renovation, and/or construction of military housing, a series of management practices were implemented at HC to manage soil impacted by organochlorine pesticides, referred to as "pesticide-impacted soil"[30]. The practices for managing this pesticide-impacted soil are presented in a HC-specific soil management plan, which was developed for use during construction and renovation activities. This management plan is periodically updated to capture changes in risk criteria, and/or procedures being used to investigate and manage pesticide-impacted soil during construction and renovation activities at HC. Thus, this plan presents the site-specific criteria and procedures used to assess pesticide-impacted soil at HC.

The first plan version of the plan developed for HC was the *MPPIS* which was finalized for HC in 2006.[31] The *MPPIS* was updated and renamed the *Pesticide-Impacted Soils Investigation and Management Program Manual* in 2009.[32] Under the most recent version of the *Program Manual*,

[26] (KJC 1991)
[27] (Tetra Tech 2007a)
[28] (Tetra Tech 2005; USAF 2002)
[29] (Waller 2005)
[30] Pesticide-impacted soil is defined as soil having organochlorine pesticide concentrations, specifically aldrin, chlordane, and dieldrin, exceeding the applicable site-specific risk criteria established for HC.
[31] (Tetra Tech 2006c)
[32] (Tetra Tech 2009a)

dated August 31, 2011[33], the procedures call for excavation of pesticide-impacted soil to a depth of at least 1-foot below final grade in areas that would not be covered by hardscapes after new construction is completed. The excavated areas are then capped by at least 1-foot of clean soil to bring the HC project site to final grade. Any pesticide-impacted soil under hardscapes (e.g. roads, building foundations, sidewalks, driveways, and parking lots), would not need to be removed because the hardscapes provide a long-term barrier to exposure. Placement of excavated pesticide-impacted soil under new hardscapes is also used as a method to permanently manage pesticide-impacted soil and prevent the exposure pathways of direct contact, inhalation, and ingestion that may be associated with exposed pesticide-impacted soil.

Additional controls are provided in the *Program Manual* pertaining to management and export of soil and materials from HC for off-site disposal. The *Program Manual* specifies that pesticide-impacted soil must not be exported off-site for disposal or management; all pesticide-impacted soil must be managed within the HC property boundary. In addition, any pesticide-impacted soil or any soil exceeding the Tier 1 EALs that is not considered pesticide-impacted, would not be managed or placed in any areas identified as ecological habitats or wetlands at HC.

Any soil/material exported off of HC property is profiled and cannot have detected COPCs with concentrations that exceed the respective environmental screening levels, specifically, the HDOH Tier 1 EALs for unrestricted use for sites where groundwater is a potential drinking water resource and a surface water body is located within 150 meters of a release site (Table A-2)[34]; and (2) the Toxicity Characteristic, Leaching Procedure (TCLP)[35]. For landfill disposal, the soil cannot have detected COPCs with concentrations that exceed HDOH Tier 1 EALs where groundwater is not potential drinking water resource and a surface water body is located greater than 150 meters of a release site (Table B-1); (2) the Direct Exposure Action Levels (DEALs), Commercial / Industrial Land Use Scenario (Table I-2)[36]; and (3) TCLP.[37, 38]

2.2.2 Description of Release

The release occurred during redevelopment of the Site when pesticide-impacted soil that originated from excavating footprints of former buildings was improperly placed or graded into open areas[39], and not subsequently covered by hardscapes. This pesticide-impacted soil was not detected until after construction at the Site was completed or nearing completion. The pesticide-impacted soil at the Hale Na Koa I-1 neighborhood was detected and mitigated in 2007. Based on the results of confirmation soil sampling conducted in 2010[40], the Hale Na Koa I-1 neighborhood was included in the *Voluntary Agreement* in February 2011[41], and subsequently evaluated as a part of the remedial action[42]. Further evaluation by HC and HDOH of the analytical results from 2010 confirmation soil sampling at the Hale Na Koa I-1 determined that this neighborhood did not a require a removal action[43]. The pesticide-impacted soil at the Earhart I-4 neighborhood was detected and mitigated in 2010. Based on the results of the confirmation soil sampling conducted 2010, the pesticide-impacted soil at Earhart I-4 neighborhood was considered to have been addressed prior to the initiation of the *Voluntary*

[33] (Tetra Tech 2011d)
[34] (HDOH 2009)
[35] (CFR 2010)
[36] (HDOH 2009)
[37] (CFR 2010)
[38] (Tetra Tech 2011d)
[39] Open areas are defined as undeveloped land outside of the former building footprints and 3-foot building zones.
[40] (Tetra Tech 2010f)
[41] (HC 2011)
[42] (HDOH 2011a)
[43] (HDOH 2011d)

Agreement; however, due to the pesticide-impacted soil detected at Earhart I-4, confirmation soil sampling was conducted at the remaining three Site neighborhoods Earhart I-2, Earhart I-3, and Onizuka II-1. These results of this confirmation soil sampling indicated that pesticide-impacted soil was present in some of the DUs sampled at these neighborhoods; the detection of this pesticide-impacted soil initiated the remedial action process implemented by HC and HDOH in July 2010, and the inclusion of these neighborhoods into the scope of the *Voluntary Agreement*[44]. As part of the remedial action, a SI was conducted at these three neighborhoods. Based on the preliminary results of the SI, HC implemented three ROs to address the immediate risk posed by exposed pesticide-impacted soil at the Earhart I-2 and Earhart I-3 neighborhoods. The results of the previous investigations including the SI are summarized below, and the results of the SI are provided in their entirety in the *RI Report*.[45] The ROs are summarized in Section 3.1 and detailed in the *RAR*.[46]

2.2.3 Investigations at the Hale Na Koa I-1 Neighborhood (2004 through 2010)

Based on the preliminary findings of the Phase I ESA conducted in 2004 (and finalized in January 2005)[47], and the known application methods used to treat building foundations with organochlorine pesticides, a discrete soil sampling investigation was conducted at Hale Na Koa I-1 (the former Capehart neighborhood) in 2004[48]. For this investigation, discrete soil samples were collected within the building driplines and close to the foundations of the existing buildings prior to demolition.

The results of the 2004 discrete soil sampling investigation indicated that organochlorine pesticides were present in Hale Na Koa I-1 soil at concentrations exceeding the HDOH EALs[49]. In 2006, a soil investigation to characterize the extent of the pesticide-impacted soil at the Hale Na Koa I-1 was performed, whereby DUs were delineated to distinguish a 10-foot zone of soil around the buildings.[50] It is important to note that the entire Site was characterized during this investigation; that is, some of the DUs included this 10-foot zone around the buildings, while others were located in open areas between the buildings and backyards. The results of this investigation indicated that nineteen of the sampled DUs were identified as having exposed pesticide-impacted soil. The soil in these nineteen DUs was managed by excavation of the soil to 1-foot below planned final grade, and placement of a 1-foot thick clean soil cap which was completed in 2007.

Confirmation soil sampling of Hale Na Koa I-1 was performed in 2010[51]. For this confirmation soil sampling investigation, the Hale Na Koa I-1 neighborhood was divided into eleven DUs and sampled using multi-incremental (MI) soil sampling methodology.[52] Five of these DUs included the nineteen DUs where pesticide-impacted soil was previously identified and managed; these DUs were sampled at the 0 to 6 and 6 to 12-inch depth intervals. The remaining six DUs for the areas that had previously tested as not being pesticide-impacted were sampled from the 0 to 6-inch depth interval only. The results of the confirmation soil sampling investigation indicated that organochlorine pesticide concentrations in the MI soil samples do not exceed the applicable

[44] (HC 2011)
[45] (Tetra Tech 2012c)
[46] (Tetra Tech 2012d)
[47] (Tetra Tech 2005)
[48] (Tetra Tech 2004)
[49] (HDOH 2005)
[50] (Tetra Tech 2006a)
[51] (Tetra Tech 2010f)
[52] (Tetra Tech 2010b)

risk criteria[53], and concludes that there is no exposed pesticide-impacted soil at Hale Na Koa I-1.

2.2.4 Investigations at the Earhart I-2, Earhart I-3, Earhart I-4, and Onizuka II-1 Neighborhoods (2006 through 2010)

Prior to demolition, open area soil sampling around the existing buildings was conducted at the Earhart I-2, Earhart I-3, and Earhart I-4 neighborhoods, and limited open area sampling was conducted at the Onizuka II-1 neighborhood.[54] The results of the soil sampling indicated that pesticide-impacted soil was not present in the upper 6 inches of soil in these neighborhoods. Demolition and redevelopment of Earhart I-2 neighborhood was conducted between March 2007 and August 2008, Earhart I-3 from March 2008 and August 2009, and Onizuka II-1 from February 2008 to June 2009. Demolition of the Earhart I-4 began in June 2008. Since demolition and soil management at the Earhart I-4 neighborhood was underway when environmental oversight was implemented, HC decided to conduct verification soil sampling during ongoing construction in areas at Earhart I-4 where pesticide-impacted soil had already been managed. Based on previous oversight, Tetra Tech performed confirmation soil sampling in open areas at Earhart I-4 between August and December 2009.[55] The confirmation soil sampling identified that organochlorine pesticides were present in surface soil. Based on these results, the upper 1-foot of open area soil at Earhart I-4 was removed and placed into burial pits at the Onizuka II-2 neighborhood. Clean soil removed from Onizuka II-2 to create the burial pits was used to install a 1-foot clean soil cap at Earhart I-4. Confirmation soil sampling was performed at Earhart I-4 after the cap was installed which indicated that no pesticide-impacted soil remained in surface soil at Earhart I-4.[56]

Confirmation soil sampling was also conducted following completion of new housing construction at the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods.[57] Ten open area DUs were sampled at Earhart I-2, six open area DUs were sampled at Earhart I-3, and five open area DUs were sampled at Onizuka II-1. The results of the confirmation soil sampling indicated that organochlorine pesticides were present in soil at all ten open area DUs at Earhart I-2, all six open area DUs at Earhart I-3, and two of five open area DUs at Onizuka II-1.[58]

2.2.5 Site Investigation (SI) (2010)

As a result of the confirmation soil sampling at the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods, meetings between HDOH and HC were conducted in July 2010, and the SI was planned. Two Sampling and Analysis Plans were developed where the entire exposed ground surfaces within the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods were subdivided into DUs of up to 5,500 sq ft in size.[59] The area of each DU only included the exposed surface area, including landscaped areas, but excluded the measured areas of hardscapes. The DUs were also defined by the nature of the land use, so that they corresponded to front yards, back yards, play areas, or common areas (such as pedestrian corridors) used by residents and guests. The soil in each DU was sampled using MI sampling methodology, which involves collecting 30 to 50 individual soil samples (or "increments") from points spread out across the DU. These increments are combined into a single composite sample; and mixing and processing the composite sample is conducted during laboratory preparation to ensure that a

[53] (Tetra Tech 2009a)
[54] (Tetra Tech 2006b and 2007b)
[55] (Tetra Tech 2009c)
[56] (Tetra Tech 2010a, 2010c, 2010d, 2010i, 2010L, and 2010m)
[57] (Tetra Tech 2010b)
[58] (Tetra Tech 2010e, 2010f, and 2010h)
[59] (Tetra Tech 2010g, 2010h, 2010j, and 2010k)

representative subsample of the composite sample is analyzed. The MI soil samples are a means of directly estimating the average concentration of pesticides within the DU. For the SI, the Earhart I-2 neighborhood was divided into a total of 330 DUs, the Earhart I-3 neighborhood was divided into 180 DUs, and the Onizuka II-1 neighborhood was divided into 21 DUs. The MI soil samples were collected from the 0 to 6-inch and 6 to 12-inch depth intervals, resulting in samples representing the average concentrations of pesticides within these depth intervals for each DU.

Between August and October 2010, the SI was performed with MI soil samples collected from the 0 to 6 and 6 to 12-inch depth intervals at each DU. These MI soil samples were submitted for analysis of organochlorine pesticides by EPA Method 8081. The results of the SI indicated that the soil was impacted with residual organochlorine pesticides, specifically aldrin, chlordane, and dieldrin at the three neighborhoods sampled for the SI. At the request of HDOH, following review by Tetra Tech and HC, the preliminary analytical results for organochlorine pesticides from the soil samples collected for the SI were tabulated and transmitted to HDOH on a daily basis. The complete analytical results for the SI are provided in the *RI Report*[60].

2.2.6 Removal Action (RO) (2010 through 2011)

The daily review of the preliminary SI analytical results by HC, Tetra Tech, and HDOH indicated that organochlorine pesticides detected in soil at some of the sampled DUs were present at concentrations that posed an immediate human health risk to HC workers, residents, and guests. Based on meetings between HC, HDOH, and Tetra Tech risk assessors, it was agreed that the immediate risk was posed by the non-carcinogenic risk from organochlorine pesticide concentrations in soil. As a result, the decision making process for ROs was developed based on calculation of the Hazard Index (HI) for each MI soil sample. Hickam Communities, in consultation with HDOH, used interim site-specific EALs to further screen the soil sample results. Based on the results of this screening, the RO was initiated in September 2010 to address the pesticide-impacted soil detected at the three neighborhoods. These removal actions were identified for specific DUs at the Earhart I-2 and Earhart I-3 neighborhoods; no DUs were identified at Onizuka II-1 neighborhood for action under the RO process.

The RO process consisted of three ROs, Removal Action No. 1 (RO #1), Removal Action No. 2 (RO #2), and Removal Action No. 3 (RO #3). These ROs were implemented in sequential order between October 2010 and August 2011. RO #1 and RO #2 were implemented to address soil with organochlorine pesticide concentrations that presented the highest health risks at the Site. The RO #1 and RO #2 were conducted based on immediate human health concerns, while HC conducted the RO #3 voluntarily, as described below. The ROs are summarized here, and presented in detail in the *RAR*[61].

2.2.6.1 Removal Action No. 1

The RO #1 was implemented starting in October 15, 2010 and completed by early January 2011. For RO #1, two actions (RO-1A and RO-1B) were taken based on the risk criteria under the provided in the 2009 *Program Manual*[62], referred to as the "2006 HHRA Standard". Under RO-1A, soil that contained concentrations associated with a combined non-carcinogenic risk described by an HI >10 were targeted for excavation of the upper 1-foot of soil, placement of a marker layer of orange geotextile fabric, and capping with 1-foot of soil with clean soil.[63] A total

[60] (Tetra Tech 2012c)
[61] (Tetra Tech 2012d)
[62] (Tetra Tech 2009a)
[63] (Tetra Tech 2010m)

of four DUs in Earhart I-2, and one DU in Earhart I-3 met this criterion and were selected for action under RO-1A. At the same time, a second response action was initiated under RO-1B to ensure that turf grass in areas with soil presenting an intermediate level of risk was maintained so that the grass cover would act as an effective barrier to exposure. Under RO-1B, one DU in the Earhart I-2 neighborhood was identified where a large enough area of grass cover was inadequate and the DU was selected for excavation and replacement of the upper 1-foot of soil.

