Department of Health
HEER Office, 1582
Kamehameha Avenue,
Hilo, Hawai'i 96720-4623

FACT SHEET
Proposed Soil Cleanup Action at the former Kohala Sugar Company
Pesticide Mixing Site, North Kohala, Hawai'i

TMK 3-5-5-019:025

Introduction

The State of Hawai'i Department of Health (HDOH) is publishing this fact sheet to provide information and to solicit comments from persons interested in the proposed arsenic, dioxin, and semivolatile organic compounds cleanup project by the Hawai'i Island Community Development Corporation (HICDC) at a property located in North Kohala, Hawai'i County (Figure 1). The HDOH Hazard Evaluation and Emergency Response Office (HEER Office) is providing oversight, and the investigation and public participation requirements are being conducted pursuant with Hawai'i Administrative Rules Chapter 11-451. This fact sheet outlines the proposed cleanup options and the remedy proposed to address soil contamination at the site.

A Draft Removal Action Report presents details on alternative remedies to address elevated soil contamination at the former Kohala Sugar Company Pesticide Mixing Site. Each alternative is described and evaluated in terms of effectiveness, implementability and cost. A recommendation is made on the preferred remedy to address the soil contamination.

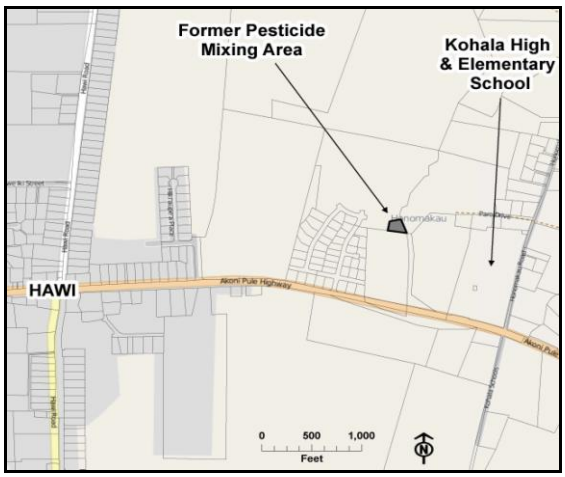

Figure 1. Site Location in North Kohala

Site Description and Property Information

The subject property (site) consists of approximately 0.5 acres of land in the vicinity of the town of Hawi, North Kohala District, Hawai'i, which formerly housed Kohala Sugar Company pesticide storage and mixing facilities. The parcel TMK is 03-5-5-019:25 (portion). The site supported former operations in the plantation fields, and is now surrounded by fallow, highly vegetated pasture land or residential properties. Former facilities remaining on the site include two (upper and lower) rock/concrete retaining walls and four empty steel above-ground storage tanks. A fence has been installed around the former pesticide mixing area to prevent trespasser direct contact with site soils.

Site investigations have been conducted by HDOH and environmental consultants for the property owner to identify the contaminants of concern and areas of soil contamination. Arsenic and dioxin are the principle chemicals of concern and soil environmental hazards. Arsenic was historically used as an herbicide in sugar cane cultivation, while dioxin is a byproduct of other historically used pesticides and herbicides such as pentachlorophenol.

Soils within a ¼-acre area at the former pesticide mixing area (the "source area" within the ½-acre site) show elevated arsenic and dioxin concentrations, extending to a depth of approximately 3 feet below the ground. Moderately elevated soil dioxin is also present just south of the HICDC property, and contamination is assumed to extend east of the HICDC property. This fact sheet and proposed cleanup action addresses the HICDC property only. Action to assess and address soil contamination on the adjacent properties is on-going.

HDOH manages soil arsenic hazards based on a measure of bioaccessible arsenic, which is the fraction of total arsenic that is expected to be available for uptake by way of incidental soil

ingestion of arsenic-contaminated soil. HDOH has developed four soil categories (A-D) based on bioaccessible arsenic levels. Category A soils have naturally-occurring background levels of arsenic. Soils with bioaccessible arsenic below 23 mg/kg (Category B soils) are considered minimally impacted, and are "within acceptable health risks for long-term exposure". Category C soils (moderately impacted) have bioaccessible arsenic levels from 23 to 95 mg/kg, and sites with these soils need further evaluation or controls for unrestricted (i.e residential) land use. Sites with Category C soils may be suitable for commercial or industrial land uses. Category D soils with bioaccessible arsenic above 95 mg/kg (heavily impacted) typically require remedial action irrespective of future land use.

Dioxin levels are expressed using a Toxic Equivalency Factor (TEQ), which is a method of summing the toxic effects of the multiple dioxin and furan compounds typically identified and generating a single TEQ dioxin value. Like arsenic, HDOH has developed four soil categories based on TEQ dioxin levels: Category A (natural background levels) when TEQ dioxin is below 20 ng/kg, Category B (minimally impacted) when TEQ dioxin is between 20-240 ng/kg, Category C (moderately impacted) when TEQ dioxin is between 240-1,500 ng/kg, and Category D (heavily impacted) when TEQ dioxin is above 1,500 ng/kg.

Site investigation work indicates that there are approximately 1,300 cubic yards (cy) of Category C and Category D arsenic/dioxin contaminated soils at the site which need to be remediated.

Removal Action Objectives

The primary focus of the removal action is to address elevated arsenic and dioxin in the soils at the site to provide protection of human and ecological health by preventing direct exposures to impacted soils. The removal action objectives are as follows:

1. Remediate portions of the property anticipated for future unrestricted (residential) land use to appropriate bioaccessible arsenic and TEQ dioxin soil concentrations, herein defined as removal action levels.
2. Prevent migration of contaminants to surface or groundwater.
3. Minimize potential risk to human health or ecological receptors from exposure to dioxin and arsenic impacted soil, during and after the removal action.

The property owner anticipates unrestricted (residential) land use for the site property, therefore all Category C and D soils will be remediated.

Proposed Remedy

A number of removal action alternatives were considered to address the soil contamination on site. The removal action alternatives selected for final consideration included:

1. No Action (included for comparative baseline)
2. Excavation and Offsite Landfill Disposal of Arsenic/Dioxin Category C and D Soils
3. Onsite Containment Cell for Arsenic/Dioxin Category C and D Soils

Each alternative was considered in light of the Removal Action Objectives for the site as well as effectiveness, implementability, and cost. The proposed removal action alternative recommended is alternative 2: Excavation and Offsite Landfill Disposal of Arsenic/Dioxin Category C and D Soils. This option was judged effective to ensure that any risks to human health or the environment would be avoided. This alternative consists of excavation of all moderately to heavily impacted arsenic and dioxin soils (exceeding 23 mg/kg bioaccessible arsenic and 240 ng/kg TEQ dioxin) and disposal in an approved landfill (West Hawai'i).

Next Steps and Community Involvement

HDOH encourages members of the public to review and comment on the DRAFT Removal Action Report (DRAFT RAR) and proposed remedy for this project during the comment period of December 5, 2013 through January 8, 2014. Written comments should be e-mailed (by January 8, 2014) to John Peard at john.peard@doh.hawaii.gov or mailed to the following address:

John Peard, Project Manager
Hawai'i Department of Health, HEER Office
1582 Kamehameha Ave.
Hilo, Hawai'i 96720-4623

A public meeting will be held during the public comment period to provide an overview of investigations at the site, answer questions, and discuss the Draft RAR including the remediation options considered and proposed. Comments from the public will be accepted at this meeting (and throughout the public comment period). This meeting will be held at the following location and time:

Location: Old Courthouse, North Kohala Senior Center
Address: Kapa'au, HI 96755
Date: Thursday, December 12, 2013
Time: 6:00PM – 8:00PM

After the public comment period is over (after Jan. 8, 2014), HDOH will review and consider all comments received as well as any additional HDOH staff or management input before selecting the final cleanup remedy for the site.

USEPA Cleanup Grant Application by HICDC

Public review and input is also solicited on a Draft Cleanup Grant application for this site that HICDC is planning to finalize and submit to USEPA by January 22, 2014. Eligible sites that are selected in this competitive federal cleanup grant program may receive up to $200,000 to assist in cleanup efforts. The Draft Cleanup Grant application will also be discussed at the public meeting regarding the proposed site cleanup remedy noted above (Dec. 12, 2013, 6-8 PM, Kohala Senior Center, Kapa'au). Copies of the Draft Cleanup Grant application are available through HICDC and HDOH (see contacts below), and comments are requested by January 8, 2014. Comments on the proposed grant application should be mailed or emailed to:

Brian T. Nishimura, Planning Consultant
101 Aupuni Street, Suite 217
Hilo, Hawai'i 96720, or
email: btnishi@hawaiiantel.net

Information Repository

Relevant portions of the Administrative Record for this site are available for review at the North Kohala Public Library (see Reference Desk) and the HDOH Environmental Health Building in Hilo at 1582 Kamehameha Avenue until January 8, 2014. This includes the Draft Removal Action Report (with the proposed remedy), other site investigation documents, and a copy of the HICDC Draft Cleanup Grant Application to the USEPA. The complete administrative record for the former North Kohala Sugar company site is available for review upon request to HDOH.

Copies of this site Fact Sheet, the Draft Removal Action Report, and the HICDC Draft Cleanup Grant application are also available to view or download from the HDOH HEER Office website at: http://hawaii.gov/doh/heer See the "What's New" section on the homepage and look for announcement and links for the Proposed Soil Cleanup Action at the former Kohala Sugar Company Pesticide Mixing Site.

For any inquiries regarding the proposed cleanup project, contact:
John Peard, HDOH Project Manager, at
(808) 960-0080, or john.peard@doh.hawaii.gov

For questions on the Draft Cleanup Grant application to USEPA, contact:

Brian Nishimura (for HICDC), at

(808) 935-7692, or btnishi@hawaiiantel.net

DRAFT REMOVAL ACTION REPORT

Former Kohala Sugar Company Pesticide Mixing Site North Kohala, Hawaii

VOLUME I OF II

REPORT

Prepared for
Hawaii Island Community Development Corporation

Prepared by

Integral Consulting Inc.
285 Century Place
Suite 190
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ACSI
94-515 Ukee Street
Suite 301
Waipahu, HI 96797

November 21, 2013

UNCOMMON SYNERGIES | TECHNICAL INTEGRITY | EXCEPTIONAL RESULTS

DRAFT REMOVAL ACTION REPORT

Former Kohala Sugar Company
Pesticide Mixing Site
North Kohala, Hawaii

Prepared for
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November 21, 2013

CONTENTS

LIST OF FIGURES ..... **iv**

LIST OF TABLES ..... **v**

ACRONYMS AND ABBREVIATIONS ..... **vi**

1 INTRODUCTION **1-1**

1.1 PURPOSE OF REPORT 1-1
1.2 LOCATION AND SITE DESCRIPTION 1-1
1.3 PREVIOUS INVESTIGATIONS 1-1

2 SAMPLING AND ANALYSIS FINDINGS **2-1**

2.1 MOBILIZATION 1 – HDOH, AUGUST 2009 2-1
2.2 MOBILIZATION 2 – WESTON AND HDOH, DECEMBER 2010 2-2
2.3 MOBILIZATION 3 – HDOH, OCTOBER 2011 2-2
2.4 EVALUATION OF HAZARDOUS WASTE POTENTIAL 2-3
2.5 CLEAN FILL SOIL EVALUATION 2-4
2.6 ESTIMATED VOLUME OF CONTAMINATED SOIL 2-4

3 ENVIRONMENTAL HAZARD EVALUATION **3-1**

3.1 CONCEPTUAL SITE MODEL 3-1
3.2 ENVIRONMENTAL HAZARD EVALUATION 3-1
3.3 CHEMICALS OF CONCERN 3-2
3.3.1 Arsenic 3-2
3.3.2 Dioxin 3-2
3.3.3 Other Chemicals of Concern 3-3
3.4 SUMMARY OF ENVIRONMENTAL HAZARDS 3-3

4 REMOVAL ACTION SUMMARY **4-1**

4.1 REMOVAL ACTION OBJECTIVES 4-1
4.2 REMOVAL ACTION LEVELS 4-1
4.3 SUMMARY OF REMOVAL OPTIONS 4-1
4.4 REMOVAL ALTERNATIVES EVALUATION CRITERIA 4-2

5 REMOVAL ALTERNATIVES EVALUATION **5-1**

5.1 ALTERNATIVE 1 – NO ACTION 5-1
5.1.1 Effectiveness 5-1
5.1.2 Implementability 5-1

5.1.3 Cost 5-1
5.2 ALTERNATIVE 2 – LANDFILL DISPOSAL 5-1
5.2.1 Effectiveness 5-2
5.2.2 Implementability 5-2
5.2.3 Cost 5-3
5.3 ALTERNATIVE 3 – ONSITE CAPPING 5-3
5.3.1 Effectiveness 5-3
5.3.2 Implementability 5-4
5.3.3 Cost 5-5
5.4 COMPARISON OF ALTERNATIVES AND RECOMMENDATION 5-5
6 CONCEPTUAL DESIGN AND IMPLEMENTATION 6-1
6.1 REMOVAL ACTION WORK PLAN 6-1
6.2 SITE PREPARATION ACTIVITIES 6-1
6.3 SOIL EXCAVATION AND DISPOSAL 6-2
6.4 POST-EXCAVATION CONFIRMATORY SAMPLING AND ANALYSIS 6-2
6.5 SITE RESTORATION 6-2
6.6 PROJECT CLOSE-OUT 6-3
7 CONCLUSIONS AND RECOMMENDATIONS 7-1
8 REFERENCES 8-1

Appendices (in Volume II)

Appendix A. Laboratory Reports for August 2009 HDOH Sampling Event
Appendix B. Laboratory Report for December 2010 Weston Sampling Event
Appendix C. Laboratory Report for December 2010 HDOH Sampling Event
Appendix D. Laboratory Report for October 2011 HDOH Sampling Event
Appendix E. Laboratory Reports for July/August 2013 Integral/ACSI Sampling Events

LIST OF FIGURES

Figure 1. Site Location Map

Figure 2. Site Vicinity, Aerial Photograph, and Property Boundaries

Figure 3. Site Vicinity, Aerial Photograph, and Neighboring Properties

Figure 4. Site Features

Figure 5. Decision Units and Sample IDs

Figure 6. Waste Characterization Sampling Areas

Figure 7. Environmental Hazard Map – Arsenic in Surface Soils (0–6 in. bgs)

Figure 8. Environmental Hazard Map – Dioxin in Surface Soils (0–6 in. bgs)

LIST OF TABLES

Table 1. Surface and Subsurface Soil Sampling Results and Environmental Hazard Screening

Table 2. TEQ Dioxin Calculations

Table 3. Waste Characterization Soil Sampling Results

Table 4. Clean Fill Soil Sampling Results

Table 5. Soil Volumes Exceeding Environmental Action Levels

Table 6. Cost Estimate for Alternative 2a – On-Island Landfill Disposal

Table 7. Cost Estimate for Alternative 2b – Mainland Landfill Disposal

Table 86. Cost Estimate for Alternative 3a – Soil Cap

Table 9. Cost Estimate for Alternative 3b – Concrete Cap

Table 10. Comparison of Removal Action Alternatives

ACRONYMS AND ABBREVIATIONS

ACSI	Advanced Compliance Solutions, Inc.
AST	above-ground storage tank
bgs	below ground surface
CRM	concrete rubble masonry
cy	cubic yards
DU	decision unit
EAL	environmental action level
EHMP	Environmental Hazard Management Plan
EPA	Environmental Protection Agency
HDOH	Hawaii Department of Health
HEER	Hazard Evaluation and Emergency Response
HICDC	Hawaii Island Community Development Corporation
Integral	Integral Consulting Inc.
MI	multi-increment
ND	non-detect
PAH	polycyclic aromatic hydrocarbon
PPE	personal protective equipment
RAL	removal action level
RAO	removal action objective
RCRA	Resource Conservation and Recovery Act
SVOC	semivolatile organic compound
TCLP	toxicity characteristic leaching procedure
TMK	Tax Map Key
TEQ	toxic equivalency
Weston	Weston Solutions, Inc.
XRF	X-ray fluorescence

1 INTRODUCTION

1.1 PURPOSE OF REPORT

This draft removal action report presents alternative remedies to address elevated soil arsenic and other chemicals at the former Kohala Sugar Company Pesticide Mixing Site property in North Kohala, Island of Hawaii. Each alternative is described in detail and evaluated in terms of effectiveness, implementability and cost. A recommendation is made on the preferred remedy to address the soil arsenic problem. This report has been commissioned by the Hawaii Island Community Development Corporation (HICDC), who is performing residential development on the subject property and surrounding properties.

