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ENVIRONMENTAL REMEDIATION AT DA NANG AIRPORT

Environmental Assessment

in Compliance with 22 CFR 216

June 2010

Environmental Remediation at Da Nang Airport

Environmental Assessment in Compliance with 22 CFR 216

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ACRONYMS AND ABBREVIATIONS

10-80 Division	10-80 Division of the Ministry of Health
ADB	Asian Development Bank
ADS	Automated Directives System
Airport	Da Nang Airport
ATSDR	United States Agency for Toxic Substances and Disease Registry
BEM	BEM Systems, Inc.
BEO	Bureau Environmental Officer
bgl	below ground level
BOD	biological oxygen demand
°C	degrees Celsius
CAAV	Civil Aviation Agency of Vietnam
CDM	CDM International, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	United States Code of Federal Regulations
CH_4	methane
CO_2	carbon dioxide
CO_{2e}	carbon dioxide equivalent
COD	chemical oxygen demand
COPC	contaminant of potential concern
cm	centimeter
d	day
DOD	United States Department of Defense
DQO	data quality objective
EA	environmental assessment
EIA	environmental impact assessment
EMMP	environmental mitigation and monitoring plan
ESS	environmental scoping statement
°F	degrees Fahrenheit
FAA	United States Foreign Assistance Act
FAR	United States Federal Acquisition Regulation
FDA	United States Food and Drug Administration
FS	feasibility study
g	gram
GAC	granular activated carbon
GCL	geosynthetic clay liner
GCMS	gas chromatography – mass spectrometry
GHG	greenhouse gas
GSO	General Statistics Office
GVN	Government of Vietnam

ha	hectare
Hatfield	Hatfield Consultants
HDPE	high-density polyethylene
HMU	Hanoi Medical University
hr	hour
JAC	Joint Advisory Committee
IEE	Initial Environmental Examination
IOM	Institute of Medicine
IPTD	in-pile thermal desorption
ISTD	in-situ thermal desorption
kg bw	kilogram body weight
km	kilometer
km^2	square kilometer
kwh	kilowatt hour
LLDPE	linear low-density polyethylene
m	meter
m^2	square meter
m^3	cubic meter
MAC	Middle Airports Corporation
MCL	maximum contaminant level
MDL	method detection limit
MLA	former Mixing and Loading Area
mm	millimeter
MOD	Ministry of Defense
MoNRE	Ministry of Natural Resources and Environment
MOU	Memorandum of Understanding
N_2O	nitrous oxide
NGO	non-governmental organization
NIP	National Implementation Plan
O&M	operation and maintenance
Office 33	Office of the National Steering Committee 33
OSHA	Occupational Health and Safety Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
pg	picogram
PIRA	former Pacer Ivy Re-Drumming Area
PISA	former Pacer Ivy Storage Area
PPE	personal protective equipment
ppm	parts per million
ppt	parts per trillion
PRG	Preliminary Remediation Goal

the Project	Environmental Remediation at Da Nang Airport: Assessments and Engineering Designs and Plans for Dioxin Contamination
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
SA	former Storage Area
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SS	suspended solids
t	ton (metric)
TCDD	tetrachlorodibenzo-p-dioxin
TCVN	Vietnam National Standard
TEQ	toxicity equivalent
TOC	total organic carbon
UNDP	United Nations Development Programme
U.S.	United States
USAID	United States Agency for International Development
U.S.C.	United States Code
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USG	United States Government
UXO	unexploded ordnance
VAST	Vietnam Academy of Science Technology
VAT	value added tax
VOC	volatile organic compound
VRTC	Vietnam-Russia Tropical Centre
WHO	World Health Organization
yr	year

Section 1. Introduction

1.1. USAID Environmental Health and Remediation Program

The airports at Da Nang, Bien Hoa, and Phu Cat have been referred to as dioxin "hotspots" due to high dioxin concentrations remaining decades after large volumes of Agent Orange and other defoliants were handled at these sites. The Government of Vietnam (GVN) has requested assistance from the United States (U.S.) to remediate dioxin-contaminated soil and sediment at Da Nang, and from the United Nations Development Program (UNDP) at Bien Hoa.

In 2007, the U.S. Congress appropriated $3 million to carry out Agent Orange/dioxin health and remediation activities in Vietnam. The U.S. Congress has since appropriated an additional $3 million for each year in 2009 and 2010. Approximately one-third of the total $9 million has been programmed to support health and social services to people with disabilities of the Greater Da Nang area. The remaining two-thirds have been programmed for environmental remediation for Da Nang Airport (Airport). Within the U.S. Government (USG), the U.S. Agency for International Development (USAID) was designated as the lead agency to implement assistance programs in Vietnam, in cooperation with the U.S. Department of State, the U.S. Department of Health and Human Services, the U.S. Department of Defense (DOD), and the U.S. Environmental Protection Agency (USEPA). Assistance to Vietnam is part of a multilateral effort requiring the closest possible cooperation and coordination with international agencies, other donors, non-governmental organizations (NGOs), and public and private foundations.

In 2008, USAID launched its environmental health and remediation program. It awarded a cooperative agreement to East Meets West Foundation to provide health, rehabilitation, and education services for people with disabilities of Da Nang. Vietnam Assistance to the Handicapped was granted an award to provide capacity building in rehabilitation medicine and to provide health, rehabilitation and social services in three Da Nang Districts. Save the Children was awarded a cooperative agreement to provide training and livelihood development support to people with disabilities of Da Nang. These activities started in October 2008 and will continue through September 2011.

In October 2008, USAID awarded a contract to CDM International, Inc. (CDM) to carry out the project, "Environmental Remediation at Da Nang Airport: Assessments and Engineering Designs and Plans for Dioxin Contamination" (the Project). Under this contract, CDM is to prepare an environmental assessment (EA) for dioxin remediation at the Airport. CDM will develop engineering designs for the remedial technology alternative selected through the EA process and develop a remediation workplan for design implementation. This workplan will detail the process steps associated with the remediation activity and identify specific engineering controls and protective measures. This will inform the final Environmental Management and Monitoring Plan (EMMP) which will be included as part of bid documents for the procurement of goods and services for remedial action. In conjunction with development of the remediation workplan, CDM will conduct a gender assessment that examines functional labor categories associated with each step of the remediation process to determine whether gender-specific

measures are necessary. The gender assessment will also determine project beneficiaries, by gender, to track longer term project benefits. Using engineering designs, the remediation workplan, and gender assessment as the point of departure, CDM will prepare a Health and Safety Plan, Health and Safety Training Plan, and a Sampling and Analysis and Monitoring Plan to be implemented during the remedial action phase.

1.2. Coordination with Other USG Agencies and Donors on Environmental Remediation in Vietnam

Since 2000, USG agencies have engaged with their Vietnamese counterparts to work on the complex Agent Orange/dioxin issue, notably through the bilateral Joint Advisory Committee (JAC) on Agent Orange/dioxin that was created to coordinate collaborative research on this issue. The JAC, co-chaired by the USEPA and the GVN's Ministry of Natural Resources and Environment (MoNRE), has met four times since its inception. USEPA has supported joint research on dioxin analysis and workshops on methodologies for dioxin screening, remediation, and site characterization. Elements of this work included a pre-feasibility study (FS) for dioxin remediation at the Airport and design and implementation of a 6-month treatability study for bioremediation treatment of dioxin with funding from the Ford Foundation.

In 1999, the Prime Minister of Vietnam issued Decision 33, which established the National Steering Committee 33 and assigned it responsibility for coordination of dioxin-related matters and for development of short-, medium-, and long-term dioxin implementation and research plans. The MoNRE Minister chairs the National Steering Committee, and its multi-sectoral membership includes participants from the Academy of Science and Technology, the Ministry of Defense (MOD), the Ministry of Foreign Affairs, the Ministry of Health, the Ministry of Planning and Investment, the Ministry of Finance, the Ministry of Science and Technology, the Ministry of Justice, the Ministry of Labor, and the Office of Government. The Office of the National Steering Committee 33 (Office 33) was established under MoNRE as the implementing arm of the National Steering Committee 33. Office 33 is the implementation counterpart of USAID on dioxin-related activities. In December 2009, USAID and MoNRE, through Office 33, entered into a Memorandum of Understanding (MOU) regarding implementation of USAID's Environmental Health and Remediation Program. The MOU established the partnership framework for program implementation. Preparation of the EA is one activity that is being implemented under the MOU.

In addition to USG agencies, NGOs such as the Ford Foundation and the Bill and Melinda Gates Foundation have played important roles in dioxin remediation efforts over the past several years. The Ford Foundation has been instrumental in the identification of dioxin hotspots in Vietnam The Ford Foundation also provided financial support for detailed assessments of dioxin contamination at the Airport and surrounding area in 2006 and 2009. In 2008, in conjunction with the USG, it financed interim mitigation measures to help reduce potential exposure of residents and workers at the Airport, which included: a ban on fishing and agricultural activities, construction of a barrier wall along the northern boundary of the Airport, temporary capping of the former Mixing and Loading Area (MLA), and construction of a sediment filtration system upstream of Sen Lake. The Bill and Melinda Gates Foundation and

Atlantic Philanthropies are presently financing a $6 million environmental laboratory that, when completed, will provide Vietnam with high-resolution dioxin analysis capability.

UNDP has been another significant contributor on this issue. UNDP and Office 33 co-sponsored a workshop in February 2009 to build consensus among the GVN and donors on a national-level approach for dioxin remediation. Conference participants concluded that dioxin concentrations at the three former airbases of Da Nang, Bien Hoa, and Phu Cat were present in levels high enough to warrant significant investments in remediation. Participants agreed to a short-term goal of dioxin containment to eliminate the possibility of human exposure and a longer-term goal of dioxin destruction. They also agreed to share lessons learned as information evolves on remediation processes at the key dioxin hotspot sites of Da Nang, Bien Hoa, and Phu Cat. UNDP also conducted soil and sediment sampling investigations at Bien Hoa and Phu Cat in 2008, which provided important information for dioxin characterization at these sites.[1]

In August 2009, the United Nation's Global Environment Facility approved the $5 million "Vietnam Environmental Remediation of Dioxin Contaminated Hotspots" project. UNDP and Office 33 are co-implementers of the project. The purpose of the project is to further delineate hotspot areas in Bien Hoa, to evaluate appropriate treatment technologies for dioxin destruction, and to build capacity of Vietnamese counterparts to develop an environmental remediation plan for Bien Hoa. UNDP's program for Bien Hoa is following a similar track to that which USAID has adopted at Da Nang: to conduct an environmental impact assessment and develop designs for the best approach to remove dioxin from hotspots in these areas. UNDP's program also provides for an overarching umbrella framework that facilitates donor coordination among those working on environmental remediation of dioxin in Vietnam.

[1] VRTC/Hatfield 2009.

Section 2. Purpose

2.1. Purpose and Need for the Proposed Action

The Da Nang Airport is located within Da Nang City within a densely populated urban area. Three of the municipality's seven districts are adjacent to the Airport: Thanh Khe, Hai Chau, and Cam Le Districts, which have a combined population of approximately 436,000. The Airport facility is used by both the MOD and the Civil Aviation Agency of Vietnam (CAAV). It is an international airport, with flights arriving from and departing to cities such as Bangkok, Vientiane, Hong Kong, Phnom Penh, and Taipei. The GVN plans to expand the Airport facilities and runways, and construction has already commenced in some areas.

2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (dioxin) is a toxic chemical which is associated with a range of health effects.[2] Studies conducted to date show that dioxin concentrations within hotspot areas of the Airport substantially exceed international standards and Vietnamese standards for dioxin. [3] Uncontrolled access to contaminated areas of the Airport and transport of contaminated soils and sediments resulted in human exposures primarily through agricultural activities and fish consumption. Although the human exposure pathway was largely interrupted as a result of 2008 interim containment measures, these measures are not permanent. Therefore, the GVN has requested U.S. assistance with environmental remediation at this site.

To eliminate further human and wildlife exposure to dioxin at this site, the GVN initially proposed that, as the next step toward remediation at the Airport, contaminated soil and sediment be removed and contained at a secure landfill to be constructed at the southern end of the base. A containment program would involve removal of dioxin from a wetland ecosystem located in close proximity to residential areas, and construction of a secure onsite landfill further from residential areas at the southern end of the airport. However, the EA has identified an environmentally safer, more effective alternative, which has been selected as the preferred project alternative.

2.2. Threshold Determination

On May 26, 2009, the Asia Bureau Environmental Officer (BEO) approved the Initial Environmental Examination (IEE) for "Environmental Remediation at Da Nang Airport." This approval included a positive Threshold Determination that pertains to engineering design and remedial action activities, because such activities may pose a significant risk to the environment. CDM has been awarded a contract to prepare assessments and engineering designs and plans for dioxin remediation at the Airport. Therefore, an EA must be completed and approved by the Asia BEO before these USAID-financed activities can proceed.

The purpose of this EA is to fulfill requirements for environmental remediation at the Airport in accordance with Title 22 U.S. Code [U.S.C.] of Federal Regulations [CFR] Chapter 216 (22 CFR 216.6[a]) which states:

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[2] ATSDR 1998.
[3] Hatfield/Office 33 2007 and Hatfield/Office 33 2009.

> "The purpose of the Environmental Assessment is to provide Agency and host country decision makers with a full discussion of significant environmental effects of a proposed action. It includes alternatives which would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of development objectives can be weighed against any adverse impacts upon the human environment or any irreversible or irretrievable commitment of resources."

This EA provides the basis for selection of the preferred project alternative and includes an EMMP for the significant impacts that are identified through the EA process. Furthermore, design documents, remediation work plan, health and safety plan, and a health and safety training plan will be developed for the preferred alternative. If additional potentially significant impacts on the environment are identified during the design process, the EA will be amended to reflect these. Furthermore, EMMPs will be developed for each implementing mechanism identified for the remedial action phase, based on the remediation workplan(s), health and safety plan(s), health and safety training plan(s), and sampling and analysis monitoring plans that are to be prepared under the engineering planning and design activity. These EMMPs will be included with each procurement action related to this EA.

Vietnamese environmental law and its environmental compliance regulations also require an Environmental Impact Assessment (EIA) for dioxin remediation activities. While USAID's EA process requires consideration of project alternatives, the GVN EIA procedures are based on a single project proposal, and require submission of feasibility analyses, designs, and cost estimates. Therefore, the USAID EA represents a first step in the GVN EIA process. After approval of the EA, the EIA will be prepared and submitted to the GVN along with preliminary designs, plans, specifications, and cost estimates.

2.3. Environmental Scoping Statement

In support of the EA, an Environmental Scoping Statement (ESS) was prepared for the Project in compliance with 22 CFR 216, which USAID's Asia BEO approved in February 2010. Scoping sessions were held with stakeholders as part of this process in October 2009 which identified the need to explore a range of viable alternatives for dioxin containment at the Airport. They also help to identify the environmental issues that the EA must address. As a result of field visits and scoping sessions, the ESS identified the following environmental issues to be addressed in the EA:

- Human health risks associated with cleanup of unexploded ordnance and munitions
- Surface water hydrology
- Surface water quality
- Groundwater
- Air quality and indirect effects on human health

- Greenhouse gases
- Terrestrial ecosystems and biodiversity
- Wetlands, aquatic ecosystems, and aquatic biodiversity
- Noise
- Natural or depletable resources

2.4. Stakeholder Engagement and Host Government Consultations

During the eight month period (October 2009-May 2010) that the EA was under development, USAID and it contractors held 14 meetings/site visits/workshops to discuss various aspects of the EA process and technical matters. A list of these is provided below.

- Initial Field Visit to Da Nang Airport – October 14, 2009 (Da, Nang)
- Workshop to Reconcile USAID's Environmental Compliance Procedures with GVN's Environmental Impact Procedures – October 15, 2009 (Hanoi)
- Workshop to Discuss Bioremediation Technology – December 9, 2009 (Hanoi)
- Presentation of Da Nang Environmental Sampling Plan to USEPA – December 10, 2009 (Hanoi)
- Field Visit to Dioxin Sites of Da Nang Airport – December 14, 2009 (Da Nang)
- Workshop Discussion with Da Nang Stakeholders – December 15, 2009 (Da Nang)
- Assessment and Engineering Planning and Design Workplan Presentation (including discussion of how the EA process is necessary for designs and plans to proceed) – December 16, 2009 (Hanoi)
- Presentation of Initial EA findings to USAID, USEPA, and U.S. State Department – January 5, 2010 (Washington, DC)
- EA Progress Report Workshop – January 29, 2010 (Hanoi)
- Draft EA Presentation to USAID, USEPA, and U.S. State Department – February 26, 2010 (Hanoi)
- Draft EA Presentation to Hanoi Stakeholders – March 16, 2010 (Hanoi)
- Draft EA Presentation to Da Nang Stakeholders – March 18, 2010 (Da Nang)

- Technical Workshop on In-Situ Thermal Desorption/In-Pile Thermal Desorption (ISTD/IPTD) – May 18, 2010 (Hanoi)

- Field Visit and Technical Workshop on ISTD/IPTD and 2010 Sampling Results (including estimates of extent of contamination) – May 20, 2010 (Da Nang)

Hanoi stakeholders participating in workshops and meetings during this period included the Science Advisory Panel of National Committee 33, Office 33, MoNRE Department of Pollution Management, MoNRE Department of Environmental Impact Assessments and Appraisal, and MoNRE Department of Hazardous Waste Management. MOD representation included Agency for Science, Technology and Environment, Vietnam-Russia Tropical Centre (VRTC), ADCC Company Air Force Command, High Command of Chemical Arms, High Command of Engineers Arms, Air Force and Air Defense Services, and Strategy Department. The CAAV was also represented. Stakeholders from the Da Nang area included representatives from the Army Corp 372 (Da Nang Airbase), the Middle Airports Corporation (MAC), and Da Nang Power Company. Representatives from the People's Committee of Hai Chau District, the People's Committee of Thanh Khe District and the People's Committee of Cam Le District also participated. As a result of these meetings, close coordination on technical matters was achieved. Furthermore, the meetings resulted in significant information sharing that enabled a much more concise assessment than might not have otherwise been the case. The ongoing exchange enabled the high level of consensus reached on the results and findings of the EA. In addition to the ongoing exchange with host government counterparts, USAID/Vietnam regularly consulted with USG stakeholders, including the U.S. Embassy, U.S. State Department, USAID/Washington, and USEPA.

2.5. Legal and Regulatory Considerations

2.5.1. VIETNAM

The GVN's proposed action for dioxin remediation at Da Nang Airport was to remove dioxin contaminated soil and sediment and dispose of it in a secure onsite landfill. The GVN has established a national cleanup standard for dioxin of 1,000 parts per trillion (ppt) toxicity equivalent (TEQ) in soil and 150 ppt TEQ in sediment.[4] The EA adopts GVN's national dioxin standards in determining the extent and depth of contamination to be addressed and in determining the treatment level than must be attained to achieve a final remedy.

2.5.2. UNITED STATES

Dioxin remediation is particularly complex due to the stringent cleanup goals (normally measured in the ppt range) that are required for protection of public health and the environment. The 1984 Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act (RCRA) banned land disposal of dioxin contaminated waste.[5] Consequently, if dioxin is to be contained it must be in a secure landfill designed, constructed, and permitted in accordance with 40 CFR 264 Hazardous Waste Disposal Regulations.

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[4] TCVN 8183: 2009.

[5] 40 CFR 260-280.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA),[6] is the U.S. federal law designed to cleanup abandoned hazardous waste sites and is commonly known as Superfund. CERCLA, as amended by SARA, directs USEPA to select a permanent remedy or treatment whenever possible for Superfund hazardous waste sites.[7] Containing waste in a secure onsite landfill is the least preferred alternative, and is generally only considered when a destruction remedy is determined to be infeasible, for example, due to community objections to the selected treatment option or due to funding limitations.[8]

The 2007 Annual Status Report for Treatment Technologies for Site Clean Ups[9] states that from 1982 to 2005, approximately 3,000 Records of Decision (RODs) and ROD Amendments were signed to select the remedies for Superfund hazardous waste sites. Of those, 56% selected treatment remedies (some [16%] included a containment component of the remedy), 17% selected containment remedies with no treatment, 12% selected other remedies including long term monitoring and/or institutional controls (e.g., land use restrictions), and the remaining 15% determined no further action was required. The report does not provide information on which of the sites address dioxin contamination, the volume of contaminated material, or the cost of the remedies. However, it provides a benchmark to relate the remedies under evaluation for the Airport to remedies selected for Superfund hazardous waste sites in the U.S. USEPA's Annual Status Report Remediation Database lists 19 dioxin/furan contaminated sites for which remediation of soil is operational or has been completed under the Superfund program[10]. As shown in Table 1, incineration was the selected remedy for 13 of the 19 dioxin/furan sites (10 offsite and 3 onsite). Solidification/stabilization was applied at two sites, ex situ thermal desorption was applied at two sites, in situ thermally enhanced recovery was applied at one site, and bioventing was applied at one site. Overall, incineration is one of the most common ex situ treatment technologies for all hazardous waste sites; however, in recent years the number of RODs that include incineration have declined. For example, 29% of ex situ treatment remedies between 1982 and 2002 included incineration, but this percentage declined to 6% during the period from 2002 to 2005.[11]

According to USEPA, "remediation technologies for the cleanup of dioxin-contaminated soils and sediments are still being developed, and many of the accepted techniques rely on thermal destruction, though physical, chemical, and biological technologies show promise."[12] Dioxin site cleanups in the U.S. have historically been shown to be technically complex with remediation activities for a single site taking at least 10 years from site discovery through final remedial action.

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[6] 42 U.S.C. 9601 et seq.
[7] Section 121[b] of SARA.
[8] USEPA 2007.
[9] USEPA 2007.
[10] USEPA Office of Solid Waste and Emergency Response Office of Innovative Technologies Annual Status Report Remediation Database: http://cfpub.epa.gov/asr/.
[11] USEPA 2007.
[12] USEPA Office of Solid Waste and Emergency Response Office of Technology Innovation: http://www.clu-in.org/contaminantfocus/default.focus/sec/Dioxins/cat/Overview/.

TABLE 1. DIOXIN CONTAMINATED SITES IN THE UNITED STATES FOR WHICH REMEDIAL ACTION WAS COMPLETED UNDER THE SUPERFUND PROGRAM[1]

	Site Name	ROD Date	Technology	State
1	Woodbury Chemical	1985	Incineration (offsite)	Colorado
2	Baird & McGuire	1986	Incineration (onsite)	Massachusetts
3	Minker/Stout/Romaine Creek	1988	Incineration (offsite)	Missouri
4	Selma Pressure Treating	1988	Solidification/Stabilization	California
5	Syntex Facility	1988	Incineration (offsite)	Missouri
6	Times Beach Site	1988	Incineration (onsite)	Missouri
7	Jacksonville Municipal Landfill	1990	Incineration (offsite)	Arkansas
8	Pristine, Inc.	1990	Thermal Desorption (ex situ)	Ohio
9	Rogers Road Municipal Landfill	1990	Incineration (offsite)	Arkansas
10	Shenandoah Stables	1990	Incineration (offsite)	Missouri
11	Vertac, Inc.	1990	Incineration (onsite)	Arkansas
12	Eastern Diversified Metals	1991	Incineration (offsite)	Pennsylvania
13	Ellisville Site	1991	Incineration (offsite)	Missouri
14	Koppers Co., Inc. (Morrisville Plant)	1992	Incineration (offsite)	North Carolina
15	Southern California Edison, Visalia Pole Yard	1994	Bioventing	California
16	Arkwood Inc.	1995	Incineration (offsite)	Arkansas
17	Standard Steel and Metal Salvage Yard (United States Department of Transportation)	1996	Solidification/Stabilization	Alaska
18	Coleman-Evans Wood Preserving	1997	Thermal Desorption (ex situ)	Florida
19	Wyckoff/Eagle Harbor	2000	Thermally Enhanced Recovery (in situ)	Washington

Notes:
1 – USEPA Office of Solid Waste and Emergency Response Office of Innovative Technologies Annual Status Report Remediation Database: http://cfpub.epa.gov/asr/search.cfm. Database search criteria: Contaminant – "dioxins and furans"; Media – "soil (ex situ)" and "soil (in situ)"; Status – "operational" and "completed".

Table 2 provides site profile characteristics of selected dioxin sites in the U.S. and Vietnam. The U.S. sites listed here include Times Beach (Missouri), Baird and McGuire (Massachusetts), Vertac (Arkansas), and the Dow Chemical site (Michigan). The sites in Vietnam include Bien Hoa, Da Nang, and Phu Cat airbases. Site contamination of the U.S. and Vietnam sites are similar, volume of contaminated material and cleanup goals. Lessons learned from dioxin site cleanups in the U.S. will provide a valuable contribution to dioxin remediation at Da Nang.

TABLE 2. CHARACTERISTICS OF SELECTED DIOXIN CONTAMINATED SITES IN THE UNITED STATES AND VIETNAM

Site	Source	Maximum Dioxin Concentr-ation (ppt)	Clean Up Goal	Material	Volume (Tons)	Treatment Technology	Cost (U.S. Dollars)	RI/FS	ROD	Remedial Action End Date
Times Beach (Missouri)[1]	Hexachlorophene Production Waste Oil used for road dust control throughout Missouri	1,800,000	1,000 ppt for surface soils in residential settings; 10 ppt for soils above a depth of 1 foot; 20,000 ppt in commercial and industrial settings	Soil and Debris	265,000	On Site Rotary Kiln Incineration	110,000,000	1984	1995	1997
Baird and McGuire (Holbrook, Massachusetts)[1]	Land Disposal of chemical production wastes	270,000	None (Technology Based)	Soil and Sediment	214,000	On Site Rotary Kiln Incineration	133,000,000	1986	1986	1996
Vertac (Jackson, Arkansas)[1]	Herbicide Production	400,000	1 in a million lifetime risk of cancer for a 70 year exposure	Waste and Soil	10,831	On Site Rotary Kiln Incineration	31,700,000	1978	1990	1994
Dow Chemical Site: Tittabawasee and Saginaw Rivers (Midland, Michigan)[2]	Chemical Production Wastewater Discharge into surface water	1,600,000	90 ppt	Soil and Sediment	83,000					
Da Nang Airport (Vietnam)	Herbicide Use	365,000	1000 ppt soil/150 ppt sediment	Soil and Sediment	93,000 (estimate)					
Bien Hoa Airbase (Vietnam)[3]	Herbicide Use	409,818	1000 ppt soil/150 ppt sediment	Soil and Sediment	150,000 (estimate)	Landfill and bioremediation				
Phu Cat (Vietnam)[3]	Herbicide Use	238,000	1000 ppt soil/150 ppt sediment	Soil and Sediment	3,450 (estimate)					

Notes:
1 – USEPA Office Technology Innovation. 2005. EPA-542-R-05-006. http://www.clu-in.org/pops.
2 – USEPA Region 5 Cleanup Sites. http://www.epa.gov/region5/sites/dowchemical/.
3 – UNDP 2009a.

To ensure that the environmental remediation activities for the Airport are consistent with best standards and practice, USAID will, to the extent feasible, follow processes and approaches used for dioxin site remediation in the U.S. The assessment, design, and remedy implementation process USAID is following for the Airport is similar to the Superfund process, which begins with site discovery and preliminary investigation (similar to the results achieved through the Ford Foundation investigations conducted between 2006 and 2009).[13] This is followed by a Remedial Investigation (RI), which determines the nature and extent of contamination and the risk to public health and the environment. USAID conducted sampling in 2010 to build upon data collected in previous investigations and refine estimates of extent of contamination and volume of contaminated materials requiring treatment. Under Superfund, a FS is then conducted to evaluate remedial alternatives. Similarly, this EA provides an evaluation of four remedial alternatives for the Airport. In the Superfund program, USEPA issues a ROD to identify the cleanup goals and selected remedy for the site; a Remedial Design is then developed for the selected remedial alternative, and finally, a Remedial Action is conducted to implement the design and to cleanup the contamination. Following approval of this EA, which provides the evaluation and selection of the Airport remedial action, USAID will prepare engineering designs and specifications and develop a remediation workplan to support remedial action implementation.

2.5.3. CONSIDERATION OF REQUIREMENTS OF BOTH COUNTRIES

In preparing the EA, USAID considered the site context and the legal and regulatory context of both countries. The following laws and regulations were identified as having potential applicability either to the EA, or to the remediation of dioxin contamination at the Airport; this list is not comprehensive.

Laws and Regulations

- U.S. Foreign Assistance Act (FAA) Section 117 and 22 CFR 216, Automated Directive System (ADS) 201.5 and 204 – Environmental Compliance
- FAA 611(a)(1) – Adequate Planning
- U.S. Brooks Act and U.S. Federal Acquisition Regulation (FAR) Part 36--Engineering Integrity
- USAID ADS 201.3.9.3--Gender Considerations
- Vietnamese Construction Regulation Standard Article 3.3
- Viet Nam Labor Code, Article 113 of Chapter X – Gender Restrictions on Employment at Hazardous Waste Sites
- Vietnam National Law on Environmental Protection: No. 52/2005/QH11
- Vietnam National Standard (TCVN) 8183: 2009--Dioxin Standard for Soil and Sediment

[13] Hatfield/Office 33 2007 and Hatfield/Office 33 2009.

- Vietnam Law on Gender Equality Article 13, Section 1, 3a
- Vietnam Law on Construction No. 16-2003-QH11.
- Vietnam Decree No 68/2005/ND-CP dated 20/5/2005 and Government Circular No. 12/2006/TT-BCN guiding the implementation of the Decree stipulate that unsafe chemicals must be treated appropriately.
- Vietnam Announcement No 69/2002 of the Political Bureau directs the Government to strengthen international cooperation in preventing and overcoming consequences of the use of toxic chemicals in the War.
- Vietnam Decision 155/1999/QD-TTg of the Prime Minister of the Government on promulgating regulation of hazardous waste management.
- Vietnam Decision No 64/2003/QD-TTg of the Prime Minister of the Government approving the plan for thoroughly handling establishments which cause serious environmental pollution.
- Vietnam Decision No. 67/2004/QD-TTg dated 27 April 2004 of the Prime Minister regarding the approval of the Action Plan for the Period of 2004-2010 in Overcoming Consequences of Toxic Chemicals
- Vietnam Decision of the Prime Minister No 184/2006/QD-TTg (8/2006) approving the National Implementation Plan (NIP) of the Stockholm Convention on Persistent Organic Pollutants.[14]

Guidance

- U.S. Hazardous Waste Clean Up Process
- U.S. Occupational Health and Safety Administration(OSHA) Standards—29 CFR 1910—for health and safety (monitoring activity)
- 40 CFR 264 Hazardous Waste Disposal Regulations
- USEPA. Draft Recommended Interim Preliminary remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites. December 30, 2009.
- Vietnam Circular No. 05/2008/TT-BTNM--Guide to Strategic Environmental Assessment, Environmental Impact Assessment, and Environmental Protection Commitment
- Vietnam Decree No. 21/2008/ND-CP-- Amending and Supplementing a Number of Articles of Government Decree No. 80/2006/ND-CP, Detail and Guide to the Implementation of a Number of Articles of the Law on Environmental Protection

[14] UNDP 2009a.

- Vietnam Decree No. 80/2006/ND-CP--Detail and Guide to the Implementation of a Number of Articles of the Law on Environmental Protection
- Vietnam Decision No. 60/2002/QD BKHCNMT, guidance for the design of hazardous waste landfills.[15]

[15] UNDP 2009a.

Section 3. Summary

3.1. Project Area

The Da Nang City population is approximately 825,000, consisting of 401,235 males and 420,943 females, with an average population density of about 640 persons/ square kilometer (km^2). Hai Chau, Thanh Khe and Cam Le Districts are located adjacent to the airport. Hai Chau District includes 13 wards, and its population of 196,842 is the largest of the three districts. It has a population density of 92 people/ hectare (ha). Thanh Khe District, located between the airport property and Da Nang Bay, includes 10 wards. It has a population of 169,268, with a population density of 181/people/ha. Cam Le District includes 6 wards. It has a population of 70,052, with a population density of 21 people/ha.[16]

The Airport property is located within Da Nang City and is used by both MOD and the CAAV. It has a total area of 820 ha, of which 150 ha are allocated to civil aviation, and the remaining 670 ha are under the jurisdiction of the MOD. It is an international airport, with flights arriving from and departing to cities such as Bangkok, Vientiane, Hong Kong, Phnom Penh, and Taipei. The GVN plans to expand the Airport and requires dioxin removal from the northern area of the Airport to allow for extension of the runway and expanded taxiways.[17]

Dioxin hotspots identified at the Airport are primarily located in the northern portion of the Airport property (Figure 1) and include the:

- 2 ha MLA;
- 1.6 ha former Storage Area (SA);
- 3.5 ha Drainage Ditch consisting of 0.9 ha of sediments in the main drainage ditch, associated minor drainage ditches, and the drainage outlet from Sen Lake to the Da Nang storm drain, as well as the 2.6 ha area of contaminated soils on either side of the main drainage ditch;
- 0.8 ha area east of the Drainage Ditch (Eastern Hotspot);
- Sen Lake and the Eastern Wetland, two hotspots with a combined area of 8.5 ha; and
- 0.3 ha dioxin hotspot located in an isolated area of the southern portion of the Airport property at the former Pacer Ivy Storage Area (PISA).

[16] 2008 population figures taken from General Statistics Office online database.
[17] Da Nang Centre for Environmental Technology 2009.

FIGURE 1. DIOXIN HOTSPOTS IDENTIFIED AT DA NANG AIRPORT

Studies conducted to date show that dioxin concentrations within hotspot areas of the Airport substantially exceed international Vietnamese standards for dioxin.[18,] It is clear that dioxin has entered the aquatic and human food chain, and that levels in the human population are above World Health Organization (WHO) standards.[19] Interim mitigation measures (a ban on fishing and agricultural activities, construction of a barrier wall along the northern boundary of the Airport, temporary capping of the MLA, and construction of a sediment filtration system upstream of Sen Lake) implemented in 2007 with financial assistance from the Ford Foundation and the USG helped to reduce dioxin exposure to the local population, although it is recognized that these measures only provide a temporary solution to the problem.

Dioxin is a toxic chemical associated with a range of health effects.[20] 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic form of dioxin, and was the main congener present in the Agent Orange mixture. In the main hotspot areas of the Airport, TCDD comprises greater than 90% of the TEQ, indicating Agent Orange as the source of contamination. Other dioxin congeners are expressed in terms of 2,3,7,8-TCDD TEQ. The GVN has established a national cleanup standard for dioxin in soil in hotspot areas of 1,000 ppt TEQ in soil and 150 ppt TEQ in sediment.[21]

Using the GVN dioxin cleanup goals for soil and sediment, the remediation effort will need to address an estimated volume of 61,700 cubic meters (m^3) of contaminated material in the six hotspots at the Airport. Table 3 provides the estimated excavation volume (m^3) and footprint (square meters [m^2]) for each hotspot.

TABLE 3. DIOXIN HOTSPOTS AT DA NANG AIRPORT—VOLUME AND AREA OF CONTAMINATED MATERIAL[1]

Hotspot	Volume (m^3)	Area (m^2)
Mixing and Loading Area	19,500	19,600
Storage Area	8,900	16,200
Drainage Ditch[2]	8,500	35,600
Eastern Hotspot	500	7,700
Sen Lake and Eastern Wetland	22,800	85,400
Pacer Ivy Storage Area	1,400	3,200
Total	61,600	167,700

Notes:
1 – These estimates were derived from data collected during previous studies conducted between 2007 and 2009 by Hatfield/Office 33, the estimates of dioxin contamination provided in Allen and Fong (2009), as well as results from additional samples collected in January 2010 (see Appendix A1) by USAID. Appendix A2 presents the methodology used to calculate the excavation volumes.
2 – The Drainage Ditch hotspot consists of 9,200 $m^2$of contaminated sediments and 26,400 m^2 of contaminated soils, requiring an excavation of 3,300 m^3 of sediments and 5,200 m^3 of soils.

[18] MOD 1997 [unpublished data], Xenobiotic Detection Systems 2006, Hatfield/Office 33 2007, and Hatfield/Office 33 2009.
[19] Hatfield/Office 33 2007 and Hatfield/Office 33 2009.
[20]ATSDR 1998.
[21] TCVN 8183: 2009.

3.2. Alternatives

A number of technologies and/or management strategies have potential applicability for treatment of dioxin contamination in soil and sediments. A screening process was used to identify the most viable technology options to consider as alternatives based on environmental impact, effectiveness, feasibility, and cost. Previous studies have been performed to review technologies potentially applicable to dioxins associated with Agent Orange in Vietnam.[22] The technologies that received unfavorable assessments in these reports were not considered further in this EA. The highest scoring technologies presented in the UNDP report were considered for evaluation under this EA. The BEM Systems, Inc. (BEM) (2007) report appeared to give significantly greater weight to the cost criterion than to demonstrated effectiveness; both are given equal weight in the current screening process. If a technology/strategy was determined to be effective for containment, it was retained for further consideration even if it is not considered effective for treatment. Table 4 summarizes the technologies that were considered and findings of the screening process.

TABLE 4. SCREENING OF POTENTIALLY APPLICABLE TECHNOLOGIES/ STRATEGIES FOR DIOXIN REMEDIATION AT DA NANG AIRPORT

Technology/Strategy	Retained?	Criteria Not Met
No Action	Yes[1]	Effectiveness – will not meet cleanup objectives
Incineration	No	Effectiveness – shown to generate significant concentrations of dioxins in off-gas; this can be mitigated through off-gas treatment. Implementability – public perception could be a significant problem given the potential for dioxin air emissions.
Base-Catalyzed Decomposition	No	Implementability/Cost – large quantity of byproduct generated that would require a large landfill in addition to the treatment process.
Ball Milling with Active Landfill	No	Effectiveness – neither ball milling nor a biologically active landfill have been demonstrated at large scales to treat dioxins to below project cleanup objectives. Implementability/Cost – this approach requires full-scale implementation of both technologies.
In-Situ/In-Pile Thermal Desorption Destruction (ISTD/IPTD)	Yes	
Geo-Melt™ Process	No	Effectiveness – has never been applied full-scale for dioxin treatment
Passive Landfill	Yes[2]	
Active Landfill	Yes[3]	Effectiveness – has never been applied full-scale for dioxin treatment; has never been demonstrated to treat dioxins below project cleanup objectives (1,000 ppt soil; 150 ppt sediment).

Notes:
1 – Retained as a baseline although it fails the effectiveness criterion.
2 – Expected to be effective for containment, but not for long-term treatment.
3 – Expected to be effective for containment, but not demonstrated for treatment.

[22] UNDP 2009 and BEM 2007.

Based on the screening analysis discussed above and an assessment of the site conditions at the Airport during the scoping process, USAID selected four remedial alternatives for consideration under this EA. These include: 1) No Action; 2) Passive Landfill Containment; 3) Active Landfill (Bioremediation); and 4) ISTD/IPTD Destruction. These are discussed briefly below.

3.2.1. NO ACTION

Under the No Action alternative, the contaminated soil and sediment would be left in place, and no mitigation measures would be implemented. This alternative is required to be included under 22 CFR 216 and serves as a baseline for comparison to the other alternatives. No Action is not considered an appropriate alternative because concentrations of dioxin substantially exceed the Vietnamese National Standard for dioxin in soil and sediment[23] and USEPA's proposed preliminary remediation goals (PRGs) for dioxin in soil[24]. Furthermore, the Airport expansion is planned to take place within hotspot areas which eliminate the option of leaving the contaminated soil and sediment in place.

3.2.2. PASSIVE LANDFILL

The Passive Landfill alternative was the originally proposed action. This alternative would involve construction of a secure onsite landfill on the Airport premises and removal, dewatering, transport, and deposition of contaminated material into the landfill. This approach would provide a means to securely contain dioxin for the lifetime of the landfill (assumed to be 50 years), and is an approved option for containing dioxin at contaminated sites in the U.S. This would require construction of a large aboveground landfill, equivalent to approximately four football fields in area and 1.5 stories high. Operation and maintenance (O&M) and environmental monitoring and management would be required for a minimum of 50 years. At the end of this period, it is expected that dioxin levels of contaminated material in the landfill would remain significantly above GVN cleanup standards. Construction of a new landfill or dioxin destruction would be necessary at that time, with an additional significant cost.

3.2.3. ACTIVE LANDFILL (BIOREMEDIATION)

An active landfill would provide the same containment benefit as the Passive Landfill alternative. Under this alternative, however, additives would be mixed with contaminated material to facilitate growth of bacteria that might destroy dioxin. These "bulking agents" would add up to 40% to the volume of material to be contained in the landfill, resulting in a much larger landfill (more than five football fields in area and 1.5 stories high). Bioremediation has not been applied full scale for dioxin destruction; therefore, the design parameters for a large landfill to facilitate the bioremediation process are uncertain. As a result, it is difficult to predict whether the Active Landfill alternative would result in dioxin destruction to meet cleanup goals. How long this process might take is also unknown, and as a result, it is difficult to determine the need for long-term O&M and environmental monitoring and management.

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[23] TCVN 8183: 2009.
[24] USEPA 2009a.

3.2.4. IN SITU/IN PILE THERMAL DESORPTION

ISTD/IPTD was selected as the preferred project alternative in this EA. ISTD/IPTD is an innovative dioxin destruction technology that was developed by Royal Dutch Shell.[25] This is the only alternative of the three technology options considered for the EA that has been proven to destroy dioxin to levels that meet both soil and sediment GVN national dioxin standards.[26]

Under this alternative, the contaminated material would be excavated and placed into two or three stockpiles near the contaminated areas. The stockpiles would then be heated to 335 degrees Celsius (°C) to destroy 95% of the dioxins. The remaining dioxin would be drawn through an air treatment system for removal, resulting in air emissions that are below regulatory limits. This technology has been applied successfully at a similarly-sized dioxin site in Alhambra, California for which the California Department of Toxic Substances Control granted unrestricted land use status after treatment.[27] The Government of Japan conducted a carefully controlled pilot test of ISTD/IPTD that led to the technology being approved for dioxin destruction in Japan.[28]

3.3. EA Evaluation and Results

The EA included preparing conceptual designs corresponding to 10% of the final design for each alternative and used the following criteria to select the preferred alternative for the Airport: 1) effectiveness of the alternatives to achieve cleanup goals and be ultimately a final remedy for dioxin cleanup; 2) implementability of each alternative at the Airport; 3) potential environmental impacts of each alternative; and, 4) cost of the alternatives. Tables 5, 6, 7, and 8 provide the results of evaluating these criteria, respectively.

3.3.1. EFFECTIVENESS EVALUATION

The EA evaluated each alternative based on its ability to meet dioxin remediation goals, either through containment or through destruction. Both the Passive and Active Landfill alternatives were found to be effective for containment. Although the Passive Landfill alternative provides a 50-year remedial solution, it will not provide for full dioxin destruction over the long term. The effectiveness of the Active Landfill alternative for destruction of dioxin to meet treatment goals is unknown. The ISTD/IPTD alternative would not require construction of a landfill and would not include long-term containment. Rather, the ISTD/IPTD alternative would bring dioxin concentrations in treated soils and sediments to below cleanup goals. A summary of the results of the effectiveness evaluation is provided in Table 5.

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[25] http://newsite.terratherm.com/about/history.htm.
[26] ENSR 2000, Baker and La Chance 2003, Baker et al. 2007 and Heron et al. 2010.
[27] Baker et al. 2007.
[28] Heron et al. 2010.

TABLE 5. COMPARISON OF EFFECTIVENESS EVALUATION OF THE REMEDIAL ALTERNATIVES

PASSIVE LANDFILL	ACTIVE LANDFILL	ISTD/IPTD
Effective for containment: Proven containment strategy; hazardous waste landfills have been used successfully for decades worldwide; 50-year solution. **Ineffective for treatment:** Dioxins would be expected to persist for many decades and would require eventual treatment.	**Effective for containment:** Proven containment strategy; hazardous waste landfills have been used successfully for decades worldwide. **Unknown effectiveness for treatment:** Review of the scientific literature on microbial degradation of chlorinated dioxins[1] shows some degradation of 2, 3, 7; 8-TCDD, but no studies demonstrate degradation below either GVN cleanup goals. Initial results from USEPA and Vietnam Academy of Science Technology (VAST) pilot study[2] show approximately 50% dioxin degradation after 120 days; however, it remains unclear whether cleanup goals can be met and scalability of the pilot study to full-scale application is uncertain.	**Effective for treatment (no long-term containment required):** Several well-documented case studies[3] have shown that ISTD/IPTD can treat 2, 3, 7, 8-TCDD to concentrations below GVN cleanup standards. Concentrations of dioxins in exhaust gas in previous case studies were orders of magnitude below regulatory limits. • Over 95% of dioxins will be destroyed in situ. • If design calculations show that granular activated carbon (GAC) would not meet emissions standards for exhaust gas, then a thermal oxidizer would be considered. • Dispersion between the stack and property boundaries or locations of other receptors would be considered in this analysis as well.

Notes:
1 – Field and Sierra-Alvarez 2008.
2 – Allen and Fong 2009 and Allen 2010.
3 – ENSR 2000, Baker and La Chance 2003, Baker et al. 2007, and Heron et al. 2010.

3.3.2. IMPLEMENTABILITY EVALUATION

All of the remedial alternatives can be implemented at the Airport. Table 6 presents a summary of the challenges of implementing each alternative.

TABLE 6. COMPARISON OF IMPLEMENTABILITY EVALUATION OF THE REMEDIAL ALTERNATIVES

PASSIVE LANDFILL	ACTIVE LANDFILL	ISTD/IPTD
Landfill siting: an ideal site does not exist on Airport property. **Haul route:** long haul route and high number of truckloads required. **Fill material:** Significant amount of fill material (~140,000 m^3) required for landfill construction, operation, and closure. **Long-term O&M:** 50 years after construction.	**Landfill siting:** an ideal site does not exist on Airport property. **Haul route:** long haul route and high number of truckloads required. **Fill material:** Significant amount of fill material (~200,000 m^3) required for landfill construction, operation, and closure. **Electrical use:** estimated ~33,000 kilowatt hours (kwh)/year (yr) required for nutrient distribution system operation (10 years). **Bioremediation design uncertainty:** • Target mechanism: aerobic, aerobic cometabolic, anaerobic, or combination? • Design basis for full scale: distribution of microbes and nutrients/substrates, bioavailability of TCDD, longevity of nutrients/substrates relative to persistence of TCDD, and ability to maintain desired geochemical conditions **Long-term O&M:** assumed to be 10 years after construction, but may be more if degradation does not occur.	**Electrical use:** estimated 21,000,000 kwh for 6 months of continuous treatment time per pile (two piles total). **Mobilization:** some equipment and technical expertise will have to come from overseas. **Air monitoring:** must ensure emissions do not exceed regulatory limits; GAC and/or thermal oxidizer would be used. **Geotechnical properties of soil post-treatment:** limited quantitative data available, but one study indicated no significant effect.[1] Conservative design assumptions made to stockpile soil and revegetate it post-treatment rather than to use it as structural fill.

Notes:
1 – Heron et al. 2009.

3.3.3. ENVIRONMENTAL CONSEQUENCES

The overall potential environmental impact of all three remedial alternatives is substantial. The remedial action requires the excavation, transport, and deposition of dioxin-contaminated soil from the hotspots into a landfill or stockpile. The wetland ecosystem (Sen Lake) must be drained and dredged to remove contaminated sediments. Impacts to wetlands and terrestrial and aquatic biota are unavoidable over the short term, in order to eliminate the possibility of future dioxin exposure to humans and the environment. Detailed assessments of the potential environmental impacts associated with each alternative were conducted for this EA and are summarized below and in Table 7.

The Passive Landfill alternative would require hauling approximately 7,500 truckloads of contaminated soil and sediment. In addition, approximately 10,000 truckloads of clean fill would need to be brought in from offsite, an action in and of itself that could require a GVN EIA if all the clean fill material were to be obtained from a single new source. The total distance of material that would be hauled is approximately 369,000 kilometers (km). The most significant potential environmental impacts of the Passive Landfill alternative include risks from unexploded ordnance (UXO), munitions bunker decommissioning at the landfill site, potential impacts on surface water quality, contaminated fugitive dust/sediment exposure to workers and area residents, noise impacts, impacts to natural resources due to the large size of the landfill footprint, and potential environmental impacts associated with long-term operation of the

landfill. The potential environmental impact of the Passive Landfill was found to be lower than the No Action and Active Landfill alternatives, but significantly greater than the ISTD/IPTD alternative.

The Active Landfill alternative would require hauling approximately 7,500 truckloads of contaminated soil and sediment. In addition, approximately 17,000 truckloads of clean fill and bulking agent would need to be brought in from offsite, an action in and of itself that could require a GVN EIA if all the clean fill material were to be obtained from a single new source. Potential environmental impacts of the Active Landfill alternative are incrementally greater than those of the Passive Landfill due to the need for a larger temporary storage and dewatering area, and the need for a larger landfill footprint to accommodate the up to 40% increase in total volume of material. Greater contact with contaminated material would be necessary to mix it with bulking agents to facilitate the biological reaction process. As a result, the potential environmental impacts associated with UXO, munitions bunker decommissioning at the landfill site, potential impacts on surface water quality, contaminated fugitive dust/sediment exposure to workers and area residents, noise impacts, and impacts to natural resources are greater than those of the Passive Landfill and significantly greater than those of the ISTD/IPTD alternative.

The ISTD/IPTD alternative does not require large storage and dewatering operations, upgrade of the haul routing, long hauling distance, UXO clearance and munitions bunker decommissioning at the landfill site, construction of the landfill, and deposition of contaminated material into the landfill. The hauling distance is roughly half of that required of the Passive and Active Landfill alternatives, and the need for clean fill for construction and operation is less than half of that needed for the Active Landfill alternative and 60% less than that of the Passive Landfill alternative. The potential environmental impacts to surface water quality due to contaminated wastewater discharges are less than 10% of those estimated for the Passive Landfill alternative and less than 20% of those estimated for the Active Landfill alternative. Following ISTD/IPTD treatment, it is likely that soils could be used as fill for a variety of purposes, but geotechnical testing would need to be performed before using the soils as structural fill. As no long-term O&M and environmental monitoring concerns exist after treatment with the ISTD/IPTD alternative, there are no potential long-term impacts; in contrast to the two landfill alternatives. This alternative was assessed as having a lower overall potential environmental impact than any of the other alternatives that were assessed.

The assessment results were used to rank the alternatives to identify the environmentally-preferred alternative which is the alternative with the lowest overall potential environmental impact. The results of the environmental impact analysis of the four alternatives are summarized in Table 7. For each assessment criterion, the three alternatives (excluding No Action) are ranked depending on their relative potential environmental impacts. A score of "1" indicates the highest relative potential environmental impact and a score of "3" indicates the lowest potential environmental impact. Lower cumulative scores are associated with the greatest potential environmental impact among the evaluated alternatives. It should be noted that no weighting has been given to each of the impact assessment criteria.

TABLE 7. COMPARISON OF POTENTIAL ENVIRONMENTAL IMPACTS OF THE REMEDIAL ALTERNATIVES

Potential Environmental Impact	**Assessment Criterion**	**Remedial Alternative (Environmental Impact Ranking; 1 = Highest Impact Total Score. The Lower the Score, the Higher the Environmental Impact Ranking)**		
		Passive Landfill (Total Score = 29)	**Active Landfill (Total Score = 24) Highest Potential Environmental Impact**	**ISTD/IPTD (Total Score = 37) Lowest Potential Environmental Impact**
Potential Environmental and Associated Human Risks Associated with Cleanup of UXO and Munitions	Qualitative Assessment based on land area affected by Project	Significant (2)	Significant (1)	Significant (3)
		Requirements to remediate munitions bunkers and possible other similar facilities in the southwestern part of the Airport property are unknown.		
Potential Impacts on Surface Water Hydrology	Qualitative Assessment	Insignificant (3)	Insignificant (3)	Insignificant (3)
Potential Impacts on Surface Water Quality	Volume of Project-Affected Water Generated and Requiring Treatment before Release	262,242 m^3 (1)	136,597 m^3 (2)	23,603 m^3 (3)
Potential Impacts on Groundwater Resources	Qualitative Assessment	Insignificant (3)	Insignificant (3)	Insignificant (3)
Potential Impacts on Groundwater Quality	Qualitative Assessment	Insignificant (3)	Insignificant (3)	Insignificant (3)
Potential Effects of Extraction, Transport, Containment, and Treatment of Dioxin-Contaminated Material on Air Quality and Human Exposure	Relative Potential Exposure Index for Dioxin	Intermediate (2)	Highest (1)	Lowest (3)
Potential Effects of Emissions of Other contaminants of potential concern (COPCs) and Dust on Air Quality and Human Exposure	Qualitative Assessment	Significant (1)	Significant (1)	Significant (1)

TABLE 7. COMPARISON OF POTENTIAL ENVIRONMENTAL IMPACTS OF THE REMEDIAL ALTERNATIVES

Potential Environmental Impact	Assessment Criterion	Remedial Alternative (Environmental Impact Ranking; 1 = Highest Impact Total Score. The Lower the Score, the Higher the Environmental Impact Ranking)		
		Passive Landfill (Total Score = 29)	Active Landfill (Total Score = 24) Highest Potential Environmental Impact	ISTD/IPTD (Total Score = 37) Lowest Potential Environmental Impact
Potential Contribution to Greenhouse Gases	Tons (metric) (t) of carbon dioxide (CO_2) generated by the Project	3,925 t (3)	5,059 t (2)	7,926 t (1)
Potential Effects on Terrestrial Ecosystems and Terrestrial Biodiversity	Qualitative Assessment	Insignificant (1)	Insignificant (1)	Insignificant (1)
Potential Effects on Wetlands, Aquatic Ecosystems, and Aquatic Biodiversity	Qualitative Assessment	Insignificant (1)	Insignificant (1)	Insignificant (1)
Potential Effects on Noise Levels	Total Estimated Duration of Equipment Use	7,340 hours (hrs) (2)	7,790 hrs (1)	3,030 hrs (3)
	Total Distance Driven by Hauling Equipment	369,920 km (2)	580,570 km (1)	230,600 km (3)
Potential Effects on Natural or Depletable Resource Requirements	Amount of clean fill required	138,200 m^3 (2)	201,300 m^3 (1)	84,300 m^3 (3)
Potential Effects on Land Use	Land Area Disturbed	296,050 m^2 (2)	334,950 m^2 (1)	183,100 m^2 (3)
Potential Long-Term Environmental Risks Associated with Operation of the Project	Qualitative Assessment	Significant (1)	Unknown (2)	Insignificant (3)

3.3.4. COST EVALUATION

The EA includes cost estimates for each of the three alternatives based on Superfund guidance. Although such cost estimates are normally associated with a -30%+50% cost range, at this 10% conceptual design phase of the Project, underlying cost assumption for these estimates with respect to contaminated material volumes, local labor, electricity, and value added tax (VAT) have been refined significantly. Therefore, the range may be narrower than -30 + 50%. Cost estimates assume a 2-year implementation period for the three remedial alternatives. Longer implementation timeframes will increase total cost. Table 8 provides a summary of the cost estimates for each alternative.

TABLE 8. COMPARISON OF ESTIMATED COSTS ($ MILLION) OF THE REMEDIAL ALTERNATIVES (COST RANGE -30%+50%)

Component	Passive Landfill	Active Landfill	ISTD/ IPTD	Cost Differentiators Between Alternatives
Disposal	$11.5	$11.5	$8.7	Less excavation, hauling, and site clearing/prep for ISTD/IPTD
Construction	$10.3	$15.5	$24.4	Various
Subtotal (First 2 years)	$21.8	$27.0	$33.1	
Long Term O&M	$3.2	$0.7	$0	Passive Landfill: 50 years Active Landfill: 10 years ISTD/IPTD: none
EMMP Implementation	$10.8	$3.0	$0.6	Passive Landfill: 50 years Active Landfill: 10 years ISTD/IPTD: none
Overall Total	**$35.8**	**$30.7**	**$33.7**	

3.4. Selected Preferred Project Alternative

Table 9 summarizes the results of the alternatives analysis in this EA. The ISTD/IPTD alternative was found to have the highest treatment effectiveness, the highest feasibility, the lowest potential environmental impact, and a cost in the same range as the other alternatives. The Passive Landfill alternative was the most expensive option, ranked third in terms of environmental impact, was possibly feasible in the context of the Airport, and, while effective for containment, does not provide a final remedy. The Active Landfill alternative was associated with the highest environmental impact, while its effectiveness for destroying dioxin to cleanup goals is uncertain. The Active Landfill alternative is possibly feasible in the context of the Airport although it is unclear whether it would provide a final remedy. No action is not considered a viable alternative due to the high levels of dioxin contamination present at the site and because the Airport expansion project will require removal of dioxin from hotspot areas. Based on these results, USAID has selected ISTD/IPTD as the preferred alternative for dioxin remediation at the Airport. As described in Section 2, this alternative was not the originally proposed action for the Airport remediation program.

TABLE 9. SUMMARY OF EA FINDINGS FOR DIOXIN REMEDIATION AT DA NANG AIRPORT

Alternative	Effectiveness (i.e., dioxin ≤ cleanup goals/"final remedy")?	Implementable	Environmental Assessment	Estimated Cost (in Millions) -30%+50%	Implementation Schedule
No Action	No	Yes	Highest overall potential environmental impact	Externalized	NA
Passive Landfill	No	Yes with challenges	Third-highest overall potential environmental impact	$35.8M	2-year construction, and 50 years long term O&M
Active Landfill (Bioremed-iation)	Uncertain	Yes with challenges	Second-highest overall potential environmental impact	$30.7M	2-year construction, and 10 years long term O&M
ISTD/IPTD	Yes	Yes with challenges	Lowest overall potential environmental impact	$33.7M	2-year construction and no long term O&M

Notes:
This table summarizes the results of the alternatives analysis in this EA; it also provides a summary of the implementation schedule for each remedy (additional details regarding schedule are provided in the conceptual designs of each alternative).

3.5. Stakeholder Response

Formal approval of the revised proposed action will occur through an exchange of letters to take place after the EA receives USAID Asia BEO approval and during the GVN approvals process for the EIA.

USAID and GVN participated in two workshops in March 2010 (March 16, 2010 in Hanoi and March 18, 2010 in Da Nang) to review the findings of the Draft EA. The objectives of the workshops were to: present the findings of the EA; obtain stakeholder input into the assumptions used to complete the EA; and, to obtain consensus on the technology option to be selected as the "preferred" alternative for the EA and subsequent EIA. At the completion of the workshops, the following conclusions were reached:

- The No Action alternative cannot be considered as a viable alternative.
- GVN participants indicated their full support and agree on using the best technology for destroying dioxins at the Airport. The ISTD/IPTD alternative has many merits. The ISTD/IPTD alternative costs are in the same range as both of the landfill alternatives and the EA demonstrates that ISTD/IPTD is the preferred alternative. However, GVN specified that they would like the remediation activities to proceed in such a way that

performance of the technology in the Da Nang context is guaranteed prior to full scale implementation.

- The Passive Landfill is an acceptable alternative for dioxin containment and is used in other international contexts. Although the ISTD/IPTD alternative is associated with reduced environmental consequences and is expected to reach GVN cleanup goals (i.e., a final remedy), GVN wants to keep the Passive Landfill alternative as the default alternative if for some reason the ISTD/IPTD alternative cannot be implemented at the Airport.

- The Active Landfill alternative has not been proven effective for dioxin remediation in the U.S. or other international contexts. GVN does not support further discussion of this alternative in the context of the Da Nang remediation effort.

The GVN will need to approve the Project at the Prime Minister's level. This approval will most likely take place as part of the EIA acceptance process.

Section 4. Baseline Information

This section provides general baseline (i.e., current) information about the Airport area, dioxin contamination at the Airport, potential exposure pathways, and gender considerations for the Project. Section 6 (Affected Environment) provides baseline environmental condition information.

4.1. Da Nang Airport and Surrounding Communities

Da Nang City has a population of approximately 825,000 persons as of 2008 (male: 401,235; female: 420,943), with an average population density of about 640 persons/m^2 (Table 10). The Airport property is located within the urban part of Da Nang City and is surrounded by three urban districts: Hai Chau on the northeast and east; Thanh Khe on the northwest and west; and Cam Le on the southwest, south, and southeast (Figure 2). The three districts are densely populated, with most of the land in these districts used for housing, industrial facilities, transportation, and other facilities. With the exception of Cam Le District, few areas near the Airport property are used for agriculture, aquaculture, or forestry. These land uses in Cam Le District are generally to the southwest of, and not immediately adjacent to, the Airport property.