During planning of RO #1, HC decided to excavate and replace soil in three additional DUs in the Earhart I-2 area that were adjacent to the selected DUs, and to remove soil from small parts of three other adjacent DUs. All pesticide-impacted soil removed during RO-1A and RO-1B was stockpiled at a temporary pesticide-impacted soil management area, and subsequently placed into Burial Pit No. 6b constructed in the Onizuka II-3 neighborhood on April 22, 2011.[64]

2.2.6.2 Removal Action No. 2

The RO #2 was implemented starting on January 4, 2011 and completed by the end of April 2011. Following completion of RO #1, RO #2 was designed to address DUs in which organochlorine pesticide concentrations with an HI >1, based on modified exposure assumptions that were presented in the memorandum entitled *Revised Analysis of Potential Removal Alternatives, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods* and referred to as the "2010 Analysis of Potential Removal Alternatives (APRA) Standard".[65]

On the basis of this analysis, for RO #2, three actions were implemented. Under RO-2A, one additional DU in the Earhart I-2 area was selected for excavation of the upper 1-foot of soil, placement of a marker layer of orange geotextile fabric, and capping with 1-foot of soil with clean soil. A second response action was undertaken under RO-2B (RO-2B1 and RO-2B2) to inspect landscaping strips adjacent to homes in 41 DU and identify specific landscaping strip DUs requiring installation geotextile barriers in landscape strips. Under RO-2B1 and RO-2B2, actions were implemented at a total of 29 landscaping strip DUs. For the third response action, which was undertaken under RO-2C, a total of 195 DUs with intermediate pesticide concentrations were identified for inspection. The inspection was to evaluate if bare areas were present in the DUs that required hydroseeding to improve grass cover. Under RO-2C, actions were implemented at a total of 23 bare area DUs. All pesticide-impacted soil removed during RO #2 was stockpiled at a temporary pesticide-impacted soil management area, and placed into a pesticide-impacted soil Burial Pit No. 6b constructed in the Onizuka II-3 neighborhood on April 22, 2011.[66]

2.2.6.3 Removal Action No. 3

The RO #3 was implemented starting on January 5, 2011 and completed August 4, 2011. The RO #3 was developed based on reevaluation of the human health risks associated with dieldrin and aldrin presented in the *Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities* (*HHRE WP*)[67] and referred to as the "2011 HHRE Standard". Based on these modified EALs, one action (RO-3) was conducted to address DUs with an HI >1.[68] Under RO-3, ten DUs in Earhart I-2 and four DUs in Earhart I-3, which identified with combined pesticide concentrations representing an HI >1, were excavated to a depth of 9 inches below final grade, a marker layer of orange geotextile fabric installed, and the soil replaced with clean fill and

[64] (Tetra Tech 2012d)
[65] (Tetra Tech 2010n and 2010p)
[66] (Tetra Tech 2012d)
[67] (Tetra Tech 2011a)
[68] (Tetra Tech 2011b)

reseeded (a depth of 6-inch below final grade for this excavation was presented in the work plan for RO #3, which was approved by the HDOH in its letter dated June 9, 2011[69]. The final depth of 9-inches for the excavations was based on geotechnical concerns for the clean fill soil. The pesticide-impacted soil excavated during RO-3 was placed into a pesticide-impacted soil berm constructed at the Earhart I-2 neighborhood in February 2012.[70]

2.3 Current/Future Land Use

The Site currently consists of new multi-unit residential housing that is managed by HC. The residential homes at the Site are occupied and are primarily leased by military personnel. Since HC holds a 50-year ground lease of the Site property, this property is expected to remain used for residential housing until at least 2057.

2.4 Chemicals of Potential Concern (COPCs)

Chemicals of Potential Concern are chemicals that have been detected in the environment that may adversely impact human or ecological receptors. These COPCs were identified based on the most recent soil sampling data collected from August 12 through October 12, 2010 to characterize the DUs identified in accordance with HDOH guidelines within the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods. All soil samples were analyzed by EPA Method 8081 for organochlorine pesticides. For this evaluation, all pesticides detected in at least one soil sample were identified as COPCs and evaluated further in the *EHE*. Chemicals detected at the Site are summarized in Table 2-1 and include aldrin, chlordane, dieldrin, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), endrin, endrin ketone, endosulfan sulfate, delta-BHC, and methoxychlor. The primary chemicals of concern identified at the site are organochlorine pesticides, including chlordane, aldrin, dieldrin, DDD, DDE, and DDT. Other organochlorine pesticides, such as endosulfan sulfate, endrin, endrin ketone, delta-BHC, and methoxychlor, have been detected sporadically at concentrations close to their detection limits. These compounds do not contribute significantly to the cumulative risk from organochlorine pesticides at the Site.

2.5 Conceptual Site Model (CSM)

As indicated by HDOH guidance provided in *Screening for Environmental Hazards at Sites with Contaminated Soil and Groundwater*[71], a basic understanding of environmental hazards associated with contaminated soil and groundwater is a critical component in the overall environmental response process. The potential environmental hazards and targeted environmental hazards that were evaluated as part of the *EHE* are summarized in the following sections.

[69] (HDOH 2011c)
[70] (Tetra Tech 2012d)
[71] (HDOH 2011f)

Table 2-1. Chemicals of Potential Concern in Soil

Chemical [a]
Aldrin
Chlordane [b]
Dieldrin
DDD
DDE
DDT
Endrin
Endrin ketone
Endosulfan sulfate [c]
delta-BHC [c]
Methoxychlor [c]

[a] All organochlorine pesticides detected in soil as part of site investigation activities conducted at the Site in 2010 are included in this table.
[b] Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.
[c] Listed chemical detected at low levels in one sample.

2.5.1 Potential Environmental Hazards

Common environmental hazards that should be evaluated at release sites include:

Soil

- Direct exposure risks to human health;
- Intrusion of subsurface vapors in buildings;
- Leaching and subsequent impacts to groundwater resources;
- Impacts to terrestrial habitats; and
- Gross contamination and general resource degradation.

Groundwater

- Impacts to drinking water resources;
- Impacts to aquatic habitats;
- Intrusion of subsurface vapors in to buildings; and
- Gross contamination and general resource degradation.

Potential environmental hazards were evaluated for their applicability to the Site. Potential environmental hazards that were considered to be insignificant at the Site based on available information were eliminated from further consideration and are not evaluated further. Potential environmental hazards identified as posing a potential threat to human health and/or the environment were evaluated further in the *EHE*.

2.5.2 Targeted Environmental Hazards

A summary of potential environmental hazards and their significance at the Site is provided below in Table 2-2.

Direct Exposure. As described in more detail in the *EHE*, direct exposure to soil was retained and evaluated in the *EHE*.

Vapor Intrusion. Vapor intrusion was eliminated as a potential environmental hazard because none of the COPCs are classified as volatile compounds by EPA or HDOH.

Leaching/Groundwater Impacts. The chlorinated pesticides detected at the Site have low solubilities and bind tightly to soils (i.e., have very limited mobility) and therefore, are not considered to pose a significant soil leaching hazard in regard to contamination of groundwater.

Drinking Water Resource Impacts. Contamination of drinking water supplies was eliminated due to the following: the limited mobility of the COPCs, groundwater beneath the study area is brackish and is not suitable for commercial, residential, or recreational use, and because potable water is supplied to JBPHH from US Navy storage tanks outside the base.

Ecotoxicity. As discussed in the *EHE*, terrestrial and aquatic ecotoxicity was eliminated from consideration due to the low mobility of the COPCs and due to a lack of sensitive habitat/receptors within the Site and immediately adjacent to the Site.

Gross Contamination. Gross contamination was eliminated because the maximum detected levels of pesticides within the Site are well below the corresponding HDOH screening levels for gross contamination.

Table 2-2. Potential Environmental Hazards

Medium	Potential Environmental Hazard	Potentially Significant?
Soil	Direct exposure threats to human health	Yes
	Intrusion of subsurface vapors in buildings	No
	Leaching and subsequent impacts to groundwater	No
	Impacts to terrestrial habitats	No
	Gross contamination and general resource degradation	No
Groundwater	Impacts to drinking water sources	No
	Impacts to aquatic habitats	No
	Intrusion of subsurface vapors into buildings	No
	Gross contamination and general resource degradation	No

2.6 Exposed Populations and Exposure Pathways

The identification of potentially exposed populations and exposure pathways is a critical component of developing health protective environmental action levels. An exposure pathway describes the course a chemical takes from a source to an exposed individual. Based on current and anticipated future conditions at the Site, the chemical exposures that could potentially be associated with the three neighborhoods were identified considering the following four factors:

- Sources of COPCs;
- Environmental media in which COPCs have been detected (i.e. soil);
- Exposure of contact points with the environmental media (e.g. direct contact with soil); and

- Exposure routes for chemical intake by a receptor (e.g. soil ingestion).

The exposure pathways identified for the Site are based on evaluations of the likelihood of receptors directly contacting COPCs and the mechanisms governing the fate and transport of the COPCs.

2.6.1 Potential Receptors

Potentially exposed human populations (receptors) were identified for current and expected future land-use scenarios. The Site is currently developed for residential land use and it is anticipated that it will remain in its current use over the course of the 50-year lease between HC and the USAF, which does not expire until 2057. Human populations that could potentially be exposed to pesticide-impacted soil within the Site under current and expected future conditions, include residential receptors (adults and children), landscaping/maintenance workers, and construction workers.

For the *EHE*, residential, landscape/maintenance worker, and construction worker receptors were evaluated. For landscape/maintenance workers and construction worker receptors, a reasonably anticipated future exposure scenario includes exposure to previously buried pesticide-impacted soil due to excavation or erosion. Similarly, if pesticide-impacted soil remaining at the Site is brought to the surface in the future, residents could also be potentially exposed.

Thus, for CSM development, the potentially affected human populations include:

- Residential receptors (adults and children)
- Landscape/maintenance workers, and
- Construction workers.

2.6.2 Exposure Media and Exposure Pathways

As indicated above, direct exposure to pesticide-impacted soil by residents and future workers is the potential environmental hazard evaluated in the *EHE*. The complete exposure pathways for potentially affected populations identified above include: 1) incidental ingestion of soil; 2) dermal contact with soil; and 3) inhalation of airborne particulates.

Potential receptors and exposure pathways are summarized in Table 2-3. The CSM summarizing the potential and retained environmental hazards for pesticide-impacted soil at the Site is presented in Table 2-4.

Table 2-3. Potential Receptors and Exposure Pathways

Receptor	Medium	Exposure Pathway
On-Site Resident (Adult and Child)	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation
Landscape/Maintenance Worker	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation
Construction Worker	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation

Table 2-4. Conceptual Site Model for Organochlorine Pesticides [a]

Primary Sources	Primary Release Mechanism	Secondary Sources	Potential Environmental Hazards		Hazards Present Under Current or Future Conditions?			
					Current		Future	
					Residents	Construction/ Maintenance Workers	Residents	Construction/ Maintenance Workers
Historical Maintenance Activities for Residential Units (Application of pesticides under and around building foundations for termite control)	Soil moving activities associated with recent construction work	Soil	Risk to Human Health	Direct Exposure [b] - ingestion - dermal contact - dust inhalation	No [i]	No [i]	Yes	Yes
				Vapor Intrusion into Buildings	----	----	----	----
			Risk to Terrestrial Ecological Habitats [c]		No		No	
			Leaching [d]		No		No	
			Gross Contamination [e]		No		No	
		Groundwater	Risk to Human Health [f]	Direct Exposure	----		----	
				Vapor Intrusion into Buildings	----		----	
			Risk to Aquatic Ecological Habitats [g]		----		----	
			Gross Contamination [h]		----		----	

[a] Conceptual Site Model is based on EAL Surfer Summary Reports for organochlorine pesticides (HDOH 2011g). It is assumed that the Site is not located within 150 meters of a surface water body or sensitive aquatic habitat, and groundwater is not a current drinking water resource.
[b] Human health hazards include direct exposure to contaminated soil or inhalation of airborne dust.
[c] Assumes significant terrestrial ecological habitat is impacted due to contamination with resulting toxicity to flora/fauna.
[d] Assumes potential leaching of soil contaminants resulting in impacts to underlying groundwater.
[e] Gross contamination hazards for soil include potential explosive hazards, odors and general nuisance concerns, and general resource degradation.
[f] Human health hazards include ingestion of contaminated groundwater and potential dermal and inhalation exposures during showering.
[g] Assumes contaminated groundwater discharges/migrates to an aquatic habitat. Contaminants in groundwater screened using chronic aquatic toxicity action levels for sites < 150 meters from a surface water body.
[h] Gross contamination hazards for groundwater include taste and odor concerns for drinking water, presence of free product, odors, and general resource degradation.
[i] Due to remediation activities completed at the Site, current hazards are not likely to exist for current residents. Similarly, for current landscape/maintenance and construction workers who may engage in intrusive soil activities, institutional controls are currently in place to ensure that Occupational Safety and Health Administration safe practices are followed by maintenance and construction workers in areas of the Site associated with remaining pesticide-impacted soil.

3.0 MAGNITUDE AND EXTENT OF REMAINING CONTAMINATION

This section describes the contamination or presumed contamination remaining at the Site based on previous investigations and ROs implemented at the Site. As a result of these actions, there are no current hazards posed by pesticide-impacted soil at the Site; however, residual pesticide-impacted soil is known or presumed to be present beneath clean soil caps and hardscapes, and known to be present in on-site management areas.

3.1 Residual Pesticide-Impacted Soil

The primary means by which organochlorine pesticides were introduced into Site soil is through termiticide application. The application method was likely a combination of spraying soil surfaces prior to the construction of concrete slab foundations, and subsequent injection through utility openings in the foundations, and along foundation perimeters following construction of the homes. For this type of application, the intended application depths are not expected to have exceeded 2 to 3 feet below grade. Although some downward migration may have occurred immediately after the initial application (when the organochlorine pesticides were still dissolved in carrier solvents), any subsequent movement of organochlorine pesticides sorbed to soil particles due to leaching is expected to be minimal. [72]

Pesticide-impacted soil was placed at greater depths during HC construction activities due to:

- Known use of pesticide-impacted soil as backfill for some utility trenches;
- Intentional burial of pesticide-impacted soil in the Onizuka Village neighborhood burial pits (Figure 3-1); and
- Other potential (and unverified) burial of pesticide-impacted soil.

These locations are summarized below, and presented in detail in maps provided in the *EHMP* and the *LUCID*.

3.1.1 Removal Action at the Earhart I-2 and Earhart I-3 Neighborhoods

As a result of the ROs, DUs with combined organochlorine pesticide concentrations representing HI >1 were identified based on results of the SI were excavated to at least 9-inches below final grade, and a marker layer of orange geotextile fabric installed followed by clean fill soil. Following the completion of the RO, calculated HIs for those remaining DUs at the Site are considered acceptable for current use.

3.1.2 Hale Na Koa I-1 and Onizuka II-1 Neighborhoods

At the remaining areas of the Site, consisting of the Hale Na Koa I-1 and Onizuka II-1 neighborhoods, pesticide-impacted soil was remediated (Hale Na Koa I-1), or has been managed under hardscapes, and/or under at least 1-foot of clean soil (Hale Na Koa I-1 and Onizuka II-1). At Onizuka II-1, no excavations were conducted under the RO and pesticide-impacted soil is assumed to be present at depths greater than at 1-foot below final grade. There is no marker layer of orange geotextile fabric installed at Hale Na Koa I-1 or Onizuka II-1.

[72] (Tetra Tech 2009b)

3.1.3 Utility Trenches

Pesticide-impacted soil was used to backfill utility trenches in some areas at the Earhart I-2 and Earhart I-3 neighborhoods. The depths of utility trenches range from approximately 1-foot (irrigation lines) to approximately 10 feet below final grade (water mains and sewer lines). The use of pesticide-impacted soil as trench backfill was discontinued in 2010, but pesticide-impacted soil could be present in utility trenches at the Site. The *LUCID* provides maps indicating the locations where pesticide-impacted soil is known or assumed to be present in utility trenches.

3.1.4 Soil Management Areas at Hickam Communities

As a result of construction, redevelopment, and renovation at HC project sites, including ROs, no pesticide-impacted soil is transported off-site for disposal. Although soil generated by these activities is commonly managed within the HC project boundary by placement under hardscapes and/or a 1-foot clean soil cap, two other management methods are used at HC, which are described below.

3.1.4.1 Burial Pits

To manage pesticide-impacted soil, burial pits are constructed within the HC property boundary. To construct these burial pits, soil is excavated in open areas to a maximum depth of 5-feet above mean sea level (approximately 8 to 12 feet below final grade), which is deeper than the expected depth of pesticide application. These burial pits are then backfilled with pesticide-impacted soil, a marker layer of orange geotextile fabric installed, followed by a 2-foot clean soil cap.