1.2 LOCATION AND SITE DESCRIPTION

The subject site consists of approximately 0.5 acre of land which formerly housed pesticide mixing operations for the Kohala Sugar Company facilities (Figures 1, 2, and 3). The site is a portion of the larger TMK parcel 03-5-5-019: 025, owned by HICDC, located 1.5 miles mauka of the Pacific Ocean coastline in the vicinity of the town of Hawi, North Kohala District, Hawaii. The site is surrounded by fallow, highly vegetated former plantation land and pasture land. Residential housing on HICDC land is located within 500 ft of the site to the southwest, and the Kohala Mission School is located to the east within several hundred feet. A chain link fence has been installed around the former pesticide mixing area to prevent trespasser direct contact with site soils. Former facilities remaining on the site include two (upper and lower) concrete rubble masonry (CRM) retaining walls and four steel above-ground storage tanks (ASTs) (Figure 4). A very large banyon tree is present at the center of the site, with roots grown into the CRM walls. Further description of the site and its surroundings can be found in Weston Solutions, Inc. (Weston; 2011).

1.3 PREVIOUS INVESTIGATIONS

The site was listed on the Comprehensive Environmental Response, Compensation, and Liability Information System in 2009 (EPA ID No.: HIN000908796). Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office conducted initial soil sampling at the site in August 2009, collecting multi-increment (MI) samples from four decision units (DUs). HDOH identified dioxins/furans (dioxin), metals (arsenic, lead, and mercury) and semivolatile organic compounds (SVOCs) at concentrations at or above HDOH environmental action levels (EALs) for unrestricted (i.e., residential) land use (HDOH 2011).

In December 2010, Weston collected 10 additional MI samples (plus 2 replicate MI samples) from surface and subsurface (up to 48 in. depth) soils at the site (Weston 2011) to further

delineate the extent of soil impacts. At the same time, HDOH HEER Office staff collected MI samples from two DUs on private property adjacent to the HICDC property and two DUs to the north of the site. The HDOH sampling DUs were contiguous with Weston's sampling DUs, designed to support site characterization. HDOH conducted an addition soil sampling program in October 2011 to further delineate the lateral extent of soil impacts.

2 SAMPLING AND ANALYSIS FINDINGS

Site soils have been extensively sampled using DUs and the MI sampling protocols by HDOH HEER Office staff and Weston. This section summarizes the findings of those sampling and analysis programs. A map of the layout of DUs is provided as Figure 5, and a summary of soil sample analytical results (showing all compounds with one or more sample result exceeding the residential Tier 1 EAL) is provided as Table 1. Please refer to Figure 5 and Table 1 during the following discussion. Toxic equivalency (TEQ) dioxin calculations based on individual dioxin/furan congener concentrations and the World Health Organization 2005 toxic equivalency factors are provided in Table 2. TEQs are calculated considering non-detect values to be zero, and also considering non-detect values to be one-half of the detection limit.[1] TEQ dioxin values using one-half the detection limit (higher calculated concentrations) are used for screening purposes on Table 1.

2.1 MOBILIZATION 1 – HDOH, AUGUST 2009

HDOH HEER Office staff conducted initial soil sampling at the site in August 2009. They sampled four DUs laid out across the former pesticide mixing site area. MI surface soil samples were collected from the four DUs (DU-1 through DU-4), and one of the DUs was MI sampled in triplicate for quality assurance purposes. The layout of the four initial DUs is shown on Figure 5.

MI samples were analyzed for a broad suite of chemical compounds, including SVOCs, OCPs, chlorinated herbicides, carbamate pesticides, metals (arsenic, lead, and mercury), and dioxins/furans (dioxin). Laboratory reports for the HDOH August 2009 sampling are provided in Appendix A.

The MI sample from DU-1 showed the highest levels of arsenic and dioxin. Total arsenic was 820 mg/kg in the <2 mm particle size soil and 1,300 mg/kg in the <0.25 mm particle size soil; bioaccessible arsenic was 230 mg/kg (measured in <0.25 mm particle size soil). HDOH recommends the use of bioaccessible arsenic in assessment of human health direct contact hazard. The HDOH EAL for bioaccessible arsenic for unrestricted [residential] land use is 23 mg/kg. Other compounds identified at concentrations above unrestricted land use EALs included lead, mercury, polycyclic aromatic hydrocarbon compounds (PAHs; a subset of SVOC compounds) and pentachlorophenol. All four DUs sampled by HDOH showed one or more compound present at concentrations exceeding a residential EAL.

[1] Test America lab reports (Appendices A through D) are not consistent in reporting dioxin/furan concentrations as "ND" (non-detect). For some reports, they reported ND if below the reporting limit, in other cases they reported ND if below the method detection limit.

2.2 MOBILIZATION 2 – WESTON AND HDOH, DECEMBER 2010

Weston and HDOH conducted additional soil sampling at the site in December 2010. They laid out five additional DUs on HICDC property that wrapped around the initial four HDOH DUs, identified as DU-7, DU-8, DU-10, DU-11, and DU-20. Surface soil (0–6 in. below ground surface [bgs]) MI samples were collected from these five DUs. Subsurface MI soil samples were collected beneath DU-1, DU2, and DU-8 (the areas previously shown [DU-1 and DU-2] or anticipated [DU-8] to have the highest contaminant impacts). Subsurface soil MI samples were collected from 6 to 24 in. bgs in all three DUs, and subsurface soil MI samples from 24 to 48 in. bgs were collected from DU-1 and DU-2. At the same time that Weston was collecting the soil samples on the HICDC property, HDOH collected surface MI samples from two DUs (DU-14 and DU-15) contiguous to the Weston DUs but on an adjacent property not owned by HICDC (the Harbottle property). In addition to soil sampling, Weston collected a rinsate sample from the old, rusted ASTs on the site. Visual observations indicated that there were no residual solids in the tanks.

Samples collected during the December 2010 mobilization by Weston and HDOH were submitted to Test America laboratory for analysis of a broad suite of compounds. Analytical results are compared to the unrestricted land use EALs as shown in Table 1. EALs are based on the following scenario: 1) land use will be "Unrestricted"; 2) groundwater utility is "Drinking Water"; and 3) the distance to nearest surface water body is "greater than 150m." Surface soil samples (0–6 in. bgs) from DU-7, DU-8, DU-10, and DU-15 exceeded unrestricted land use EALs for one or more compounds. All three subsurface samples from the 6–24 in. depth interval exceeded an EAL for one or more compounds. These samples were collected in DU-1, DU-2, and DU-8. The deeper (24 to 48 in. depth interval) subsurface sample collected in DU-2 (sample ID DU-12-4) exceeded EALs for dioxin. The 24 to 48 in. sample from DU-1 did not show an EAL exceedence. Based on this limited subsurface data set, it is likely that soil contamination exceeding EALs extends beyond 24 in. in depth in the contiguous area composed of DU-1, DU-2, and DU-8.

2.3 MOBILIZATION 3 – HDOH, OCTOBER 2011

HDOH HEER Office staff collected MI surface soil samples from three additional DUs in October 2011, to help further bound the lateral extent of EAL exceedances at the site. The samples were collected in DU-16 and DU-17 (north of DU-10), and in DU-18 (south of DU-15). Analytical results indicate no EAL exceedances in the DU-16 and DU-17 surface soil samples collected from the northern perimeter of the site. TEQ dioxin levels exceeded the EAL in DU-18 to the south of prior sampling areas, on the adjacent Harbottle property. See sample results summarized in Table 1.

2.4 EVALUATION OF HAZARDOUS WASTE POTENTIAL

Soils with high levels of arsenic, if generated (excavated) during remediation activities, could potentially be a "characteristic" hazardous waste if they exceeded the Resource Conservation and Recovery Act (RCRA) regulatory limits as determined by the toxicity characteristic leaching procedure (TCLP). The highest arsenic concentrations observed in site soils were in DU-8, with total arsenic reported at 2,030 mg/kg. This sample also exhibited high bioaccessible arsenic, at 519 mg/kg. If soils fail TCLP for arsenic, and are determined to be a hazardous waste, they would require shipping to the mainland for disposal in a hazardous waste landfill.[2] If soils are determined to be non-hazardous, they could be disposed in the West Hawaii Sanitary Landfill.

To evaluate hazardous waste potential, Integral/ACSI collected additional soil samples in July and August 2013 from the site. Soils were collected from areas expected to represent "worst case" conditions (highest total arsenic levels). Based on prior HDOH and Weston sampling and analysis, the highest arsenic concentrations were observed in shallow (0–6 in. depth) soils in DU-1, DU-2 and DU-8, within the lower elevation area east of (below) the lower rock retaining wall. Therefore, Integral/ACSI laid out two additional decision units to collect MI samples for waste characterization. Each of the additional decision units was 30 ft by 80 ft in dimension, as shown on Figure 6. MI samples consisting of 30 sample increments were collected from the 0 to 6 in. depth interval from each DU on July 25, 2013. Samples were identified as WC-01 and WC-02 ("WC" for "waste characterization"). Due to uncertainties on the location of increments for sample DU-02, it was recollected on August 8, 2013 and identified as WC-03. The original sample WC-02 was not analyzed.

Review of prior HDOH and Weston soil sample results for the site revealed no concentrations of compounds on the RCRA toxicity characteristic list (40 compounds) greater than 20 times the TCLP regulatory level[3], with the exception of arsenic, lead and mercury. Therefore, samples Table 3 provides a summary of laboratory results, full lab reports are provided in Appendix E. WC-01 and WC-03 were analyzed for TCLP metals (the three metals identified above and the five others RCRA metals). No TCLP results were above regulatory levels for determination of hazardous waste. Arsenic was reported in WC-01 and WC-03 at 2.6 mg/kg and 0.89 mg/kg, respectively, as compared to a regulatory level of 5 mg/kg. In order to ensure that waste characterization samples reflected "worst case" conditions, total arsenic was also tested in these waste characterization samples. WC-01 and WC-03 were determined to contained 3000 mg/kg and 930 mg/kg, respectively (Table 3). Total arsenic in WC-01 was higher than reported for any previously evaluated soil sample at the site, and therefore is believed to be representative of "worst case" conditions. In summary, waste characterization sampling and analysis confirms

[2] An alternative to mainland landfill disposal would be soil treatment to stabilize the arsenic such that it passed the TCLP test, effectively "de-characterizing" the hazardous waste. Evaluation of the potentially cost and efficacy of such treatment is beyond the scope of this draft removal action report.
[3] As a "rule of thumb", samples with total concentrations of compounds <20 times the TCLP regulatory limit will not fail TCLP (exceed the regulatory limit) due to insufficient chemical mass.

that site soils, if excavated, would not be considered a hazardous waste and would be suitable for landfill disposal at the West Hawaii Sanitary Landfill.

2.5 CLEAN FILL SOIL EVALUATION

At the request of HICDC, Integral/ACSI collected a MI sample of surface soils (0–6 in. depth) from an open field area (former agricultural and ranch land) on HICDC property approximately ¼ mile distance from the former pesticide mixing site (location shown on Figure 2), for evaluation as clean fill soil suitable for use in a site remedy. Sample CF-01 ("CF" for "clean fill") was collected on July 25, 2013, and analyzed for total metals, organochlorine pesticides and dioxins/furans. These compounds are the most likely contaminants to be found in former agricultural fields. Results of the sampling and analysis are presented on Table 4 (original lab reports in Appendix E).

Results of sampling and analysis indicate that potential fill soils are clean, as there were no exceedences of HDOH Tier 1 EALs. Therefore, these soils would be suitable for use in construction of a remedy at the former pesticide mixing site (i.e. excavation backfill or soil cap material).

2.6 ESTIMATED VOLUME OF CONTAMINATED SOIL

The volume of soil likely exceeding residential EALs for one or more compounds has been estimated based on the MI sampling of site DUs. Table 5 provides a summary of the areas and estimated depths of contaminated soil above EALs within the DUs. Uncertainty exists in the depth of soil contamination beneath DU-2 and DU-8.

Based on the interpreted depth of contamination above EALs in the various DUs (see basis for estimates in Table 5), we estimate a total contaminated soil volume of 1,300 cubic yards (cy), which includes a 20 percent contingency to account for depth uncertainty.

3 ENVIRONMENTAL HAZARD EVALUATION

3.1 CONCEPTUAL SITE MODEL

Former sugar plantation facilities and operational areas at the site, related to agricultural cultivation and processing of sugar, are believed to have been the source of release of chemical contaminants. Sampling of soils was performed at and around those facilities/operations to identify soil impacts. Releases of pesticide and herbicide chemicals are believed to have occurred at the site as chemicals were mixed and transferred to field vehicles for application. Releases of chemicals would have entered site soils from the surface and migrated downward through the soil column. Contaminated surface soils could also have been transported downslope by surface erosion. The source of PAHs in site soils is not known. However, based on observed concentrations of individual PAH compounds less than 10 mg/kg and understanding of site history, PAH residues in site soils may be the result of decayed asphalt pavement, used oil application to roadways, or vehicle exhaust.

3.2 ENVIRONMENTAL HAZARD EVALUATION

Chemicals detected in soil were evaluated using the HDOH EAL "Surfer" tool (HDOH 2012a). Chemical concentrations in site soils observed in DU sampling and laboratory analyses from the HDOH 2009 study, Weston and HDOH 2010 studies, or HDOH 2011 study were compared to HDOH EALs. Table 1 presents a summary of chemical concentrations in soil samples, showing only those compounds with one or more exceedence of a Tier 1 EAL. Chemicals of concern (exceeding an EAL) include TEQ dioxins, arsenic, lead, mercury, PAHs (i.e., benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene), and pentachlorophenol.

HDOH guidance recommends evaluating soil environmental hazards to include human direct contact (ingestion, dermal absorption and inhalation), vapor emissions to indoor air, terrestrial ecotoxicity, gross contamination, and leaching (potential impact to groundwater). The dominant hazard for chemicals in soil at the subject site is direct contact. Screening with the EAL Surfer also indicated that pentachlorophenol exhibited a potential leaching hazard in DU-1 and DU-2. None of the chemicals of concern is volatile; therefore, vapor emissions to indoor air are not a concern. None of the gross contamination EALs was exceeded for site conditions. HDOH has not established terrestrial ecotoxicity screening levels, and no ecological risk screening was performed by Integral for the project.

3.3 CHEMICALS OF CONCERN

Arsenic and dioxin were determined to be the most significant chemicals of concern in terms of human direct contact hazard. Table 1 highlights the concentrations of chemicals in site soils.

3.3.1 Arsenic

Arsenic is a common soil contaminant in Hawaii, often related to its use as an herbicide in former sugar cane production. At the subject site, arsenical herbicides are believed to have been managed prior to 1950. HDOH recommends the management of arsenic by evaluation of total and bioaccessible arsenic. In recent guidance (HDOH 2012b), HDOH describes arsenic soil categories based on the magnitude of bioaccessible arsenic levels. Bioaccessible arsenic is the fraction of total arsenic that is extracted from soil using an *in vitro* laboratory test designed to simulate conditions within the human gastrointestinal tract (Drexler and Brattin 2007; Brattin et al. 2013). HDOH has developed four soil categories based on bioaccessible arsenic levels: Category A (natural background levels), Category B (minimally impacted), Category C (moderately impacted) and Category D (heavily impacted). The bioaccessible levels for each soil category are shown in the legend of Figure 7. Remediation is typically recommended for Category C and D soils.

Figure 7 shows the bioaccessible arsenic levels observed in surface soils (0–6 in. bgs) at the site, color coded by soil arsenic categories. Decision units DU-1, DU-2, DU-8, and DU-10 contain bioaccessible arsenic in surface soils at Category D levels. Arsenic Category C soils were not identified in surface soils, and the balance of soils were in Category A and B levels. Subsurface soils (6–24 in. depth) in DU-1 and DU-2 had bioaccessible arsenic at Category C levels, and subsurface soils in DU-08 had Category D arsenic soils (see Table 1, subsurface soils are not depicted on Figure 7).

3.3.2 Dioxin

Dioxin is a highly toxic chlorinated organic compound, commonly observed in soils formerly used for agriculture in Hawaii where pesticides/herbicides such as pentachlorophenol were applied. Similar to arsenic, HDOH has published specific guidance for the management of dioxin, with associated dioxin soil categories based on dioxin concentrations (HDOH 2010). Like arsenic, HDOH has developed four soil categories based on TEQ[4] dioxin levels: Category A (natural background levels), Category B (minimally impacted), Category C (moderately impacted) and Category D (heavily impacted). The TEQ dioxin levels for each soil category are shown in the legend of Figure 8. Remediation is typically recommended for Category C and D soils.

[4] TEQ is a method of summing the toxic effects of the various dioxin and furan congeners (related compounds), and generating a singe TEQ value for comparison against risk-based levels.