The Airport property is located within Da Nang City and is used by both MOD and the CAAV. It has a total area of 820 ha, of which 150 ha are allocated to civil aviation, and the remaining 670 ha are under the jurisdiction of the MOD. It is an international airport, with flights arriving from and departing to cities such as Bangkok, Vientiane, Hong Kong, Phnom Penh, and Taipei. The GVN plans to expand the Airport and requires dioxin removal from the MLA, the SA, and Sen Lake to allow for extension of the eastern runway to the north and expanded taxiways.[29] There are at least 14 lakes on the Airport property which are still used today for fishing and aquaculture. Fishing activities on Sen Lake have been banned since 2007, but this ban has not been implemented on other lakes. During the 1960s, land use in the Da Nang City area was very different, particularly north of the Airport; large tracts of land were used for rice agriculture, and several of the wetlands in the area could be considered as extensions of the Sen Lake ecosystem.[30]

General information on Da Nang City and the districts of Thanh Khe, Cam Le, and Hai Chau is provided in Table 10. A number of people reside on the western edge of the Airport property, between the western boundary and the active runways. These are primarily military personnel, Airport workers, and their families.

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[29] Da Nang Centre for Environmental Technology 2009.
[30] Hatfield/Office 33 2007.

FIGURE 2. DA NANG AIRPORT AND SURROUNDING COMMUNITIES

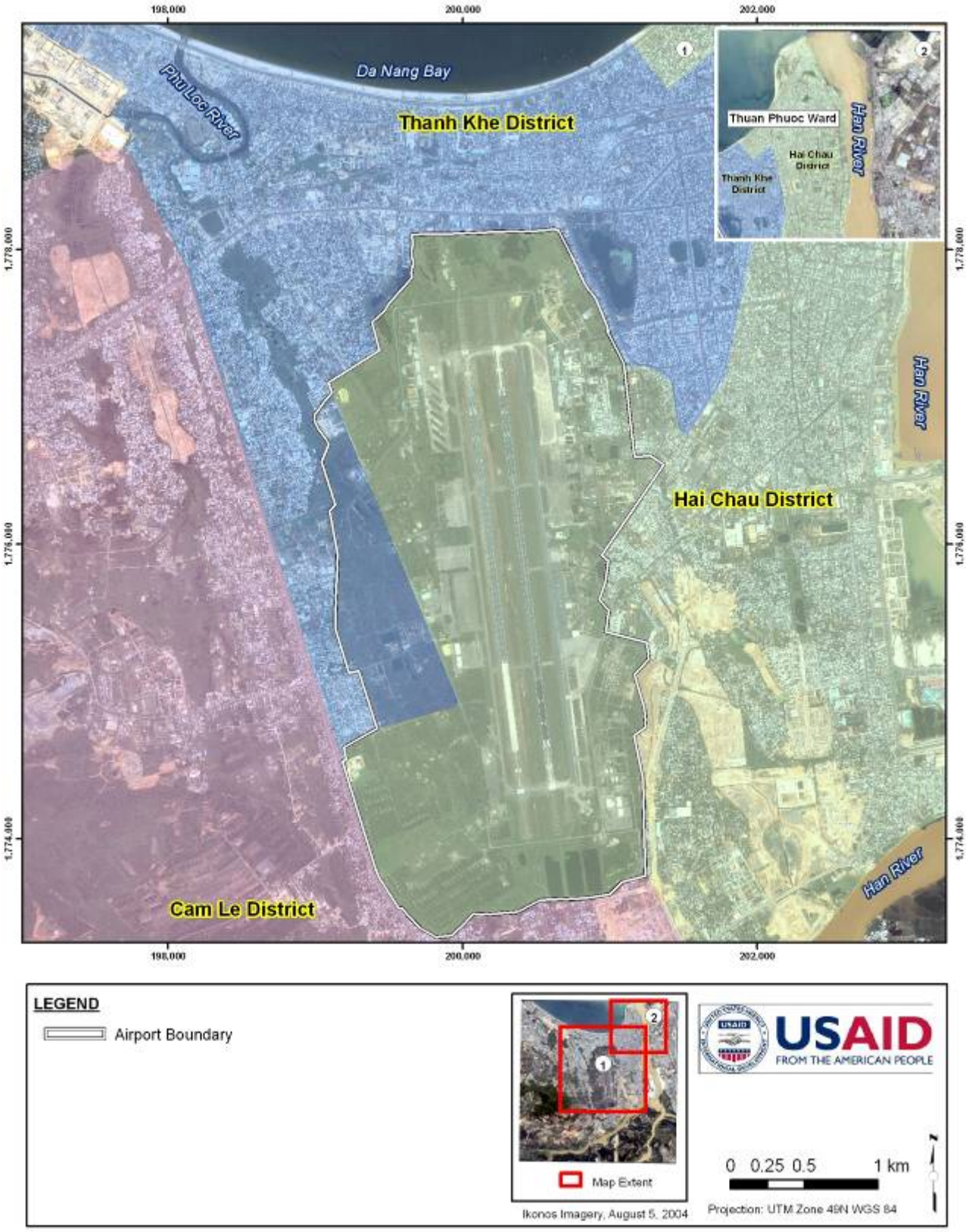

TABLE 10. DA NANG CITY DISTRICTS ADJACENT TO DA NANG AIRPORT[1]

	Hai Chau District	Thanh Khe District	Cam Le District
General			
Area (ha)	2,135	936	3,376
Total Population	196,842	169,268	70,052
Male Population	94,721	83,418	33,993
Female Population	102,121	85,850	36,059
Population Density (persons/ha)	92	181	21
Number of Wards	13	10	6
Land Use (ha, as of 2007)			
Total Agriculture Land	23	18	826
Rice	0	0	536
Other Cultivated Crops[2]	0	10	217
Tree Crops[3]	23	8	73
Aquaculture	0	0	28
Forestry Land[4]	0	0	210
Special Use Land[5]	1,328	388	956
Residential Land	473	454	676
Unused Land	311	76	680

Notes:
1 – Information as of 2008 unless otherwise noted (Da Nang Statistics Office 2008).
2 – Other cultivated crops include beans, groundnut, corn, and other vegetables
3 – Tree crops include coconut, pepper, and cashew.
4 – Forestry land is defined as land used for the cultivation of trees for timber, other building products, or pulp and paper.
5 – Special Use Land includes roads, industrial zones, retail facilities, and canals.

4.2. Dioxin Contamination at Da Nang Airport

The Airport is recognized as a dioxin hotspot due to high 2,3,7,8-TCDD concentrations remaining decades after large volumes of Agent Orange and other herbicides were stored, handled and spilled at this site during Operation Ranch Hand during the Vietnam War.[31] Several studies of dioxin contamination in and around the Airport have been conducted since 1997 (Table 11). This section provides a summary of the key studies conducted at the Airport, and provides details on the amount of contaminated material to be remediated under this Project.

[31] Dwernychuk et al. 2002

TABLE 11. DIOXIN STUDIES UNDERTAKEN BETWEEN 1997 AND 2010 AT DA NANG AIRPORT

Agency (Reference)	Year	Number of Samples	Sample Type	Analytical Technique	Laboratory
MOD[1]	1997-1998	~ 330	Soil and Biological	Gas Chromatography – Mass Spectrometry (GCMS) (low resolution)	Vietnam (some in Russia and Japan)
MOD and Hanoi Medical University (HMU)[2]	2000-2005	200	Biological	GCMS (low resolution)	Vietnam (some in Japan)
VAST, MoNRE, MOD, and USEPA[3]	2005	109/179	Soil and Biological	CALUX	USA
Hatfield/10-80 Division[4]	2005	21	Soil and Sediment	GCMS (high resolution)	Canada (AXYS)
Hatfield/ Office 33[5]	2006-2007	147	Soil, Sediment, Fish, Vegetation, Blood and Breast Milk	GCMS (high resolution)	Canada (AXYS)
Hatfield/ Office 33[6]	2009	127	Soil, Sediment, Fish	GCMS (high resolution)	Canada (AXYS)
		115	Blood and Breast Milk	GCMS (high resolution)	Canada (AXYS)
USAID	2010	71	Soil, Sediment, Surface/Ground water	GCMS (high resolution)	Canada (AXYS)

Notes:
1 – MOD unpublished data.
2 – MOD and HMU unpublished data.
3 –Xenobiotic Detection Systems Inc. 2006.
4 – Hatfield/10-80 Division 2006.
5 – Hatfield/Office 33 2007.
6 – Hatfield/Office 33 2009.

4.2.1. SUMMARY OF PREVIOUS STUDIES AT DA NANG AIRPORT

Prior to 2005, there was limited information in the scientific literature on dioxin levels in and around the Airport.[32] The earliest recorded dioxin investigations at the Airport were conducted by MOD in 1997[33], and by MOD and HMU between 2000-2005.[34] MOD found high concentrations of dioxin in Sen Lake sediments (measured as TEQs; maximum 12,393.2 ppt) in 1997 from a number of sampling locations. MOD's 1997 previously unpublished data from sampling and analysis of sediment from Sen Lake were made available to the Project team, and are provided in Appendix A1 and in the figures in this report.

[32] Dwernychuk 2005
[33] MOD unpublished data
[34] MOD and HMU unpublished data.

From 2003 to 2005, with funding from the Ford Foundation, Hatfield and the 10-80 Division of the Ministry of Health (10-80 Division) conducted a review of all suspected dioxin hotspots in Vietnam, including Da Nang.[35] The project, entitled "Identification of New Agent Orange/Dioxin Contamination Hotspots in Southern Viet Nam," consisted of two phases: Phase I involved the identification of potentially contaminated sites that may pose a risk to human health; and, Phase II included confirmation of selected Phase I sites through a field sampling program, further refinement of human health risks, and recommendations for future action. A total of 21 soil and sediment samples were analyzed for dioxins and furans outside of the Airport as part of the project. Elevated dioxin levels were recorded in soils and sediments from a number of sites, including a ditch in Hai Chau District immediately east of the Airport, and from a former wetland area in Thanh Khe District. Based on these results, recommendations were made for further assessment on the Airport (as well as the Bien Hoa and Phu Cat airports and other suspected hotspots identified in the study), to determine the extent of contamination and possible exposure of the local population to dioxin[36].

Concurrently, in 2005, under a joint study conducted by VAST, MoNRE, MOD, and USEPA, soil and sediment samples, as well as biological tissues, were collected and analyzed from the Airport (using CALUX)[37].

Data from the studies conducted between 1997 and 2005[38] focused on analysis at the three main hotspot areas at the northern end of the Airport, including soils from the MLA and SA, and sediments from Sen Lake. Significant dioxin contamination (>10,000 ppt TEQ) was found in many of the samples analyzed[39], and these data were instrumental in helping to provide a more detailed understanding of contamination levels in hotspots at the northern end of the Airport. The 2005 data[40] were also included in the estimations of extent of contamination at the Airport presented in this EA, and in calculations of volumes of contaminated soil which need to be treated. These data are presented in Appendix A1 (and in the figures in this report).

Between October 2006 and April 2007, with funding from the Ford Foundation, Office 33 and Hatfield Consultants (Hatfield) undertook the "Da Nang Dioxin Assessment and Mitigation Project. [41] This project investigated the issue of residual dioxin contamination on the Airport property and in the surrounding environment, and developed mitigation measures to help prevent dioxin exposure to local populations. The study focused on the three main hotspots at the north end of the Airport, and included analysis of 147 samples for dioxins, furans and other chemical contaminants in soils, sediments, fish tissues and human blood. Data are presented in Appendix A1 (and in the tables and figures in this report), as well as in the Hatfield/Office 33 2007 report.[42]

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[35] Hatfield/10-80 Division 2006 and Dwernychuk et al. 2006.
[36] Hatfield/10-80 Division 2006 and Dwernychuk et al. 2006.
[37] Xenobiotic Detection Systems Inc. 2006.
[38] MOD unpublished data and Xenobiotic Detection Systems Inc. 2006.
[39] Xenobiotic Detection Systems Inc. 2006.
[40] Xenobiotic Detection Systems Inc. 2006.
[41] Hatfield/Office 33 2007 and Boivin et al. 2007.
[42] Hatfield/Office 33 2007.

The key results of the Hatfield/Office 33[43] sampling program at the Airport in 2006 were as summarized below:

- Significant quantities of TCDD were detected in samples analyzed, with maximum concentrations recorded in soils from the MLA (365,000 ppt).

- Dioxin congener profiles confirmed that the main source of dioxin contamination in the northern area of the Airport was Agent Orange and other dioxin-containing herbicides. TCDD contributed over 90% of the TEQ (TCDD toxic equivalents) in soil and sediment samples collected from the MLA, SA, and Sen Lake.

- The maximum TCDD levels recorded in fish fat samples from Sen Lake was 3,000 ppt, 100 times above acceptable levels for human consumption established by Health Canada. Fish contaminated with dioxins from Sen Lake were being consumed by fishermen (and likely some members of the general public). As a point of reference, the U.S. Food and Drug Administration (FDA) issued a recall of fish with dioxin levels higher than 1 pg/g (1 ppt) TEQ wet weight.[44]

- Dioxin levels recorded in vegetation (i.e., lotus, sweet potato) collected at Sen Lake in 2006 were generally low, although there was potential for human exposure to dioxin through contact with contaminated soil and sediments used for growing these food items on the Airport property.

- Blood dioxin levels recorded (n=55 patients sampled) in some Da Nang residents were the highest reported for Vietnam to date, and exceeded international standards for these chemicals. Individuals working on the Da Nang Airbase at Sen Lake (harvesting fish and lotus, and gardening) had the highest dioxin concentrations in their blood – more than 100 times globally acceptable levels. The highest TCDD level of 1,150 ppt (1,220 ppt TEQ; 94% TCDD) was recorded in a 42-year-old male who had worked on the Airport and consumed fish from the Sen Lakes since 1990. A number of other contaminants, including polychlorinated biphenyls (PCBs), were also recorded in blood samples analyzed. As a point of reference, The U.S. Agency for Toxic Substances and Disease Registry (ATSDR) notes that blood dioxin levels typical of those found in developing countries rarely exceed 10 ppt.[45]

- People most affected by direct exposure to dioxins from the Da Nang hotspot were members of an extended family that fished and harvested lotus from Sen Lake, and gardened along its banks. Given that a number of people had consumed fish and harvested lotus from Sen Lake for decades, and that people living outside the Airport could easily gain access to the site, exact numbers of highly exposed people were unknown. Recommendations were made to verify the number of potentially impacted people.

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[43] Hatfield/Office 33 2007 and Boivin et al. 2007.
[44] USDA Food Safety and Inspection Service 1997.
[45] ATSDR 1998.

In June 2007, a workshop was organized in Hanoi by MOD and the DOD to share information on dioxin contamination in Vietnam, and more specifically, the "Pacer Ivy" mission, which took place in 1971. In logistics operations, the word "Pacer" refers to the movement of material, and the word "Ivy" is a short-form of "Inventory."[46] On April 17, 1970 all uses of Agent Orange were halted in Vietnam and all remaining materials were put into storage. The Pacer Ivy mission was launched on September 15, 1971 to consolidate, re-drum and ship all remaining Agent Orange material in South Vietnam to Johnston Island in the Central Pacific Ocean. New potential dioxin hotspots were identified at the Airport during this June 2007 workshop, in the south-western portion of the Airport, namely the PISA and the former Pacer Ivy Re-Drumming Area (PIRA). These areas had not been previously sampled for dioxin contamination, and concerns were raised regarding the existence of other potential dioxin hotspots on the Airport and in surrounding areas.

Following identification of the PISA and PIRA areas,[47] with funding from the Ford Foundation, Hatfield and Office 33 implemented the project "Comprehensive Assessment of Dioxin Contamination in Da Nang Airport, Viet Nam: Environmental Levels, Human Exposure and Options for Mitigating Impacts"[48] This study consisted of two phases: Phase I focused on sampling and analysis of soils from the PISA and PIRA, and also included monitoring of areas in the north of the Airport that were identified as being highly contaminated in the 2006 study .[49] Although the sampling focus was on the two Pacer Ivy sites, a comprehensive assessment of the entire Airport area (and the city surrounding the perimeter of the Airport) was also conducted in January 2009 in order to determine if there were additional unidentified contaminated sites. Phase II of the study was conducted in April 2009 to determine potential human exposure to dioxins and furans in communities surrounding the Airport. Blood and breast milk were collected from randomly selected participants (from all districts surrounding the Airport), and from individuals who had been tested in 2006 in order to determine any temporal trends in dioxin levels. As part of the Phase II study, additional environmental samples were collected from the PISA to better delineate the extent of contamination based on Phase I results.[50]

A total of 127 environmental (soil, sediment and fish tissue) and 115 human (blood and breast milk) samples were analyzed as part of the 2009 Hatfield/Office 33 Da Nang study. Data are presented in Appendix A1 (and in the tables and figures in this report), as well as in the Hatfield/Office 33 2009 report.[51] Key results are summarized below:

- As recorded in 2006, significant quantities of TCDD were detected in samples analyzed from the north end of the Airport in January 2009. Dioxin levels at this location continued to exceed international standards and guidelines for these toxic chemicals.

- One soil sample in the PISA, and one surface sample adjacent to the PISA in the southern area of the Airport, exceeded Vietnamese standards and guidelines for TCDD

[46] Young 2007.
[47] Young 2007.
[48] Hatfield/Office 33 2009.
[49] Hatfield/Office 33 2007.
[50] Hatfield/Office 33 2009.
[51] Hatfield/Office 33 2009.

(1,180 and 13,400 picograms [pg]/ gram [g] dry weight, respectively). At the PIRA, all samples exhibited low TCDD levels (1.21 to 79.9 pg/g dry weight). The proportion of TCDD to TEQ concentrations at, and adjacent to, the PISA was generally low which might indicate other possible sources of dioxin contamination.

- All soil and sediment samples analyzed from the west and east of the Airport exhibited low TCDD concentrations (non-detect to 46.1 pg/g dry weight).

- The maximum TCDD concentration recorded in tilapia fish fat from Sen Lake in 2009 was 7,900 ppt (wet weight basis), which greatly exceeded the acceptable level established by the U.S. Department of Agriculture (USDA).[52] In 2006, tilapia fat levels were 3,000 ppt (wet weight basis). Possible explanations for increased dioxin concentrations in Sen Lake tilapia between 2006 and 2009 include higher bioconcentration in larger fish over time, and longer residency periods for fish in the lake. Since cessation of fishing practices at Sen Lake in 2007, average fish sizes (and average age) appear to have increased over time, resulting in increased bioaccumulation in biological tissues.

- Fish samples analyzed from 12 other lakes on the Airport property in 2009 generally exhibited low dioxin levels. Therefore, the key concern is potential for consumption of contaminated fish from Sen Lake, and not from other water bodies on the Airport property.

- Analysis of blood dioxin/furan levels from randomly selected individuals in different communities surrounding the Airport in 2009 confirmed high concentrations in people living north, east and west of the Airport. Highest levels were again found in Sen Lake workers who were re-tested in 2009; their dioxin concentrations were not significantly different from those recorded in 2006. Although contamination levels in people living around the Airport are clearly from a variety of sources, working on the Airport was found to increase blood TEQ and TCDD above background levels.

- The distribution of blood dioxin levels in people from the wards surrounding the Airport (Anh Khe Ward in Thanh Khe District, Khue Trung Ward in Cam Le District, and Thuan Tay Ward in Hai Chau District) showed that working on the Airport was the strongest predictor of elevated dioxin levels in blood. Eating fish from Sen Lake also was deemed a significant risk factor for elevated dioxin in blood.

- TCDD concentrations in human blood from donors of Khue Trung Ward in Cam Le District, which exhibited the lowest TCDD and TEQ levels, were all less than 10 pg/g. The low percentage of TCDD in these TEQ values (none exceeded 40%) also indicated that it is unlikely that those sampled were directly impacted by Agent Orange exposure in soils, sediment, water or food supplies. This was also true for individuals sampled in 2006 from the reference area, Thuan Phuoc Ward in Hai Chau District.

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[52] USDA 1997.

- In contrast, some, but not all, individuals sampled from other wards surrounding the Airport exhibited TCDD concentrations greater than 10 pg/g. These include residents from Anh Khe Ward in Thanh Khe District, Thuan Tay Ward in Hai Chau District, and 2006 donors from Chinh Gian Ward in Hai Chau District. These wards are located on the east, north and west sides of the Airport, within 1 km of the boundary.

- Dioxins and furans were recorded in all breast milk samples analyzed in 2009 (n=14). All breast milk samples analyzed (n=14) exhibited TEQs exceeding the WHO Tolerable Daily Intake standard of 4 pg TEQ/kilogram body weight (kg bw)/day (d). Maximum levels were recorded in a young primaparous female (232 ppt TCDD) who previously consumed fish from Sen Lake.

A total of 410 environmental samples, including 198 soil/sediment, 41 fish/vegetation, and 171 human blood and breast milk samples were collected and analyzed for dioxin and furan concentrations over the course of the Hatfield/10-80 Division[53] and Hatfield/Office 33[54] studies conducted between 2005 and 2009. General conclusions from previous studies cited above, relevant to the estimation of contaminated area, and calculation of volume of contaminated of soils in the current USAID Project, are as follows:

- The northern end of the Airport is a significant dioxin hotspot. Soil and sediment samples from the southern, eastern, and western areas of the Airport exhibit significantly less dioxin contamination than those analyzed from the northern areas. Levels of dioxin contamination in samples analyzed from the southern Airport area near former Pacer Ivy sites were low.

- Concentrations of dioxins and furans in soils in the MLA and SA greatly exceed the GVN standard of 1,000 ppt TEQ.

- Dioxin concentrations in sediments of Sen Lake and north Airport drainage ditches were also markedly higher than the GVN standard of 150 pg/g TEQ.

- The drainage canals leading from the MLA and SA to and Sen Lake are likely the primary mechanism for spreading dioxin contaminated sediment beyond the Airport boundaries.

- Sample analysis suggests that there is minimal dioxin contamination in the southern Airport property near former Pacer Ivy sites.

- Sampling results discussed above have enabled the definition of dioxin hotspots at the Airport. These are primarily located in the northern portion of the Airport property and include the MLA, SA, Drainage Ditch, Sen Lake and the Eastern Wetland. In addition, a small hotspot is located in an isolated area of the southern portion of the Airport property at the PISA.

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[53] Hatfield/10-80 Division 2006.
[54] Hatfield/Office 33 2007 and Hatfield/Office 33 2009.

- The highest concentrations of dioxins in contaminated soils/sediments occur in the top 10-centimeter (cm) layer; some contamination was found at deeper levels (e.g., >30 cm), but only in limited areas in the MLA, SA, and PISA at the Airport.

- Other contaminants contributing to the polychlorinated dibenzo-p-dioxin (PCDD)/polychlorinated dibenzofuran (PCDF) load are also present in the environment and human population, both inside and outside the perimeter of the Airport, including PCBs, organochlorine pesticides, and hydrocarbons.

- Results from the Hatfield/Office 33 study[55] suggested that the interim mitigation measures implemented in 2007 have resulted in a reduction in exposure levels in the human population surrounding the Airport.

4.2.2. JANUARY 2010 USAID SAMPLING AT DA NANG AIRPORT

The analytical data collected prior to 2010 provided a detailed understanding of contamination at the Airport; however, additional data were needed to refine the lateral and vertical extent of contaminated material requiring cleanup. Specifically, more information was needed to complete the engineering designs and provide information that will guide decision-making related to site remediation. Therefore, a sampling and analysis plan (SAP) was prepared to obtain additional dioxin contamination information for the site.[56]

The specific data quality objectives (DQOs) of this SAP were as follows:

1. Determine the vertical and lateral extent of dioxin/furan contamination in soil in the MLA, SA, and Drainage Ditch.

2. Determine the vertical and lateral extent of dioxin/furan contamination in sediment of Sen Lake and the Eastern Wetland.

3. Determine chemical concentration baseline conditions for groundwater, surface water, and the proposed landfill site.

4. Determine whether COPCs other than dioxins/furans are present in soils and/or sediments that may affect the remedial design, O&M of the remedy, and/or health and safety aspects of the remedy implementation.

5. Determine whether soil properties of the contaminated soil would affect the remedial design.

Specific sampling and analysis was therefore performed to address each of these DQOs, as described in the SAP. Sampling at the Airport occurred at the MLA, SA, Sen Lake, Eastern Wetland, PISA, the proposed landfill site, and the key surface water and groundwater sites near the perimeter of the Airport. These data are presented in Appendix A1.

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[55] Hatfield/Office 33 2009.
[56] CDM 2010b.

Due to the high costs of analyzing all samples collected, some samples were categorized as Tier I and analyzed following collection, while others samples were set aside for future analysis (Tier II), as needed based on Tier I results. Tier I surface soil and sediment samples were analyzed for dioxins and furans. Soil and sediment core (i.e., subsurface) Tier I samples were also analyzed for particle size analysis and total organic carbon (TOC). Water samples were analyzed for polycyclic aromatic hydrocarbons (PAHs), PCBs, metals, and volatile organic compounds (VOCs). A small subset of surface soil and sediment samples were also analyzed for PAHs, PCBs, metals, and VOCs. Table A1.1 of Appendix A1 details the samples collected, and the number and type of analyses performed, for each type of environmental media.

The data collected satisfied the DQOs for this sampling effort, but also revealed new contaminated areas that will require further delineation either prior to Project implementation or as part of confirmation sampling conducted during Project implementation. The analytical results from the 2010 sampling program indicated that dioxin contamination at the northern end of the Airport is more extensive than indicated by earlier studies. Specifically, the reach of contamination potentially extends further west of the MLA, in an area that is currently under construction for the airport runway expansion. The lateral extent of contamination in the Drainage Ditch was significantly more widespread than originally anticipated, and an additional hotspot (Eastern Hotspot) to the east of the Drainage Ditch and SA was also identified.

Results of the 2010 sampling include the following, as organized by their respective DQO:

<u>DQO #1: Determine the vertical and lateral extent of dioxin/furan contamination in soil in the MLA, SA, and Drainage Ditch.</u>

- The lateral extent of contamination in the MLA was better defined, especially along the eastern and northern boundaries. Sampling along the west and northwest boundaries of the MLA identified additional dioxin contamination, and also areas that will require further sampling and analysis. Further sampling along the southern edge of the MLA was not possible due to the presence of Airport site utilities. Soil samples were also collected and analyzed from three soil cores that were advanced up to depths of 180 cm below ground surface. However, despite their proximity to samples collected in past studies that had indicated high dioxin concentrations in this area, many of these deeper samples did not exhibit contamination above the cleanup goals.

- The lateral extent of contamination at the SA was also better defined following the 2010 sampling program. The boundary of contamination was identified along the northwest corner. Additional contamination was identified along the west border of the SA, and along the south border towards the MLA. As with the MLA, further sampling to the west was not possible due to ongoing site construction activities. Soil samples collected at depths up to 150 cm and analyzed further defined the vertical extent of contamination.

- Samples collected along both sides of the Drainage Ditch (from the MLA and SA to Sen Lake) greatly improved the understanding of contamination extent in these areas. Sampling results identified contaminated areas along the entire extent of the Drainage Ditch, including the area between the MLA and the SA, and also identified a new

hotspot (Eastern Hotspot) located between the Drainage Ditch and the Eastern Wetland. Sampling results helped identify the western extent of contamination along the Drainage Ditch north of the SA, but additional site characterization is also needed to verify this.

DQO #2: Determine the vertical and lateral extent of dioxin/furan contamination in sediment of Sen Lake and the Eastern Wetland.

- Sediment samples collected from Sen Lake provided a better understanding of contaminant distribution, both vertically and laterally.

- The samples collected in the Eastern Wetland provided a detailed understanding of contaminant distribution, as very limited data existed in this large area prior to the 2010 program. However, a significant portion of the Eastern Wetland was not accessible by the sampling team, due to the difficult terrain and health and safety considerations.

DQO#3: Determine chemical concentration baseline conditions for groundwater, surface water, and the proposed landfill site.

- Samples of site groundwater and surface water, including some collected from outside the Airport, provided baseline data for water hardness, total metals concentrations, and VOC, PCB, and PAH concentrations. The purpose of these samples was to establish baseline conditions to ensure that remediation activities do not have a detrimental impact on any of these constituents relative to their baseline concentrations.

- VOCs and PCBs were not detected in surface and groundwater samples.

- PAH (e.g., naphthalene, benzo[a]pyrene, benzo[a]anthracene, etc.) concentrations in groundwater were low, ranging from non-detect to 6.16 ppt. For comparison purposes, the USEPA maximum contaminant level (MCL) for public drinking water supplies for total PAHs is 200 ppt, which is well above the total concentration observed in all collected groundwater samples. PAH concentrations in surface water samples ranged from non-detect to 32.7 ppt.

- Groundwater and surface water samples were also analyzed to determine a baseline level for dioxins. Both groundwater samples were non-detect for 2,3,7,8-TCDD (the USEPA MCL for public drinking water supplies for 2,3,7,8-TCDD is 0.03 ppt). The two surface water samples collected from Sen Lake were non-detect for 2,3,7,8-TCDD and the surface water sample collected from the Drainage Ditch had a 2,3,7,8-TCDD concentration of 90.4 ppt.

- Samples collected at the proposed landfill site near the PISA provided additional information regarding dioxins and furan levels in this area.

DQO#4: Determine whether COPCs other than dioxins/furans are present in soils and/or sediments that may affect the remedial design, O&M of the remedy, and/or health and safety aspects of the remedy implementation.

- The data collected during the 2010 survey will help improve the basis for future design and planning related to remedy O&M and health and safety during implementation. The data collected are also helpful to GVN with respect to current and future construction and operations at the Airport.

- Background (i.e., naturally occurring and anthropogenic) levels of metals at the Airport are not known, but for comparison purposes, all metals levels were below USEPA Region 9 industrial PRGs with the exception of arsenic which ranged in concentration in soil and sediment from 6 to 328 parts per million (ppm) (the USEPA Region 9 industrial PRG for arsenic in soil is 1.6 ppm, no PRG is established for sediment).

- Several PAHs were detected with levels ranging from 0.1 to 44.5 ppm in all soil and sediment samples except one sediment sample collected from Sen Lake which had PAH levels ranging from 2.4 to 459 ppm. USEPA Region 9 has not established industrial PRGs for total PAHs. The levels of these COPCs will be considered when preparing the health and safety plans for the remedial action. All of these detections are far below levels that would have an impact on the design of the remedy.

- The concentrations of PCBs and VOCs were below detection limits, with the exception of a minor toluene detection of 0.240 ppm in one of the sediment samples; for comparison purposes, the USEPA Region 9 industrial PRG for toluene in industrial soil is 45,000 ppm. It should be noted that VOCs and other COPCs have previously been detected at the MLA, SA, and along Sen Lake during previous sampling efforts.

DQO#5: Determine whether soil properties of the contaminated soil would affect the remedial design.

- The soil property data collected confirm that the soils and sediments will be compatible with the remedial alternatives under consideration. The high fraction of sands present in the material will be conducive to remediation. The high percent moisture in the sediment can be reduced as needed. It is not expected that the low pHs or organic carbon observed would impact any of the remedial alternatives being considered.

- The estimated extent of contamination based on the 2010 sampling program and data from previous studies is presented in Figure 3.

Samples collected and analyzed in 2010 under the Project provided important new information about the site, as they comprise approximately one-third of the total number of soil and sediment samples analyzed from the northern end of the Airport. Using these 2010 data, and the previously collected data, the amount and extent of contaminated material requiring remediation was calculated with improved levels of accuracy. While conducting excavation, samples will be collected from the excavation limits to verify that all soil/sediment above the cleanup levels has been removed. A field screening method for dioxin analysis does not exist; therefore, all confirmation samples must be shipped to an analytical laboratory and will require

a 2-3 week turnaround time for results. Having a reasonably accurate estimate of the amount and extent of dioxin-contaminated material at the Airport at this stage of the Project is critical to ensure that excessive iterations of excavation will not be required, resulting in cost increases and schedule delays.

However, data gaps remain in the following locations at the Airport:

- A small area along the southern edge of the MLA could not be sampled due to the presence of underground utilities.
- The Eastern Wetland could not be sampled as planned due to inaccessibility and health and safety concerns.
- The area west of the MLA and SA could not be sampled because airport officials did not allow the sampling team access due to Airport construction activity.
- The extent of contamination between the MLA and SA is not well understood, because this area was not known to be contaminated prior to these sampling efforts, and therefore few samples were collected and analyzed in this area.
- The extent of contamination north of the Eastern Hotspot between the Drainage Ditch and Sen Lake is not well known because this area was not known to be contaminated prior to these sampling efforts and because this area was not accessible during sampling.
- The depth of contamination in the MLA is not well understood because 2010 samples collected did not exhibit high dioxin concentrations, despite their proximity to areas previously[57] identified as having high concentrations. The 2010 samples do not show contamination below depths of 60 cm, but previously collected samples[58] show contamination well above cleanup goals in the samples collected from as deep as 90 cm below ground surface.
- Additional soil sampling and dioxin analysis will be required to verify depth of contamination at the MLA, and in perimeter areas of the MLA, SA and Sen Lake which have been disturbed by ongoing Airport construction activity.

Despite these uncertainties, estimates of the area and volume of dioxin contamination were determined using the results of all samples analyzed to date. All dioxin and furan data were arranged on a scale site plan and TEQ contours for areas were hand-drawn above the cleanup levels of 150 ppt for sediments and 1,000 ppt for soils. The contours were used to divide the site into discrete sections, each with differing levels of contamination, and the total area of each section was calculated. Appropriate excavation depths were determined for each section, based on TEQ data. Finally, each section's area was multiplied by its respective depth, and the

[57] Xenobiotic Detection Systems Inc. 2006 and Hatfield/Office 33 2007.
[58] Xenobiotic Detection systems Inc. 2006.

contributions from each area were summed. This methodology is described in more detail in Appendix A2.

As noted above, the 2010 sampling effort expanded Project knowledge regarding the extent and area of contamination at the Airport. Areas that were not known to be contaminated were identified, such as the Eastern Hotspot between the Drainage Ditch and the Eastern Wetland, the area west of the MLA and the SA, the soils adjacent to the Drainage Ditch, and most of the Eastern Wetland. Areas that had previously not been included in excavation estimates, such as the PISA, were also included.

4.2.3. UPDATED SITE AREA PROFILE

Table 12 provides a summary of dioxin concentrations above cleanup goals for samples collected from 1997 through 2010. Although each of the sampling activities had different objectives, collectively, the data provide an overall sense of the extent to which dioxin concentrations of hotspot sites exceed cleanup goals. It is important to note that for purposes of this table, the extent of each hotspot location is as defined in Appendix A2, Figure A2.1; previous reports may have defined the extent of each hotspot differently. Also, the sampling locations are generally biased toward areas of higher concentration in that the sampling events specifically targeted areas suspected to have dioxin impacts. Given this context, 44% of the overall samples collected exceeded GVN's dioxin standards. Sixty-three percent of the samples analyzed from the MLA exceeded GVN standards, 79% of the samples from the Drainage Ditch exceeded standards, 33% of the samples from the SA exceeded standards, and 41% of samples from Sen Lake exceeded standards.

TABLE 12. SUMMARY OF RESULTS OF SAMPLING OF DIOXIN HOTSPOTS OF DA NANG AIRPORT 1997-2010

Media and Location[1]	Number of Samples	Minimum TCDD (as TEQ) Concentration (ppt)	Maximum TCDD (as TEQ) Concentration (ppt)	Number of Samples Exceeding GVN Dioxin Standard	Percentage of Samples Exceeding GVN Dioxin Standard
1997 MOD Sampling Results					
Soil					
Mixing and Loading Area	2	51,248	69,444	2	100%
Storage Area	1	42,576	42,576	1	100%
Pacer Ivy Storage Area	0	n/a	n/a	n/a	n/a
Eastern Hotspot[2]	0	n/a	n/a	n/a	n/a
Sediment					
Drainage Ditch	0	n/a	n/a	n/a	n/a
Sen Lake Complex	25	2.2	12,393	9	36%

TABLE 12. SUMMARY OF RESULTS OF SAMPLING OF DIOXIN HOTSPOTS OF DA NANG AIRPORT 1997-2010

Media and Location[1]	Number of Samples	Minimum TCDD (as TEQ) Concentration (ppt)	Maximum TCDD (as TEQ) Concentration (ppt)	Number of Samples Exceeding GVN Dioxin Standard	Percentage of Samples Exceeding GVN Dioxin Standard
2006 Hatfield Sampling Results					
Soil					
Mixing and Loading Area	9	899	365,000	8	89%
Storage Area[3]	10	24.5	106,000	7	70%
Pacer Ivy Storage Area	0	n/a	n/a	n/a	n/a
Eastern Hotspot[2]	1	1,830	1,830	1	100%
Sediment					
Drainage Ditch[4]	3	4,150	8,580	3	100%
Sen Lake Complex	15	18.9	6,820	7	47%
2009 Hatfield Sampling Results					
Soil					
Mixing and Loading Area	0	n/a	n/a	n/a	n/a
Storage Area	0	n/a	n/a	n/a	n/a
Pacer Ivy Storage Area	19	4.4	20,600	3	16%
Eastern Hotspot[2]	0	n/a	n/a	n/a	n/a
Sediment					
Drainage Ditch[5]	2	4,200	11,700	2	100%
Sen Lake Complex	2	2,740	4,540	2	100%
2010 USAID Sampling Results					
Soil					
Mixing and Loading Area	20	2.57	6,930	4	20%
Storage Area	12	768	41,900	5	42%
Pacer Ivy Storage Area	1	1,260	1,260	1	100%
Eastern Hotspot[2]	1	1,620	1,620	1	100%
Sediment					
Drainage Ditch[6]	9	152	13,100	6	67%
Sen Lake Complex	19	6.96	5,370	5	26%

TABLE 12. SUMMARY OF RESULTS OF SAMPLING OF DIOXIN HOTSPOTS OF DA NANG AIRPORT 1997-2010

Media and Location[1]	Number of Samples	Minimum TCDD (as TEQ) Concentration (ppt)	Maximum TCDD (as TEQ) Concentration (ppt)	Number of Samples Exceeding GVN Dioxin Standard	Percentage of Samples Exceeding GVN Dioxin Standard
			All Samples		
Soil					
Mixing and Loading Area	31	2.57	365,000	14	63%
Storage Area	23	768	106,000	13	33%
Pacer Ivy Storage Area	20	4.4	20,600	4	20%
Eastern Hotspot[2]	2	1,620	1,830	2	100%
Sediment					
Drainage Ditch	14	152	13,100	11	79%
Sen Lake Complex	61	2.2	12,393	23	41%
Overall Total	**151**	**2.2**	**365,000**	**67**	**44%**

Notes:
1 – The extent of each hotspot location is as defined in Appendix A2, Figure A2.1; previous reports may have defined the extent of each hotspot differently.
2 – The Eastern Hotspot is considered to be the area that includes SAP624 and 06VN042.
3 – The Storage Area listed in under the "2006 Hatfield Sampling Results" is considered to be the area that includes soil samples except, 06VN072 (water treatment basin adjacent to the Storage Area) – sediment.
4 – The Drainage Ditch listed in under the "2006 Hatfield Sampling Results" is considered to be the area that includes 06VN047 and 06VN048 (soils next to drainage ditch), 06VN081 (drainage ditch sediment).
5 – The Drainage Ditch listed in under the "2009 Hatfield Sampling Results" is considered to be the area that includes 304A (soils) next to drainage ditch and 302A (drainage ditch sediment).
6 – The Drainage Ditch listed under the "2010 USAID Sampling Results" is considered to be the area that includes seven soil samples (SAP626, SAP628, SAP630, and SAP634 through SAP637) and two sediment samples (SAP527 and SAP528).
n/a – no samples taken.

Table 13 presents a comparison of maximum observed dioxin concentrations in surface and subsurface soil and sediment samples analyzed from the Airport between 2007 and 2010 and GVN cleanup standards. As shown on the table, the maximum depth dioxin (TCDD as TEQ) has been detected at the MLA, SA, PISA, and Sen Lake is 180 cm, 150 cm, 115 cm, and 50 cm, respectively.

TABLE 13. TCDD (AS TEQ) CONCENTRATIONS OF DA NANG AIRPORT SURFACE AND SUBSURFACE SOIL AND SEDIMENT BASED ON HOTSPOT SAMPLING RESULTS 2007- 2010[1]

	Surface[2] Soil/Sediment		Subsurface[2] Soil/Sediment		
Media and Hotspot Location	**Maximum TEQ Surface Concentration and Depth**	**# of Times Maximum Surface Concentration Exceeds GVN Cleanup Standards[3]**	**Maximum TEQ Subsurface Concentration and Depth**	**# of Times Maximum Subsurface Concentration Exceeds GVN Cleanup Standards[3]**	**Maximum Depth TCDD (as TEQ) was Detected and Corresponding TEQ Concentration**
Soil					
Mixing and Loading Area	365,000 ppt (0-10 cm)	365	10,700 ppt (30-60 cm)	11	150-180 cm (21 ppt)
Storage Area	106,000 ppt (0-10 cm)	106	14,100 ppt (60-90 cm)	14	120-150 cm (50-727 ppt)
Pacer Ivy Storage Area	20,600 ppt (0-10 cm)	21	189 ppt (30-60 cm)	1.3	90-115 cm (7 ppt)
Eastern Hotspot	1,830 ppt (0-10 cm)	2	n/a	n/a	n/a
Mixed Soil and Sediment					
Drainage Ditch[4]	13,100 ppt (0-30 cm)	13	n/a	n/a	n/a
Sediment					
Sen Lake and Eastern Wetland	6,820 ppt (0-10 cm)	45	67 ppt (30-50 cm)	0	30-50 cm (15-67 ppt)

Notes:
1 – Data from USAID 2010 sampling and Hatfield/Office 33 2007 and 2009.
2 – Surface is defined as 0-30 cm, subsurface as depths greater than 30 cm.
3 - Soil Cleanup Standard = 1,000 ppt; Sediment Cleanup Standard = 150 ppt (TCVN: 8183 2009).
4 – Drainage ditch is a mix of soil and sediment samples.
n/a – no samples taken at subsurface depths.

Using all of the data collected to date, updated estimates of soil and sediment volumes were calculated. These estimates were derived from data collected during previous studies and results from the January 2010 sampling (Appendices A1 and A2). As a result of the 2010 sampling program and new data, the volume of contaminated material increased 50% above estimates based on previous studies. Table 14 provides the recent estimate of excavation volume (m^3) and footprint (m^2) for each hotspot. Figure 3 provides a map of northern area hotspots in association with drawings of airport expansion plans. There is considerable overlap between airport expansion plans with the western boundary of the MLA, SA and Sen Lake hotspots.[59] It will be necessary for GVN to take action to ensure the integrity of the remedial action program through eliminating potential conflicts with the airport expansion activity.

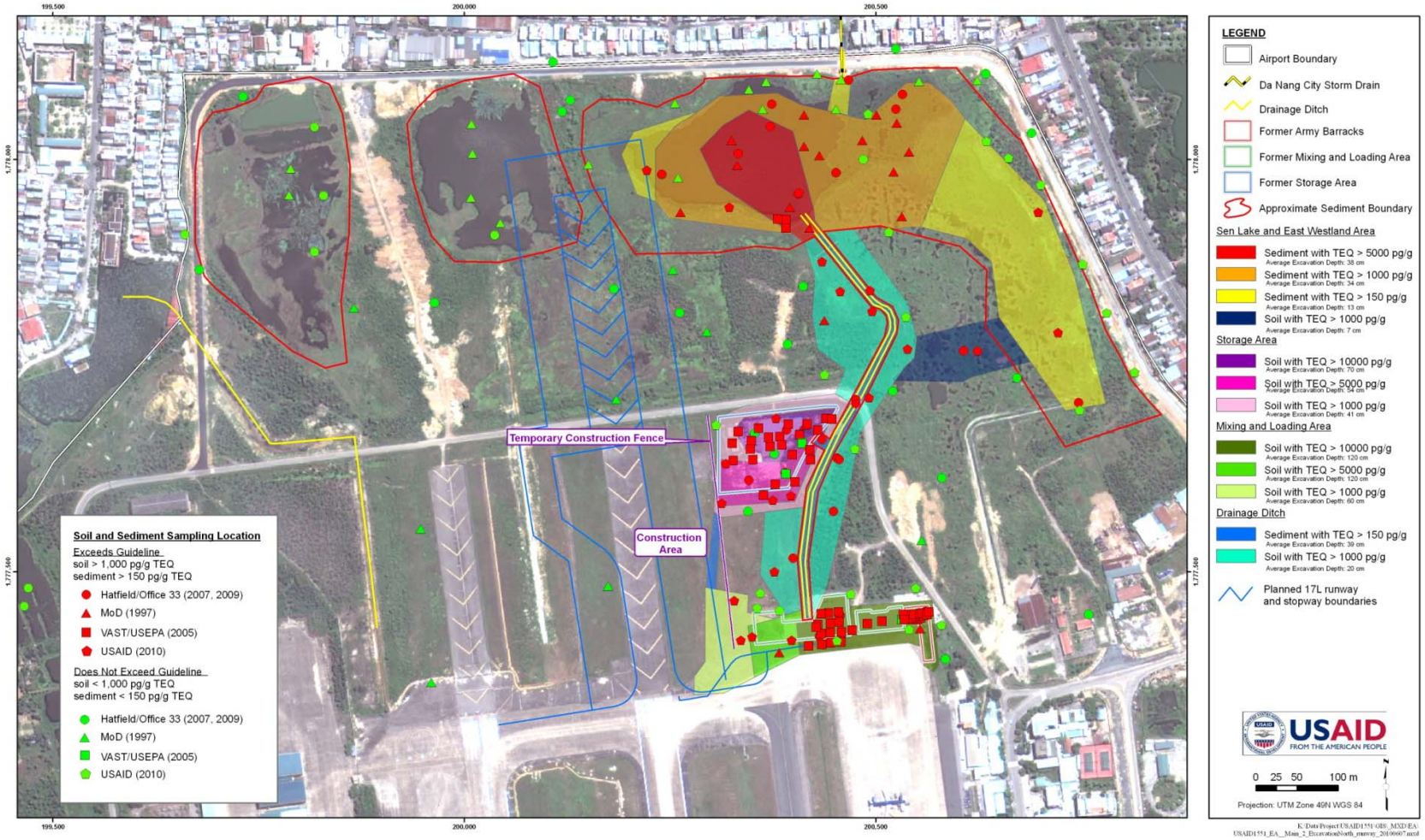
TABLE 14. AREA AND VOLUME ESTIMATES OF CONTAMINATED MATERIAL TO BE REMEDIATED

Hotspot	Estimates based on data from Previous Studies (Previous Estimates)		Estimates based on data from Previous and 2010 Studies (Current Estimates)	
	Area (m^2)	Volume(m^3)	Area (m^2)	Volume (m^3)
Mixing and Loading Area	10000	11000	19600	19500
Storage Area	13400	8500	16200	8900
Drainage Ditch	2900	1500	35600	8500
Eastern Hotspot	0	0	7700	500
Sen Lake and Eastern Wetland	40000	20000	85400	22800
Pacer Ivy Storage Area	0	0	3200	1400
Total	**66300**	**41000**	**167700**	**61600**

Average pre-treatment estimates were calculated for each of the hotspot areas, with average sediment dioxin concentrations estimated at 1,501 ppt, and average soil dioxin concentrations of 5,603 ppt (Table 15). It is important to note that these calculations should not be used to estimate human exposure prior to excavation because they include contaminated and uncontaminated media from a range of depths. Human exposure would most likely occur from surface contamination, where highest dioxin concentrations are found. Average concentrations are important when considering treatment technologies.

[59] Airport Expansion Plans provided by MAC.

FIGURE 3. ESTIMATED AREA TO BE EXCAVATED TO REACH GVN CLEANUP STANDARDS[60] (SOIL: 1000 PPT AND SEDIMENT: 150 PPT) IN RELATIONSHIP TO EXPANSION PLANS FOR THE NORTHERN AREA OF THE AIRPORT[61]



[60] TCVN 8183: 2009.
[61] Airport Expansion Plans provided by MAC.

TABLE 15. AVERAGE PRE-TREATMENT CONCENTRATIONS OF DA NANG HOTSPOT AREAS

Hotspot	Average Pre-Treatment Concentration (ppt)*
Mixing and Loading Area	7,096
Storage Area	4,240
Drainage Ditch	3,905 (soil) / 2,720 (sediment)
Eastern Hotspot	1,710
Sen Lake and Eastern Wetland (sediments)	1,325
Pacer Ivy Storage Area	1,260

Notes:
These estimates were derived from data collected during previous studies conducted between 2007 and 2009 by Hatfield/Office 33, the estimates of dioxin contamination provided in Allen and Fong (2009), as well as results from additional samples collected in January 2010 (see Appendix A1) by USAID. Appendix A2 presents the methodology used to calculate the pre-treatment concentrations.

4.3. Potential Exposure Pathways

The existing evidence indicates that dioxin from the MLA and SA adheres to soil particles and moves via the Drainage Ditch and via air transport into Sen Lake and nearby areas. Humans are exposed through ingestion of contaminated fish, direct dermal contact with soils and sediments, and likely via inhalation of dust.

There are several potential exposure pathways identified at the Airport:

Localized Transport Pathways – Contaminated surface soil may travel via erosion and surface water runoff into waterways and wind driven dust.

Dietary Exposure/Ingestion – Fish originating from the Airbase were historically consumed by fishermen, their families, and likely some members of the general public. Aquatic animals (i.e., ducks) may also be a source of food exposure along with certain aquatic vegetation, particularly lotus.

Soil Ingestion – People and/or children who come in close and regular contact with contaminated soils derived from the site may ingest small amounts of the soil.

Dermal Absorption – Dermal absorption may occur in situations where certain people contact the soil or sediment during activities such as working onsite, or wading into sediments while fishing, harvesting lotus, etc. Soil or sediment contacting the skin for prolonged periods may result in small amounts of contaminant adhering and absorbing across the skin.

Inhalation of Fugitive Airborne Particulates – Because the surficial soil is contaminated, the finer contaminated particulates may, on occasion, become suspended in the air due to wind erosion or disturbance by vehicle traffic and then inhaled and absorbed across the respiratory pathway.

These pathways and the overall conceptual exposure model of dioxin contamination at the Airport are represented in Figure 4. Exposure pathways are summarized for each potential type of human receptor in Table 16.

TABLE 16. POTENTIALLY AFFECTED RECEPTORS AROUND DA NANG AIRPORT

People Impacted	Exposure Pathway
Workers and extended families	Localized transport pathways, dietary exposure, soil ingestion, dermal absorption, inhalation
Nearby Da Nang residents	Dietary exposure, soil ingestion, dermal absorption, inhalation
Airport passengers	Inhalation

Figure 4 illustrates and summarizes how contaminant sources, exposure pathways, and receptors are linked together to form the potential for health risk associated with dioxin contamination at the Airport.

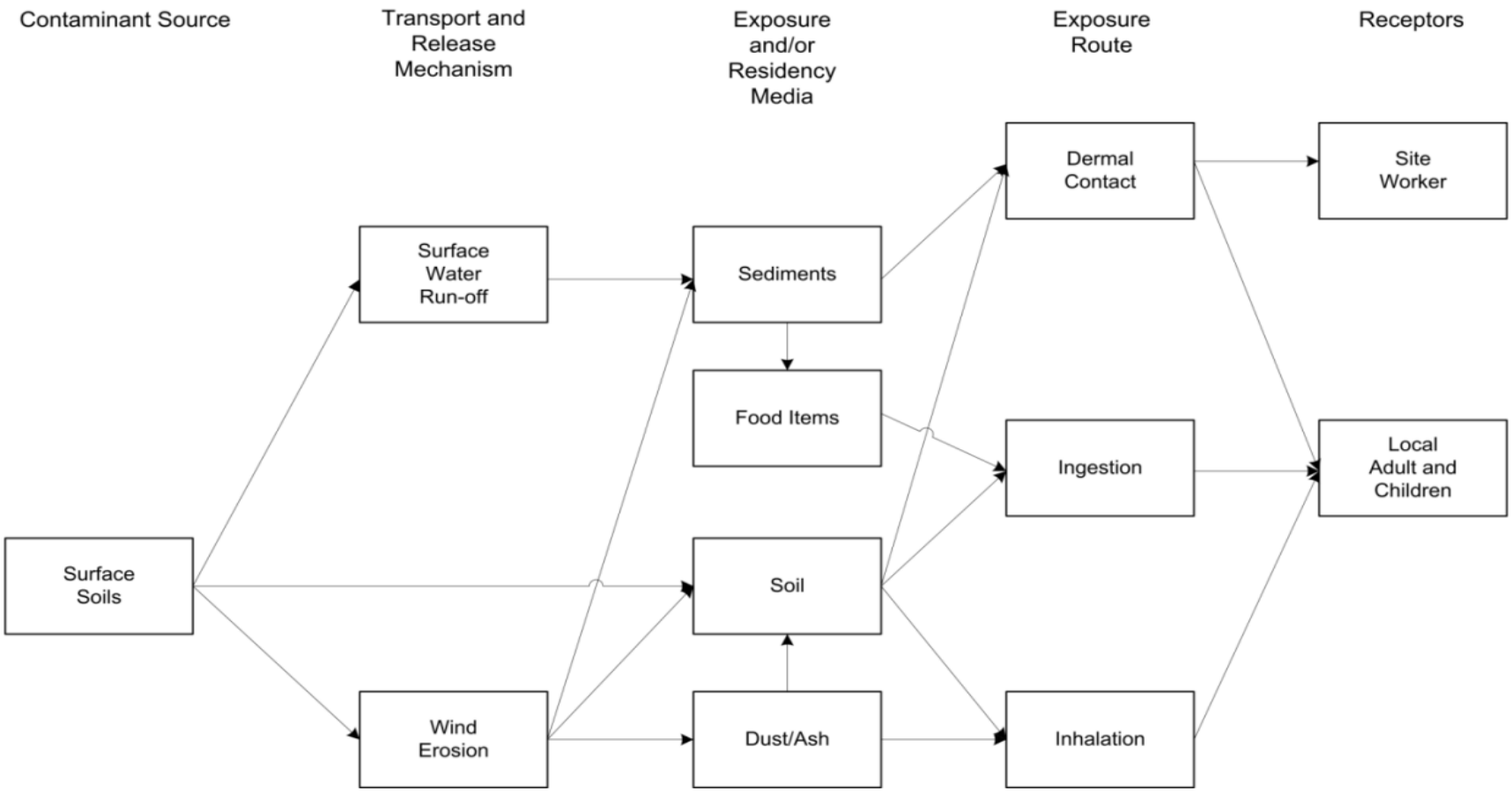
4.4. Gender Considerations

Vietnam has one of the highest economic participation rates in the world. In 2002, 85% of men and 83% of women between the ages of 15 and 60 were engaged in economic activity.[62] Men and women are employed in different sectors of the economy; men are more commonly employed in fishing, mining, construction, transport, and communications. Female-dominated industries include light manufacturing, health, and social work.[63] Within the construction industry, women constitute 12% of the labor force, and make up 26% of the transport and communications sector.[64] Due to their role in the household, women form a greater percentage of the informal labor force. Therefore, it is reasonable to assume that women may have previously or currently work at the Airport or may work at the Airport in the future.

There are provisions under Vietnam's Labor Code that are designed to protect women from hazardous environments. Article 113 of Chapter X[65] states that women may not be hired for "heavy or dangerous jobs which necessitate contact with noxious substances having harmful effects on their reproductive and child-rearing function." Vietnam's Law on Gender Equality also allows specific provisions for protecting the health and safety of women, while still promoting equal opportunities for men and women. Under Article 113, Section 1, 3a, employers must create safe working conditions for women that may have direct contact with noxious substances. Consideration of these restrictions will be a necessary component of designs and plans for an environmental remediation activity to ensure that they are adhered to. Examining gender differences and perceptions toward risk-taking in the workplace will also need to be considered as part of planning for the environmental remediation activity.

[62] World Bank and others 2003.
[63] ADB 2005.
[64] GSO 2003.
[65] Vietnam Labor Code: Article 113 of Chapter X: The labor user is not allowed to use female labor for heavy or dangerous jobs which necessitate contact with noxious substances having harmful effects on the reproductive and child rearing functions of the women laborer

FIGURE 4. CONCEPTUAL EXPOSURE MODEL FOR AFFECTED RECEPTORS AT DA NANG AIRPORT



Section 5. Alternatives Evaluation

5.1. Screening of Potentially Applicable Technologies/Strategies

A number of technologies and/or management strategies have potential applicability for treatment of dioxin contamination in soil and sediments. A screening process was used to identify the most viable technology options to consider as alternatives based on environmental impact, effectiveness, feasibility, and cost. Previous studies have been performed to review technologies potentially applicable to dioxins associated with Agent Orange in Vietnam.[66] The technologies that received unfavorable assessments in these reports were not considered further in this EA. The highest scoring technologies presented in the UNDP report are included.[67] The BEM (2007) report provided more weight to the cost criterion than to demonstrated treatment effectiveness; both are given equal weight in the current screening process. It is also important to note that if a technology/strategy is effective for containment, it can be retained for further consideration even if it is not effective for treatment. Table 17 shows the technologies and strategies considered for screening, as well as whether each was retained for more detailed evaluation. For each technology or strategy that was screened out, the criterion for which it did not meet is identified.

[66] BEM 2007 and UNDP 2009b.
[67] UNDP 2009b.

TABLE 17. SCREENING OF POTENTIALLY APPLICABLE TECHNOLOGIES/STRATEGIES FOR DIOXIN REMEDIATION AT DA NANG AIRPORT

Technology/Strategy	Retained?	Criteria Not Met
No Action	Yes[1]	Effectiveness – will not meet cleanup objectives
Incineration	No	Effectiveness – shown to generate significant concentrations of dioxins in off-gas; this can be mitigated through off-gas treatment. Implementability – public perception could be a significant problem given the potential for dioxin air emissions.
Base-Catalyzed Decomposition	No	Implementability/Cost – large quantity of byproduct generated that would require a large landfill in addition to the treatment process.
Ball Milling with Active Landfill	No	Effectiveness – neither ball milling nor a biologically active landfill have been demonstrated at large scales to treat dioxins to below GVN cleanup standards. Implementability/Cost – this approach requires full-scale implementation of both technologies.
ISTD/IPTD	Yes	
Geo-Melt™ Process	No	Effectiveness – has never been applied full-scale for dioxin treatment
Passive Landfill	Yes[2]	
Active Landfill	Yes[3]	Effectiveness – has never been applied full-scale for dioxin treatment; has never been demonstrated to treat dioxins below GVN cleanup standards (1,000 ppt soil; 150 ppt sediment).

Notes:
1 – Retained as a baseline although it fails the effectiveness criterion.
2 – Expected to be effective for containment, but not for treatment.
3 – Expected to be effective for containment, but not demonstrated for treatment.

As a result of the screening process, assessment of site conditions, and input and feedback received during scoping sessions, four remedial alternatives were identified for assessment in the EA:

No Action – Under Section 6 of 22 CFR 216, the EA must include the alternative of No Action. The No Action alternative will examine the potential environmental impacts of not addressing dioxin contamination at the Airport. This alternative will establish baseline information and estimate the continuing routes of exposure that could persist over a number of years without action. This alternative will provide a baseline against which other alternatives can be assessed.

Landfill Containment (Passive Landfill) – This alternative would contain dioxin in a secure onsite landfill for 50 years. This was the originally proposed action at initiation of the EA process.

Landfill Containment with Bioremediation (Active Landfill) – This alternative would contain dioxin in a secure onsite landfill, but also include bioremediation as a dioxin destruction technology.

ISTD/IPTD – This alternative would make use of a high heat in situ/in-pile thermal desorption destruction process to treat dioxin. It would not require construction of a secure onsite landfill.

5.2. Evaluation Process of Retained Remedial Alternatives

The four retained alternatives were further evaluated through the consideration of: 1) effectiveness of the alternatives to achieve cleanup goals and ultimately be a final remedy for the Project; 2) implementability of each alternative; 3) the detailed assessment of relative environmental impacts for each alternative; and 4) development of conceptual designs for each alternative (to the extent possible) that served as the basis to evaluate cost. The discussion below provides an overview of each of the four alternatives, their effectiveness, implementability, and cost.

5.2.1. CONCEPTUAL DESIGNS AND COST ESTIMATES

Identification and evaluation of potential costs for remedial alternatives is integral to the evaluation process to help determine the best approach to address the contamination issue at the site. The remedial alternative costs presented in this EA were developed in accordance with A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002.[68] Although the EA process is distinct from the CERCLA (i.e., Superfund) FS process, the objectives and intent (as well as Project concept development) for this EA are sufficiently similar to the CERCLA process to warrant use of this guidance.

At the alternatives evaluation stage, the design for the remedial alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." The cost engineer must make assumptions about the detailed design in order to prepare the cost estimate. As a project progresses, the design becomes more complete and the cost estimate becomes more "definitive," thus increasing the accuracy of the cost estimate.