There are currently no burial pits located at the neighborhoods within the Site. The burial pits at HC were installed in the Onizuka II-2 and Onizuka II-3 neighborhoods starting in 2009; the last available pit was closed in the fall of 2011 (Figure 3-1). Approximately 1,318 cubic yards (CY) of soil from RO #1 and 245 CY of soil from RO #2 is managed in Burial Pit No. 6b located in the Onizuka II-3 neighborhood.[73]

3.1.4.2 Soil Berms

With the pending closure of the burial pits at the Onizuka Village neighborhood, soil berming was identified as a new management option for pesticide-impacted soil at HC. Soil berms are an above-ground management method where pesticide-impacted soil is placed into an elongated berm, compacted, covered with a marker layer of orange geotextile fabric, and then capped with 2-feet of clean soil. This clean cap is subsequently landscaped with a groundcover.

To manage the soil generated from the Historic Homes District, and the soil from generated from RO #3, construction of a soil berm was proposed at the Earhart I-2 neighborhood to manage this pesticide-impacted soil (Figure 3-2). The berm was engineered and constructed based on plans and procedures presented in the *Soil Management Plan for Pesticide-Impacted Soil Berms, Earhart I-2 Neighborhood, DCN: 2626001.0002.F01,*[74] which was approved by HDOH in its letter dated August 22, 2011.[75] The total capacity of the Earhart I-2 soil berm is

[73] (Tetra Tech 2012d)
[74] (Tetra Tech 2011c)
[75] (HDOH 2011e)

approximately 15,500 CY,[76] including approximately 1,390 CY of pesticide-impacted soil from RO #3 which was transported to the berm in February 2012.[77]

[76] (Tetra Tech 2011c)
[77] (Tetra Tech 2012d)

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4.0 ENVIRONMENTAL HAZARD EVALUATION (EHE)

An *EHE* was prepared for the Site and included as Appendix E of the *RI Report*.[78] The purpose of the EHE was to recommend alternative EALs and provide corresponding support documentation to support soil management and cleanup at HC. The proposed alternative EALs were derived to incorporate the most up-to-date scientific practices and to reflect current recommended risk assessment guidelines. The alternative residential EALs provided in the *EHE* and used in this evaluation are considered to be protective of human health, particularly when coupled with strict soil management controls at JBPHH, such as restrictions on digging associated with the residential leases, maintaining good lawn cover, and other restrictions to be instituted as part of the long-term management of the Site. The land use restrictions will be detailed in the *LUCID* for HC.

The alternative EALs in the *EHE* have been used to evaluate potential human health risks in the four neighborhoods, in accordance with HDOH risk assessment guidelines in order to evaluate the need for, or scope of, potential remediation/mitigation efforts in the Hickam neighborhoods.

As described in the *EHE*, the soil within each DU sampled during the SI was evaluated using the 2011 HHRE Standard presented draft *HHRE WP* dated October 31, 2011,[79] and approved by HDOH in its letter dated June 7, 2011.[80] As per the HDOH-approved 2011 HHRE Standard, a DU is not considered to pose a threat to human health and the environment due to organochlorine pesticides if all of the following criteria are met:

1. The cumulative excess cancer risk (ECR) for aldrin plus dieldrin must not exceed 1×10^{-4};

2. The cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5};

3. The cumulative ECR for all COPCs must not exceed 1×10^{-4}; and

4. The hazard index for all COPCs must not exceed 1. If any of these criteria are not met, then the soil within the DU is considered to pose a threat to human health and the environment and must be treated accordingly.

Although aldrin and dieldrin are the primary chemicals of concern at the Site, alternative EALs are also provided for both child and adult residents for all organochlorine pesticides detected in soil during the 2010 Site investigation. The full list of residential EALs approved for the Site is summarized in Table 4-1 (child resident) and in Table 4-2 (adult resident). These values were developed as part of the final *HHRE WP* dated October 7, 2011[81] and approved by HDOH in its letter dated October 31, 2012,[82] with final approval provided by HDOH in its letter dated February 27, 2012.[83]

The Site has been thoroughly investigated, and, as part of the *EHE*, specific portions of the Site have been identified where either remediation or the implementation of soil management or

[78] (Tetra Tech 2012c)
[79] (Tetra Tech 2011a)
[80] (HDOH 2011b)
[81] (Tetra Tech 2011e)
[82] (HDOH 2011h)
[83] (HDOH 2012b)

institutional controls were required during the three ROs to mitigate direct exposures to contaminants in soil that could pose an environmental hazard.

Table 4-1. 2012 Residential EALs – Child Resident

Chemical	HC Site-Specific Soil Screening Levels (mg/kg)	
	Cancer	Noncancer
	Target Risk [(a)]	Target HQ = 1
Aldrin	42.1	12.2
Chlordane	42.6	38.3
Dieldrin	20.4	9.8
DDD	48.7	-
DDE	34.4	-
DDT	46	67
Endrin	-	30.1
Endrin Ketone	-	30.1
Endosulfan Sulfate	-	601.6
delta-BHC	-	38.3
Methoxychlor	-	501.4

[(a)] Target risk of 1×10^{-4} applies only to aldrin and dieldrin; the cancer EALs for all other compounds were derived based on a target risk of 1×10^{-5}.
mg/kg: milligrams per kilogram
HQ: hazard quotient

Table 4-2. 2012 Recommended Alternative Residential EALs – Adult Resident

Chemical	HC Site-Specific Soil Screening Levels (mg/kg)	
	Cancer	Noncancer
	Target Risk [(a)]	Target HQ = 1
Aldrin	209.4	60.9
Chlordane	219.8	188.8
Dieldrin	101.4	48.7
DDD	253.6	-
DDE	179	-
DDT	223.7	326
Endrin	-	156.5
Endrin Ketone	-	156.5
Endosulfan Sulfate	-	3,130.5
delta-BHC	-	188.9
Methoxychlor	-	2,609

[(a)] Target risk of 1×10^{-4} applies only to aldrin and dieldrin; the cancer EALs for all other compounds were derived based on a target risk of 1×10^{-5}.
mg/kg: milligrams per kilogram
HQ: hazard quotient

5.0 REMEDIAL ACTION OBJECTIVES AND ESTABLISHING ALTERNATIVES

This section presents the RAOs for the project, which are the critical metrics necessary to achieve short and long-term protection of human health and the environment. This section also presents general response actions to be considered for inclusion in the identification, evaluation, and recommended selection of remedial alternatives in order to meet the RAOs. Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBC) criteria relevant to the response actions considered are also presented. Section 5.4 incorporates the evaluation of response actions and identifies the list of recommended remedial alternatives to be evaluated for the Site.

5.1 Remedial Action Objectives (RAOs)

Remedial action objectives are specific goals to be achieved by the remedy selected for the Site. These RAOs are specific to the anticipated exposure scenarios based on current and future use of the Site, site characteristics, COPCs, and potential outcomes. Based on the evaluation of both current and historic data, the primary environmental hazard associated with the Site is human direct exposure to pesticide-impacted soil. Therefore, the selected remedial action will need to sufficiently address this hazard.

5.1.1 Determination Of Remedial Action Objectives

The primary remedial action objective is to reduce the remaining risk from residual pesticide-impacted soil at the Site to acceptable levels. The remedial action alternatives evaluated must address the following RAOs:

- Reduce contaminant concentrations in Site soil. Reduction of contaminant concentrations may be achieved by either directly removing contaminated soil by excavation, or by treating compacted soil using a commonly accepted technology such as bioremediation.
- Remove direct exposure pathways between contaminants and receptors. This objective can be accomplished by destroying the contaminants, changing the physical state of the contaminated media, placing a barrier that would prevent direct contact between contaminants and receptors, and/or implementation of institutional controls for the Site.
- Prevent migration of contaminants. This objective can be accomplished by removing or destroying the contaminants, changing the physical state of the contaminated media, placing a barrier to immobilize contaminants, and/or establishing institutional controls for the Site.
- Minimize potential adverse impacts. Minimization of impacts would apply to the surrounding communities and the environment during implementation of the remedy. The alternative must meet long-term standards regarding protection of human health that can be accomplished through management practices or institutional controls.
- Compliance with ARARs. Meet all applicable federal, state and local regulations pertaining to the Site and the specific remedial action.

5.2 Potentially Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBC) Criteria

An ARAR is any state or federal statute that pertains to protection of human life and the environment in addressing specific conditions or use of a particular cleanup technology at a cleanup site. As defined in the State Contingency Plan[84], "Applicable requirements" means those federal, state, and local requirements that are legally applicable to a hazardous substance of pollutant or contaminant, response action, location, or other circumstance found at a site. Generally ARAR and TBC criteria are considered laws, statutes, or guidelines which should be considered in addition to the specific cleanup criteria identified in Hawai'i Administrative Rules (HAR) §11-451 and Hawai'i Revised Statute (HRS) 128D.

Because ARARs do not exist for every chemical or circumstance, TBC criteria, specifically nonpromulgated federal or state advisories and/or guidance materials, may help determine the levels or goals that are protective of human health and the environment and the necessary approach needed to carry out certain actions or requirements. Since TBCs are nonpromulgated they are not legally binding and do not have the status of ARARs.

The ARARs and TBCs fall into three broad categories:

- Chemical-specific, which establish numerical standards limiting the concentration of substances in the medium of concern or medium affected by the cleanup action;
- Location-specific, which restrict the concentration of a substance or the performance of the cleanup action on the basis of site location; and
- Action-specific, which restrict the performance and design standards of a particular cleanup action on the basis of a technology or activity.

These ARAR and TBC categories and their applicability to the Site are discussed below in Sections 5.2.1 through 5.2.3.

5.2.1 Potential Chemical-Specific ARARs and TBCs

In addition to action levels or cleanup criteria being conducted under this remedial action under the State Contingency Plan (HAR §11-451), or the Hawai'i Environmental Response Law (HRS 128D, Part I)[85], no chemical-specific ARARs or TBCs are identified for the Site.

5.2.2 Potential Location-Specific ARARs and TBCs

Typical location-specific ARARs are federal and state regulations that protect cultural and ecological resources. Location-specific requirements may set restrictions on activities in specific locations, such as wetlands, historical sites, or coastal areas. No location-specific ARARs or TBCs are identified for the Site.

5.2.3 Potential Action-Specific ARARs and TBCs

Action-specific requirements are usually technology or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the

[84] *Hawai'i Administrative Rules (HAR) Title 11 Department of Health, Chapter 451 State Contingency Plan*. August 2, 1995.
[85] *Hawai'i Revised Statutes (HRS) Hawai'i Environmental Response Law, Chapter 128D, Part I: Environmental Response Law*. As Amended 1990.

particular response activities selected for a site. Table 5-1 presents the potential action-specific ARARs.

Table 5-1. Action Specific ARARs

Citation/Description	Applicability to Site
40 Code of Federal Regulations (CFR) Part 261. Resource Conservation and Recovery Act (RCRA) Hazardous Waste Classification Criteria Solid wastes are classified as hazardous if they are listed wastes or exhibit characteristics of ignitability, corrosivity, reactivity, or toxicity. RCRA hazardous wastes are subject to regulations governing transport, treatment, storage, and disposal.	**Applicable to ex-situ alternatives described in this RAA.** Excavated soil must be evaluated to determine if it is a hazardous waste under RCRA. These requirements are applicable for any alternative that involves excavation and off-site disposal of material that may include hazardous waste.
40 CFR 268.48 RCRA Universal Treatment Standards Soil must be treated also for their underlying constituents (known as the universal treatment standard).	**Applicable to any alternative in this RAA involving treatment of hazardous waste.** These requirements provide for universal treatment standards to each hazardous constituent listed.
40 CFR 265.300-265.310, 265.117-265.120 RCRA Landfill Requirements *HRS 342H* *HAR §11-58* These sections set forth federal and state requirements governing owners and operators of facilities that dispose of hazardous waste in landfills, including design and operating requirements, monitoring and inspection, closure and post closure.	**Applicable to any alternative in this RAA where hazardous waste is left in place or disposed of off-site.** Substantive provisions applicable to any alternative where hazardous waste is left in place or disposed of off-site. Waste must comply with the federal and state landfill requirements.
29 CFR 1926.652 Safety and Health Regulations for Construction – Requirements for Protective Systems *HAR §12-132.2-1* Incorporation of Federal Standard 29 CFR 1926.652 This section sets for federal requirements for excavations, specifically the shoring requirement in 1926.652(a)(1)(ii) where excavations less than 5 feet in depth do not require shoring if examination of the ground by a competent person provides no indication of potential cave-in.	**Applicable to all alternatives in this RAA that involve excavation or other disruption of the soil.**
HAR §11-60.1-33 HAR Fugitive Dust This regulation requires responsible parties to take reasonable precautions to prevent visible fugitive dust from becoming airborne.	**Applicable to all alternatives in this RAA that involve excavation or other disruption of the soil.**
HRS §19-342J Hazardous Waste Management Act Protects the health, safety, and welfare of citizens, natural resources and the environment; requires permit to treat, store, and dispose of hazardous waste. Pertains to discharge of hazardous or solid waste on or into the land, air, or water, including groundwater.	**Applicable to any alternative in this RAA that involves excavation and off-site disposal of material that may include hazardous waste.**

5.3 General Response Actions (GRAs)

The GRAs presented here are based on the guidance provided in the *TGM* for compliance with HAR §11-451-8. This RAA has considered the following hierarchy of general response action alternatives in order of descending preference. These GRAs are described, and the applicability to the Site presented in Table 5-2:

Table 5-2. The GRAs and Applicability to the Site

GRA	Applicability
Reuse or Recycling. Mostly pertains to released hazardous substances such as recovered petroleum "free product", or scrap metals	**Not Applicable.** There is no source or volume that is recoverable. There is no known technology that will separate residual organochlorine pesticides from soil. Even if this technology exists, since use of organochlorine pesticides has been cancelled by the EPA, there would be no end user for any recycled pesticides, and they would require destruction.
Destruction or Detoxification. Neutralization of contaminants through alteration of the molecular structures using technologies such as biodegradation or incineration.	**Not Applicable.** Due to the persistent nature of organochlorine pesticides in soil, bioremediation of soil either ex-situ (land farming with aeration) or in-situ (application of bacteria and nutrients directly to soil) has proven to be ineffective. A bioremediation pilot study was performed on pesticide-impacted soil at the HC, and in laboratory bench testing between December 2009 and January 2010. Review of these results indicated that they were either inconclusive or that the effectiveness of this method for pesticide-impacted soil was poor (ENPRO 2010). Although incineration has been used to destroy pesticide-impacted soil, it not considered implementable at the Site due to the volume of soil that would require incineration. The incineration would be completed in an on-site kiln with an exhaust scrubber; however the resultant ash and spent scrubbers would still require disposal. The possibility of impacts to air quality from such a large-scale incineration project cannot be ruled out.
Separation, Concentration, or Volume Reduction. Contaminated material may be completely or partially separated from material that is not contaminated, or the volume of the contamination reduced using technologies such as soil vapor extraction.	**Not Applicable.** No technologies were identified or readily available that can effectively separate or reduce concentrations and/or volumes of organochlorine pesticides in soil.
Immobilization of Hazardous Substances. By changing the physical state of a contaminant, the contaminant may be immobilized. Commonly used technologies would include vitrification of contaminated soil or use of chemical additives to reduce bioavailability of contaminants.	**Not Applicable.** No proven technologies such as chemical additives were identified or readily available that would effectively immobilize organochlorine pesticides in soil.
On-site or Off-site Disposal, Isolation, or Containment. Contaminated media may be placed in at engineered facility designed to minimize the future release of hazardous substances. This would include on-site capping and management of the soil, or off-site landfill disposal.	**Applicable.** On-site or off-site disposal or containment has proven to be an effective and efficient response action in Hawai'i and has been implemented at HC. This GRA has been retained for further evaluation below.
Institutional Controls or Long-Term Monitoring.	**Applicable.** The use of management plans regarding pesticide-impacted soil have been demonstrated as

Table 5-2. The GRAs and Applicability to the Site

GRA	Applicability
Use of institutional controls to restrict access and/or long-term monitoring to assess changes in contaminant distribution over time.	implementable at HC. This GRA has been retained for further evaluation below.

5.3.1 On-site or Off-site Disposal, Isolation, or Containment

This GRA has been selected as being applicable to the Site since HC has already been removing and managing pesticide-impacted soil from construction sites within the HC property boundary since 2006. This on-site management consists of a combination of capping under hardscapes and/or 1 to 2 feet of clean soil, or placement into burial pits or soil berms (Section 3.1.4). Although off-site disposal is not used as a pesticide-impacted soil management option at HC (all pesticide-impacted soil is currently managed within HC), placement in an engineered facility such as a landfill can still be considered a viable option.