Figure 8 shows a similar, but more extensive, pattern of surface soil contamination as observed for arsenic. Surface soils (0–6 in. bgs) in DU-1, DU-2, DU-7, DU-8, and DU-10 show dioxin Category D soils. DU-3 and DU-4, on the HICDC property, and DU-15 and DU-18 on the adjacent Harbottle property, contain dioxin Category C soils. Subsurface soils (6–24 in. bgs) in DU-1 and DU-2 contain dioxin Category C soils, and in DU-8 contain dioxin Category D soils. Deeper subsurface soils (24–48 in. bgs) in DU-2 contain dioxin Category C soils.

3.3.3 Other Chemicals of Concern

In addition to arsenic and dioxin, lead, mercury and PAHs were observed at concentrations above unrestricted land use EALs. Lead was reported in surface soils of DU-1 at 230 mg/kg, slightly above the EAL of 200 mg/kg. Mercury was reported in surface soils of DU11 and DU-2 at 14 and 8 mg/kg, above the EAL of 4.7 mg/kg. SVOCs were reported in DU-1, DU-2, DU-3, and DU-4 at concentrations above EALs. Benzo(a)pyrene was reported in surface soils of DU-10 and DU-14 (on Harbottle property) above EALs.

3.4 SUMMARY OF ENVIRONMENTAL HAZARDS

Arsenic, lead, mercury, dioxin, PAHs, and pentachlorophenol were observed on the site above the direct contact EAL for unrestricted land use. Pentachlorophenol was observed above the EAL for leaching (potential for groundwater contamination). Mercury was reported in surface soils (0–6 in. bgs) of DU-1, DU-2, and DU-8 at 14, 8, and 6.9 mg/kg, respectively, above the EAL of 4.7 mg/kg. Four individual PAHs (benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene) exceeded EALs in surface soils (0–6 in. bgs) of DU-4. One PAH (benzo(a)pyrene) was at or above the EAL in surface soils (0–6 in. bgs) in DU-3 and DU-10 on HICDC property, and in DU-14 on the Harbottle property. The EAL for pentachlorophenol was exceeded in surface soils (0–6 in. bgs) of DU-1, DU-2, and DU-4. Of the chemicals of concern, arsenic and dioxin are the most extensive (greatest lateral and vertical extent at concentrations above EALs), and can be considered the chemicals of concern driving the remediation process. If arsenic and dioxin are addressed, the other lesser chemicals of concern will be addressed in kind.

The leaching hazard from pentachlorophenol is not considered to be a significant environmental hazard, since the area of impact above the leaching EAL is small (DU-1, DU-2 and DU-4), and the concentrations are no more than four times the leaching EAL. In addition, depth to groundwater is several hundred feet, and the aquifer is thick and transmissive (large groundwater flux).

Based on a comprehensive review of chemical concentrations in site soils, we believe that the principal hazards are arsenic and dioxin by direct contact, and that these should be the basis of the removal action levels.

4 REMOVAL ACTION SUMMARY

Soils containing arsenic and dioxin (as well as lead, mercury and SVOCs) at the former Kohala Sugar Company property present a potential direct exposure risk to humans and may present terrestrial ecotoxicity hazards. Based on these findings a removal action is recommended. In order to determine the most appropriate removal action approach, an evaluation of removal action alternatives was performed. The goal of this process is to screen and evaluate options that would be effective, technically and administratively feasible, and cost effective at addressing the soil arsenic and dioxin issues at the subject property.

4.1 REMOVAL ACTION OBJECTIVES

The primary focus of the removal action is to address elevated arsenic and dioxin (and several other chemicals) in the soils at the site to provide protection of human and ecological health by preventing direct contact exposures to contaminated soils. The removal action objectives (RAOs) are as follows:

1. Remediate portions of the property anticipated for future unrestricted (residential) land use to appropriate bioaccessible arsenic and TEQ dioxin soil concentrations, herein defined as removal action levels (RALs)
2. Prevent migration of contaminants to surface or groundwater
3. Minimize potential risk to human health or ecological receptors from exposure to arsenic- and dioxin-impacted soil, during and after the removal action.

4.2 REMOVAL ACTION LEVELS

The RALs are the target concentration of bioaccessible arsenic and TEQ dioxins that will be achieved by the removal action to allow appropriate site land use. Considering the planned unrestricted (residential) land use at the subject property, all Category C and D soils shall be addressed. A bioaccessible arsenic RAL of less than or equal to 23 mg/kg and a TEQ dioxin RAL of 240 ng/kg are recommended for the site. Soils exceeding these RALs (Category C and D soils) will require remediation.

4.3 SUMMARY OF REMOVAL OPTIONS

Based on the above-stated RAOs and RAL, Integral proposes the following removal alternatives be considered. Since leaching of site contaminants and impact to groundwater do not represent a significant site risk, the removal alternatives considered consist of proven methods for

eliminating human direct contact risk and terrestrial ecological risk. There are several alternatives or options that have the potential to meet the RAOs for the site, including the following:

1. No Action (does not meet RAOs, included for comparative baseline)

2a. On-Island Landfill Disposal

2b. Mainland Landfill Disposal

3a. Soil Cap

3b. Concrete Cap.

4.4 REMOVAL ALTERNATIVES EVALUATION CRITERIA

Each alternative was evaluated against the following three performance criteria:

- Effectiveness
- Implementability
- Cost.

The ***effectiveness*** criterion addresses the ability of the remedial alternative to provide:

- Overall protection of human health and the environment
- Achievement of RAOs
- Short-term effectiveness
- Reduction of toxicity, mobility, and volume of contaminants by treatment
- Long-term effectiveness and permanence
- Compliance with regulatory requirements.

The ***implementability*** criterion addresses:

- Technical feasibility (i.e., technology, reliability, and implementation limitations, e.g., terrain, logistics)
- Amount of time to implement
- Complexity (e.g., number of steps to complete)
- Administrative feasibility (local land management, permits, right-of-ways, zoning)
- Suitability of land for future uses
- Availability of equipment, materials and services.

The ***cost*** criterion addresses:

- Overall cost to implement the removal action (initial construction costs and long-term operations and maintenance [O&M] costs).

5 REMOVAL ALTERNATIVES EVALUATION

The four alternatives carried forward are evaluated herein. Supporting cost estimates for each alternative are provided in Tables 6 through 9. Only arsenic- and dioxin-contaminated soils on the HICDC property are considered in the following removal alternatives. Removal or remedial actions on the adjacent Harbottle and Westrum properties are not considered.

5.1 ALTERNATIVE 1 – NO ACTION

The No Action alternative, included as a comparative baseline, consists of no removal actions and leaving the site in its current condition. Under this alternative, no engineering features or institutional controls (signage, deed notices, etc.) are employed to prevent potential human or ecological risks from exposure to arsenic-impacted soils.

5.1.1 Effectiveness

The No Action alternative would not achieve RAOs and, most importantly, would not protect against incidental human direct contact with arsenic or dioxin contaminated soil.

5.1.2 Implementability

There are no issues of implementability for the No Action alternative, since by definition no action is planned.

5.1.3 Cost

There is no cost associated with the No Action alternative.

5.2 ALTERNATIVE 2 – LANDFILL DISPOSAL

Excavation and landfill disposal of arsenic- and dioxin-contaminated soils exceeding the RALs constitutes the second remedial alternative for evaluation. The general tasks under this option include site preparation, soil excavating and loading, transporting and disposal of soil at a landfill, and site restoration. Alternatives 2a and 2b consider soil disposal either at an on-island landfill (West Hawaii Sanitary Landfill in lower Pu'uanahulu) or at a mainland landfill, respectively. This alternative consists of tasks including post-excavation confirmation sampling, backfilling excavations with clean soil, and restoring the site with vegetative ground cover. This alternative is based on the assumption that all excavated soils meet regulatory levels and are not considered a hazardous waste requiring potential treatment and/or disposal in a hazardous waste (mainland, Subtitle C landfill).

Based on prior sampling and analysis by HDOH and Weston, and supplemental waste characterization sampling and analysis performed by Integral/ACSI (Section 2.4), arsenic and dioxin contaminated soil potentially excavated from the site would be considered non-hazardous solid waste. The only solid waste landfill on the Island of Hawaii that is permitted to accept contaminated soil is the West Hawaii Sanitary Landfill in lower Pu'uanahulu, managed by Waste Management Solutions, Inc. This facility is located approximately 30 miles from the subject site. Discussions with Waste Management staff indicate that site soils would be accepted for disposal at the West Hawaii Sanitary Landfill.

Soils exceeding the unrestricted land use RAL (arsenic and dioxin Category C and D soils) are shown as orange and red shaded areas on Figures 7 and 8. Approximately 1,300 cy of soil is estimated to require removal and disposal under this alternative. Considering 1.6 tons of soil per in-place cubic yard, some 2,000 tons would require excavation and disposal. Further details on scope elements for this alternative are provided in Tables 6 and 7.

5.2.1 Effectiveness

Excavation and offsite disposal of soils exceeding the unrestricted land use RAL would be an effective long-term remedy to meet RAOs. It would eliminate the potential for human direct contact risks associated with arsenic- and dioxin-contaminated soils and minimize risk to potential environmental receptors at the site. This alternative would remove arsenic and dioxin to acceptable RALs, thereby, reducing the toxicity, mobility, and volume of contamination at the property; however, the impacted soil would still need to be disposed at a permitted landfill facility. Short-term effectiveness, during and immediately after the removal action, is only moderate since there is potential exposure to site workers and the community during implementation of the soil excavation, transport, and disposal. Short-term effectiveness can be improved by strong engineering and management controls, such as personal protective equipment (PPE) for workers and air monitoring and mitigations for dust suppression, dust barriers, etc. This alternative would be in compliance with regulatory requirements.

5.2.2 Implementability

The excavation and offsite disposal of soil can be implemented using traditional construction techniques. This alternative is simple in approach, i.e., "dig and haul." Dust control and soil erosion control measures must be implemented during excavation and loading activities to ensure community and worker health and safety. Approximately 2,000 tons (or one hundred 20-ton loads) of contaminated soil would have to be transported by truck over local roadways, resulting in increased truck traffic and potential neighborhood disturbances. Local permitting is expected to be required in order to perform soil excavation work. This would include stormwater and grading/grubbing permits.

5.2.3 Cost

The total estimated cost for Alternative 2a - On-Island Landfill Disposal alternative is estimated at $484,000. The cost of Alternative 2b – Mainland Landfill Disposal is estimated at $1,774,000. Details are provided in Tables 6 and 7.

5.3 ALTERNATIVE 3 – ONSITE CAPPING

Onsite containment and capping of contaminated soils is a proven removal technology designed to improve the condition of targeted property and eliminate direct contact hazards associated with a contaminated soil or waste material. Under Alternative 3, soils exceeding the unrestricted land use RALs for arsenic and dioxin will be contained in place and capped with either clean soil (Alternative 3a) or a concrete cap (Alternative 3B). The contaminated soil containment area, after capping, would not be used for future residential redevelopment.

The areas of arsenic and dioxin contaminated soils exceeding RALs (Category C and D soils) are shown on Figures 7 and 8. The footprint of dioxin contaminated soils is greater than that for arsenic, and it is this larger footprint that would define the capping area. It includes DU-1, DU-2, DU-3, DU-4, DU-7, DU-8, and DU-10 (orange and red areas on Figure 8). The remedy would consist of constructing a concrete stem wall at the property boundaries along the south and east perimeters of the impacted area. This wall will support the onsite cap, and will function to prevent migration of contaminated soil onto the remediated area from adjacent, unmitigated properties (Harbottle and Westrum properties). Additionally, the stem wall will retain and direct stormwater within the HICDC property boundary.

For the soil cap alternative (2a), the cap system will consist of a demarcation barrier (e.g., geomembrane) and labeled warning tape placed above the contaminated soil, covered by at least 2 ft of clean cover soil. Stanchions would be placed at the corners of the containment area, with signage indicating that arsenic- and dioxin-contaminated soils are present beneath the soil cap. For the concrete cap alternative (2b), geotextile fabric and crushed stone subbase would be placed above the contaminated soil, followed by a 6 in. thick concrete surface layer.

Institutional controls, to include deed notice and environmental covenant, with land use restrictions, and an Environmental Hazard Management Plan (EHMP), would be implemented as a final component of this removal action alternative. Long-term inspection and maintenance of the soil or concrete cap would be required in perpetuity.

5.3.1 Effectiveness

Storage within an onsite capped containment area is an effective remedy to eliminate the potential for human and ecological direct contact with exposed arsenic- and dioxin-contaminated soils. The soils that present a direct contact hazard (Category C and D soils) are

placed under a soil or concrete cap, providing a physical barrier eliminating the potential for exposure. This remedy effectively mitigates human health and environmental hazards. This scenario is not considered a permanent solution, since the contaminated soil has not been completely eliminated, but it does meet long-term effectiveness goals. Overall this alternative would protect human health and the environment. Storage in an onsite capped containment area would not reduce the toxicity or volume of the contaminated soil, but the engineered cap would prevent direct contact risks and significantly decrease contaminant mobility potential.

Long-term effectiveness of the cover system can be increased by engineering and institutional controls to prevent unwanted intrusive activities. Engineering controls include visible subsurface barriers (geotextile fabric, buried warning tape) for the soil cap alternative, and a physical surface barrier under the concrete cap for that alternative. Both capping alternatives will include perimeter stanchions with signage indicating that contaminated soils are located within the perimeter of the stanchions. Institutional controls, such as land use and/or deed restrictions, will ensure that the location and engineering features of the containment cell are known and documented to ensure long-term safety. Long-term effectiveness of the concrete cap is expected to be greater than for the soil cap. The soil cap will require ongoing maintenance to limit the establishment of deep rooting plants, which may breach the soil cap and compromise the cap's structural integrity, and surface repairs for any soil erosion that may occur.

Short-term effectiveness of the capping alternatives is lessened by potential contaminant exposure to workers and the community during implementation of the grading, geotextile placement, and capping work. This exposure risk can be overcome by proper worker PPE, air monitoring, and mitigations such as dust suppression, dust barriers, etc. This alternative would be in compliance with regulatory requirements.

5.3.2 Implementability

This alternative is technically feasible and avoids transporting contaminated soil over public roadways, and will not consume valuable landfill space. An engineering design and construction plans would be described in a removal action work plan that would be prepared in advance of work to ensure proper implementation. All engineering and construction components of this remedy are readily implemented using standard environmental remediation and civil construction techniques. Dust control and soil erosion control measures will be implemented during soil excavation, relocation, and grading activities to prevent nuisance and contaminant migration.

Local permitting is expected to be required in order to perform soil excavation work and build an onsite soil or concrete cap. This would include stormwater and grading/grubbing permits. Land use restrictions, in the form of a deed notice (environmental covenant) and an associated EHMP, will be recorded for the area of the property where the soil or concrete cap is placed.

5.3.3 Cost

The total estimated cost for the On-site Capping remedy for Category C and D Soils alternatives are $365,000 for the soil capping alternative (3a) and $364,000 for the concrete capping alternative (3b). Costs include construction costs to implement the remedy and long-term O&M costs to maintain the remedy in perpetuity. In order to fully account for the long-term cost of ownership of a capping remedy, the net present value of anticipated O&M costs are included in cost estimates for alternatives 3a and 3b. Details are provided in Tables 8 and 9.

5.4 COMPARISON OF ALTERNATIVES AND RECOMMENDATION

Table 10 provides a comparison of the removal action alternatives presented herein. Of the five removal action alternatives presented, Alternative 1 (No Action) does not meet the minimum requirements of protecting human health and the environment, since RAOs are not achieved and, in particular, because hazards posed by soils containing arsenic and dioxin above the RALs are not addressed.

Comparison of Alternative 2a (on-island landfill disposal), Alternatives 2b (mainland landfill disposal), Alternative 3a (soil cap) and Alternative 3b (concrete cap) on the basis of effectiveness, implementability, and cost, provides some noticeable contrasts.

In terms of effectiveness, all four remedies are generally effective at preventing human direct contact exposure with contaminated soils. Since arsenic in soil cannot be eliminated, and dioxin can only be destroyed using very expensive thermal technologies, a key differentiator is the location where the material will reside for the long term. Alternatives 2a/2b provide the greatest long-term effectiveness since the contaminated soil is moved to a permitted landfill facility designed and managed for the purpose of long-term storage of solid waste materials. After implementing the remedy, the site is available for future use without future constraints. There is no difference in effectiveness between Alternatives 2a and 2b, only a difference in whether the receiving landfill is in Hawaii or the mainland. Alternatives 3a and 3b provide somewhat less effectiveness than Alternatives 2a/2b, since the contaminated soils will remain on the site and will have to be managed in that location for the foreseeable future. Alternative 3a (soil cap) will be less effective than Alternative 3b (concrete cap), as the potential for accidental intrusion beneath the cap and contact with contaminated soils is higher. The concrete cap provides both a more visible indication that the site should not be disturbed, as well as a more difficult and unlikely situation for accidental (or intentional) intrusive activities.