The remedial alternative cost estimates were developed during the EA primarily for the purpose of comparing Project alternatives during the remedial selection process, not for establishing Project budgets. As a remedial alternative moves from the planning stage into the design and implementation stage, the level of project definition increases, thus allowing for a more accurate cost estimate. An "early" estimate of the remedial alternative's life cycle costs is made during the FS to make a remedy selection decision. The levels of detail employed in making these estimates are conceptual, but are considered appropriate for making choices between alternatives. The information provided in the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. As a project progresses, the design becomes more complete and the cost estimate becomes more "definitive," thus increasing the accuracy of the cost estimate.

Costs for remedial alternatives are expected to have accuracies between -30% to +50% of actual costs, based on the scope presented. However, in this case, cost estimates have been substantially refined to take into account better estimates obtained in this study for volume of material to be treated, labor costs, power costs, and value added taxes. Therefore, the actual cost range of these estimates may be narrower than -30% to +50%, but the true range is difficult to determine. Factors such as increased project duration and phased implementation that might require longer field implementation time and strengthened temporary containment

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[68] USEPA 2000.

measures will increase the cost, although by an undetermined amount. It is important to note that the costs were valued consistently across alternatives, and therefore, estimates allow for reliable comparisons between alternatives.

Flexibility is incorporated into each alternative for the location of Project facilities and the period in which Project implementation will be completed. Assumptions of the Project scope and duration are defined for each alternative to provide cost estimates for the various remedial alternatives. Important assumptions specific to each remedial alternative are summarized in the description of the alternative. Additional assumptions are included in the detailed cost estimate backup, which can be found in Appendix A3.

5.2.2. EFFECTIVENESS AND IMPLEMENTABILITY

Each alternative was evaluated based on its effectiveness for containment and treatment. For this EA, strong consideration is given to whether the alternative provides a "final remedy" that would reduce dioxin concentrations to meet GVN standards.

All alternatives were determined to be implementable at the Airport, but each has specific challenges associated with implementation. The implementability challenges are discussed below for each alternative.

5.2.3. ENVIRONMENTAL IMPACT

Detailed assessments of the potential environmental impacts associated with each alternative were conducted and used to rank the alternatives to determine the environmentally preferred alternative.

5.3. Alternatives Evaluation Findings

5.3.1. NO ACTION ALTERNATIVE

Under Section 6 of 22 CFR 216(c)(3), the EA must include the alternative of No Action. The No Action alternative examines the potential environmental impacts of not addressing dioxin contamination at the Airport. This alternative establishes baseline information and estimates the continuing routes of exposure that could persist over a number of years without action. This alternative provides a baseline against which other alternatives are assessed.

Conceptual Design

Under the No Action alternative, the contaminated soil/sediment would be left in place and no mitigation measures would be implemented.

Effectiveness

The No Action alternative would not effectively reduce dioxin concentrations to meet GVN cleanup standards. As a result, exposure pathways would remain that pose a potential threat to environmental, biological, and human receptors. Without action and given current levels of contamination, existing dioxin pathways would likely persist for several decades or longer. This situation would be unacceptable to the USG and the GVN.

Implementability

The No Action alternative is implementable, as it does not require any action.

Cost

The No Action alternative has no cost associated with implementation or long- term O&M. However, there would be significant externalized costs, such as the costs associated with illness that might result from exposure to dioxin above remediation goals. While these costs cannot be quantified, they are important and could be substantial.

5.3.2. PASSIVE LANDFILL ALTERNATIVE

Conceptual Design

The conceptual design of the Passive Landfill was developed from GVN Decision No. 60/2002/QD-BKHCNMT, and similar USEPA regulations,[69] which provide technical guidance for the design of hazardous waste landfills. In general, the Passive Landfill alternative would consist of: excavating contaminated soil from the MLA, SA, Drainage Ditch, Eastern Hotspot, and PISA; excavating contaminated sediments from the Drainage Ditch, Sen Lake, and Eastern Wetland; dewatering the contaminated material; and transporting contaminated material to a constructed landfill located in the southwestern area of the Airport property. Several munitions bunkers are present at this site, and for purposes of the EA, it has been assumed that these bunkers would be removed prior to landfill construction. If removal of the munitions bunkers from the proposed landfill site is not possible, then it will be necessary to consider alternative sites elsewhere on the Airport property.

Figure 5 shows the general location of each of the major components of the Passive Landfill alternative (excavation/hotspot areas, Temporary Storage and Dewatering Area, landfill site, and haul road) in an overall plan view of the Airport. Figure 6 is a conceptual plan view layout of the Passive Landfill alternative, and Figure 7 provides a conceptual cross section of the Passive Landfill alternative to show key components of the landfill.

Mobilization and Project Preparation

Clearing all Project Areas of UXO – All existing UXO within the Project area (excavation areas, Temporary Storage and Dewatering Area, and landfill site) would be detected and cleared prior to the commencement of any Project activities. In addition, the munitions bunkers at the landfill site would be cleared and demolished prior to landfill construction.

Equipment, Facilities, Project Setup – Equipment and vehicles would be procured, two equipment decontamination stations would be constructed (one in the area of the hotspots and another in the landfill area), and the Project work areas would be set up. The set up would include establishing surface water runoff diversions around the main Project work areas to minimize the amount of project-affected water requiring treatment before being returned to existing drainages. It is expected that diverted surface runoff would be conveyed to the natural drainage entering the eastern wetland.

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[69] 40 CFR 264, Subpart N.

FIGURE 5. CONCEPTUAL DESIGN OF REMEDIAL ALTERNATIVES PROPOSED FOR THE DA NANG AIRPORT

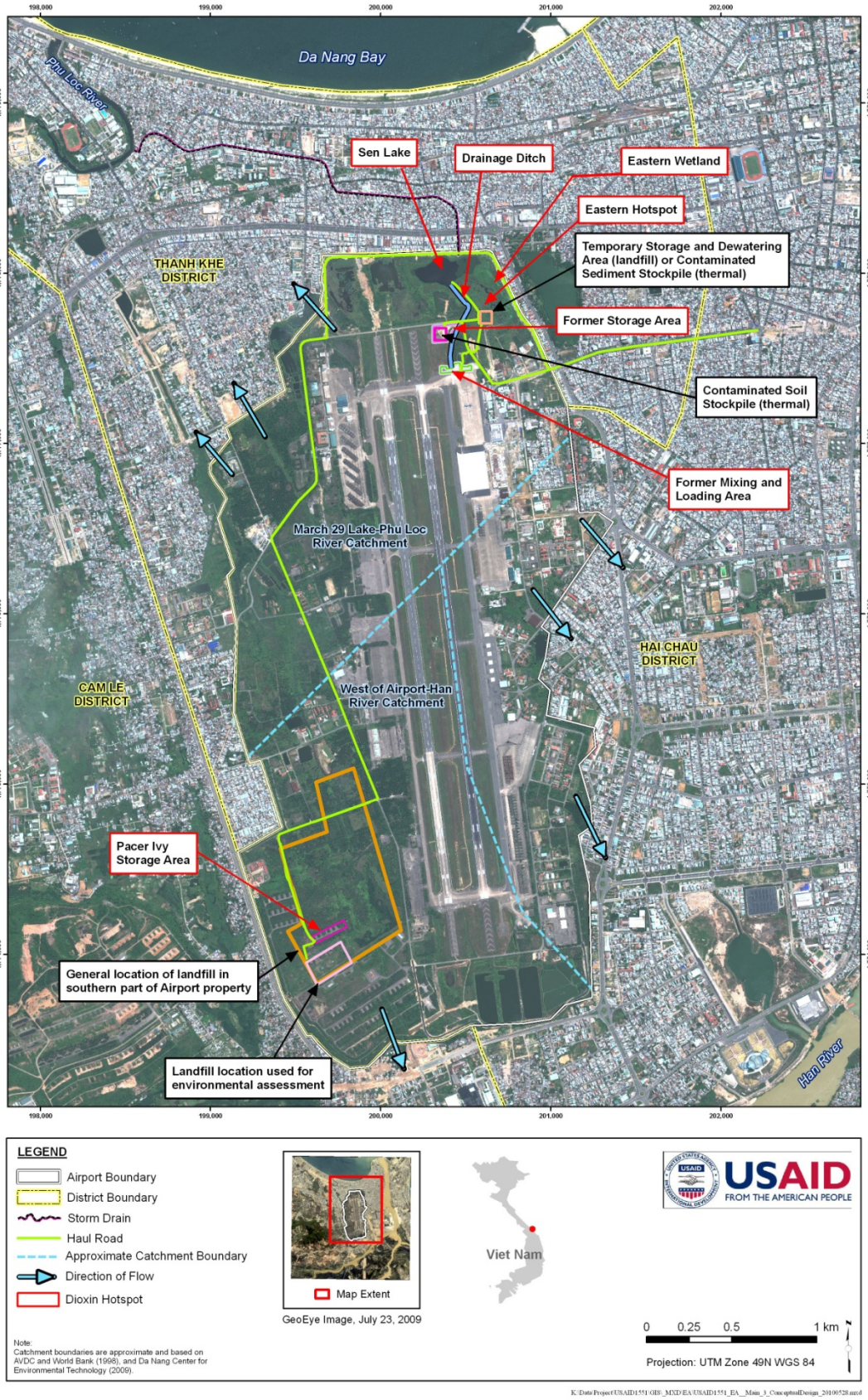
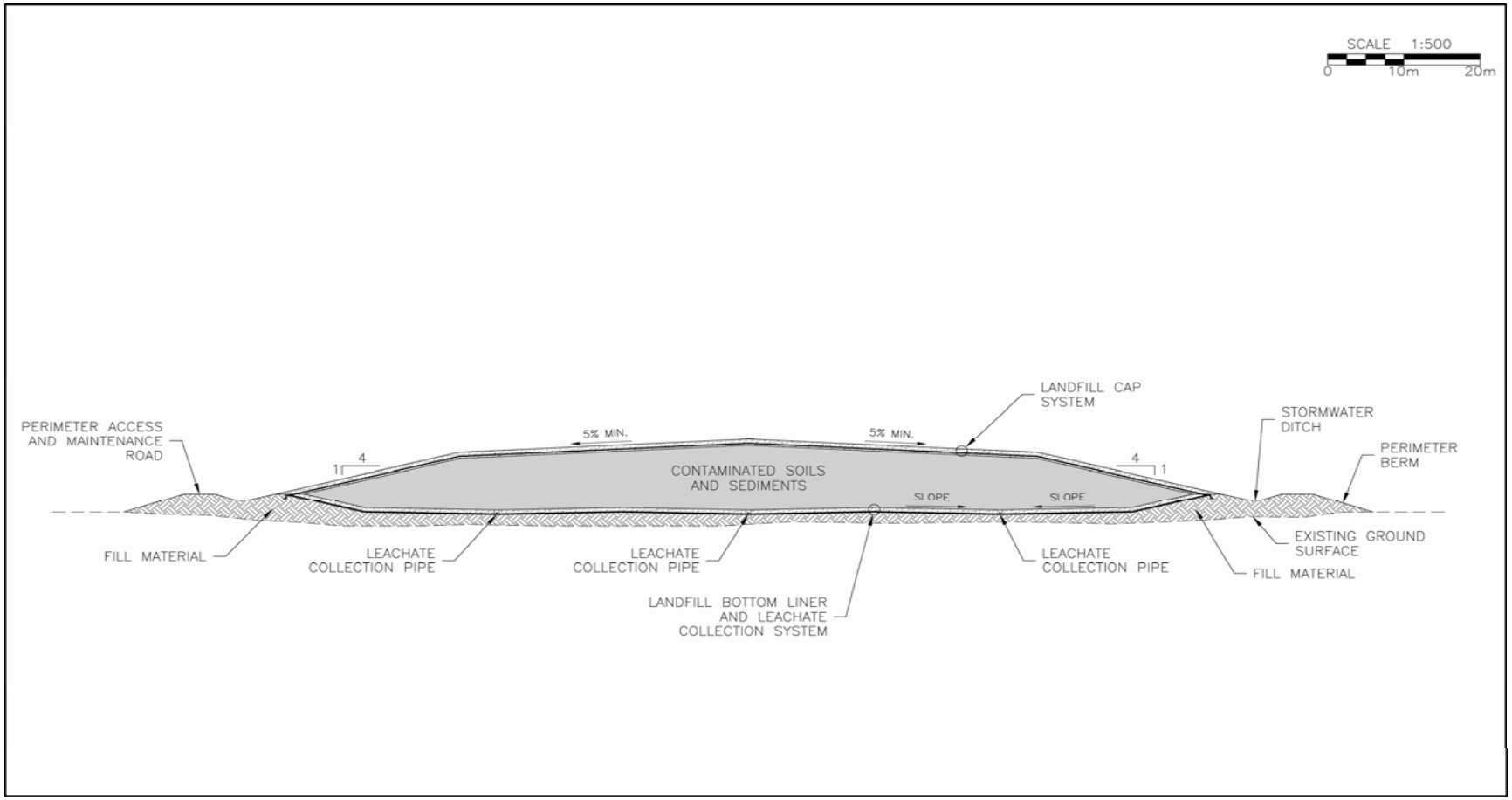


FIGURE 6. CONCEPTUAL LAYOUT OF PASSIVE LANDFILL ALTERNATIVE

FIGURE 7. CONCEPTUAL LANDFILL CROSS-SECTION



Construction of Temporary Storage and Dewatering Area for Contaminated Material – All excavated contaminated material (soil and sediments) would be dewatered in an approximately 2.1 ha temporary storage area. Project-affected water generated from the Temporary Storage and Dewatering Area would be returned to natural drainages when GVN discharge standards are met after treatment.

Haul Road Upgrading and Widening – The 7.4-km haul road from the hotspot area in the northeastern part of the Airport property to the landfill site in the southwestern part would be upgraded and widened to accommodate truck traffic hauling contaminated material from the Temporary Storage and Dewatering Area to the landfill. This would consist of widening the haul road to 10 meters (m) and repaving it.

Excavation of Contaminated Material

Excavation of Contaminated Soils from MLA and Placement into Temporary Storage and Dewatering Area – The MLA area (Photo 1, which can be found in the Photo Section following the text) would first be cleared and grubbed in preparation for excavation. An estimated 19,500 m^3 of contaminated soil from the MLA would then be excavated and transported to the Temporary Storage and Dewatering Area. To minimize the generation of project-affected water from precipitation and groundwater seepage, excavated areas would be filled with clean soil (likely from offsite borrow sources) as soon as practicable after excavation.

Estimates of the locations to be excavated and depths to which excavation would be required are described in Appendix A2. Confirmation sampling will determine the final excavation limits within the MLA.

Excavation of Contaminated Soils and Sediments from SA and Drainage Ditch and Placement into Temporary Storage and Dewatering Area – The SA and Drainage Ditch would first be cleared and grubbed in preparation for excavation (Photo 2, Photo 3, and Photo 4). An estimated 17,400 m^3 of contaminated soil and sediments from the SA and Drainage Ditch would then be excavated and transported to the Temporary Storage and Dewatering Area. As with excavation in the MLA, excavated areas in the SA and Drainage Ditch areas would be filled with clean soil as soon as practicable after excavation so as to minimize the generation of project-affected water from precipitation and groundwater seepage. Water normally conveyed to Sen Lake by the Drainage Ditch would be re-routed to the natural drainage entering the eastern wetland.

Estimates of the locations to be excavated and depths to which excavation would be required are described in Appendix A2. Confirmation sampling will be needed to determine the final excavation limits within the SA and Drainage Ditch.

Excavation of Contaminated Soils from PISA and Placement into Landfill – The PISA would first be cleared and grubbed in preparation for excavation. An estimated 1,400 m^3 of contaminated soil would then be excavated and transported directly to the landfill since the two are in close proximity of one another. To minimize the generation of project-affected water from precipitation and groundwater seepage, excavated areas would be filled with clean soil (likely from offsite borrow sources) as soon as practicable after excavation.

Estimates of the locations to be excavated and depths to which excavation would be required are described in Appendix A2. Confirmation sampling will be needed to determine the final excavation limits within the PISA.

Excavation of Contaminated Soils and Sediments from Eastern Hotspot and Placement into Temporary Storage and Dewatering Area – The Eastern Hotspot would first be cleared and grubbed in preparation for excavation. An estimated 500 m^3 of contaminated soil would then be excavated and transported to the Temporary Storage and Dewatering Area. Excavated areas would be filled with clean soil as soon as practicable after excavation so as to minimize the generation of project-affected water from precipitation and groundwater seepage.

Estimates of the locations to be excavated and depths to which excavation would be required are described in Appendix A2. Confirmation sampling will determine the final excavation limits within the Eastern Hotspot.

Excavation of Contaminated Sediments from Sen Lake and Placement into Temporary Storage and Dewatering Area (Photo 5) – An estimated 22,800 m^3 of contaminated sediments will be excavated from Sen Lake and the associated wetlands. The excavation of contaminated sediments from Sen Lake is expected to proceed as follows:

1. Two inflatable Aqua Dam bladders would be placed in the lake to divide it into three separate areas.

2. Water from one portion of the lake would be pumped into other parts of the lake, taking care to ensure the flow rate of pumped water does not exceed the conveyance capacity of the Sen Lake outlet and culvert.

3. Sediment would be excavated from one of the drained portions of the lake and transported to and placed in the Temporary Storage and Dewatering Area.

4. The process would be repeated with the two remaining parts of the lake. It may be necessary to temporarily divert water entering the Eastern Wetland (and therefore the eastern third of the lake) when the eastern third of the lake is drained and excavated.

5. The inflatable Aqua Dam bladders would be removed and required drainage systems restored after excavation, returning the lake to previous conditions, with contaminated sediments.

The specific portions of Sen Lake to be excavated and the specific depths to which excavation would be required, will depend on final delineation of specific hotspots areas within Sen Lake and the Eastern Wetland.

Landfill Construction

Clean Soil Fill – Approximately 75,000 m^3 of clean fill from offsite borrow sources would be needed to establish a landfill subgrade above flood levels and used for construction, operation, and closure of the landfill. This clean fill would be hauled to the landfill site from borrow pits off the Airport property.

Functional Components – The conceptual design for the Passive Landfill alternative includes three major functional components: 1) the bottom liner system; 2) the leachate collection and removal system; and, 3) the final cap system.

Bottom Liner System

The bottom liner prevents offsite migration of any liquids and leachate from the contaminated soil and sediments in the landfill to the surrounding subsurface. Typically, landfill bottom liners are a combination of several layers, each designed to stop leachate migration and/or allow its extraction. The layers included in this design are as follows, from bottom to top:

- A compacted soil subgrade, constructed from imported fill material, which keeps the bottom of the landfill above historical flood levels.
- A geosynthetic clay liner (GCL), which provides the last barrier for migration of leachate outside the landfill.
- A 60-mil thick high-density polyethylene (HDPE) geomembrane, referred to as the Secondary Liner, which has extremely low permeability and strong chemical resistance.
- A geocomposite layer, where any leaks through the primary geomembrane would be detected and removed by a collection system.
- Another 60-mil thick HDPE geomembrane (the primary liner), which forms the primary barrier to leachate migration.

This conceptual arrangement is typically used to provide the functional redundancy and additional measures of safety desired for hazardous waste landfills. These layers are shown conceptually in the cross-section presented in Figure 7. The inclusion of sufficient fill to elevate the landfill above the flood level is a critical component, as this type of landfill design is not expected to provide the same duration of environmental protection when partially submerged as it will when elevated.

Leachate Collection and Removal System

The primary function of the leachate collection and removal system is to collect and remove leachate before it can permeate the liner layers. In this design, the leachate collection system is located immediately above the bottom liner system and consists of a geocomposite layer overlain by a 60-cm layer of sand. The sand serves as a drainage layer and a protective cover for the liner system. The leachate is collected within pipes wrapped in gravel that are spaced at intervals across the bottom of the landfill. The pipes will convey the leachate to a treatment system, likely consisting of a concrete vault or chamber containing activated carbon, where it is treated prior to discharge.

Final Cap System

This conceptual design is based on the assumption that during placement of the contaminated soil and sediment, a clean soil cover will periodically be placed over the top to limit the area of exposed contaminated media. However, when additional material is ready to be placed, the majority of any soil cover may be removed to maximize the capacity of the landfill for

contaminated soils and sediments. Once all the contaminated soil has been hauled to and placed in the landfill, a permanent landfill cap would be constructed to fully encapsulate the landfill.

The landfill cap is designed to prevent liquid from infiltrating the landfill and becoming leachate. The components of the permanent landfill cap design, from bottom to top, are:

- A 30-cm intermediate soil cover over contaminated soil and sediment.
- A GCL layer, as a last barrier to prevent infiltration.
- A 40-mil linear low-density polyethylene (LLDPE) geomembrane, which offers good ultraviolet and chemical resistance and high tensile strength without sacrificing flexibility.
- A geocomposite layer to protect the geomembrane and provide drainage of the overlying soil cover.
- A 60-cm soil cover.
- Grass, which is designed to prevent surface erosion.

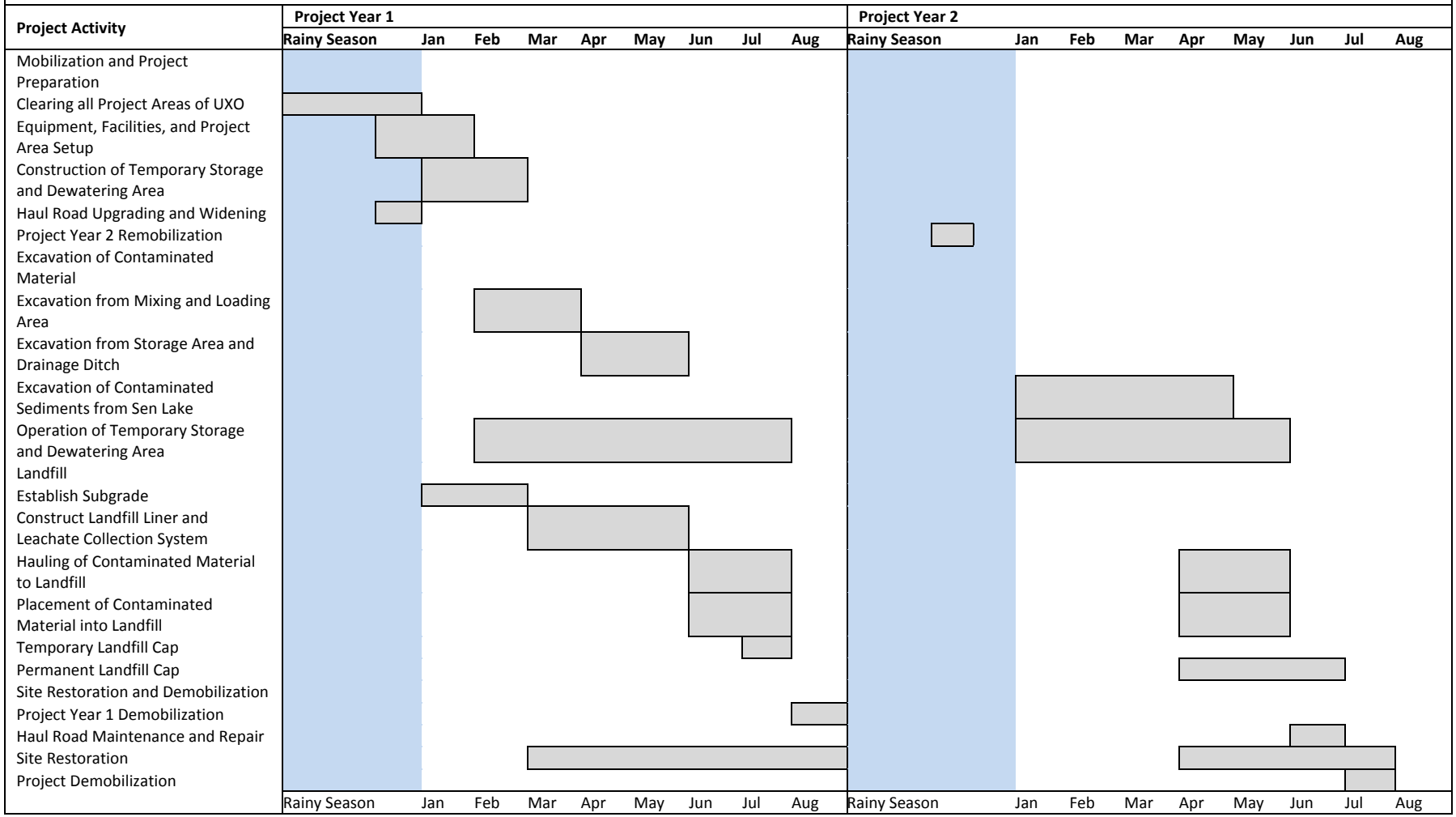
Similar to the bottom liner system, the final cap system is designed to prevent downward migration of water. However, rather than collect the water, the cap is designed to shed the water. The cap will have a minimum slope in all areas of 5% to minimize infiltration. A temporary cap would be used after Year 1 to minimize infiltration during the rainy season. The sides of the landfill will be sloped at 4 horizontal to 1 vertical (4H:1V or 25%) to minimize the required footprint, which is expected to be 110 m by 210 m (excluding support facilities).

Stormwater that drains off the cap will be collected by perimeter ditches and routed to ponds prior to discharge. An access road will encircle the landfill and also provide access to the top of the landfill.

<u>Hauling of Contaminated Material to Landfill</u> – Contaminated material would be hauled along the upgraded 7.4-km haul road from the Temporary Storage and Dewatering Area to the landfill location. Contaminated soils would be hauled in Project Year 1, while contaminated sediments would be hauled in Project Year 2 (see construction and operation schedule in Figure 8). The dredging of Sen Lake and removal of contaminated sediments will occur after the soil excavations to prevent cross-contamination.

<u>Placement of Contaminated Material into Landfill</u> – Contaminated material would be placed within cells in the landfill, with the landfill cells being filled sequentially. Depending on the amount of soil and sediment excavated, it is expected that the height of the landfill will be between 4 and 8 m.

FIGURE 8. INDICATIVE PROJECT SCHEDULE FOR PASSIVE LANDFILL ALTERNATIVE



Site Restoration and Demobilization

Haul Road Maintenance and Repair – Repairs to and maintenance of the haul road would be conducted once all contaminated material has been transported to the landfill, in order to return the road to its pre-Project use of being the major north-south access route for the Airport.

Site Restoration – Site restoration activities would be decided in consultation with the Airport Authority and would generally consist of returning project-affected areas to pre-project or better conditions.

Project Demobilization – All Project equipment and facilities would be removed from the Project area.

Footprint

The area of the total footprint for the Passive Landfill alternative is estimated to be 296,050 m^2, consisting of:

- 167,700 m^2 of area of contaminated soils and sediments to be excavated;
- 21,000 m^2 for the Temporary Storage and Dewatering Area;
- 74,000 m^2 for haul road upgrade and widening; and
- 33,350 m^2 for the landfill footprint.

Construction and Operation Schedule

It is expected that the Passive Landfill alternative would be constructed over a 2-year period. For cost estimation purposes, it is assumed that the Passive Landfill would require long term O&M for 50 years after closure, according to GVN requirements.

The main schedule components for implementation of the Passive Landfill alternative are as follows (Figure 8):

Year 1

- UXO Clearance: September – December (4 months, rainy season)
- Mobilization and Preparation: completed in February (~3 months)
- Soils Excavation: February through May (4 months)
- Landfill Construction: January through May (5 months)
- Site Restoration and Demobilization: March through August (6 months)

Year 2

- Remobilization and Preparation: completed before December (~1 month)

- Sediments Excavation: January through May (5 months)
- Landfill Construction: April through June (3 months)
- Site Restoration and Demobilization: April through July (4 months)

Effectiveness

Effective for containment – Hazardous waste landfills have been used successfully for decades worldwide to contain a variety of contaminants, including dioxins, furans, and other persistent organic pollutants. Design guidance and regulations for such landfills are readily available in the U.S., Vietnam, and in many other countries. This is a proven containment strategy.

Ineffective for treatment – The environmental half-life for chlorinated dioxins without some form of active treatment is generally thought to be measured in decades[70]. The dioxins would be expected to persist for many decades and would require eventual treatment.

Implementability

Landfill Siting Concerns

The Passive Landfill alternative would occupy a footprint of about 100 m by 210 m, or slightly larger than four football fields in size. An ideal site for a hazardous waste landfill of necessary size and without deficiencies or issues does not exist on the Airport property. Shallow groundwater, flooding potential, proximity to adjacent residences and developments, future airport expansion plans, and existing structures (i.e., munitions bunkers) are some of the siting challenges. These issues can be overcome, but with impact to cost.

Three locations at the Airport were evaluated during a site visit on December 14, 2009 as potential landfill sites for the containment of dioxin contaminated soil and sediment. All three locations, described in more detail below, were noted to have deficiencies and issues. Sites 1 and 2 are not deemed suitable due to their inadequate buffers, space restrictions, proximity to water bodies, and potential conflicts with future development. If the munitions bunkers identified in Site 3 can be demolished and removed, it is believed that Site 3 is the most suitable location due to its relative isolation, available buffers from the Airport and surrounding community, and ample space for the landfill and support facilities. If the removal of the bunkers is not possible, then it will be necessary to consider alternative sites elsewhere on the property, such as immediately north of Site 3.

Site 1 – Area East of Sen Lake

The proposed area is located on a narrow strip of land between the airbase perimeter road and Sen Lake. Based on the available future development plans for the Airport for Year 2015 and Year 2025, this area will be developed. As a result, either the development plans will need to be modified to account for the landfill or, if not feasible, the site will need to be eliminated from consideration.

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[70] Field and Sierra-Alvarez 2008.

The site is in close proximity to the airbase perimeter wall (less than 10 to 15 m) and surrounding community and homes (15 to 20 m). The site is long and narrow (approximately 275 m by 50 m). In general, landfill sites that have uniform perimeters (square) are more cost effective. The site may not have sufficient space to accommodate the excavated soils and sediment without expanding into the eastern portion of Sen Lake. This would increase construction costs and also decrease the storage capacity of Sen Lake.

For construction, adequate room to accommodate contractor staging and storage areas does not appear to exist nearby. The more remote these areas are from the landfill construction site, the greater the construction cost will be. The location would abut Sen Lake and, as a result, there would be little to no buffer between the landfill and the lake. This area of the airbase is the lowest and prone to flooding. As it is desirable to construct a landfill above the flood stages, additional fill material will be required to establish the landfill subgrade. Of the three sites, it is the closest to the contaminated soil and sediment areas and would have the shortest haul distance. The haul route for excavated soil and sediment would require interaction with civilian traffic near the airport entrance and also come in close proximity (< 20 m) to homes along the airbase perimeter.

Site 2 – Lake C

The proposed area would be located in Lake C at the north end of the western runway. In order to construct a landfill that is not located in the groundwater, it will be necessary to dewater, demuck, and backfill the lake. This will result in substantially increased construction costs. While constructing a lined landfill below the groundwater level may be feasible, it will be a more complex design and more expensive to construct due to added dewatering requirements, pumping systems, and general construction costs. In addition, O&M costs will be substantially higher due to the required pumping systems throughout the life of the landfill, including post-closure.

The site is in close proximity to the airbase perimeter wall and surrounding community and homes. The site will likely have sufficient space to accommodate the excavated soils and sediments. However, the elimination of Lake C will reduce the water storage capacity of the airbase. This area of the airbase is prone to flooding. As it is desirable to construct a landfill above the flood stages, additional fill material will be required to establish the landfill subgrade.

Height limitations to the landfill will be critical due to the close proximity of Lake C to the end of the runways. In addition, there may also be additional limitations placed on construction, such as equipment heights, hours of operation, etc. In the event that it may be desired to extend the western runway in the future, the landfill cannot encroach upon the eastern portion of Lake C that would be in line with the runway.

Of the three proposed sites, Lake C is the second closest to the contaminated soil and sediment areas. The haul route for excavated soil and sediment would require interaction with civilian traffic near the airport entrance and also come in close proximity (< 20 m) to homes along the airbase perimeter.

Site 3 – Area West of South End of Airport

The site is located in the southwest corner of the airbase, to the west of the runways, and is part of the West of Airport-Han River Catchment.

Of the three potential sites, this site is the most isolated, offers the greatest buffers from the runways and surrounding community/homes, and provides the most space to accommodate the landfill and associated facilities (i.e., stormwater ponds, leachate management, contractor staging and storage areas, etc.). The site currently has approximately 13 ammunition bunkers, at least some of which will require removal and demolition. If removal of the bunkers is not possible, the site does not have sufficient room to accommodate the landfill and will not be suitable. While the site is located on the higher ground of the airbase, there is a depression in the landfill area that appears to hold water during parts of the year. As it is desirable to construct a landfill above the flood stages and groundwater, additional fill material will be required to establish the landfill subgrade.

As the site is located perpendicular to the runway, it might provide an opportunity to obtain a greater landfill height relative to the other two potential landfill locations. However, of the three sites, it is the farthest from the contaminated soil and sediment areas, and would have the longest haul distance. The haul route for excavated soil and sediment would require interaction with civilian traffic near the airport entrance and also come in close proximity to homes along the northern airbase perimeter and buildings on the west side of the airbase.

The potential haul route on the west side of the airbase is bumpy and rough. The road will require improvements to reduce the potential for spillage and/or require limitations on vehicle speed and traffic control.

Haul Route

The relatively long haul route, especially for Site 3, and the number of trucks required for the volume of contaminated material increase both the environmental impact and the cost significantly. Shortening the route may not be feasible due to the requirements of minimizing impacts to airport operations and safety considerations.

Fill Material

A significant amount of fill material (~140,000 m^3) will be required for landfill construction, operation, and closure. The fill material will be used to establish a landfill subgrade above flood-prone areas, and to construct the dewatering area, leachate collection system, operational cover, and the final cover system. This is primarily a cost issue, but also affects the environmental impact.

Cost

At the alternatives evaluation stage, the design for the remedial alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." The cost engineer must make assumptions about the detailed design in order to prepare the cost estimate. Costs for remedial alternatives are expected to have accuracies between -30% to +50% of actual costs, based on the scope presented. The accuracy range of –30% to +50%

means that, for an estimate of $100,000, the actual cost of an alternative is expected to be between $70,000 and $150,000. Detailed cost estimate backup is provided in Appendix A3. The total cost estimate for this alternative is $35.8M, comprising construction ($10.28M), excavation and disposal ($11.5M), O&M ($3.26M), and monitoring and mitigation ($10.8M).

The construction cost estimate for this alternative is split into two sections: the "Landfill Passive" estimate includes work that is specific to this alternative and the "Landfill Disposal" estimate includes work that is common to both landfill alternatives, such as excavation of the contaminated soils and sediments. Main elements of the two sections of this cost estimate are listed below. A summary of the overall Passive Landfill alternative cost is provided in Table 18 and detailed backup of the cost estimate is provided in Appendix A3.

The "Landfill Passive" estimate includes the following costs:

Landfill Construction

- Site preparation: clearing and grubbing of the proposed landfill location and UXO clearing and disposal, but not demolition of the munitions bunkers.
- Grading: placement of subgrade fill to bring the landfill above the flood level, and fill for the perimeter berm and longitudinal slope.
- Liner system installation: placement of the bottom liner layers, leachate collection system piping, and the leachate treatment manhole.

Landfill Operation

- Spreading and compaction of contaminated soils and sediments in place at the landfill.
- Installation of the remaining leachate treatment system components.
- Monitoring well network installation.

Landfill Closure – installation of the cap layers.

Indirect Costs – permits, insurance, and bonds; general conditions; overhead; and profit, but not tax, escalation, or contingency (contingency is added later).

The "Landfill Disposal" estimate includes the following costs:

Site Preparation – installation and maintenance of decontamination areas at excavation sites, traffic control, health and safety oversight during all phases of work, clearing and grubbing the sites, construction of soil storage and dewatering areas, and UXO clearing or disposal.

Excavation – excavation of MLA, SA, Drainage Ditch, PISA, Eastern Hotspot, Sen Lake, and Eastern Wetland (using Aqua Dam bladders).

Hauling – from excavation sites and Temporary Storage and Dewatering Areas to landfill location.

TABLE 18. SUMMARY OF COST ESTIMATE FOR PASSIVE LANDFILL ALTERNATIVE

Project Alternative 2
Passive Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client: USAID Vietnam
Site: Da Nang Airport
Location: Da Nang, Vietnam
Phase: Environmental Assessment of Project Alternatives
Level of Project Definition: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2010 (FY10)
Date: February 8, 2010

Description: The Passive Landfill Alternative will consist of excavating contaminated soil from the MLA and SA hotspots and contaminated sediments from the drainage ditch and Sen Lake, dewatering the contaminated material and transporting it to a constructed landfill located in the southwestern area of the Airport property.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Passive	1	LS	$5,578,903	$5,578,903	Includes subgrade fill and preparation, liners, leachate collection system, waste placement, and cover.
SUBTOTAL				$5,578,903	
Contingency (Scope and Bid)	25%			$1,394,726	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$6,973,629	
Project Management	5%			$348,681	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$557,890	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$418,418	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,046,044	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$9,344,662	
TOTAL with VAT (assumed 10%)	10%			$10,279,128	
TOTAL CAPITAL COST				**$10,279,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$10,279,000	**$5,139,500**	Annual capital cost over the assumed duration.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Disposal	1	LS	$6,243,038	$6,243,038	Includes site clearing/preparation, excavation, decontamination, dewatering, hauling, backfilling, site restoration, and UXO screening and clearing of excavation and landfill areas. Excludes demolition of munitions bunkers at landfill site.
SUBTOTAL				$6,243,038	
Contingency (Scope and Bid)	25%			$1,560,760	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$7,803,798	
Project Management	5%			$390,190	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$624,304	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$468,228	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,170,570	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$10,457,090	
TOTAL with VAT (assumed 10%)	10%			$11,502,799	
TOTAL CAPITAL COST				**$11,503,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$11,503,000	**$5,751,500**	Annual capital cost over the assumed duration.

Project Alternative 2

Passive Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam	**Description:**	The Passive Landfill Alternative will consist of excavating contaminated soil from the MLA and SA hotspots and contaminated sediments from the drainage ditch and Sen Lake, dewatering the contaminated material and transporting it to a constructed landfill located in the southwestern area of the Airport property.
Site:	Da Nang Airport		
Location:	Da Nang, Vietnam		
Phase:	Environmental Assessment of Project Alternatives		
Level of Project Definition:	10% (Conceptual)		
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)		
Date:	February 8, 2010		

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-LANDFILL MAINTENANCE (Years 3 through 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Passive Landfill O&M	1	LS	$35,466	$35,466	Includes annual landfill O&M; assume 0.3% of landfill construction capital costs.
SUBTOTAL				$35,466	
Contingency (Scope and Bid)	25%			$8,867	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$44,333	
Project Management	10%			$4,433	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	15%			$6,650	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$6,650	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$62,066	
TOTAL with VAT (assumed 10%)	10%			$68,273	
TOTAL ANNUAL O&M COST				**$68,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 3 THROUGH 50)	48	YR	$68,000	**$3,264,000**	Annual O&M Cost over the assumed duration.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MONITORING (Years 1 through 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Environmental Mitigation and Monitoring Plan (EMMP) Implementation	1	LS	$118,220	$118,220	Includes sampling and analysis required by the EMMP; assume 1% of landfill construction capital costs.
SUBTOTAL				$118,220	
Contingency (Scope and Bid)	25%			$29,555	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$147,775	
Project Management	8%			$11,822	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	10%			$14,778	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$22,166	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$196,541	
TOTAL with VAT (assumed 10%)	10%			$216,195	
TOTAL ANNUAL O&M COST				**$216,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 1 THROUGH 50)	50	YR	$216,000	**$10,800,000**	Annual O&M Cost over the assumed duration.

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	O&M	Operations and Maintenance
LS	Lump Sum	QTY	Quantity
NA	Not Applicable	UXO	Unexploded Ordinance

Site Restoration – removal of temporary facilities, restoration of the site, paving the haul road.

Indirect Costs – permits, insurance, and bonds; general conditions; overhead; and profit, but not tax, escalation, or contingency (contingency is added later).

5.3.3. ACTIVE LANDFILL ALTERNATIVE

Conceptual Design

The conceptual design for the Active Landfill was developed from GVN Decision No. 60/2002/QD-BKHCNMT, and similar USEPA documents, including 40 CFR 264, Subpart N, which provide technical guidance for the design of hazardous waste landfills. In general, the Active Landfill alternative would consist of excavating contaminated soil from the MLA, SA, Drainage Ditch, Eastern Hotspot, and PISA and contaminated sediments from the Drainage Ditch, Sen Lake, and Eastern Wetland, dewatering the contaminated material, and transporting it to a constructed landfill located in the southwestern area of the Airport property. The Active Landfill would also include elements intended to stimulate yet to be determined biological processes with the potential to degrade TCDD. Several munitions bunkers are present at this site, and for purposes of the EA, it has been assumed that these bunkers would be removed prior to landfill construction. If removal of the bunkers is not possible, then it will be necessary to consider alternative sites elsewhere on the property.

The general location of each of the major components of the Active Landfill alternative is shown in Figure 9 as a conceptual plan view layout of the Active Landfill alternative. The conceptual Passive Landfill alternative cross section shown in Figure 7 is generally applicable for the Active Landfill alternative to show key components of the landfill.

Mobilization and Project Preparation

Same as Passive Landfill alternative.

Excavation of Contaminated Material

Same as Passive Landfill alternative.

Landfill Construction

The conceptual design of the Active Landfill alternative is similar to the Passive Landfill alternative, and would have many of the same structural components. Key differences between the Active and Passive Landfill designs are described below.

Clean Soil Fill – Because of the additional operational space and the additional volume required for the bulking agents (see below), the Active Landfill alternative would require a larger footprint (115 m by 350 m), compared to the Passive Landfill Alternative. Therefore, approximately 100,000 m^3 of clean fill from offsite borrow sources would be needed to establish a landfill subgrade above flood levels and be used for construction, operation, and closure of the landfill. This clean fill would be hauled to the Project site from borrow pits outside the Airport property.

FIGURE 9. CONCEPTUAL LAYOUT OF ACTIVE LANDFILL ALTERNATIVE

Functional Components – The Active Landfill alternative includes containing contaminated soil and sediments in a landfill and applying bioremediation technology to reduce dioxin concentrations to below the GVN cleanup standards. Conceptually, it is assumed that a bioremediation delivery system would be used to distribute oxygen, substrate, and/or nutrients to the bacteria to facilitate biodegradation. However, an effective pathway for biodegradation of TCDD to below GVN cleanup standards has not been demonstrated, so details of a distribution system are currently speculative. Therefore, the biodegradation system included in this design and cost estimate should be considered a placeholder at best, as it is based on some very preliminary assumptions about the required length of conveyance, pipe sizing, and required equipment. If this alternative were pursued, this portion of the conceptual design would require further revision.

Additional capacity would be required in the Active Landfill footprint and the associated construction areas for several reasons as described below:

- A bulking agent such as sawdust is required to assist in the bioremediation process (up to 40% by volume). The bulking agent would be required to be uniformly mixed or layered with the contaminated soil and sediments in the landfill to assist in the bioremediation process.
- A relatively shallow landfill is desired to maximize control over distribution of contaminants, bulking agents, nutrients, etc.
- Operational flexibility and control is afforded to the filling process (specifically what material goes where, and how deep it is placed, etc.), which would be needed to optimize the bioremediation.
- Contaminated sediments and soils would need to be mixed before placement to ensure a uniform distribution of dioxin throughout the landfill and to utilize the sediments as a potential microbial inoculum source for the soils. This would require a larger Temporary Storage and Dewatering Area than for the Passive Landfill alternative in order to be able to accommodate all contaminated soils and sediments.

Site Restoration and Demobilization

Same as Passive Landfill alternative.

Footprint

The area of the total footprint for the Active Landfill alternative is estimated to be 334,950 m^2, consisting of:

- 167,700 m^2 of area of contaminated soils and sediments to be excavated;
- 53,000 m^2 for the Temporary Storage and Dewatering Area;
- 74,000 m^2 for haul road upgrade and widening; and
- 40,250 m^2 for the landfill footprint.

Construction and Operation Schedule

It is expected that the Active Landfill alternative would be constructed over a 2-year period. For cost estimation purposes, it is assumed that the Active Landfill would require long-term O&M for 10 years after closure to achieve GVN cleanup standards; however, the rate of dioxin degradation is unknown.

The main schedule components for implementation of the Active Landfill alternative are as follows (Figure 10):

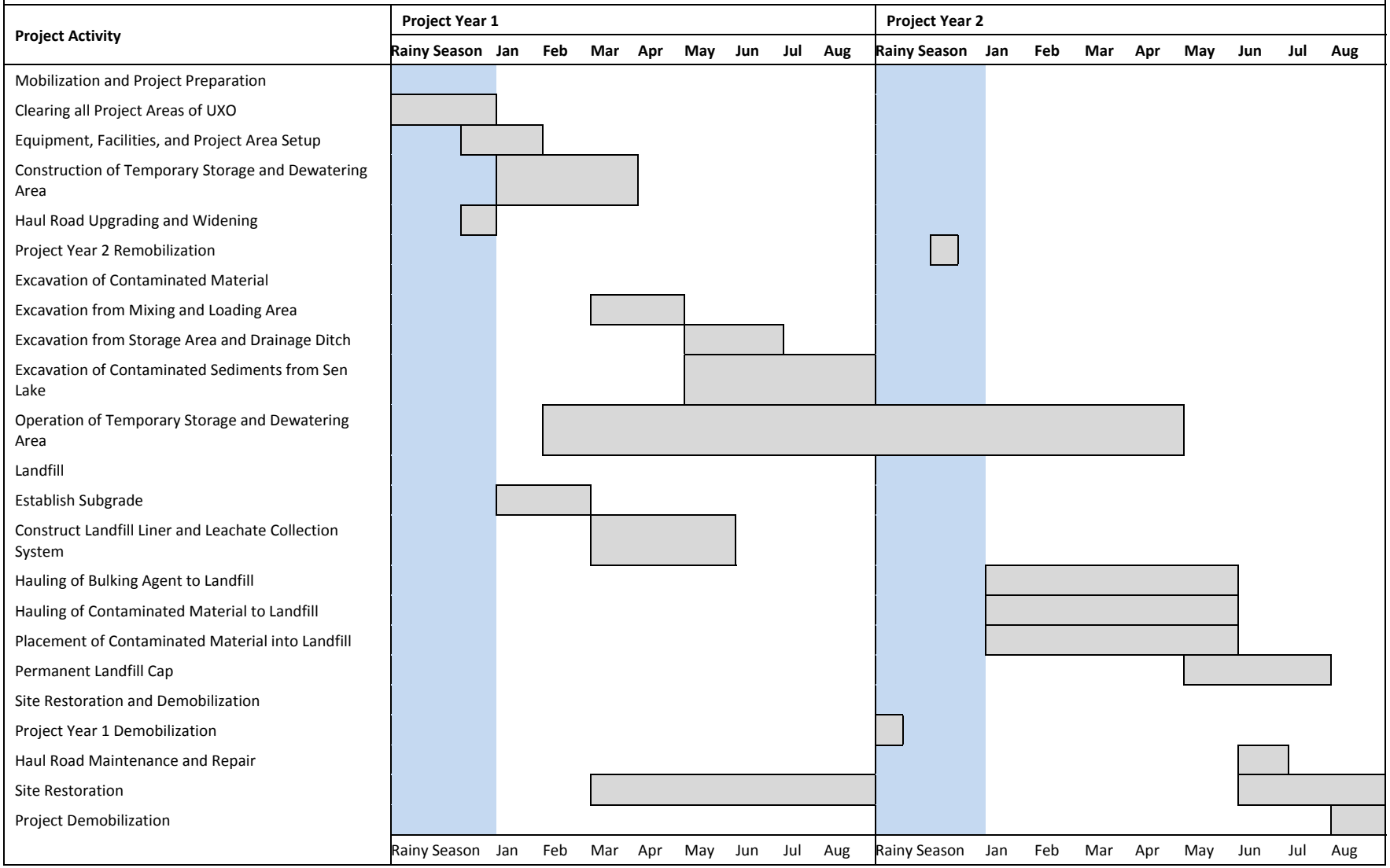
Year 1

- UXO Clearance: September – December (4 months, rainy season)
- Mobilization and Preparation: completed in March (~3 months)
- Excavation: March through August (6 months)
- Operation of Storage and Dewatering Area: February into Year 2 (14 months total)
- Landfill Construction: January through May (5 months)
- Site Restoration and Demobilization: March through September (~7 months)

Year 2

- Remobilization and Preparation: completed before December (~1 month)
- Operation of Storage and Dewatering Area: Year 1 through April (14 months total)
- Landfill Construction: January through July (7 months)
- Site Restoration and Demobilization: June through August (3 months)

FIGURE 10. INDICATIVE PROJECT SCHEDULE FOR ACTIVE LANDFILL ALTERNATIVE



Effectiveness

Effective for containment – The containment aspect of the design for the Active Landfill would be very similar to the Passive Landfill. As noted for the Passive Landfill alternative, hazardous waste landfills have been used successfully for decades worldwide in containing a variety of contaminants, including dioxins, furans, and other persistent organic pollutants. Design guidance and regulations for such landfills are readily available in the U.S., Vietnam, and in many other countries. This is a proven containment strategy.

Unknown effectiveness for treatment – Field and Sierra-Alvarez (2008) published a review of the scientific literature on microbial degradation of chlorinated dioxins that spanned a period from 1980 to 2006. In this review, over 40 studies were included that evaluated 100 different biological culture and dioxin congener combinations. While some degradation of 2,3,7,8-TCDD was often observed, none of the studies included demonstrated degradation to less than 1,000 ppt for soils and 150 ppt for sediments. In addition, neither the BEM (2007) report nor the UNDP (2009) report identified any documented studies in which biodegradation was shown to treat dioxins below GVN cleanup standards. As noted on the USEPA's Technology Innovation Program:[71]

"Bioremediation is regarded as an attractive possibility for cleaning up dioxin-contaminated soil, but its real applicability and effectiveness is unknown. The following technical obstacles continue to limit the application of bioremediation: 1) only very specialized biological systems can be effective against the high toxicity, low volubility, and high absorptivity of dioxin; 2) a very stringent cleanup standard must be met; and, 3) it may be difficult to find a microorganism that can effectively deactivate dioxins under the different conditions present at existing dioxin-contaminated sites."

Potential biodegradation pathways for TCDD include aerobic, anaerobic, and aerobic cometabolic. In general, aerobic pathways have been shown to be more effective for lesser chlorinated dioxins, and the anaerobic pathway to be more effective for more chlorinated dioxins. A summary of the Field and Sierra-Alvarez (2008) review paper on chlorinated dioxin biodegradation is provided below.

- Aerobic (growth of bacteria on TCDD as a carbon and energy source in the presence of oxygen) – Only a few well-documented examples of this biodegradation pathway for chlorinated dioxins have been identified in the scientific literature. Of those four studies, none demonstrated biodegradation of TCDD. In fact, all four studies showed only degradation of monochlorinated dioxins. The bacteria responsible for the degradation in these studies included species of Sphingomonas, Pseudomonas, and Burkholderia.

- Anaerobic (growth of bacteria on TCDD as a carbon and energy source in the absence of oxygen) – Eight different studies were identified in the literature dating from 1995 to 2004 that evaluated 19 different congener and culture combinations. TCDD was not

[71] http://www.clu-in.org/contaminantfocus/default.focus/sec/Dioxins/cat/Treatment_Technologies/

tested directly in any of the combinations, although 1,2,3,4-tetrachloro-dibenzo-p-dioxin was tested in several combinations. In 17 out of the 19 combinations, either one or two chlorines was removed, while in two of the combinations, at least some dechlorination of three chlorines was reported. Percent removal ranged from 2.8% to 95.8% for the 17 cases where it was reported. The highest removal for the 12 cases that started with either 1,2,3,4-tetrachloro-dibenzo-p-dioxin (eleven) or 1,2,3,7,8-pentachloro-dibenzo-p-dioxin (one) was 89.7%. Nine of the twelve reported removals of 42.3% or less.

- Aerobic bacterial cometabolic (fortuitous degradation of chlorinated dioxins during growth on some other substrate) – Over 20 different studies from the literature dating from 1980 to 2006 evaluated 63 congener and culture combinations. Most (84%) of the evidence reported is for degradation of mono- or dichloro-dibenzo-p-dioxins. Only two of the combinations included TCDD, with one reporting 61.2% degradation in 244 days, and the other did not report a percent removal. Two other combinations included 1,2,3,4-TCDD, and those reported 13.2% and 18% removal. The bacteria implicated included species of Alcaligenes, Rhodococcus, Sphingomonas, Terrabacter, Pseudomonas, Bacillus, Burkholderia, Beijerinckia, Klebsiella, and Erwinia.

- Aerobic fungal cometabolic – Seven different studies from 1985 to 2005 were identified in the literature review reporting degradation of chlorinated dioxins by fungi. It appears that only one of those studies evaluated TCDD. The lignin peroxidase and manganese peroxidase enzymes were the focus of these studies. The highest percent removal reported in these studies by Field and Sierra-Alvarez (2008) was 55% for a dichloro-dibenzo-p-dioxin.

While strategies to accomplish biodegradation of TCDD to sufficiently low levels might be demonstrated in the future, documentation of such strategies has not yet been obtained. As a result, a basis for design of an effective active landfill is not readily available. Some specific data gaps that need to be addressed to ensure treatment effectiveness include the following:

What degradation pathway should an active landfill be designed to stimulate – aerobic, aerobic cometabolic, anaerobic, or a combination?

- What examples are available of well-documented studies that show degradation of TCDD to below target cleanup levels by the design mechanism, especially at a large scale?

- What examples are available that demonstrate how to engineer a full-scale active landfill for TCDD to ensure all of the soil is subjected to the desired conditions without any physical mixing after initial emplacement?

- If necessary, will inoculation of microorganisms be feasible and successful when increasing the scale by five orders of magnitude relative to the pilot test? If it is not necessary, how would a sufficiently uniform distribution of native microorganisms (which are notoriously heterogeneous) be ensured at the scale of a landfill to achieve the necessary destruction throughout without physical mixing?

A primary reason for retaining this alternative for consideration is that a pilot bioremediation study is being undertaken at the Airport. After 180 days of treatment, the extent of degradation of TCDD under various experimental conditions was approximately 25 to 40% (concentrations reduced from between 40,000 ppt and 50,000 ppt to approximately 30,000 ppt)[72]. TCDD concentrations remained more than 30 times the target soil cleanup level (1,000 ppt) at that time. It is not known whether the bioavailability of TCDD has become limiting (even for extracellular enzymes) as concentrations have decreased. This and the stringent cleanup standard were two of the three technical obstacles to biodegradation of dioxins noted on the USEPA website quoted above. The degradation pathway cannot be determined from the pilot test data; however, growth of bacteria such as Sphingomonas and actinomycetes has apparently been measured in the aerobic treatment cells. It is not yet clear which actinomycetes are being measured, but Rhodococcus and Terrabacter, reported in the literature review to play a role in aerobic cometabolism of chlorinated dioxins, are both actinomycetes. Actinomycetes have been shown to produce angular dioxygenase enzymes, which have been documented to degrade dioxins and furans cometabolically.[73]

Implementabilty

For containment, an Active Landfill has the same implementability issues as the Passive Landfill alternative. In addition, the Active Landfill has the following implementability issues:

Landfill size – Due to the added volume of the bulking material, the landfill area size will increase to approximately 100 m by 270 m (excluding support facilities), or slightly larger than five football fields in size. This will also increase the amount of fill material required (~200,000 m^3) for construction, operation, and closure. These items are primarily cost issues, although they have potential environmental impacts as well.

Electrical service – The distribution system will require electrical service to the landfill. Depending upon the electrical loads required and the availability of such service nearby, this cost impact could vary.

For treatment, implementability is unknown – Challenges to implementation include the following:

- It is not clear which degradation pathway is appropriate for design (aerobic, aerobic cometabolic, anaerobic, or a combination).
- Contaminated sediments and soils would need to be mixed before placement to ensure a uniform distribution of dioxin throughout the landfill and to utilize the sediments as a potential microbial inoculum source for the soils. This would require a larger Temporary Storage and Dewatering Area than for the Passive Landfill alternative in order to be able to accommodate all contaminated soils and sediments.

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[72] Allen 2010.
[73] Iida et al. 2002.

- More operational control would be required regarding where and when material is placed in the landfill and the thickness of the material that is laid down. This, plus the fact that the Active Landfill alternative would require more material to be placed than the Passive Landfill alternative, means that more time would be needed to fill the landfill.

- This alternative has not yet been successfully demonstrated at a small scale, and it is therefore not possible to determine whether the conditions required to facilitate the desired results are implementable at full scale. Some key issues to be resolved include: distribution of microbes, distribution of nutrients and/or substrates, bioavailability of TCDD, longevity of nutrients and/or substrates relative to persistence of TCDD, ability to maintain desired geochemical conditions, etc.

- The GVN and Da Nang Airport Authority have commented that a landfill with a height of 4 m and a footprint of 180 m by 180 m (which would provide the estimated volume required for an active landfill) is too large. In preliminary discussions, USEPA indicated that a 2-m height would be ideal for an active landfill, but it now appears the height might need to be 6 m or more to satisfy the footprint limitations.

The above exceptions are reflected in the indicative schedule for the Active Landfill alternative. For cost estimation purposes (see Appendix A3), it is assumed that the Active Landfill bioremediation system would require O&M for 10 years after closure.

Cost

At the alternatives evaluation stage, the design for the remedial alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." The cost engineer must make assumptions about the detailed design in order to prepare the cost estimate. As noted previously, costs for remedial alternatives are expected to have accuracies between -30% to +50% of actual costs, based on the scope presented. A detailed cost estimate backup is provided in Appendix A3. The total cost estimate for this alternative is $30.7M, comprising construction ($15.5M), excavation and disposal ($11.5M), O&M ($0.7M), and monitoring and mitigation ($3.0M).

The construction cost estimate for this alternative is split into two sections: the "Landfill Active" estimate includes work that is specific to this alternative, and the "Landfill Disposal" estimate includes work that is common to the Passive Landfill alternative. Main elements of the “Landfill Active” section of this cost estimate are listed below and elements of the “Landfill Disposal” section are the same as the Passive Landfill. A summary of the overall Active Landfill alternative cost is provided in Table 19 and detailed backup of the cost estimate is provided in Appendix A3.

TABLE 19. SUMMARY OF COST ESTIMATE FOR ACTIVE LANDFILL ALTERNATIVE

Project Alternative 3

Active Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: While no proven dioxin bioremediation technology currently exists (CDM International 2010, Appendix A5), the Active Landfill Alternative nevertheless considers a general Project configuration that could potentially accommodate a bioremediation technology.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Active	1	LS	$8,557,266	$8,557,266	Includes subgrade fill and preparation, liners, leachate collection system, waste placement, cover, and air distribution wells. Excludes bioremediaition distribution system.
SUBTOTAL				$8,557,266	
Contingency (Scope and Bid)	25%			$2,139,317	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$10,696,583	
Project Management	5%			$534,829	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	6%			$641,795	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$641,795	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,604,487	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$14,119,489	
TOTAL with VAT (assumed 10%)	10%			$15,531,438	
TOTAL CAPITAL COST				**$15,531,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$15,531,000	**$7,765,500**	Annual capital cost over the assumed duration.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Disposal	1	LS	$6,243,038	$6,243,038	Includes site clearing/preparation, excavation, decontamination, dewatering, hauling, backfilling, site restoration, and UXO screening and clearing of excavation and landfill areas. Excludes demolition of munitions bunkers at landfill site.
SUBTOTAL				$6,243,038	
Contingency (Scope and Bid)	25%			$1,560,760	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$7,803,798	
Project Management	5%			$390,190	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$624,304	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$468,228	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,170,570	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$10,457,090	
TOTAL with VAT (assumed 10%)	10%			$11,502,799	
TOTAL CAPITAL COST				**$11,503,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$11,503,000	**$5,751,500**	Annual capital cost over the assumed duration.

Project Alternative 3

Active Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: While no proven dioxin bioremediation technology currently exists (CDM International 2010, Appendix A5), the Active Landfill Alternative nevertheless considers a general Project configuration that could potentially accommodate a bioremediation technology.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MAINTENANCE (Years 3 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Active Landfill O&M	1	LS	$44,401	$44,401	Includes annual landfill O&M; assume 0.3% of landfill construction direct capital costs.
SUBTOTAL				$44,401	
Contingency (Scope and Bid)	25%			$11,100	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$55,501	
Project Management	10%			$5,550	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	15%			$8,325	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$8,325	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$77,701	
TOTAL with VAT (assumed 10%)	10%			$85,471	
TOTAL ANNUAL O&M COST				**$85,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 3 THROUGH 10)	8	YR	$85,000	**$680,000**	Annual O&M Cost over the assumed duration.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MONITORING (Years 1 through 11)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Environmental Mitigation and Monitoring Plan (EMMP) Implementation	1	LS	$148,004	$148,004	Includes sampling and analysis required by the EMMP; assume 1% of landfill construction direct capital costs.
SUBTOTAL				$148,004	
Contingency (Scope and Bid)	25%			$37,001	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$185,005	
Project Management	8%			$14,800	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	10%			$18,501	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$27,751	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$246,057	
TOTAL with VAT (assumed 10%)	10%			$270,663	
TOTAL ANNUAL O&M COST				**$271,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 1 THROUGH 11)	11	YR	$271,000	**$2,981,000**	Annual O&M Cost over the assumed duration.