Both the on-site management and off-site disposal options remove the exposure pathway to pesticide-impacted soil by HC workers, residents, and guests; however, they are problematic to implement in the long-term. For on-site management, the majority of available space at HC has already been identified and used to manage pesticide-impacted soil. The burial pits at Onizuka Village have been filled to capacity, and even though soil berming has been approved for use at HC, there is also limited space available for berm construction.

Off-site disposal options on O'ahu are reliant on only two landfills (PVT and Waimanolo Gulch), which are nearing capacity. Also, if the soil profile indicates that the COPCs are present at concentrations exceeding HDOH Tier 1 EALs[86], the soil will be unsuitable for use by the landfill as daily cover (i.e. the soil that is used to bury garbage each day). For soil that is not suitable for use as daily cover, if the landfill agrees to accept this impacted soil, it must be directly disposed in the appropriate cells at the landfill.

5.3.2 Institutional Controls or Long-Term Monitoring

Institutional controls are included as an applicable GRA for the Site. Institutional controls are land-use controls that apply administrative methods to restrict and/or prevent exposure to potential hazards at a site. For a remedial action, institutional controls can be used in situations where it is not feasible or necessary to remove all contamination at a remedial action site.[87] This GRA is very applicable to the Site since there are established mechanisms already being implemented by HC. Institutional controls currently being implemented, or are in development at HC consist of:

- Program Manual: Targeted to HC construction workers and subcontractors, the *Program Manual* provides HC-specific procedures and controls for investigating and managing pesticide-impacted soil during redevelopment and renovation at HC.
- Pesticide-Awareness Program. Targeted at HC construction workers, subcontractors, and maintenance workers, mandatory pesticide-impacted soil training is required to be completed by all workers who may potentially be exposed to pesticide-impacted soil.

[86] (HDOH 2011g)
[87] (HDOH 2009)

- LUCID. Targeted at HC maintenance workers and subcontractors, the *LUCID* identifies the location of all known or presumed pesticide-impacted soil on HC property, and provides standard operating procedures for planning conducting soil disturbing work during maintenance, and during emergency repairs of underground utilities.
- Resident Guide: The *Resident Guide* is provided as an attachment to the tenant lease, and is targeted at HC residents. The *Resident Guide* provides a clear restriction on soil disturbing activities by residents on their leased property, or any other areas at HC.

Since HC implemented administrative and management controls for pesticide-impacted soil early in Construction Phase I, and continued into Construction Phase II, HC workers and staff are already familiar with potential hazards posed by pesticide-impacted soil at HC, and the procedures required for management of this soil. Further, all activities at the Site will be conducted in accordance with these controls as a long-term program since HC will retain control the Site over their 50-year ground lease with the USAF.

5.4 Proposed Remedial Alternatives

Based on the retained GRAs, four proposed remedial alternatives have been identified which range from no action to an unrestricted use scenario. These four alternatives were selected because: (1) the lack of an immediate hazard to residents or construction workers at the Site and receptors at the Site; and (2) the summary of retained general response actions. These alternatives are presented below and will be further evaluated against effectiveness, implementability, and cost in Section 6.0.

5.4.1 Alternative 1: No action

The “no action” alternative does not require any remedial actions at the Site. Inclusion of the no action alternative is recommended in order to establish a baseline for the evaluation of other alternatives.[88] For the baseline condition of the Site, a scenario is applied where no actions have yet been conducted in response to the initial discovery of pesticide-impacted soil. Although existing administrative and soil management controls may be implemented under this alternative, they would not be required, nor would any additional controls or long-term monitoring of the Site. Alternative 1 evaluates site conditions in the absence of the three ROs (RO #1, RO #2, and RO #3), and is the only alternative in the RAA where this baseline scenario is applied.

5.4.2 Alternative 2: Cleanup to Unrestricted Use: On-site Placement

Based on where residual pesticide-impacted soil is known or presumed to be present at the Site (Section 3.0), this alternative would allow for unrestricted future use of the Site, regardless of construction activities, through the removal of all pesticide-impacted soil at the Site, including the pesticide-impacted soil berm constructed at the Earhart I-2 neighborhood at the Site (Section 3.1.4). The pesticide-impacted soil removed during the RO #1 and RO #2 that was at Onizuka II-3 Burial Pit No. 6b would not require excavation since this soil is already managed outside the boundary of the Site. For unrestricted use to apply, no soil at the Site would have organochlorine pesticide concentrations exceeding the respective HDOH Tier 1 EALs (for unrestricted land use in areas that are greater than 150 meters from the nearest surface water body and where groundwater is not considered a current or potential drinking water source)[89].

[88] (HDOH 2009)
[89] (HDOH 2011g)

For unrestricted use, no further remedial actions would be required, nor the implementation of land use controls or long-term monitoring. The removed soil would be managed within the HC property boundary.

Under this alternative, HC would be required to characterize all soil at the Site to determine any soil exceeding the HDOH Tier I criteria. This characterization would involve advancing borings sited on a 200 square foot grid to a depth of 10 feet below grade, and soil samples collected at 1 foot intervals from each boring for analysis of organochlorine pesticides. Any soil horizons having organochlorine pesticides exceeding the respective HDOH Tier 1 EALs would be excavated and removed. For areas not accessible (for example beneath current structures or homes), investigation and soil removal would be conducted at a later date in the event the structures are removed or renovated. Based on the known and presumed location of residual pesticide-impacted soil at the Site, the costs associated with this removal assumed an average depth of removed soil would be 4 feet below grade across the Site. Actual depths and soil volumes would be determined during the characterization efforts. The Site would then be backfilled with clean soil and compacted in lifts to planned final grade. During development of Alternative 2, characterization and removal of surface soil using an assumed average depth of 1-foot below grade was considered. Any soil deeper than 1-foot below grade in areas where surface soil exceeds the HDOH Tier 1EALs would be managed in place using institutional controls since this deeper soil may also exceed the HDOH Tier 1 EALs. Although this scenario would reduce the amount soil requiring removal, the overall effect would not change the scoring significantly. The cost for excavating all surface soil to return the Site to unrestricted use would still be prohibitive, and the remaining soil would still require implementation of institutional controls and long-term monitoring.

Since the purpose of this alternative is cleanup of the Site to an unrestricted use scenario, the removed soil could not be managed within the Site boundary, but would require management elsewhere on HC property. This on-site management would likely consist primarily of soil berming since available burial pit sites have already reached capacity at HC. Any areas including soil excavated during the remediation would require long-term controls and monitoring including inspection, maintenance, and repair of soil berms.

5.4.3 Alternative 3: Cleanup to Unrestricted Use: Off-site Disposal

Similar to Alternative 2, this alternative also would require further investigation and removal of all pesticide-impacted soil at the Site, the making the entire Site suitable for unrestricted use. This would include removal of the pesticide-impacted soil berm constructed at the Earhart I-2 neighborhood at the Site, and the soil from RO #1 and RO #2 managed at the Onizuka Village Burial Pit No. 2b (Section 3.1.4). Under this alternative, however, all of the removed soil would be transported by truck off-site for disposal at a local landfill on O‘ahu (e.g. PVT or Waimanolo Gulch).

5.4.4 Alternative 4: Implementation of Institutional Controls.

Alternative 4 consists of no further remedial action and implementation of institutional controls at the Site. As discussed in Section 5.3.2, administrative and soil management controls for pesticide-impacted soil have been implemented at HC since 2006. Additional institutional controls would include the *LUCID* and the preparation of a comprehensive *EHMP*, which would outline proactive inspections and long-term monitoring to ensure that all administrative and soil management controls are being consistently and effectively implemented at the Site. Given the importance of the *EHMP* in regards to the evaluation of this alternative, a draft *EHMP* has been submitted to HDOH for review. It should be noted that the final RAA will be predicated upon

HDOH approval the draft final *EHMP*[90]. Further the *EHMP* may be amended as a result of any pertinent concerns expressed during the public review of the RAM.

To ensure that institutional controls are maintained over the 50-year ground lease, long-term monitoring of institutional controls provided in the *Program Manual, LUCID*, and the *EHMP* will include:

- Updates to the project plans (including maps) due to changes in where pesticide-impacted soil is known or presumed to be present at the Site. This might occur as a result of repairs where a previously impacted area is excavated and backfilled with clean soil during planned maintenance or emergency repairs (e.g. removal of pesticide-impacted soil previously managed in a utility trench);
- Regular inspections and reporting for the condition of soil management controls such as soil caps, grass cover, and hardscapes;
- Environmental oversight and reporting during planned maintenance work, or soil disturbing work during emergency repairs;
- Outreach to HC residents to maintain awareness of pesticide-impacted soil-related hazards and restrictions.

[90] (Tetra Tech 2012a)

6.0 DETAILED ANALYSIS AND COMPARISON OF RETAINED REMEDIAL ALTERNATIVES

The purpose of this section is to present a detailed analysis of each of the four proposed remedial alternatives compared the three threshold criteria of effectiveness, implementability, and cost; the RAOs are included in the effectiveness criterion. This section will conclude with scoring of the alternatives which is intended to support the recommended preferred remedial alternative for the Site, which will be presented in Section 7.0.

6.1 Response Action Screening Criteria

The TGM[91] for remedial actions describes three criteria that should be evaluated for each alternative (or technology) during the preliminary screening process. These criteria are effectiveness, implementability, and cost, as described below.

6.1.1 Effectiveness

The effectiveness of a response action alternative refers to the degree to which the action meets threshold criteria and RAOs. The key aspects of the effectiveness criterion include:

- The overall protection of human health and the environment.
- The short-term effects of the response action alternative on human health and the environment during implementation. This would include the impacts to nearby communities, site workers, and the surrounding environment. This would also include the time required until the remedial objective alternatives are achieved.
- The long-term effectiveness of managing the residual risk remaining from any remaining contamination and the adequacy and reliability of controls used to manage the treated residuals or untreated contaminated media.
- The degree to which the response action complies with ARARs established for the Site.
- The degree to which the response action reduces the toxicity, mobility, and/or volume of the hazardous substance or contaminated media.

6.1.2 Implementability

The implementability of an alternative is measured by considering the technical and administrative feasibility of implementing any aspect of the response action alternative. Technical feasibility includes such factors as the availability of equipment, facilities, and specialists; reliability of the technology; and the compatibility of the technology with current and future site conditions. Administrative feasibility includes factors such as the availability of necessary approvals to implement the technology and the degree of community acceptance.

6.1.3 Cost

The cost of each response action is a significant factor in determining the selected remedy. Cost considerations not only include capital costs, but the life-cycle costs such as operation and maintenance (O&M) costs for implementing a specific alternative. Costs that are grossly excessive and disproportionate compared to other actions are one factor that may be used to eliminate one or more alternatives.

[91] (HDOH 2009)

6.2 Comparative Analysis of Remedial Alternatives

This section provides comparison of the four remedial alternatives. The purpose of the comparison is to evaluate all aspects of each alternative to select the most appropriate and effective preferred alternative(s) as a proposed remedy for the Site. This will be completed by listing the "pros and cons" of each alternative, and then each alternative will be compared and scored based on the three criteria of effectiveness (both short and long-term), implementability (technical and administrative) and cost. A comparison of the alternatives is presented in Table 6-1. A comparison of the costs of each alternative is presented in Table 6-2, and a complete breakdown of these costs is provided in Appendix A.

6.2.1 Alternative 1: No Action

Since Alternative 1 assumes a baseline condition for the Site where no removal or remedial actions have been implemented, this alternative has low effectiveness in the short and long-term. This is due to the potential for current and future exposures to pesticide-impacted soil present in surface soil at the Site.

Issues to Consider:

- The COPC concentrations would not be reduced at the Site since pesticide-impacted soil would remain in surface soil at the Site.
- There are short and long-term exposure pathways for HC workers, residents, and guests to pesticide-impacted soil. There is also an increased long-term potential exposure hazard to construction and maintenance workers from insufficient controls that could result in disturbance and exposure to pesticide-impacted soil.
- Existing institutional controls will be under long-term monitoring by HC over the 50-year ground lease. There would no additional institutional controls or an *EHMP* developed under the remedial action process to further restrict or prevent the potential for future exposure to pesticide-impacted soil.

Practicality of Implementation:

- Implementation of this alternative would have no impact on the military mission and JBPHH, the surrounding communities, or environment.
- There are currently institutional controls provided by *Program Manual, LUCID,* and *the Resident Guide,* in place at the Site.

Cost to Implement and Maintain:

- No cost for implementing and maintaining Alternative 1.

6.2.2 Alternative 2: Cleanup to Unrestricted Use (On-Site Placement)

Alternative 2 would only be moderately effective for the Site. Even though it would remove all of the pesticide-impacted soil from the Site, in the short term this alternative has low effectiveness since the excavation and removal of currently capped pesticide-impacted soil would present a potential exposure hazard to residents from dust emissions, or spillage of soil during transport.

Issues to Consider:

- The COPC concentrations would be reduced at the Site since all of the pesticide-impacted soil would be removed.
- No further land-use controls would be required since the Site would be suitable for unrestricted use.
- The overall volume of pesticide-impacted soil is not eliminated by this alternative since it would not be destroyed or detoxified, only be moved for long-term management at other neighborhoods within HC
- Management of removed pesticide-impacted soil at HC would require additional land-use controls.
- Limited available space for on-site management of pesticide-impacted soil at HC. There is the potential of migration of pesticide-impacted soil during excavation and removal through dust emissions and spills.

Practicality of Implementation:

- Would be difficult to implement since removal of pesticide-impacted soil from beneath homes and structures could only be conducted following removal or renovation of these homes and structures.
- Large scale characterization and removal of pesticide-impacted soil from open areas around homes and structures would require relocation of HC residents, and costs incurred by terminating the leases, identifying alternative housing, and providing moving expenses for residents.
- Relocation of military personnel has potential negative impacts on the military mission at JBPHH, and implementation of this alternative could meet resistance by the USAF and US Navy.

Cost to Implement and Maintain:

- Extremely high cost for implementing and maintaining Alternative 2.

There are homes and infrastructure present at the Site, and the cost of demolishing and rebuilding these structures, or relocating HC residents, was not included in the estimate provided in Table 6-2. Even though a 6-month schedule was used estimate costs following demolition of the neighborhood, it is unlikely that entire neighborhoods would be demolished in one event to excavate the pesticide-impacted soil beneath them. It is more likely that the soil under homes would be removed following the future removal of these structures for redevelopment, or due to a change of use at the Site.

For Alternative 2, soil berms are the most likely on-site soil management option. The O&M procedures for soil berms used to estimate the costs in Table 6-2 include irrigation, inspections and reporting, and berm and landscape maintenance and repair. The O&M costs assume annual costs over 45 years based on a start date of 2012 and the year of termination of the ground lease in 2057. The O&M costs are assumed to be static and have not been amortized.

6.2.3 Alterative 3: Cleanup to Unrestricted Use: (Off-Site Disposal)

Alternative 3 would only be moderately effective for the Site. Even though it would remove all of the pesticide-impacted soil from the Site, in the short-term this alternative has low effectiveness since the excavation and removal of currently capped pesticide-impacted soil would present a potential exposure hazard to residents from dust emissions, or spillage of soil during transport.

Issues to Consider:

- The COPC concentrations would be reduced at the Site since all of the pesticide-impacted soil would be removed.
- No further land-use controls would be required since the Site would be suitable for unrestricted use.
- The overall volume of pesticide-impacted soil is not eliminated by this alternative since it would not be destroyed or detoxified, only transported to off-site landfills on O‘ahu for disposal.
- Limited capacity in local landfills, and no guarantee that they would accept such large volumes of pesticide-impacted soil.
- There is the potential of migration of pesticide-impacted soil during excavation and removal through dust emissions and spills.
- Large potential disruption to military operations due to heavy truck traffic on roads at JBPHH. There would also be a high “carbon footprint” associated with using diesel trucks to transport the soil off-site.