From a technical and construction perspective, all alternatives can be readily implemented. Alternative 2 (offsite landfill disposal), involves significant truck traffic through the local community and across county roads, which increases traffic safety risk and nuisance issues, whereas with Alternative 3 (capping), construction activities are confined to the site. The onsite

capping alternatives will require land use restrictions, in the form of a deed notice (environmental covenant) and an associated EHMP.

Alternative 2 (excavation and offsite landfill disposal) provides the least restrictions on future use and redevelopment at the property, in that no areas are subject to land use restrictions designed to prevent intrusion through the impounded soil capping system. The landfill alternative also permanently removes the contaminated soil from the site, leaving a clean site behind for future use. This remedy would alleviate the potential for community stigma related to having a contaminated site (albeit capped) located in a residential community for perpetuity.

The cost of Alternative 2b (Mainland Landfill Disposal) is the highest of all alternatives at $1,774,000. Alternative 2a, On-Island Landfill Disposal, is the next highest cost at $484,000. The onsite capping remedies have slightly lower cost, with the soil cap alternative estimated to cost $365,000, and the concrete cap alternative estimated at $364,000.

Based on comparison of the remedial alternatives, Alternative 2a (On-Island Landfill Disposal) provides the best balance of effectiveness, implementability, and cost. In addition, this remedy results in a clean site, with no loss of land use, no need to manage long-term O&M, and no potential community stigma of having a closed contaminated site in the neighborhood. Based on thoughtful comparison of the alternatives, On-Island Landfill Disposal is recommended for selection by HDOH as the approved removal action alternative.

6 CONCEPTUAL DESIGN AND IMPLEMENTATION

This section provides a description of the conceptual design for implementation of Alternative 2a, consisting of excavation and on-island landfill disposal of arsenic and TEQ dioxin Category C and D soil.

6.1 REMOVAL ACTION WORK PLAN

Following HDOH approval of the recommended remedy, a removal action work plan containing construction specifications and implementation plans will be prepared and submitted to HDOH for review, comment and approval before commencing work. Health and safety protocols, including specialized training requirements for workers, will be presented in an environmental health and safety plan for activities performed during implementation of the contaminated soil remediation. The environmental health and safety plan will include special precautions for handling and respiratory protection, as well as prevention of cross contamination between the HICDC property and adjacent properties.

6.2 SITE PREPARATION ACTIVITIES

Preparatory work to facilitate remedy implementation will include the following activities: 1) clearing of vegetation and fencing; 2) installation of a construction access road; 3) removal of one large banyan tree, and; 4) disassembly and removal of four steel ASTs. Vegetation within the impacted area consists of dense shrubs and trees. To facilitate survey work and delineation of cap extent, grubbing work shall bring vegetation to ground level. Existing fencing surrounding the impacted area, and ranch fencing along the northern perimeter of the site, will be removed to provide vehicle access from Kumakua Street. Silt fencing will be installed along property boundaries to prevent cross-property migration of contaminated soil.

No access road exists at the subject site; heavy duty vehicles necessary for remedy construction will require installation of a gravel access road. Integrated within the western (upper) CRM wall, as depicted in Figure 4, is a large banyan tree. Above-ground vegetation and root systems of the banyan tree must be removed prior to implementing the recommended remedy. West of the CRM wall are four ASTs. Two vertical tanks measure approximately 10 ft in height and 8 ft in diameter, and two horizontal tanks measure approximately 20 ft long and 6 ft in diameter. All ASTs are empty and rinsate testing (Weston 2011) indicated that residual contents are non-hazardous. Prior to implementing the recommended remedy, each tank shall be disassembled and either recycled or disposed according to state and federal requirements.

Planned excavation limits will be marked to facilitate soil excavation. Site work perimeters will be established, and soil loading and equipment decontamination areas will be constructed.

6.3 SOIL EXCAVATION AND DISPOSAL

Soil within the DUs containing arsenic and TEQ dioxins exceeding RALs will be excavated and loaded into dump trucks for transport and disposal at the West Hawaii Landfill. The depth of initial soil excavation will be based on prior sampling and analysis work (see estimated soil contamination depths on Table 5). A portable X-ray fluorescence (XRF) instrument, capable of measuring total arsenic levels, will be used to confirm that soil excavation depths are adequate.

During soil excavation and truck loading, water spray will be used as necessary to prevent generation of dust. A site health & safety manager will be on site during all soil handling periods to ensure compliance with the project-specific Health & Safety Plan, including dust control measures. Soils will be transported from the site to the landfill by a licensed trucking firm in dump trucks with tarp covers to prevent soil release during transport. Soil will be dumped at the landfill under the direction of Waste Management personnel.

Rock and cement from the existing retaining walls, and roots associated with the banyon tree and other vegetation, are anticipated to be generated during excavation work along with soils. This larger debris material will be managed as waste material and will be landfill disposed. No attempt to "clean" and reuse the debris will be made.

6.4 POST-EXCAVATION CONFIRMATORY SAMPLING AND ANALYSIS

Once soils have been removed to design limits and as further required by real-time XRF analysis, a comprehensive post-excavation confirmation sampling and analysis program will be implemented. The sampling and analysis will consist of MI sampling of soils on the excavation bottom and sidewalls, in accordance with a sampling design described in the HDOH-approved removal action work plan. If samples are determined to meet the RALs, then the excavation work will be deemed complete, and site restoration work will commence. If soils within certain confirmation DUs do not meet RALs, then further excavation and additional confirmation sampling will be undertaken – until RALs are achieved across the project site.

6.5 SITE RESTORATION

Upon attainment of RALs, as demonstrated by post-excavation sampling and analysis, the excavation will be backfilled with clean soil and graded to conform with the surrounding topography. Nearby clean soils from HICDC property are anticipated to be used for backfill. Once placed and compacted, soils will be re-vegetated with grasses to prevent soil erosion and allow for future use.

6.6 PROJECT CLOSE-OUT

Upon completion of the removal action work, a removal action completion report will be submitted describing the work performed, providing as-built drawings of the engineered remedy and certifying attainment of the RALs. Upon review and approval of the completion report, HDOH will issue a No Further Action letter, indicating that site cleanup has been achieved. After such time, the site should be available for unrestricted use.

7 CONCLUSIONS AND RECOMMENDATIONS

This removal action report addresses the need for remedial action of arsenic- and dioxin-impacted soils at the subject property. Based on soil investigations at the site, it has been determined that these contaminants are present at concentrations requiring a response action. RAOs have been developed as follows:

1. Remediate portions of the property anticipated for future unrestricted (residential) land use to appropriate bioaccessible arsenic and TEQ dioxin soil concentrations (RALs)
2. Prevent migration of contaminants to surface or groundwater
3. Minimize potential risk to human health or ecological receptors from exposure to arsenic- and dioxin-impacted soil, during and after the removal action.

RALs are defined to be consistent with the lower limits of Category C soils, consisting of 23 mg/kg bioaccessible arsenic and 240 ng/kg TEQ dioxins. All soils above the RALs (Category C and D soils) shall be addressed by the removal action. Other chemicals of concern will be remediated to Tier 1 direct exposure EAL concentrations.

Four removal action alternatives (plus the No Action alternative) were evaluated in term of effectiveness, implementability, and cost. Alternative 2a, On-Island Landfill Disposal, was determined to provide the best balance of human health and environmental protectiveness at a reasonable cost.

Upon approval of the recommended removal action alternative by HDOH, a removal action work plan will be prepared to provide design specifications and guidance in implementing the proposed remedy.

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FIGURES

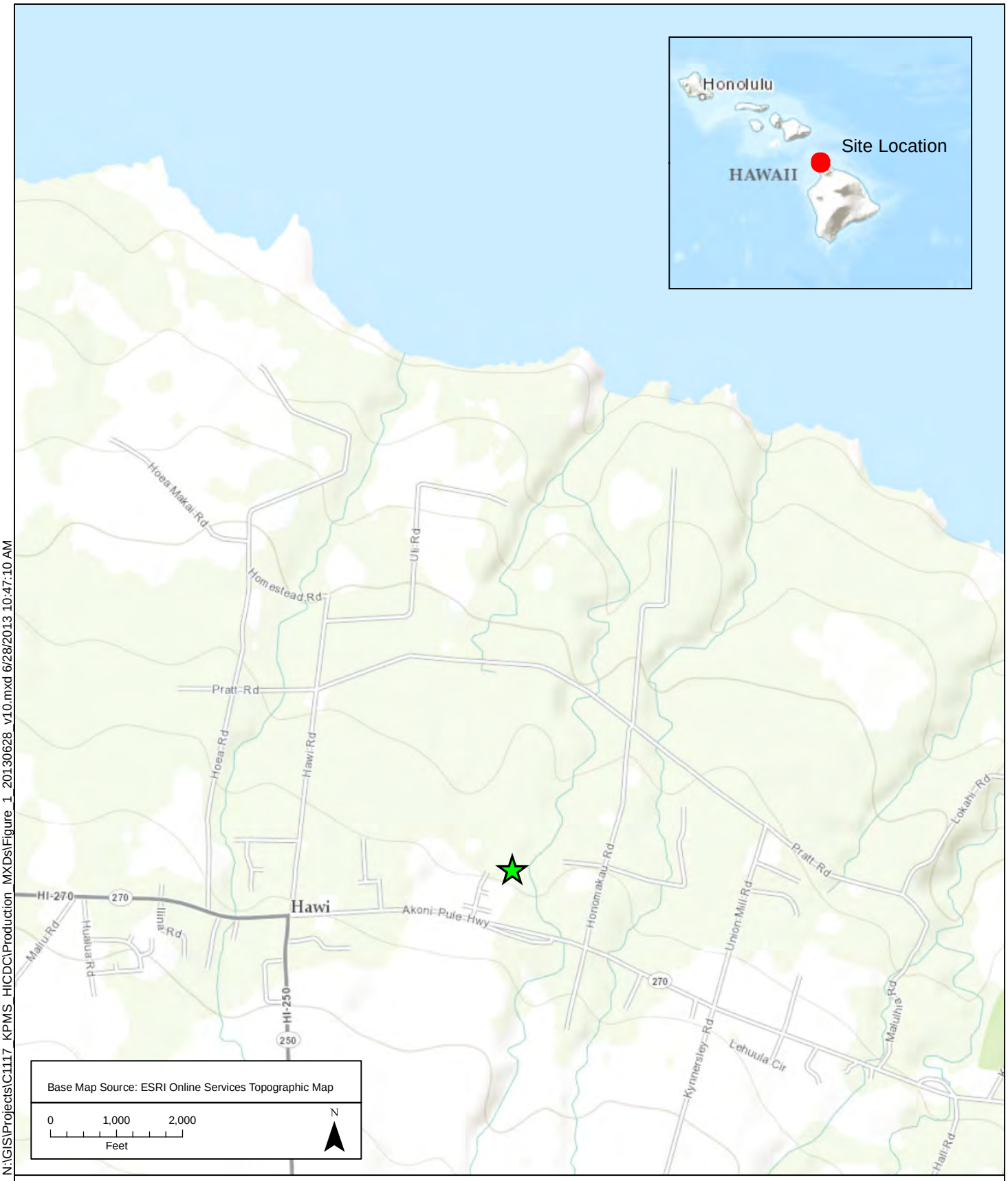

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Figure 1.
Site Location Map
Former Kohala Sugar Company Pesticide Mixing Site

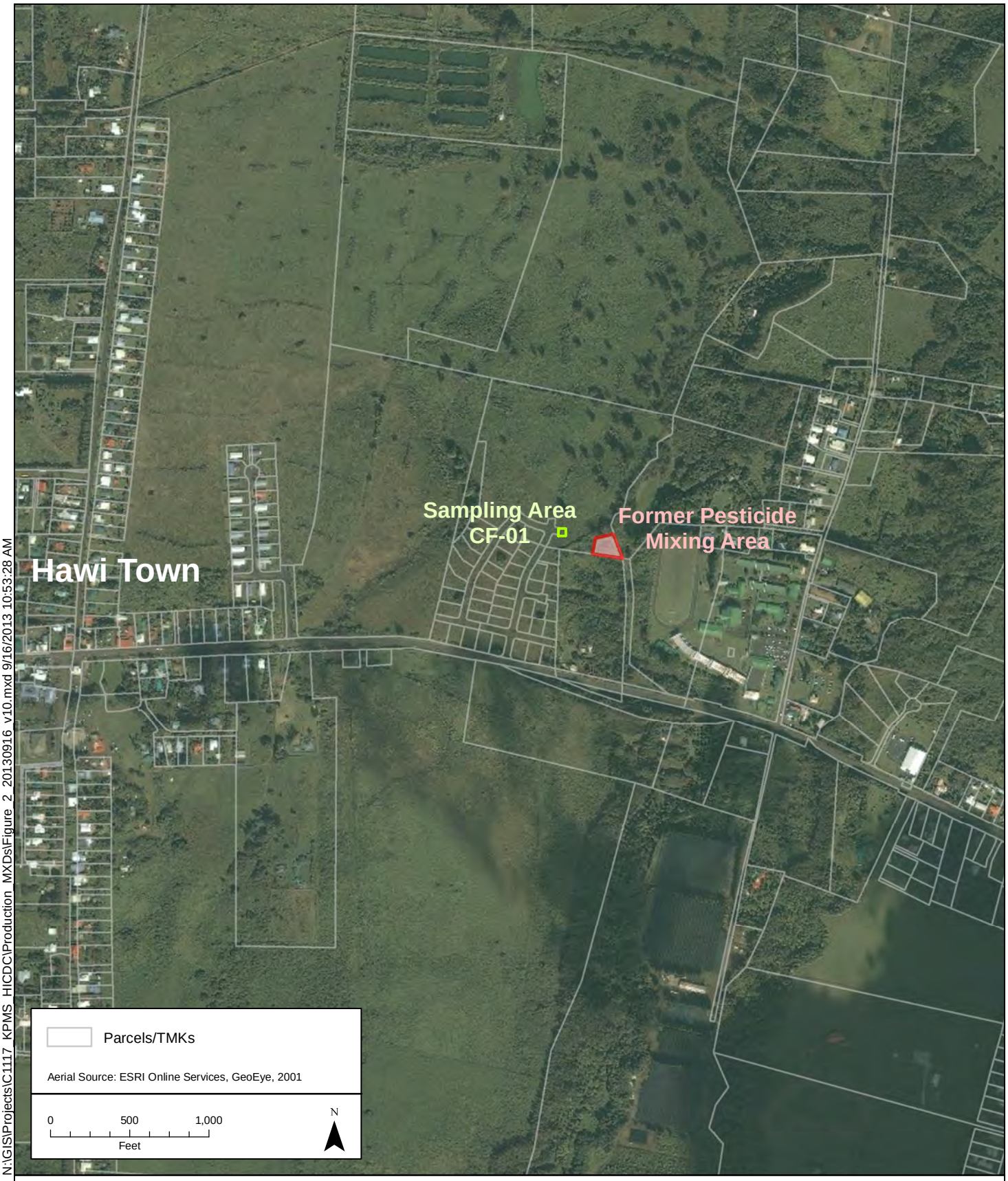

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Figure 2.
Site Vicinity, Aerial Photograph, and Property Boundaries
Former Kohala Sugar Company Pesticide Mixing Site

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Figure 3.
Site Vicinity, Aerial Photograph, and Neighboring Properties
Former Kohala Sugar Company Pesticide Mixing Site