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	O&M	Operations and Maintenance
LS	Lump Sum	QTY	Quantity
NA	Not Applicable	UXO	Unexploded Ordinance

The "Landfill Active" estimate includes the following costs:

Landfill Construction

- Site preparation: clearing and grubbing of the proposed landfill location, but not demolition of the munitions bunkers, and not UXO clearing or disposal.
- Grading: placement of subgrade fill to bring the landfill above the flood level, and fill for the perimeter berm and longitudinal slope.
- Liner system installation: placement of the bottom liner layers, leachate collection system piping, and the leachate treatment manhole.

Landfill Operation

- Spreading and compaction contaminated soils and sediments and bulking material in place at the landfill.
- Installation of the bioremediation distribution system (which is highly speculative at this stage).
- Installation of the remaining leachate treatment system components.
- Monitoring well network installation.

Landfill Closure – installation of the cap layers.

Indirect Costs – permits, insurance, and bonds; general conditions; overhead; and profit; but not tax, escalation, or contingency (contingency is added later).

5.3.4. ISTD/IPTD ALTERNATIVE

Conceptual Design

The ISTD/IPTD alternative would include excavation of contaminated soil and sediment, and transport to stockpile areas at the north end of the airport for treatment.

Dioxins are particularly recalcitrant to remediation, as they do not partition well into either soil, gas or groundwater from soil. However, at higher temperatures, the dioxins can be volatilized and either completely oxidized or pyrolized into coke, depending on the presence of oxygen. Dioxins still present in the aqueous phase can be destroyed via hydrolysis or hydrous pyrolysis at higher temperatures. Therefore, thermal treatments can be effective for dioxins.[74]

In past applications, dioxins have been treated in the presence of other contaminants, such as PAHs or PCBs. When these contaminants are present at high levels, they do not interfere with dioxin treatment, but they generally require more elaborate off-gas treatment system components, such as thermal or catalytic oxidizers. Analysis of recent soil samples collected at

[74] ENSR 2000, Baker and La Chance 2003, Baker et al. 2007 and Heron et al. 2010.

the Da Nang site indicated that only low levels of organic contaminants were present (Appendix A1). This would simplify treatment of off-gas because it would focus primarily on dioxins, which require only GAC as the base available technology. However, it should be noted that GAC is also very effective for removal of most organic contaminants from vapor as long as concentrations are not too high.

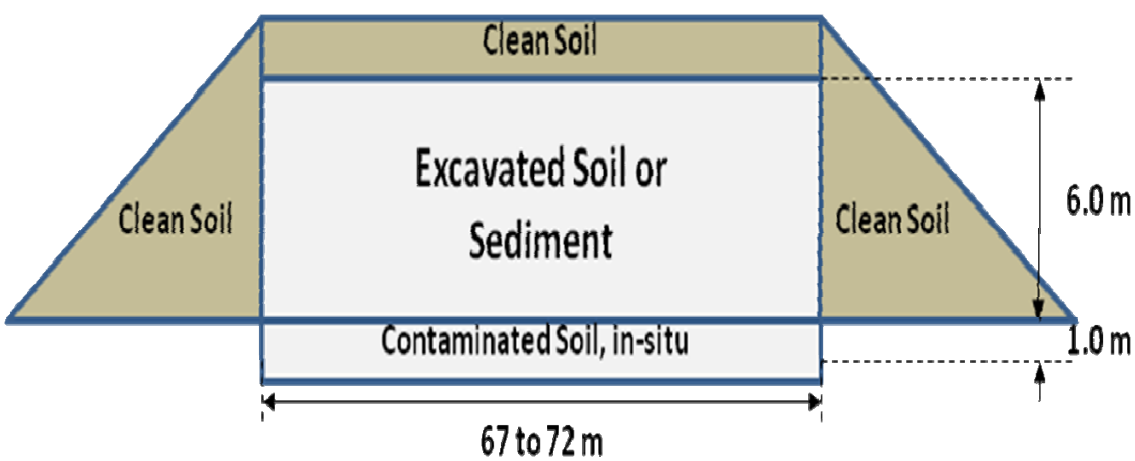
With the ISTD/IPTD alternative, contaminated soil from the MLA, SA, Drainage Ditch, Eastern Hotspot, and PISA as well as contaminated sediments from the Drainage Ditch, Sen Lake, and Eastern Wetland would be excavated, stockpiled, and thermally treated to below GVN cleanup standards. The general location of the components (excavation/hotspot areas, Contaminated Soil Stockpile, and Contaminated Sediment Stockpile) are shown in Figure 5. Similar to the landfill alternatives, it is expected that the ISTD/IPTD would also be implemented over a 2-year period.

A conceptual drawing of a stockpile of contaminated material for combined ISTD/IPTD is shown in Figure 11. The following two contaminated material stockpiles would be required:

- Contaminated Soil Stockpile: stockpile consisting of contaminated material from the SA, MLA, Eastern Hotspot, and PISA with contaminated material occupying a volume of approximately 67 m by 67 m by 6 m above-grade (27,000 m^3) and a total area, including a clean soil berm, of approximately 7,300 m^2.

- Contaminated Sediment Stockpile: stockpile consisting of contaminated sediments from Sen Lake, Eastern Wetland, and the Drainage Ditch with contaminated material occupying a volume of approximately 72 m by 72 m by 6 m (31,000 m^3), and a total area, including a clean soil berm, of approximately 8,100 m^2.

FIGURE 11. CONCEPTUAL DESIGN OF ISTD/IPTD CONTAMINATED MATERIAL STOCKPILES



Mobilization and Project Preparation

Clearing all Project Areas of UXO – All existing UXO within the Project area (excavation areas, Contaminated Soil Stockpile, and Contaminated Sediment Stockpile) would be detected and cleared prior to the commencement of any Project activities.

Equipment, Facilities, Project Setup – Equipment and a vendor would be procured, an equipment decontamination station would be constructed in the area of the hotspots, and the Project work areas would be set up. The set up would include establishing surface water runoff diversions around the main Project work areas to minimize the amount of project-affected water requiring treatment before being returned to existing drainages. It is expected that diverted surface runoff would be conveyed to the natural drainage entering the eastern wetland.

Creation of Contaminated Soil Stockpile

Preparation of Contaminated Soil Stockpile – The Contaminated Soil Stockpile would be located on top of a portion of the SA hotspot. The ground would be cleared, grubbed, and leveled, and a drainage system and a sump would be set up to manage any water that drains from the stockpile.

Excavation of Contaminated Material from the SA – Contaminated soil from the remaining SA hotspot (i.e., not covered with the stockpile) would be excavated, transported to, and placed in the Contaminated Soil Stockpile. To minimize the generation of project-affected water from precipitation and groundwater seepage, excavated areas would be filled with clean soil as soon as practicable after excavation. Water normally conveyed by the Drainage Ditch would be re-routed to the natural drainage entering the eastern wetland.

Estimates of the locations to be excavated and depths to which excavation would be required are described in Appendix A2. Confirmation sampling will be needed to determine the final excavation limits within the SA.

Excavation of Contaminated Material from the MLA, PISA, and Eastern Hotspot – An estimated 21,400 m^3 of contaminated soil from the MLA, PISA, and Eastern Hotspot would be excavated, transported to, and placed in the Contaminated Soil Stockpile. The Contaminated Soil Stockpile will have dimensions of approximately 67 m by 67 m by 6 m (27,000 m^3), and have a total footprint, including a clean soil berm, of approximately 7,300 m^2. A conceptual cross section of the stockpile is shown in Figure 11. As with excavation in the SA, excavated areas in the MLA, PISA, and Eastern Hotspot would be filled with clean soil as soon as practicable after excavation so as to minimize the generation of project-affected water from precipitation and groundwater seepage.

Estimates of the locations to be excavated and depths to which excavation would be required are described in Appendix A2. Confirmation sampling will be needed to determine the final excavation limits within the MLA.

Importing of Clean Fill to Form Contaminated Soil Stockpile and Creation of Clean Soil Berm – The Contaminated Soil Stockpile would require approximately 22,000 m^3 of clean fill on all sides

and the top to provide stability during the ISTD/IPTD process. This clean fill would be hauled to the Project site from borrow pits off the Airport property.

Thermal Treatment of Contaminated Soil Stockpile

Installation of Non-Pile Equipment – All the non-pile equipment required for ISTD/IPTD would be installed while the Contaminated Soil Stockpile is constructed.

Installation of In-Pile Equipment – Heater boreholes spaced approximately 3 m apart, heated vapor extraction wells spaced approximately 10 m apart, and air inlet and vapor recovery wells spaced approximately 10 m and 15 m apart, respectively, would be installed once construction of the Contaminated Soil Stockpile is complete. A vapor cover would also be installed, with all heating elements, off-gas vapor systems, and pile monitoring systems installed. The vapor cover will likely consist of a light concrete aggregate, as well as a layer of clean fill. The combination of the vapor cover and the vacuum on the air inlet wells will prevent any vapor from escaping the piles. The cover will also prevent water from entering the pile and representing an additional heat sink that would waste energy being applied for heat treatment. While the top of the cover will be warm, its thickness and exposure to the atmosphere will prevent it from being so hot that it will boil water. Thus, steam generation from rainfall on the cover would be insignificant.

In the case of the Contaminated Soil Stockpile, it is anticipated that the pile will be located on the southern half of the SA (Figure 5). This will allow contaminated soils underneath the pile to be treated in place (i.e., the entire SA will not require excavation). Based on the 2010 data (Appendices A1 and A2), the average depth of contamination above target treatment levels in the southern half of the SA is 0.54 m. Assuming the water table is present at a depth of 1 m, heater wells could be installed through the pile to just below the bottom of the contaminated interval without entering the water table. This will allow in situ treatment of those soils to occur while the soil pile is treated, without undue loss of energy caused by heating the groundwater. If it is determined during the final design that 0.46 m is not enough separation to prevent unwanted heat loss to groundwater, the entire SA will be excavated, and the bottom of the soil treatment pile and the associated heater wells will be at ground surface.

Thermal Treatment of Contaminated Soil Stockpile – Thermal treatment of the contaminated soil stockpile would then proceed. The following steps would be required: shakedown; heating to boiling temperature, boiling and drying (to reduce water content in the pile), heating to target temperature, sampling and analysis, and cooldown. Successful treatment of the dioxins requires soil temperatures be elevated to approximately 335°C. This would be accomplished via the placement of heater boreholes that raise the temperature of adjacent soil or sediment within the stockpile. Soil temperature near the heater boreholes would be approximately 700 to 800°C so as to achieve sufficient heating between boreholes.

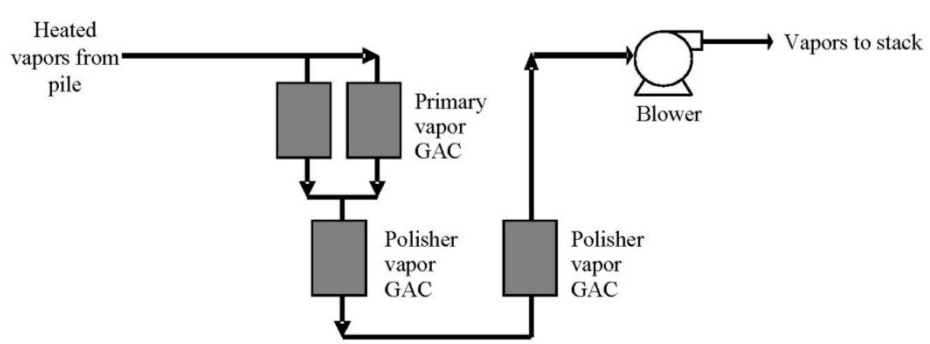
The time for the pile to reach the boiling temperature of water is estimated to be about 30 days. Once that temperature is reached, it will remain there until most of the water content of the soil and/or sediment in the pile is evaporated. Based on the estimated water content of the piles, the time required for this phase is estimated to be about 60 days. The higher the water content, the longer this stage will take. Approximately 80 more days will be required to heat the piles to the target temperature (minimum of 335 C between heater wells).

It should be noted that the highest temperatures in the piles (700 to 800°C adjacent to the heater wells) will be well below the temperature required for vitrification to occur. Vitrification of sand occurs at greater than 1000°C, as the glass transition temperature for quartz sand is 1175°C.

Approximately 95% of the dioxins would be destroyed in the piles by the mechanisms of oxidation, hydrolysis, and/or hydrous pyrolysis. Recovery of the remaining dioxins would be accomplished via heated vapor extraction wells. Air inlet wells would be installed to allow sufficient flow through the stockpile. Based on conceptual modeling of this system, it is anticipated that heater boreholes would be installed with 3-m spacing, and air inlet and vapor recovery wells would be installed with 10-m and 15-m spacing, respectively. For the 67 m by 67 m Contaminated Soil Stockpile, it would be expected that approximately 550 heater borings, 50 heated vapor extraction wells, and 25 air inlet wells would be needed. As noted above, the combination of a vacuum constantly applied to the heated vapor extraction wells and the vapor cover will prevent any contaminated vapor from escaping the pile through a route other than the vapor extraction and treatment system. An air-to-air heat exchanger would be used to minimize power consumption by transferring energy from the extracted air to the pile inlet air.

Dioxins in off-gas can be effectively treated via vapor-phase GAC. No other hazardous byproducts of this treatment process for dioxins have been observed in past applications. Concentrations of dioxins in the treated off-gas are expected to be orders of magnitude lower than the most strict air regulations in the U.S., as evidenced by application of the technology in California. For this site, extracted soil vapor would be pulled into vessels containing GAC. The first two vessels would be arranged in parallel, due to the expected high mass loading, and the following two vessels would be arranged in series to polish the vapor stream prior to discharge. A process flow diagram is shown in Figure 12. The stack releasing treated off-gases would be strategically located to maximize the distance from populated areas.

FIGURE 12. PROCESS FLOW DIAGRAM FOR ISTD/IPTD EXTRACTED FLUIDS TREATMENT SYSTEM



Estimated contaminant mass = 200 kg

A small water condensate stream will be produced by the air treatment system. Given the low aqueous solubility of dioxins, it is believed that concentrations of dioxins in the condensate will

be extremely low. However, it is likely that the condensate stream would be treated by GAC as a polishing step prior to discharge as a precautionary step both for dioxins and for any other organic co-contaminants that might be present.

It is expected that treatment of each pile would require approximately 21,000,000 kwh of power. The Da Nang Power Company has indicated that a dedicated line can be brought into the site from a nearby substation with sufficient power to support the Project.

Removal of In-Pile Equipment – All the in-pile equipment would be removed after the cooldown phase from the clean soil pile for use in the Contaminated Sediments Stockpile.

Creation of Contaminated Sediment Stockpile

Preparation of Contaminated Sediment Stockpile – The contaminated sediment stockpile would be located east-northeast of the SA (Figure 5). The area would be cleared, grubbed, and leveled, and a bottom liner with a drainage system and a sump would be laid down to manage the water that drains from the stockpile. In addition, a temporary unpaved haul road would be constructed from Sen Lake to the Contaminated Sediment Stockpile.

Excavation of Contaminated Material from Sen Lake – Excavation of contaminated sediments from Sen Lake, Eastern Wetland, and the Drainage Ditch would proceed in the same manner as described above for the Passive Landfill alternative. After excavation from Sen Lake, the excavated material would be conveyed directly to the Contaminated Sediment Stockpile. The Contaminated Sediment Stockpile will have dimensions of approximately 72 m by 72 m by 6 m (31,000 m^3), and have a total footprint, including a clean soil berm, of approximately 8,100 m^2. Similar to the Contaminated Soil Stockpile, it is anticipated that heater boreholes would be installed with 3-m spacing, and air inlet and vapor recovery wells would be installed with 10-m and 15-m spacing, respectively. For the 72 m by 72 m Contaminated Sediment Stockpile, it would be expected that approximately 600 heater borings, 60 heated vapor extraction wells, and 30 air inlet wells would be needed.

Importing of Clean Fill to Form Contaminated Sediment Stockpile and Creation of Clean Soil Berm – The Contaminated Sediment Stockpile would require approximately 24,000 m^3 of clean fill on all sides and the top to provide stability during the thermal desorption process. This clean fill would be hauled to the Project site from borrow pits off the Airport property.

Thermal Treatment of Contaminated Sediment Stockpile

Thermal treatment of the Contaminated Sediment Stockpile, consisting of installation of in-pile equipment, thermal treatment, and removal of in-pile equipment would proceed in the same manner as for the thermal treatment of the Contaminated Soil Stockpile.

Site Restoration and Demobilization

Disposal of Treated Soil Stockpile – The treated soil stockpile would be disposed of in a location to be determined in consultation with GVN. For cost estimation purposes (see Appendix A3), it is assumed that the treated soil would be placed, graded, and seeded in a permanent stockpile at/near the treatment area.

Disposal of Treated Sediment Stockpile – The treated sediment stockpile would be disposed of in a location to be determined in consultation with GVN. For cost estimation purposes (see Appendix A3), it is assumed that the treated sediment would be placed, graded, and seeded in a permanent stockpile at/near the treatment area.

Site Restoration – Site restoration activities would be decided upon in consultation with the Airport Authority and would generally consist of returning project-affected areas to pre-Project or better conditions.

Project Demobilization – All Project equipment and facilities would be removed from the Project area.

Footprint

The area of the total footprint for the ISTD/IPTD alternative is estimated to be 183,100 m^2, consisting of:

- 167,700 m^2 of area of contaminated soils and sediments to be excavated;
- 7,300 m^2 for the footprint for the contaminated soil stockpile; and
- 8,100 m^2 for the footprint for the contaminated sediment stockpile.

Construction and Operation Schedule

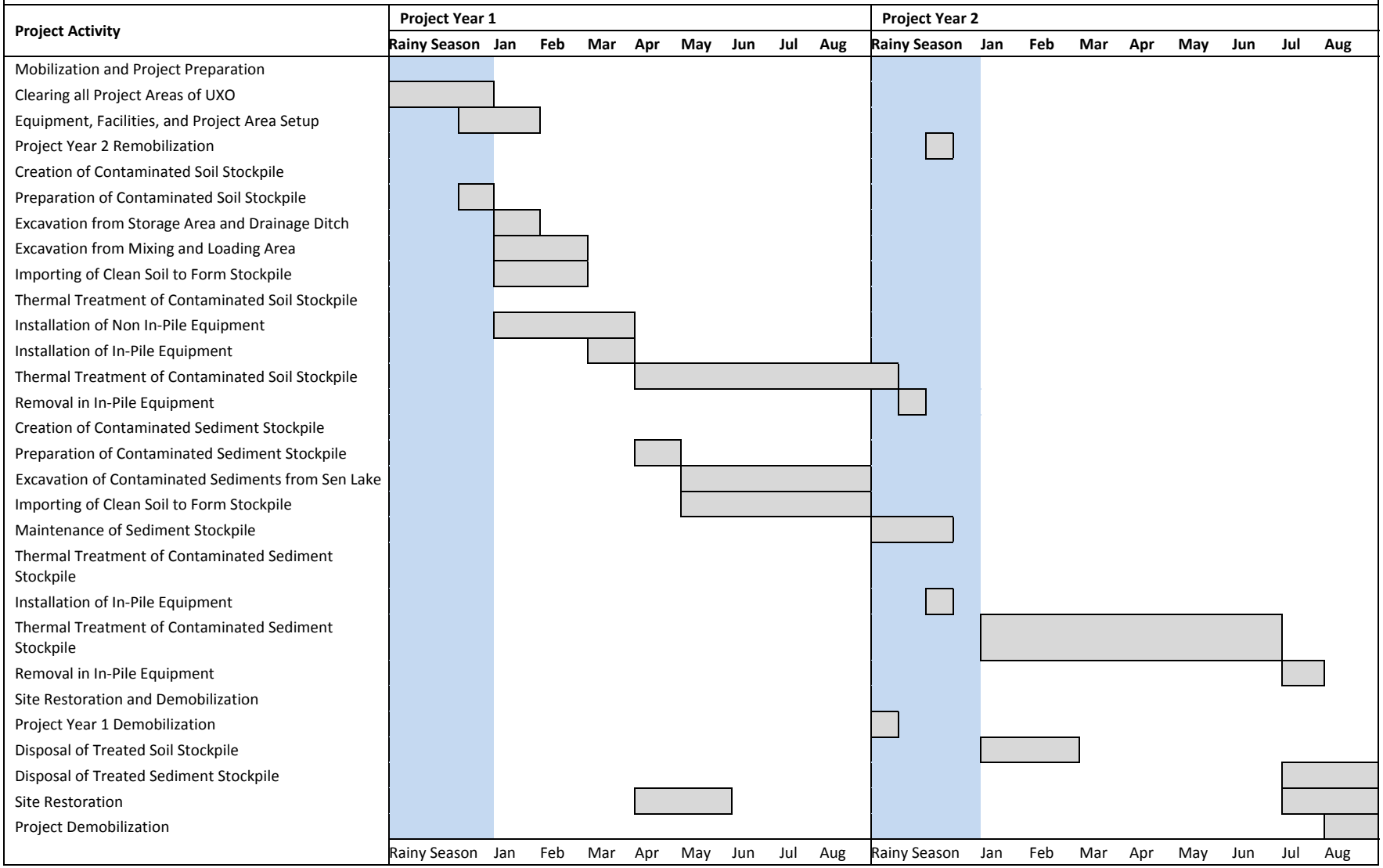
It is expected that the ISTD/IPTD alternative would be constructed and operated over a 2-year period. Dioxin concentrations would be reduced to or below GVN cleanup standards by the end of operation; therefore, no long term O&M would be required.

The main schedule components for implementation of the ISTD/IPTD alternative are as follows (see Figure 13):

Year 1

- UXO Clearance: September – December (4 months, rainy season)
- Mobilization and Preparation: completed in January (~2 months)
- Soil Stockpile Creation: December through February (3 months)
- Soil Stockpile Treatment: January into Year 2 Rainy Season (~6 months)
- Sediment Stockpile Creation: April into Year 2 Rainy Season (~8 months)
- Site Restoration and Demobilization: April through May (2 months)

FIGURE 13. INDICATIVE PROJECT SCHEDULE FOR ISTD/IPTD ALTERNATIVE



Year 2

- Soil Stockpile Treatment: Year 1 into Rainy Season (~7 months)
- Remobilization and Preparation: completed before December (~1 month)
- Sediment Stockpile Creation: Year 1 into Rainy Season (~8 months total)
- Sediment Stockpile Treatment: Year 2, Rainy Season through July (~7 months)
- Site Restoration and Demobilization: Rainy Season through August (12 months, but intermittent)

Effectiveness

Effective for treatment (no long-term containment required) – Several well-documented case studies[75] have shown that ISTD or IPTD can treat chlorinated dioxins, including TCDD, to concentrations well below the target cleanup goals for either soil or sediment. Of particular interest is a full-scale site in Alhambra, California, where the regulatory agency determined all cleanup goals were met and the site was appropriate for unrestricted land use with no further action.[76] Also, a recent demonstration in Japan provided sufficient results to gain approval from the Japanese Ministry of Environment for applying the technology to treat dioxins in Japan.[77] Table 20 summarizes the results of these key case studies. In all cases, initial concentrations were of a similar order of magnitude expected for stockpiles to be treated at the Airport, and final concentrations were below even the treatment standard for sediment of 150 pg TEQ/g.

Multiple studies have demonstrated that over 95% of dioxins and other high-boiling point compounds are destroyed *in situ* using ISTD/IPTD. For example, the Rocky Mountain Arsenal Hex Pit Treatability Study, which was overseen by the USEPA SITE Program, included a mass balance for PCDD/furans . The SITE program report stated, "These data further suggest that the application of the ISTD thermal well technology at the Hex Pit site will reduce the mass of these contaminants by greater than 95% *in situ*, while producing process condensate and process vapor with relatively low contaminant concentrations".[78] In other examples, treatability testing has shown that PAH-contaminated soils treated at 300°C (572 degrees Fahrenheit [°F]) for three days achieved much lower residual contaminant concentrations than soils treated at 400°C (752°F) for just one day.[79] There are two primary reasons for the successful treatment of high-boiling point compounds such as PAHs, PCBs, and PCDD/furans at temperatures significantly lower than their respective boiling points. First, heating the subsurface to above 300°C increases the contaminants' vapor pressures over one million-fold. Second, longer

[75] ENSR 2000, Baker and La Chance 2003, Baker et al. 2007 and Heron et al. 2010.
[76] Baker et al. 2007.
[77] Heron et al. 2010.
[78] ENSR 2000.
[79] Baker et al. 2007.

residence times in the heated zone have resulted in significantly higher removals of various PCB Aroclors,[80] and the same was seen for PAHs.[81]

Concentrations of dioxins in exhaust gas for all case studies (Table 20) were within orders of magnitude below regulatory limits. Adsorption on GAC is considered a Best Available Technology for removal of compounds like dioxins and furans (PCDD/furans) that have a high octanol-water partitioning coefficient. PCDD/furans are bound tenaciously to GAC, and especially with a lead-polish configuration of GAC vessels cannot break through. Again, based on measurements from past projects, over 95% of the dioxins are expected to be destroyed in-situ. If detailed design calculations were to show that use of serial GAC vessels alone will not meet the standards, then the need for a thermal oxidizer would be considered. Dispersion between the stack and property boundaries or locations of other receptors would be considered in this analysis.

TABLE 20. PERTINENT CASE STUDY DATA FOR ISTD/IPTD FOR TREATMENT OF DIOXINS

Site	Target Media	Average Pre-Treatment Concentration (pg-TEG/g)	Average Post-Treatment Concentration (pg-TEG/g)	Exhaust Gas Concentration (ng-TEG/nm^3)
Yamaguchi, Japan[1]	Sediment	1,800	67.75	0.000018
Alhambra, California, USA[2]	Soil	18,000	110	0.0071
Cape Giradeau, Missouri, USA[3]	Soil	6,500	3.2	0.0029
Ferndale, California, USA[3]	Soil	3,200	7.3	0.0055

Notes:
1 - Heron et al. 2010.
2 – Baker et al. 2007.
3 – Baker and LaChance 2003.

Implementability

The ISTD/IPTD alternative would require a footprint of about 15,400 m^2 distributed in two separate stockpiles. However, one of those stockpiles would be located on top of the SA, so a new area would not be disturbed. ISTD/IPTD is implementable with the associated challenges described in the subsections below.

Energy Usage

It is estimated that about 21,000,000 kwh will be required for each of the two stockpiles to be treated, for a total of 42,000,000 kwh. This is on the order of a light to medium-sized industrial facility. The local power company in Da Nang has indicated it can provide this power and has

[80] Heron et al. 2010.
[81] Baker et al. 2007.

provided a cost estimate for running power to the site from the nearest substation. This cost is included in the preliminary estimate.

Mobilization

Much of the equipment and technical expertise for this technology will have to come from overseas (probably the U.S.). This will impact cost, and has been included in the preliminary cost estimate.

Air Monitoring

Significant air monitoring will be required to ensure emissions do not exceed designated limits. This was also the case for the Alhambra, California project and can be included in the operations.[82] Based on the previous case studies, it is anticipated that the use of multiple GAC units will be sufficient to meet all air emissions regulations.

Soil Integrity

Limited quantitative data are available regarding the impact of ISTD/IPTD on geotechnical properties of soil. However, for the Alhambra, California project,[83] the California Department of Toxic Substances Control requested geotechnical testing of the post-treatment soils. Samples were tested for parameters of dry and wet bulk density, calculated porosity, as-received moisture content, saturated hydraulic conductivity by the falling-head method, and particle size analysis. It was concluded that ISTD treatment did not significantly affect the geotechnical properties of the soil.[84] This conclusion was based on the fact that post-treatment soil samples exhibited saturated hydraulic conductivity and total porosity values consistent with sandy loam material, and consistent with the texture of the pre-treated soil. Thus, for the sandy soils at the Airport, it is likely that they could be used as fill for a variety of purposes following treatment, but geotechnical testing should be performed before using the soils as structural fill. It is possible that treatment of the sediments with a high organic fraction might have a greater impact on geotechnical properties; however, such material would likely be unsuitable for structural fill even without thermal treatment. It is currently assumed that treated soils and sediment would simply be spread on the land surface and revegetated, but testing of the soils could be performed to determine whether other beneficial uses are possible following treatment.

Cost

At the alternatives evaluation stage, the design for the remedial alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." The cost engineer must make assumptions about the detailed design in order to prepare the cost estimate. A detailed cost estimate backup is provided in Appendix A3. The total cost estimate for this alternative is $33.74M, comprising construction ($24.38M), excavation and disposal ($8.77M), and monitoring and mitigation ($0.59M). No long term O&M beyond the 2-year operating timeframe would be required.

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[82] Baker et al., 2007.
[83] Heron et al. 2009.
[84] Heron et al. 2009.

The construction cost estimate for this alternative is split into two sections: the "ISTD/IPTD" estimate, which mainly includes work performed by the thermal subcontractor, and the "ISTD/IPTD Disposal" estimate, which includes work the excavation of the contaminated soils and sediments and placement into stockpiles. Main elements of the two sections of this cost estimate are listed below. A summary of the overall ISTD/IPTD alternative cost is provided in Table 21 and detailed backup of the cost estimate is provided in Appendix A3.

The "ISTD/IPTD" estimate includes the following costs:

Design and Installation – Design, permitting, procurement, mobilization, furnishing of power to the stockpile site and related equipment, pile construction, drilling and installation of pile wells, installation of the vapor cover and the treatment system, all mechanical and electrical work, and commissioning.

Operation – Maintenance, spare parts, subcontractor labor, travel, and per diem, process monitoring, waste and GAC disposal, and equipment rental fees.

Demobilization – Removal of treatment equipment, reporting, and electrical power costs.

The "ISTD/IPTD Disposal" estimate includes the following costs:

Site Preparation – Installation and maintenance of decontamination areas at excavation sites, traffic control, health and safety oversight during all phases of work, clearing and grubbing the sites, construction of soil storage and dewatering areas, and UXO clearing or disposal.

Excavation – At the MLA, SA, Drainage Ditch, Eastern Hotspot, PISA, Sen Lake and the Eastern Wetland (using Aqua Dam bladders for Sen Lake).

Hauling – From excavation sites to treatment piles.

Site Restoration – Removal of temporary facilities, and restoration of the site.

Indirect Costs – Permits, insurance, and bonds, general conditions, overhead, and profit, but not tax, escalation, or contingency (contingency is added later).

TABLE 21. SUMMARY OF COST ESTIMATE FOR ISTD/IPTD ALTERNATIVE

Project Alternative 4

Thermal (ISTD / IPTD)

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: In this alternative, contaminated soil from the MLA and the SA, as well as contaminated sediments from the drainage ditch and Sen Lake, would be excavated, stockpiled, and thermally treated to below regulatory limits. Figure 2 outlines the general location of each of the major components of the ISTD/IPTD thermal alternative. It is expected that the ISTD/IPTD alternative will also be implemented over a 2-year period.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Thermal Alternative	1	LS	$16,789,205	$16,789,205	Includes permitting, mobilization/demobilization of system from overseas, system construction and installation, power, commissioning, operation, monitoring, effluent/GAC treatment.
SUBTOTAL				$16,789,205	
Contingency (Scope and Bid)	0%			$0	20% scope and bid contingency included in treatment subcontractor estimate.
SUBTOTAL				$16,789,205	
Project Management	5%			$839,460	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	6%			$1,007,352	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$1,007,352	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$2,518,381	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$22,161,750	
TOTAL with VAT (assumed 10%)	10%			$24,377,925	
TOTAL CAPITAL COST				**$24,378,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$24,378,000	**$12,189,000**	Annual capital cost over the assumed duration.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
ISTD/IPTD Alternative	1	LS	$4,760,183	$4,760,183	Includes site clearing/preparation, excavation, decontamination, dewatering, hauling, backfilling, permanent stockpiling of treated soil/sediment, site restoration, and UXO screening and clearing of excavation areas.
SUBTOTAL				$4,760,183	
Contingency (Scope and Bid)	25%			$1,190,046	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$5,950,229	
Project Management	5%			$297,511	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$476,018	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$357,014	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$892,534	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$7,973,306	
TOTAL with VAT (assumed 10%)	10%			$8,770,637	
TOTAL CAPITAL COST				**$8,771,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$8,771,000	**$4,385,500**	Annual capital cost over the assumed duration.

Project Alternative 4

Thermal (ISTD / IPTD)

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client: USAID Vietnam
Site: Da Nang Airport
Location: Da Nang, Vietnam
Phase: Environmental Assessment of Project Alternatives
Level of Project Definition: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2010 (FY10)
Date: February 8, 2010

Description: In this alternative, contaminated soil from the MLA and the SA, as well as contaminated sediments from the drainage ditch and Sen Lake, would be excavated, stockpiled, and thermally treated to below regulatory limits. Figure 2 outlines the general location of each of the major components of the ISTD/IPTD thermal alternative. It is expected that the ISTD/IPTD alternative will also be implemented over a 2-year period.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MONITORING (Years 1 through 3)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Environmental Mitigation and Monitoring Plan (EMMP) Implementation	1	LS	$107,747	$107,747	Includes sampling and analysis required by the EMMP; assume 0.5% of treatment and disposal direct capital costs.
SUBTOTAL				$107,747	
Contingency (Scope and Bid)	25%			$26,937	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$134,684	
Project Management	8%			$10,775	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	10%			$13,468	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$20,203	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$179,130	
TOTAL with VAT (assumed 10%)	10%			$197,043	
TOTAL ANNUAL O&M COST				**$197,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 1 THROUGH 3)	3	YR	$197,000	**$591,000**	Annual O&M Cost over the assumed duration.

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each
GAC	Granular Activated Carbon
LS	Lump Sum
NA	Not Applicable
O&M	Operations and Maintenance
QTY	Quantity
UXO	Unexploded Ordinance

Section 6. Affected Environment

This section presents a description of the environmental resources of the Airport and Da Nang City that may be potentially influenced by one or more of the remedial alternatives.

Existing baseline information on most environmental resources is limited. In particular, a detailed description of the temporal and spatial variability of most of the environmental resources does not exist. This includes COPCs that may be either associated with dioxin contamination or with the operation of an Air Force military base and international airport.

The quality of the current environmental baseline does not limit the ability to assess the environmental effects of the remedial alternatives. However, it will be necessary to continue to augment the environmental baseline with additional field programs prior to the start of Project construction in order to properly monitor the environmental effects of the Project.

6.1. Main Catchments

Three small catchments drain the Airport property.[85] The environmental conditions of two of these catchments are relevant to the potential environmental effects of the remedial alternatives:

- March 29 Lake-Phu Loc River Catchment – This approximately 900 ha catchment drains the northern section of the Airport. It contains the four dioxin hotspots, the lakes and wetlands at the northern end of the Airport, and surrounding area; it is where many of the Project activities would occur. The majority of the catchment that is within the Airport boundary drains out of the Airport property via a culvert on the north side of Sen Lake, which leads to a covered municipal stormwater drain that empties into the Phu Loc River as it flows into Da Nang Bay.

- West of Airport-Han River Catchment – This approximately 700 ha catchment drains the southwestern section of the Airport where the landfill would be constructed and operated. Drainage from this catchment flows via a covered municipal stormwater drain into the Han River that also flows eventually into Da Nang Bay.

During the high rain months of October and November, flooding is common in Da Nang City, including the Airport.

[85] Da Nang Urban Environmental Company 1998.

6.2. Physical Environmental Resources

6.2.1. CLIMATE

The climate in Da Nang City (Figure 14) is characterized by:

- An average annual temperature of 25.9°C, with a "winter" season from October to March in which the temperatures are somewhat cooler than the "summer" season from April to September.
- An average humidity of 82%.
- An average annual rainfall of approximately 2,000 millimeters (mm).
- A dry season lasting generally from January to August and a rainy season lasting generally from September to December. Approximately 75% of the total annual rainfall occurs during the rainy season, with 30% of total annual rainfall occurring in October.
- Approximately four typhoons and tropical storms annually.
- Predominantly east-southeast, north-northwest, and south-southwest winds in the dry season and predominantly north-northwest winds in the rainy season.

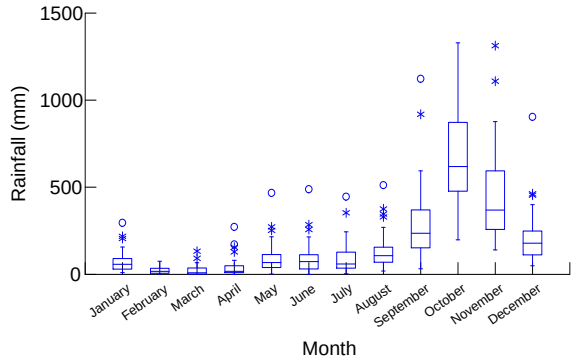
6.2.2. SOILS AND SEDIMENTS

The physical and chemical characterization of soils and sediments in the March 29 Lake-Phu Loc River and the West of Airport-Han River catchments is currently incomplete. Other than the dioxin characterization studies there has to date been little baseline environmental characterization of the soils and sediments in these parts of the Airport.

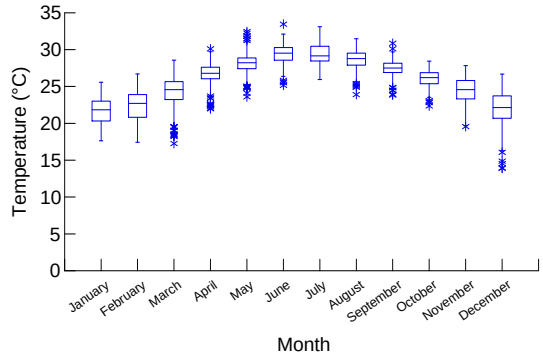
Figure 15 contains the location of the soil and sediment sampling on which the description of current soil and sediment conditions presented below is based. Detailed soils and sediment baseline data are provided in Appendix A4.

FIGURE 14. SUMMARY OF CLIMATIC CONDITIONS FOR DA NANG CITY

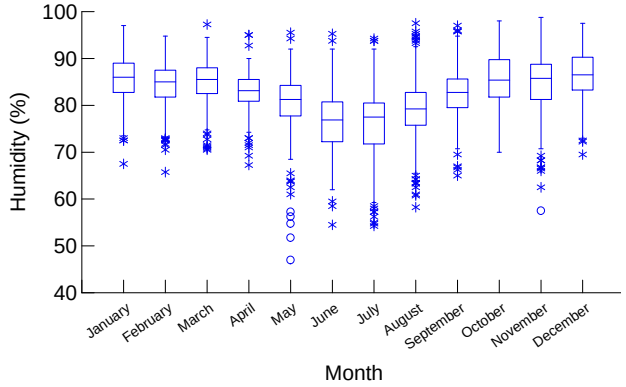
PRECIPITATION



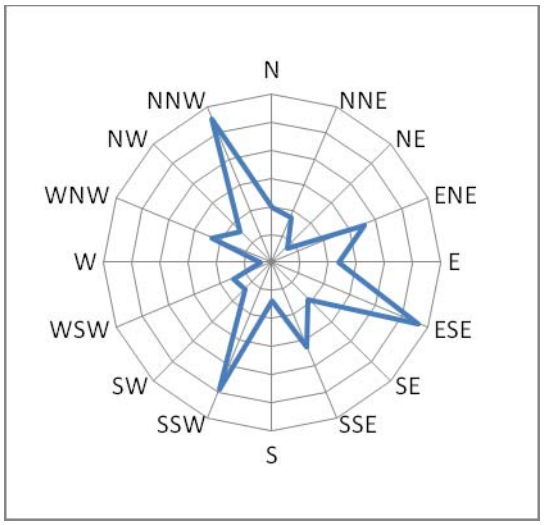
TEMPERATURE



HUMIDITY



WIND DIRECTION, DRY SEASON



WIND DIRECTION, RAINY SEASON

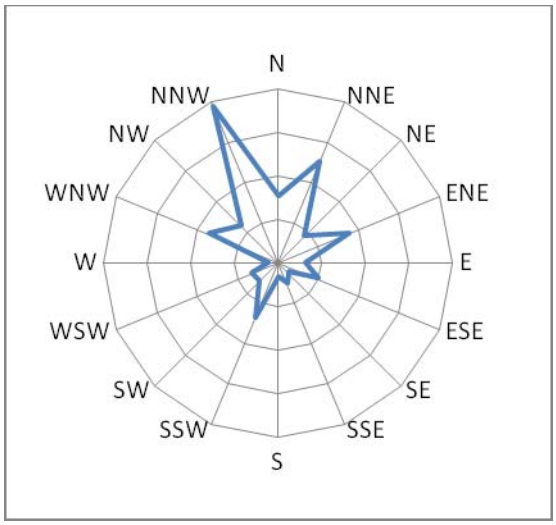


FIGURE 15. LOCATION OF BASELINE COPC SAMPLES FOR DA NANG AIRPORT

March 29 Lake-Phu Loc River Catchment

Soils in the March 29 Lake-Phu Loc River catchment are sandy with generally low organic content (less than 1.0% TOC), and are generally acidic, while sediments in the lakes of the March 29 Lake-Phu Loc River catchment are acidic, comprised of approximately 50% sand, 30% silt, and 20% clay, and contain approximately 7% TOC (Table A4.1). Soil boring logs prepared during the January 2010 field program[86] confirm that surface soils in the MLA and SA (to a depth of 2.1 m) are comprised entirely of loose fine quartz sands.

In addition to the known major herbicides (Agents Orange, Purple, Blue, Pink, Green and White), other chemicals including fungicides, insecticides, wetting agents, wood preservatives, insect repellants and other herbicides are known to have been used in Vietnam by US and Australian forces.[87] Unlike 2,3,7,8-TCDD contamination, which can be linked to Agent Orange usage, linking other COPCs to USG activities is not possible without detailed information about the types (formulations), quantities, and locations where these chemicals were stored and used. Similarly, information regarding the potential usage and storage of COPCs by the GVN at Da Nang Airport post-1975 is lacking. A summary of the existing information on COPC concentrations in the March 29 Lake-Phu Loc River catchment soils and sediments is presented below (COPC information for sediments exists only for Sen Lake):

- In the absence of soil standards, measured concentrations of PCBs in soils were below existing standards for sediments (Table A4.2).
- Measured concentrations of total PCBs in Sen Lake sediments were above existing standards (Table A4.2). This exceedence is due to elevated concentrations of PCB-118 (Aroclor).
- Measured concentrations of a number of organochlorine pesticides were above existing standards in some locations, including dieldrin, hexachlorobenzene, aldrin, as well as some forms of chlordane and endosulphan (Table A4.3).
- Measured concentrations of most PAHs in soils were below existing standards (Table A4.4).
- Measured concentrations of a number of PAHs in Sen Lake sediments were above existing standards (Table A4.4).
- Measured concentrations of petroleum hydrocarbons (Table A4.5) and chlorophenols (Table A4.6) were generally below detection limits for both soils and sediments.
- Measured concentrations of a number of metals in Sen Lake sediments have exceeded sediment standards (Table A4.7). Measured exceedances have occurred in the top 6 cm

[86] Dong 2010.
[87] IOM 1994.

of lake sediments, with most measured exceedances occurring in the top 2 cm of lake sediments.

- Metals concentrations in soil in the MLA and SA exceeded USEPA Region 5 standards for antimony, arsenic, barium, copper, lead, vanadium, and zinc. Method detection limits (MDLs) also exceeded soil standards for cadmium, cobalt, and thallium (Table A4.8). The small amount of sediment sampling that has been conducted in the Phu Loc River indicates concentrations of a number of metals exceed existing standards (Table A4.9). There is no information on concentrations of other COPCs in Phu Loc River sediments.

West of Airport-Han River Catchment

Less information is available for soils in the West of Airport-Han River catchment (the catchment in which the landfill would be located), than for the March 29 Lake-Phu Loc River catchment. Visual observations made during sampling for dioxin characterization studies suggest soils in this part of the Airport are also sandy. The measured concentrations of most metals are below existing standards, with the exception of mercury (Table A4.10). No information exists on the concentration of other COPCs in the West of Airport-Han River catchment.

6.2.3. GROUNDWATER RESOURCES

Two hydrogeological cross-sections created for other projects[88] transect the March 29 Lake-Phu Loc River Catchment (Figure 16). Nguyen (2009a) and Office 33 (2008) describe the main aquifers in this hydrogeological sequence which is found throughout the Airport property.

The uppermost Holocene aquifer consists of yellow-grey, fine to medium sand and clayey sand and ranges in thickness from 8 m to 15 m. Groundwater levels range seasonally between 0.3 m to 3 m below ground level (bgl), with groundwater levels generally ranging between 2 m to 3 m bgl in the dry season. The permeability of the Holocene aquifer ranges between 1.42 and 1.9 m/d.[89] Groundwater flow direction in the March 29 Lake-Phu Loc River catchment is to the north and in the West of Airport-Han River Catchment is to the south,[90] which corresponds to the direction of surface water flows in these catchments.

An aquitard, less than 5 m thick, underlies the unconfined Holocene Aquifer, and is comprised largely of clays. The Lower Pleistocene and Cambrian Ordovician Aquifers underlie the aquitard and are the source for much of the drinking and domestic water supply of Da Nang City.

6.2.4. GROUNDWATER QUALITY

The current understanding of groundwater quality information for the March 29 Lake-Phu Loc River and the West of Airport-Han River catchments is poor. Only basic groundwater quality information is available for a few locations, and little information exists on concentrations of many COPCs.

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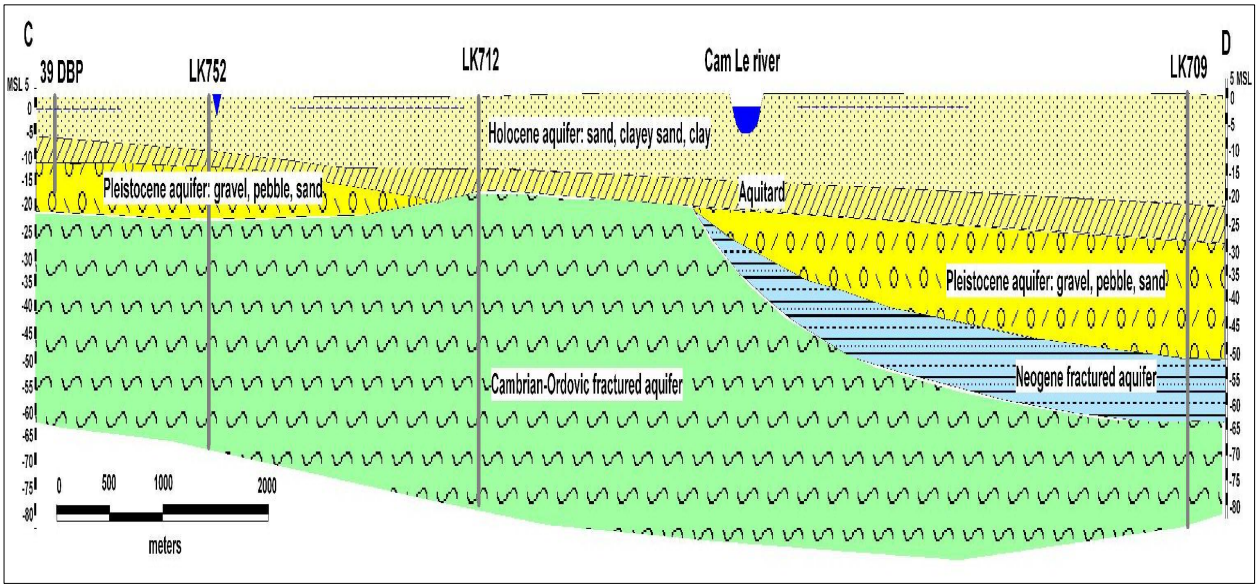
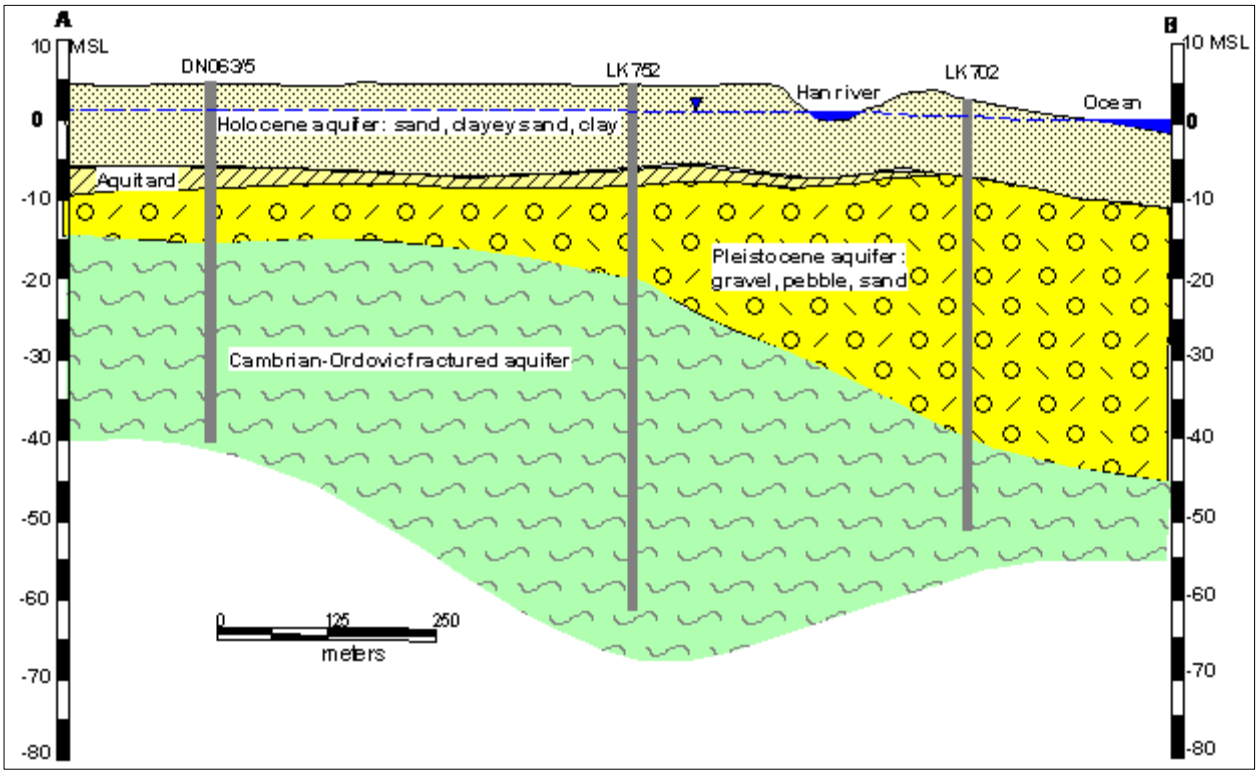
[88] Nguyen 2009a.
[89] Nguyen 2009a.
[90] Office 33 2008.

FIGURE 16. HYDROGEOLOGICAL CROSS-SECTIONS TRANSECTING THE MARCH 29 LAKE-PHU LOC RIVER CATCHMENT



See Figure 15 for location of cross-section.
Note: Airport property within March 29 Lake-Phu Loc River catchment is to immediate left of LK752.



See Figure 15 for location of cross-sections.
Note: Airport property within March 29 Lake-Phu Loc River catchment is between 39DBP and LK752.

March 29 Lake-Phu Loc River Catchment

Groundwater quality information exists for a single well in the March 29 Lake-Phu Loc River catchment within the Airport property, although some groundwater quality data have been collected for the catchment outside the Airport property (Table A4.11 to A4.14). Relatively few measured exceedances of either Vietnamese or USEPA standards are found in metals, although manganese is the most common exceedance outside the Airport Property. Sampling conducted in January 2010 indicated that PCBs, PAHs, and VOCs all were below guidelines and/or MDLs.

West of Airport-Han River Catchment

In the West of Airport-Han River Catchment, groundwater was sampled historically in two wells and in the January 2010 program at one location. COPCs measured include metals, PCBs, PAHs, and VOCs (Table A4.11 to A4.14). The dataset indicates a few metals exceedances (either Vietnamese or USEPA standards) in the two wells that were sampled historically, while no exceedances were noted in the January 2010 sampling.

6.2.5. SURFACE WATER QUALITY

March 29 Lake-Phu Loc River Catchment

Until the sampling conducted in January 2010, there was little characterization of surface water quality in the lakes and wetlands in the March 29 Lake-Phu Loc River catchment that comprises the north part of the Airport. A range of COPCs (in addition to Agent Orange and other major herbicides) were used by U.S. military forces prior to 1971; however, detailed information about these chemicals (quantities, formulations, storage and usage etc.) is lacking, and therefore linking present day concentrations to past activities is difficult. Similarly, information regarding the potential storage and usage of COPCs by the GVN post-1975 at Da Nang airport is lacking. Sen Lake has been sampled for metals, PCBs, PAHs, and VOCs with the concentrations of dissolved oxygen, biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia, iron, and oil exceeding GVN surface water quality guidelines for domestic purposes; however, all water samples met the guidelines for non-domestic.

January 2010 samples analyzed from Sen Lake and the drainage canal showed exceedances of USEPA and/or Vietnamese guidelines with respect to arsenic, aluminum, manganese, and iron.

Water quality in the Phu Loc River downstream of the Airport is characteristic of many polluted urban watercourses and reflects inputs of biological and industrial waste (Table A4.17, Table A4.18). BOD, dissolved oxygen levels, suspended solids (SS) concentrations, oil, and total coliform counts are routinely above national Vietnamese standards; concentrations of a number of metals, particularly lead, iron, and cadmium are above Vietnamese and USEPA standards.

West of Airport-Han River Catchment

The water quality of the minor watercourses and water bodies in the West of Airport-Han River Catchment is unknown.

6.2.6. AIR QUALITY

Air quality information on the Airport property collected in support of the Airport expansion EIA[91] indicates concentrations of all measured air quality variables were below existing standards (Table A4.19).

6.3. Natural and Biological Resources

6.3.1. TERRESTRIAL ECOSYSTEMS AND BIODIVERSITY

March 29 Lake-Phu Loc River Catchment

The terrestrial ecosystems on the Airport property within the March 29 Lake-Phu Loc River catchment are degraded, consisting primarily of grasses and shrubs, with patches of planted exotic tree species such as eucalyptus. These terrestrial ecosystems have scant biodiversity value (Photo 7 and Photo 8). In addition, because urban settlements cover the entire area between the northern boundary of the Airport and Da Nang Bay, there are no significant biodiversity areas in the March 29 Lake-Phu Loc River catchment downstream of the Airport property.

West of Airport-Han River Catchment

The terrestrial ecosystems on the Airport property within the West of Airport-Han River Catchment are also degraded, although less so than the March 29 Lake-Phu Loc River catchment. However, much of the vegetation consists of scrub grasses and shrubs, with little tree cover (Photo 9 and Photo 10). These terrestrial ecosystems have negligible biodiversity value. In addition, because urban settlements cover the entire area between the southern boundary of the Airport and the Han River, there are no biodiversity concerns in the West of Airport-Han River catchment downstream of the Airport property.

6.3.2. AQUATIC ECOSYSTEMS AND BIODIVERSITY

March 29 Lake-Phu Loc River Catchment

The lakes and wetlands in the March 29 Lake-Phu Loc River catchment in the northern part of the Airport (Sen Lake, Lake B, Lake C, Xuan Lake and March 29 Lake) are part of a coastal plain running the entire length of Da Nang City. Aquatic resources have historically been harvested by local residents in these lakes and wetlands. Harvesting of aquatic resources from these lakes and wetlands at the north end of the Airport was prohibited in 2007 following the detection of high dioxin levels in fish tissues and higher than normal dioxin levels in the blood samples of persons using the lake for economic purposes.

West of Airport-Han River Catchment

Aquatic ecosystems in the part of the Airport property within the West of Airport-Han River Catchment is largely restricted to surface drainages conveying airport runoff, as well as four

[91] Da Nang Centre for Environmental Technology 2009.

small artificial lakes formed at the time of Airport construction.[92] These lakes are used for aquaculture and are dredged every year.

6.3.3. ENDANGERED SPECIES

A baseline survey of terrestrial and aquatic biodiversity will be conducted in the initial stages of Project implementation and will include surveys to identify the possible presence of rare and endangered species. The EMMP will contain explicit descriptions regarding how rare and endangered species will be handled during the Project.

[92] Office 33 2008.

Section 7. Environmental Consequences

This section presents a complete description of the potential environmental impacts associated with each remedial alternative.

7.1. Environmental Impacts Not Considered

The ESS indicated a number of environmental resources could likely be excluded from the EA; additional environmental information obtained since the ESS was prepared confirms that the environmental resources listed in this section do not need to be considered in this EA.

- Nature Reserves and Protected Areas – There are three nature reserves and protected areas in Da Nang City, the closest of which is at the northwestern end of Da Nang Bay (Son Tra Nature Reserve) approximately 7 km from the northern part of the Airport property. None of the remedial alternatives would negatively influence any of the nature reserves and protected areas.

- Cultural and Historic Sites – There are no designated cultural and historic features on the Airport property, and none of the remedial alternatives would negatively influence cultural and historic sites outside of the Airport property.

- Tourism Resources –While there are significant tourism resources throughout Da Nang City, these are located far from the Airport property. None of the remedial alternatives would negatively influence tourism resources in Da Nang City.

7.2. Potential Effects on Land Use

7.2.1. Description of Effects

Potential effects on Land Use are associated with the land disturbance area (in m^2) of each of the alternatives.

7.2.2. Impact Analysis

Table 22 shows the land disturbance area associated with the four alternatives.

The Active Landfill alternative is associated with the greatest land disturbance area, and is almost twice that of the ISTD/IPTD alternative and 13% greater than the Passive Landfill alternative. The disturbance area of the Passive Landfill alternative is 60% greater that of the ISTD/IPTD alternative.

The current land use of the Airport Property is already limited by residential housing on all borders and Da Nang Bay to the north. The runway expansion planned in the future for the northern portion of the Airport will limit encroachment upon the eastern portion of Lake C, which may impact the excavation of Sen Lake. Height limitations of the landfill are also critical, due to the close proximity to the end of the runways.

TABLE 22. COMPARISON OF LAND DISTURBANCE AREA FOR THE REMEDIAL ALTERNATIVES

Alternative	Remediation Step	Land Disturbance Area (m^2)
No Action	Mixing Loading Area (footprint)	19,600
	Storage Area (footprint)	16,200
	Drainage Ditch (footprint)	35,600
	Eastern Hotspot (footprint)	7,700
	Sen Lake and Eastern Wetland (footprint)	85,400
	PISA (footprint)	3,200
	Total Land Disturbance Area	167,700
Passive Landfill	Total Area to be Excavated with (footprint of all areas to be excavate)	167,700
	Footprint of Temporary Storage and Dewatering Area	21,000
	Haul Road Upgrade and Widening	74,000
	Landfill Footprint	33,350
	Total Land Disturbance Area	296,050
Active Landfill	Total Area to be Excavated with (footprint of all areas to be excavate)	167,700
	Footprint of Temporary Storage and Dewatering Area	53,000
	Haul Road Upgrade and Widening	74,000
	Landfill Footprint	40,250
	Total Land Disturbance Area	334,950
ISTD/IPTD	Total Area to be Excavated with (footprint of all areas to be excavate)	167,700
	Footprint of Contaminated Soil Stockpile	7,300
	Footprint of Contaminated Sediment Stockpile	8,100
	Total Land Disturbance Area	183,100

7.2.3. ASSESSMENT

Land use impacts are assessed as **Significant** for all three alternatives, with the ISTD/IPTD alternative having the lowest potential land use impact and the Active Landfill alternative having the greatest potential land use impact.

7.3. Potential Environmental And Health Impacts Associated With Cleanup Of Unexploded Ordnance

7.3.1. DESCRIPTION OF EFFECTS

Given that the Airport has served as a military base, surveying for and clearing UXO would be required for all Project areas under any remedial alternative.

7.3.2. IMPACT ANALYSIS

The proposed landfill siting location in the southwestern part of the Airport property has a number of munitions bunkers whose age, contents, and overall integrity are unknown (Photo 6). The level of environmental contamination being generated by these munitions bunkers, and the length of time that might be required to remediate these facilities and dispose of them in order for a landfill to be properly constructed, are unknown. These impacts are applicable to both the Passive and Active Landfill alternatives. The northern part of the Airport, where many of the Project activities would be located under all three remedial alternatives, has no such munitions bunkers; more standard protocols for surveying and clearing of UXO would be required in this Project area.