Practicality of Implementation:

- Would be difficult to implement since removal of pesticide-impacted soil from beneath homes and structures could only be conducted following removal or renovation of these homes and structures.
- Large scale characterization and removal of pesticide-impacted soil from open areas around homes and structures would require relocation of HC residents, and costs incurred by terminating the leases, identifying alternative housing, and providing moving expenses for residents.
- Relocation of military personnel has potential negative impacts on the military mission at JBPHH, and implementation of this alternative could meet resistance by the USAF and US Navy.

Cost to Implement and Maintain:

- Extremely high cost for implementing Alternative 3.

There are homes and infrastructure present at the Site, and the costs of demolishing and rebuilding these structures, or relocating HC residents, was not included in the estimate provided in Table 6-2. Even though a 6-month schedule was used estimate costs following demolition of the neighborhood, it is unlikely that entire neighborhoods would be demolished in one event to excavate the pesticide-impacted soil beneath them. It is more likely that the soil under homes would be removed following the future removal of these structures for redevelopment, or due to a change of use at the Site.

For Alternative 3, off-site disposal assumes soil will be loaded and transported directly to the landfill. No on-site handling (stockpiling) or transporting costs are included in Table 6-2. Additional project management costs for Alternative 3 include part-time staff for tracking of all of the waste shipments/manifests. There would be no O&M costs incurred for this alternative since the pesticide-impacted soil would be disposed off-site. Further, since the Site would be suitable for unrestricted use, no institutional controls would be required.

6.2.4 Alterative 4: Institutional Controls

Alternative 1 is highly effective for the Site. Since no current hazards are present at the Site, and institutional controls would be provided by the *Program Manual* and the *Resident Guide*, with additional controls and monitoring provided by the *LUCID* and the *EHMP*, it has high effectiveness in both the short term and long-term.

Issues to Consider:

- The COPC concentrations would not be reduced at the Site since residual pesticide-impacted soil would remain at the Site.
- There is no short-term exposure pathway for HC workers, residents, and guests from pesticide-impacted soil; however, there is a long-term potential exposure hazard to construction and maintenance workers if institutional controls are not properly maintained HC.
- Although capping provides a barrier preventing short-term exposure and mobilization of pesticide-impacted soil, in the long-term, there is the potential for disturbance and migration of pesticide-impacted soil.
- Existing and additional institutional controls will be under long-term monitoring by HC over the 50-year ground lease.

Practicality of Implementation:

- There are currently institutional controls provided by *Program Manual* and *the Resident Guide,* in place at the Site.
- Implementation of this alternative would have minimal impacts on the military mission and JBPHH, the surrounding communities, or environment.
- There would be additional institutional controls provided by the *LUCID* and the *EHMP* developed under the remedial action process to further restrict or prevent the potential for future exposure to residual pesticide-impacted soil.
- The implementation of these institutional controls would be monitored over the long-term.

Cost to Implement and Maintain:

- Moderate cost for implementing and maintaining Alternative 4.

For Alternative 4, costs for annual O&M of the *Program Manual*, *LUCID*, and *EHMP* are included in Table 6-2 on a per year basis. The annual O&M cost for the *Program Manual* is expected to be phased out after 5 years as the Construction Phase II nears completion.

Costs for the development of the *LUCID* and *EHMP* under Alternative 4 are included in this final cost comparison in Table 6-2. Costs for the development of the *MPPIS* and the *Program Manual* are not included in Table 6-2 since these plans were developed prior to the remedial action; however the estimated development costs for the *MPPIS* and the *Program Manual*, are provided in Appendix A for reference. Additional costs included in Table 6-2 are the estimated costs for monitoring and maintaining institutional controls over the 50-year ground lease.

Table 6-1. Remedial Alternatives Analysis.

Criteria	Remedial Alternative			
	1 No Action	2 Unrestricted Use (On-Site Management)	3 Unrestricted Use (Off-Site Management)	4 Institutional Controls
Effectiveness: **Overall Protection of Human Health and the Environment**	**Low Effectiveness.** --Short-term: Low effectiveness since pesticide-impacted soil would still be present at the Site --Long-term: Low since all pesticide-impacted soil would still be present at the site. It does not allow for additional mandated long-term institutional controls. There are existing plans to address pesticide-impacted soil management; however, these soil management plans are not an EHMP developed under the remedial action process.	**Moderate Effectiveness**. --Short-term: Low effectiveness since there is no need to conduct excavation since there are current hazards. Excavation of residual pesticide-impacted soil may present a risk to residents by exposing capped pesticide-impacted soil. Excavation of contaminated soil has the potential of creating dust emissions and the possibility of distribution of contaminated soil outside of work areas during excavation and transport. --Long-term: High effectiveness since removes all of the contamination and leaves site in "unrestricted use" condition.	**Moderate Effectiveness.** --Short-term: Low effectiveness since there is no need to conduct excavation since there are current hazards. Excavation of residual pesticide-impacted soil may present a risk to residents by exposing capped pesticide-impacted soil. Excavation of contaminated soil has the potential of creating dust emissions and the possibility of distribution of contaminated soil outside of work areas during excavation and transport. --Long-term: High effectiveness since removes all of the contamination and leaves site in "unrestricted use" condition.	**High Effectiveness.** --Short-term: High effectiveness because there is no existing hazard. Also, since HC has already have institutional controls in place for pesticide-impacted soil since 2004. These institutional controls are presented in pesticide-impacted soil Management Program Manual. HC staff is already familiar with pesticide-impacted soil management procedures. --Long- term: Over-protective for long-term because of the institutional controls and the EHMP (which is a remedial action document). In addition, the Site will be managed by HC for the next 50 years under the 50 year ground lease, and the adherence to institutional controls can be monitored by HC.
Effectiveness: **Compliance with ARARs**	**Moderate Effectiveness** --Complies with ARARs; however, would not comply with protectiveness measures identified in HAR §11-451.	**High Effectiveness.** --Complies with ARARs	**High Effectiveness.** --Complies with ARARs	**High Effectiveness.** --Complies with ARARs
Effectiveness: **Reduction of Toxicity, Mobility, and Volume**	**Low Effectiveness.** --Short and long-term: There is no reduction in volume, and pesticide-impacted surface soil has the potential to be distributed within and outside the Site. Low effectiveness since it does not remove or reduce the toxicity	**Low Effectiveness.** --The intent of this criterion is to evaluate actual reduction of contaminant. In the case of excavation, the toxicity is not being reduced since the pesticide-impacted soil is being removed and placed in another location at HC. --Since pesticide-impacted soil is being transported, there is the potential for distributing the soil during excavation by dust emission, and during loading, transport and off-loading by both dust emissions and spills.	**Moderate Effectiveness.** --The intent of this criterion is to evaluate actual reduction of contaminant. In the case of excavation, the toxicity is not being reduced since the pesticide-impacted soil is being removed and placed at another location on O‘ahu. --Since pesticide-impacted soil is being transported, there is the potential for distributing the soil during excavation by dust emission, and during loading, transport and off-loading by both dust emissions and spills.	**Low Effectiveness.** --Short term: Since residual pesticide-impacted soil is capped, there is no current need to reduce toxicity; reduction of toxicity is not really applicable. --Long term: Low effectiveness since it does not remove or reduce the toxicity.
Implementability: **Technical Feasibility**	**High Implementability.** --Does not require any additional work to implement.	**Low Implementability.** --Would require the demolition and rebuilding of the neighborhoods. Removal of soil in areas not currently occupied, but that soil removal from backyards and under foundations would only happen if/when a house was demolished. --Contaminated soil could not be managed on the Site and would require management in other areas at HC.	**Low Implementability.** --Would require the demolition and rebuilding of the neighborhoods. Removal of soil in areas not currently occupied, but that soil removal from backyards and under foundations would only happen if/when a house was demolished. --Soil transported off-site for Landfill disposal would create a significant disruption to occupied neighborhoods and would require extensive planning to implement. --Availability of landfill space on O‘ahu is limited. --there is a high carbon footprint associated with truck transport of large quantities of soil. .	**High Implementability.** --Institutional controls already adopted at HC. Any additional institutional controls would be fairly easy to implement. --Project plans already developed for management of contaminated soil. --High degree of familiarity on soil management procedures at HC.
Implementability: **Administrative Feasibility**	**High Implementability.** --No administration of this alternative is required.	**Low Implementability.** --Would require extensive coordination with the USAF, and HC residents. --Possible relocation of HC residents who are active military personnel during excavation may interfere with military directives.	**Low Implementability.** --Would require extensive coordination with the USAF, and HC residents. --Possible relocation of HC residents who are active military personnel during excavation may interfere with military directives.	**High Implementability.** --Easy to implement since pesticide-impacted soil institutional controls are already adopted at HC. Comprehensive management plan in the EHMP will integrate easily into the existing management and monitoring strategies. --High degree of familiarity on soil management procedures at HC.
Cost: **Overall Costs**	**No Cost.** --No cost in implementation of this alternative. --No annual O&M Costs.	**High Cost.** --Highly expensive to implement --Long-term O&M costs for managing contaminated soil at HC.	**High Cost.** --highly expensive to implement --No O&M costs	**Low to Moderate Cost.** --HC-specific project plans have already been developed no cost incurred in the implementation. There will be a cost associated with the EHMP. --O&M costs would be incurred for updates to existing plans and EHMP.

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Table 6-2. Comparison of Estimated Costs

Description	Alternative			
	1	2	3	4
Project Management and Planning	$0	$587,920	$801,243	$2,850
Implementation of Remedy	$0	$63,275,409	$55,505,056	$57,000
Waste Management	$0	$50,923,530	$167,951,750	$0
Documentation / Reporting	$0	$151,000	$151,000	$0
Estimated Total Capital Costs	***$0***	***$114,937,859***	***$224,409,050***	***$59,850***
Estimated Cost Over for the Duration of the 50-year Ground Lease [(a)]	***$0***	***$11,457,794***	***$0***	***$7,793,249***
Grand Total	***$0***	***$126,395,653***	***$224,409,050***	***$7,853,099***

[(a)] Calculated for the remaining time on the ground lease (2057 – 2012 = 45 years)

6.3 Summary of Comparative Analysis of Remedial Alternatives

The comparative analysis of remedial alternatives with respect to the screening criteria is summarized using numerical values in Table 6-3. The alternative with the highest ranking for a specific criterion was given a score of 5 and the alternative with the lowest ranking for a specific criterion was given a score of 1. Therefore, the alternative with the highest total numerical value would rank the highest in this scoring system. It should be noted that the rankings were based on an "equal-weight" scoring system, where all criteria were considered to be of equal importance. This is often not the case, particularly in situations where funding is limited or in the presence of other constraints.

Table 6-3. Ranking of Remedial Alternatives

Criteria	Alternative			
	1	2	3	4
Effectiveness: Overall protection of human health and the environment	1	2	3	5
Effectiveness: Short-term effectiveness	1	1	1	5
Effectiveness: Long-term effectiveness	1	4	4	5
Effectiveness: Reduction of toxicity, mobility, and volume	1	1	2	2
Effectiveness: Compliance with ARARs	2	5	5	5
Implementability: Technical feasibility	5	1	1	5
Implementability: Administrative feasibility	5	3	3	5
Cost: Overall Costs	5	1	1	4
Total Score	***21***	***18***	***20***	***36***

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7.0 PREFERRED ALTERNATIVE

A remedy for a remedial action site can consist of more than one remedial alternative; however, one alternative was selected as the most effective, implementable, and cost effective for addressing environmental hazards at the Site. The preferred alternative selected as the proposed remedy for the Site is Alternative 4 – no further remedial action and institutional controls.

Alternative 4 was selected based on the following:

- There are no current hazards for HC workers, residents, and guests from pesticide-impacted soil at the Site.
- There are currently institutional controls provided by *Program Manual* and *the Resident Guide,* in place at the Site.
- Implementation of this alternative would have minimal impacts on the military mission and JBPHH, the surrounding communities, or environment.
- There would be additional institutional controls provided by the *LUCID* and the *EHMP* developed under the remedial action process to further restrict or prevent the potential for future exposure to residual pesticide-impacted soil.
- Reasonable costs to implement and maintain over HC's 50-year lease.
- The implementation of these institutional controls would have long-term monitoring by HC since they hold a 50-year ground lease on the property.

Successful implementation of Alternative 4 is contingent upon:

- Continued implementation and maintenance by HC of the existing institutional controls provided by the *Program Manual*, and the *Resident Guide*;
- Development and maintenance of the *LUCID* and the *EHMP* for the Site; and
- Long-term monitoring and reporting to ensure all institutional controls are in place and consistently implemented at the Site by HC.

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8.0 REFERENCES

ENPRO Environmental. 2010. *Interim Progress Report, Demonstration Bioremediation Project, Pesticides in Soil, Earhart I-4 Construction Site, Hickam Air Force Base*. Prepared for Actus Lend Lease, February 2, 2010.

CFR (Code of Federal Regulations). 2010. Table 1, CFR 40, Chapter I, Section 261.24, Toxicity Characteristic. Electronic Code Federal Regulations accessed at the GPO Internet Web site: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div8&view=text&node=40:25.0.1.1.2.3.1.5&idno=40

HAFB (Hickam Air Force Base). 2006. *Final Environmental Impact Statement, Housing Privatization Phase II, Hickam Air Force Base and Bellows Air Force Station, O'ahu, Hawai'i*. December 2006.

HC (Hickam Communities LLC). 2010. *Hickam Communities Resident Guide and Community Standards Handbook, Attachment A to Tenant Lease. Effective as of 1 January 2010*. Prepared by Hickam Communities LLC. 2010.

_____. 2011. *Voluntary Agreement for Environmental Response Actions, 4813-0003-0216.1.063953-00002.* Agreement between Hickam Communities LLC and Hawai'i Department Health. February 18, 2011.

HDOH (Hawai'i Department of Health). 2005. *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater*. HDOH Environmental Management Division. Hazard Evaluation and Emergency Response. Interim Final, May 2005.

_____. 2009. *Interim Final Technical Guidance Manual for Implementation of the Hawai'i State Contingency Plan*. Prepared by Hawai'i Department of Health Environmental Management Division. June 21, 2009.

_____. 2011a. *Subject: Review of Review of Decision Unit Area Selection at the Hale Na Koa Neighborhood, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i (1/27/2011). Facility/Sites: Air Force MFH HAFB Hale Na Koa I-1. 2011-107-ES*. Letter from Eric Sadoyama HDOH to Roger Franklin, Lend Lease LLC - Public Partnerships. February 28, 2011.

_____. 2011b. *Subject: Review of Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam. 2011-303-ES*. Letter from Eric Sadoyama HDOH to Roger Franklin, Lend Lease LLC - Public Partnerships. June 7, 2011.

_____. 2011c. *Subject: Review of Draft Removal Action No. 3 Work Plan, Removal Actions for Pesticide-Impacted Soil, Earhart I-2, Earhrt I-3, and Onizuka II-1 (5/19/11). Facility/Sites: Hickam Communities sites. 2011-310-ES*. Letter from Eric Sadoyama HDOH to Roger Franklin, Lend Lease LLC - Public Partnerships. June 9, 2011.

_____. 2011d. *Review of Evaluation of Adequacy of the Previous Sampling Conducted at the Hale Na Koa I-1 and Onizuka II-1 Neighborhoods (5/6/2011). Facility/Sites: Air Force MFH HAFB Hale Na Koa I-1, Air Force MFH HAFB Onizuka II-1. 2011-454-ES*. Letter

from Eric Sadoyama HDOH to Roger Franklin, Lend Lease LLC - Public Partnerships. August 22, 2011.

_____. 2011e. *Subject: Pesticide-Impacted Soil Berm at Earhart 1-2, Facility Sites: Air Force MFH HAFB Earhart 1-2, 2011-469-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). August 22, 2011.

_____. 2011f. *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater*. HDOH Environmental Management Division. Fall 2011 Updates. Hazard Evaluation and Emergency Response. Interim Final, Fall 2011.