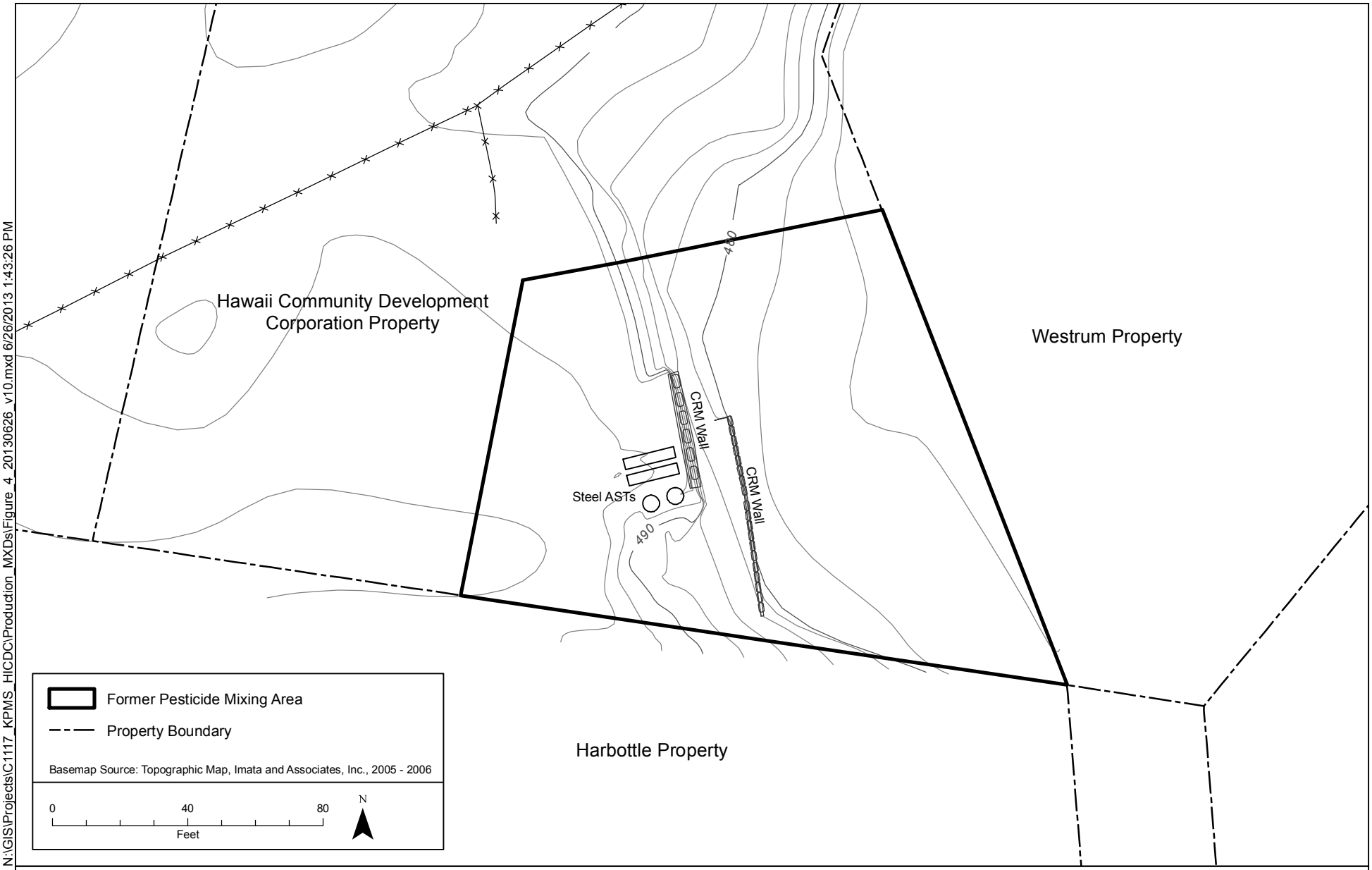

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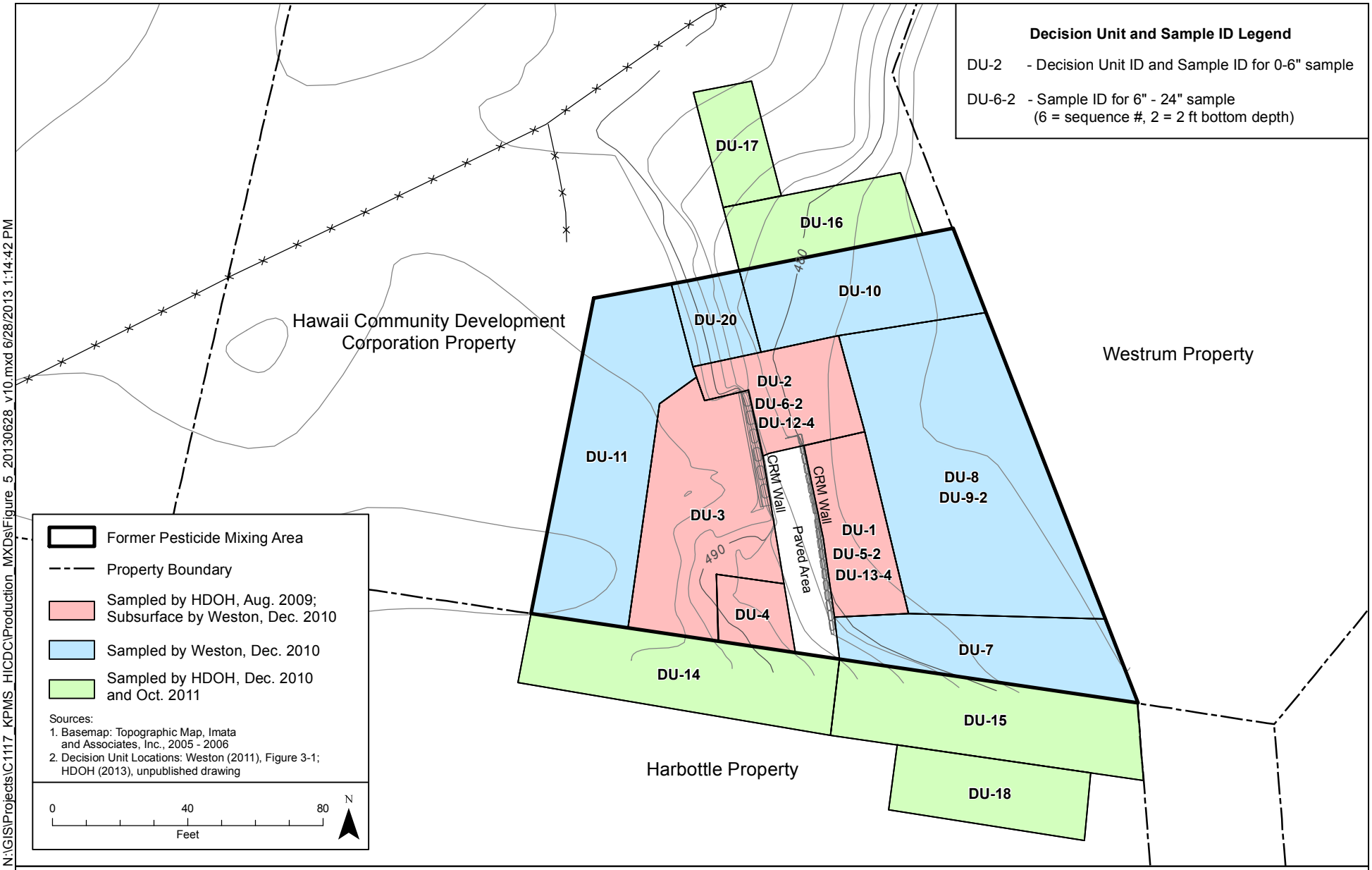
Figure 4.
Site Features
Former Kohala Sugar Company Pesticide Mixing Site



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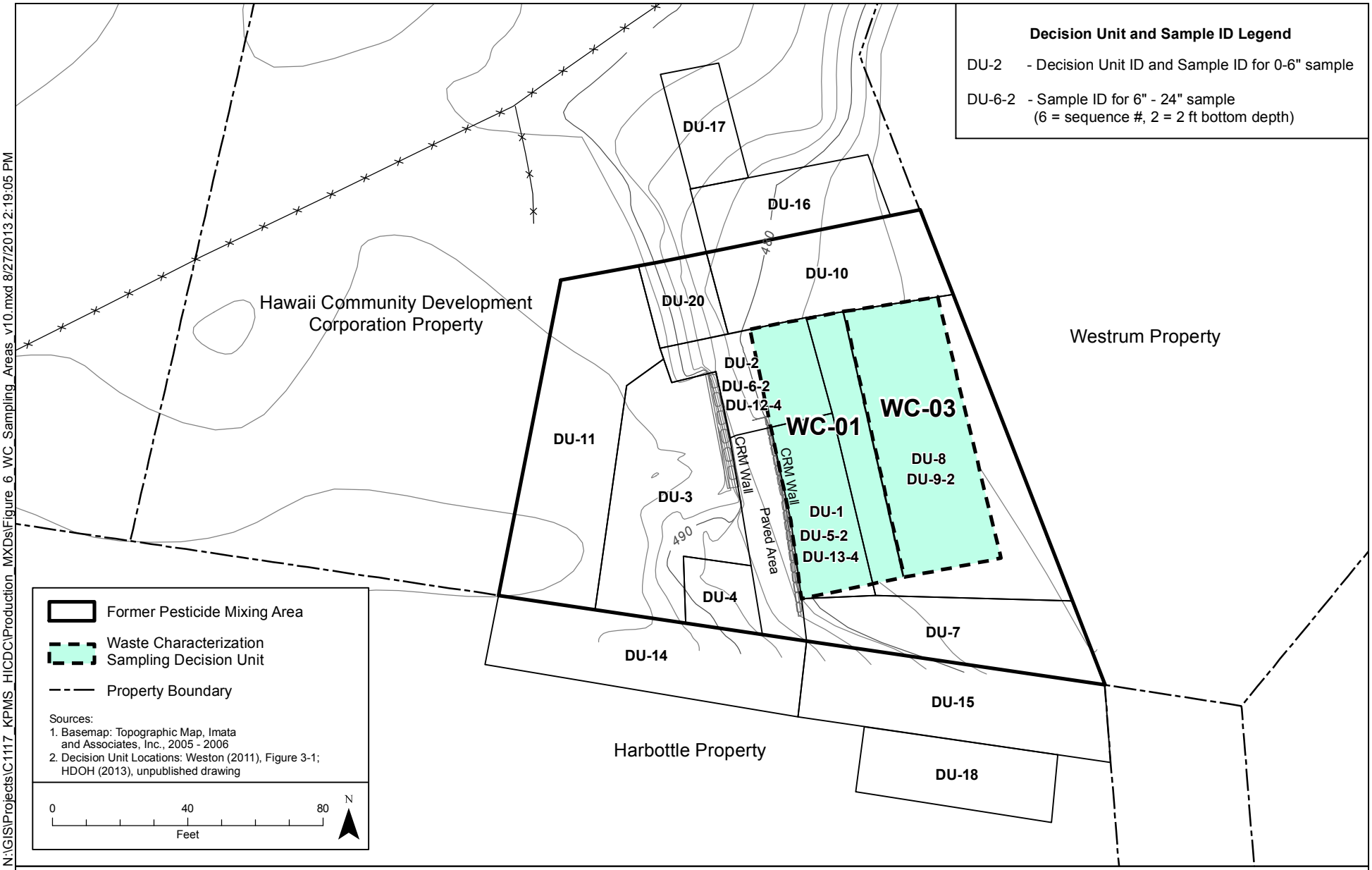
integral consulting inc.

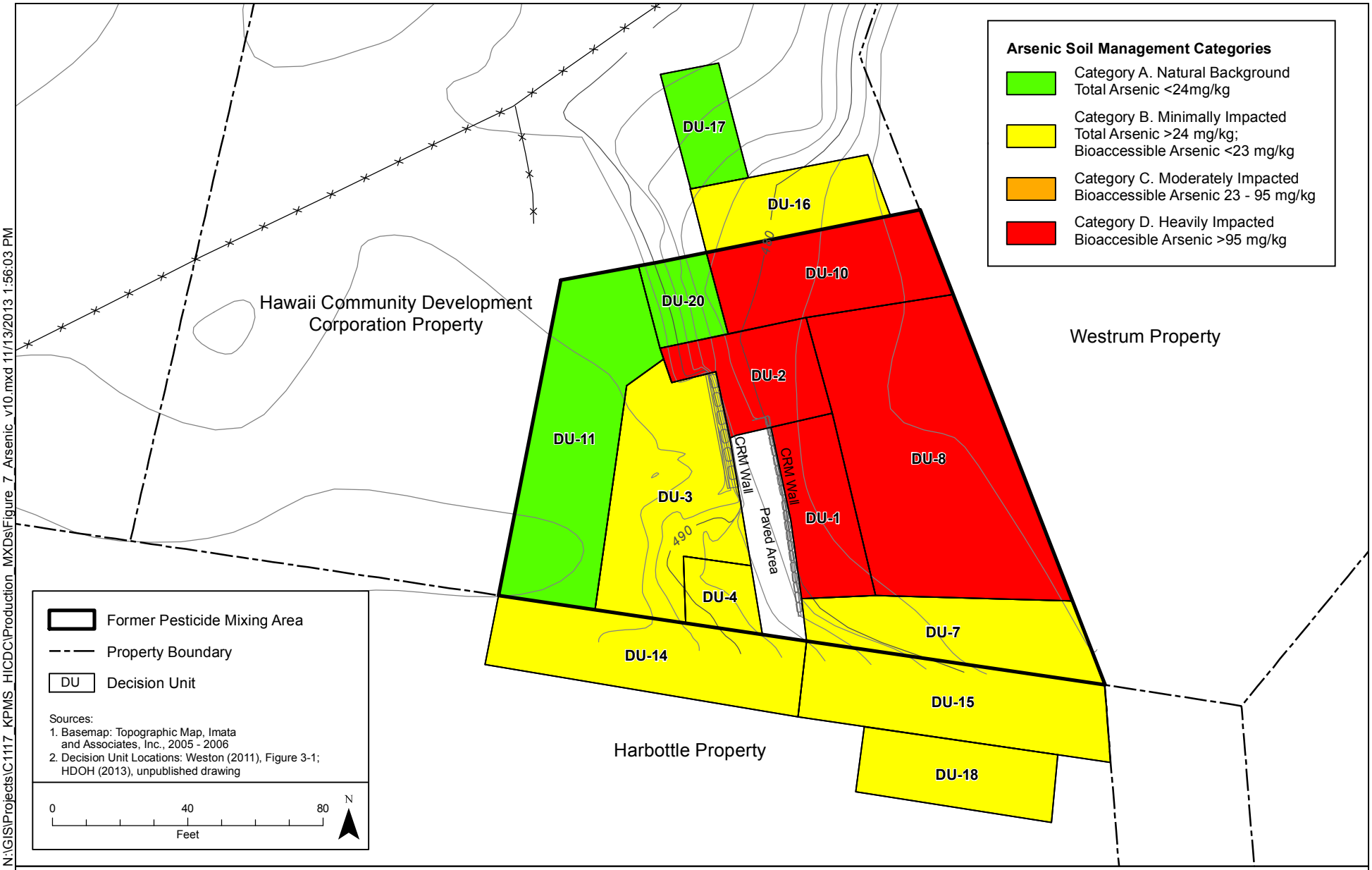
Figure 5.
Decision Units and Sample IDs
Former Kohala Sugar Company Pesticide Mixing Plant



N:\GIS\Projects\C1117_KPMS_HICDC\Production_MXDs\Figure_6_WC_Sampling_Areas_v10.mxd 8/27/2013 2:19:05 PM

integral consulting inc.

Figure 6.
Waste Characterization Sampling Areas
Former Kohala Sugar Company Pesticide Mixing Plant



N:\GIS\Projects\C1117_KPMS_HICDC\Production_MXDs\Figure_7_Arsenic_v10.mxd 11/13/2013 1:56:03 PM

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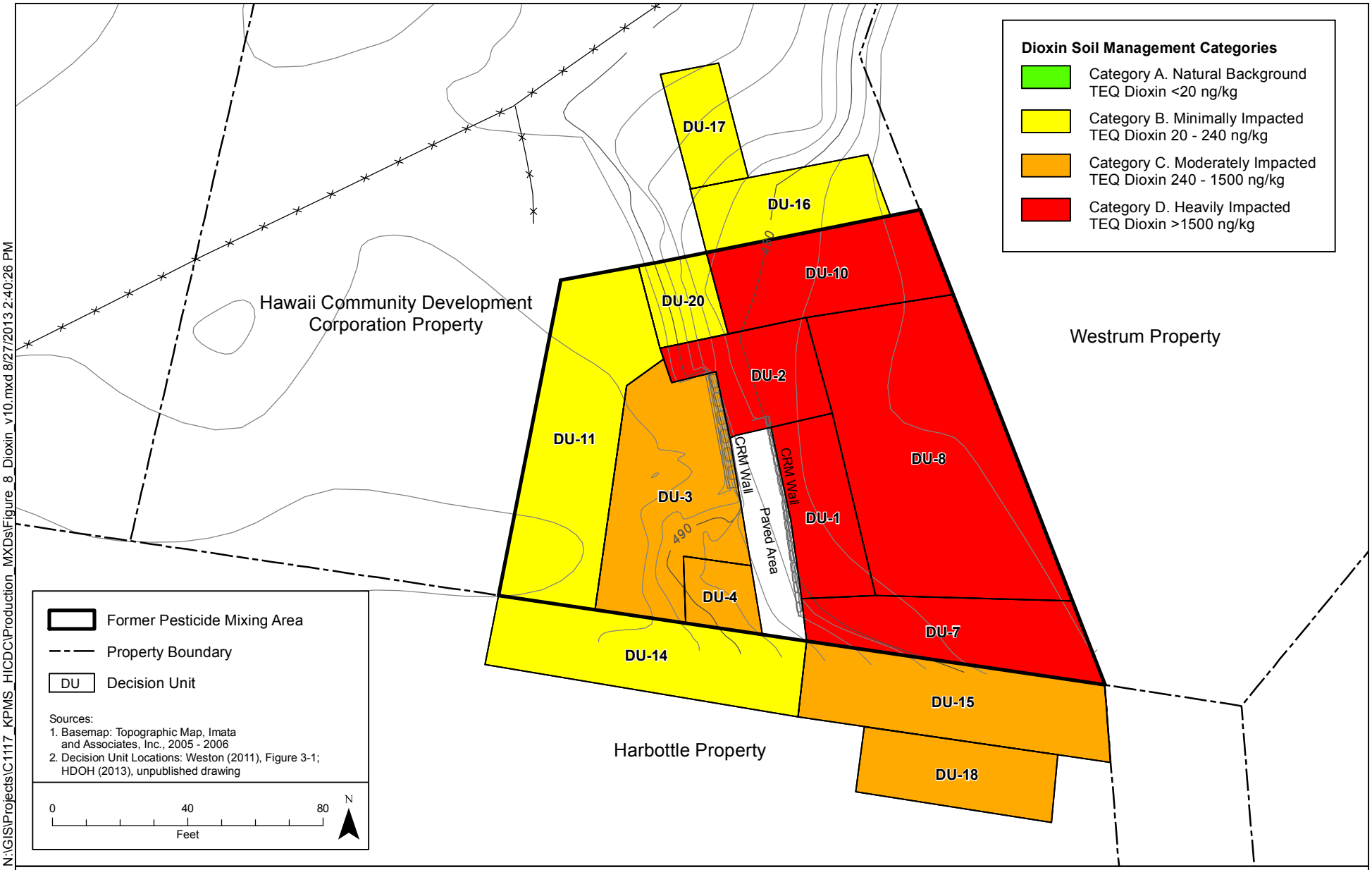
Figure 7.
Environmental Hazard Map
Arsenic in Surface Soils (0-6 in. bgs)
Former Kohala Sugar Company Pesticide Mixing Plant



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integral consulting inc.