7.3.3. ASSESSMENT

The potential environmental and associated human health risks associated with cleanup of UXO and munitions are assessed as **Significant** for all three remedial alternatives. However, as the potential risk from UXO is related to the size of the footprint for each alternative, the potential risk from UXO is greatest for the Active Landfill alternative and lowest for the ISTD/IPTD alternative. In addition, the requirements for remediating munitions bunkers (and possibly other similar facilities located in the southwestern part of the Airport property) in order for the Passive or Active Landfill alternatives to proceed, is unknown.

7.4. Effects on Surface Water Hydrology

7.4.1. DESCRIPTION OF EFFECTS

Implementation of any of the three alternatives would result in changes to surface water hydrology. These changes to surface water hydrology would occur from:

- Clean water diversions around Project areas in order to manage surface runoff and to minimize the generation of project-affected water, and to enable certain Project activities to occur such as the excavation of the Drainage Ditch hotspot.

- Potential changes to the hydrology of Sen Lake, and possibly the eastern wetland area, during the removal of contaminated sediments from the lake.

7.4.2. IMPACT ANALYSIS

The impacts of any of the remedial alternatives on surface water hydrology would be short in duration, reversible, and generally low in magnitude:

- The area over which the Project activities would occur is small relative to both the total area of the Airport property and the total area of the two catchments.

- The diversion of Sen Lake inflows via the Drainage Ditch to the Eastern Wetland during excavation of Sen Lake sediments (and the reverse if eastern wetland sediments need to be excavated), would by itself have no effect on Sen Lake hydrology.

- The road currently designated as the haul road for the Passive and Active Landfill alternatives already incorporates culverts and surface runoff drainage systems to

accommodate watercourse flows. These would be maintained and enhanced as required when the road is upgraded under these alternatives.

- The excavation of sediments from Sen Lake is a required component of all three remedial alternatives. Mitigation measures may be required to limit the hydrologic effects of excavating Sen Lake sediments, but these would be applied irrespective of the remedial alternative that is selected.

7.4.3. ASSESSMENT

Project effects on surface water hydrology are assessed as **Insignificant** for all remedial alternatives.

7.5. Effects on Surface Water Quality

7.5.1. DESCRIPTION OF EFFECTS

All three alternatives would have potential impacts on surface water quality due to the generation of project-generated contaminated waste water.

Passive and Active Landfill Alternatives

The major sources of project-affected water in the Passive and Active Landfill alternatives would be:

- Precipitation on the Temporary Storage and Dewatering Area during its operation
- Precipitation on the landfill during placement of contaminated material
- Precipitation on contaminated soil during excavation
- Groundwater seepage into open excavations
- Dredging of Sen Lake and dewatering of sediments
- Generation of landfill leachate

ISTD/IPTD Alternative

The major sources of project-affected water in the ISTD/IPTD alternative would be:

- Precipitation on contaminated soil during excavations
- Groundwater seepage into open excavations
- Precipitation on the soil and sediment stockpiles during set-up, maintenance, and treatment

7.5.2. IMPACT ANALYSIS

Appendix A5 provides detailed calculations and assumptions for the volume of project-affected water generated for each remedial alternative; these are summarized in Table 23.

Passive Landfill Alternative

The amount of project-generated contaminated wastewater under the Passive Landfill alternative is estimated at approximately 262,240 m^3. Most of this is generated as landfill leachate, assuming a 50-year lifespan and 60 percent of wet season precipitation being generated as leachate.[93] Operation of the Temporary Storage and Dewatering Area, and water associated with sediments excavated from Sen Lake, are estimated together to generate approximately 6,675 m^3 of project-affected water, while other Project activities are estimated to generate smaller amounts of project-affected water requiring treatment.

Active Landfill Alternative

The amount of project-affected water generated under the Active Landfill alternative is estimated at approximately 137,600 m^3 (Table 23). Less project-affected water would be generated by landfill leachate under the Active Landfill alternative (10 year lifespan), assuming successful implementation. Project-affected water generated by operation of the Temporary Storage and Dewatering Area would be significantly greater than in the Passive Landfill alternative (68,200 m^3), as this facility would be larger and would have to remain in place longer in order to accommodate the requirement to uniformly mix contaminated soil and sediments prior to placing in the Active Landfill. Other Project activities (groundwater seepage into excavations, Sen Lake dredgate water) are estimated to generate smaller amounts of project-affected water requiring treatment.

ISTD/IPTD Alternative

The amount of project-affected water generated under the ISTD/IPTD alternative is estimated at approximately 23,600 m^3. The lower volume of project-affected water in this alternative (as compared to the two Landfill alternatives) is because there would be no operation of a Temporary Storage and Dewatering Area and there would be no landfill leachate. This is partially offset by the project-affected water that would be generated from the construction and operation of the Contaminated Soil and Contaminated Sediment Stockpiles.

7.5.3. ASSESSMENT

The ISTD/IPTD alternative is assessed as having the lowest potential environmental impact on water quality of the three remediation alternatives, while the Active Landfill alternative is assessed as having the highest potential impact on water quality.

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[93] Visvanathan et al. 2003.

TABLE 23. ESTIMATED VOLUMES OF CONTAMINATED WASTEWATER FOR THE REMEDIAL ALTERNATIVES

			Passive Landfill		Active Landfill		ISTD/IPTD	
	Project Activity	**Effect**	**Impact Analysis**	**Amount (m^3)**	**Impact Analysis**	**Amount (m^3)**	**Impact Analysis**	**Amount (m^3)**
A.	Operation of temporary storage and dewatering area[1]	Precipitation	11 months duration, 21,000 m^2 area, dry season, 100% exposure[8]. Assume 80% infiltration[2].	3,336	14 months duration (11 months dry season, 4 months wet season). Area is 53,000 m^2, temporary cover during wet season[8]. Assume 80% infiltration (dry season) and 30% infiltration (wet season)[2,3].	68,209	---	---
B.1	MLA Excavation (includes PISA) [1]	Precipitation[2,8]	2 months total duration (dry season). Total excavation area = 22,800 m^2. One quarter open for a maximum of 2 weeks (5,700 m^2). Assume 50% infiltration	102.9	2 months total duration (dry season). Total excavation area = 22,800 m^2. One quarter open for a maximum of 2 weeks (5,700 m^2). Assume 50% infiltration	102.9	2 months total duration (dry season). Total excavation area = 22,800 m^2. One quarter open for a maximum of 2 weeks (5,700 m^2). Assume 50% infiltration	102.9
B.2		Groundwater seepage	Total excavation area = 22,800 m^2. Excavation depth estimated at 1.1 m. One quarter open for a maximum of 2 weeks (4,900 m^2).Q (flow) estimated at 0 as proposed excavation is above modeled groundwater elevation (1.5 m bgl)[4].	0	Total excavation area = 22,800 m^2. Excavation depth estimated at 1.1 m. One quarter open for a maximum of 2 weeks (4,900 m^2).Q (flow) estimated at 0 as proposed excavation is above modeled groundwater elevation (1.5 m bgl)[4].	0	Total excavation area = 22,800 m^2. Excavation depth estimated at 1.1 m. One quarter open for a maximum of 2 weeks (4,900 m^2).Q (flow) estimated at 0 as proposed excavation is above modeled groundwater elevation (1.5 mbgs)[4].	0
C.1	SA & Drainage Ditch Excavation[1]	Precipitation[2,8]	2 months total duration (dry season). Total excavation area = 51,800 m^2. One quarter open for a maximum of 2 weeks (12,950 m^2). Assume 50% infiltration	234	2 months total duration (dry season). Total excavation area = 51,800 m^2. One quarter open for a maximum of 2 weeks (12,960m^2). Assume 50% infiltration	234	1 month total duration (dry season). Total excavation area = 51,800 m^2. One quarter open for a maximum of 1 week (12,950 m^2). Assume 50% infiltration	116.9

TABLE 23. ESTIMATED VOLUMES OF CONTAMINATED WASTEWATER FOR THE REMEDIAL ALTERNATIVES

			Passive Landfill		Active Landfill		ISTD/IPTD	
	Project Activity	**Effect**	**Impact Analysis**	**Amount (m^3)**	**Impact Analysis**	**Amount (m^3)**	**Impact Analysis**	**Amount (m^3)**
C.2		Groundwater seepage	Total excavation area = 51,800 m^2. Excavation depth estimated at 1.6 m. One quarter open for a maximum of 2 weeks (12,950m^2). Q (flow) estimated at 0.026 - 0.35 m^3/day[4].	5.2	Total excavation area = 51,800 m^2. Excavation depth estimated at 1.6 m. One quarter open for a maximum of 2 weeks (12,960 m^2). Q (flow) estimated at 0.026 - 0.35 m^3/day[4].	5.2	Total excavation area = 51,800 m^2. Excavation depth estimated at 1.6 m. One quarter open for a maximum of 2 weeks (12,960 m^2). Q (flow) estimated at 0.026 - 0.35 m^3/day[4].	5.2
D.	Sediment Excavation[5]	Management of dredgate	Initial saturation = 30%, where n=Vv/V, Porosity (n) = 0.35, Porosity volume (V_v) = 11,130 m^3.	3,339	Initial saturation = 30%, where n=Vv/V, Porosity (n) = 0.35, Porosity volume (V_v) = 11,130 m^3.	3,339	Initial saturation = 30%, where n=Vv/V, Porosity (n) = 0.35, Porosity volume (V_v) = 11,130 m^3.	3,339
E.	Placement of contaminated material in landfill[1]	Precipitation[2,8]	4 months duration, dry season (2 weeks/cell). Filled sequentially. 8 cells, maximum exposure 1/4 of landfill. Assume 80% infiltration.	75.8	4 month duration, dry season (1.3 weeks/cell). Filled sequentially. 12 cells, maximum exposure ¼ of landfill. Assume 80% infiltration.	97.5	---	---
F.1	Pile Construction & Treatment[1]	Precipitation on soil stockpile[2,3,8]	---	---	---	---	7,300 m^2 area of soil stockpile - 1 month pile construction (dry season), 100% exposure, 95% infiltration; treatment - 5 months (dry season), 1 month (wet season) - vapor barrier capped, 10% infiltration	5,045

TABLE 23. ESTIMATED VOLUMES OF CONTAMINATED WASTEWATER FOR THE REMEDIAL ALTERNATIVES

			Passive Landfill		Active Landfill		ISTD/IPTD	
	Project Activity	**Effect**	**Impact Analysis**	**Amount (m^3)**	**Impact Analysis**	**Amount (m^3)**	**Impact Analysis**	**Amount (m^3)**
F.2		Precipitation on sediment stockpile[2,3,8]	---	---	---	---	8,100 m^2 sediment stockpile - maintenance and setup - 3 months (dry season) 100% exposure, 95% infiltration, 4 months (wet season) temporary cap (10% infiltration); treatment - 6 months (dry season) - vapor barrier capped, 10% infiltration	14,994
G.	Operation of Landfill	Leachate[7]	50 year lifespan[8]. Footprint (excluding support facilities) = 21,000 m^2. Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate[6].	255,150	10 year lifespan[8].Footprint (excluding support facilities) = 27,000 m^2.Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate[6].	65,610	---	---
	Total			**262,242**		**137,597**		**23,603**

Notes:

Impact analysis based on conceptual design of each remedial alternative and indicative schedules outlined in Figures 8, 10, and 13.

1 Infiltration rates based on professional judgment and literature values (Wanielista et al. 1997; Vesilind et al. 2002).

2 Dry season 1970-2009 Monthly average rainfall (mm) used.

3 Wet season 1970-2009 Monthly average rainfall (mm) used.

4 Q = 0.2 - 2.9 m^3 based on range of K values. Q= (dh/dl)KA, where, K = Hydraulic conductivity (Nguyen Hoang Van 2009a), dh/dl = hydraulic gradient (assumed from topographic relief and MOD personal communication), A = cross-sectional area (assumed entire length of open excavation (square) perimeter to estimate worst case flows) and groundwater estimated at 1.5 mbgs (dry season) (Office 33, 2008 - measured groundwater at 2-2.5 mbgs).

5 ISTD/IPTD Cost Estimate (Appendix A3).

6 Visvanathan et al. 2003. Effects of Monsoon Conditions on generation and composition of landfill leachate – lysimeter experiments with various input and design features.

7 Wet season 1970-2009 Annual Average rainfall (mm) used.

8 Assumptions made as site specific data unavailable at time of analysis.

Rainfall data source - Nguyen (2009a).

7.6. Effects on Groundwater

7.6.1. DESCRIPTION OF EFFECTS

The ESS identified the following potential effects of the Project on groundwater:

- The depth of groundwater would influence depth of excavation possible for landfill. It would also influence amount of groundwater seepage into excavations, and amount of pumping and treatment required from excavations before discharge into the natural environment.
- There is the potential for contamination of shallow groundwater due to the generation of landfill leachate, although with use of a landfill lining, the potential for this contamination is low.

7.6.2. IMPACT ANALYSIS

All excavation activities are scheduled to occur in the dry season when groundwater levels are at the lowest. For this reason, the amount of groundwater seepage into excavations is expected to be minimal, and would comprise an insignificant portion of the total volume of project-affected water generated by any of the remedial alternatives (Table A5.1 and Table A5.2).

Under the Passive and Active Landfill alternatives, a sufficient amount of clean fill would be imported to raise the landfill above flood levels and shallow groundwater. The Temporary Storage and Dewatering Area for the Landfill alternatives, and the stockpiles for the ISTD/IPTD, are not currently designed above flood levels and may in the rainy season be subject to flooding by shallow groundwater. This would generate additional project-contaminated wastewater requiring treatment. The presence of a uniform aquitard beneath the shallow aquifer means impacts to the deeper aquifers are unlikely.

7.6.3. ASSESSMENT

Project effects on groundwater are assessed as **Insignificant** for all alternatives.

7.7. Potential Effects of Dioxin-Contaminated Material on Air Quality

7.7.1. DESCRIPTION OF EFFECTS

This section assesses the potential environmental effects of extracting, dewatering, stockpiling, transporting, containing, and treating dioxin-contaminated material causing a release of this material into the air, transport, and dispersion of this material through the air, and potential exposure to this material by persons working and living on or near the Airport property.

7.7.2. IMPACT ANALYSIS

Appendix A6 provides the detailed calculations and modeling assumptions in assessing the potential effects of extraction, transport, containment, and treatment of dioxin-contaminated materials on air quality.

Passive Landfill Alternative

The main sources of potential exposure in the Passive Landfill alternative are the existence of two larger stationary Project areas in which dioxin-contaminated material would be exposed to the environment for an extended period of time: the Temporary Storage and Dewatering Area, and the landfill itself. Landfill cells would be covered once they have been filled with contaminated material but would need to remain open during filling. In addition, the Temporary Storage and Dewatering Area would need to be partially exposed so that trucks can be loaded with contaminated material for transport to the Landfill site.

The transport of contaminated material along the haul road is a major potential source of dioxin contamination. Trucks conveying dioxin-contaminated material are significant sources of dioxin that require mitigation and monitoring. Without appropriate engineering controls in place, there would be a risk of potential exposure to dioxin along those parts of the haul road alignment that are near residential areas on the Airport and near the main airport entrance. However, the dioxin exposure associated with temporary storage, dewatering, and deposition of contaminated soil and sediment into the landfill are much higher than material transport.

Active Landfill Alternative

The relative potential for human exposure to dioxin contaminated fugitive dust emissions as a result of excavation, dewatering, stockpiling, transporting, containing, and treating dioxin-contaminated material in the Active Landfill alternative is estimated to be the highest of any of the three remedial alternatives.

The main source of additional potential dioxin exposure in the Active Landfill alternative, as compared to the Passive Landfill alternative, is the additional total exposure caused by:

- The longer operation of the Temporary Storage and Dewatering Area
- The longer time required to fill the landfill due to having to layer in the bulking agent
- A likely higher proportion of the total landfill area that would need to be open at any given time given the pattern required of laying down the contaminated material

ISTD/IPTD Alternative

The ISTD/IPTD alternative is predicted to result in less potential exposure to poorer air quality caused by extracting, dewatering, stockpiling, transporting, containing, and treating dioxin-contaminated material. The main reason for this is that the ISTD/IPTD alternative would have no large facilities in which dioxin-contaminated material would be exposed to the environment for an extended period of time. The Contaminated Soil and Contaminated Sediment Stockpiles would be exposed while they are being constructed, but would be covered by clean fill on all sides to create the stockpile and the clean soil berm. This potential exposure would be limited

relative to the potential exposure generated by the Temporary Storage and Dewatering Area and the landfill in either of the two Landfill alternatives.

7.7.3. ASSESSMENT

The ISTD/IPTD alternative is expected to result in the lowest total potential dioxin exposure from air emissions of any of the three remedial alternatives. The need in both Landfill alternatives to operate the Temporary Storage and Dewatering Area and the landfill - two large facilities in which dioxin-contaminated material would be exposed to the environment for an extended period of time – create a level of potential exposure that is not expected to be generated under the ISTD/IPTD alternative. The gender differences in effects of exposure to dioxin make the differences in potential dioxin exposure among the three remedial alternatives even more significant.

7.8. Potential Effects of Other COPCs and Dust on Air Quality

7.8.1. DESCRIPTION OF EFFECTS

This section assesses the potential environmental effects of emissions of other COPCs and dust on air quality, transport, and dispersion of these pollutants, and potential exposure to this material by persons working and living on or near the Airport property.

7.8.2. IMPACT ANALYSIS

The following are expected to be the potential sources of other COPCs and dust:

- Excavation of contaminated materials and transport to the stockpiles, dewatering areas, or to the landfill
- Transport of clean fill and other materials into the Project area
- Emissions from the stack in the ISTD/IPTD alternative

All three remedial alternatives require the excavation, hauling, and manipulation of large volumes of contaminated soil and sediment. The release of other COPCs and dust is a potential significant environment impact for all three remedial alternatives.

The Passive and Active Landfill alternatives would require greater amounts of contaminated soil and sediment to be handled and transported than in the ISTD/IPTD alternative. The amount of other COPCs and dust being generated from excavation and transport is therefore likely to be greater in the two Landfill alternatives than in the ISTD/IPTD alternative. Stack emissions during stockpile thermal treatment in the ISTD/IPTD alternative may contain other COPCs that are released into the air and this is a potential source of contamination relevant only to ISTD/IPTD. Other COPCs in treatment system off-gas would be sequestered by GAC. In any case, data from samples collected in January 2010 suggest no other COPCs are present at high enough concentrations to cause a problem in off-gas from an ISTD/IPTD system. If new data suggest other COPCs are present at levels of concern, their presence can be mitigated during the design of the off-gas treatment system so as to prevent any potential risk.

7.8.3. ASSESSMENT

Potential effects on emissions of other COPCs and dust on air quality and human exposure to other COPCs and dust are assessed as **Significant** for all alternatives.

7.9. Potential Effects on Greenhouse Gas Emissions

7.9.1. DESCRIPTION OF EFFECTS

Implementation of any of the three remedial alternatives would result in effects on climate change, specifically due to the generation of greenhouse gases (GHGs). For the purposes of this analysis, CO_2, and carbon dioxide equivalent (CO_{2e}) will be referred to collectively as GHG emissions.

Passive and Active Landfill Alternatives

The following activities have been excluded from the analysis due to insufficient data and/or having an assumed minimal contribution: 1) mobilization of materials/equipment to Vietnam; 2) operation of decontamination areas; 3) electricity requirements of passive landfill operations; 4) landfill gas emissions during operations; and 5) maintenance of the stockpiles and disposal of the treated soil for the thermal desorption alternative. Clearing and grubbing of the landfill area, SA and MLA have been excluded from the analysis as the potential Project effects for all three remedial alternatives are Insignificant.

The major sources of GHGs in both Landfill alternatives would be:

- Operation of equipment to construct Temporary Storage and Dewatering Area
- Operation of equipment to upgrade the roads
- Operation of equipment to construct the landfill
- Operation of equipment to construct decontamination areas
- Operation of equipment during excavations
- Operation of equipment to dredge Sen Lake
- Transportation of contaminated material to the dewatering area and landfill
- Importing of fill to construct Temporary Storage and Dewatering Area, build landfill subgrade, backfill excavated areas and construct the decontamination areas
- Operation of equipment to provide a temporary and final cap landfill
- Transportation of bulking agents to landfill to adequately mix the contaminated material for bioremediation (Active Landfill alternative only)

ISTD/IPTD Alternative

The major sources of GHGs in the ISTD/IPTD alternative would be:

- Operation of equipment required to construct the treatment stockpiles
- Operation of equipment to construct the ISTD/IPTD treatment system
- Operation of equipment to construct decontamination areas
- Operation of equipment during excavations
- Operation of equipment to dredge Sen Lake
- Transportation of contaminated material to the stockpiles
- Importing of fill to construct the stockpiles, backfill excavated areas, and construct the decontamination areas
- Electricity required for treatment of the stockpiles

7.9.2. IMPACT ANALYSIS

Appendix A7 provides detailed calculations and assumptions for the GHG emissions generated for each remedial alternative.[94] Table 24 provides a summary of the results.

Passive Landfill Alternative

The GHG emissions generated under the Passive Landfill alternative are estimated at 3,925 t. These estimated GHG emissions are split more or less evenly between GHG emissions generated from construction and excavation activities and hauling of materials.

Active Landfill Alternative

The GHG emissions generated under the Active Landfill alternative are estimated at 5,060 t. The differences in GHG emissions between the two Landfill alternatives are:

- More clean fill is required for the Active Landfill alternative as compared to the Passive Landfill alternative. Additional clean fill is needed for the larger Temporary Storage and Dewatering Area to ensure uniform mixing for bioremediation.
- Requirements for electricity to operate the Active Landfill for a 10-year period, and the fact that 14% and 38% of Vietnam's electricity is generated from coal and natural gas, respectively (Appendix A7).
- The requirement for, and transport of, bulking agents increases the GHG emissions by 321 t.

[94] For the purposes of this analysis CO_2 is the primary GHG of concern, except in the case of the transportation where methane (CH_4) and nitrous oxide (N_2O) are included and shown as CO_{2e}.

TABLE 24. COMPARISON OF ESTIMATED GHG EMISSIONS FOR THE REMEDIAL ALTERNATIVES

	Project Activity	Passive Landfill		Active Landfill		ISTD/IPTD	
		Impact Analysis	**Amount (t)**	**Impact Analysis**	**Amount (t)**	**Impact Analysis**	**Amount (t)**
A.	Construction & Operation of Temporary Storage & Dewatering Area	Construction: Dozer, Compactor, Grader, 14 m^3 trucks; 2 month duration, 24,900 m^3 (imported soil, boulders), 30 km round-trip[2]. Operation: Dozer, 11 months duration	774	Construction: Dozer, Compactor, Grader, 14 m^3 trucks; 2 month duration, 63,000 m^3 (imported soil, boulders), 30 km round-trip[2]. Operation: Dozer, 14 months duration	1322.5	---	---
B.	Road Upgrades[2]	Assume 1 paver, 14 m^3 truck; 1 month duration	55.3	Assume 1 paver; 14 m^3 truck; 1 month duration	55.3	---	---
C.	Landfill Construction - Establish subgrade & liner and leachate collection system	Dozer, Grader. 75,000 m^3 import fill. 14 m^3 trucks, import fill source 30 km round-trip, 5 months duration[2]	1192.7	Dozer, Grader. 100,000 m^3 import fill. 14 m^3 trucks, import fill source 30 km round-trip, 5 months duration[2].	1498.2	---	---
D.	Pile Construction	---	---	---	---	Dozer, Compactor, Grader; 14 m^3 trucks[2]; 22,000 m^3 import fill soil stockpile (2500 m^3 gravel); 24,000 m^3 fill sediment stockpile (2,500 m^3 gravel) [2]; 6 months importing; 5 months pile preparation	976.6
E.	Thermal Treatment System Construction	---	---	---	---	GHGs generated equivalent to landfill construction - Dozer, Grader [2]	276.4
F.	Construction of Decontamination Areas[2]	Dump Trucks, Dozer, Grader, Compactor. 0.5 months for 2 stations; 1,200 m^3 gravel/cobbles	56.1	Dump Trucks, Dozer, Grader, Compactor. 0.5 months for 2 stations; 1,200 m^3 gravel/cobbles	56.1	Dump Trucks, Dozer, Grader, Compactor. 0.25 months for 1 station; 600 m^3 gravel/cobbles	28.1
G.	Hauling contaminated soil/sediment to Dewatering Area	14/27 m^3 trucks. 28,400/23,300 m^3 soil/sediment. 200/400 meter distance (PISA 1,400 m^3, 7.5 km) [2]	22.2	14/27 m^3 trucks. 28,400/23,300 m^3 soil/sediment. 200/400 meter distance (PISA 1,400 m^3, 7.5 km) [2]	22.2	---	---

TABLE 24. COMPARISON OF ESTIMATED GHG EMISSIONS FOR THE REMEDIAL ALTERNATIVES

	Project Activity	Passive Landfill		Active Landfill		ISTD/IPTD	
		Impact Analysis	Amount (t)	Impact Analysis	Amount (t)	Impact Analysis	Amount (t)
H.	Hauling contaminated soil/sediment to Stockpiles	---	---	---	---	36,900/23,300 m^3 soil/sediment. 4 month duration. MLA to SA Stockpile 200 m; Sen Lake to sediment stockpile 400 m	82.8
I.	Hauling contaminated soil/sediment to Landfill	14/27 m^3 trucks. 4 month duration. 61,600 m^3 to be hauled; return distance of 15 km^2 (PISA 200 m)	389.4	14/27 m^3 trucks. 4 month duration. 61,600 m^3 to be hauled; return distance of 15 km^2 (PISA 200 m)	389.4	---	---
J.	SA Excavation	Dozer, Grader, Art-Wheel Loader (3.6 m^3). 2 month duration. 8,900 m^3	165.8	Dozer, Grader, Art-Wheel Loader (3.6 m^3). 2 month duration. 8,900 m^3	165.8	Dozer, Grader, Art-Wheel Loader (3.6 m^3). 1 month duration. 8,900 m^3	82.9
K.	MLA/PISA Excavation	Dozers, Grader, Art-Wheel Loader (3.6 m^3). 2 month duration. (MLA), 0.25 month (PISA). 19,500 m^3 (MLA), 1,400 m^3 (PISA)	186.5	Dozers, Grader, Art-Wheel Loader (3.6 m^3). 2 month duration (MLA), 0.25 month (PISA). 19,500 m^3 (MLA), 1,400 m^3 (PISA)	186.5	Dozers, Grader, Art-Wheel Loader (3.6 m^3). 2 months duration (MLA), 0.25 month (PISA). 19,500 m^3 (MLA), 1,400 m^3 (PISA)	186.5
L.	Sediment Excavation	3 Dozers; 4 month duration; 31,800 m^3	331.6	3 Dozers; 4 month duration; 31,800 m^3	331.6	3 Dozers; 4 month duration; 31,800 m^3	331.6
M.	Backfilling Excavations	Dozer, Compactor, 4 rear dump trucks (14 m^3). 1 month duration[2]; 29,800 m^3 import fill, 30 km round-trip	419.4	Dozer, Compactor, 4 rear dump trucks (14 m^3). 1 month duration[2]; 29,800 m^3 import fill, 30 km round-trip	419.4	Dozer, Compactor, 4 rear dump trucks (14 m^3). 1 month duration[2]; 29,800 m^3 import fill, 30 km round-trip	419.4
N.	Importing Bulking Material	---	---	14 m^3 trucks[2]. 4 month duration. 40% of contaminated soil/sediment required for bulking materials (24,080 m^3)	321	---	---
O.	Landfill Capping[2]	Dozer, Compactor, Grader. Temporary Cap 1 month. Final Cap 3 months	331.6	Dozer, Compactor, Grader. Final Cap 3 months	248.7	---	---
P.	Stockpile Removal	---		---		Removal of two stockpiles and use of material on Airport property	237.8

TABLE 24. COMPARISON OF ESTIMATED GHG EMISSIONS FOR THE REMEDIAL ALTERNATIVES

	Project Activity	Passive Landfill		Active Landfill		ISTD/IPTD	
		Impact Analysis	**Amount (t)**	**Impact Analysis**	**Amount (t)**	**Impact Analysis**	**Amount (t)**
Q.	Operations	-3	---	Two pumps and a blower running 4 hours per day for ten years	41.9	21,000,000 kWh/pile; 6 months treatment time/pile; 2 piles	5304.1
	Total		**3925**		**5059**		**7926**

[1] Assumptions based on Soil & Sedimentation Remediation Opinion of Probable Construction Cost, January 2010 (Landfill & Thermal) (CDM 2010a) unless stated otherwise

[2] Assumptions made by Hatfield as site specific data unavailable at time of analysis

[3] GHGs due to landfill operations has been excluded from this analysis

ISTD/IPTD Alternative

The GHG emissions generated under the ISTD/IPTD alternative are estimated at 7,926 t. The higher GHG emissions are caused by the electricity requirements for ISTD/IPTD treatment of the two contaminated material stockpiles (Appendix A7). This is significantly greater than the reduced requirements for transporting contaminated material to a landfill or importing clean fill for various facilities in the Passive and Active Landfill alternatives.

7.9.3. ASSESSMENT

The Passive Landfill alternative has the lowest potential environmental impact with respect to GHG emissions, while the ISTD/IPTD alternative has the highest potential environmental impact with respect to GHG emissions as a result of the requirement for large amounts of electricity for thermal treatment of the stockpiles.

7.10. Potential Effects on Terrestrial Ecosystems and Biodiversity

7.10.1. DESCRIPTION OF EFFECTS

Implementation of any three of the remedial alternatives would result in the temporary loss of some terrestrial habitat and associated biodiversity:

- In the northeast part of the Airport, as a result of excavation of dioxin hotspots, creation and operation of Temporary Storage and Dewatering Areas (Landfill alternatives), creation and operation of Contaminated Soil and Sediment Stockpiles (ISTD/IPTD alternative), as well as construction laydown areas.
- Along the haul road alignment in the southwestern area of the Airport property (as a result of widening).
- Loss of terrestrial habitat associated with the landfill (both Landfill alternatives).

7.10.2. IMPACT ANALYSIS

The impacts of any of the remedial alternatives on terrestrial ecosystems and biodiversity are assessed based on limited baseline data available. The impacts are considered small in magnitude, short in duration, and largely reversible because:

- The terrestrial habitats on the Airport property are highly-altered and degraded as a result of human activities, and contain negligible terrestrial biodiversity value.
- Excavation and construction areas would be reclaimed and restored once the Project is complete; the landfill cap would be vegetated, thereby creating terrestrial habitat with a habitat value that would likely be similar to existing terrestrial ecosystems.

The relative impacts of the landfill alternatives are approximately three times that of the ISTD/IPTD alternative, based on the area of disturbance.

7.10.3. ASSESSMENT

Potential environmental impacts on terrestrial ecosystems and biodiversity are assessed as **Insignificant** for all Project alternatives. A baseline survey of terrestrial biodiversity, including surveys for possible presence of rare and endangered species, will be conducted in the initial stages of Project implementation to confirm this assessment.

7.11. Potential Effects on Wetlands, Aquatic Ecosystems, and Aquatic Biodiversity

7.11.1. DESCRIPTION OF EFFECTS

Most of the wetlands, aquatic ecosystems, and aquatic biodiversity that may be affected by the Project are located in the northern part of the Airport property. Potential effects on these aquatic environmental resources may occur as a result of changes in hydrologic conditions in Sen Lake and its associated wetlands, and changes in water quality.

7.11.2. IMPACT ANALYSIS

Project effects on surface water hydrology have been assessed as **Insignificant** for all three remedial alternatives. The impacts of any of the remedial alternatives on wetland, aquatic ecosystems, and aquatic biodiversity are assessed based on limited baseline data available.

With respect to the effect of any changes in hydrologic conditions on Sen Lake and its associated wetlands:

- The diversion of Sen Lake inflows via the Drainage Ditch to the Eastern Wetland during excavation of Sen Lake sediments (and the reverse if eastern wetland sediments need to be excavated) would have no effect on Sen Lake hydrology.

- The excavation of sediments from Sen Lake would be a required component of all three remedial alternatives. Mitigation measures may be required to limit the hydrologic effects of excavating Sen Lake sediments and disposal of contaminated fish, but these would be applied irrespective of the remedial alternative selected.

There would be no long-term effect on wetlands from hydrologic changes; post-construction hydrologic conditions would be essentially the same as pre-construction so that flows to the wetlands are not altered. Based on area of disturbance, the impacts of the landfill alternatives and the ISTD/IPTD alternative are identical.

With respect to potential effects via changes in surface water quality, all project-affected water would be treated to the required standards prior to release.

7.11.3. ASSESSMENT

Potential environmental impacts on wetlands, aquatic ecosystems, and aquatic biodiversity are assessed as **Insignificant** for all Project alternatives. A baseline survey of aquatic biodiversity, including surveys for possible presence of rare and endangered species, will be conducted in the initial stages of Project implementation to confirm this assessment.

7.12. Potential Effects on Noise Levels

7.12.1. Description of Effects

All three remedial alternatives would require the use of equipment and machinery for construction of Project facilities such as the landfill, contaminated material stockpiles, and the Temporary Storage and Dewatering Area. They would also require truck movement and hauling of contaminated from the hotspots to these facilities, as well as clean materials from off-site borrow sources. This equipment, machinery, and truck hauling would increase noise levels on, and in the vicinity of, the Airport.

7.12.2. Impact Analysis

Two indicators of the amount of noise that would be generated for each remedial alternative are provided in Table 25: the estimated duration with which equipment and machinery would be used; and, the total estimated distance driven by trucks for materials hauling.

TABLE 25. COMPARISON OF NOISE IMPACTS FOR THE REMEDIAL ALTERNATIVES[95]

	Passive Landfill	Active Landfill	ISTD/IPTD
Total Estimated Duration of Heavy Machinery Equipment Use (hr)	7,340	7,780	3,020
Total Distance Driven by Hauling Equipment (km)	369,920	580,570	230,600

The values of both of these indicators are estimated to be lowest for the ISTD/IPTD alternative, because there would be less material to transport and a set of facilities that, cumulatively, would be smaller than for the other two remedial alternatives. Conversely, the values of both these indicators would be highest for the Active Landfill alternative because there would be the most material to transport and a set of facilities that, cumulatively, would be larger than for the other two remedial alternatives.

7.12.3. Assessment

The ISTD/IPTD alternative is assessed as having the lowest potential environmental impact on noise levels associated with the Project.

[95] Estimates generated from GHG calculations (Appendix A7).

7.13. Potential Effects on Natural or Depletable Resource Requirements

7.13.1. Description of Effects

All three remedial alternatives would require the importation of clean fill, gravel and, in the case of the Active Landfill alternative, a bulking agent to mix with contaminated materials before placing in the landfill. The sources of these materials are unknown, and there may be environmental effects associated with providing these materials for the Project. There may also be cumulative environmental effects, particularly when considered in the context of the demands for these types of materials throughout Da Nang City, especially clean fill and gravel.

7.13.2. Impact Analysis

It is noted that fill used for constructing the dewatering area (Landfill alternatives) or the soil and sediment stockpiles (ISTD/IPTD alternative) could be used as the clean fill for backfilling the excavated areas. The conceptual designs of the alternatives currently have these excavated areas being filled in within two weeks of excavation in order to minimize the generation of project-affected water. The assessment conclusions described below and shown in Table 26 are based on the maximum required volumes of clean fill that may be required.

TABLE 26. COMPARISON OF CLEAN FILL REQUIRED FOR THE REMEDIAL ALTERNATIVES

Material Required	Amount Of Material Required (m^3)		
	Passive Landfill	**Active Landfill**	**ISTD/IPTD**
Landfill Construction (subgrade, liner, cap)	75,000	100,000	0
Decontamination Areas	1,200	1,200	600
Construction of Dewatering Area	24,900	63,000	0
Construction of Soil and Sediment Stockpiles	0	0	46,000
Clean Fill required to Fill Excavations in SA and MLA	38,300	38,300	38,300
Total	**138,200**	**201,300**	**84,300**

The Passive and Active Landfill alternatives would require approximately 140,000 and 200,000 m^3 of clean fill, respectively, while the ISTD/IPTD alternative would require approximately 60% of the clean fill required in the Passive Landfill alternative. These differences are due largely to the fill requirements to create the landfill subgrade, which are not required in the ISTD/IPTD alternative.

Vietnamese environmental legislation requires a full EIA to be prepared for any facility that extracts "minerals" to use as leveling and filling materials with a capacity of 100,000 m^3 of fill per year or greater.[96] If the clean fill for the Project were to be obtained from a new, single source, a full GVN EIA would be required specifically for the provision of clean fill for both the Passive Landfill and Active Landfill alternatives.

7.13.3. ASSESSMENT

Given that the clean fill requirements for both Landfill alternatives are greater than the EIA trigger in Vietnamese environmental regulations, potential environmental impacts on natural or depletable resources are assessed as **Significant** for both Landfill alternatives and **Insignificant** for the ISTD/IPTD alternative.

7.14. Potential Long-Term Environmental Risks Associated with Operation of the Project

7.14.1. DESCRIPTION OF EFFECTS

There may be potential environmental impacts associated with the operation of the Project once it has been constructed.

7.14.2. IMPACT ANALYSIS

There are long-term environmental risks associated with the O&M of the landfill in the Passive Landfill alternative. The material within the Passive Landfill would still be contaminated above GVN dioxin remediation targets, and improper O&M of the Passive Landfill may result in the release of this contaminated material back into the natural environment. This is assessed as Significant and requiring mitigation.

The long-term environmental risks associated with the operation of the landfill in the Active Landfill alternative are Unknown, as the specific configuration and operation of a landfill for dioxin remediation cannot be described at this time.

For the ISTD/IPTD alternative, Project operation is the actual thermal treatment of the contaminated material stockpiles. There are insignificant risks associated with the operational phase of the ISTD/IPTD alternative.

7.14.3. ASSESSMENT

The ISTD/IPTD alternative is assessed as having the lowest potential long-term environmental risk of the alternatives.

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[96] Decree No. 21 2008.

Section 8. Results of the Environmental Assessment

8.1. No Action Alternative

The No Action alternative has no cost associated with implementation or long term O&M. However, there would be significant externalized costs (e.g., dealing with health effects of neighboring community, impact to Airport expansion, etc.) that cannot be accurately estimated.

The No Action alternative would result in continuation over the long term of the following environmental impacts:

- Soil concentrations that exceed GVN standards by 27 to 107 times the national cleanup goal of 1,000 ppt.[97]
- Sediment concentrations that exceed GVN standards by 20 to 67 times the national cleanup goal of 150 ppt.[98]
- Continued fish contamination at levels that exceed standards by more than 400 times the Health Canada consumption guidelines for edible fish tissue (20 pg/g TEQ wet weight).
- Continued exposure of airport workers.
- Continued potential exposure to area residents.
- Persistence of dioxin in soil and sediment that exceeds GVN standards for at least several more decades, with associated persistence of exposure pathways that could impact environmental, biological and human receptors.

8.2. Environmental Ranking of Remedial Alternatives

The overall potential environmental impact of all alternatives is substantial. All alternatives require the excavation, transport, and deposition of dioxin-contaminated soil from the hotspots into a landfill or stockpile. The wetland ecosystem (Sen Lake and Eastern Wetland) must be drained and dredged to remove contaminated sediments. Impacts to wetlands and terrestrial and aquatic biota are unavoidable over the short term, in order to eliminate the possibility of future dioxin exposure to humans and the environment. A summary of the environmental issues that are common to all three remedial alternatives is provided in Table 27.

The assessment results were used to rank the alternatives to identify the environmentally-preferred alternative which is the alternative with the lowest overall potential environmental impact. The results of the environmental impact analysis of the remedial alternatives are summarized in Table 28. For each assessment criterion, the three alternatives (excluding No Action) are ranked depending on their relative potential environmental impacts. A score of "1"

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[97] TCVN 8183: 2009.
[98] TCVN 8183: 2009.

indicates the highest relative potential environmental impact and a score of "3" indicates the lowest potential environmental impact. Lower cumulative scores are associated with the greatest potential environmental impact among the evaluated alternatives. It should be noted that no weighting has been given to each of the impact assessment criteria.

TABLE 27. PROJECT ACTIVITIES AND ENVIRONMENTAL ISSUES COMMON TO THE REMEDIAL ALTERNATIVES

Activity	Environmental Issues
Excavation of hotspot soil areas	▪ Increased dust levels due to earthworks activities ▪ Increased noise and air emissions from construction equipment ▪ Management of surface water and groundwater inflows into excavations
Excavation of sediment from Sen Lake	▪ Increased noise and air emissions from construction equipment ▪ Increased turbidity and pollutant dispersion in Sen Lake ▪ Potential increase in odor levels ▪ Requires drainage of a wetland system with potential impacts on aquatic biota ▪ Management of contaminated water with the dewatering of sediments
Construction of dewatering area, surface water management system, and decontamination areas	▪ Increased dust levels due to earthworks activities ▪ Increased noise and air emissions from construction equipment ▪ Management of project-affected and 'clean' surface water
Hauling contaminated soil/sediment to dewatering area	▪ Increased dust levels due to transportation activities ▪ Increased noise and air emission from construction equipment ▪ Management of dredgate ▪ Management of project-affected surface water
Import of backfill materials	▪ Increased traffic levels on transportation route from backfill source quarry ▪ Increased dust levels on transportation route from backfill source quarry ▪ Increased noise and air emissions on transportation route from backfill source quarry
Backfill/reclaim excavation and construction areas	▪ Increased dust levels due to earthworks activities ▪ Increased noise and air emission from construction equipment ▪ Management of surface water and groundwater inflows into excavation ▪ Management of landscape restoration activities
Provide safe working environment for workers with gender specific requirements for women	▪ Potential presence of UXO ▪ Potential increased exposure levels to dust, noise, air emissions, and contaminated materials, particularly for the most sensitive receptors (children, women)
Provide sanitary facilities for workers	▪ Management of wastewater and domestic waste generated by workers

TABLE 28. COMPARISON OF POTENTIAL ENVIRONMENTAL IMPACTS OF THE REMEDIAL ALTERNATIVES

Potential Environmental Impact	Assessment Criterion	Remedial Alternative (Environmental Impact Ranking; 1 = Highest Impact Total Score. The Lower the Score, the Higher the Environmental Impact Ranking)		
		Passive Landfill (Total Score = 29)	**Active Landfill (Total Score = 24) Highest Potential Environmental Impact**	**ISTD/IPTD (Total Score = 37) Lowest Potential Environmental Impact**
Potential Environmental and Associated Human Health Risks Associated with Cleanup of UXO and Munitions	Qualitative Assessment based on land area affected by Project	Significant (2)	Significant (1)	Significant (3)
		Requirements to remediate munitions bunkers and possible other similar facilities in the southwestern part of the Airport property are unknown.		
Potential Impacts on Surface Water Hydrology	Qualitative Assessment	Insignificant (3)	Insignificant (3)	Insignificant (3)
Potential Impacts on Surface Water Quality	Volume of project-Affected Water Generated and Requiring Treatment before Release	262,242 m^3 (1)	136,597 m^3 (2)	23,603 m^3 (3)
Potential Impacts on Groundwater Resources	Qualitative Assessment	Insignificant (3)	Insignificant (3)	Insignificant (3)
Potential Impacts on Groundwater Quality	Qualitative Assessment	Insignificant (3)	Insignificant (3)	Insignificant (3)
Potential Effects of Extraction, Transport, Containment, and Treatment of Dioxin-Contaminated Material on Air Quality and Human Exposure	Relative Potential Exposure Index for Dioxin	Intermediate (2)	Highest (1)	Lowest (3)
Potential Effects of Emissions of Other COPCs and Dust on Air Quality and Human Exposure	Qualitative Assessment	Significant (1)	Significant (1)	Significant (1)
Potential Contribution to Greenhouse Gases	t of CO_2 generated by the Project	3,925 t (3)	5,059 t (2)	7,926 t (1)

TABLE 28. COMPARISON OF POTENTIAL ENVIRONMENTAL IMPACTS OF THE REMEDIAL ALTERNATIVES

Potential Environmental Impact	Assessment Criterion	Remedial Alternative (Environmental Impact Ranking; 1 = Highest Impact Total Score. The Lower the Score, the Higher the Environmental Impact Ranking)		
		Passive Landfill (Total Score = 29)	**Active Landfill (Total Score = 24) Highest Potential Environmental Impact**	**ISTD/IPTD (Total Score = 37) Lowest Potential Environmental Impact**
Potential Effects on Terrestrial Ecosystems and Terrestrial Biodiversity	Qualitative Assessment	Insignificant (1)	Insignificant (1)	Insignificant (1)
Potential Effects on Wetlands, Aquatic Ecosystems, and Aquatic Biodiversity	Qualitative Assessment	Insignificant (1)	Insignificant (1)	Insignificant (1)
Potential Effects on Noise Levels	Total Estimated Duration of Equipment Use	7,340 hrs (2)	7,790 hrs (1)	3,030 hrs (3)
	Total Distance Driven by Hauling Equipment	369,920 km (2)	580,570 km (1)	230,600 km (3)
Potential Effects on Natural or Depletable Resource Requirements	Amount of clean fill required	138,200 m^3 (2)	201,300 m^3 (1)	84,300 m^3 (3)
Potential Effects on Land Use	Land Area Disturbed	296,050 m^2 (2)	334,950 m^2 (1)	183,100 m^2 (3)
Potential Long-Term Environmental Risks Associated with Operation of the Project	Qualitative Assessment	Significant (1)	Unknown (2)	Insignificant (3)

8.2.1. ENVIRONMENTALLY PREFERRED ALTERNATIVE - ISTD/IPTD

A comparison of potential environmental impacts (Table 28), effectiveness (Table 29), implementability (Table 30), and cost (Table 31), was made of the alternatives. Based on this, a simple ranking was prepared for each to identify the preferred remedial alternative (Table 32). The ISTD/IPTD alternative was found to have the lowest potential environmental impact of the three remedial alternatives for dioxin remediation at the Airport for the following reasons:

- The ISTD/IPTD alternative would have the lowest potential exposure of local residents to dioxin that might be released into the air and dispersed as a result of extraction, transport, containment, and treatment of contaminated soil and sediments.

- The ISTD/IPTD alternative would not require mitigation of the significant unknown risks associated with cleanup of munitions bunkers in the southwestern area of the Airport property being considered for the Landfill alternatives.

- The ISTD/IPTD alternative requirements for generation and treatment of project-affected water would be lower than for the Landfill alternatives.

- The ISTD/IPTD alternative would have the lowest potential impact on noise levels from Project activities, and would also have the lowest potential effect on natural or depletable resource requirements, as it would have the lowest requirements for clean fill.

- There are insignificant long-term environmental risks associated with the operational phase of the ISTD/IPTD alternative.

- The ISTD/IPTD alternative would have the highest GHG emissions of any of the three remedial alternatives; this would require some form of mitigation, perhaps in the form of purchasing carbon credits to offset emissions. Mitigation measures for ISTD/IPTD would be less expensive and easier to implement than mitigation required to: 1) minimize higher levels of potential dioxin exposure resulting from extraction, transport, containment, and treatment with the Landfill alternatives; 2) remove munitions bunkers prior to implementing either of the Landfill alternatives; or 3) minimize long-term environmental risk associated with operation of the Passive Landfill.

TABLE 29. COMPARISON OF EFFECTIVENESS EVALUATION OF THE REMEDIAL ALTERNATIVES

Passive Landfill	Active Landfill	ISTD/IPTD
Effective for containment: Proven containment strategy; hazardous waste landfills have been used successfully for decades worldwide; 50-year solution. **Ineffective for treatment:** Dioxins would be expected to persist for many decades and would require eventual treatment.	**Effective for containment:** Proven containment strategy; hazardous waste landfills have been used successfully for decades worldwide. **Unknown effectiveness for treatment:** Review of the scientific literature on microbial degradation of chlorinated dioxins[1] shows some degradation of 2,3,7,8-TCDD, but no studies demonstrate degradation below either GVN cleanup goals. Initial results from USEPA and VAST pilot study show approximately 50% dioxin degradation after 120 days[2]; however, it remains unclear whether cleanup goals can be met and scalability of the pilot study to full-scale application is uncertain.	**Effective for treatment (no long-term containment required):** Several well-documented case studies[3] have shown that ISTD/IPTD can treat 2,3,7,8-TCDD to concentrations below GVN cleanup standards. Concentrations of dioxins in exhaust gas in previous case studies were orders of magnitude below regulatory limits. • Over 95% of dioxins will be destroyed *in-situ*. • If design calculations show that GAC would not meet emissions standards for exhaust gas, then a thermal oxidizer would be considered. • Dispersion between the stack and property boundaries or locations of other receptors would be considered in this analysis as well.

Notes:
1 – Field and Sierra-Alvarez 2008.
2 – Allen and Fong 2009 and Allen 2010.
3 – ENSR 2000, Baker and La Chance 2003, Baker et al. 2007 and Heron et al. 2010.

TABLE 30. COMPARISON OF IMPLEMENTABILITY EVALUATION OF THE REMEDIAL ALTERNATIVES

Passive Landfill	Active Landfill	ISTD/IPTD
Landfill siting: an ideal site does not exist on Airport property. **Haul route:** long haul route and high number of truckloads required. **Fill material:** Significant amount of fill material (~140,000 m^3) required for landfill construction, operation, and closure. **Long term O&M:** 50 years after construction.	**Landfill siting:** an ideal site does not exist on Airport property. **Haul route:** long haul route and high number of truckloads required. **Fill material:** Significant amount of fill material (~200,000 m^3) required for landfill construction, operation, and closure. **Electrical use:** estimated ~33,200 kwh/yr required for nutrient distribution system operation (10 years). **Bioremediation design uncertainty:** • Target mechanism: aerobic, aerobic cometabolic, anaerobic, or combination? • Design basis for full scale: distribution of microbes and nutrients/substrates, bioavailability of TCDD, longevity of nutrients/substrates relative to persistence of TCDD, and ability to maintain desired geochemical conditions **Long term O&M:** assumed to be10 years after construction, but may be more if degradation does not occur.	**Electrical use:** estimated 21,000,000 kwh for 6 months of continuous treatment time per pile (two piles total). **Mobilization:** some equipment and technical expertise will have to come from overseas. **Air monitoring:** must ensure emissions do not exceed regulatory limits; GAC and/or thermal oxidizer would be used. **Geotechnical properties of soil post-treatment:** limited quantitative data available, but one study[1] indicated no significant effect. Conservative design assumptions made to stockpile soil and revegetate it post-treatment rather than to use it as structural fill.

Notes:
1 – Heron et al. 2009.

TABLE 31. COMPARISON OF ESTIMATED COSTS ($ MILLION) OF THE REMEDIAL ALTERNATIVES (COST RANGE -30%+50%)

Component	Passive Landfill	Active Landfill	ISTD/ IPTD	Cost Differentiators Between Alternatives
Disposal	$11.5	$11.5	$8.7	Less excavation, hauling, and site clearing/prep for ISTD/IPTD
Construction	$10.3	$15.5	$24.4	Various
Subtotal (First 2 years)	$21.8	$27.0	$33.1	
Long Term O&M	$3.2	$0.7	$0	Passive Landfill: 50 years Active Landfill: 10 years ISTD/IPTD: none
EMMP Implementation	$10.8	$3.0	$0.6	Passive Landfill: 50 years Active Landfill: 10 years ISTD/IPTD: none
Overall Total	**$35.8**	**$30.7**	**$33.7**	

TABLE 32. SUMMARY OF EA FINDINGS FOR DIOXIN REMEDIATION AT DA NANG AIRPORT

Alternative	Effectiveness (i.e., dioxin ≤ cleanup goals/"final remedy")?	Implementable	Environmental Assessment	Estimated Cost (in Millions) (-30% +50%)	Implementation Schedule
No Action	No	Yes	Highest overall potential environmental impact	Externalized	NA
Passive Landfill	No	Yes with challenges	Third-highest overall potential environmental impact	$35.8M	2-year construction, and 50 years long term O&M
Active Landfill (Bioremediation)	Uncertain	Yes with challenges	Second-highest overall potential environmental impact	$30.7M	2-year construction, and 10 years long term O&M
ISTD/IPTD	Yes	Yes with challenges	Lowest overall potential environmental impact	$33.7M	2-year construction and no long term O&M

Notes:
This table summarizes the results of the alternatives analysis in this EA; it also provides a summary of the implementation schedule for each remedy (additional details regarding schedule are provided in the conceptual designs of each alternative.

8.2.2. NEXT ENVIRONMENTALLY PREFERRED ALTERNATIVE – PASSIVE LANDFILL

The Passive Landfill alternative is ranked second in terms of potential environmental impacts associated with dioxin remediation at the Airport for the following reasons:

- The Passive Landfill alternative would have a higher potential exposure of local residents to airborne dioxin as a result of extraction, transport, containment, and treatment of contaminated soil and sediments than the ISTD/IPTD alternative. However, the Passive Landfill alternative would have a much lower potential exposure than the Active Landfill alternative.

- The Passive Landfill alternative would have the lowest estimated GHG emissions of the three remedial alternatives.

- The Passive Landfill alternative is the second-ranked alternative with respect to generation and required treatment of project-affected water.

- However, the Passive Landfill alternative would require mitigation of the significant unknown risks associated with cleanup of UXO, in particular, the munitions bunkers in the southwestern area of the Airport property being considered for the Landfill site.

8.2.3. LEAST ENVIRONMENTALLY PREFERRED ALTERNATIVE – ACTIVE LANDFILL

The Active Landfill alternative is the least-preferred remedial alternative for dioxin remediation at the Airport. The Active Landfill alternative would have the highest potential exposure of local residents as a result of release of dioxin into the air and dispersed during extraction, transport, containment, and treatment of contaminated soil and sediment. The potential exposure for the Active Landfill would be higher than the Passive Landfill because of the increased handling of contaminated material that would be required. This has significant negative implications for gender-specific effects of dioxin exposure generated by this alternative. In addition, as with the Passive Landfill alternative, the Active Landfill alternative would require mitigation of the significant risks associated with cleanup of UXO, in particular, the munitions

Section 9. Environmental Mitigation and Monitoring

9.1. Overview

After the EA is approved, detailed engineering designs, remediation workplan, health and safety plan, health and safety training plan, and sampling and analysis monitoring plan will be prepared for the alternative selected through the EA process. These will inform the final EMMP. The discussion below pertains to information that has been developed based on 10% conceptual designs of the three technology alternatives considered in the EA. However, the EA may need to be amended should the design and planning process lead to changes or identify additional environmental impacts. The Final EMMP will be developed based on engineering designs and plans for the selected alternative. The EMMP will be included as part of procurement documents used for solicitation of goods and services for remedial action.

9.2. Environmental Mitigation

The most important mitigation measure for controlling environmental impacts during the remediation process include worker personal protective measures during UXO clearance, worker protective measures during the remediation process, control of releases of dioxin contaminated material into surface water and air, control of noise and odor during remediation activities, and protection of threatened, endangered or sensitive species during the remediation process. Specific environmental issues and mitigation measures are outlined in Table 33.

TABLE 33. KEY ENVIRONMENTAL ISSUES AND MITIGATION MEASURES

Key Environmental Issues	Mitigation Measures
Threats to Endangered or Threatened species	A biological survey will be conducted prior to commencement of construction.
	A biologist will be employed during construction activities who is trained in identification of endangered or threatened species with habitats located in the geographic area of the Project site.
	If threatened or endangered species are identified during the construction phase, the contractor will immediately notify USAID and stop work until an effective management plan can be initiated.
Increased dust levels due to earth works activities and on transportation routes	Develop **air and noise quality management plan** to address issues relating to increased dust levels. Mitigation measures may include:
	Scheduling excavation activities to minimize time and area of excavation which remains open/exposed
	Frequent spraying/damping down of excavation areas, excavated soil, worksite surface, and sensitive areas along transportation route
	Covering stockpiles, dewatering area, and transportation vehicles to avoid windblown dust mobilization

TABLE 33. KEY ENVIRONMENTAL ISSUES AND MITIGATION MEASURES

Key Environmental Issues	Mitigation Measures
	Cleaning transportation vehicles and construction equipment in decontamination area prior to leaving excavation areas
	Cleaning transportation vehicles prior to exiting backfill source quarry
Increased noise and air emissions from construction equipment and on transportation routes	Develop **air and noise quality management plan** to address issues related to increased noise and air emissions. Mitigation measures may include:
	Ensuring all vehicles and machinery have a register of quality
	Scheduling regular maintenance of construction equipment and transportation vehicles
	Avoiding construction and transportation activities during night time
	Purchasing of carbon credits to provide offsets to mitigate project-generated GHG emissions
Management of project-affected and 'clean' water	Develop **water management plan** to address all water management issues relating to project-affected and 'clean' water including design details of:
	Clean water diversion systems around excavation/construction areas
	Project-affected water collection, storage and treatment systems (for excavation areas, including Sen Lake, and Temporary Storage and Dewatering Area)
	Operation of vehicle decontamination areas between excavation areas, landfill, dewatering area, and stockpiles
	Water testing and water release requirements
Increased turbidity and pollutant dispersion and potential increase in odor levels in Sen Lake	Develop **dredging management plan** which provides design details of how turbidity and odor impacts will be minimized using:
	Proposed aquadam bladder to divide lake into sections
	Pumps and pumping schedule to transfer water to alternate lake section prior to excavation
	Specific dredgate excavation equipment
	Odor suppressant materials
Management of UXO (Component 3: Health and Safety Plan)	Develop detailed **UXO management plan** to address how all Project areas will be surveyed and cleared of UXO prior to commencement of work activities including, but not limited to:
	Providing training and personal protective equipment (PPE) and safety procedures to Project workers

TABLE 33. KEY ENVIRONMENTAL ISSUES AND MITIGATION MEASURES

Key Environmental Issues	Mitigation Measures
	Providing education and mitigation measures for nearby residents and airport personnel and passengers during Project construction
Increased traffic levels on transportation route	Develop **traffic management plan** to address issues relating to traffic impact. Mitigation measures may include:
	Choosing most appropriate transportation route in reducing impact to humans (in consultation with community, where necessary)
	Choosing most appropriate route for truck size to minimize impact to road surface
	Scheduling transportation activities to avoid, where possible, times of maximum congestion (rush hours) and maximum disturbance (night times)
Management of landscape restoration	Develop **restoration and reclamation plan** to address how excavation and construction areas will be restored/reclaimed including details of:
	Schedule for restoration/reclamation activities
	Methods and materials for restoration (revegetation, etc.)
Potential increased exposure levels of dust, noise, and air emissions to Project workers and nearby residents. Potential increased exposure to Project workers and nearby residents, with particular concern to women (Component 3: Health and Safety Plan)	Develop **site specific health and safety plan** to address mitigative measures required for reducing potential impact to workers including, but not limited to:
	Gathering of data on the workers, including their age, sex, awareness on the dioxin issue, food consumption patterns and work history
	Distribution of awareness raising materials for workers, with a specific emphasis on women of child-bearing age, regarding the hazards of working in hotspot areas; and
	Training of field crews to ensure adequate protection and proper utilization of personal protective equipment.
Management of domestic waste and wastewater generated by Project workers	Develop **waste and wastewater management plan** to address all issues relating to the collection/disposal of solid waste and disposal/treatment of wastewater
Generation of GHGs during Project implementation	Purchase sufficient carbon credits to offset GHG emissions

Any ongoing activities found to be either inconsistent with the EMMP, or when new potentially significant environmental concerns are identified, activities shall be halted until an environmental review is conducted and USAID approves conditions for mitigation.

9.3. Environmental Monitoring

The existing baseline data on most environmental resources for this Project are limited. Therefore, prior to the start of Project construction, a comprehensive environmental baseline survey will be undertaken. These baseline data will act as indicators in monitoring environmental effects of the Project during construction and operation activities. Following this baseline survey, a targeted monitoring plan will be developed. This plan will outline where surveyed monitoring points should be established and parameters to be analyzed to determine baseline surface water, groundwater, sediment, and air quality conditions. This plan will provide specific details on the:

- Type of monitoring required (analytical testing, field measurements, visual inspections, etc.)
- Frequency of monitoring required (daily, weekly, monthly, annually, etc.)
- Monitoring roles and responsibilities (contractor, environmental monitor, etc.)
- Reporting responsibilities

9.4. Gender Considerations In Environmental Mitigation And Monitoring Plan (EMMP) Design And Implementation

In conjunction with development of engineering designs and plans, CDM will also prepare a gender assessment in relationship to environmental remediation at the Airport. The assessment will evaluate functional labor categories of the remediation process and determine whether there are gender-specific regulatory restrictions that must be considered or whether there are gender-specific behaviors that might lead to greater risk-taking in the work environment. If such issues are identified, specific measures for controlling these will be included in the remediation workplan and in the final EMMP.