_____. 2011g. *HDOH Environmental Action Levels, Supplemental Models in Excel Format, EAL Surfer*. 2005 EALs updated in Fall 2011. Accessed at internet website URL:

_____. 2011h. *Subject: Review of Revised Draft Preliminary Human Health Risk Evaluation Work Plan (October 7, 2011), Facility/Sites: Hickam Communities sites, 2011-627-ES.* Letter from Eric Sadoyama HDOH to Roger Franklin, Lend Lease LLC - Public Partnerships. October 31, 2011.

_____. 2012a. *Subject: Review of Removal Action Report F01 (December 20, 2011) and Remedial Alternatives Analysis D04 (December 29, 2011), Facility Sites: Air Force MFH Hickam Communities Remedial Action, 2012-045-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). February 3, 2012.

_____. 2012b. *Subject: Validation of adjusted EALs for the Hickam Communities Remedial Action site, Facility/Site: Air Force MFH Hickam Communities Remedial Action, 2012-137-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). February 27, 2012.

_____. 2012c. *Subject: Review of Hickam Communities remedial documents RAR F02, RI D04, EHE D04, RAA D06, RAM D01, EHMP D04, and LUCID D03, Facility/Site: Air Force MFH Hickam Communities Remedial Action, 2012-245-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). April 16, 2012.

_____. 2012d. *Subject: Review of Hickam Communities remedial documents RAR F03, RI D05, EHE D05, RAA D07, RAM D02, EHMP F01, and LUCID F01, Facility/Site: Air Force MFH Hickam Communities Remedial Action, 2012-332-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). May 25, 2012.

_____. 2012e. *Subject: Review of Hickam Communities remedial documents RAR F03, RI F01, EHE F01, RAA F01, RAM D01, EHMP F02, and LUCID F02, Facility/Site: Air Force MFH Hickam Communities Remedial Action, 2012-348-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). June 4, 2012.

KJC (Kennedy, Jenks, Chilton Consulting Engineers). 1991. *Final Pre-Construction Survey (PCS) of Hickam Family Housing Project Site, 90 Dwelling Units, FY 90-92. Onizuka Village, Hickam AFB, Oʻahu, Hawaiʻi*. July 1991.

Tetra Tech. 2004. *Phase II Environmental Site Assessment Capehart and Earhart Village Housing Areas, Hickam Air Force Base Oʻahu, Hawaiʻi*. Prepared for Actus Lend Lease LLC. March.

_____. 2005. *Phase I Environmental Site Assessment, Capehart and Earhart Village Housing Areas, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Actus Lend Lease LLC. January 26, 2005.

_____. 2006a. *Letter Report from S. Toma to J. Apitz. Subject: Capehart and Earhart Village Housing Areas Site Characterization, Hickam Air Force Base, Oʻahu, Hawaiʻi, Soil Sampling for Chlordane, Dieldrin, and Aldrin*. Prepared for Actus Lend Lease LLC. June 5, 2006.

_____. 2006b. *Hickam Community Housing Earhart Village 1-Acre Sampling Protocol, memorandum to Kelly Chuck, from Steffany Toma, Tetra Tech.* Prepared for Hickam Community Housing LLC. September 1, 2006.

_____. 2006c. *Management Plan for Pesticide-Impacted Soils, Hickam Community Housing, Hickam Air Force Base, Oʻahu, Hawaiʻi. Rev 0*. Prepared for Hickam Community Housing LLC. October 16, 2006.

_____. 2007a. *Phase I Environmental Site Assessment, Hickam Phase II Military Family Housing (MFH), Hickam Air Force Base, Honolulu, Hawaiʻi*. Prepared for Actus Lend Lease LLC. July 2007.

_____. 2007b. *Final Report – Phase II Environmental Assessment, Surface and Subsurface Soil Investigation, Report, Hickam AFB And Bellows AFS, Oʻahu, Hawaiʻi*. Prepared For: Actus Lend Lease, LLC. July 18, 2007.

_____. 2009a. *TO#10 – Pesticide-Impacted Soils Investigation and Management Program Manual. Hickam Air Force Base, Oʻahu, Hawaiʻi. DCN: 2392501.0001.F01.* Prepared for Hickam Community Housing LLC. May 2009.

_____. 2009b. *TO#24 Leachability of Aldrin, Dieldrin, and Chlordane from Soils Literature Review.* Memorandum to Robert Lloyd, Development Manager, Hickam Community Housing LLC, from Tom Whitehead CHG, Technical Lead, Tetra Tech. Prepared for Hickam Community Housing LLC. December 1, 2009.

_____. 2009c. *TO#18 Letter Report on Results of Open Area Verification Sampling, (September/October 2009) at the Earhart 1-4 Neighborhood, Hickam Air, Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing LLC. December 31, 2009.

_____. 2010a. *TO#36 Summary of Findings Report for Post Remediation Confirmation Sampling at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. April 14, 2010.

_____. 2010b. *TO#49 Sampling And Analysis Plan, Verification Soil Sampling, Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-Neighborhoods, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing LLC. March 24, 2010.

_____. 2010c. *TO#36 Summary of Findings Report for Post Remediation Confirmation Sampling of Area B at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. June 3, 2010.

_____. 2010d. *TO#36 – Summary of Findings Report for Post-Remediation, Confirmation Soil Sampling of Decision Unit C at the Earhart I-4, Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. June 22, 2010.

_____. 2010e. *TO#50 Summary of Findings Report for Surface Soil Investigation at the Earhart I-2 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing LLC. June 24, 2010.

_____. 2010f. *TO#49 Summary of Findings Report for Confirmation Soil Sampling at the Hale Na Koa I-1 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi.* Prepared for Hickam Community Housing LLC. June 28, 2010.

_____. 2010g. *TO#48 Summary of Findings Report for Surface Soil Investigation at the Onizuka II-1 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Communities LLC. July 1, 2010.

_____. 2010h. *TO#51 Summary of Findings Report for Surface Soil Investigation at the Earhart I-3 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing LLC. July 1, 2010.

_____. 2010i. *TO#36 – Summary of Findings Report for Post-Remediation Confirmation Soil Sampling of Decision Unit D at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. August 5, 2010.

_____. 2010j. *TO#56 Sampling and Analysis Plan, Earhart I-2 and Earhart I-3 Neighborhoods, Hickam Air Force Base, Oʻahu, Hawaiʻi*. DCN: 2616902.0001.F01. Prepared for Hickam Communities, LLC. August 6, 2010.

_____. 2010k. *TO#56 Sampling and Analysis Plan, Onizuka II-1 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi. DCN: 2616902.0002.F01*. Prepared for Hickam Communities, LLC. August 6, 2010.

_____. 2010L. *TO#36 – Summary of Findings Report for Post-Remediation Confirmation Soil Sampling of Decision Unit E at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. August 19, 2010.

_____. 2010m. *TO#36 – Revised Summary of Findings Report for Post-Remediation Confirmation Soil Sampling of Decision Unit Da at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. September 30, 2010.

_____. 2010n. *TO#56 Removal Action Work Plan No. 1, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawaiʻi*. Prepared for Hickam Communities LLC. October 11, 2010.

_____. 2010p. *TO#56, Revised Analysis of Potential Removal Alternatives, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Oʻahu Hawaiʻi.* Prepared for Hickam Communities, LLC. DCN 2653504.006.F01. November 24, 2010.

_____. 2010q. *TO#56, Removal Action No. 2 Work Plan, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods. Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DCN: 2653504.002.F01*. Prepared for Hickam Communities LLC. December 2010.

_____. 2011a. *TO#56, Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i*. Prepared for Hickam Communities LLC. DCN: 2653504.021.D01. May 13, 2011.

_____. 2011b. *TO#56, Removal Action No. 3 Work Plan, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawai'i.* Prepared for Hickam Communities LLC. DCN: 2653504.020.F01. June 14, 2011.

_____. 2011c. *TO#70 Soil Management Plan for Pesticide-Impacted Soil Berms, Earhart I-2 Neighborhood, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DCN: 2626001.0002.F01*. Prepared for Hickam Communities LLC. July 27, 2011.

_____. 2011d. *TO#68, Pesticide-Impacted Soil Investigation and Management Program Manual. DCN: 2770101.0001.F03*. Prepared for Hickam Communities LLC. August 31, 2011.

_____. 2011e. *TO#56, Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i*. Prepared for Hickam Communities LLC. DCN: 2653504.021.F01. October 31, 2011.

_____. 2012a. *TO#99 Land Use Controls Inventory Document, Hickam Communities Property, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DCN: 2884201.0001.F03*. Prepared for Hickam Communities LLC. June 7, 2012.

_____. 2012b. *TO#98.1 Environmental Hazard Management Plan, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DCN: 2883401.0001.F03*. Prepared for Hickam Communities LLC. June 7, 2012.

_____. 2012c. *TO#109 Remedial Investigation Report, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawai'i. DCN: 2653505.001.F02*. Prepared for Hickam Communities LLC. June 7, 2012.

_____. 2012d. *TO#113 Removal Action Report, Actions Implemented Under Removal Actions No. 1, No. 2, and No. 3, Hickam Communities Remedial Action Site, Joint Base Pearl Harbor-Hickam, Hawai'i. DCN: 2653504.004.F05*. Prepared for Hickam Communities LLC. June 7, 2012.

_____. 2012e. *TO#108 Draft Response Action Memorandum, Hickam Communities Remedial Action Site, Joint Base Pearl Harbor-Hickam, Hawai'i. DCN: 2893601.0001.F02*. Prepared for Hickam Communities LLC. June 7, 2012.

USACE (US Army Corps of Engineers). 1997. *Final Environmental Assessment and Finding of No Significant Impact. Temporary Lodging Facility. Hickam Air Force Base. Honolulu, O'ahu, Hawai'i. Prepared for Department of the Air Force, Pacific Air Forces, Hickam AFB.* Prepared by US Army Corps of Engineers, Pacific Ocean Division. August 1997.

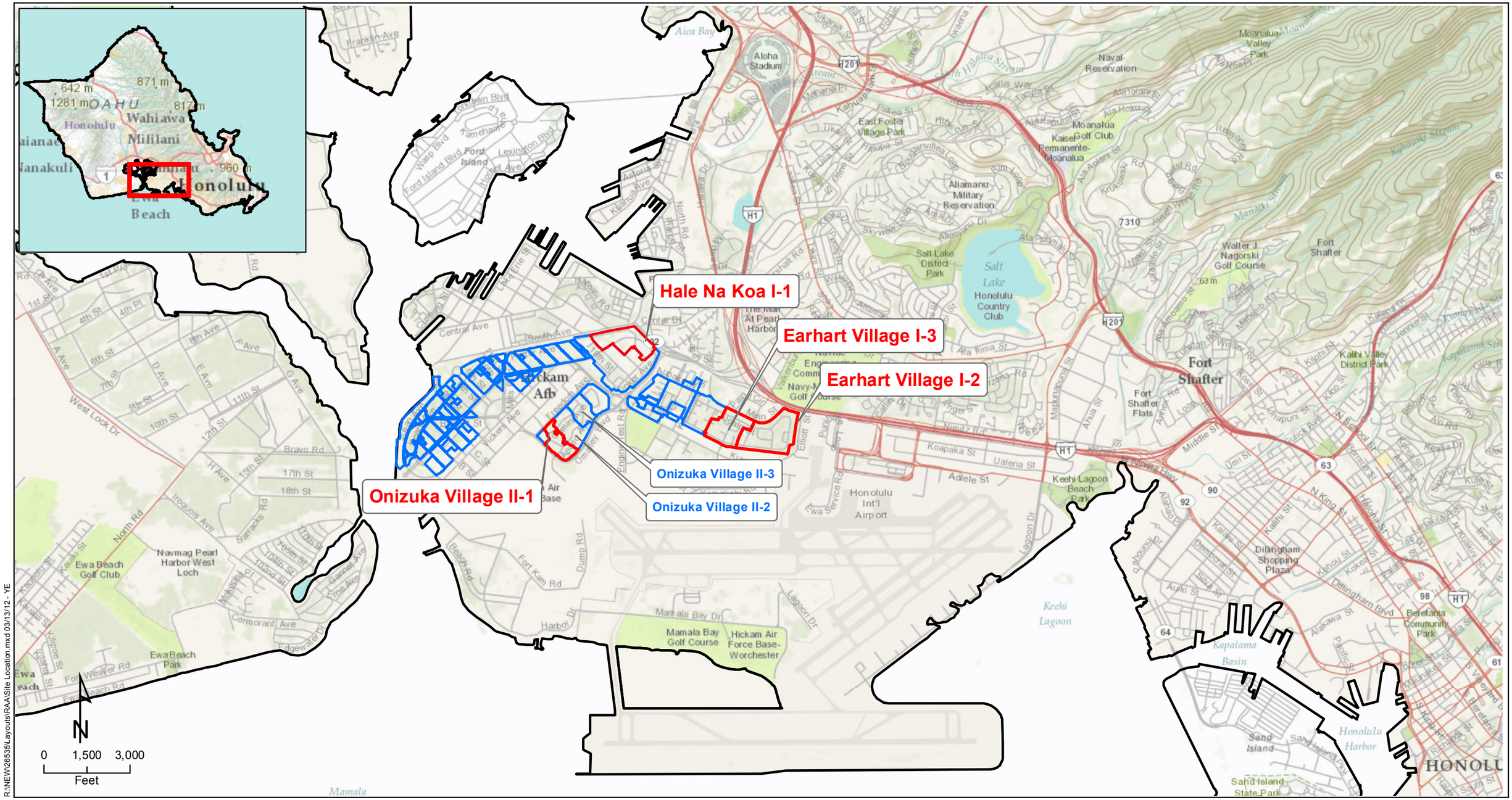
USAF (US Air Force). 1998. *Final Base Hydrogeology and Regional Mapping Report. Underground Fuel Storage and Distribution System Site Verification and Remediation Program. Prepared for 15th Air Base Wing CES/CEVR, Hickam AFB, by Air Force Center for Environmental Excellence, Environmental Services Office*. May 1998.

_____. 2002. *Supplemental Environmental Baseline Survey, Capehart, Earhart Village, and Original 36 Military Family Housing Areas, Hickam Air Force Base, Hawai'i.* Headquarters Air Force Center for Environmental Excellence, Environmental Planning Division. October 2002.

US Environmental Protection Agency (EPA). 1993. *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA. EPA 540-R-93-057.* February 1993. Washington, DC: Office of Emergency and Remedial Response.

Waller (J.M. Waller Associates). 2005. *Environmental Baseline Survey for the Military Family Housing Privatization Phase II Hickam AFB*. Prepared for United States Air Force 15th Airlift Wing, Hickam AFB, Hawai'i. November 2005.