Figure 8.
Environmental Hazard Map
Dioxin in Surface Soils (0-6 in. bgs)
Former Kohala Sugar Company Pesticide Mixing Plant

TABLES

Table 1. Surface and Subsurface Soil Sampling Results and Environmental Hazard Screening

	Environmental Action Levels [a]																			
	Soil Environmental Hazards						Sample ID:	KPMA-DU-1	KPMA-DU-2	KPMA-DU-3	KPMA-DU-4 [b]	KPMA-DU-5 [b]	KPMA-DU-6 [b]	DU-5-2	DU-6-2	DU-07	DU-8 [c]	DU-9-2	DU-10	DU-11	DU-12-4
							Decision Unit ID:	DU-1	DU-2	DU-3	DU-4	DU-4	DU-4	DU-1	DU-2	DU-7	DU-8	DU-8	DU-10	DU-11	DU-2
							Sample Depth:	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	6"-24"	6"-24"	0"-6"	0"-6"	6"-24"	0"-6"	0"-6"	24"-48"
							Sampled By:	HDOH	HDOH	HDOH	HDOH	HDOH	HDOH	WESTON	WESTON	WESTON	WESTON	WESTON	WESTON	WESTON	WESTON
Compounds	Direct Exposure	Vapor Emissions To Indoor Air	Terrestrial Ecotoxicity	Gross Contamination	Leaching	Background	Sample Date:	8/17/09	8/17/09	8/17/09	8/17/09	8/17/09	8/17/09	12/14/10	12/14/10	12/13/10	12/13/10	12/14/10	12/14/10	12/15/10	12/15/10
Dioxins-Furans (ng/kg)																					
TEQ Dioxins-Furans [f]	240	nonvolatile	site-specific	1E+09	180000	240		**11000**	**7100**	**250**	**660**	**610**	**900**	**420**	**1000**	**4700**	**4700**	**1400**	**1800**	63	230
Metals (mg/kg)																					
Arsenic, total (<2 mm fraction)	23	nonvolatile	site-specific	1000	use batch test	24		821	788	24	28	34	25	306	368	66.9	2030	489	714	15.2	35.6
Arsenic, bioaccessible[g] (<0.25 mm fraction)	23	NA	NA	NA	NA	NA		**234**	**197**	NA	NA	ND	NA	**54.7**	**59.9**	8.6	**519**	**98.9**	**176**	NA	3.6
Lead	200	nonvolatile	site-specific	1000	use batch test	73		**210**	64	25	109	135	120	20.1	66	14	89.8	12.4	43.9	18.4	11.5
Mercury	4.7	use soil gas	site-specific	500	use batch test	0.72		**14.2**	**8.0**	0.31	0.44	0.47	0.42	0.56	1.21	0.57	**6.92**	0.53	1.6	0.42	0.78
Semivolatile organic compounds (µg/kg)																					
Benzo(a)pyrene	150	nonvolatile	site-specific	500000	5700	NA		ND	ND	**295**	**998**	**3220**	**1810**	4.6 J	ND	36 J	41 J	3.1 J	**150**	15 J	ND
Benzo(a)anthracene	1500	nonvolatile	site-specific	500000	10000	NA		202	ND	199	1050	**3240**	**1890**	3.5 J	ND	23 J	41 J	ND	150	13 J	ND
Benzo(b)fluoranthene	1500	nonvolatile	site-specific	500000	9200	NA		366	202	558	**1960**	**5780**	**3350**	8.3 J	23 J	63	95	7.3 J	260	27 J	7.6 J
Dibenzo(a,h)anthracene	150	nonvolatile	site-specific	500000	12000	NA		91	ND	89	**172**	**548**	**293**	ND	ND	7.7 J	13 J	ND	27 J	ND	ND
Indeno(1,2,3-cd)pyrene	1500	nonvolatile	site-specific	500000	30000	NA		161	109	193	546	**1750**	966	3.6 J	ND	34 J	39 J	4 J	93	10 J	739 J
Pentachlorophenol	890	nonvolatile	site-specific	500000	820	NA		**3470**	**3520**	250	725	554	**1760**	0.5	1.37	0.31 J	3.02	4.48	0.57	0.22 J	0.30 J

Table 1. Surface and Subsurface Soil Sampling Results and Environmental Hazard Screening

	Environmental Action Levels [a]																	
	Soil Environmental Hazards						Sample ID:	DU-13-4	DU-14	DU-15 [d]	DU-16 [d]	DU-17 [d]	DU-18 [c]	DU-19 [c]	DU-20	KSPMA2-DU-1 [e]	KSPMA2-DU-2 [e]	KSPMA2-DU-3 [e]
							Decision Unit ID:	DU-1	DU-14	DU-15	DU-15	DU-15	DU-8	DU-8	DU-20	DU-16	DU-17	DU-18
							Sample Depth:	24"-48"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"
							Sampled By:	WESTON	HDOH	HDOH	HDOH	HDOH	WESTON	WESTON	WESTON	HDOH	HDOH	HDOH
Compounds	Direct Exposure	Vapor Emissions To Indoor Air	Terrestrial Ecotoxicity	Gross Contamination	Leaching	Background	Sample Date:	12/15/10	12/13/10	12/13/10	12/13/10	12/13/10	12/13/10	12/13/10	12/15/10	10/12/11	10/12/11	10/12/11
Dioxins-Furans (ng/kg)																		
TEQ Dioxins-Furans [f]	240	nonvolatile	site-specific	1E+09	180000	240		150	80	220	**470**	280	**4200**	**4200**	55	130	50	**350**
Metals (mg/kg)																		
Arsenic, total (<2 mm fraction)	23	nonvolatile	site-specific	1000	use batch test	24		80.5	24.6	73.5	151	115	1440	2440	8.6	32	11	35
Arsenic, bioaccessible[g] (<0.25 mm fraction)	23	NA	NA	NA	NA	NA		10.8	NA	NA	NA	NA	NA	**660**	NA	NA	NA	NA
Lead	200	nonvolatile	site-specific	1000	use batch test	73		9.69	23.4	22	29	27.6	83.4	62.8	12.9	9.6	9.1	17
Mercury	4.7	use soil gas	site-specific	500	use batch test	0.72		0.85	0.63	0.73	1.06	1.08	2.96	3.03	0.43	0.27	0.39	0.62
Semivolatile organic compounds (µg/kg)																		
Benzo(a)pyrene	150	nonvolatile	site-specific	500000	5700	NA		6.6 J	**169**	16.9	72.5	23.5	52 J	130	10	ND	ND	ND
Benzo(a)anthracene	1500	nonvolatile	site-specific	500000	10000	NA		6.5 J	94.8	13.7	49.4	17.9	44 J	110	9.2 J	ND	ND	ND
Benzo(b)fluoranthene	1500	nonvolatile	site-specific	500000	9200	NA		13 J	272	29.4	112	45	120	250	25 J	ND	ND	ND
Dibenzo(a,h)anthracene	150	nonvolatile	site-specific	500000	12000	NA		ND	19.9	ND	10.8	ND	16 J	37 J	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	1500	nonvolatile	site-specific	500000	30000	NA		539 J	65.5	9.58	39.2	11.6	46 J	94	8.6 J	ND	ND	ND
Pentachlorophenol	890	nonvolatile	site-specific	500000	820	NA		NA	NA	NA	NA	NA	4.81	1.87	0.21 J	ND	ND	130

Notes:

Table includes only compounds with one or more sample result exceeding HDOH Tier 1 EAL.

Screening color coding:

Exceeds Direct Contact EAL (bioaccessible arsenic screening in lieu of total arsenic)

Exceeds Direct Contact and Leaching EALs

EAL = environmental action level

HDOH = Hawaii Department of Health

NA = not analyzed

ND = not detected at lab detection limit

J = estimated value. Analyte detected but a concentration less than the quantitation limit.

[a] HDOH Environmental Action Levels for:
Land Use: Unrestricted
Groundwater Utility: Drinking Water
Distance to nearest surface water body >150m

[b] Samples DU-4, DU-5 and DU-6 are triplicate multi-increment (MI) samples of surface soils (0"-6") from Decision Unit 4

[c] Samples DU-8, DU-18 and DU-19 are triplicate MI samples of surface soils (0"-6") from Decision Unit 8

[d] Samples DU-15, DU-16 and DU-17 are triplicate MI samples of surface soils (0"-6") from Decision Unit 16

[e] Sample IDs DU-16, DU-17 and DU-18 were used by Weston in December 2010, and again by HDOH in October 2011. The reader is cautioned to refer to sample ID, Decision Unit ID and Sample Depth to avoid confusion.

[f] Dioxin and furan congeners are converted to Toxic Equivalency (TEQ) value of most toxic congener (2,3,7,8-TCDD); 1/2 detection limit value used for non-detect values.

[g] Bioaccessible arsenic measured using SBRC-gastric in vitro method.

Table 2. TEQ Dioxin Calculations

	Sample ID ->	HSH0123-01				HSH0123-02				HSH0123-03				HSH0123-04			
				TEQ [a]				TEQ				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0) [d]	(ND=DL/2) [e]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)
2,3,7,8-TCDD	1	450		450	450	260		260	260	120		120	120	79		79	79
1,2,3,7,8-PeCDD	1	1400		1400	1400	440		440	440	13		13	13	38		38	38
1,2,3,4,7,8-HxCDD	0.1	2100		210	210	970		97	97	37		4	4	91		9	9
1,2,3,6,7,8-HxCDD	0.1	19000		1900	1900	12000		1200	1200	150		15	15	730		73	73
1,2,3,7,8,9-HxCDD	0.1	4500		450	450	2200		220	220	80		8	8	240		24	24
1,2,3,4,6,7,8-HpCDD	0.01	350000		3500	3500	260000		2600	2600	4900		49	49	27000		270	270
OCDD	0.0003	1200000		360	360	1100000		330	330	50000		15	15	230000		69	69
2,3,7,8-TCDF	0.1	42		4	4	16		2	2	2.3		0	0	3.1		0	0
1,2,3,7,8-PeCDF	0.03	160		5	5	96		3	3	ND	1.8	0	0	5.8		0	0
2,3,4,7,8-PeCDF	0.3	190		57	57	150		45	45	ND	2.3	0	0	7.6		2	2
1,2,3,4,7,8-HxCDF	0.1	3400		340	340	4700		470	470	35		4	4	120		12	12
1,2,3,6,7,8-HxCDF	0.1	1700		170	170	1300		130	130	18		2	2	57		6	6
2,3,4,6,7,8-HxCDF	0.1	1500		150	150	1100		110	110	20		2	2	46		5	5
1,2,3,7,8,9-HxCDF	0.1	ND	54	0	3	ND	31	0	2	ND	0.56	0	0	ND	2.3	0	0
1,2,3,4,6,7,8-HpCDF	0.01	140000		1400	1400	93000		930	930	1400		14	14	6600		66	66
1,2,3,4,7,8,9-HpCDF	0.01	7500		75	75	7600		76	76	100		1	1	350		4	4
OCDF	0.0003	250000		75	75	520000		156	156	4500		1	1	13000		4	4
			Total TEQ	**10546**	**10549**		Total TEQ	**7068**	**7070**		Total TEQ	**248**	**248**		Total TEQ	**661**	**661**
			Round 2-sigfigs [f]	**11000**	**11000**		Round 2-sigfigs	**7100**	**7100**		Round 2-sigfigs	**250**	**250**		Round 2-sigfigs	**660**	**660**

Table 2. TEQ Dioxin Calculations

	Sample ID ->	HSH0123-05				HSH0123-06				DU-5-2				DU-6-2			
				TEQ				TEQ				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)
2,3,7,8-TCDD	1	98		98	98	83		83	83	ND	8.4	0	4	ND	10	0	5
1,2,3,7,8-PeCDD	1	35		35	35	40		40	40	ND	44	0	22	ND	89	0	45
1,2,3,4,7,8-HxCDD	0.1	78		8	8	100		10	10	ND	86	0	4	ND	170	0	9
1,2,3,6,7,8-HxCDD	0.1	660		66	66	990		99	99	660		66	66	1400		140	140
1,2,3,7,8,9-HxCDD	0.1	190		19	19	250		25	25	180		18	18	ND	400	0	20
1,2,3,4,6,7,8-HpCDD	0.01	23000		230	230	40000		400	400	16000		160	160	43000		430	430
OCDD	0.0003	230000		69	69	330000		99	99	190000		57	57	610000		183	183
2,3,7,8-TCDF	0.1	14		1	1	3.8		0	0	ND	5.5	0	0	ND	6.6	0	0
1,2,3,7,8-PeCDF	0.03	6.6		0	0	7.7		0	0	ND	7.7	0	0	ND	12	0	0
2,3,4,7,8-PeCDF	0.3	9.1		3	3	9.5		3	3	ND	7.8	0	1	ND	19	0	3
1,2,3,4,7,8-HxCDF	0.1	130		13	13	170		17	17	130		13	13	ND	360	0	18
1,2,3,6,7,8-HxCDF	0.1	65		7	7	67		7	7	ND	56	0	3	ND	140	0	7
2,3,4,6,7,8-HxCDF	0.1	55		6	6	56		6	6	ND	54	0	3	ND	150	0	8
1,2,3,7,8,9-HxCDF	0.1	ND	2.2	0	0	ND	2.3	0	0	ND	5.5	0	0	ND	14	0	1
1,2,3,4,6,7,8-HpCDF	0.01	5400		54	54	9700		97	97	5800		58	58	14000		140	140
1,2,3,4,7,8,9-HpCDF	0.01	280		3	3	480		5	5	320		3	3	830		8	8
OCDF	0.0003	12000		4	4	19000		6	6	11000		3	3	37000		11	11
			Total TEQ	**615**	**615**		Total TEQ	**896**	**896**		Total TEQ	**379**	**416**		Total TEQ	**912**	**1027**
			Round 2-sigfigs	**610**	**610**		Round 2-sigfigs	**900**	**900**		Round 2-sigfigs	**380**	**420**		Round 2-sigfigs	**910**	**1000**