The construction and transportation industries in Vietnam are male-dominated industries. This could imply that a low percentage of women would seek employment related to the remediation activities. Women that do seek remediation employment opportunities will be offered strong protection under Vietnam law to protect them from being exposed to hazardous environments. However, since women may not be aware of, or do not exercise the rights accorded to them by law and regulations,[99] it is important that the Project implement specific provisions to protect women. When considering Project activities, it is important to consider how men's and women's different responsibilities within society make them more or less susceptible to health problems that could arise as a result of the Project.

If women's access to employment opportunities related to the remediation activities is limited due to legal restrictions concerning female employees involved with remediation activities, consideration should be given to alternative income generation activities, as required under

[99] ADB 2005.

Vietnam Labor Law. Under Article 109 of Chapter X[100], women should be offered equal employment opportunities to men, even in non-traditional jobs. In that article, the State ensures the right to equality of women with men in all domains of work and shall adopt policies or encouraging labor users to create conditions for women laborers to have regular jobs. It shall also apply the system of work according to a flexible time schedule. Employers are strictly prohibited from conduct which is discriminatory towards a female employee or conduct which degrades the dignity and honor of a female employee. An employer must implement the principle of equality of males and females in respect of recruitment, utilization, wage increases, and wages. Furthermore, they will need to be paid equally to men, and receive the same benefits, according to Article 111.[101]

The Health and Safety Plan under development includes the use of PPE to prevent dioxin exposure. However, due to the cumbersome nature of the equipment, especially in tropical climates, alternative solutions to standard PPE may need to be proposed before the equipment can be used effectively.

The Project will result in positive impacts for both men and women living and working on or around the airbase. The risk of potential dioxin exposure will be significantly reduced as a result of the successful completion of the remediation activities; however, extreme caution needs to be exercised in removing and transporting contaminated material both for workers and Da Nang residents.

Consideration should be given to dioxin transport and exposure pathways for Da Nang residents, during the removal and transportation of contaminated soil. Exposure pathways include dietary exposure, soil ingestion, dermal absorption and inhalation. The potential increased exposure levels for Da Nang residents from dust and air will be addressed through the Health and Safety Plan. Specific recommendations related to prevention of potential dioxin exposure for all workers will be a critical component of the Health and Safety Plan.

The Traffic Management Plan will ensure that the most appropriate route is selected to minimize the impacts to humans. The Traffic Management Plan should be communicated to Da Nang residents as part of the awareness campaign to ensure that they take extra precautions to reduce exposure during transport times.

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[100] Viet Nam Labour Code: Article 109 of Chapter X: The State ensures the right to equality of women with men in all domains of work and shall adopt policies or encouraging labour users to create conditions for women labourers to have regular jobs. It shall also apply the system of work according to a flexible time schedule.

[101] Viet Nam Labour Code: Article 111 of Chapter X: 1. Employers are strictly prohibited from conduct which is discriminatory towards a female employee or conduct which degrades the dignity and honour of a female employee. An employer must implement the principle of equality of males and females in respect of recruitment, utilization, wage increases, and wages.

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PHOTOS

Photo 1. Panorama of the Former Mixing and Loading Area (December 2009).

Photo 2. Panorama of the Former Storage Area (December 2009).

Photo 3. The Drainage Area Looking South Towards the Airport Runway (December 2009).

Photo 4. The Drainage Ditch Looking North Away from the Airport Runway (December 2009).

Photo 5. Panorama of Sen Lake from the Western Edge of the Weir Looking North (December 2009).

Photo 6. Proposed Landfill Location in the Southwestern Area of the Airport (December 2009).

Photo 7. Vegetation in Northwest MLA within the March 29 Lake – Phu Loc River Catchment (December 2009).

Photo 9. Vegetation Around the SA Within the March 29 Lake – Phu Loc River Catchment (December 2009).

Photo 9. Vegetation in the Southwest Landfill Area (December 2009).

Photo 10. Vegetation in the Southwest Landfill area Looking West (December 2009).

APPENDICES

APPENDIX A1

ANALYTICAL RESULTS, DA NANG AIRPORT, JANUARY 2010

APPENDIX A1. ANALYTICAL RESULTS, DA NANG AIRPORT, JANUARY 2010

1.0 INTRODUCTION

The field sampling program at Da Nang Airport (DNA) implemented in January 2010 was conducted as per the Sampling and Analysis Plan (SAP) prepared by CDM and Hatfield for USAID VIETNAM (CDM 2009). This appendix provides information related to the field sampling methodology based on the Field Work Instructions (Appendix A in the SAP), debriefing notes following the sampling program, and figures and tables of final dioxin and furan analytical results. Also included are dioxin/furan results from previous studies (Hatfield and Office 33 2007 and 2009; USEPA/VAST and MOD unpublished data). Collectively, these data will be used to generate dioxin concentration maps and for estimating volumes of materials that require remediation.

2.0 SAMPLING METHODOLOGY

2.1 BACKGROUND

The specific sampling methodology used for Da Nang soil, sediment, and water for dioxin/furan and COPC analysis was presented in the Field Work Instructions in the SAP (CDM 2009). Please refer to the SAP for more detailed information regarding sampling methodology.

As stated in the SAP (CDM 2009), the overall objective of the January 2010 field investigation was to collect data required to fill gaps in the existing data, to provide information required to complete the engineering designs and specifications for Site remediation, and to provide information that would guide decision making related to Site remediation. The specific objectives of the sampling effort were to:

1. Determine the vertical and lateral extent of dioxin/furan contamination in soil in the Mixing and Loading Area, Storage Area, and Drainage Ditch;
2. Determine the vertical and lateral extent of dioxin/furan contamination in sediment of Sen Lake and the eastern wetland;
3. Determine chemical concentration baseline conditions for groundwater, surface water, and the proposed landfill site (one of the remedial alternatives included for evaluation in the Environmental Assessment [EA]);
4. Determine whether chemicals of potential concern (COPCs) other than dioxins/furans are present in soils and/or sediments that may affect the remedial design, operations and maintenance (O&M) of the remedy, and/or health and safety aspects of the remedy implementation; and
5. Determine whether soil properties of the contaminated soil would affect the remedial design.

In addition, field sampling on the DNA was required to provide internationally-accepted analytical data using high-resolution GCMS. All dioxin/furan and polycyclic aromatic hydrocarbon (PAH) analysis were performed by AXYS Analytical Services, Ltd. in Sidney, British Columbia, Canada. Supplemental polychlorinated biphenyl (PCB), metal and volatile organic compound (VOC) analyses were completed at ALS Canada Ltd. Laboratories in Vancouver or Edmonton.

2.2 HEALTH AND SAFETY

Health, safety, and security of Hatfield, CDM and Vietnamese personnel working on the project was top priority, to protect workers from exposure to toxic contamination and unexploded ordnance (UXO), and to ensure safety of all day-to-day fieldwork activities.

Demining personnel from the Ministry of Defense (MOD) accompanied Hatfield and CDM staff to all sites and screened all sampling sites prior to collection of soils/sediments on the DNA and in the surrounding community.

2.3 SAMPLES COLLECTED AND ANALYZED

Sampling at the DNA occurred on the "Hot Spots" at the Mixing/Loading Area, former Storage Area, Sen Lake and the eastern wetland, the proposed landfill site near the former Pacer Ivy Storage Area, and the key surface water and groundwater sites near the perimeter of the DNA.

All sediment and soil dioxin samples collected were split into two batches, one for archiving in Viet Nam, and one for transportation to Canada for HR GCMS analysis by AXYS and archiving. The Viet Nam archive samples also serve as a back-up for the supplemental metals, PCBs and PAH analyses.

It was necessary to select a subset of samples (i.e., Tier 1 samples) to be submitted for analytical testing due to cost constraints instead of analyzing all collected samples immediately. Tier 1 sample locations were selected based on best professional judgment with the goal of selecting samples that would maximize the characterization of the lateral and vertical extent of contamination. Tier 2 samples will be submitted for analysis at a later date if data gaps remain and the extent of contamination is not delineated with the Tier 1 samples.

The Tier 1 sediment, soil and water samples were analyzed for the following variables:

- Dioxins/furans (all congeners);
- Particle size analysis (PSA) and total organic carbon (TOC) (only core and pit samples); and
- PBCs, PAHs, VOCs and total metals (subset).

Table 1 provides the total number of samples collected during the program, and the number of samples analyzed under Tier 1 for dioxins/furans. Also included are the numbers of samples collected and analyzed for PAHs, PCBs, metals, VOCs, TOC and PSA. Table A1.1 provides the complete set of all samples collected during the program, their locations, and analyses conducted on each sample. This includes Tier 1 dioxin/furan analyses, and samples collected and analyzed for PAHs, PCBs, metals, VOCs, TOC and PSA.

TABLE 1 SAMPLES COLLECTED AND ANALYZED, DA NANG AIRPORT, JANUARY 2010

Media	Number Collected	Number of Samples Analyzed for Tier 1						
		Dioxin/ Furan	PAHs	PCBs	Metals	VOCs	TOC/PSA	Field (Site) Duplicate
Sediment	35	21	3	3	3	3	13	2
Soil	114	45	2	2	2	2	24	6
Surface Water	3	3	3	3	3	3	NA	0
Ground Water	5	2	5	5	5	5	NA	0
QA/QC	11	3	1	1	1	1	0	NA

NA = not appropriate

The attached figures (Figures A1.1 to A1.8) provide a spatial view of sample distribution and analytical results for toxic equivalency quotient (TEQ) (parts per trillion [ppt]) in soil and sediment. Analytical results for all dioxin congeners and other COPCs in soil, sediments and water are provided in Tables A1.1 to A1.14.

2.4 QUALITY ASSURANCE

Field QC samples were collected in accordance with the SAP (CDM 2009) to provide information on equipment decontamination, sample handling, storage, and shipment procedures. These are also indicative of ambient conditions and/or equipment conditions that may affect the quality of the samples. The field QC samples collected for this sampling event are described below:

- A total of eight field duplicates (six soil, two sediment) were collected during the sampling event. Field duplicates were collected from the same sampling location as the original ("parent") sample, collected consecutively and using identical procedures. The field duplicates are intended to measure the "total system" variability from both the environment and laboratory, including the variability component resulting from the inherent environmental heterogeneity. Field duplicates were submitted to the laboratory as blind samples, in that they were not identified as duplicates and they were separate and unique from the "parent" sample. Of the eight field duplicates collected, two were submitted for Tier 1 analysis (one soil, one sediment).
- Three rinsate samples were collected (one from each type of sampling equipment: Ekman/Ogeechee corer/soil corer sampling apparatus) during the mid-point of sampling, to provide a measure of potential cross-contamination. Rinsate blanks consisted of a sample of analyte-free water passed through/over a pre-cleaned/decontaminated sampling device and placed in a clean area to attempt to simulate a worst-case condition regarding ambient air contributions to sample contamination. The samples are an effective indicator of cross contamination resulting from equipment residues. Of the three rinsate samples collected, one was submitted for Tier 1 analysis.
- Two trip blanks of laboratory-provided clean matrices (one sand and one water) were shipped to and from Viet Nam in the cooler containing VOC samples without being opened during the sampling event.

Trip blanks were collected to assess cross-contamination of target analytes within the coolers during shipment. Trip blanks were not submitted for Tier 1 analysis.

- Temperature blanks were not carried in each cooler as the laboratories use digital temperature readers to record sample temperature upon receipt by the laboratory.

In addition, split samples were collected at all soil and sediment sampling locations. At each soil/sediment sample location, the soil/sediment was homogenized and divided into two sample jars: one to be shipped to the laboratory in Canada and one for archiving in Viet Nam by Office 33. For surface water and groundwater samples, one additional 1-L glass jar was filled for archiving in Viet Nam.

To ensure samples were not contaminated during the collection process, a number of sampling procedures were incorporated:

- Sampling generally proceeded from the least to the most contaminated areas (below), although some sampling occurred simultaneously by different teams:
  - Proposed Landfill Site;
  - Sen Lake, eastern wetland, drainage canal and surrounding environs;
  - Mixing/Loading Area; and
  - Storage Area.
- Disposable powder-free latex gloves were used to handle all samples. Gloves were changed between sample sites;
- All sampling equipment that came in direct contact with samples was constructed of stainless steel;
- All stainless steel equipment (dissection trays, scalpels, forceps, calipers, etc.) was rinsed in ambient water, triple rinsed with reagent grade hexane and triple rinsed with reagent grade acetone, before each use and between sample collections (see equipment decontamination below);
- Sample jars were pre-labeled, cross-referenced to field sheets, stored in a cool/dark area, and where feasible, transported to freezer facilities with two hours of collection;
- The location of each sampling station was recorded using a hand-held GPS and still photography to ensure repeatability in future sampling programs; and
- Smoking was not permitted in the vicinity of sampling activities.

3.0 PLANNED VS. ACTUAL SAMPLE LOCATIONS

- Samples directly south of the Mixing and Loading Area concrete cap and directly north of the runway were not collected per the SAP due to the presence of underground utility lines.
- Ongoing construction to the west of the Mixing and Loading Area and Storage Area prohibited collection of samples at these sites. The location of the temporary construction fence and disturbed area is provided in the attached figures. This will result in a significant data gap, and will limit the ability to determine extent of contamination in the Mixing and Loading Area.
- Proposed sample locations in the eastern wetland area of Sen Lake had to be changed, given the safety concerns of navigating uneven terrain that was filled with water and inaccessible by boat.

4.0 SUMMARY OF DEBRIEFING MEETINGS WITH GVN

Following field work conducted January 19 to 26, 2010, debriefing meetings were held on January 27 and 29, 2010 in Da Nang and Ha Noi, respectively. The following notes were made regarding the sampling program:

- The Government of Viet Nam (GVN) agreed to wait for the sampling results to determine whether additional samples need to be collected west of the Mixing and Loading Area, west of the Storage Area, and south of the Mixing and Loading Area to delineate extent of contamination.
- GVN suggested the area up to the runway should be assumed to have dioxin levels above cleanup goals. Since the runway configuration has not changed since 1972, contamination underneath the runway is not anticipated.
- One attendee at the January 29, 2010 debriefing meeting in Ha Noi suggested that the Canadian analytical laboratory results should be confirmed by an independent laboratory. In response to this concern, CDM explained that QC samples (e.g., field duplicates, rinsates) were collected for the purpose of quality assurance. The purpose of these QC samples was to measure accuracy and precision of the results. Additionally, CDM noted that Office 33 was provided with a complete set of split samples that they could analyze independently to confirm the results of the Canadian analytical laboratory.

5.0 HEALTH AND SAFETY

The importance of appropriate health and safety protective equipment is understood and valued by the team; however, the cumbersome protective clothing/respirators made work difficult in the tropical Vietnam climate. The team agrees that remediation work will require a high level of protective clothing; however, some adjustments will need to be made from the equipment that was used during sampling to ensure effective working conditions. The following suggestions should be considered in development of the health and safety program for remediation:

- Some personal protective equipment used during the sampling event may not be well suited for extensive/long duration use during remediation activities.
- Vietnamese input should be gathered and incorporated into the remediation health and safety program.
- Backhoes and other heavy equipment equipped with pressurized operator cabins should be used to allow for safe handling and transport of contaminated material.
- Vietnam Decision 68 should be used to provide health and safety guidance for the remediation work.

6.0 ANALYTICAL RESULTS

This appendix contains summary tables of results for each sample analyzed for Tier 1 of the January 2010 program. Tables are organized by area, and TEQ values that exceed the guidelines for sediment (150 pg/g TEQ) and soil (1,000 pg/g TEQ) are highlighted. Historical TCDD and/or TEQ values have also been provided, from previous studies at Da Nang Airport (Hatfield 2007 and 2009; EPA/VAST and MOD, unpublished data). Data tables are provided for 2010 particle size and TOC results for soils and sediments, and COPC results for water, soil and sediment samples. Historical COPC data are reported in Appendix A4. Data are also presented in two series of figures highlighting dioxin levels (TEQs) at various depths sampled.

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Table A1.3 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in Sen Lake (East Wetland) sediment samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

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Table A1.6 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in former Mixing and Loading Area soil samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

Table A1.7 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) at the proposed landfill site (soils, pg/g [ppt] dry weight), and surface and ground water samples (pg/g [ppt] wet weight), Da Nang Airport, Viet Nam; January 2010.

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Figure A1.2 Sample locations for the landfill site at Da Nang Airport, 2010.

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Figure A1.6 January 2010 and historical sampling results (pg/g TEQ) – over 60 cm depth.

Figure A1.7 January 2010 and historical sampling results (pg/g TEQ) – all depths.

Figure A1.8 January 2010 and historical sampling results (pg/g TEQ) at the proposed landfill site.

Table A1.1 Site locations, and samples collected and analyzed for Tier 1; Da Nang Airport, Viet Nam; January 2010.

Note: Y=Yes; N=No; blank=not collected for analysis.

SITE ID	Location	Easting	Northing	UTMZone	Type	Layer (cm)	Collected?	Tier 1 Dioxin/Furan	PAHs	PCBs	VOCs	Metals	PSA/ TOC	Notes
SEDIMENTS														
Sen Lake (Open Water)														
SAP503-1	West Sen Lake	200222	1777987	49	Sediment Core	0-15	Y	Y					Y	
SAP503-2	West Sen Lake	200222	1777987	49	Sediment Core	15-30	Y	Y					Y	
SAP503-3	West Sen Lake	200222	1777987	49	Sediment Core	30-50	Y	Y					Y	
SAP504-1	Mid Sen Lake	200407	1777960	49	Sediment Core	0-15	Y	Y	Y	Y	Y	Y	Y	
SAP504-2	Mid Sen Lake	200407	1777960	49	Sediment Core	15-30	Y	Y					Y	
SAP504-3	Mid Sen Lake	200407	1777960	49	Sediment Core	30-50	Y	Y					Y	
SAP505-1	East Sen Lake	200491	1778055	49	Sediment Core	0-15	Y	Y					Y	
SAP505-2	East Sen Lake	200491	1778055	49	Sediment Core	15-30	Y	Y					Y	
SAP505-3	East Sen Lake	200491	1778055	49	Sediment Core	30-50	N							Could not sample >30 cm
SAP524	West Sen Lake	200288	1777988	49	Sediment Grab	0-15	Y	N						Too much vegetation
SAP525	SW Sen Lake	200283	1777942	49	Sediment Grab	0-15	Y	N						Too much vegetation
SAP526	South Sen Lake	200322	1777942	49	Sediment Grab	0-15	Y	Y						
Sen Lake (Eastern Wetland)														
SAP501-1	Sen Lake Wetland 'A'	200662	1778004	49	Sediment Core	0-15	Y	Y	Y	Y	Y	Y	Y	
SAP501-2	Sen Lake Wetland 'A'	200662	1778004	49	Sediment Core	15-30	Y	Y					Y	
SAP501-3	Sen Lake Wetland 'A'	200662	1778004	49	Sediment Core	30-50	N							Could not sample >30 cm
SAP510	Sen Lake Wetland 'A'	200635	1778022	49	Sediment Grab	0-15	Y	Y						
SAP511	Sen Lake Wetland 'A'	200649	1778014	49	Sediment Grab	0-15	Y	N						
SAP512	Sen Lake Wetland 'A'	200681	1777977	49	Sediment Grab	0-15	Y	N						
SAP502	Sen Lake Wetland 'B'	200698	1777936	49	Sediment Grab	0-15	Y	Y						
SAP513	Sen Lake Wetland 'B'	200701	1777969	49	Sediment Grab	0-15	Y	Y						
SAP514	Sen Lake Wetland 'B'	200714	1777918	49	Sediment Grab	0-15	Y	N						
SAP515	Sen Lake Wetland 'B'	200768	1777843	49	Sediment Grab	0-15	Y	N						
SAP516	Sen Lake Wetland 'C'	200729	1777907	49	Sediment Grab	0-15	Y	N						
SAP517	Sen Lake Wetland 'C'	200752	1777873	49	Sediment Grab	0-15	Y	Y						
SAP518	Sen Lake Wetland 'C'	200764	1777852	49	Sediment Grab	0-15	Y	N						
SAP519	Sen Lake Wetland 'C'	200781	1777814	49	Sediment Grab	0-15	Y	Y						
SAP597	Sen Lake Wetland 'C'	200722	1777790	49	Sediment Grab	0-15	Y	Y						Site added in field
SAP521-1	Sen Lake Wetland 'D'	200822	1777721	49	Sediment Core	0-15	Y	N	Y	Y	Y	Y	Y	
SAP521-2	Sen Lake Wetland 'D'	200822	1777721	49	Sediment Core	15-30	Y	N					Y	
SAP521-3	Sen Lake Wetland 'D'	200822	1777721	49	Sediment Core	30-50	Y	N					Y	
SAP520	Sen Lake Wetland 'D'	200815	1777742	49	Sediment Grab	0-15	Y	Y						Substitute for SAP521 D/F
SAP522	Sen Lake Wetland 'D'	200705	1777668	49	Sediment Grab	0-15	Y	N						
SAP523	Sen Lake Wetland 'D'	200748	1777696	49	Sediment Grab	0-15	Y	Y						
Drainage Ditch/Treatment Pond Sediments														
SAP527	Weir at Sen Lake	200435	1777876	49	Sediment Grab	0-15	Y	Y						
SAP528	Drainage Canal at SA	200492	1777711	49	Sediment Grab	0-15	Y	Y						Substitute for SAP530 D/F
SAP529	Treatment Pond at SA	200440	1777665	49	Sediment Grab	0-15	Y	N						
SAP530	Drainage Canal at MLA	200428	1777500	49	Sediment Grab	0-15	Y	N						Too much vegetation
SOILS														
Area Between Drainage Ditch and Sen Lake Eastern Wetland Sampling Area														
SAP620	SE Sen Lake - N1	200516	1777912	49	Soil Surface	0-30	Y	Y						
SAP621	SE Sen Lake - N2	200570	1777869	49	Soil Surface	0-30	Y	N						
SAP623	SE Sen Lake - S1	200660	1777779	49	Soil Surface	0-30	Y	N						
SAP624	SE Sen Lake - S2	200624	1777768	49	Soil Surface	0-30	Y	Y						
SAP595	SE Sen Lake - E1	200691	1777752	49	Soil Surface	0-30	Y	N						Site added in field
SAP596	SE Sen Lake - E2	200715	1777763	49	Soil Surface	0-30	Y	N						Site added in field
Drainage Ditch (Perimeter)														
SAP625	Drainage Canal - W1	200417	1777880	49	Soil Surface	0-30	Y	N						
SAP626	Drainage Canal - W2	200457	1777840	49	Soil Surface	0-30	Y	Y						
SAP627	Drainage Canal - W3	200430	1777775	49	Soil Surface	0-30	Y	N						

Table A1.1 Site locations, and samples collected and analyzed for Tier 1; Da Nang Airport, Viet Nam; January 2010.

Note: Y=Yes; N=No; blank=not collected for analysis.

SITE ID	Location	Easting	Northing	UTMZone	Type	Layer (cm)	Collected?	Tier 1 Dioxin/Furan	PAHs	PCBs	VOCs	Metals	PSA/ TOC	Notes
SAP628	Drainage Canal - W4	200496	1777816	49	Soil Surface	0-30	Y	Y						
SAP629	Drainage Canal - W5	200491	1777756	49	Soil Surface	0-30	Y	N						
SAP630	Drainage Canal - W6	200438	1777739	49	Soil Surface	0-30	Y	Y						
SAP631	Drainage Canal - W7	200437	1777675	49	Soil Surface	0-30	Y	N						
SAP632	Drainage Canal - W8	200422	1777614	49	Soil Surface	0-30	Y	N						
SAP634	Drainage Canal - E5	200475	1777649	49	Soil Surface	0-30	Y	Y						
SAP635	Drainage Canal - E4	200539	1777770	49	Soil Surface	0-30	Y	Y						
SAP636	Drainage Canal - E3	200537	1777809	49	Soil Surface	0-30	Y	Y						
SAP637	Drainage Canal - E2	200493	1777841	49	Soil Surface	0-30	Y	Y						
SAP638	Drainage Canal - E1	200463	1777899	49	Soil Surface	0-30	Y	N						
Storage Area														
SAP601-1	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	0-30	Y	N					Y	
SAP601-2	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	30-60	Y	N					Y	
SAP601-3	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	60-90	Y	Y	Y	Y	Y	Y	Y	
SAP601-4	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	90-120	Y	N						
SAP601-5	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	120-150	Y	Y						
SAP601-6	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	150-180	Y	N						
SAP601-7	NW Storage Area	200358	1777667	49	Soil Core/Soil Pit	180-210	Y	N						
SAP602-1	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	0-30	Y	N					Y	
SAP602-2	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	30-60	Y	N					Y	
SAP602-3	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	60-90	Y	Y					Y	
SAP602-4	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	90-120	Y	N						
SAP602-5	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	120-150	Y	Y						
SAP602-6	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	150-180	Y	N						
SAP602-7	SW Storage Area	200355	1777634	49	Soil Core/Soil Pit	180-210	Y	N						
SAP603-1	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	0-30	Y	N					Y	
SAP603-2	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	30-60	Y	N					Y	
SAP603-3	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	60-90	Y	Y					Y	
SAP603-4	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	90-120	Y	N						
SAP603-5	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	120-150	Y	Y						
SAP603-6	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	150-180	Y	N						
SAP603-7	East Storage Area	200386	1777658	49	Soil Core/Soil Pit	180-210	Y	N						
SAP640	Storage Area - N1	200306	1777678	49	Soil Surface	0-30	Y	Y						
Storage Area (Cont'd.)														
SAP641	Storage Area - N2	200320	1777678	49	Soil Surface	0-30	Y	N						
SAP642	Storage Area - N3	200379	1777686	49	Soil Surface	0-30	Y	Y						
SAP643	Storage Area - N4	200465	1777694	49	Soil Surface	0-30	Y	N						
SAP644	Storage Area - C1	200318	1777631	49	Soil Surface	0-30	Y	Y						
SAP645	Storage Area - C2	200333	1777631	49	Soil Surface	0-30	Y	N						
SAP646	Storage Area - S1	200313	1777583	49	Soil Surface	0-30	Y	Y						
SAP647	Storage Area - S2	200328	1777592	49	Soil Surface	0-30	Y	N						
SAP648	Storage Area - S3	200375	1777587	49	Soil Surface	0-30	Y	Y						
SAP649	Storage Area - S4	200397	1777592	49	Soil Surface	0-30	Y	Y						
Mixing and Loading Area														
SAP604-1	West MLA	200384	1777433	49	Soil Core/Soil Pit	0-30	Y	N					Y	
SAP604-2	West MLA	200384	1777433	49	Soil Core/Soil Pit	30-60	Y	N					Y	
SAP604-3	West MLA	200384	1777433	49	Soil Core/Soil Pit	60-90	Y	N					Y	
SAP604-4	West MLA	200384	1777433	49	Soil Core/Soil Pit	90-120	Y	N						
SAP604-5	West MLA	200384	1777433	49	Soil Core/Soil Pit	120-150	Y	N						
SAP604-6	West MLA	200384	1777433	49	Soil Core/Soil Pit	150-180	Y	N						
SAP604-7	West MLA	200384	1777433	49	Soil Core/Soil Pit	180-210	Y	N						
SAP605-1	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	0-30	Y	N					Y	
SAP605-2	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	30-60	Y	Y	Y	Y	Y	Y	Y	
SAP605-3	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	60-90	Y	N					Y	

Table A1.1 Site locations, and samples collected and analyzed for Tier 1; Da Nang Airport, Viet Nam; January 2010.

Note: Y=Yes; N=No; blank=not collected for analysis.

SITE ID	Location	Easting	Northing	UTMZone	Type	Layer (cm)	Collected?	Tier 1 Dioxin/Furan	PAHs	PCBs	VOCs	Metals	PSA/ TOC	Notes
SAP605-4	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	90-120	Y	Y						
SAP605-5	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	120-150	Y	N						
SAP605-6	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	150-180	Y	N						
SAP605-7	Mid-west MLA	200435	1777426	49	Soil Core/Soil Pit	180-210	Y	N						
SAP606-1	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	0-30	Y	N					Y	
SAP606-2	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	30-60	Y	Y					Y	
SAP606-3	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	60-90	Y	N					Y	
SAP606-4	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	90-120	Y	Y						
SAP606-5	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	120-150	Y	N						
SAP606-6	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	150-180	Y	N						
SAP606-7	Mid-east MLA	200509	1777436	49	Soil Core/Soil Pit	180-210	Y	N						
SAP607-1	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	0-30	Y	Y					Y	
SAP607-2	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	30-60	Y	N					Y	
SAP607-3	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	60-90	Y	N					Y	
SAP607-4	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	90-120	Y	Y						
SAP607-5	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	120-150	Y	N						
SAP607-6	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	150-180	Y	Y						
SAP607-7	East MLA (perimeter)	200580	1777435	49	Soil Core/Soil Pit	180-210	Y	N						
SAP633	MLA perimeter - E of Cana	200430	1777534	49	Soil Surface	0-30	Y	N						
SAP651	MLA perimeter - NW1	200353	1777538	49	Soil Surface	0-30	Y	N						
SAP652	MLA perimeter - NW2	200356	1777456	49	Soil Surface	0-30	Y	Y						
SAP653	MLA perimeter - NW3	200331	1777447	49	Soil Surface	0-30	Y	N						
SAP654	MLA perimeter - NW4	200328	1777465	49	Soil Surface	0-30	Y	Y						
SAP655	MLA perimeter - NW5	200360	1777474	49	Soil Surface	0-30	Y	Y						
SAP656	MLA perimeter - CW1	200336	1777429	49	Soil Surface	0-30	Y	N						
SAP657	MLA perimeter - CW2	200377	1777500	49	Soil Surface	0-30	Y	Y						
SAP658	MLA perimeter - CW3	200383	1777453	49	Soil Surface	0-30	Y	Y						
SAP659	MLA perimeter - CW4	200403	1777442	49	Soil Surface	0-30	Y	N						
Mixing and Loading Area (Cont'd.)														
SAP660	MLA perimeter - SW1	200336	1777417	49	Soil Surface	0-30	Y	Y						
SAP661	MLA perimeter - SW2	200350	1777421	49	Soil Surface	0-30	Y	Y						
SAP662	MLA perimeter - SW3	200398	1777417	49	Soil Surface	0-30	Y	Y						
SAP663	MLA perimeter - NE1	200515	1777507	49	Soil Surface	0-30	Y	Y						
SAP664	MLA perimeter - NE2	200421	1777475	49	Soil Surface	0-30	Y	N						
SAP665	MLA perimeter - NE3	200470	1777473	49	Soil Surface	0-30	Y	Y						
SAP666	MLA perimeter - N E4	200497	1777479	49	Soil Surface	0-30	Y	N						
SAP667	MLA perimeter - NE5	200549	1777480	49	Soil Surface	0-30	Y	Y						
SAP668	MLA perimeter - CE1	200473	1777457	49	Soil Surface	0-30	Y	N						
SAP669	MLA perimeter - CE2	200521	1777455	49	Soil Surface	0-30	Y	N						
SAP670	MLA perimeter - CE3	200562	1777463	49	Soil Surface	0-30	Y	N						
SAP671	MLA perimeter - SE1	200453	1777416	49	Soil Surface	0-30	Y	Y						
SAP672	MLA perimeter - SE2	200488	1777426	49	Soil Surface	0-30	Y	N						
SAP673	MLA perimeter - SE3	200524	1777428	49	Soil Surface	0-30	Y	N						
SAP674	MLA perimeter - SE4	200541	1777430	49	Soil Surface	0-30	Y	Y						
SAP675	MLA perimeter - SE5	200585	1777389	49	Soil Surface	0-30	Y	N						
SAP676	MLA perimeter - SE6	200583	1777409	49	Soil Surface	0-30	Y	N						
Proposed Landfill Site														
SAP610-1	Landfill Centre	199571	1773975	49	Soil Core/Soil Pit	0-30	Y	Y					Y	
SAP610-2	Landfill Centre	199571	1773975	49		30-60	Y	N						
SAP610-3	Landfill Centre	199571	1773975	49		60-90	Y	N						
SAP610-4	Landfill Centre	199571	1773975	49		90-120	Y	N					Y	
SAP610-5	Landfill Centre	199571	1773975	49		120-150	Y	N						
SAP610-6	Landfill Centre	199571	1773975	49		150-180	Y	N						
SAP610-7	Landfill Centre	199571	1773975	49		180-210	Y	N					Y	
SAP681	Landfill West	199437	1774095	49	Soil Surface	0-30	Y	Y						

Table A1.1 Site locations, and samples collected and analyzed for Tier 1; Da Nang Airport, Viet Nam; January 2010.

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SITE ID	Location	Easting	Northing	UTMZone	Type	Layer (cm)	Collected?	Tier 1 Dioxin/Furan	PAHs	PCBs	VOCs	Metals	PSA/ TOC	Notes
SAP682	Landfill North	199641	1774081	49	Soil Surface	0-30	Y	Y						
SAP683	Landfill South	199556	1773865	49	Soil Surface	0-30	Y	N						
SAP684	Landfill East	199851	1774056	49	Soil Surface	0-30	Y	Y						
WATER QUALITY														
Surface Water Samples														
SAP701	Sen Lake Middle	200351	1777986	49	Water Quality	Surface	Y	Y	Y	Y	Y	Y		
SAP702	Sen Lake Outlet	200467	1778100	49	Water Quality	Surface	Y	Y	Y	Y	Y	Y		
SAP703	Drainage Canal at SA	200498	1777703	49	Water Quality	Surface	Y	Y	Y	Y	Y	Y		
Groundwater (Well) Samples														
SAP706	Well 1	199224	1777964	49	Water Quality	Spigot	Y	Y	Y	Y	Y	Y		
SAP708	Well 3	199459	1773758	49	Water Quality	Spigot	Y	Y	Y	Y	Y	Y		
SAP709	Well 4	201326	1777986	49	Water Quality	Spigot	Y	N	Y	Y	Y	Y		
SAP710	Well 5	201451	1777872	49	Water Quality	Spigot	Y	N	Y	Y	Y	Y		
SAP711	Well 6	201374	1776415	49	Water Quality	Spigot	Y	N	Y	Y	Y	Y		
QUALITY ASSURANCE														
Equipment QC														
SAP802	Rinsate				Rinsate 1 - Ekman		Y	N						
SAP803	Rinsate				Rinsate 2 - Ogeechee		Y	N						
SAP811	Rinsate				Rinsate 3 - Soil corer		Y	Y						
Water Trip Blank		1-250mL glass amber jar					Y	N						
Soil Trip Blank		1-250mL glass amber jar					Y	N						
Soil/Sediment QC														
SAP810	SAP668 DUP	200473	1777457	49	Soil Duplicate		Y	N						
SAP807	SAP676 DUP	200583	1777409	49	Soil Duplicate		Y	N						
SAP815	SAP597 DUP	200722	1777790	49	Soil Duplicate		Y	N						
SAP812	SAP601-3 DUP	200358	1777667	49	Soil Duplicate		Y	Y	Y	Y	Y	Y		
SAP805	SAP656 DUP	200336	1777429	49	Soil Duplicate		Y	N						
SAP806	SAP655 DUP	200360	1777474	49	Soil Duplicate		Y	N						
SAP809	SAP527 DUP	200435	1777876	49	Sed Duplicate		Y	Y						
SAP808	SAP528 DUP	200492	1777711	49	Sed Duplicate		Y	N						

Table A1.2 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in Sen Lake (Open Water) sediment samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

Sample ID	Location	Media and Depth	PCDD (pg/g dry weight)						PCDF (pg/g dry weight)						TEQ (WHO 1998) ND=1/2DL	TEQ (WHO 2005) ND=1/2DL	TCDD as % of TEQ (2005)
			2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF			
Sen Lake (Open Water)																	
SAP503-1	West Sen Lake	Sediment 0-15cm	261	391	153	697	2090	11400	125	219	92.3	37.3	46.2	32	307	**309**	84.5
SAP503-2	West Sen Lake	Sediment 15-30cm	33.5	147	111	521	1570	8670	18.3	39.7	12.3	5.37	7.94	NDR 5.37	53.9	55.6	60.3
SAP503-3	West Sen Lake	Sediment 30-50cm	1.73	112	81.3	416	1030	5490	0.672	24.3	1.35	0.478	0.427	NDR 0.523	13.6	14.7	11.8
SAP504-1	Mid Sen Lake	Sediment 0-15cm	5160	5600	565	1390	3360	15500	939	2230	1680	372	310	238	5370	**5370**	96.1
SAP504-2	Mid Sen Lake	Sediment 15-30cm	63.3	164	110	518	1360	6580	13.3	45.2	15.6	6.78	7.99	6.55	78.2	79.5	79.6
SAP504-3	Mid Sen Lake	Sediment 30-50cm	51.6	161	112	514	1380	6830	9.84	39	8.65	4.44	6.39	4.92	65.5	66.8	77.2
SAP505-1	East Sen Lake	Sediment 0-15cm	41.2	78.5	39.8	211	584	2880	14.9	29	11.8	6.07	8.04	7.21	50.7	51.2	80.5
SAP505-2	East Sen Lake	Sediment 15-30cm	1.08	32.2	26.6	144	334	1380	0.41	4.85	0.287	0.096	0.192	NDR 0.241	5.03	5.3	20.4
SAP526	South Sen Lake	Sediment 0-15cm	4030	4450	610	1680	4900	25900	1160	2170	1340	580	700	546	4350	**4350**	92.6

ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.

NDR = Non-detect ratio; peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND ("0").

Orange shading indicates value exceeds Vietnamese guideline of 150 pg/g TEQ for sediment.

Table A1.3 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in Sen Lake (East Wetland) sediment samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

Sample ID	Location	Media and Depth	PCDD (pg/g dry weight)						PCDF (pg/g dry weight)						TEQ (WHO 1998) ND=1/2DL	TEQ (WHO 2005) ND=1/2DL	TCDD as % of TEQ (2005)
			2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF			
Sen Lake (East Wetland)																	
SAP501-1	Wetland 'A'	Sediment 0-15cm	58	80	36	172	673	3850	7.81	40.4	37	48.4	50.4	27.2	72.1	72.5	80.0
SAP501-2	Wetland 'A'	Sediment 15-30cm	44.1	59.6	30.1	111	454	3340	8.33	41.8	38	42.3	53.2	34.3	54.2	54.5	80.9
SAP510	Wetland 'A'	Sediment 0-15cm	19.9	23.9	7.74	59.2	256	2010	1.77	6.16	5.01	5.06	13.7	17.9	23.3	23.7	84.0
SAP502	Wetland 'B'	Sediment 0-15cm	181	206	29.4	98.4	484	3820	17.2	66.5	48.5	43	48.6	30	192	**192**	94.3
SAP513	Wetland 'B'	Sediment 0-15cm	25	58.4	66.5	207	772	6210	30.5	152	189	234	250	110	56.9	55.2	45.3
SAP517	Wetland 'C'	Sediment 0-15cm	3.96	8.16	4.91	39.4	149	3210	1.98	11.2	7.71	8.86	11.2	10.9	6.46	6.96	56.9
SAP519	Wetland 'C'	Sediment 0-15cm	10.5	53.4	33.9	181	393	7450	3.13	18.7	15.2	16.4	22.2	59.1	21	22.3	47.1
SAP597	Wetland 'C'	Sediment 0-15cm	394	817	605	1820	6560	36100	165	1010	921	1090	1330	645	575	**570**	69.1
SAP520	Wetland 'D'	Sediment 0-15cm	22.8	28.4	6.63	78	379	6770	3.67	16.8	12.7	16.6	25.9	19.1	30.3	31.4	72.6
SAP523	Wetland 'D'	Sediment 0-15cm	106	116	22.3	111	596	7580	11.5	59	59.2	84.4	149	151	120	121	87.6

ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.

NDR = Non-detect ratio; peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND ("0").

Orange shading indicates value exceeds Vietnamese guideline of 150 pg/g TEQ for sediment.

Table A1.4 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in Drainage Canal sediments, and perimeter and eastern soil samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

Sample ID	Location	Media and Depth	PCDD (pg/g dry weight)						PCDF (pg/g dry weight)						TEQ (WHO 1998) ND=1/2DL	TEQ (WHO 2005) ND=1/2DL	TCDD as % of TEQ (2005)
			2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF			
Drainage Ditch/Treatment Pond Sediments																	
SAP527	Weir at Sen Lake	Sediment 0-15cm	1780	2000	299	932	3970	27200	199	712	527	526	806	839	1890	**1890**	15.0
SAP528	Drainage Canal at SA	Sediment 0-15cm	6770	7180	724	1100	1090	2470	404	1610	1480	245	70.2	40.1	6960	**6960**	97.3
Area Between Drainage Ditch and Sen Lake Eastern Wetland Sampling Area																	
SAP620	SE Sen Lake - N1	Soil 0-30cm	569	809	476	1820	7060	50700	86.1	433	495	976	1760	1500	723	728	78.2
SAP624	SE Sen Lake - S2	Soil 0-30cm	1220	1440	602	3900	30600	260000	139	765	1050	3670	3480	1060	1590	**1620**	75.3
Drainage Ditch (Perimeter)																	
SAP626	Drainage Canal - W2	Soil 0-30cm	5220	6060	1390	2670	9650	54100	483	1840	1950	1510	2890	2750	5650	**5650**	92.4
SAP628	Drainage Canal - W4	Soil 0-30cm	12200	13300	2830	4650	6900	22500	1740	5010	4370	1340	722	487	13100	**13100**	93.1
SAP630	Drainage Canal - W6	Soil 0-30cm	47.4	172	235	848	4180	20100	21.8	128	134	401	844	764	149	152	31.2
SAP634	Drainage Canal - E5	Soil 0-30cm	236	258	41.6	89.8	302	6680	11	58.1	84	28.7	24.4	28.2	249	250	94.4
SAP635	Drainage Canal - E4	Soil 0-30cm	2190	2540	538	1020	2620	15100	185	926	1090	769	718	450	2360	**2360**	92.8
SAP636	Drainage Canal - E3	Soil 0-30cm	627	806	326	942	3660	24200	85.7	440	517	707	1140	969	743	743	84.4
SAP637	Drainage Canal - E2	Soil 0-30cm	1640	2560	1330	2880	9700	49500	235	937	979	1320	2540	2320	1970	**1970**	83.2

ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.

NDR = Non-detect ratio; peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND ("0").

Orange shading indicates value exceeds Vietnamese guidelines of 150 pg/g TEQ for sediment or 1,000 pg/g TEQ for soil.

Table A1.5 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in former Storage Area soil samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

Sample ID	Location	Media and Depth	PCDD (pg/g dry weight)						PCDF (pg/g dry weight)						TEQ (WHO 1998) ND=1/2DL	TEQ (WHO 2005) ND=1/2DL	TCDD as % of TEQ (2005)
			2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF			
Former Storage Area																	
SAP601-3	NW Storage Area	Soil 60-90cm	1430	1560	67.2	86.4	165	12000	88	368	367	79.6	15.3	4.07	1450	**1460**	97.9
SAP601-5	NW Storage Area	Soil 120-150cm	47.5	50.7	1.19	2.49	35.6	2870	2.29	5.79	8.38	1.04	0.509	0.665	49.4	50	95.0
SAP602-3	SW Storage Area	Soil 60-90cm	14100	14400	46.5	88.6	208	10400	42.5	129	131	20.6	2.75	5.36	14100	**14100**	100.0
SAP602-5	SW Storage Area	Soil 120-150cm	726	741	1.99	7.38	21.5	1370	2.47	7.13	7.96	0.817	0.508	NDR 0.539	726	727	99.9
SAP603-3	East Storage Area	Soil 60-90cm	967	1020	8.89	18.5	272	26100	23.2	96.7	74.1	6.79	1.42	NDR 0.771	975	980	98.7
SAP603-5	East Storage Area	Soil 120-150cm	172	185	8.96	59	215	9910	6.7	24	17.1	1.42	0.924	NDR 0.724	178	180	95.6
SAP640	Storage Area - N1	Soil 0-30cm	722	745	129	265	439	4470	27	90.1	237	70.3	17.4	19.1	767	768	94.0
SAP642	Storage Area - N3	Soil 0-30cm	41600	42100	889	758	696	4240	609	3550	3100	509	92.9	54.9	41900	**41900**	99.3
SAP644	Storage Area - C1	Soil 0-30cm	8070	8210	79.8	137	298	13800	59.3	204	187	27.8	< 0.325	4.81	8090	**8100**	99.6
SAP646	Storage Area - S1	Soil 0-30cm	5600	5710	26.1	60.3	162	3200	18.7	48	44	3.86	5.54	4.15	5610	**5610**	99.8
SAP648	Storage Area - S3	Soil 0-30cm	5940	6200	430	646	870	5160	127	504	704	146	40.5	20.9	6100	**6100**	97.4
SAP649	Storage Area - S4	Soil 0-30cm	6270	7220	2470	4550	5570	12400	364	1760	2380	1070	882	451	6840	**6840**	91.7

ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.

NDR = Non-detect ratio; peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND ("0").

Orange shading indicates value exceeds Vietnamese guideline of 1,000 pg/g TEQ for soil.

Table A1.6 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in former Mixing and Loading Area soil samples (pg/g [ppt] dry weight), Da Nang Airport, Viet Nam; January 2010.

Sample ID	Location	Media and Depth	PCDD (pg/g dry weight)						PCDF (pg/g dry weight)						TEQ (WHO 1998) ND=1/2DL	TEQ (WHO 2005) ND=1/2DL	TCDD as % of TEQ (2005)
			2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF			
Former Mixing and Loading Area																	
SAP605-2	Mid-west MLA	Soil 30-60cm	10700	11000	31	72.2	125	6250	65.7	199	134	52.1	8.41	4.13	10700	**10700**	100.0
SAP605-4	Mid-west MLA	Soil 90-120cm	293	300	< 0.234	8.1	105	7560	1.68	2.43	1.89	1.47	< 0.262	NDR 1.43	295	296	99.0
SAP606-2	Mid-east MLA	Soil 30-60cm	NDR 2.76	0.262	3.32	205	200	5820	0.549	0.549	0.177	0.378	< 0.162	1.05	1.76	2.9	NC
SAP606-4	Mid-east MLA	Soil 90-120cm	NDR 2.45	0.74	< 0.225	23	98.2	3320	0.291	0.291	< 0.193	0.913	0.355	NDR 0.448	1.09	1.73	NC
SAP607-1	East MLA (perimeter)	Soil 0-30cm	11.7	12.8	0.237	11.2	93	5810	NDR 0.938	1.25	2.42	0.549	1.78	NDR 1.70	13.6	14.6	80.1
SAP607-4	East MLA (perimeter)	Soil 90-120cm	NDR 8.12	2.37	< 0.423	46.4	177	2450	0.591	0.591	0.647	< 0.333	0.664	1.1	2.21	2.57	NC
SAP607-6	East MLA (perimeter)	Soil 150-180cm	19.9	21.5	3.11	24.1	81.8	1620	2.02	5.11	4.35	1.6	1.11	1.86	21	21.3	93.4
SAP652	MLA perimeter - NW2	Soil 0-30cm	396	416	52.7	108	210	4070	25.5	74.9	130	23.4	6.63	5.01	417	418	94.7
SAP654	MLA perimeter - NW4	Soil 0-30cm	1430	1530	246	338	417	2700	106	384	583	130	12.1	11.9	1510	**1510**	94.7
SAP655	MLA perimeter - NW5	Soil 0-30cm	321	344	45.2	154	244	3430	17.5	68.6	119	33.3	4.65	6.46	329	329	97.6
SAP657	MLA perimeter - CW2	Soil 0-30cm	13300	14600	3180	5620	5820	8340	993	3760	4610	1410	261	107	14100	**14100**	94.3
SAP658	MLA perimeter - CW3	Soil 0-30cm	43.1	45.4	4.11	33.3	309	5400	2.64	7.3	10.7	8.19	16.6	19.6	48.6	49.7	86.7
SAP660	MLA perimeter - SW1	Soil 0-30cm	4380	4520	59.3	68	42.5	384	67.8	350	229	29.8	3.43	4.3	4400	**4400**	99.5
SAP661	MLA perimeter - SW2	Soil 0-30cm	6860	7210	183	290	308	3820	141	578	701	75.5	41.5	NDR 21.9	6930	**6930**	99.0
SAP662	MLA perimeter - SW3	Soil 0-30cm	2590	2770	260	712	394	10100	70.1	396	367	79.2	25.9	14.9	2640	**2640**	98.1
SAP663	MLA perimeter - NE1	Soil 0-30cm	596	631	45.7	163	268	5160	< 0.804	38.4	12.9	4.23	6.14	10.5	605	606	98.3
SAP665	MLA perimeter - NE3	Soil 0-30cm	911	947	20.9	53.6	178	4690	18.3	74.1	61.8	11.6	4.23	8.23	919	920	99.0
SAP667	MLA perimeter - NE5	Soil 0-30cm	350	387	36.9	275	2620	16300	22.2	95.3	117	164	553	720	382	385	90.9
SAP671	MLA perimeter - SE1	Soil 0-30cm	911	947	20.9	53.6	178	4690	18.3	74.1	61.8	11.6	4.23	8.23	919	920	99.0
SAP674	MLA perimeter - SE4	Soil 0-30cm	4.35	4.95	0.782	7.88	143	2370	NDR 0.719	0.235	1.22	0.86	5.26	12.7	6.02	6.36	68.4

ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.
NDR = Non-detect ratio; peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND ("0").
NC = Not calculated as NDR values of TCDD are considered equal to "0".
Orange shading indicates value exceeds Vietnamese guideline of 1,000 pg/g TEQ for soil.

Table A1.7 Concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) at the proposed landfill site (soils, pg/g [ppt] dry weight), and surface and ground water samples (pg/g [ppt] wet weight), Da Nang Airport, Viet Nam; January 2010.

Sample ID	Location	Media and Depth	PCDD (pg/g dry weight)						PCDF (pg/g dry weight)						TEQ (WHO 1998) ND=1/2DL	TEQ (WHO 2005) ND=1/2DL	TCDD as % of TEQ (2005)
			2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF			
Proposed Landfill Site																	
SAP610-1	Landfill Centre	Soil 0-30cm	0.504	0.579	0.366	7.8	48.6	551	0.134	0.655	0.557	4.31	7.48	6.31	1.23	1.33	37.9
SAP681	Landfill West	Soil 0-30cm	0.748	0.984	1.7	21.2	130	2670	0.43	1.93	1.63	4.21	7.05	5.54	2.4	2.89	25.9
SAP682	Landfill North	Soil 0-30cm	1010	1680	1020	2110	2400	4710	165	1110	1500	489	115	85.1	1260	**1260**	80.2
SAP684	Landfill East	Soil 0-30cm	0.386	1.05	2.73	30.7	227	3940	0.313	2.34	2.54	11.2	28.3	37.7	3.86	4.6	8.4
WATER QUALITY																	
Surface Water Samples																	
SAP701	Sen Lake - Mid-lake	Grab	NDR 7.34	NDR 1.29	< 0.514	0.761	1.52	103	2.32	15.2	2.87	0.7	< 0.514	< 0.514	0.956	0.92	NC
SAP702	Sen Lake - Outlet	Grab	NDR 3.24	NDR 1.01	< 0.510	< 0.510	0.766	54.6	1.31	3.61	1.31	< 0.510	< 0.510	< 0.510	0.987	0.942	NC
SAP703	Drainage Canal at SA	Grab	90.4	97.2	7.51	12.2	21.4	129	14.4	38.2	11.6	0.815	2.38	2.4	94.2	94.1	96.1
Well Water Samples																	
SAP706	Well 1 (near NW Airport)	Grab	NDR 0.754	< 0.550	< 0.550	< 0.550	< 0.550	3.09	< 0.550	0.774	< 0.550	< 0.550	< 0.550	< 0.550	0.935	0.875	NC
SAP708	Well 3 (near landfill)	Grab	NDR 0.768	0.545	< 0.538	< 0.538	< 0.538	NDR 3.32	< 0.538	2.11	< 0.538	< 0.538	< 0.538	< 0.538	0.918	0.859	NC

ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.

NDR = Non-detect ratio; peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND ("0").

NC = Not calculated as NDR values of TCDD are considered equal to "0".

Orange shading indicates value exceeds Vietnamese guidelines of 150 pg/g TEQ for sediment or 1,000 pg/g TEQ for soil.

Table A1.8 **Results of sediment/soil analyses for particle size, total organic carbon, metals, VOCs, PCBs, and PAHs; Da Nang Airport, Viet Nam; January 2010.**

Sample ID	SAP501-1	SAP504-1	SAP521-1	SAP601-3	SAP605-2	SAP812 (601-3)
Date Sampled	21-JAN-10	22-JAN-10	21-JAN-10	26-JAN-10	25-JAN-10	26-JAN-10
Matrix	Sediment	Sediment	Sediment	Soil	Soil	Soil
Physical Tests						
% Moisture	27.3	65.1	26.9	12.1	13.0	11.6
pH	5.45	5.36	5.20	4.14	8.21	4.20
Particle Size						
% Gravel (>2mm)	<1.0	<1.0	<1.0	<1.0	7.0	<1.0
% Sand (2.0mm - 0.063mm)	85.0	28.0	79.0	82.0	75.0	83.0
% Silt (0.063mm - 4um)	2.0	46.0	5.0	6.0	10.0	6.0
% Clay (<4um)	13.0	26.0	16.0	11.0	8.0	11.0
Organic / Inorganic Carbon						
Total Organic Carbon (%)	1.19	7.59	0.98	0.12	<0.10	<0.10
Metals (mg/kg)						
Aluminum (Al)	4,440	27,700	9,540	11,800	10,400	12,400
Antimony (Sb)	1	15	1	1	1	1
Arsenic (As)	6	328	9	257	151	296
Barium (Ba)	22	115	31	8	25	8
Beryllium (Be)	<0.50	1	<0.50	<0.50	<0.50	<0.50
Bismuth (Bi)	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	0	5	0	<0.10	<0.10	<0.10
Calcium (Ca)	77	2,420	222	<50	5,000	<50
Chromium (Cr)	6	33	14	14	17	15
Cobalt (Co)	<2.0	6	<2.0	<2.0	3	<2.0
Copper (Cu)	6	33	13	2	18	2
Iron (Fe)	2,570	45,200	14,200	5,500	8,150	5,960
Lead (Pb)	26	91	29	4	7	4
Lithium (Li)	<2.0	17	3	3	4	3
Magnesium (Mg)	144	812	398	162	557	173
Manganese (Mn)	7	277	45	11	79	14
Mercury (Hg)	0	0	0	0	0	0
Molybdenum (Mo)	0	3	0	0	0	0
Nickel (Ni)	<5.0	11	<5.0	<5.0	6	<5.0
Phosphorus (P)	68	381	216	<50	96	<50
Potassium (K)	<200	780	320	260	520	280
Selenium (Se)	0	2	0	0	0	0
Silver (Ag)	<0.10	0	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	<200	<200	<200	<200	<200	<200
Strontium (Sr)	1	13	3	<0.50	12	<0.50
Thallium (Tl)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	8	5	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	26	79	60	48	116	48
Vanadium (V)	7	40	16	18	19	19
Zinc (Zn)	17	540	55	7	14	8
Volatile Organic Compounds (mg/kg)						
Benzene	<0.040	<0.20	<0.040	<0.040	<0.040	<0.040
Bromobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Bromochloromethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Bromodichloromethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Bromoform	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Bromomethane	<0.10	<0.50	<0.10	<0.10	<0.10	<0.10
n-Butylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
sec-Butylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
tert-Butylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Carbon tetrachloride	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Chlorobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Dibromochloromethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Chloroethane	<0.10	<0.50	<0.10	<0.10	<0.10	<0.10
Chloroform	<0.10	<0.50	<0.10	<0.10	<0.10	<0.10
Chloromethane	<0.10	<0.50	<0.10	<0.10	<0.10	<0.10
2-Chlorotoluene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
4-Chlorotoluene	<0.20	<1.0	<0.20	<0.20	<0.20	<0.20
1,2-Dibromo-3-chloropropane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,2-Dibromoethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Dibromomethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,2-Dichlorobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,3-Dichlorobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050

Table A1.8 **Results of sediment/soil analyses for particle size, total organic carbon, metals, VOCs, PCBs, and PAHs; Da Nang Airport, Viet Nam; January 2010.**

Sample ID	SAP501-1	SAP504-1	SAP521-1	SAP601-3	SAP605-2	SAP812 (601-3)
Date Sampled	21-JAN-10	22-JAN-10	21-JAN-10	26-JAN-10	25-JAN-10	26-JAN-10
Matrix	Sediment	Sediment	Sediment	Soil	Soil	Soil
1,4-Dichlorobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Dichlorodifluoromethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1-Dichloroethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,2-Dichloroethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1-Dichloroethene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
cis-1,2-Dichloroethene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
trans-1,2-Dichloroethene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Methylene chloride	<0.30	<1.5	<0.30	<0.30	<0.30	<0.30
1,2-Dichloropropane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,3-Dichloropropane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
2,2-Dichloropropane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1-Dichloropropene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
cis-1,3-Dichloropropene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
trans-1,3-Dichloropropene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Ethylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Hexachlorobutadiene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Isopropylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
p-Isopropyltoluene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Naphthalene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
n-Propylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Styrene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1,1,2-Tetrachloroethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1,2,2-Tetrachloroethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Tetrachloroethene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Toluene	0.240	<0.25	<0.050	<0.050	<0.050	<0.050
1,2,3-Trichlorobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,2,4-Trichlorobenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1,1-Trichloroethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,1,2-Trichloroethane	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Trichloroethene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Trichlorofluoromethane	<0.10	<0.50	<0.10	<0.10	<0.10	<0.10
1,2,3-Trichloropropane	<0.020	<0.10	<0.020	<0.020	<0.020	<0.020
1,2,4-Trimethylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
1,3,5-Trimethylbenzene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Vinyl chloride	<0.10	<0.50	<0.10	<0.10	<0.10	<0.10
o-Xylene	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
m+p-Xylenes	<0.050	<0.25	<0.050	<0.050	<0.050	<0.050
Surrogate: 4-Bromofluorobenzene (%)	90	83	93	97	93	89
Surrogate: 1,2-Dichloroethane d4 (%)	Not reportable[1]	Not reportable	Not Reportable	Not Reportable	Not Reportable	Not Reportable
Surrogate: Toluene d8 (%)	Not reportable	Not reportable	Not Reportable	Not Reportable	Not Reportable	Not Reportable
Polychlorinated Biphenyls (mg/kg)						
Aroclor 1016	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1221	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1232	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1242	<0.010	0.048	<0.010	<0.010	<0.010	<0.010
Aroclor 1248	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1254	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1260	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1262	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Aroclor 1268	<0.010	<0.020	<0.010	<0.010	<0.010	<0.010
Total PCBs	<0.050	<0.10	<0.050	<0.050	<0.050	<0.050
Surrogate: Decachlorobiphenyl (%)	93	94	87	75	87	90
Polycyclic Aromatic Hydrocarbons (mg/kg)						
Naphthalene	2.16	15	4.22	1.2	NQ	
Acenaphthylene	0.471	2.39	1.05	< 0.048	NDR 0.149	< 0.121
Acenaphthene	0.116	2.53	1.03	< 0.162	< 0.063	< 0.286
Fluorene	0.322	5.49	1.86	< 0.030	0.117	< 0.085
Phenanthrene	3.09	26.3	20.7	0.122	1.28	< 0.344
Anthracene	0.368	8.98	9.55	< 0.026	0.163	< 0.368
Fluoranthene	5.41	167	29.4	0.143	1.6	< 0.126
Pyrene	5.54	171	41.4	NDR 0.054	2.48	< 0.127
Benz[a]anthracene	2.44	67.7	16.3	NDR 0.020	0.855	< 0.056
Chrysene	5.43	125	44.5	0.158	2.51	0.21
Benzo[b]fluoranthene	4.77	172	37.2	< 0.029	2.49	0.102

Table A1.8 **Results of sediment/soil analyses for particle size, total organic carbon, metals, VOCs, PCBs, and PAHs; Da Nang Airport, Viet Nam; January 2010.**

Sample ID	SAP501-1	SAP504-1	SAP521-1	SAP601-3	SAP605-2	SAP812 (601-3)
Date Sampled	21-JAN-10	22-JAN-10	21-JAN-10	26-JAN-10	25-JAN-10	26-JAN-10
Matrix	Sediment	Sediment	Sediment	Soil	Soil	Soil
Benzo[j,k]fluoranthenes	3.9			< 0.031	1.6	
Benzo[e]pyrene	3.41	82.1	19	NDR 0.043	1.69	< 0.121
Benzo[a]pyrene	3.33	73	12.8	< 0.039	1.37	< 0.136
Perylene	3.71	459	5.71	< 0.041	0.722	< 0.136
Dibenz[a,h]anthracene	0.784	14.6	2.92	< 0.029	0.288	< 0.348
Indeno[1,2,3-cd]pyrene	NDR 3.77	68.4	NDR 11.5	NDR 0.062	1.54	< 0.130
Benzo[ghi]perylene	3.66	72.5	11.7	NDR 0.062	1.5	< 0.128
2-Methylnaphthalene	0.837	9.41	6.48	0.48	0.687	
2,6-Dimethylnaphthalene	0.393	12.3	7.47	< 0.261	0.487	< 0.789
2,3,5-Trimethylnaphthalene	1.04	24.1	24.9	< 0.114	1.36	< 0.230
1-Methylphenanthrene	0.545	42.3	26.6	0.036	0.451	< 0.117
Dibenzothiophene	0.388	7.16	11	NDR 0.015	0.202	< 0.038
% Moisture	24.7	69.8	25.8	10.9	12.3	9.88

"<" = less than the detection limit; number following this symbol represents the detection limit.