FIGURES



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Site Boundary

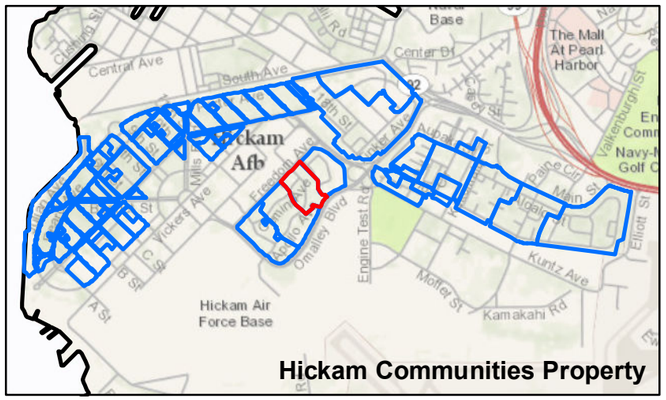
Hickam Communities Project Boundary

Remedial Action Site
Remedial Alternative Analysis - 2012

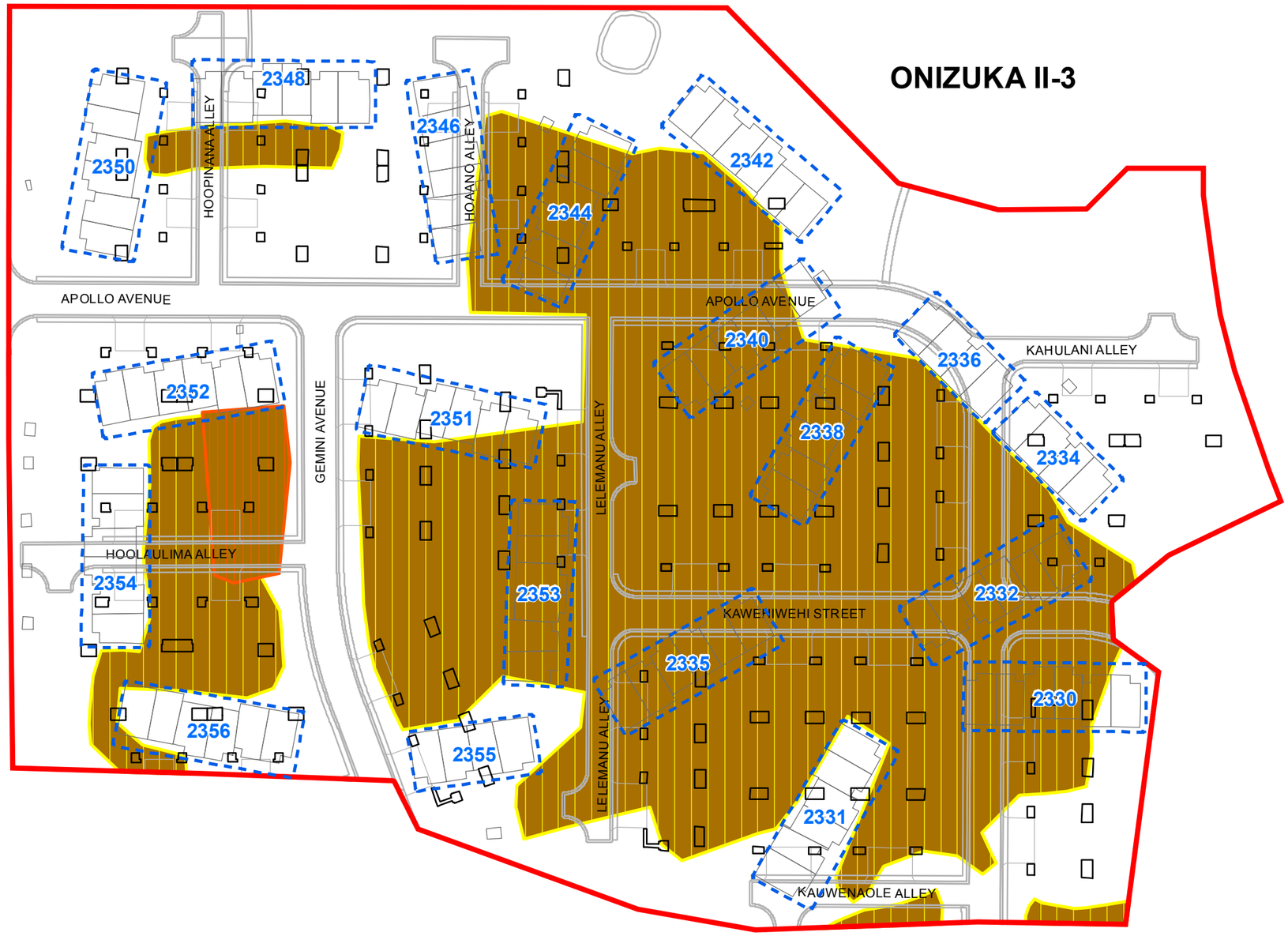
Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

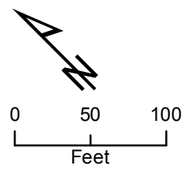
TETRA TECH

Figure 1-1



ONIZUKA II-3





This is a draft map. The final topographic map for the burial pits is still outstanding.

Onizuka II-3 Boundary
New Building Footprints
Roads
Burial Pits
Old Building Footprints
Burial Pit #6b

Notes:

- **Inset map shows Hickam Communities Property Boundary Line.**
- **Within the burial pits, PI soil is expected under building foundations and in utility trenches**
- **An orange geotextile marker layer has been installed between the clean soil cap and the PI soil**
- **Within burial pits, all soil removed from deeper than 1 foot has to be assumed pesticide-impacted unless tested**
- **Within burial pits, PI soil has been placed up to an elevation of 5 feet amsl**

TETRA TECH

Onizuka II-3 Burial Pits
Remedial Alternative Analysis - 2012

Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

Figure 3-1

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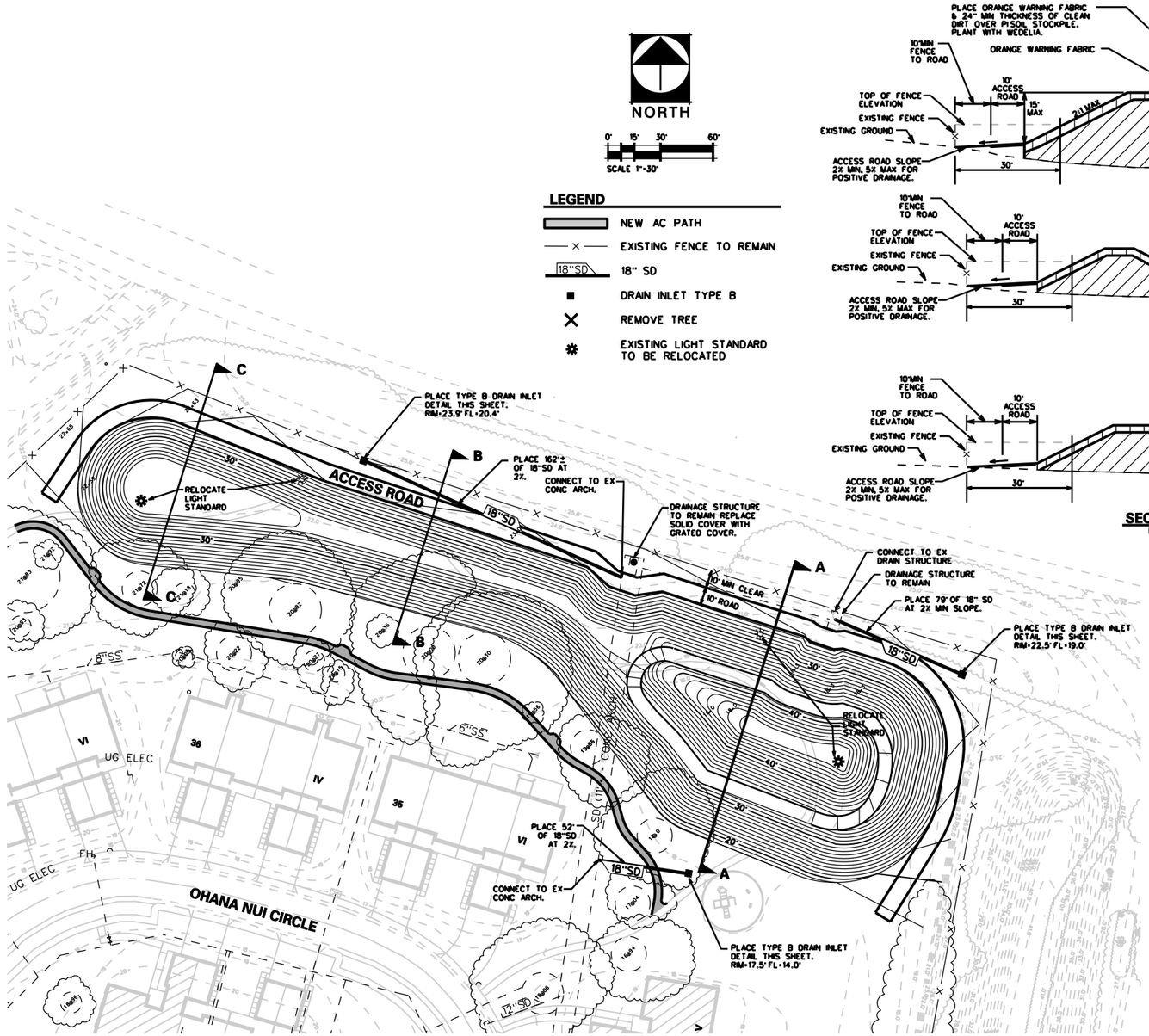
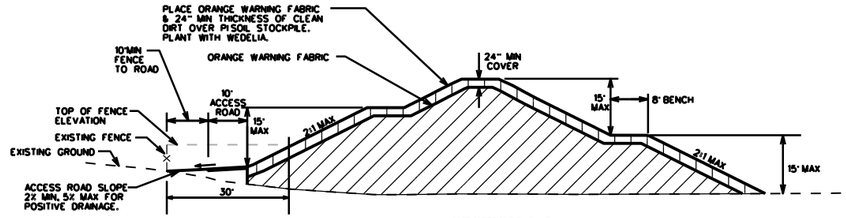
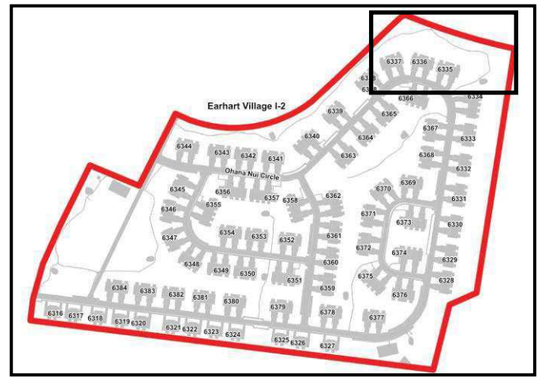


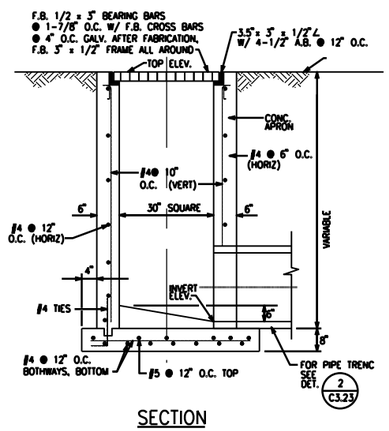


SECTION A-A
NO SCALE

SECTION C-C
NO SCALE

NOTE:
STOCKPILE CAPACITY 15,500± CUBIC YARDS OF PISOILS AND 4,000 CY CLEAN SOILS.





SECTION

Earhart Village I-2

Hardscapes

TETRA TECH

Source: KASL March 2011

Berm Location at Earhart I-2 Neighborhood
Remedial Alternatives Analysis - 2012

Joint Base Pearl Harbor-Hickam O'ahu, Hawai'i

Figure 3-2

r:\new\29287\CorelProposed Berm Location.cdr - 04/26/12 - YE

APPENDIX A
COST ESTIMATE BREAKDOWN BY ALTERNATIVE

Table A-1
Cost Breakdown for Remedial Alternatives 2 and 3
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Hale Na Koa I-1 Neighborhood	Unit Cost		ALTERNTIVE 2 Cleanup to Unrestricted Use: On-Site Placement			ALTERNATIVE 3 Cleanup to Unrestricted Use: Off-Site Disposal		
	Cost	**per Unit**	**QTY**	**Unit**	**Subtotal Cost**	**QTY**	**Unit**	**Subtotal Cost**
Project Management								
Direct project management	0.4%	LS	1	LS	**$92,747**	0.75	LS	**$158,554**
Remedial Action Soil Management Plan	$20,000	LS	1	LS	**$20,000**	1	LS	**$20,000**
Health & Safety Plan	$8,000	LS	1	LS	**$8,000**	1	LS	**$8,000**
Pre-Excvation Investigation								
Borings on 200 ft^2 grid	$500	EA	6,875	EA	**$3,437,483**	6,875	EA	**$3,437,483**
Excavation & Backfill								
Removal of PI soil	$15	CY	203,703	CY	**$3,055,545**	203,703	CY	**$3,055,545**
Hauling – on-site	$4	CY	264,813	CY	**$1,059,252**	0	CY	**$0**
Handling – on-site	$3	CY	264,813	CY	**$794,439**	0	CY	**$0**
Backfill purchase and transport	$10	CY	264,813	CY	**$2,648,130**	264,813	CY	**$2,648,130**
Backfill placement and compaction	$12	CY	264,813	CY	**$3,177,756**	264,813	CY	**$3,177,756**
Replace grass and vegetation	$0.14	ft^2	1,374,993	ft^2	**$192,499**	1,374,993	ft^2	**$192,499**
Confirmation Soil Sampling								
Floor of Excavation	$0.50	ft^2	1,374,993	ft^2	**$687,497**	1,374,993	ft^2	**$687,497**
Soil Disposal								
Hauling to disposal site	$15	ton	0	ton	**$0**	344,257	ton	**$5,163,854**
Off-site disposal	$100	ton	0	ton	**$0**	344,257	ton	**$34,425,690**
On-Site Soil Managmement								
Soil Berm Construction	$50	CY	161,424	CY	**$8,071,180**	0	CY	**$0**
Annual O&M	$0.25	CY	161,424	CY	**$40,356**	0	CY	**$0**
O&M over 45 years	$40,356	annually	45	years	**$1,816,015.50**	0	years	**$0**
Reporting								
Remedial Action Report	$35,000	LS	1	LS	**$35,000**	1	LS	**$35,000**
				TOTAL	***$25,095,543***			***$53,010,007***

Table A-1
Cost Breakdown for Remedial Alternatives 2 and 3
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Earhart I-2 Neighborhood	Unit Cost		ALTERNTIVE 2 Cleanup to Unrestricted Use: On-Site Placement			ALTERNATIVE 3 Cleanup to Unrestricted Use: Off-Site Disposal		
	Cost	per Unit	QTY	Unit	Subtotal Cost	QTY	Unit	Subtotal Cost
Project Management								
Direct project management	0.4%	LS	1	LS	**$176,445**	0.75	LS	**$246,739**
Remedial Action Soil Management Plan	$20,000	LS	1	LS	**$20,000**	1	LS	**$20,000**
Health & Safety Plan	$8,000	LS	1	LS	**$8,000**	1	LS	**$8,000**
Pre-Excvation Investigation								
Borings on 200 ft^2 grid	$500	EA	10,703	EA	**$5,351,625**	10,703	EA	**$5,351,625**
Excavation & Backfill								
Removal of PI soil	$15	CY	317,133	CY	**$4,756,995**	317,133	CY	**$4,756,995**
Hauling – on-site	$4	CY	412,273	CY	**$1,649,092**	0	CY	**$0**
Handling – on-site	$3	CY	412,273	CY	**$1,236,819**	0	CY	**$0**
Backfill purchase and transport	$10	CY	412,273	CY	**$4,122,730**	412,273	CY	**$4,122,730**
Backfill placement and compaction	$12	CY	412,273	CY	**$4,947,276**	412,273	CY	**$4,947,276**
Replace grass and vegetation	$0.14	ft^2	2,140,650	ft^2	**$299,691**	2,140,650	ft^2	**$299,691**
Confirmation Soil Sampling								
Floor of Excavation	$0.50	ft^2	2,140,650	ft^2	**$1,070,325**	2,140,650	ft^2	**$1,070,325**
Soil Disposal								
Hauling to disposal site	$15	ton	0	ton	**$0**	535,955	ton	**$8,039,324**
Off-site disposal	$100	ton	0	ton	**$0**	535,955	ton	**$53,595,490**
On-Site Soil Managmement								
Soil Berm Construction	$50	CY	412,273	CY	**$20,613,650**	0	CY	**$0**
Annual O&M	$0.25	CY	412,273	CY	**$103,068**	0	CY	**$0**
O&M over 45 years	$103,068	annually	45	years	**$4,638,071.25**	0	years	**$0**
Reporting								
Remedial Action Report	$35,000	LS	1	LS	**$35,000**	1	LS	**$35,000**
				TOTAL	***$48,925,719***			***$82,493,195***