Table 2. TEQ Dioxin Calculations

	Sample ID ->	DU-07				DU-08				DU-9-2				DU-10			
				TEQ				TEQ				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)
2,3,7,8-TCDD	1	160		160	160	610		610	610	ND	32	0	16	430		430	430
1,2,3,7,8-PeCDD	1	ND	440	0	220	ND	300	0	150	ND	98	0	49	ND	110	0	55
1,2,3,4,7,8-HxCDD	0.1	620		62	62	ND	670	0	34	ND	210	0	11	ND	190	0	10
1,2,3,6,7,8-HxCDD	0.1	4000		400	400	6200		620	620	2400		240	240	1900		190	190
1,2,3,7,8,9-HxCDD	0.1	1500		150	150	1600		160	160	740		74	74	470		47	47
1,2,3,4,6,7,8-HpCDD	0.01	100000		1000	1000	170000		1700	1700	66000		660	660	54000		540	540
OCDD	0.0003	1100000		330	330	1600000		480	480	520000		156	156	630000		189	189
2,3,7,8-TCDF	0.1	ND	36	0	2	ND	37	0	2	ND	7.8	0	0	ND	37	0	2
1,2,3,7,8-PeCDF	0.03	ND	52	0	1	ND	40	0	1	ND	11	0	0	ND	15	0	0
2,3,4,7,8-PeCDF	0.3	ND	67	0	10	ND	110	0	17	ND	22	0	3	ND	40	0	6
1,2,3,4,7,8-HxCDF	0.1	1000		100	100	1800		180	180	560		56	56	590		59	59
1,2,3,6,7,8-HxCDF	0.1	500		50	50	ND	620	0	31	ND	170	0	9	ND	220	0	11
2,3,4,6,7,8-HxCDF	0.1	ND	340	0	17	ND	490	0	25	ND	110	0	6	ND	190	0	10
1,2,3,7,8,9-HxCDF	0.1	ND	28	0	1	ND	56	0	3	ND	13	0	1	ND	12	0	1
1,2,3,4,6,7,8-HpCDF	0.01	40000		400	400	58000		580	580	14000		140	140	18000		180	180
1,2,3,4,7,8,9-HpCDF	0.01	2100		21	21	4100		41	41	1400		14	14	1100		11	11
OCDF	0.0003	91000		27	27	130000		39	39	39000		12	12	47000		14	14
			Total TEQ	**2700**	**2951**		Total TEQ	**4410**	**4671**		Total TEQ	**1352**	**1446**		Total TEQ	**1660**	**1754**
			Round 2-sigfigs	**2700**	**3000**		Round 2-sigfigs	**4400**	**4700**		Round 2-sigfigs	**1400**	**1400**		Round 2-sigfigs	**1700**	**1800**

Table 2. TEQ Dioxin Calculations

	Sample ID ->	DU-11				DU-12-4				DU-13-4				KHB-DU-14			
				TEQ				TEQ				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)
2,3,7,8-TCDD	1	5.5		6	6	ND	5.8	0	3	5		5	5	20		20	20
1,2,3,7,8-PeCDD	1	ND	5.6	0	3	ND	5.6	0	3	ND	16	0	8	ND	0.74	0	0
1,2,3,4,7,8-HxCDD	0.1	14		1	1	ND	27	0	1	25		3	3	ND	0.21	0	0
1,2,3,6,7,8-HxCDD	0.1	67		7	7	240		24	24	220		22	22	93		9	9
1,2,3,7,8,9-HxCDD	0.1	28		3	3	ND	56	0	3	57		6	6	46		5	5
1,2,3,4,6,7,8-HpCDD	0.01	2500		25	25	7900		79	79	5600		56	56	3100		31	31
OCDD	0.0003	27000		8	8	300000		90	90	65000		20	20	30000		9	9
2,3,7,8-TCDF	0.1	ND	1.9	0	0	ND	1.7	0	0	ND	2	0	0	ND	0.41	0	0
1,2,3,7,8-PeCDF	0.03	ND	0.92	0	0	ND	3.1	0	0	ND	2.2	0	0	ND	0.84	0	0
2,3,4,7,8-PeCDF	0.3	ND	1.2	0	0	ND	4.1	0	1	ND	2.7	0	0	ND	0.85	0	0
1,2,3,4,7,8-HxCDF	0.1	15		2	2	ND	65	0	3	40		4	4	ND	1.2	0	0
1,2,3,6,7,8-HxCDF	0.1	ND	7.7	0	0	ND	23	0	1	ND	22	0	1	ND	1	0	0
2,3,4,6,7,8-HxCDF	0.1	ND	7.5	0	0	ND	12	0	1	ND	15	0	1	ND	1.1	0	0
1,2,3,7,8,9-HxCDF	0.1	ND	0.46	0	0	ND	4.8	0	0	ND	2	0	0	ND	1.2	0	0
1,2,3,4,6,7,8-HpCDF	0.01	690		7	7	2100		21	21	1900		19	19	750		8	8
1,2,3,4,7,8,9-HpCDF	0.01	37		0	0	ND	170	0	1	100		1	1	36		0	0
OCDF	0.0003	2000		1	1	5900		2	2	4700		1	1	2000		1	1
			Total TEQ	**59**	**63**		Total TEQ	**216**	**232**		Total TEQ	**136**	**147**		Total TEQ	**82**	**83**
			Round 2-sigfigs	**59**	**63**		Round 2-sigfigs	**220**	**230**		Round 2-sigfigs	**140**	**150**		Round 2-sigfigs	**82**	**80**

Table 2. TEQ Dioxin Calculations

	Sample ID ->	KHB-DU-15				KHB-DU-16				KHB-DU-17				DU-18			
				TEQ				TEQ				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)
2,3,7,8-TCDD	1	ND	0.67	0	0	ND	1.7	0	1	ND	1.3	0	1	710		710	710
1,2,3,7,8-PeCDD	1	ND	3.4	0	2	ND	10	0	5	ND	12	0	6	ND	230	0	115
1,2,3,4,7,8-HxCDD	0.1	ND	4.4	0	0	ND	10	0	1	ND	6	0	0	ND	500	0	25
1,2,3,6,7,8-HxCDD	0.1	320		32	32	950		95	95	560		56	56	5500		550	550
1,2,3,7,8,9-HxCDD	0.1	ND	3.6	0	0	270		27	27	ND	4.8	0	0	1300		130	130
1,2,3,4,6,7,8-HpCDD	0.01	11000		110	110	21000		210	210	13000		130	130	140000		1400	1400
OCDD	0.0003	100000		30	30	200000		60	60	130000		39	39	1400000		420	420
2,3,7,8-TCDF	0.1	ND	2	0	0	ND	4.5	0	0	ND	2.9	0	0	ND	170	0	9
1,2,3,7,8-PeCDF	0.03	ND	3.4	0	0	ND	7.5	0	0	ND	6.3	0	0	ND	62	0	1
2,3,4,7,8-PeCDF	0.3	ND	3.4	0	1	ND	7.6	0	1	ND	6.4	0	1	ND	110	0	17
1,2,3,4,7,8-HxCDF	0.1	ND	5.2	0	0	ND	8.5	0	0	ND	6.5	0	0	1700		170	170
1,2,3,6,7,8-HxCDF	0.1	ND	4.5	0	0	ND	7.5	0	0	ND	5.7	0	0	ND	460	0	23
2,3,4,6,7,8-HxCDF	0.1	ND	4.8	0	0	ND	7.9	0	0	ND	6.1	0	0	ND	480	0	24
1,2,3,7,8,9-HxCDF	0.1	ND	5.2	0	0	ND	8.5	0	0	ND	6.5	0	0	ND	37	0	2
1,2,3,4,6,7,8-HpCDF	0.01	4000		40	40	6200		62	62	4200		42	42	54000		540	540
1,2,3,4,7,8,9-HpCDF	0.01	260		3	3	470		5	5	260		3	3	3900		39	39
OCDF	0.0003	10000		3	3	15000		5	5	9600		3	3	110000		33	33
			Total TEQ	**218**	**222**		Total TEQ	**463**	**473**		Total TEQ	**272**	**282**		Total TEQ	**3992**	**4207**
			Round 2-sigfigs	**220**	**220**		Round 2-sigfigs	**460**	**470**		Round 2-sigfigs	**270**	**280**		Round 2-sigfigs	**4000**	**4200**

Table 2. TEQ Dioxin Calculations

	Sample ID ->	DU-19				DU-20				KSPMA2-DU-1				KSPMA2-DU-2			
				TEQ				TEQ				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=RL/2)	Result	DL [c]	(ND=0)	(ND=RL/2)	Result	DL [c]	(ND=0)	(ND=RL/2)
2,3,7,8-TCDD	1	710		710	710	18		18	18	28		28	28	9.1		9	9
1,2,3,7,8-PeCDD	1	ND	310	0	155	5.2		5	5	8.3		8	8	ND	4	0	2
1,2,3,4,7,8-HxCDD	0.1	ND	540	0	27	8.9		1	1	14		1	1	ND	3.6	0	0
1,2,3,6,7,8-HxCDD	0.1	5500		550	550	42		4	4	140		14	14	46		5	5
1,2,3,7,8,9-HxCDD	0.1	1300		130	130	20		2	2	42		4	4	ND	2.9	0	0
1,2,3,4,6,7,8-HpCDD	0.01	140000		1400	1400	1300		13	13	4600		46	46	2100		21	21
OCDD	0.0003	1400000		420	420	14000		4	4	37000		11	11	18000		5	5
2,3,7,8-TCDF	0.1	ND	110	0	6	1.5		0	0	1.9		0	0	ND	4.5	0	0
1,2,3,7,8-PeCDF	0.03	ND	20	0	0	ND	0.76	0	0	ND	1.5	0	0	ND	6.1	0	0
2,3,4,7,8-PeCDF	0.3	ND	150	0	23	ND	1	0	0	ND	1.5	0	0	ND	6.2	0	1
1,2,3,4,7,8-HxCDF	0.1	1800		180	180	10		1	1	36		4	4	ND	5.6	0	0
1,2,3,6,7,8-HxCDF	0.1	ND	530	0	27	5.8		1	1	18		2	2	ND	4.8	0	0
2,3,4,6,7,8-HxCDF	0.1	ND	480	0	24	5.5		1	1	16		2	2	ND	5.4	0	0
1,2,3,7,8,9-HxCDF	0.1	ND	49	0	2	ND	0.33	0	0	ND	1.7	0	0	ND	5.8	0	0
1,2,3,4,6,7,8-HpCDF	0.01	50000		500	500	420		4	4	1200		12	12	490		5	5
1,2,3,4,7,8,9-HpCDF	0.01	3300		33	33	23		0	0	63		1	1	ND	5.9	0	0
OCDF	0.0003	120000		36	36	1200		0	0	2700		1	1	1500		0	0
			Total TEQ	**3959**	**4222**		Total TEQ	**55**	**55**		Total TEQ	**134**	**134**		Total TEQ	**45**	**50**
			Round 2-sigfigs	**4000**	**4200**		Round 2-sigfigs	**55**	**55**		Round 2-sigfigs	**130**	**130**		Round 2-sigfigs	**45**	**50**

Table 2. TEQ Dioxin Calculations

	Sample ID ->	KSPMA2-DU-3				CF-01			
				TEQ				TEQ	
Congener	TEF[b]	Result	DL [c]	(ND=0)	(ND=DL/2)	Result	DL [c]	(ND=0)	(ND=DL/2)
2,3,7,8-TCDD	1	ND	37	0	19	1.2		1	1
1,2,3,7,8-PeCDD	1	ND	44	0	22	4.6		5	5
1,2,3,4,7,8-HxCDD	0.1	ND	34	0	2	8.3		1	1
1,2,3,6,7,8-HxCDD	0.1	580		58	58	41		4	4
1,2,3,7,8,9-HxCDD	0.1	ND	27	0	1	21		2	2
1,2,3,4,6,7,8-HpCDD	0.01	15000		150	150	1100		11	11
OCDD	0.0003	130000		39	39	12000		4	4
2,3,7,8-TCDF	0.1	ND	8.5	0	0	0.85		0	0
1,2,3,7,8-PeCDF	0.03	ND	62	0	1	0.8		0	0
2,3,4,7,8-PeCDF	0.3	ND	64	0	10	0.93		0	0
1,2,3,4,7,8-HxCDF	0.1	ND	62	0	3	11		1	1
1,2,3,6,7,8-HxCDF	0.1	ND	53	0	3	6.5		1	1
2,3,4,6,7,8-HxCDF	0.1	ND	59	0	3	5.4		1	1
1,2,3,7,8,9-HxCDF	0.1	ND	64	0	3	ND	0.19	0	0
1,2,3,4,6,7,8-HpCDF	0.01	3700		37	37	260		3	3
1,2,3,4,7,8,9-HpCDF	0.01	ND	60	0	0	15		0	0
OCDF	0.0003	12000		4	4	720		0	0
			Total TEQ	**288**	**354**		Total TEQ	**33**	**33**
			Round 2-sigfigs	**290**	**350**		Round 2-sigfigs	**30**	**30**

Notes:

All results in ng/kg (pg/g)

NA = not analyzed
ND = not detected

[a] TEQ = Toxic Equivalent value, where all dioxin/furan congeners are converted to 2,3,7,8-TCDD equivalent concentrations based on TEF for that compound
[b] World Health Organization 2005 Toxic Equivalency Factor for dioxin/furan congeners, relative to 2,3,7,8-TCDD
[c] DL = Detection Limit (lowest concentration at which an analyte can be detected)
[d] TEQ calculation with ND values set at zero
[e] TEQ calculation with ND values set at 1/2 the DL
[f] 2-sigfigs = two significant figures

Table 3. Waste Characterization Soil Sampling Results

Compound	Regulatory Limit	WC-01	WC-03
TCLP (mg/L)			
Arsenic	5.0	2.6	0.89
Barium	100	ND (0.01)	0.24
Cadmium	1.0	0.023	0.004
Chromium	5.0	0.035	0.0096
Lead	5.0	ND (0.03)	0.0049
Selenium	1.0	ND (0.10)	ND (0.05)
Silver	5.0	ND (0.05)	ND (0.02)
Mercury	0.2	ND (0.002)	ND (0.002)
Totals (mg/kg)			
Arsenic		3000	930

Notes:
ND (0.01) = compound not detected at reporting limit of 0.01 mg/L
TCLP = toxicity characteristic leaching procedure

Table 4. Clean Fill Soil Sampling Results

Compound	EAL [a]	Sample CF-01
Metals (mg/kg)		
Arsenic	24	20
Barium	1000	60
Chromium	1100	92
Lead	200	15
Mercury	4.7	0.55
Organochlorine Pesticides (µg/kg)		
gamma-BHC	37	1.6
Chlordane (technical)	16000	5.9
Dioxins/Furans (ng/kg)		
TEQ Dioxins	240	30 [b]

Notes:

Only detected compounds are shown.
EAL = environmental action level

[a] Tier 1 Environmental Action Level (EAL) for soil where land use is unrestricted, groundwater is drinking water resource

[b] TEQ calculated assuming 1/2 detection limit for non-detect samples (see Table 2 for TEQ calculation)

Table 5. Soil Volumes Exceeding Environmental Action Levels

DU	Area (ft^2)	Depth (ft) [a]	Volume (ft^3)	Volume (CY)	Tons [b]
DU-01	1,050	3.0	3,150	117	187
DU-02	1,042	3.0	3,126	116	185
DU-03	2,363	1.0	2,363	88	140
DU-04	421	1.0	421	16	25
DU-07	1,573	2.0	3,146	117	186
DU-08	4,427	3.0	13,281	492	787
DU-10	1,654	2.0	3,308	123	196
Total	12,530	-	28,795	1,066	1,706
Total with 20% contingency (rounded) [c]			**35,000**	**1,300**	**2,000**

Notes:

CY = cubic yard

[a] Basis of interpreted depth of contamination

DU-01 Sample DU-5-2 (6-24") failed for dioxin and arsenic; sample DU-13-4 (24-48") passed

DU-02 Sample DU-6-2 (6-24") failed for dioxin and arsenic; sample DU-12-4 (24-48") passed

DU-03 Only a surface soil sample, but dioxin levels moderate, likely extend below 6"

DU-04 Only a surface soil sample, arsenic low but semivolatile organic compounds fairly high, likely extend below 6"

DU-07 Only a surface soil sample, dioxins high, expect deeper contamination

DU-08 Sample DU-9-2 (6-24") failed, no deeper sample but 6-24" sample levels heavily impacted; contamination expected to extend below 24"

DU-10 Only a surface soil sample, but dioxins and arsenic high, expect deeper contamination

[b] Calculation of tonnage assumes 1.6 tons per in-place CY

[c] Excavation depth may increase based on confirmation sampling and analysis

Table 6. Cost Estimate for Alternative 2a
On-Island Landfill Disposal of Soils

Remedy Description: Excavate all arsenic and dioxin Category C and D soils and dispose at West Hawaii Landfill. Backfill excavation with clean soils. No Institutional Controls required.

Uncertainties: Vertical extent (and therefore volume) of contaminated soil has not been fully delineated.