NDR = peak detected but did not meet quantification criteria; number following this flag represents the estimated maximum possible concentration.

[1] Not Reportable = The surrogate compounds d4 1,2-Dichloroethane and d8 Toluene commonly added to the sampes prior to the VOC analysis were not added by accident, hence these data are Not Reportable (ALS Laboatory Group Certificate on Analysis).

Table A1.9 **Results of water analyses for metals, VOCs, PCBs, and PAHs; Da Nang Airport, Viet Nam; January 2010.**

Sample ID	SAP701	SAP702	SAP703	SAP706	SAP708	SAP709	SAP710	SAP711
Date Sampled	26-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10
Matrix	Surface Water	Surface Water	Surface Water	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
Physical Tests (mg/L)								
Hardness (as $CaCO_3$)	62.5	66.1	24.9	178	4.0	190	241	205
Total Metals (mg/L)								
Aluminum (Al)-Total	0.133	0.0637	0.0386	0.307	0.0057	0.0064	<0.0050	<0.0050
Antimony (Sb)-Total	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)-Total	0.0187	0.0179	0.257	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050
Barium (Ba)-Total	0.048	0.049	0.043	1.32	0.031	0.211	0.358	0.087
Beryllium (Be)-Total	<0.0010	<0.0010	<0.0010	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010
Boron (B)-Total	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	0.000026	<0.000017	0.000045	0.00104	<0.000017	0.000025	<0.000017	<0.000017
Calcium (Ca)-Total	19.8	21.1	7.82	28.5	0.88	54.4	71.4	61.4
Chromium (Cr)-Total	0.0194	0.0100	0.0119	0.0103	0.0082	0.0110	0.0077	0.0067
Cobalt (Co)-Total	<0.00030	<0.00030	<0.00030	0.0480	<0.00030	0.00504	0.00082	0.00226
Copper (Cu)-Total	0.0013	<0.0010	<0.0010	<0.0020	<0.0010	0.0024	0.0014	<0.0010
Iron (Fe)-Total	1.04	0.999	3.16	0.147	<0.030	<0.030	0.044	<0.030
Lead (Pb)-Total	0.00096	0.00095	<0.00050	0.0015	<0.00050	<0.00050	<0.00050	0.00225
Lithium (Li)-Total	<0.0050	<0.0050	<0.0050	0.011	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)-Total	3.15	3.27	1.31	25.9	0.43	13.0	15.1	12.6
Manganese (Mn)-Total	0.120	0.139	0.0639	0.855	0.00554	0.0867	0.150	0.162
Mercury (Hg)-Total	<0.000020	<0.000020	<0.000020	0.000067	<0.000020	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Total	<0.0010	<0.0010	<0.0010	<0.0020	<0.0010	<0.0010	0.0011	<0.0010
Nickel (Ni)-Total	<0.0010	<0.0010	<0.0010	0.0091	<0.0010	<0.0010	<0.0010	<0.0010
Potassium (K)-Total	7.4	7.7	4.2	18.3	2.5	38.5	27.1	9.4
Selenium (Se)-Total	<0.0010	<0.0010	<0.0010	<0.0060	0.0015	<0.0020	<0.0010	<0.0020
Silver (Ag)-Total	<0.000020	<0.000020	<0.000020	<0.000060	<0.000020	<0.000020	<0.000020	<0.000020
Sodium (Na)-Total	21.1	19.8	9.4	115	7.3	86.0	58.8	88.6
Thallium (Tl)-Total	<0.00020	<0.00020	<0.00020	0.00046	<0.00020	0.00043	0.00069	<0.00020
Tin (Sn)-Total	0.00487	<0.00050	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050
Titanium (Ti)-Total	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Total	<0.00020	<0.00020	<0.00020	<0.00040	<0.00020	0.00042	0.00073	<0.00020
Vanadium (V)-Total	<0.0010	<0.0010	<0.0010	<0.0020	<0.0010	<0.0010	0.0061	<0.0010
Zinc (Zn)-Total	<0.0050	<0.0050	0.0090	0.0573	<0.0050	<0.0050	<0.0050	<0.0050
Volatile Organic Compounds (mg/L)								
Benzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromochloromethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromodichloromethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromoform	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromomethane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
n-Butylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
sec-Butylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
tert-Butylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Carbon tetrachloride	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dibromochloromethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chloroethane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chloroform	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chloromethane	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2-Chlorotoluene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
4-Chlorotoluene	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
1,2-Dibromo-3-chloropropane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2-Dibromoethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dibromomethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2-Dichlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,3-Dichlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,4-Dichlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dichlorodifluoromethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1-Dichloroethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2-Dichloroethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1-Dichloroethene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
cis-1,2-Dichloroethene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
trans-1,2-Dichloroethene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Methylene chloride	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
1,2-Dichloropropane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,3-Dichloropropane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
2,2-Dichloropropane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1-Dichloropropene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
cis-1,3-Dichloropropene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
trans-1,3-Dichloropropene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Ethylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Hexachlorobutadiene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Isopropylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
p-Isopropyltoluene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Naphthalene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
n-Propylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Styrene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

Table A1.9 **Results of water analyses for metals, VOCs, PCBs, and PAHs; Da Nang Airport, Viet Nam; January 2010.**

Sample ID	SAP701	SAP702	SAP703	SAP706	SAP708	SAP709	SAP710	SAP711
Date Sampled	26-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10	25-JAN-10
Matrix	Surface Water	Surface Water	Surface Water	Groundwater	Groundwater	Groundwater	Groundwater	Groundwater
1,1,1,2-Tetrachloroethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,2,2-Tetrachloroethane	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tetrachloroethene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Toluene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0078	<0.0010
1,2,3-Trichlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2,4-Trichlorobenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,1-Trichloroethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,2-Trichloroethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Trichloroethene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Trichlorofluoromethane	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2,3-Trichloropropane	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
1,2,4-Trimethylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,3,5-Trimethylbenzene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vinyl chloride	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
o-Xylene	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
m+p-Xylenes	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Surrogate: 4-Bromofluorobenzene (%)	102	103	103	100	101	104	98	100
Polychlorinated Biphenyls								
Aroclor 1016	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1221	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1232	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1242	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1248	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1254	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1260	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1262	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1268	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Total PCBs	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Surrogate: Decachlorobiphenyl (%)	112	102	105	104	113	103	98	96
Polycyclic Aromatic Hydrocargons (ng/L)								
Naphthalene	32.7	6.34	11.5	3.73	3.21	4.46	4.63	NDR 5.76
Acenaphthylene	NDR 2.18	NDR 1.15	NDR 0.511	< 0.189	< 0.101	< 0.184	NDR 0.522	NDR 0.267
Acenaphthene	1.16	1.31	NDR 0.559	< 0.309	< 0.115	< 0.244	< 0.245	< 0.282
Fluorene	1.86	1.29	0.578	< 0.255	< 0.161	< 0.265	0.441	4.89
Phenanthrene	4.55	3.22	1.27	0.878	0.597	0.534	2.05	1.54
Anthracene	0.565	NDR 0.391	< 0.213	< 0.213	< 0.109	NDR 0.555	NDR 0.420	6.16
Fluoranthene	2.79	2.29	1.13	0.683	0.311	NDR 0.586	NDR 1.13	0.57
Pyrene	2.96	3.08	4.23	0.681	0.3	NDR 0.669	2.63	2.58
Benz[a]anthracene	NDR 0.149	NDR 0.218	NDR 0.106	0.234	NDR 0.050	< 0.063	< 0.078	NDR 0.096
Chrysene	0.582	0.994	0.887	0.348	0.104	< 0.075	0.155	0.164
Benzo[b]fluoranthene	0.231	0.283	0.431	0.276	< 0.070	< 0.081	< 0.086	< 0.095
Benzo[j,k]fluoranthenes	NDR 0.119	< 0.122	0.277	NDR 0.162	< 0.085	< 0.093	< 0.103	NDR 0.145
Benzo[e]pyrene	NDR 0.198	0.356	0.445	NDR 0.224	< 0.107	< 0.138	< 0.131	< 0.203
Benzo[a]pyrene	< 0.125	< 0.161	NDR 0.204	NDR 0.304	< 0.120	< 0.155	< 0.147	< 0.227
Perylene	< 0.134	< 0.165	< 0.130	< 0.153	< 0.120	< 0.149	< 0.151	< 0.216
Dibenz[a,h]anthracene	< 0.112	< 0.149	< 0.124	< 0.154	< 0.125	< 0.162	< 0.128	< 0.189
Indeno[1,2,3-cd]pyrene	NDR 0.200	NDR 0.214	NDR 0.396	NDR 0.297	NDR 0.134	< 0.135	< 0.131	< 0.253
Benzo[ghi]perylene	NDR 0.210	NDR 0.311	NDR 0.379	NDR 0.351	NDR 0.163	< 0.138	NDR 0.135	< 0.169
2-Methylnaphthalene	15.6	3.95	9.09	1.2	1.15	1.27	1.61	2.01
2,6-Dimethylnaphthalene	2.22	1.73	3.27	< 0.506	0.319	0.407	0.729	0.855
2,3,5-Trimethylnaphthalene	5.27	5.95	1.78	< 0.265	< 0.157	NDR 0.609	NDR 0.965	NDR 1.18
1-Methylphenanthrene	0.843	1.05	0.228	< 0.209	0.158	< 0.218	0.373	0.368
Dibenzothiophene	NDR 0.571	NDR 0.498	NDR 0.293	< 0.191	< 0.081	< 0.183	NDR 0.245	NDR 7.39

< = less than the detection limit; number following this symbol represents the detection limit.

NDR = peak detected but did not meet quantification criteria; number following this flag represents the estimated maximum possible concentration.

Table A1.10 Sediment and soil particle size and TOC; Da Nang Airport, Viet Nam; January 2010.

Sample ID	Date Sampled	Matrix	Particle Size				Total Organic Carbon (%)
			% Gravel (>2mm)	% Sand (2.0mm - 0.063mm)	% Silt (0.063mm - 4µm)	% Clay (<4µm)	
Sen Lake (Open Water)							
SAP503-1	26-JAN-10	Sediment	<1.0	52.0	35.0	12.0	2.29
SAP503-2	26-JAN-10	Sediment	<1.0	71.0	19.0	10.0	2.62
SAP503-3	26-JAN-10	Sediment	<1.0	74.0	17.0	8.0	2.60
SAP504-1	22-JAN-10	Sediment	<1.0	28.0	46.0	26.0	7.59
SAP504-2	22-JAN-10	Sediment	<1.0	46.0	36.0	17.0	6.80
SAP504-3	22-JAN-10	Sediment	<1.0	45.0	40.0	15.0	7.23
SAP505-1	26-JAN-10	Sediment	<1.0	83.0	12.0	5.0	0.53
SAP505-2	26-JAN-10	Sediment	<1.0	89.0	9.0	2.0	1.14
Sen Lake - Eastern Wetland							
SAP501-1	21-JAN-10	Sediment	<1.0	85.0	2.0	13.0	1.19
SAP501-2	21-JAN-10	Sediment	<1.0	85.0	9.0	5.0	0.44
SAP521-1	21-JAN-10	Sediment	<1.0	79.0	5.0	16.0	0.98
SAP521-2	21-JAN-10	Sediment	<1.0	81.0	15.0	4.0	1.43
SAP521-3	21-JAN-10	Sediment	<1.0	89.0	7.0	5.0	0.39
Storage Area							
SAP601-1	26-JAN-10	Soil	<1.0	78.0	9.0	13.0	0.25
SAP601-2	26-JAN-10	Soil	<1.0	80.0	8.0	12.0	0.15
SAP601-3	26-JAN-10	Soil	<1.0	82.0	6.0	11.0	0.12
SAP812 (Duplicate of 601-3)	26-JAN-10	Soil	<1.0	83.0	6.0	11.0	<0.10
SAP602-1	26-JAN-10	Soil	<1.0	80.0	8.0	12.0	<0.10
SAP602-2	26-JAN-10	Soil	<1.0	78.0	8.0	14.0	<0.10
SAP602-3	26-JAN-10	Soil	<1.0	81.0	6.0	13.0	<0.10
SAP603-1	26-JAN-10	Soil	<1.0	79.0	10.0	10.0	0.49
SAP603-2	26-JAN-10	Soil	<1.0	77.0	8.0	15.0	<0.10
SAP603-3	26-JAN-10	Soil	<1.0	78.0	6.0	16.0	0.11
Mixing and Loading Area							
SAP604-1	25-JAN-10	Soil	<1.0	76.0	8.0	15.0	<0.10
SAP604-2	25-JAN-10	Soil	<1.0	78.0	9.0	13.0	0.11
SAP604-3	25-JAN-10	Soil	<1.0	80.0	9.0	11.0	<0.10
SAP605-1	25-JAN-10	Soil	5.0	76.0	12.0	7.0	0.49
SAP605-2	25-JAN-10	Soil	7.0	75.0	10.0	8.0	<0.10
SAP605-3	25-JAN-10	Soil	3.0	75.0	11.0	12.0	0.28
SAP606-1	25-JAN-10	Soil	2.0	80.0	8.0	10.0	0.18
SAP606-2	25-JAN-10	Soil	1.0	83.0	8.0	9.0	0.20
SAP606-3	25-JAN-10	Soil	<1.0	81.0	9.0	10.0	0.20
SAP607-1	25-JAN-10	Soil	<1.0	80.0	9.0	11.0	0.20
SAP607-2	25-JAN-10	Soil	<1.0	83.0	7.0	10.0	0.17
SAP607-3	25-JAN-10	Soil	1.0	88.0	5.0	6.0	<0.10
Proposed Landfill Site							
SAP610-1	26-JAN-10	Soil	12.0	49.0	29.0	10.0	0.66
SAP610-4	26-JAN-10	Soil	1.0	77.0	12.0	10.0	0.28
SAP610-7	26-JAN-10	Soil	<1.0	82.0	5.0	13.0	<0.10

"<" = less than the detection limit; number following this symbol represents the detection limit.

Table A1.11 2,3,7,8-TCDD (pg/g dry weight), TEQ (pg/g) and percent TCDD of the TEQ concenration for soil and sediment samples from Da Nang Airport, Viet Nam, 2006 and 2009.

Sample ID	Location	Media	Depth	2,3,7,8-TCDD	TEQ (WHO 2005)	TCDD as % of TEQ
Former Mixing and Loading Area (MLA)						
06VN058	Site 2 - Centre	Soil	0-10 cm	361000	365000	99
06VN059	Site 2 - Centre	Soil	10-30 cm	330000	333000	99
06VN063	Site 1 - West	Soil	0-10 cm	1190	1200	99
06VN064	Site 1 - West	Soil	10-30 cm	8730	8770	100
06VN065	Site 3 - NE	Soil	0-10 cm	27700	27900	99
06VN068	Site 3 - NE	Soil	10-30 cm	36800	37000	99
06VN066	Perimeter - S of Former Barracks	Soil	0-10 cm	858	899	95
06VN067	Perimeter - N of Former Barracks	Soil	0-10 cm	4820	4980	97
06VN069	Perimeter - W of Former Barracks	Soil	0-10 cm	165000	167000	99
Former Storage Area (SA)						
06VN075	Site 1 - NW	Soil	0-10 cm	5100	5200	98
06VN076	Site 1 - NW	Soil	10-30 cm	773	787	98
06VN077	Site 1 - NW	Soil	30-50 cm	9.12	24.5	37
06VN078	Site 2 - NE	Soil	0-10 cm	106000	106000	100
06VN083	Site 3 - Centre	Soil	0-10 cm	61500	62200	99
06VN084	Site 3 - Centre	Soil	10-30 cm	336	347	97
06VN085	Site 3 - Centre	Soil	30-50 cm	136	143	95
06VN070	Site 4 - SW	Soil	0-10 cm	3350	3520	95
06VN074	Site 5 - SE	Soil	0-10 cm	63200	64600	98
Between Storage Area and Mixing and Loading Area						
06VN043	S of SA / W of Ditch	Soil	0-10 cm	136	170	80
06VN047	SE of SA / E of Ditch	Soil	0-10 cm	6080	6520	93
06VN048	N of MLA / W of Ditch	Soil	0-10 cm	3840	4150	93
Drainage System						
06VN072	Water Treatment Basin	Sediment	grab	25700	27700	93
06VN081	Ditch d/s of Storage Area	Sediment	grab	8390	8580	98
09VN302	North Base Perimeter	Sediment	grab	4080	4200	97
Airport Perimeter						
06VN036	Military Garden	Soil	0-10 cm	16.9	31	55
06VN035	Old Munitions Dump	Soil	0-10 cm	103	149	69
06VN046	5m E of Ditch, Near Main Road	Soil	0-10 cm	5400	5690	95
09VN304	North Base Perimeter	Soil	0-10 cm	11200	11700	96
06VN042	N of Airline Staff Residence	Soil	0-10 cm	1700	1830	93
06VN045	NE of SA / E of Ditch	Soil	0-10 cm	598	674	89
06VN037	S of Airlines Staff Residence	Soil	0-10 cm	165	270	61
06VN038	S of Airlines Staff Res. (Dup)	Soil	0-10 cm	150	253	59
09VN306	North Base Perimeter	Sediment	grab	534	674	79
06VN019	NE Corner Airport (2)	Soil	0-10 cm	7.91	17.1	46
06VN018	NE Corner Airport (1)	Soil	0-10 cm	43.6	72.9	60
06VN001	Btwn SA and Sen Lake (1)	Soil	0-10 cm	9.66	16.4	59
06VN003	Btwn SA and Sen Lake (2)	Soil	0-10 cm	6.44	12.2	53
06VN004	Btwn SA and Lake B (1)	Soil	0-10 cm	219	232	94
06VN006	Btwn SA and Lake B (2)	Soil	0-10 cm	14	26	54
06VN010	Btwn Lakes B & C	Soil	0-10 cm	25.4	49.2	52
06VN014	Sen Lake Garden	Soil	0-10 cm	12.5	18	69
06VN015	Sen Lake Residence	Soil	0-10 cm	1.72	4.34	40
06VN013	NW Corner Airport	Soil	0-10 cm	53.1	68.2	78
06VN073	Footpath W Airport	Soil	0-10 cm	0.212	0.643	33
06VN027	Garden SW Airport	Soil	0-10 cm	2.29	15	15

Table A1.11 (Cont'd.)

Sample ID	Location	Media	Depth	2,3,7,8-TCDD	TEQ (WHO 2005)	TCDD as % of TEQ
Da Nang City						
06VN093	March 29 Lake	Sediment	Grab	4.57	26.9	17
06VN091	N of Airport / Dien Bien Phu Street	Soil	0-10 cm	1.26	5.91	21
06VN092	NE of Airport / Dien Bien Phu Street	Soil	0-10 cm	0.649	7.36	9
06VN087	Garden near Xuan Lake	Sediment	Grab	2.58	6.66	39
06VN088	Xuan Lake (N)	Sediment	Grab	8.21	17.8	46
06VN090	Xuan Lake (S)	Sediment	Grab	2.63	16.7	16
06VN099	Thanh Khe Garden (1)	Soil	0-10 cm	26	36.1	72
06VN100	Thanh Khe Garden (2)	Soil	0-10 cm	1.28	3.94	32
06VN101	Thanh Khe Garden (3)	Soil	0-10 cm	0.616	5.34	12
06VN102	Hai Chau Garden	Soil	0-10 cm	0.644	3.14	21
Sen Lake						
06VN030	Outlet to Da Nang City	Sediment	Grab	253	292	87
06VN030**	Outlet to Da Nang City	Sediment	Grab	232	244	95
06VN031	Centre	Sediment	Grab	191	198	96
06VN031**	Centre	Sediment	Grab	184	192	96
06VN032	Centre	Sediment	Grab	2750	2980	92
06VN032**	Centre	Sediment	Grab	1140	1230	93
06VN033	SE	Sediment	Grab	61.4	68.6	90
06VN033**	SE	Sediment	Grab	63.6	69.2	92
06VN052	NE	Sediment	Grab	5440	5950	91
09VN286	Sen Lake East	Sediment	Grab	2510	2740	92
06VN053	NW	Sediment	Grab	6240	6820	91
09VN287	Sen Lake West	Sediment	Grab	4180	4540	92
06VN055	Centre-West	Sediment	Grab	3190	3520	91
06VN040	Inlet from Ditch	Sediment	Grab	1160	1290	90
Core Sample from Sen Lake						
06VN062-1	West	Sediment	0-2 cm	3730	4050	92
06VN062-2	West	Sediment	2-4 cm	674	750	90
06VN062-3	West	Sediment	4-6 cm	22.3	39.4	57
06VN062-4	West	Sediment	6-8 cm	6.15	18.9	33
06VN062-5	West	Sediment	8-10 cm	6.45	19.8	33
06VN062-6	West	Sediment	10-14 cm	4.4	20.2	22
06VN062-11	West	Sediment	30-32 cm	5.91	23.1	26
Lake B						
06VN024	North	Sediment	Grab	30.4	39.4	77
06VN029	South	Sediment	Grab	57.1	70.5	81
Lake C						
06VN021	North	Sediment	Grab	11.7	20.1	58
06VN022	North (Dup)	Sediment	Grab	8.89	16	56
06VN023	South	Sediment	Grab	4.54	7.99	57
West Airport Pond						
06VN080	Centre	Sediment	Grab	3.35	7.14	47
09VN285	West Airbase Lake	Sediment	Grab	24.2	64	37.8

Table A1.11 (Cont'd.)

Sample ID	Location	Media	Depth	2,3,7,8-TCDD	TEQ (WHO 2005)	TCDD as % of TEQ
Pacer Ivy Storage Area						
202A	Pacer Ivy Storage Area	Soil	0-10 cm	1180	1420	83
203A	Pacer Ivy Storage Area	Soil	0-10 cm	54.5	73.3	74
204A	Pacer Ivy Storage Area	Soil	0-10 cm	6.81	22.2	31
206A	Pacer Ivy Storage Area	Soil	0-10 cm	2.99	4.4	68
207A	Pacer Ivy Storage Area	Soil	0-10 cm	30.2	34.7	87
213A	Pacer Ivy Storage Area	Soil	0-10 cm	5.4	12.5	43
214A	Pacer Ivy Storage Area	Soil	0-10 cm	NDR 0.774	1.72	NC
321A*	Pacer Ivy Storage Area	Soil	0-10 cm	46.1	124	37
322A*	Pacer Ivy Storage Area	Soil	0-10 cm	NDR 1.62	1.79	NC
323A*	Pacer Ivy Storage Area	Soil	0-10 cm	NDR 1.22	4.6	NC
324A*	Pacer Ivy Storage Area	Soil	0-10 cm	1.97	6.93	28
325A*	Pacer Ivy Storage Area	Soil	0-10 cm	1.25	6.61	19
326A*	Pacer Ivy Storage Area	Soil	0-10 cm	44	75.3	58
327A*	Pacer Ivy Storage Area	Soil	0-10 cm	18.7	40.3	46
Depth Profile						
208A	Pacer Ivy Storage Area	Soil	1-10 cm	13400	20600	65
209A	Pacer Ivy Storage Area	Soil	10-30 cm	3500	5120	68
210A	Pacer Ivy Storage Area	Soil	30-60 cm	123	189	65
211A	Pacer Ivy Storage Area	Soil	60-90 cm	13.1	21.6	61
212A	Pacer Ivy Storage Area	Soil	90-115 cm	4.15	6.96	60

"<" = less than the detection limit; number following this symbol represents the detection limit.

NDR = peak detected but did not meet quantification criteria; number following this flag represents the estimated maximum possible concentration.

NC = Not calculated as NDR values of TCDD are considered "0".

Sources: Hatfield/Office 33 2007, 2009.

Table A1.12 **Results of duplicate (field and laboratory) analyses of dioxins and furans; Da Nang Airport, Viet Nam; January 2010.**

	Field Duplicates				AXYS Laboratory Duplicate Analyses							
CLIENT ID	**SAP527**	**SAP809**	**SAP601-3**	**SAP812**	**SAP501-2**	**SAP501-2**	**SAP520**	**SAP520**	**SAP528**	**SAP528**	**SAP605-4**	**SAP605-4**
	Weir at Sen Lake	**SAP527 Dup**	**Storage Area**	**SAP601-3 Dup**		**Lab Duplicate**		**Lab Duplicate**		**Lab Duplicate**		**Lab Duplicate**
2,3,7,8-TCDD	1780	2820	1430	1590	44.1	44.2	22.8	20.5	6770	7310	293	316
1,2,3,7,8-PeCDD	32.2	42.5	12.7	NDR 14.8	2.5	2.79	1.66	NDR 1.54	116	129	< 0.234	< 0.360
1,2,3,4,7,8-HxCDD	26.9	32.2	NDR 1.63	NDR 1.96	3.98	3.88	< 0.309	2.77	28.3	34.1	NDR 0.875	NDR 0.740
1,2,3,6,7,8-HxCDD	92	114	9.79	11.2	8.97	9	5.62	6.01	169	199	NDR 0.677	< 0.378
1,2,3,7,8,9-HxCDD	76.7	94.6	4.61	5.49	12.7	11.9	15.8	14.4	113	134	< 0.276	0.97
1,2,3,4,6,7,8-HpCDD	2040	2230	79.5	106	218	217	171	168	672	791	46.3	44.4
OCDD	27200	27900	12000	13400	3340	3370	6770	6620	2470	2700	7560	8060
2,3,7,8-TCDF	199	264	88	108	8.33	7.94	3.67	3.33	404	445	1.68	1.6
1,2,3,7,8-PeCDF	151	17.1	1.21	1.75	1.6	1.48	NDR 0.608	< 0.322	NDR 7.33	6.9	< 0.397	< 0.278
2,3,4,7,8-PeCDF	16.2	21.2	2.89	3.12	1.93	1.74	1.17	0.579	7.88	10.3	NDR 0.499	NDR 0.524
1,2,3,4,7,8-HxCDF	19	42.6	NDR 2.39	2.12	3.37	NDR 3.35	NDR 1.48	1.56	6.35	7.71	< 0.216	< 0.238
1,2,3,6,7,8-HxCDF	36.7	25.7	< 0.303	NDR 0.589	1.7	1.71	NDR 0.970	1.06	2.59	2.93	< 0.216	< 0.208
1,2,3,7,8,9-HxCDF	25	3.83	NDR 0.794	NDR 0.208	0.329	0.275	< 0.308	< 0.352	0.422	NDR 1.36	< 0.216	< 0.290
2,3,4,6,7,8-HxCDF	5.11	23.3	NDR 0.749	NDR 0.663	1.54	1.44	0.929	0.858	NDR 3.18	3.26	< 0.216	< 0.251
1,2,3,4,6,7,8-HpCDF	19.8	306	6.03	7.16	22.5	20.2	13.4	12.8	37.4	41.3	NDR 0.516	< 0.275
1,2,3,4,7,8,9-HpCDF	281	22	< 0.270	0.602	1.41	1.26	NDR 0.997	NDR 0.468	1.69	1.94	< 0.262	< 0.330
OCDF	21.3	634	4.07	4.25	34.3	32	19.1	20.3	40.1	54.7	NDR 1.43	NDR 0.542
Total Tetra-Dioxins	839	3180	1560	1750	59.6	60.2	28.4	20.5	7180	7800	300	323
Total Penta-Dioxins	2000	390	67.2	81.2	30.1	27.2	6.63	8.82	724	900	< 0.234	< 0.360
Total Hexa-Dioxins	299	1080	86.4	104	111	109	78	77.3	1100	1320	8.1	12.9
Total Hepta-Dioxins	932	4500	165	221	454	458	379	363	1090	1300	105	97.9
Total Tetra-Furans	3970	938	368	457	41.8	38.9	16.8	11.3	1610	1620	2.43	3.96
Total Penta-Furans	712	727	367	436	38	34.8	12.7	11	1480	1510	1.89	< 0.278
Total Hexa-Furans	527	587	79.6	94	42.3	37.2	16.6	7.22	245	279	1.47	< 0.290
Total Hepta-Furans	526	913	15.3	18.5	53.2	49.7	25.9	12.8	70.2	81.5	< 0.262	< 0.330
% Moisture	28.7	31.4	9.61	10.6	28.3	28.2	25	22.5	22.4	22.3	9.72	9.19
2,3,7,8-TCDF (C)	806	214	55.4	65.1	5.44	5.69	4.15	3.54	353	390	0.376	< 0.438
TEQ (WHO 1998) ND=0	1890	2960	1450	1600	54.2	54	30.2	26.3	6960	7530	294	317
TEQ (WHO 1998) ND=1/2DL	1890	2960	1450	1600	54.2	54.1	30.3	26.5	6960	7530	295	318
TEQ (WHO 2005) ND=0	1890	2960	1460	1600	54.5	54.4	31.3	27.5	6960	7530	296	319
TEQ (WHO 2005) ND=1/2DL	1890	2960	1460	1600	54.5	54.4	31.4	27.7	6960	7530	296	319

"<" = less than the detection limit; number following this symbol represents the detection limit.

NDR = peak detected but did not meet quantification criteria; number following this flag represents the estimated maximum possible concentration.

Table A1.13 MOD 1997 Data, Sen Lake Study - surface sediment samples.

Note: Hatfield assumes that the maximum depth refers to water column depth over sediment.

SAMPLENAME	MEDIA	WGS	UTMZone	NORTHING	EASTING	TEQ (ppt)	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)	MEDIA2
Unlabeled Point	Soil/Sediment	1984	49N	1777820	199866	2.9			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777994	200151	2.2	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778068	200256	11.8			Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778094	200367	17.8	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778097	200458	28.3			Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778043	200009	30	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777989	199789	42.4	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778096	200624	43.5	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777923	200044	44.9	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778061	200363	282.6	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778061	200452	700.5	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777936	200263	1084.1	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778005	200432	2403.3	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1778044	200526	2947	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777931	200532	4137.5	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777917	200420	4668.1	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777866	200254	11.6			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777791	200295	57.6			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777709	200185	6			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777805	200438	7455.1			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777678	200414	42576	NR	NR	Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777431	200554	69444			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777402	200383	51248			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777483	200175	8.1			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777552	199947	4.8			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777366	199960	4.3			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777538	200556	57.5			Soil
Unlabeled Point	Soil/Sediment	1984	49N	1777985	200522	4884.5	NR	NR	Sediment
Unlabeled Point	Soil/Sediment	1984	49N	1777993	200332	12393.2	NR	NR	Sediment
DN 12	Soil/Sediment	1984	49N	1778007	200010	25	NR	40	Sediment
DN 14	Soil/Sediment	1984	49N	1777957	199787	26.8	NR	50	Sediment
DN 13	Soil/Sediment	1984	49N	1777954	200008	38.5	NR	80	Sediment
DN 11	Soil/Sediment	1984	49N	1778085	200346	246.9	NR	80	Sediment
DN 8	Soil/Sediment	1984	49N	1778104	200429	643.7	NR	70	Sediment
DN 1	Soil/Sediment	1984	49N	1778095	200553	952.8	NR	70	Sediment
DN 10	Soil/Sediment	1984	49N	1777978	200260	999	NR	120	Sediment
DN 7	Soil/Sediment	1984	49N	1778054	200413	1903.6	NR	120	Sediment
DN 3	Soil/Sediment	1984	49N	1778054	200501	2728.3	NR	70	Sediment
DN 6	Soil/Sediment	1984	49N	1778016	200413	2736.1	NR	110	Sediment
DN 2	Soil/Sediment	1984	49N	1778009	200541	3904.7	NR	60	Sediment
DN 5	Soil/Sediment	1984	49N	1777942	200396	4407.3	NR	80	Sediment
DN 4	Soil/Sediment	1984	49N	1778023	200484	4675.5	NR	110	Sediment
DN 9	Soil/Sediment	1984	49N	1778023	200325	11798.6	NR	180	Sediment

Table A1.14 VAST/USEPA Data (2005).

SAMPLENAME	MEDIA	WGS	UTMZone	NORTHING	EASTING	TEQ (ppt)	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)	MEDIA2
ML-B1	Soil/Sediment	1984	49N	1777429	200472	10998	0	15	Soil
ML-A2.1	Soil/Sediment	1984	49N	1777415	200458	8560	0	30	Soil
ML-B2.1	Soil/Sediment	1984	49N	1777427	200459	11061	0	30	Soil
ML-B2.2	Soil/Sediment	1984	49N	1777427	200459	6678	30	60	Soil
ML-C2	Soil/Sediment	1984	49N	1777439	200456	10998	0	15	Soil
ML-D2	Soil/Sediment	1984	49N	1777451	200455	10998	0	15	Soil
ML-A3.1	Soil/Sediment	1984	49N	1777414	200446	11061	0	30	Soil
ML-B3	Soil/Sediment	1984	49N	1777426	200445	10998	0	15	Soil
ML-C3.1	Soil/Sediment	1984	49N	1777438	200445	9119	0	30	Soil
ML-C3.2	Soil/Sediment	1984	49N	1777438	200445	9119	30	60	Soil
ML-D3	Soil/Sediment	1984	49N	1777450	200443	10998	0	15	Soil
ML-A4.1	Soil/Sediment	1984	49N	1777412	200435	8560	0	30	Soil
ML-B4.1	Soil/Sediment	1984	49N	1777425	200434	11061	0	30	Soil
ML-B4.2	Soil/Sediment	1984	49N	1777425	200434	11061	30	60	Soil
ML-C4.1	Soil/Sediment	1984	49N	1777436	200430	9119	0	30	Soil
ML-C4.2	Soil/Sediment	1984	49N	1777436	200430	9119	30	60	Soil
ML-C4.3	Soil/Sediment	1984	49N	1777436	200430	5737	60	90	Soil
ML-D4.1	Soil/Sediment	1984	49N	1777449	200434	11577	0	30	Soil
ML-D4.2	Soil/Sediment	1984	49N	1777449	200434	6890	30	60	Soil
ML-D4.3	Soil/Sediment	1984	49N	1777449	200434	7699	60	90	Soil
ML-A5	Soil/Sediment	1984	49N	1777410	200419	8560	0	15	Soil
ML-C5	Soil/Sediment	1984	49N	1777433	200428	10998	0	15	Soil
ML-A7.1	Soil/Sediment	1984	49N	1777442	200545	8560	0	30	Soil
ML-B7.1	Soil/Sediment	1984	49N	1777442	200532	30	0	30	Soil
ML-B7.2	Soil/Sediment	1984	49N	1777442	200532	33	30	60	Soil
ML-B7.3	Soil/Sediment	1984	49N	1777442	200532	16	60	90	Soil
ML-A8	Soil/Sediment	1984	49N	1777442	200551	8560	0	15	Soil
ML-B8.1	Soil/Sediment	1984	49N	1777444	200545	10222	0	30	Soil
ML-B8.2	Soil/Sediment	1984	49N	1777444	200545	6682	30	60	Soil
ML-B8.3	Soil/Sediment	1984	49N	1777444	200545	1547	60	90	Soil
ML-C8.1	Soil/Sediment	1984	49N	1777448	200542	9119	0	30	Soil
ML-C8.2	Soil/Sediment	1984	49N	1777448	200542	9119	30	60	Soil
ML-C8.3	Soil/Sediment	1984	49N	1777448	200542	5737	60	90	Soil
ML-A9	Soil/Sediment	1984	49N	1777444	200555	10998	0	15	Soil
ML-B9.1	Soil/Sediment	1984	49N	1777446	200550	11061	0	30	Soil
ML-B9.2	Soil/Sediment	1984	49N	1777446	200550	11061	30	60	Soil
ML-B9.3	Soil/Sediment	1984	49N	1777446	200550	11061	60	90	Soil
ML-C9.1	Soil/Sediment	1984	49N	1777448	200547	9119	0	30	Soil
ML-C9.2	Soil/Sediment	1984	49N	1777448	200547	11577	30	60	Soil
ML-C9.3	Soil/Sediment	1984	49N	1777448	200547	4725	60	90	Soil

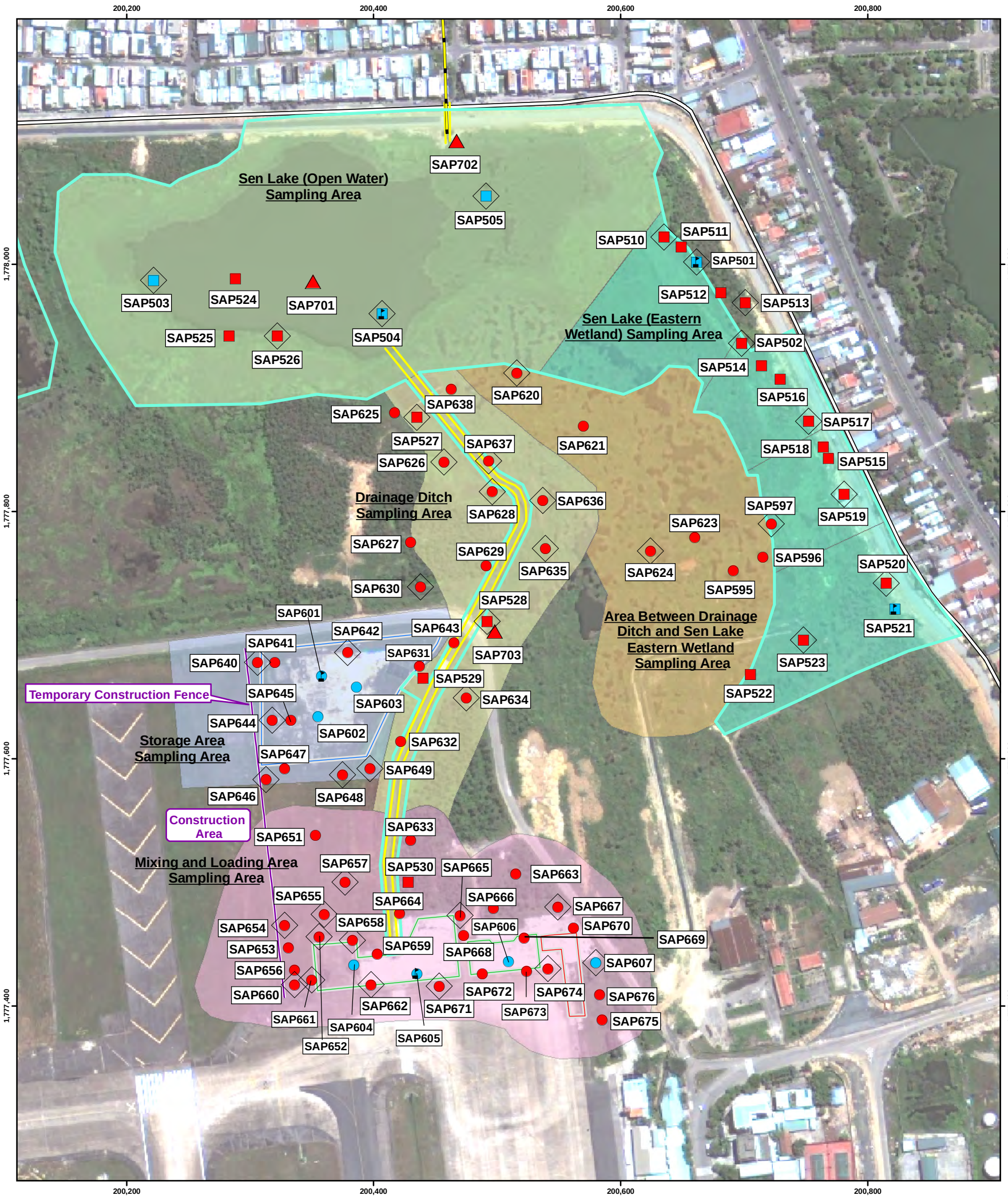
Table A1.14 (Cont'd.)

SAMPLENAME	MEDIA	WGS	UTMZone	NORTHING	EASTING	TEQ (ppt)	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)	MEDIA2
ML-B10.1	Soil/Sediment	1984	49N	1777447	200555	11061	0	30	Soil
ML-B10.2	Soil/Sediment	1984	49N	1777447	200555	5174	30	60	Soil
ML-B10.3	Soil/Sediment	1984	49N	1777447	200555	2860	60	90	Soil
ML-C10.1	Soil/Sediment	1984	49N	1777449	200554	9119	0	30	Soil
ML-C10.2	Soil/Sediment	1984	49N	1777449	200554	11577	30	60	Soil
ML-C10.3	Soil/Sediment	1984	49N	1777449	200554	4725	60	90	Soil
ML-B11.1	Soil/Sediment	1984	49N	1777447	200559	11061	0	30	Soil
ML-B11.2	Soil/Sediment	1984	49N	1777447	200559	5174	30	60	Soil
ML-B11.3	Soil/Sediment	1984	49N	1777447	200559	2860	60	90	Soil
ML-C11.1	Soil/Sediment	1984	49N	1777450	200557	11577	0	30	Soil
ML-C11.2	Soil/Sediment	1984	49N	1777450	200557	6890	30	60	Soil
ML-C11.3	Soil/Sediment	1984	49N	1777450	200557	7699	60	90	Soil
ML-B12	Soil/Sediment	1984	49N	1777448	200563	10998	0	15	Soil
ML-C12	Soil/Sediment	1984	49N	1777448	200534	10998	0	15	Soil
ML-B13	Soil/Sediment	1984	49N	1777451	200565	10998	0	15	Soil
ML-B14	Soil/Sediment	1984	49N	1777437	200490	10998	0	15	Soil
ML-B18	Soil/Sediment	1984	49N	1777440	200508	10998	0	15	Soil
ML-B20	Soil/Sediment	1984	49N	1777442	200535	10998	0	15	Soil
SA-B1	Soil/Sediment	1984	49N	1777656	200326	2811	0	15	Soil
SA-D1	Soil/Sediment	1984	49N	1777635	200327	2280	0	15	Soil
SA-A2	Soil/Sediment	1984	49N	1777670	200333	11577	0	15	Soil
SA-B3	Soil/Sediment	1984	49N	1777659	200349	11934	0	15	Soil
SA-C3	Soil/Sediment	1984	49N	1777649	200348	11934	0	15	Soil
SA-D3	Soil/Sediment	1984	49N	1777636	200351	2280	0	15	Soil
SA-A4	Soil/Sediment	1984	49N	1777674	200358	11934	0	15	Soil
SA-E4.2	Soil/Sediment	1984	49N	1777627	200365	6	30	60	Soil
SA-H4.1	Soil/Sediment	1984	49N	1777593	200364	1861	0	30	Soil
SA-H4.3	Soil/Sediment	1984	49N	1777593	200364	6928	60	90	Soil
SA-B5.1	Soil/Sediment	1984	49N	1777663	200370	4841	0	30	Soil
SA-B5.2	Soil/Sediment	1984	49N	1777663	200370	2311	30	60	Soil
SA-B5.3	Soil/Sediment	1984	49N	1777663	200370	2128	60	90	Soil
SA-C5.1	Soil/Sediment	1984	49N	1777652	200372	5290	0	30	Soil
SA-C5.2	Soil/Sediment	1984	49N	1777652	200372	3630	30	60	Soil
SA-C5.3	Soil/Sediment	1984	49N	1777652	200372	6285	60	90	Soil
SA-G5.1	Soil/Sediment	1984	49N	1777606	200378	5131	0	30	Soil
SA-G5.2	Soil/Sediment	1984	49N	1777606	200378	47	30	60	Soil
SA-G5.3	Soil/Sediment	1984	49N	1777606	200378	79	60	90	Soil
SA-A6.1	Soil/Sediment	1984	49N	1777677	200387	1889	0	40	Soil
SA-A6.3	Soil/Sediment	1984	49N	1777677	200387	2549	90	120	Soil
SA-A6.4	Soil/Sediment	1984	49N	1777677	200387	8429	120	140	Soil

Table A1.14 (Cont'd.)

SAMPLENAME	MEDIA	WGS	UTMZone	NORTHING	EASTING	TEQ (ppt)	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)	MEDIA2
SA-B6	Soil/Sediment	1984	49N	1777664	200384	11934	0	15	Soil
SA-C6.1	Soil/Sediment	1984	49N	1777654	200386	11991	0	30	Soil
SA-C6.2	Soil/Sediment	1984	49N	1777654	200386	11991	30	60	Soil
SA-C6.3	Soil/Sediment	1984	49N	1777654	200386	9	60	90	Soil
SA-F6.1	Soil/Sediment	1984	49N	1777619	200391	51	0	30	Soil
SA-F6.2	Soil/Sediment	1984	49N	1777619	200391	39	30	60	Soil
SA-F6.3	Soil/Sediment	1984	49N	1777619	200391	17	60	90	Soil
SA-A7	Soil/Sediment	1984	49N	1777679	200394	11934	0	15	Soil
SA-D7	Soil/Sediment	1984	49N	1777642	200399	4770	0	15	Soil
SA-G7	Soil/Sediment	1984	49N	1777609	200402	8560	0	15	Soil
SA-B8	Soil/Sediment	1984	49N	1777666	200408	11934	0	15	Soil
SA-C8.1	Soil/Sediment	1984	49N	1777656	200411	18	0	30	Soil
SA-C8.2	Soil/Sediment	1984	49N	1777656	200411	7	30	60	Soil
SA-C8.3	Soil/Sediment	1984	49N	1777656	200411	15	60	90	Soil
SA-A9	Soil/Sediment	1984	49N	1777679	200417	11934	0	15	Soil
SA-D9	Soil/Sediment	1984	49N	1777648	200420	8560	0	15	Soil
SA-E9.1	Soil/Sediment	1984	49N	1777636	200421	5207	0	30	Soil
SA-E9.2	Soil/Sediment	1984	49N	1777636	200421	35	30	60	Soil
SA-E9.3	Soil/Sediment	1984	49N	1777636	200421	156	60	90	Soil
SA-B10	Soil/Sediment	1984	49N	1777672	200430	11934	0	15	Soil
SA-A11	Soil/Sediment	1984	49N	1777686	200440	11934	0	15	Soil
SA-A12	Soil/Sediment	1984	49N	1777685	200447	11934	0	15	Soil
OP-C2	Sediment	1984	49N	1777927	200391	5499	0	0	Sediment
OP-A2	Sediment	1984	49N	1777928	200381	10999	0	0	Sediment
OP-B1	Sediment	1984	49N	1777917	200391	10999	0	0	Sediment

Figure A1.1 Sample locations for environmental remediation at Da Nang Airport, 2010.



LEGEND

- Airport Boundary
- Da Nang City Storm Drain
- Drainage Ditch
- Former Storage Area
- Former Army Barracks
- Former Mixing and Loading Area
- Approximate Sediment Boundary

Field Sampling Location
January 2010

- Other COPC Sample
- Sediment Core
- Sediment Grab
- Soil Core/Soil Pit
- Soil Surface
- Ground Water Quality
- Surface Water Quality
- Tier 1 Sample (to be submitted immediately for TCDD/TCDF lab analysis)

GeoEye Image, July 23, 2009

USAID FROM THE AMERICAN PEOPLE

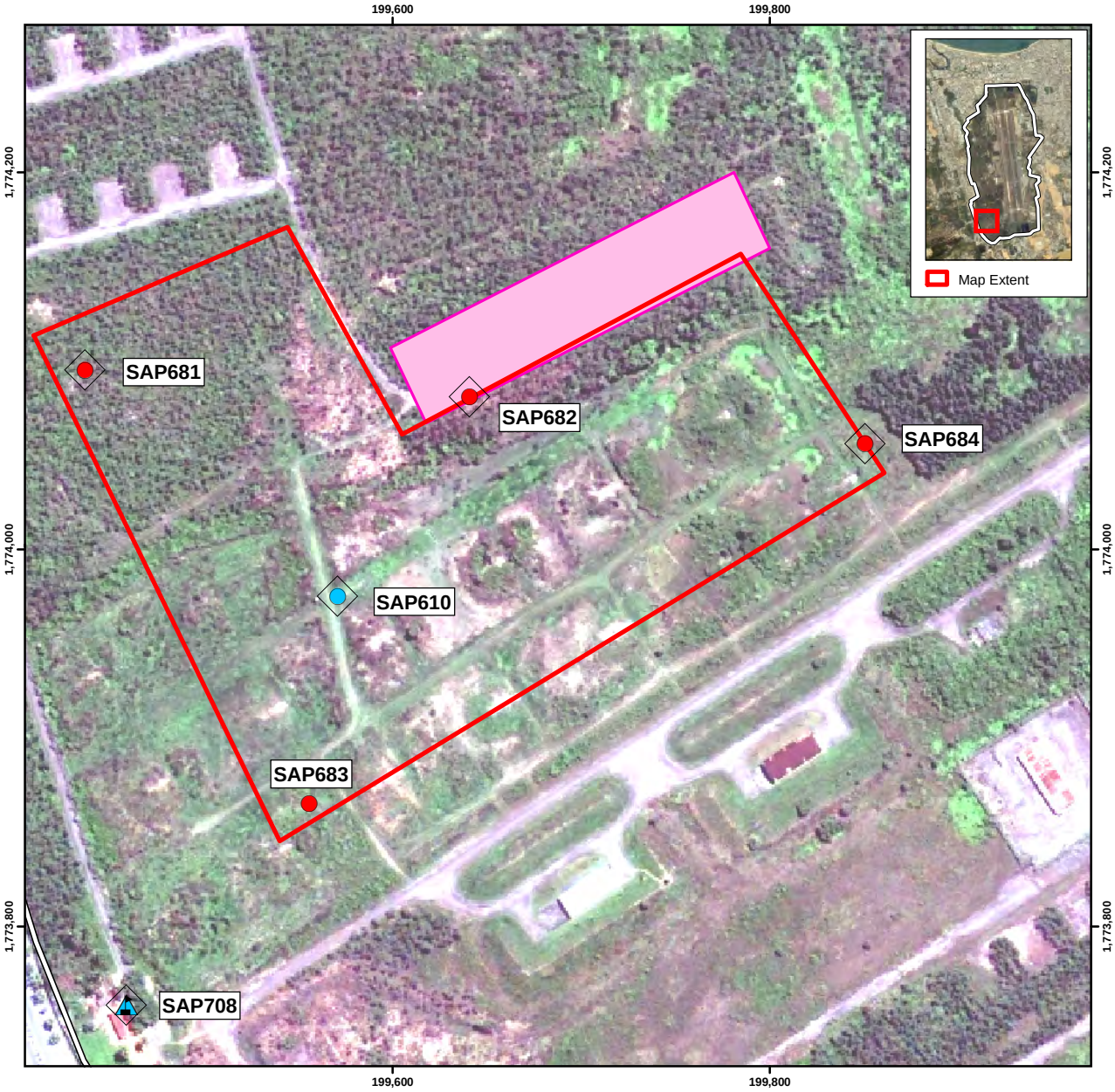
0 25 50 100 m

N

Projection: UTM Zone 49N WGS 84

K:\Data\Project\USAID1551\GIS_MXD\EA\USAID1551_EA_Appendix_A_FieldNorth_20100528.mxd

Figure A1.2 Sample locations for the landfill site at Da Nang Airport, 2010.



LEGEND

- Airport Boundary
- Pacer Ivy Storage Area
- Landfill Site

Field Sampling Location
January 2010

- Other COPC Sample
- Soil Core/Soil Pit
- Soil Surface
- Ground Water Quality
- Tier 1 Sample (to be submitted immediately for TCDD/TCDF lab analysis)

USAID FROM THE AMERICAN PEOPLE

0 25 50 100 m

Projection: UTM Zone 49N WGS 84

GeoEye Image, July 23, 2009

K:\Data\Project\USAID1551\GIS_MXD\FieldMap\USAID1551_EA_Appendix_B_FieldLandfill_20100528.mxd

Figure A1.3 Locations for ground and surface water samples at Da Nang Airport, 2010.

LEGEND

- Airport Boundary
- Da Nang City Storm Drain
- Drainage Ditch
- Former Storage Area
- Former Army Barracks
- Former Mixing and Loading Area
- Approximate Sediment Boundary

Field Sampling Location
January 2010

- Other COPC Sample
- Surface Water Quality
- Ground Water Quality
- Tier 1 Sample (to be submitted immediately for TCDD/TCDF lab analysis)

GeoEye Image, July 23, 2009

USAID FROM THE AMERICAN PEOPLE

0 125 250 500 m

Projection: UTM Zone 49N WGS 84

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Figure A1.4 January 2010 and historical sampling results (pg/g TEQ) at surface level - Sediment (0 to 15 cm depth), Soil (0 to 30 cm depth).

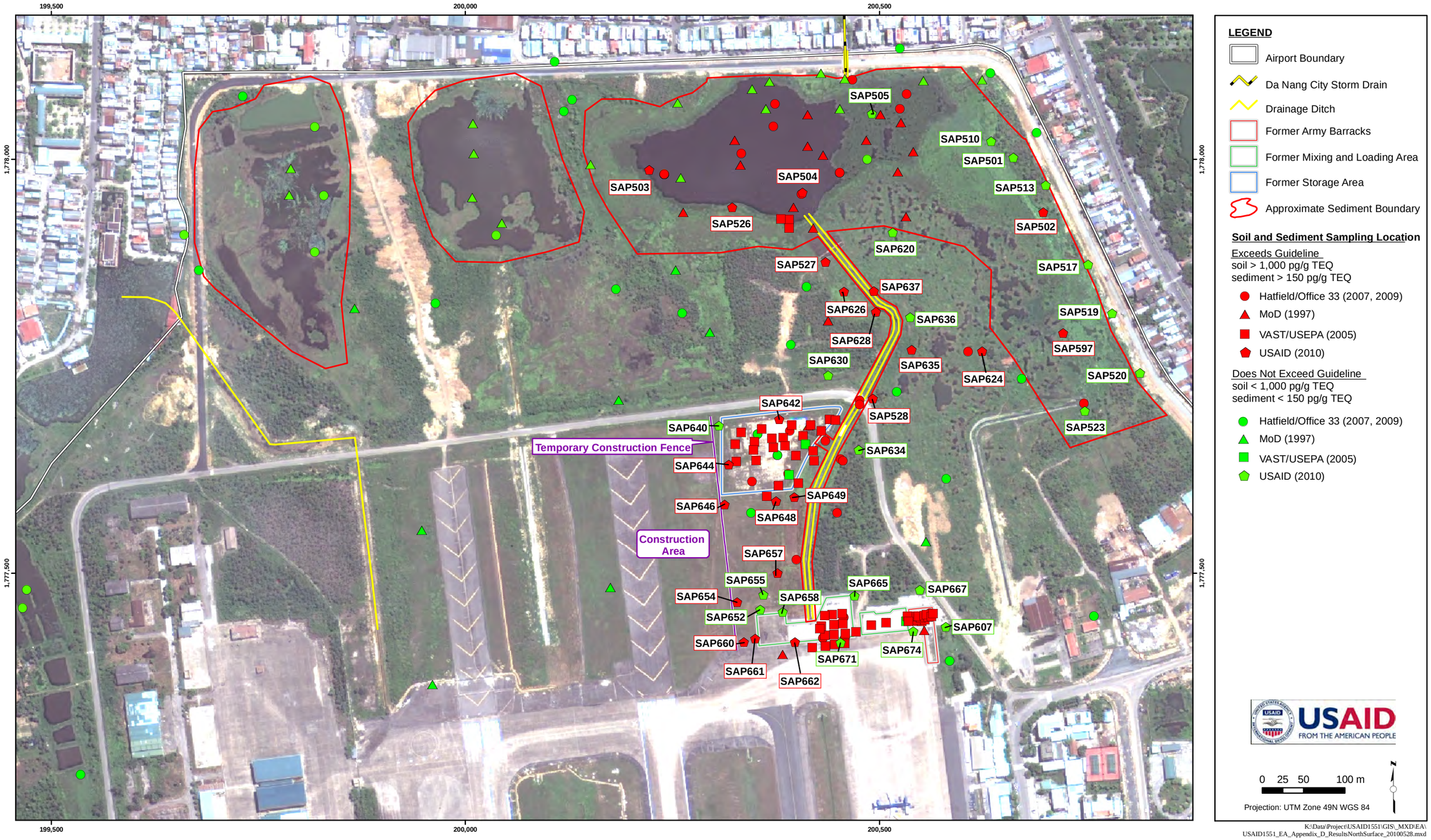

Figure A1.5 January 2010 and historical sampling results (pg/g TEQ) - Sediment (15 to 60 cm depth), Soil (30 to 60 cm depth).

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USAID1551_EA_Appendix_E_ResultsNorth30to60_20100528.mxd

Figure A1.6 January 2010 and historical sampling results (pg/g TEQ) - over 60 cm depth.

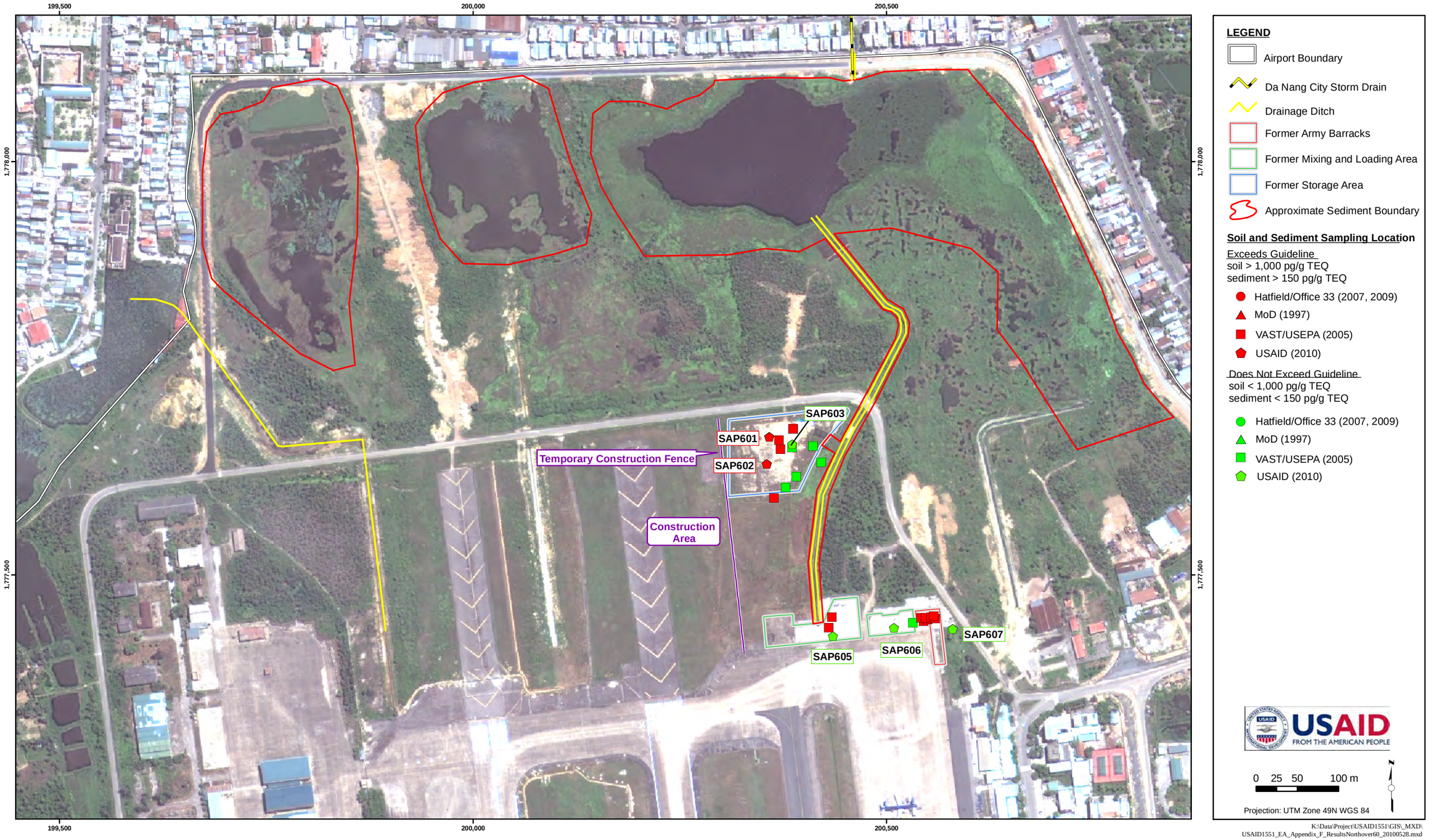


Figure A1.7 January 2010 and historical sampling results (pg/g TEQ) - all depths.