Table A-1
Cost Breakdown for Remedial Alternatives 2 and 3
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Earhart I-3 Neighborhood	Unit Cost		ALTERNTIVE 2 Cleanup to Unrestricted Use: On-Site Placement			ALTERNATIVE 3 Cleanup to Unrestricted Use: Off-Site Disposal		
	Cost	per Unit	QTY	Unit	Subtotal Cost	QTY	Unit	Subtotal Cost
Project Management								
Direct project management	0.4%	LS	1	LS	**$112,253**	0.75	LS	**$156,914**
Remedial Action Soil Management Plan	$20,000	LS	1	LS	**$20,000**	1	LS	**$20,000**
Health & Safety Plan	$8,000	LS	1	LS	**$8,000**	1	LS	**$8,000**
Pre-Excvation Investigation								
Borings on 200 ft^2 grid	$500	EA	6,804	EA	**$3,401,868**	6,804	EA	**$3,401,868**
Excavation & Backfill								
Removal of PI soil	$15	CY	201,592	CY	**$3,023,880**	201,592	CY	**$3,023,880**
Hauling – on-site	$4	CY	262,070	CY	**$1,048,280**	0	CY	**$0**
Handling – on-site	$3	CY	262,070	CY	**$786,210**	0	CY	**$0**
Backfill purchase and transport	$10	CY	262,070	CY	**$2,620,700**	262,070	CY	**$2,620,700**
Backfill placement and compaction	$12	CY	262,070	CY	**$3,144,840**	262,070	CY	**$3,144,840**
Replace grass and vegetation	$0.14	ft^2	1,360,747	ft^2	**$190,505**	1,360,747	ft^2	**$190,505**
Confirmation Soil Sampling								
Floor of Excavation	$0.50	ft^2	1,360,747	ft^2	**$680,374**	1,360,747	ft^2	**$680,374**
Soil Disposal								
Hauling to disposal site	$15	ton	0	ton	**$0**	340,691	ton	**$5,110,365**
Off-site disposal	$100	ton	0	ton	**$0**	340,691	ton	**$34,069,100**
On-Site Soil Managmement								
Soil Berm Construction	$50	CY	262,070	CY	**$13,103,500**	0	CY	**$0**
Annual O&M	$0.25	CY	262,070	CY	**$65,518**	0	CY	**$0**
O&M over 45 years	$65,518	annually	45	years	**$2,948,287.50**	0	years	**$0**
Reporting								
Remedial Action Report	$35,000	LS	1	LS	**$35,000**	1	LS	**$35,000**
				TOTAL	***$31,123,696***			***$52,461,544***

Table A-1
Cost Breakdown for Remedial Alternatives 2 and 3
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Onizuka II-1 Neighborhood	Unit Cost		ALTERNTIVE 2 Cleanup to Unrestricted Use: On-Site Placement			ALTERNATIVE 3 Cleanup to Unrestricted Use: Off-Site Disposal		
	Cost	per Unit	QTY	Unit	Subtotal Cost	QTY	Unit	Subtotal Cost
Project Management								
Direct project management	0.4%	LS	1	LS	**$71,710**	0.75	LS	**$100,182**
Remedial Action Soil Management Plan	$20,000	LS	1	LS	**$20,000**	1	LS	**$20,000**
Health & Safety Plan	$8,000	LS	1	LS	**$8,000**	1	LS	**$8,000**
Pre-Excvation Investigation								
Borings on 200 ft^2 grid	$500	EA	4,341	EA	**$2,170,438**	4,341	EA	**$2,170,438**
Excavation & Backfill								
Removal of PI soil	$15	CY	128,619	CY	**$1,929,285**	128,619	CY	**$1,929,285**
Hauling – on-site	$4	CY	167,204	CY	**$668,816**	0	CY	**$0**
Handling – on-site	$3	CY	167,204	CY	**$501,612**	0	CY	**$0**
Backfill purchase and transport	$10	CY	167,204	CY	**$1,672,040**	167,204	CY	**$1,672,040**
Backfill placement and compaction	$12	CY	167,204	CY	**$2,006,448**	167,204	CY	**$2,006,448**
Replace grass and vegetation	$0.14	ft^2	868,175	ft^2	**$121,545**	868,175	ft^2	**$121,545**
Confirmation Soil Sampling								
Floor of Excavation	$0.50	ft^2	868,175	ft^2	**$434,088**	868,175	ft^2	**$434,088**
Soil Disposal								
Hauling to disposal site	$15	ton	0	ton	**$0**	217,365	ton	**$3,260,478**
Off-site disposal	$100	ton	0	ton	**$0**	217,365	ton	**$21,736,520**
On-Site Soil Managmement								
Soil Berm Construction	$50	CY	167,204	CY	**$8,360,200**	0	CY	**$0**
Annual O&M	$0.25	CY	167,204	CY	**$41,801**	0	CY	**$0**
O&M over 45 years	$41,801	annually	45	years	**$1,881,045.00**	0	years	**$0**
Reporting								
Remedial Action Report	$35,000	LS	1	LS	**$35,000**	1	LS	**$35,000**
				TOTAL	***$19,880,225***			***$33,494,022***

Table A-1
Cost Breakdown for Remedial Alternatives 2 and 3
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Onizuka II-3 Burial Pit No. 6b Earhart I-2 Soil Berm	Unit Cost		ALTERNTIVE 2 Cleanup to Unrestricted Use: On-Site Placement			ALTERNATIVE 3 Cleanup to Unrestricted Use: Off-Site Disposal		
	Cost	per Unit	QTY	Unit	Subtotal Cost	QTY	Unit	Subtotal Cost
Project Management								
Direct project management	0.4%	LS	1	LS	**$4,765**	0.75	LS	**$8,854**
Remedial Action Soil Management Plan	$14,000	LS	1	LS	**$14,000**	1	LS	**$14,000**
Health & Safety Plan	$4,000	LS	1	LS	**$4,000**	1	LS	**$4,000**
Excavation & Backfill								
Removal of Burial Pit No. 6b	$15	CY	0	CY	**$0**	1,563	CY	**$23,445**
Removal of Earhart I-2 Soil Berm	$15	CY	15,500	CY	**$232,500**	15,500	CY	**$232,500**
Hauling – on-site	$4	CY	20,150	CY	**$80,600**	0	CY	**$0**
Handling – on-site	$3	CY	20,150	CY	**$60,450**	22,182	CY	**$66,546**
Backfill purchase and transport	$10	CY	0	CY	**$0**	1,563	CY	**$15,630**
Backfill placement and compaction	$12	CY	0	CY	**$0**	1,563	CY	**$18,756**
Replace grass and vegetation	$0.14	ft^2	27,000	ft^2	**$3,780**	33,000	ft^2	**$4,620**
Confirmation Soil Sampling								
Floor of Excavation/ Berm footprint	$10,000	LS	1	LS	**$10,000**	1	LS	**$10,000**
Soil Disposal								
Hauling to disposal site	$15	ton	0	ton	**$0**	22,182	ton	**$332,730**
Off-site disposal	$100	ton	0	ton	**$0**	22,182	ton	**$2,218,200**
On-Site Soil Managmement								
Soil Berm Construction	$50	CY	15,500	CY	**$775,000**	0	CY	**$0**
Annual O&M	$0.25	CY	15,500	CY	**$3,875**	0	CY	**$0**
O&M over 45 years	$3,875	annually	45	years	**$174,375.00**	0	years	**$0**
Reporting								
Remedial Action Report	$11,000	LS	1	LS	**$11,000**	1	LS	**$11,000**
				TOTAL	***$1,370,470***			***$2,960,281***
		GRAND TOTAL COSTS FOR RAA		***Alternative 2***	***$126,395,653***		***Alternative 3***	***$224,419,050***

Not included in calculation

PI = pesticide-impacted
O&M = operations and maintenance
LS = lump sum
CY = cubic yards
ft^2 = square feet

Excavation and Backfilling Assumptions

Volumes (in CY) calculated using an average depth of 4 feet below final grade .
Areas (in ft^2) encompass the entire neighborhood, fence-to-fence.
Costs for demolishing and rebuilding structures and infrastructure are not included here.
Borings are to 10 feet below grade and include analysis for organochlorine pesticides. Cost based on all borings being completed.
For soil hauling, disposal, and management calculations, a 30 percent soil expansion factor was added to the excavated volume.
Loads depend on truck size and each load can vary from 12 to 20 CY of soil.
Off-site disposal assumes soil will be loaded and transported directly to the landfill. No onsite handling (stockpiling) or transporting costs are included.
A conversion of 1.3 tons of soil per ton was used for to estimate tons of soil for offsite disposal; the 30 percent soil expansion factor was included.

Table A-1
Cost Breakdown for Remedial Alternatives 2 and 3
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Project Management, Schedule, and Reporting Assumptions

Project Management costs are calcuated based on 0.4 percent of the total cost of the project.

Project Management assumes a 6 month schedule to complete the project for all four neighborhoods (does not include removal of homes and infrastructure).

For both Alternative 2 or 3, estimate includes full time project manager plus a part-time account specialist dedicated to tracking and monitoring costs.

Alternative 3 estimate also part-time staff for tracking of all of the waste shipments/manifests, and any additional tracking requirements that may be required by US EPA, or the State of Hawai'i.

O&M Assumptions

Estimated O&M costs for soil berms include irrigation, inspections and reporting, berm and landscape maintenance and repair.

45 years of O&M costs assume based on termination of the ground lease in 2057 (2057 - 2012 = 45 years).

O&M costs are assumed to be static and have not been amortized

Table A-2
Cost Breakdown for Remedial Alternative 4
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Component	Unit Cost		ALTERNATIVE 4 Institutional Controls		
Project Plan: MPPIS (2006)	**Cost**	**per Unit**	**QTY**	**Unit**	**Subtotal Cost**
Project Management	5%	LS	1	LS	**$985**
Plan Preparation					
Draft Plan	$10,000	LS	1	LS	**$10,000**
GIS	$1,500	LS	1	LS	**$1,500**
Internal / Client Review	$2,000	LS	1	LS	**$2,000**
Regulatory Review/ Aproval					
Response to Comments	$5,000	LS	1	LS	**$5,000**
Finalize Plan	$1,200	LS	1	LS	**$1,200**
MPPIS O&M					
Plan Maintenance [1]	N/A				
		TOTAL			***$20,685***
Project Plan: Program Manual (2009 & 2011)	**Cost**	**per Unit**	**QTY**	**Unit**	**Subtotal Cost**
Project Management	5%	LS	1	LS	**$2,105**
Plan Preparation					
Draft Plan	$13,000	LS	2	LS	**$26,000**
GIS	$1,500	LS	2	LS	**$3,000**
Internal / Client Review	$1,500	LS	2	LS	**$3,000**
Finalize Plan					
Response to Comments	$3,850	LS	2	LS	**$7,700**
Finalize Plan	$1,200	LS	2	LS	**$2,400**
Program Manual O&M					
Plan Maintenance [2]	$2,000	annually	5	years	**$10,000**
		TOTAL			***$54,205***
Project Plan: LUCID (2012)	**Cost**	**per Unit**	**QTY**	**Unit**	**Subtotal Cost**
Project Management	5%	LS	1	LS	**$900**
Plan Preparation					
Draft Plan	$12,000	LS	1	LS	**$12,000**
GIS	$2,000	LS	1	LS	**$2,000**
Internal / Client Review	$1,000	LS	1	LS	**$1,000**
Regulatory Review/ Aproval					
Response to Comments	$2,000	LS	1	LS	**$2,000**
Finalize Plan	$1,000	LS	1	LS	**$1,000**
LUCID O&M					
Plan Maintenance [2]	$1,000	annually	45	years	**$45,000**
		TOTAL			***$63,900***

Table A-2
Cost Breakdown for Remedial Alternative 4
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Component	Unit Cost		ALTERNATIVE 4 Institutional Controls		
Project Plan: EHMP (2012)	**Cost**	**per Unit**	**QTY**	**Unit**	**Subtotal Cost**
Project Management	5%	LS	1	LS	**$1,950**
Plan Preparation					
Draft Plan	$27,000	LS	1	LS	**$27,000**
GIS	$3,000	LS	1	LS	**$3,000**
Internal / Client Review	$1,000	LS	1	LS	**$1,000**
Regulatory Review/ Aproval					
Response to Comments	$5,000	LS	1	LS	**$5,000**
Finalize Plan	$3,000	LS	1	LS	**$3,000**
EHMP O&M					
Plan Maintenance [2]	$1,000	annually	45	years	**$45,000**
		TOTAL			***$85,950***
Institutional Controls O&M	**Cost**	**per Unit**	**QTY**	**Unit**	**Subtotal Cost**
Monthly Inspections[4]	$31,800	annually	45	years	**$1,431,000**
Oversight during pre-authorized soil management activities [5]	$15,800	annually	45	years	**$711,000**
Oversight during soil management activities for emergency repairs [6]	$5,300	annually	45	years	**$238,500**
Maintenance & Repair to Soil Caps and Landscaping [7]	$0.03	ft^2	3,602,036	ft^2	**$108,061**
	$108,061	annually	45	years	**$4,862,749**
	$10,000	annually	45	years	**$450,000**
		TOTAL			***$7,693,249***
		PROJECT PLAN DEVELOPMENT		***Alternative 4***	***$59,850***
		PROJECT PLAN O&M		***Alternative 4***	***$100,000***
		INSTITUTIONAL CONTROLS O&M		***Alternative 4***	***$7,693,249***
		GRAND TOTAL COSTS FOR RAA [3]		***Alternative 4***	***$7,853,099***

Not included in calculation

MPPIS = Management Program for Pesticide-Impacted Soil

Program Manual = Pesticide-Impacted Investigation and Management Program Manual

LUCID = Land Use Controls Inventory Document

EHMP = Environmental Hazard Management Plan

O&M = operations and maintenance

ft^2 = square feet

Plan Development and O&M Assumptions

[1] No O&M costs are estimated since the MPPIS was superceded by the Program Manual in 2009.

[2] Only 5 years of annual O&M costs are assumed since it is expected that plan maintenance will be minimal after the construction project is complete at Hickam and all of the pesticide-impacted soil has been managed.

[3] Only the costs for the development of the LUCID and the EHMP are included in the estimate for the RAA.The MPPIS and the Program Manual were developed prior to the Remedial Action and these costs are only inlcuded for reference. O&M costs are included for the Program Manual, LUCID, and EHMP

.

Table A-2
Cost Breakdown for Remedial Alternative 4
Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawai'i

Institutional Controls O&M

[4] Annual costs for monthly inspections assume one HC staff over two 8-hour days for 12 months. Includes reporting time and other direct costs.

[5] Annual costs for planned oversight assume 8 hours of oversight per month with oversight by one HC staff. Includes reporting and other direct costs

[6] Annual costs for emergency oversight assumes one incident per quarter with up to 8 hours of oversight by one HC staff per incidient. Includes reporting and other direct costs.

[7] Annual cost are estimated for all four neighborhoods (without hardscapes).

[8] Quarterly newsletter and/or fact sheet

Table A-3
Areas and Soil Volumes
Hickam Communities, Joint Base Pearl Harbor Hickam, Hawai'i

Neighborhood	Depth of Excavation [1]	Area [2]	Area [3]	Volume	Volume	Volume (30% Soil Exp)
	(feet)	(ft^2)	(ft^2)	(ft^3)	(CY)	(CY)
Hale Na Koa I-1	4	838,161	1,374,993	5,499,970	203,703	264,813
Earhart I-2	4	1,320,238	2,140,650	8,562,600	317,133	412,273
Earhart I-3	4	1,017,417	1,360,747	5,442,989	201,592	262,070
Onizuka II-1	4	426,219	868,175	3,472,701	128,619	167,204
Burial Pit No. 6b [4]	n/a	n/a	n/a	n/a	1,563	2,032
Earhart I-2 Soil Berm [5]	n/a	n/a	n/a	n/a	15,500	20,150
	TOTAL	***3,602,036***	***5,744,565***	***22,978,260***	***868,110***	***1,128,543***

[1] An average excavation depth of 4 feet below grade is assumed.

[2] Area excluding hardscapes.

[3] Area fence-to-fence, including hardscapes.

[4] Total volume of removed soil from RO#1 and RO#2 placed in Burial Pit No. 6b in the Onizuka II-3 neighborhood.

[5] Total volume of berm including soil from RO#3.

ft^2 = square feet

ft^3 = cubic feet

CY = cubic yards

n/a = not applicable