Item Description	Quantity	Unit	Unit Cost	Item Cost	Assumptions
I. Site Preparation Activities					
Mobilization/Demobilization	2	lot	$1,000	$2,000	One dozer and one excavator
Install Access Road	1	lot	$25,000	$25,000	Road from cul-de-sac to site, 400 ft long, 12 ft wide, geotextile, 6" layer of 12" aggregate, 4" layer of 2.5" minus
Vegetation Clearing	1	lot	$5,000	$5,000	Vegetation removal from entire work area.
Install Erosion and Sedimentation Controls	350	ft	$3	$1,100	Silt fencing along site perimeters (and property boundaries)
Banyan Tree Removal	1	lot	$12,000	$12,000	Large banyan tree with roots into upper retaining wall. De-stump and pile green waste near site.
Remove and Scrap 4 Steel ASTs	4	ea	$1,000	$4,000	Four empty and corroded steel ASTs. Assume no scrap value.
Site Survey	1	lot	$5,000	$5,000	Licensed surveyor locates property lines and excavation area boundaries; provides pre- and post-survey drawings
II. Material Excavation/Loading for Offsite Disposal					
Material Excavation and Loading	80	hrs	$500	$40,000	Assume 2 weeks (80 hrs) excavator and dozer, excavating contaminated soil and loading in dumps
Dust Control	10	day	$2,000	$20,000	Assume 2 weeks (10 days) water truck and operator to perform dust control
XRF Screening	2	weeks	$2,000	$4,000	XRF instrument to monitor arsenic in excavation bottom to support complete contaminated soil removal
III. Hauling and Landfill Disposal of Soils					
Waste Soil Transport to West HI Landfill	2,000	ton	$25	$50,000	20 ton/truck; 100 truck loads; $120/hr PUC rate; 4 hr RT to Landfill
Tipping Fee at West HI Landfill	2,000	tons	$94	$187,000	Waste Management Solutions, Inc. in Waikaloa
Special Handling Fee @ Landfill	100	loads	$94	$9,350	Special handling fee for contaminated material (per load)
IV. Site Restoration					
Post-Excavation Confirmatory Sampling	4	analyses	$1,500	$6,000	Assume 4 MI samples after excavation. One from upper tier, 1 from middle tier, 2 from lower tier. Sample collection, metals, dioxin and SVOC analysis and reporting.
Clean Soil Backfilling and Grading	1,495	cy	$10	$14,950	Assume onsite soil obtained, placed and graded. Assume 15% compaction.
Site Restoration, Revegetation	1	lot	$3,500	$3,500	Assume revegetation by hydroseeding and minor maintenance
Subtotal Direct Construction				**$388,900**	Rounded to nearest $1000
V. Indirect Support Items					
Workplans, H&S Plan, E&S Plan, Permitting	1	ea	$20,000	$20,000	Plans provided to HDOH for review and comment. Includes engineering
HazWoper Training for Construction Workers	1	ea	$1,000	$1,000	Certified HazWoper trainer trains contractors
Project Management, Construction Oversight	1	ea	$20,000	$20,000	Field oversight, safety program, surveying, sampling, documentation
Close-Out Report, Obtain No Further Action	1	ea	$10,000	$10,000	Written report and meetings with HDOH
Institutional Controls, Legal Support	1	ea	$0	$0	No ICs required
Subtotal Indirect Costs				**$51,000**	
Project Subtotal				**$439,900**	
Contingency for Unforeseen (10%)				$43,990	
Projected Opinion of Probable Cost				**$484,000**	Rounded to nearest $1000

Table 7. Cost Estimate for Alternative 2b
Mainland Landfill Disposal of Soils

Remedy Description: Excavate all arsenic and dioxin Category C and D soils and dispose at mainland landfill. Backfill excavation with clean soils. No Institutional Controls required.

Uncertainties: Vertical extent (and therefore volume) of contaminated soil has not been fully delineated.

Item Description	Quantity	Unit	Unit Cost	Item Cost	Assumptions
I. Site Preparation Activities					
Equipment Mobilization	2	pieces	$1,000	$2,000	Mobilize excavator and dozer (or loader)
Install Access Road	1	lot	$25,000	$25,000	Road from cul-de-sac to site, 400 ft long, 12 ft wide, geotextile, 6" layer of 12" aggregate, 4" layer of 2.5" minus
Vegetation Clearing	1	lot	$2,500	$2,500	Vegetation removal from entire work area.
Install Erosion and Sedimentation Controls	350	ft	$3	$1,100	Silt fencing along site perimeters (and property boundaries)
Banyan Tree Removal	1	lot	$12,000	$12,000	Large banyan tree with roots into upper retaining wall. De-stump and pile green waste near site.
Remove and Scrap 4 Steel ASTs	4	ea	$1,000	$4,000	Four empty and corroded steel ASTs. Assume no scrap value.
Site Survey	1	lot	$5,000	$5,000	Licensed surveyor locates property lines and excavation area boundaries; provides pre- and post-survey drawings
II. Material Excavation/Loading for Offsite Disposal					
Material Excavation and Loading	80	hrs	$500	$40,000	Assume 2 weeks (80 hrs) excavator and dozer, excavating contaminated soil and loading in shipping containers
Dust Control	10	day	$2,000	$20,000	Assume 2 weeks (10 days) water truck and operator to perform dust control
XRF Screening	2	weeks	$2,000	$4,000	XRF instrument to monitor arsenic in excavation bottom to support complete contaminated soil removal
III. Hauling and Landfill Disposal of Soils					
Waste Soil Transport from Site to Kawaihae Port	2,000	tons	$16	$32,000	20 ton/truck; 100 truck loads; $120/hr PUC rate; 2 hr RT to Harbor
Transport Hawaii Port to Mainland Port	2,000	tons	$500	$1,000,000	Barge transport, nonhazardous material shipment
Transport Mainland Port to Landfill	2,000	tons	$100	$200,000	Truck transport from port to landfill
Tipping Fee at Mainland Landfill	2,000	tons	$95	$190,000	Non-hazardous waste landfill in California or Washington
IV. Site Restoration					
Post-Excavation Confirmatory Sampling	4	analyses	$1,500	$6,000	Assume 4 MI samples after excavation. One from upper tier, 1 from middle tier, 2 from lower tier. Sample collection, metals, dioxin and SVOC analysis and reporting.
Clean Soil Backfilling and Grading	1,495	cy	$10	$14,950	Assume on-site soil obtained, placed and graded. Assume 15% compaction.
Site Restoration, Revegetation	1	lot	$3,500	$3,500	Assume revegetation by hydroseeding and minor maintenance
Subtotal Direct Construction				**$1,562,050**	Rounded to nearest $1000
V. Indirect Support Items					
Workplans, H&S Plan, E&S Plan, Permitting	1	ea	$20,000	$20,000	Plans provided to HDOH for review and comment. Includes engineering
HazWoper Training for Construction Workers	1	ea	$1,000	$1,000	Certified HazWoper trainer trains contractors
Project Management, Construction Oversight	1	ea	$20,000	$20,000	Field oversight, safety program, surveying, sampling, documentation
Close-Out Report, Obtain No Further Action	1	ea	$10,000	$10,000	Written report and meetings with HDOH
Institutional Controls, Legal Support	1	ea	$0	$0	No ICs required
Subtotal Indirect Costs				**$51,000**	
Project Subtotal				**$1,613,050**	
Contingency for Unforeseen (10%)				$161,305	
Projected Opinion of Probable Cost				**$1,774,000**	Rounded to nearest $1000

Table 8. Cost Estimate for Alternative 3a
Soil Cap

Remedy Description: Soil cap over all arsenic and dioxin Category C and D soils. Institutional Controls required for onsite containment remedy.

Uncertainties:

Item Description	Quantity	Unit	Unit Cost	Item Cost	Assumptions
I. Site Preparation					
Equipment Mobilization	2	pieces	$1,000	$2,000	Mobilize excavator and dozer (or loader)
Install Access Road	1	lot	$25,000	$25,000	Road from cul-de-sac to site, 400 ft long, 12 ft wide, geotextile, 6" layer of 12" aggregate, 4" layer of 2.5" minus
Vegetation Clearing	1	lot	$5,000	$5,000	Vegetation removal from entire work area.
Install Erosion and Sedimentation Controls	350	ft	$3	$1,100	Silt fencing along site perimeters (and property boundaries)
Banyan Tree Removal	1	lot	$12,000	$12,000	Large banyan tree with roots into upper retaining wall. De-stump and pile green waste near site.
Remove and Scrap 4 Steel ASTs	4	ea	$1,000	$4,000	Four empty and corroded steel ASTs. Assume no scrap value.
Site Survey	1	lot	$5,000	$5,000	Licensed surveyor locates property lines and cap area boundaries; provides pre- and post-survey drawings
II. Closure Preparation					
Stem Wall Installation	22	CY	$900	$19,800	Concrete stem wall along neighboring property boundaries. 300 lin. ft. at 2 ft. high and 1 ft wide
Geotextile Fabric (installed)	1,389	sq yd	$10	$13,900	Geotextile installed above contaminated soil. Pinned to stem wall and other cap perimeters
Install Metal Warning Tape	1	lot	$2,000	$2,000	Metal warning tape indicating contaminated soil below
Dust Control	5	day	$2,000	$10,000	Assume 1 week (5 days) water truck and operator to perform dust control
III. Clean Soil Cap Placement					
On-site Clean Fill Soil	1,065	CY	$10	$10,648	Assume local soil obtained, 2 ft. cover thickness over 12,500 sq. ft. with 15% compaction
Place and Compact Clean Fill Soil Cap	1,065	CY	$50	$53,241	Machine and hand compaction of soil
Dust Control	5	day	$2,000	$10,000	Assume 1 week (5 days) water truck and operator to perform dust control
IV. Site Restoration					
Prepare Stormwater Runoff Features	1	lot	$5,000	$5,000	Stone along ditch. Assume surface water discharges from cap to north of site on HICDC property
Site Restoration, Revegetation	1	lot	$2,000	$2,000	Assume revegetation of disturbed perimeter areas by hydroseeding and minor maintenance
Site Signage	1	lot	$2,000	$2,000	Install visible corner stanchions and signage
Subtotal Direct Construction				**$182,689**	Rounded to nearest $1000
V. Indirect Support Items					
Workplans, H&S Plan, E&S Plan, Permitting	1	ea	$30,000	$30,000	Plans provided to HDOH for review and comment. Includes engineering design of cap. Final as-built survey.
HazWoper Training for Construction Workers	1	ea	$1,000	$1,000	Certified Hazwoper trainer trains contractors
Project Management, Construction Oversight	1	ea	$30,000	$30,000	Field oversight, safety program, surveying, sampling, documentation
Close-Out Report, Obtain No Further Action	1	ea	$10,000	$10,000	Written report and meetings with HDOH
Institutional Controls, Legal Support	1	ea	$10,000	$10,000	Deed Notice (Environmental Covenant), Environmental Hazard Management Plan
VI. Long-Term Operations and Maintenance					
Inspections, Cap Repairs, Landscaping	30	yrs	$5,000	$77,000	Labor and expenses to maintain an on-site closure; net present value (5% discount rate) over 30 year period
Subtotal Indirect Costs				**$158,000**	
Project Subtotal				**$340,689**	
Contingency for Unforeseen (10%)				$34,069	
Projected Opinion of Probable Cost				**$375,000**	Rounded to nearest $1000

Table 9. Cost Estimate for Alternative 3b
Concrete Cap

Remedy Description: Concrete cap over all arsenic and dioxin Category C and D soils. Improve retaining walls, install stormwater drainage. Institutional Controls required.

Uncertainties:

Item Description	Quantity	Unit	Unit Cost	Item Cost	Assumptions
I. Site Preparation					
Equipment Mobilization	2	pieces	$1,000	$2,000	Mobilize excavator and dozer (or loader)
Install Access Road	1	lot	$25,000	$25,000	Road from cul-de-sac to site, 400 ft long, 12 ft wide, geotextile, 6" layer of 12" aggregate, 4" layer of 2.5" minus
Vegetation Clearing	1	lot	$5,000	$5,000	Vegetation removal from entire work area.
Install Erosion and Sedimentation Controls	350	ft	$3	$1,100	Silt fencing along site perimeters (and property boundaries)
Banyan Tree Removal	1	lot	$12,000	$12,000	Large banyan tree with roots into upper retaining wall. De-stump and pile green waste near site.
Remove and Scrap 4 Steel ASTs	4	ea	$1,000	$4,000	Four empty and corroded steel ASTs. Assume no scrap value.
Site Survey	1	lot	$5,000	$5,000	Licensed surveyor locates property lines and cap area boundaries; provides pre- and post-survey drawings
II. Closure Preparation					
Stem Wall Installation	22	CY	$900	$19,800	Concrete stem wall along neighboring property boundaries. 300 lin. ft. at 2 ft. high and 1 ft wide
Perimeter Form (materials & installation)	2	day	$3,000	$6,000	Assume 4 person crew for 2 days to install wood forms along cap perimeters with no stem walls
Geotextile Fabric (installed)	1,389	sq yd	$10	$13,900	Geotextile installed above contaminated soil. Pinned to stem wall and other cap perimeters
Dust Control	5	day	$2,000	$10,000	Assume 1 week (5 days) water truck and operator to perform dust control
III. Concrete Cap Placement					
Import Aggregate Subbase	153	CY	$38	$5,729	Assume 4" layer of 2.5" based coarse, delivered and installed
Subgrade Compaction	1,389	sq yd	$10	$13,889	Compactor & Operator including mob/demob
Concrete (material delivered)	310	CY	$175	$54,282	Assume 8" concrete pour over base coarse on cap area
Concrete Finishing	32	hrs	$75	$2,400	Assume 4 person crew for one day to finish concrete surfaces
IV. Site Restoration					
Prepare Stormwater Runoff Features	1	lot	$5,000	$5,000	Stone along ditch. Assume surface water discharges from cap to north of site on HICDC property
Site Restoration, Revegetation	1	lot	$2,000	$2,000	Assume revegetation of disturbed perimeter areas by hydroseeding and minor maintenance
Site Signage	1	lot	$2,000	$2,000	Install visible corner stanchions and signage
Subtotal Direct Construction				**$189,000**	Rounded to nearest $1000
V. Indirect Support Items					
Workplans, H&S Plan, E&S Plan, Permitting	1	ea	$30,000	$30,000	Plans provided to HDOH for review and comment. Includes engineering design of cap. Final as-built survey.
HazWoper Training for Construction Workers	1	ea	$1,000	$1,000	Certified HazWoper trainer trains contractors
Project Management, Construction Oversight	1	ea	$30,000	$30,000	Field oversight, safety program, surveying, sampling, documentation
Close-Out Report, Obtain No Further Action	1	ea	$10,000	$10,000	Written report and meetings with HDOH
Institutional Controls, Legal Support	1	ea	$10,000	$10,000	Deed Notice (Environmental Covenant), Environmental Hazard Management Plan
VI. Long-Term Operations and Maintenance					
Inspections, Concrete Repairs, Landscaping	30	yrs	$4,000	$61,000	Labor and expenses to maintain an on-site closure; net present value (5% discount rate) over 30 year period
Subtotal Indirect Costs				**$142,000**	
Project Subtotal				**$331,000**	
Contingency for Unforeseen (10%)				$33,100	
Projected Opinion of Probable Cost				**$364,000**	Rounded to nearest $1000

Table 10. Comparison of Removal Action Alternatives

Removal Action	Effectiveness	Implementability	Estimated Cost[a]	Intangibles
Alternative 1: No Action	**Low** Does not address RAOs	**Low** Does not address RAOs	**$0**	
Alternative 2a: On-Island Landfill Disposal	**High** Achieves RAOs Short Term: Increase in truck traffic Long Term: No soils above RALs remain on site All property available for unrestricted reuse	**High** Achieves RAOs Standard construction methods No permitting and ICs for onsite soil containment	**$484,000**	
Alternative 2b: Mainland Landfill Disposal	**High** Achieves RAOs Short Term: Increase in truck traffic Long Term: No soils above RALs remain on site All property available for unrestricted reuse	**High** Achieves RAOs Standard construction methods No permitting and ICs for onsite soil containment	**$1,774,000**	
Alternative 3a: Soil Cap	**Moderate** Achieves RAOs Short Term: Most activities conducted on site Long Term: Category C and D soils remain on site Long Term: Routine inspection & maintenance required to prevent damage to cap	**High** Achieves RAOs Standard construction methods Requires ICs for onsite soil containment	**$375,000**	On-site containment results in loss of approximately 1/2 acre of land for future development. On-site containment cell may have negative community impact, creating stigma having contaminants remain in neighborhood.
Alternative 3b: Concrete Cap	**Moderate-High** Achieves RAOs Short Term: Most activities conducted onsite Long Term: Category C and D soils remain onsite Long Term: Minimal maintenance will be required to prevent damage to cap	**High** Achieves RAOs Standard construction methods Requires ICs for onsite soil containment	**$364,000**	On-site containment results in loss of approximately 1/2 acre of land for future development. On-site containment cell may have negative community impact, creating stigma having contaminants remain in neighborhood.

Notes:
IC = institutional control
RAL = removal action level
RAO = removal action objective

[a] Preliminary engineering estimate, including 10% contingency for unforeseens