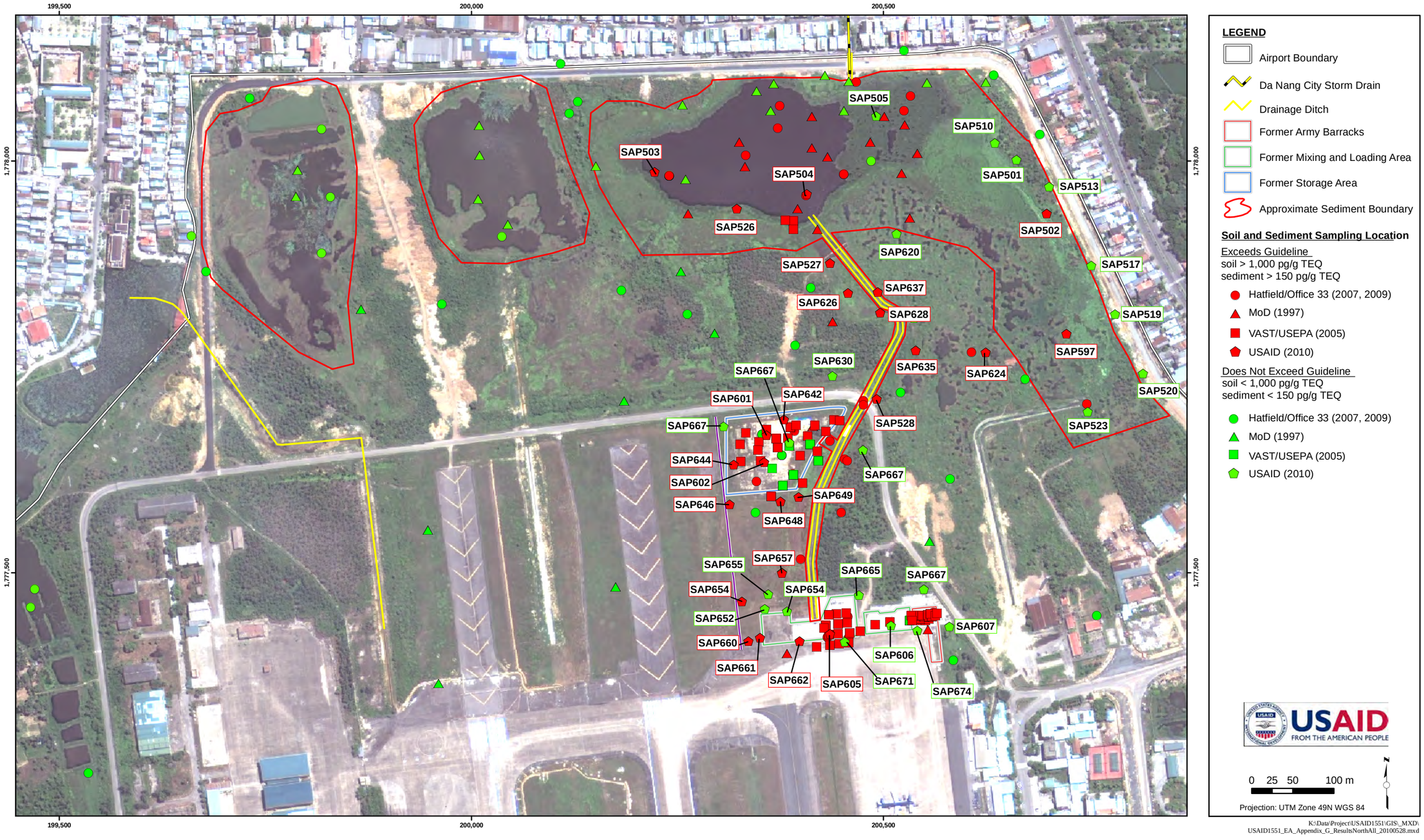
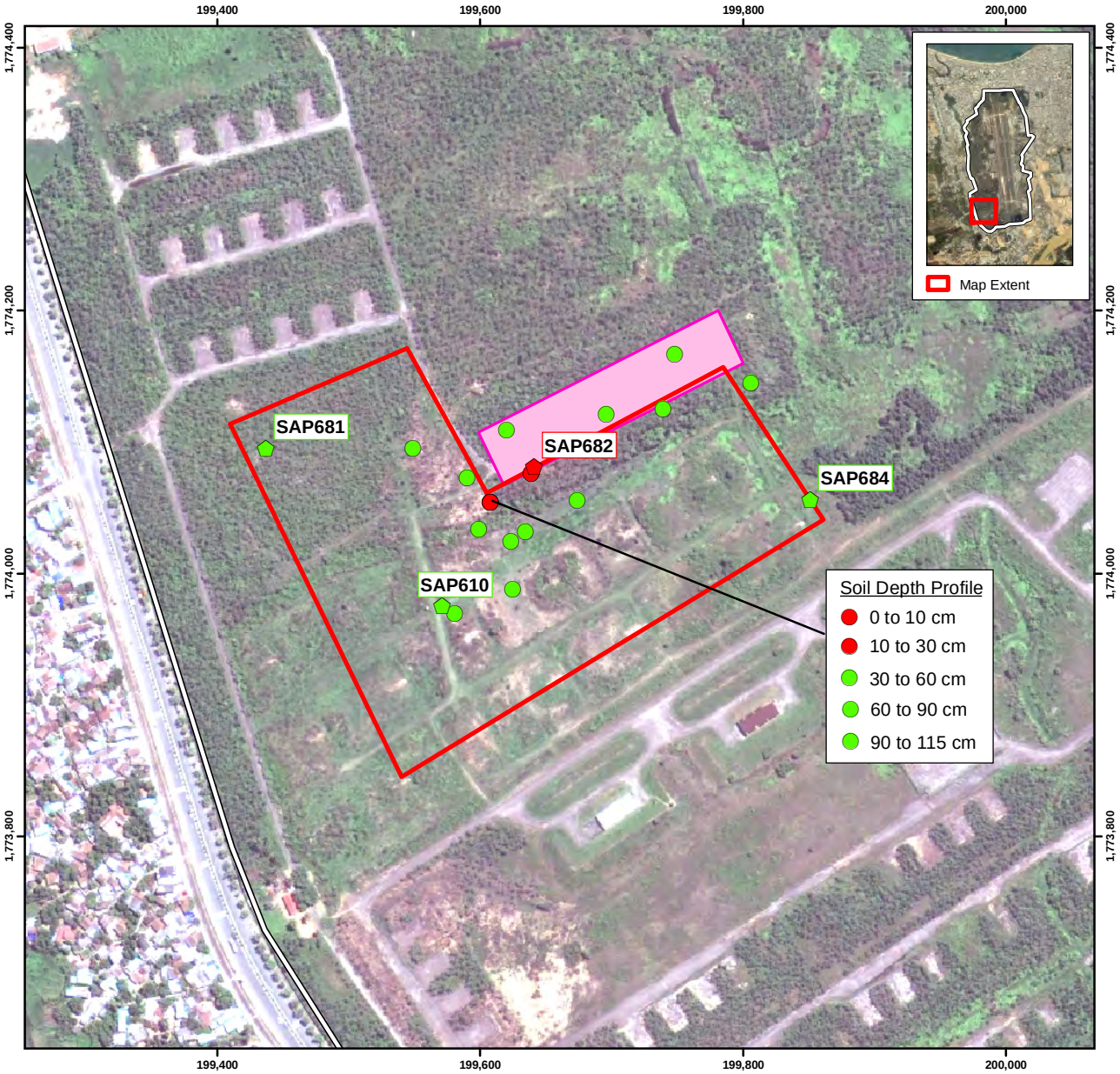


Figure A1.8 January 2010 and historical sampling results (pg/g TEQ) - Soil, landfill site.



LEGEND

Airport Boundary

Pacer Ivy Storage Area

Landfill Site

Soil Sampling Location

Exceeds Guideline

soil > 1,000 pg/g TEQ

Hatfield/Office 33 (2007, 2009)

USAID (2010)

Does Not Exceed Guideline

soil < 1,000 pg/g TEQ

Hatfield/Office 33 (2007, 2009)

USAID (2010)

0 50 100 200 m

Projection: UTM Zone 49N WGS 84

GeoEye Image July 23, 2009

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APPENDIX A2

EXCAVATION VOLUME ESTIMATES, DA NANG AIRPORT, APRIL 2010

APPENDIX A2. EXCAVATION VOLUME ESTIMATES, DA NANG AIRPORT, APRIL 2010

1.0 INTRODUCTION

The field sampling program at Da Nang Airport implemented in January 2010 was conducted as per the Sampling and Analysis Plan (SAP) prepared by CDM International (CDM) and Hatfield Consultants (Hatfield) for United States Agency for International Development (USAID) VIETNAM (CDM 2009). Results of the sampling program are described in detail in Appendix A1 of this Environmental Assessment (EA). This appendix describes how the recent analytical data were combined with historical data and used to generate an updated and detailed estimate of the volume of contaminated materials that require excavation at Da Nang Airport. This appendix details the methods and assumptions used in estimating those volumes, the results of these estimates, and provides discussion regarding the results.

2.0 METHOD OF ESTIMATION

The estimation of the volume of contaminated material at Da Nang Airport requiring excavation was performed using the methodology described below:

- Gather dioxin and furan data from the following sources (a summary of all data gathered is presented in Appendix A1):
  - 2010 sampling conducted by CDM/Hatfield;
  - 2009 and 2006 sampling conducted by Hatfield and Office 33 (Hatfield and Office 33, 2007 and 2009);
  - Unpublished analytical data from United States Environmental Protection Agency (EPA)/Vietnam Academy of Science Technology (VAST); and
  - Unpublished analytical data from the Ministry of Defense (MOD).
- Arrange all the dioxin and furan data on a scale site plan and hand-draw toxic equivalency quotient (TEQ) contours for areas above the cleanup levels of 150 parts per trillion (ppt) for sediments and 1,000 ppt for soils. Use the contours to divide the site into discrete sections, each with differing levels of contamination, and calculate the area of each section.
- Determine appropriate excavation depths for each area, based on TEQ data.
- Multiply each section's area by its respective depth, and sum up the contributions from each area.

This approach has several advantages compared to the approaches used for prior estimates. The use of all existing and recent analytical data allows for the best estimate of the lateral and vertical extent of contamination at the site. Also, the process of breaking the site into smaller discrete portions allows for a greater degree of precision in the estimating process. Rather than using site-wide average depths or even average depths across a particular area of concern such as the Storage Area, the estimate can be more closely tied to the available analytical results for each portion.

2.1 Determination of Area of Excavation

This section describes in detail how the area of excavation was determined for each portion of the site. For each area described below, once the extent of estimated excavation was determined based on site

contours, the area was calculated using Adobe Acrobat and confirmed using geographic information system (GIS). These two area estimates agreed within three percent.

2.1.1 Sen Lake and Eastern Wetland

The large number of historical and analytical data around Sen Lake, as shown in the figures in Appendix A1, facilitates drawing sediment TEQ contours over this large portion of the site. There is a large quantity of historical MOD and Hatfield data that allow for discretization of the majority of the lake, and the recent CDM/Hatfield samples provides supplementary data that help fill areas where uncertainty previously existed.

The coverage of analytical data in the Eastern Wetland is less complete. The eastern boundary of contamination was well established with the recent CDM/Hatfield samples. However, as described in Appendix A1, there was difficulty in collecting samples during the 2010 sampling program in the center and along the western boundary of the Eastern Wetland due to access issues and health and safety concerns. The sediment data collected on the eastern border of the Eastern Wetland indicate that contamination does not extend all the way to the east boundary of the Eastern Wetland. Given that sediment transport processes are likely similar on the west side of the Eastern Wetland, it is estimated that contamination does not extend to the west boundary of the Eastern Wetland.

The Sen Lake and Eastern Wetland part of the Da Nang Airport site was divided into four areas based on all the available data: sediment with TEQ greater than 5,000 ppt, sediment with TEQ between 5,000 and 1,000 ppt, sediment with TEQ between 1,000 ppt and 150 ppt, and sediment with TEQ less than 150 ppt (i.e., sediment not requiring excavation). These divisions are represented on Figure A2.1.

2.1.2 Main Drainage Ditch

There are several samples that indicate sediment in the Main Drainage Ditch is contaminated, and given the conceptual site model, it is reasonable to assume that excavation of sediment will encompass the entire Main Drainage Ditch area.

Furthermore, historical and recent samples of soil along the periphery of the Main Drainage Ditch demonstrate that contamination extends outside of the Main Drainage Ditch. Therefore, soil in these areas between the ditch boundaries and clean soil samples have been classified as contaminated for the purposes of this estimate.

The Main Drainage Ditch part of the Da Nang Airport site was divided into two areas, based on all the available data: sediment with TEQ greater than 150 ppt, and soil with TEQ greater than 1,000 ppt. These divisions are represented on Figure A2.1.

2.1.3 Storage Area (SA)

The large number of soil samples collected in 2010 and previous years allow for relatively detailed contouring in the SA area. The limits of excavation of this part of the site are bounded as follows:

- East: the Main Drainage Ditch trench is located directly to the east of the SA. Further excavation is estimated inside and along the ditch, as described above.
- South: a clean sample (06VN043) indicates that contamination does not likely extend to the southwest of the SA. However, samples SAP657 and 06NV048 both indicate that there is contamination present along the west border of the Main Drainage Ditch. Therefore, excavation is assumed to the southeast of the SA, but not to the southwest, as shown in Figure A2.1.

- West: there is a secondary drainage ditch located to the west of the SA that runs from the west side of the Mixing and Loading Area (MLA), past the west and north borders of the SA, and into the Main Drainage Ditch. It is expected that any overland flow carrying contamination from the SA would not be able to bypass this ditch and continue heading west. However, this could not be confirmed during the 2010 sampling event because of ongoing construction activities. Figure A2.1 shows the location of a construction fence that limited sample collected activities. Confirmation sampling will be performed during remediation to verify the estimate.
- North: The drainage swale on the west side of the SA extends along the north boundary. It is assumed that the ditch and the road just north of the ditch would prevent northern overland migration. This is supported by clean samples (e.g. SAP630 and 06VN001) located on the other side of the road.

The SA part of the Da Nang Airport site was divided into four areas based on all the available data: soil with TEQ greater than 10,000 ppt, soil with TEQ between 10,000 and 5,000 ppt, soil with TEQ between 5,000 ppt and 1,000 ppt, and soil with TEQ less than 1,000 ppt (i.e., soil not requiring excavation). These divisions are represented on Figure A2.1.

2.1.4 Mixing and Loading Area (MLA)

Similar to the SA, the MLA has been sampled extensively. As such, the magnitude and delineation of contamination in this area is well characterized for the majority of the MLA. Samples SAP652, SAP655, SAP658, SAP665, SAP657, SAP607, 06VN066, and SAP674 all indicate that the northern and eastern excavation boundaries are well characterized. Some portions north of this area are also bounded by excavation of soils associated with the Main Drainage Ditch, as described in Section 2.1.2. The boundary of this excavation is assumed to be controlled by the runway to the south, and the secondary drainage ditch to the west, as described for the SA. It is expected that this drainage ditch would have prevented overland flow to the west from the MLA as well. However, as at the SA, collection of further samples during the 2010 event was not possible due to construction activities, and therefore confirmation sampling will be done to verify this boundary.

The MLA part of the Da Nang Airport site was divided into four areas based on all the available data: soil with TEQ greater than 10,000 ppt, soil with TEQ between 10,000 and 5,000 ppt, soil with TEQ between 5,000 ppt and 1,000 ppt, and soil with TEQ less than 1,000 ppt (i.e., not requiring excavation). These divisions are represented on Figure A3.1.

2.1.5 Secondary Drainage Ditch

As described in Sections 2.1.3 and 2.1.4, it is expected that this Secondary Drainage Ditch prevented overland flow from the SA and MLA from travelling further west. However, as a result, it is expected that sediment in this Secondary Drainage Ditch contains contamination. Therefore, this Secondary Drainage Ditch has been included in the estimate, and classified similarly to the Main Drainage Ditch.

2.1.6 Eastern Hotspot

Between the Eastern Wetland and the Main Drainage Ditch, there are two soil samples with concentrations above soil cleanup levels (1000 ppt): SAP624 and 06VN042. The presence of contamination in this area indicates that some excavation is needed in this vicinity. As concentrations in the Eastern Wetland are lower, it is suspected that contamination in the Eastern Hotspot originated from the Main Drainage Ditch. Therefore, the extent of estimated excavation in this area is bounded by the Main Drainage Ditch soil excavation to the west. To be conservative, it is estimated that this excavation will extend to the boundary of excavation within the Eastern Wetland.

The north and south estimates of this excavation are estimated based on the locations of SAP636, SAP635, and 06VN045 (the 2006 Hatfield sample immediately south of SAP635). TEQ data from samples SAP636 and 06VN045 are both below soil cleanup limits (1,000 ppt), whereas SAP635 was above. Therefore, it estimated that the contamination extends directly east of SAP635 without expanding to the north or south. The south border of this estimated area is also bounded by 06VN037, collected immediately southwest of the SAP624.

2.1.7 Sen Lake Outlet to Da Nang City Storm Drain

Sample 06VN030 indicates that the sediment at the north end of Sen Lake, immediately before drainage into the Da Nang City Storm Drain, is contaminated. Even though there are two historical MOD samples in that area indicating some of the area is not contaminated, it is estimated that an area between the other excavation zones and the northern boundary of the site requires excavation. As such, this area is categorized as an area with sediment with TEQ greater than 150 ppt.

2.1.8 Pacer Ivy Storage Area

Samples SAP682, 202A, 208A, and 209A indicate soil contamination in a small area that spans the south corner of the Pacer Ivy Storage Area (PISA) and small portion of the adjacent proposed landfill site. As such, this area is categorized as an area with soil with TEQ greater than 1000 ppt. This area is represented on Figure A2.2.

2.2 Determination of Depth of Excavation

This section describes in detail how the depth of excavation was estimated for each portion of the site.

2.2.1 Half Depth Modeling

Half depth modeling has been utilized at the Da Nang Airport site to predict the vertical reduction in contaminant concentrations. Half depth models predict exponential concentration reduction (decay) with depth. The mathematical form of this model is as follows:

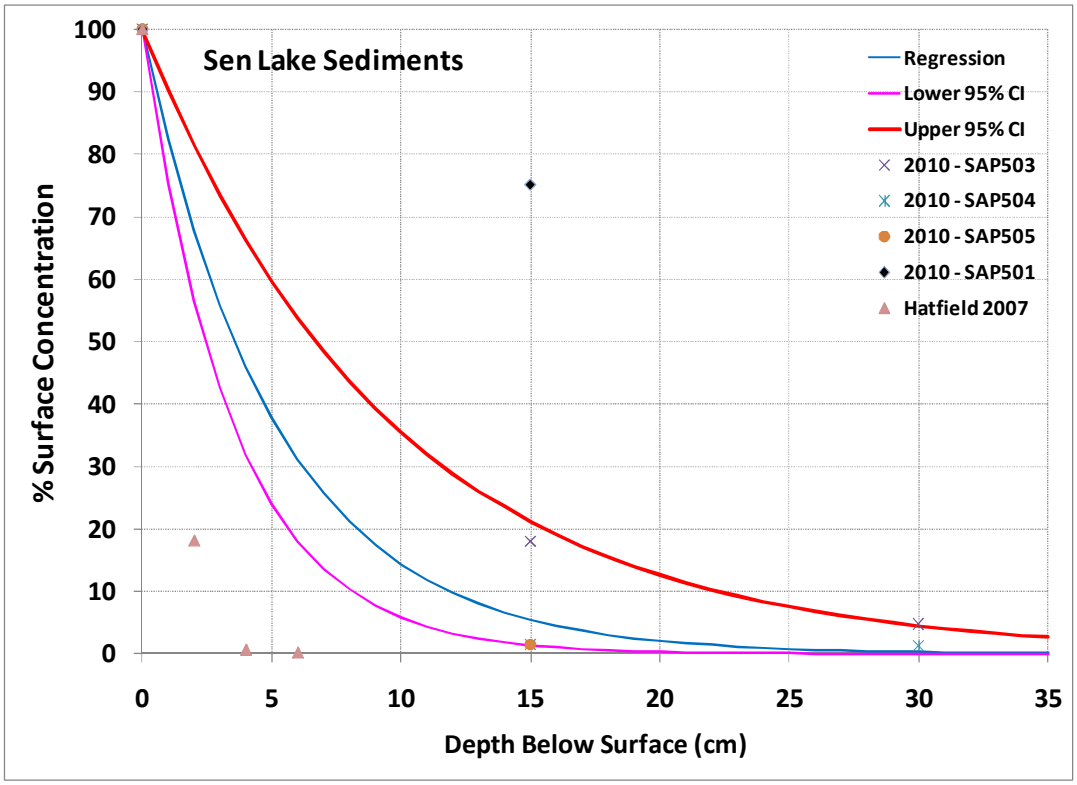
$$TEQ_{depth} = TEQ_0 \, e^{-a\,d}$$

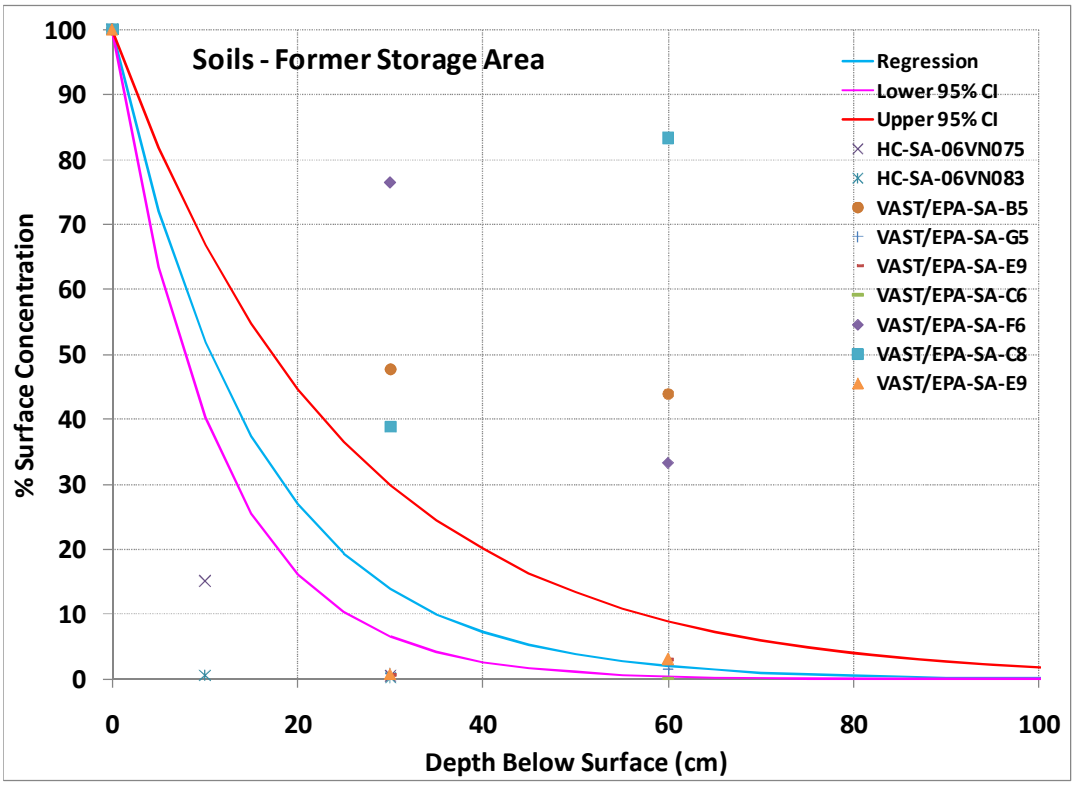
Where TEQd = TEQ at a chosen lower depth
TEQ0 = TEQ at a given upper depth (such as the surface)
a = the exponential rate constant
d = depth of soil between TEQd and TEQ0

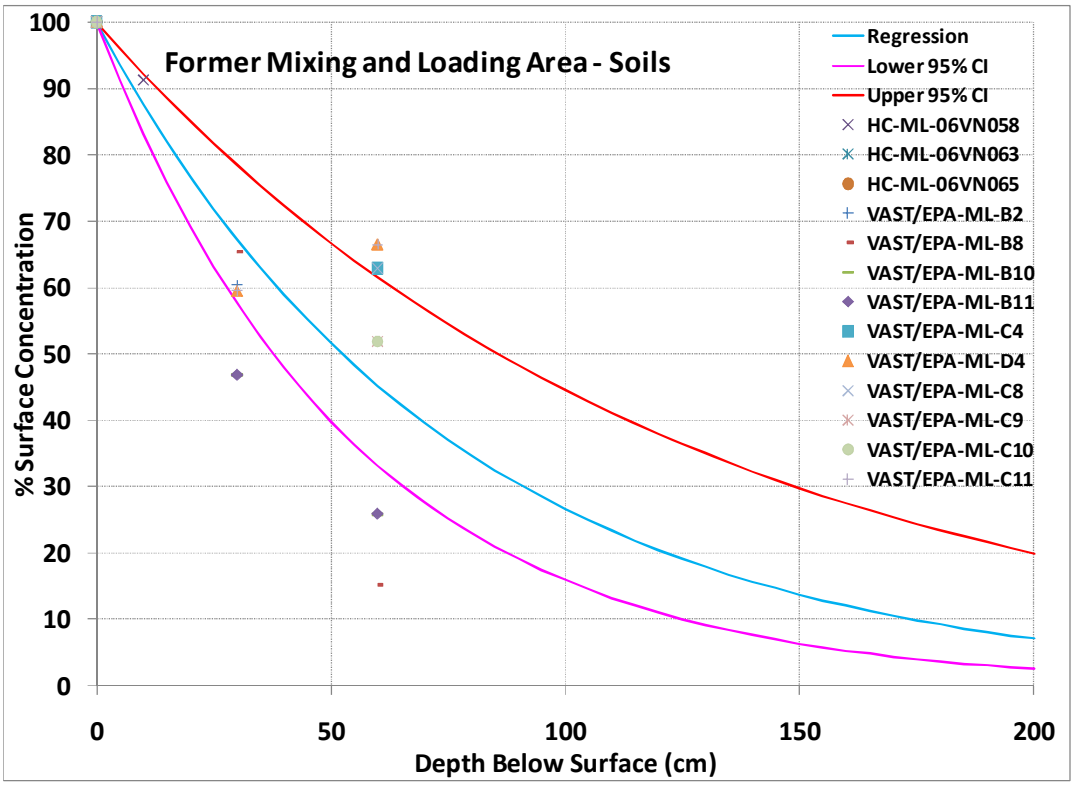
The rate of that exponential reduction (a) depends on several factors such as soil type and contaminant retardation, but those parameters are expected to be generally consistent at the site within a specific area and environmental media. Therefore, given sufficient data, a regression model can be used to fit the reduction rate to the data. With that rate, a half depth, or depth after which the concentration is expected to decrease by half, can be calculated and used to estimate the vertical extent of contamination without having analytical data from samples collected at varying depths across the site.

This approach was used to estimate excavation depths for the majority of the Da Nang Airport site. All historical and January 2010 data in which there was a surface sample plus at least one additional deeper sample taken were compiled and the above model was fit to: (i) sediment data from Sen Lake and the Eastern Wetland; (ii) SA; and (iii) MLA. The results of that fit are presented in the following table and graphs.

Area	n	Estimated a Parameter	r2	P	Estimated Half depth (cm)	Half depth – Lower 95% CL (cm)	Half depth – Upper 95% CL (cm)
Sen Lake and Eastern Wetland Sediments	17	-0.13	0.56	0.0004	3.6	2.4	6.7
Former Storage Area	26	-0.067	0.53	0.00002	10.5	7.6	17.1
Former Mixing and Loading Area	33	-0.013	0.46	0.00001	52	38	85




Soils - Former Storage Area
% Surface Concentration
Depth Below Surface (cm)
Regression
Lower 95% CI
Upper 95% CI
HC-SA-06VN075
HC-SA-06VN083
VAST/EPA-SA-B5
VAST/EPA-SA-G5
VAST/EPA-SA-E9
VAST/EPA-SA-C6
VAST/EPA-SA-F6
VAST/EPA-SA-C8
VAST/EPA-SA-E9


Former Mixing and Loading Area - Soils
% Surface Concentration
Depth Below Surface (cm)
Regression
Lower 95% CI
Upper 95% CI
HC-ML-06VN058
HC-ML-06VN063
HC-ML-06VN065
VAST/EPA-ML-B2
VAST/EPA-ML-B8
VAST/EPA-ML-B10
VAST/EPA-ML-B11
VAST/EPA-ML-C4
VAST/EPA-ML-D4
VAST/EPA-ML-C8
VAST/EPA-ML-C9
VAST/EPA-ML-C10
VAST/EPA-ML-C11

Given the uncertainty in the estimated reduction rate parameter, the half depth corresponding to the 95% upper confidence limit (UCL) of the rate constant was used in the excavation estimates. This selection provides some amount of conservatism, as it allows for the statistical possibility that the samples used in the model fitting, and the half depth resulting from that fit, are not representative of concentrations at the site. Therefore, a half depth of 6.7 centimeters (cm) was utilized for all areas with sediment excavation, and a half depth of 17.1 cm was used for soil excavation in the SA.

For the soil excavation conducted along the Main Drainage Ditch perimeter and for the Eastern Hotspot, it is expected that the presence of contamination in this areas is not attributable to surface spills as in the SA or MLA. It is more likely that these impacted soils were deposited following flooding or overland erosion. Therefore, it is expected that vertical extent of contamination in these areas is not as deep. Rather than applying a half depth derived from the soil cores collected in the SA, it is estimated that a more appropriate half depth is the one derived from sediment cores. Therefore, the sediment half depth was used for estimation of excavation volumes in the Main Drainage Ditch and Eastern Hotspot.

To determine the appropriate depth of excavation for each particular portion of the Da Nang Airport site listed in Section 2.1, the following procedure was performed:

1. Determine which surface samples were collected in each portion of the Da Nang Airport site.
2. Use the half depth model to predict the TEQ at each half depth interval below each of the surface samples.
3. Determine how many half depths of excavation are required below each sampling location to reach soil or sediment below cleanup targets (150 ppt for sediments and 1,000 ppt for soils).
4. Average together the required number of half depths for each portion of the Da Nang Airport site, and convert it into centimeters to determine the average excavation depth for each portion.

This depth was then multiplied by the estimated area for each portion of the Da Nang Airport site to determine the estimated volume of contaminated material.

2.2.2 Mixing and Loading Area

The half depth model approach predicts a half depth for the MLA of 85 cm. This is caused by the relative lack of degradation in the samples with depth, as shown in the last graph above. It is believed that vertical transport of TEQ contamination at the MLA might have been facilitated by the high volumes spilled, or by solvents associated with the chemical mixture, and therefore that the half depth model does not fit the available data in the MLA.

Further analysis of available data at the MLA shows the following:

- 10 of the 11 samples collected by VAST/USEPA within the interval of 60 to 90 cm depth below grade indicate contamination with TEQ greater than 1000 ppt, but no data were collected below 90 cm.
- Of the four soil cores performed in January 2010, three were analyzed. Two of the three cores (SAP606 and SAP607) had TEQ below the soil cleanup level at every interval analyzed, including those below 90 cm. The third sample, SAP605, had a TEQ of 10,700 ppt in the 30-60 cm interval, and a TEQ of 295 ppt in the sample from the 90-120 cm interval.

Because SAP606 and SAP607 were not strongly contaminated, SAP605 represents the only known example of contamination reduction at depths below 90 cm at the site, and clearly does not fit the

predicted half depth of 85 cm (95% UCL), or even the 38 cm (95% lower confidence level [LCL]). Given that several other data points indicate that contamination is pervasive above 90 cm, that all samples from below 120 cm are below the soil cleanup level, and that the half depth model does not appear to match any recent data, it was estimated that all areas of the MLA with surface TEQ greater than 5,000 ppt should be excavated to 120 cm. Similarly, it was estimated that in MLA areas with surface TEQ between 1000 and 5,000 ppt, the excavation extends to only 60 cm.

2.2.3 Pacer Ivy Storage Area

As the half-depth analysis above did not include historical data from the PISA, the depth of excavation in this area will be based on the depth profile data collected in 2009. Samples 208A through 212A were collected from one soil core, and indicate that contamination extends vertically at this location to the 10-30 cm interval (209A). However, the TEQ in the next lower sample (210A, from 30-60 cm) is only 189 ppt. Therefore, the depth of excavation in this area is assumed to be 45 cm.

2.3 Estimate of TEQ of Excavated Material

During the application of the half depth model, the average TEQ of the excavated material was also calculated. This was done according to the following procedure, in parallel to calculation of the excavation depth for each portion of the Da Nang Airport site:

1. Determine which surface samples were collected in each portion of the Da Nang Airport site.
2. Use the half depth model to predict the TEQ at each half depth interval below each of the surface samples.
3. Determine how many half depths of excavation are required below each sampling location to reach soil or sediment below cleanup targets (150 ppt for sediments and 1,000 ppt for soils).
4. Average together all TEQ from each interval requiring excavation, to determine the average TEQ at each sample location, and average all of those together across each portion of the Da Nang Airport site.

3.0 ESTIMATE RESULTS

Using the methods described above, the volume of contaminated soils and sediments present at each portion of the Da Nang Airport site was estimated. The results presented in this section correspond to the divisions of the Da Nang Airport site presented in Figure A2.1.

3.1 Sediment Excavation Volume

The areas and volumes of sediment excavation were estimated as shown in the table below.

Region	Estimated Area (m^2)	Average Depth (half depths)	Average Depth (cm)	Volume (m^3)	Average TEQ (ppt)	Comment
Sen Lake						
Areas > 5000 ppt	13,000	5.9	39	5,122	2,212	
Areas > 1000 ppt	38,790	5.1	34	13,147	1,320	
East Area > 150 ppt	30,720	2	13	4,097	338	Includes Eastern Wetland
West Area > 150 ppt	2,920	2	13	389	232	
Sen Lake Subtotal	85,430	4	27	22,755	1,325	
Site Drainage						
Main Drainage Ditch	7,260	5.8	39	2,808	2,902	
Secondary Drainage Ditch	1,000	6	40	400	1,841	Connects northwest MLA to southwest SA
Outlet to Da Nang City Storm Drain	977	1	7	65	292	Includes part of Sen Lake
Drainage Subtotal	9,237	5	35	3,273	2,720	
Total Sediments	**94,667**	**4.1**	**27**	**26,028**	**1,501**	

3.2 Soil Excavation Volume

The areas and volumes of soil excavation were estimated as shown in the table below.

Region	Estimated Area (m^2)	Average Depth (half depths)	Average Depth (cm)	Volume (m^3)	Average TEQ (ppt)	Comment
Storage Area (SA)						
Areas > 10000 ppt	5,330	4.1	70	3,721	6,115	
Areas > 5000 ppt	5,280	3.2	54	2,867	3,250	
Areas > 1000 ppt	5,540	2.4	41	2,280	2,425	
SA Subtotal	16,150	3	55	8,868	4,240	
Mixing and Loading Area (MLA)						
Areas > 10000 ppt	9,540	-	120	11,448	8,114	No half depth model used
Areas > 5000 ppt	3,400	-	120	4,080	8,995	No half depth model used
Areas > 1000 ppt	6,670	-	60	4,002	2,249	No half depth model used
MLA Subtotal	19,610	-	100	19,530	7,096	

Region	Estimated Area (m^2)	Average Depth (half depths)	Average Depth (cm)	Volume (m^3)	Average TEQ (ppt)	Comment
Main Drainage Ditch						
Main Drainage Ditch NW	9,800	2.7	18	1,742	3,775	West Side of Ditch, North of Storage Area
Main Drainage Ditch SW	5,260	3.5	23	1,227	4,515	West Side of Ditch, South of Storage Area
Main Drainage Ditch E	11,340	3.0	20	2,268	3,673	East Side of Ditch
Main Drainage Ditch Subtotal	26,400	3	20	5,238	3,905	
Hotspots						
Eastern Hotspot	7,670	1.0	7	511	1,710	Hot spot containing SAP624 and 06VN042
Pacer Ivy Storage Area (PISA)	3170	-	45	1427	1260	No half depth model used
Total Soils	**73,000**	**1.9**	**49**	**35,574**	**5,603**	Average half depth does not include MLA or PISA

4.0 DISCUSSION

The accuracy of this estimate is expected to be much greater than previous estimates, owing primarily to the increase in amount of available site data. Prior to the 2010 sampling efforts, many of the following sources of uncertainty had not been addressed:

- Lateral extent of contamination in the Eastern Wetland;
- Lateral extent of contamination in southwestern Sen Lake;
- Lateral extent of contamination along the Main Drainage Ditch;
- Lateral extent of contamination around the MLA;
- Lateral extent of contamination between the MLA and the SA;
- Vertical extent of contamination across most of the Da Nang Airport site, especially the MLA.

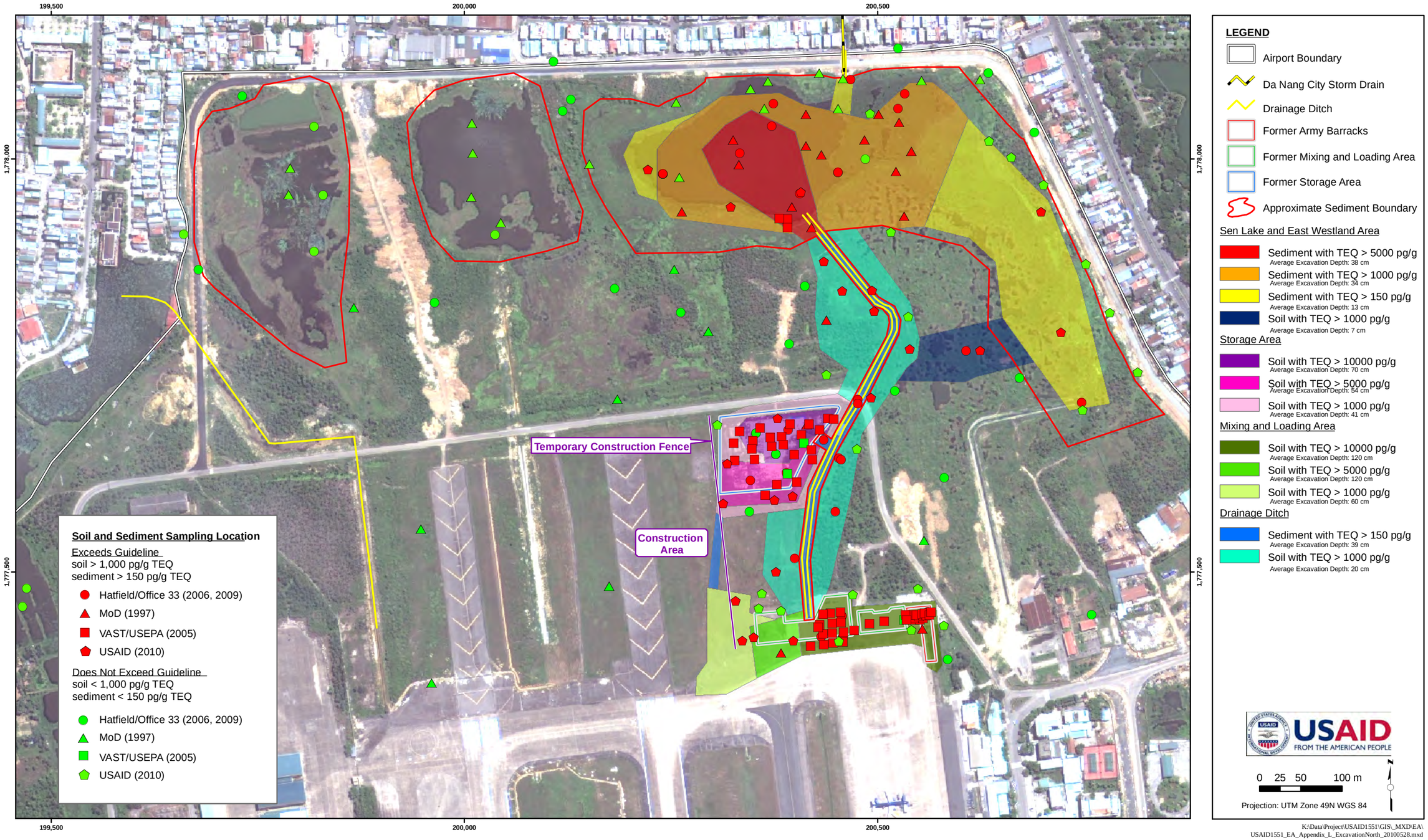
Most of these areas of previous uncertainty have been addressed via the 2010 sampling. Although the 2010 sampling results expanded the areas of known contamination, and thereby increased the volume of excavated soils and sediments that require excavation, these areas of additional excavation would have likely been discovered during post-remediation confirmation sampling or via other methods and would have required additional unforeseen effort to address them at that time. However, it is still expected that post-excavation confirmation sampling will be critical to guide excavation and confirm that the limits of excavation are sufficient and that no additional excavation is required to meet cleanup targets.

4.1 REMAINING UNCERTAINTY

These estimates include a greater level of precision compared to past estimates due to more detailed site contours and greater site discretization, a more developed half depth model, and inclusion of more data from deeper samples in the MLA. However, regardless of the improved precision and improved accuracy, there will always remain some inherent uncertainties in this kind of estimate. These uncertainties include, but are not limited to, the following:

- Lateral distribution of contamination in the area bounded by the Main Drainage Ditch, the Eastern Hotspot, the Eastern Wetland, and Sen Lake;
- Lateral distribution of contamination in the area bounded by the Secondary Drainage Ditch, the MLA, the Main Drainage Ditch, and the SA;
- Vertical distribution of contamination in the MLA;
- Lateral distribution of contamination east of the Main Drainage Ditch, between the MLA and the location of SAP634; and
- Lateral distribution of contamination to the west of the Secondary Drainage Ditch.

Figure A2.1 Estimates of extent of soil and sediment excavation, with January 2010 and historical sampling results (pg/g TEQ) at surface level.



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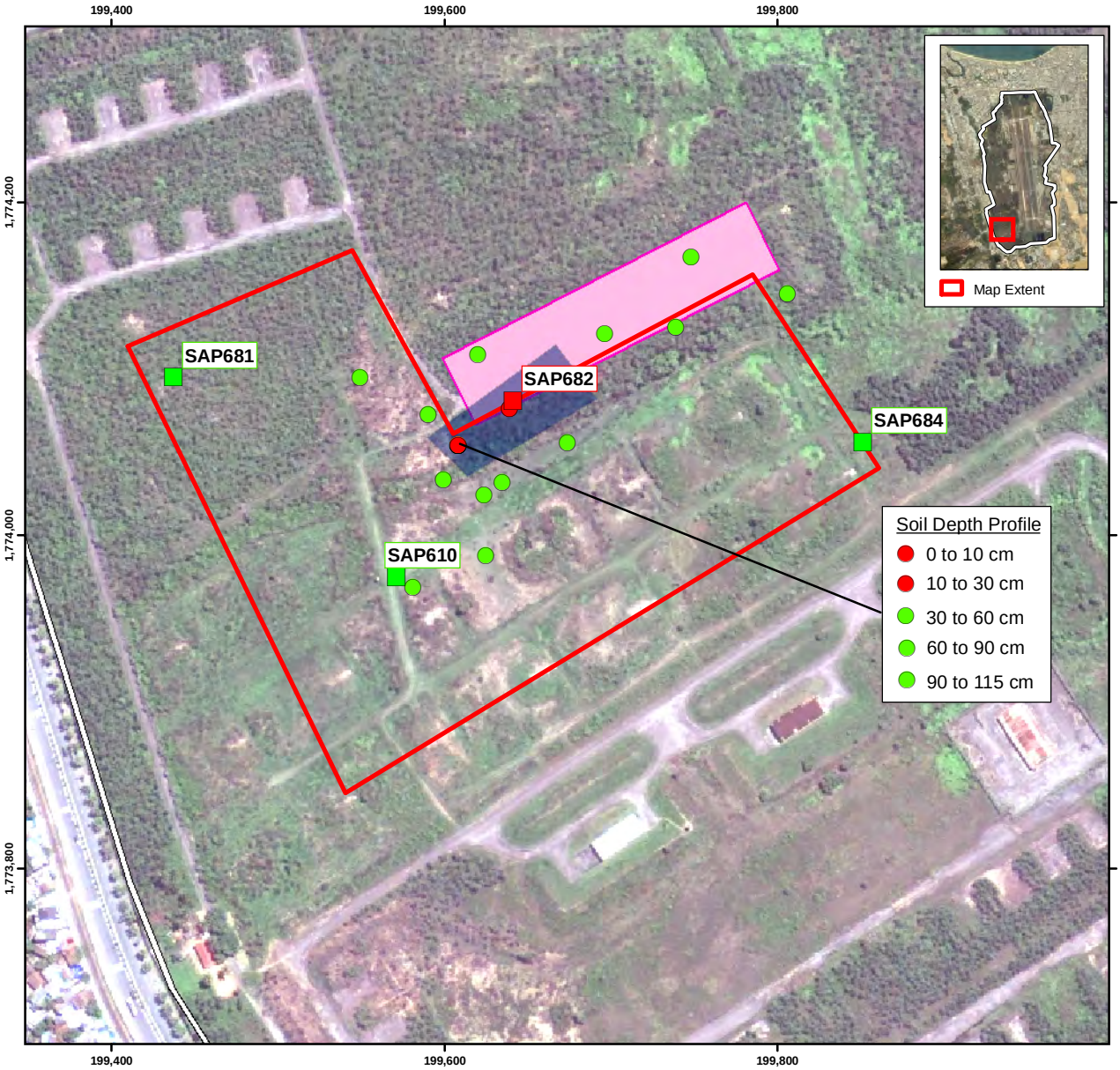
USAID1551_EA_Appendix_L_ExcavationNorth_20100528.mxd

Figure A2.2 Estimates of extent of soil and sediment excavation, with January 2010 and historical sampling results (pg/g TEQ) at surface level.



LEGEND

Airport Boundary

Pacer Ivy Storage Area

Proposed Landfill Site

Landfill Area

Soil with TEQ > 1000 pg/g
Average Excavation Depth: 45 cm

Soil Sampling Location

Exceeds Guideline

soil > 1,000 pg/g TEQ

Hatfield/Office 33 (2006, 2009)

USAID (2010)

Does Not Exceed Guideline

soil < 1,000 pg/g TEQ

Hatfield/Office 33 (2006, 2009)

USAID (2010)

USAID FROM THE AMERICAN PEOPLE

0 50 100 200 m

N

Projection: UTM Zone 49N WGS 84

GeoEye Image July 23, 2009

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APPENDIX A3

COST ESTIMATE DETAILED BACKUP

APPENDIX A3. COST ESTIMATE DETAILED BACKUP

Identification and evaluation of potential costs for project alternatives is integral to the evaluation process to help determine the best project approach to address the site. The project alternative costs presented in this EA were developed in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, EPA 540-R-00-002 (July 2000).

Although the EA process is distinct from the CERCLA FS process, the objectives and intent as well as project concept development for this EA are sufficiently similar to the CERCLA process to warrant use of this guidance.

At the alternatives evaluation stage, the design for the project alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." The cost engineer must make assumptions about the detailed design in order to prepare the cost estimate. As a project progresses, the design becomes more complete and the cost estimate becomes more "definitive," thus increasing the accuracy of the cost estimate. This process is depicted in the figure below for remedial action projects in the Superfund program; the process for implementation of project alternatives for Da Nang is similar.

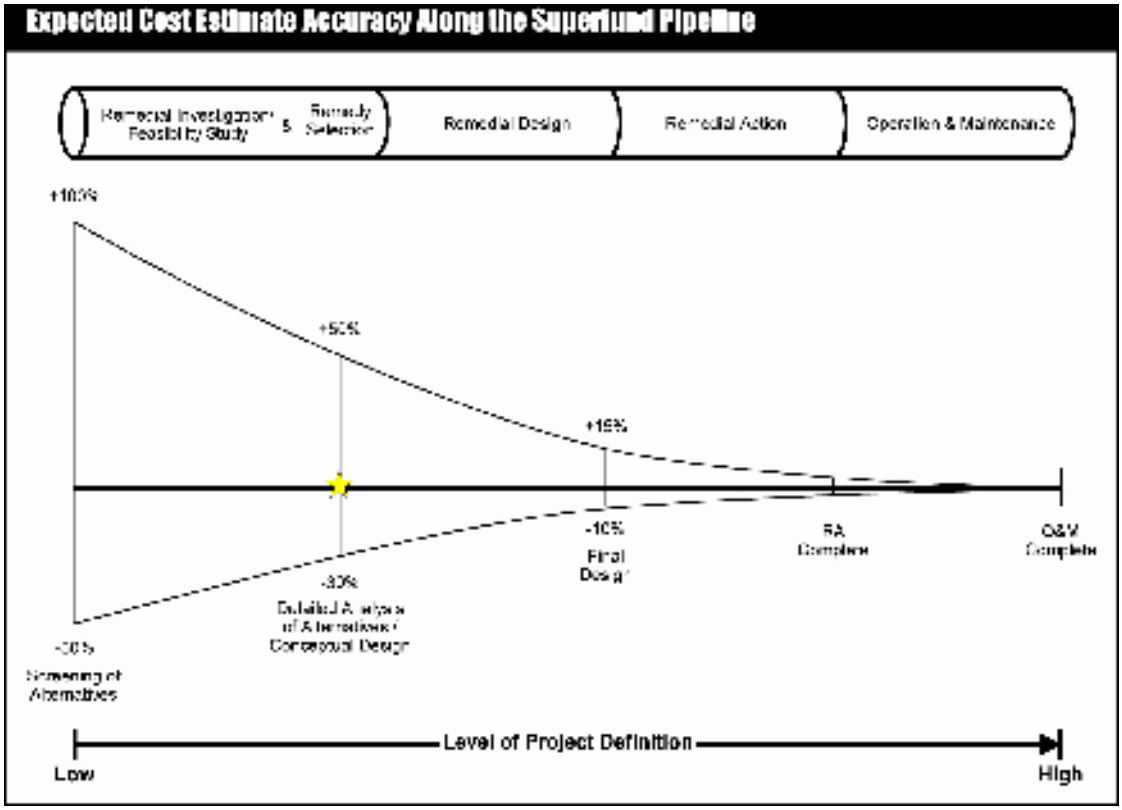

Figure from A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (July 2000) EPA 540-R-00-002, OSWER 9355.0-75

Project alternative cost estimates were developed during this phase of the EA primarily for the purpose of comparing project alternatives during the remedy selection process, not for establishing project budgets. As a project alternative moves from the planning stage into the design and implementation stage, the level of project definition increases, thus allowing for a more accurate cost estimate. An "early" estimate of the project alternative's life cycle costs is made during the FS to make a remedy selection decision. The levels of detail employed in making these estimates are conceptual but are considered appropriate for making choices between alternatives. The information provided in the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives.

Costs for project alternatives are expected to have accuracies between -30% to +50% of actual costs, based on the scope presented. The accuracy range of –30% to +50% means that, for an estimate of $100,000, the actual cost of an alternative is expected to be between $70,000 and $150,000.

Flexibility is incorporated into each alternative for the location of project facilities, the selection of cleanup levels, and the period in which project implementation will be completed. Assumptions of the project scope and duration are defined for each alternative to provide cost estimates for the various project alternatives. Important assumptions specific to each project alternative are summarized in the description of the project alternative. Additional assumptions are included in the detailed cost estimate backup.

Types of costs that are assessed for each alternative include the following categories:

Capital Costs

- Capital costs are those expenditures that are required to construct a remedial action. They are exclusive of costs required to operate or maintain the action throughout its lifetime. Capital costs consist primarily of expenditures initially incurred to build or install the remedial action (e.g., construction of a water treatment system and related site work). Capital costs include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with activities, such as mobilization/demobilization; monitoring site work; installation of extraction, containment, or treatment systems; and disposal. Capital costs also include expenditures for professional/technical services that are necessary to support construction of the remedial action.

Annual O&M Costs

- Annual O&M costs are those post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action. These costs are estimated mostly on an annual basis. Annual O&M costs include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with activities, such as monitoring; operating and maintaining extraction, containment, or treatment systems; and disposal. Annual O&M costs also include expenditures for professional/technical services necessary to support O&M activities.

Periodic Costs

- Periodic costs are those costs that occur only once every few years (e.g., 5-year reviews, equipment replacement) or expenditures that occur only once during the entire O&M period or remedial time frame (e.g., site closeout, remedy failure/replacement). These costs may be either capital or O&M costs, but, because of their periodic nature, it is more practical to consider them separately from other capital or O&M costs in the estimating process. The project alternatives provided in this EA do not include periodic costs.

Present Value of Capital, Annual O&M, and Periodic Costs

- The present value of each alternative provides the basis for the cost comparison. The present value cost represents the amount of money that, if invested in the initial year of the remedial action at a given rate, would provide the funds required to make future payments to cover all costs associated with the remedial action over its planned life. Future O&M and periodic costs are included and reduced by the appropriate present value discount rate as outlined in *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (EPA 2000a). Per the guidance, the present value analysis was performed on remedial alternatives using a 7 percent discount (interest) rate over the period of evaluation for each alternative. Inflation and depreciation were not considered in preparing the present value costs.

For comparison purposes in the EA, present value costs are not presented for comparison of project alternatives because the project funding mechanism is assumed to be through annual Congressional appropriations without use of an interest-bearing account. Thus the current costs (total project costs excluding present value discounting) were used for project alternative comparisons.

PROJECT COST ESTIMATE PRESENTATION

The costs for each project alternative are presented in three components: the cost summary, the present value analysis, and the cost backup information.

The cost summary provides the capital and annual O&M costs and assumptions used to develop the total cost of a project alternative. For each capital and O&M cost, contingency and professional/technical services costs are applied as a percentage of the unmodified capital or O&M cost.

Contingency covers unknowns or unanticipated conditions associated with construction or O&M activities. Project management, remedial design, and construction management for capital costs are professional/technical services to support construction of the project. Project management and technical support are professional/technical services to support O&M activities.

The present value analysis shows how the costs presented in the summary are distributed over the timeframe of the project (assumed to be Years 0 through 50 for purposes of the EA), and indicate the total cost without discounting (current cost) as well as the present value cost (cost with present value discounting).

The cost backup provides the detailed information used to provide the assumptions for development of capital costs presented in the cost summaries. The O&M costs for maintenance and monitoring were developed on an annual basis as a percentage of the capital costs before application of contingency and professional/technical services costs.

PROJECT COST BACKUP ASSUMPTIONS

Assumptions for each alternative cost estimate are provided in Section 5. In addition, the following assumptions were made regarding Vietnamese labor rates, unexploded ordnance (UXO) clearance rates, electrical rates, and applicable value added tax (VAT) rates.

<u>Labor rate for construction worker at Da Nang Airport = 904,000 VND/day.</u>

- Base labor rate for construction worker in 2004 = 100,000 VND/day *(Source: Decree No. 205/2004/NĐ-CP of Government dated 14-Dec-2004)*.

- Construction worker rate for 2010 = 210,000 VND/day, which assumes 210% increase from 2004 rate *(Justification for inflation percentage: Decree No. 28/2010/NĐ-CP of Government dated 25-March-2010 provides a 2010 minimum wage rate [730,000 VND/month] that is 210% higher than the 2004 minimum wage rage [350,000 VND/month]; it is therefore assumed that 210% is the inflation rate from 2004 to 2010).*
- + 20% for special conditions = 252,000 VND/day.
- + 200,000VND/day for hazard pay = 452,000 VND/day.
- x 2 workers to provide a full 8 hour day (workers are restricted to only 4 hours/day when working with a face mask) = 904,000 VND/day.

UXO Clearance Rate = 300,000,000 VND per hectare for demining.

VAT = 10% applied to all costs.

Power Rates: Per the table below; shaded cells indicate the rate to be used for this project. *(Source: Circular No. 08/2010/TT-BC of Ministry of Industry and Commerce dated 24-Feb-2010, for power prices effective 01-Mar-2010)*

Production Sector Rates	
Category	**Power price (VND/kWh)**
From 110 kV and above	
a) Normal hours	898
b) Low-load hours	496
c) High-load hours	1,758
From 22 kV to under 110 kV	
a) Normal hours	935
b) Low-load hours	518
c) High-load hours	1,825
From 6 kV to under 22 kV	
a) Normal hours	986
b) Low-load hours	556
c) High-load hours	1,885
Under 6 kV	
a) Normal hours	1,023
b) Low-load hours	589
c) High-load hours	1,938

Administrative Sector Rates	
Category	**Power price (VND/kWh)**
From 6kV kV and above	1,159
Under 6kV	1,207

Normal hours:

Monday to Saturday:
- 04:00 to 09:30 hours
- 11:30 to 17:00 hours
- 20:00 to 22:00 hours

Sunday:
- 04:00 to 22:00 hours

High-load hours:

Monday to Saturday:
- 09:30 to 11:30 hours
- 17:00 to 20:00 hours

Low-load hours:

All days: 22:00 to 04:00 hours

COST BACKUP FOR ALTERNATIVES

The following tables provide the complete cost estimates and back up detail sheets for the No Action, Passive Landfill, Active Landfill, and ISTD/IPTD alternatives.

Project Alternative 1

No Action

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: The No Action alternative will result in a continuation of existing dioxin contamination conditions, with an ongoing chemical hazard existing for dioxin concentrations on the Airport and maintenance exposure pathways for dioxin to environmental, biological, and human receptors. This alternative is acceptable to neither the Government of Vietnam nor the United States Government and it is not substantively considered in the Environmental Assessment.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Year 0)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
No Action	1	LS	$0	$0	
SUBTOTAL				$0	
Contingency (Scope and Bid)	20%			$0	10% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$0	
Project Management	10%			$0	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	20%			$0	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	15%			$0	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$0	
TOTAL CAPITAL COST				**$0**	Total capital cost is rounded to the nearest $1,000.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS (Years 0 through 30)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
No Action	1	LS		$0	Includes annual site inspection
SUBTOTAL				$0	
Contingency (Scope and Bid)	20%			$0	10% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$0	
Project Management	10%			$0	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	15%			$0	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$0	
TOTAL ANNUAL O&M COST				**$0**	Total O&M cost is rounded to the nearest $1,000.

PERIODIC COSTS

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
No Action	1	LS		$0	
SUBTOTAL				$0	
Contingency (Scope and Bid)	20%			$0	10% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$0	
Project Management	10%			$0	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$0	
TOTAL PERIODIC COST				**$0**	Total capital cost is rounded to the nearest $1,000.

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each
LS	Lump Sum
NA	Not Applicable
QTY	Quantity

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Project Alternative **1**
No Action

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project Definition:	**10% (Conceptual)**
Base Year (Year	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Year[1]	Capital Costs (Construction)[2]	Annual O&M Costs[2]	Periodic Costs[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	1.0000	$0
1	$0	$0	$0	$0	0.9346	$0
2	$0	$0	$0	$0	0.8734	$0
3	$0	$0	$0	$0	0.8163	$0
4	$0	$0	$0	$0	0.7629	$0
5	$0	$0	$0	$0	0.7130	$0
6	$0	$0	$0	$0	0.6663	$0
7	$0	$0	$0	$0	0.6227	$0
8	$0	$0	$0	$0	0.5820	$0
9	$0	$0	$0	$0	0.5439	$0
10	$0	$0	$0	$0	0.5083	$0
11	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	0.0339	$0
TOTALS:	$0	$0	$0	**$0**		$0
TOTAL PRESENT VALUE OF ALTERNATIVE 1[5]						**$0**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on Table CS-1.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Annual Discount Rate Factors Table

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project	**10% (Conceptual)**
Base Year (Year 0):	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Discount Rate (Percent): 7.0

Year	Discount Factor[1,2]	Year	Discount Factor[1,2]
0	1.0000	26	0.1722
1	0.9346	27	0.1609
2	0.8734	28	0.1504
3	0.8163	29	0.1406
4	0.7629	30	0.1314
5	0.7130	31	0.1228
6	0.6663	32	0.1147
7	0.6227	33	0.1072
8	0.5820	34	0.1002
9	0.5439	35	0.0937
10	0.5083	36	0.0875
11	0.4751	37	0.0818
12	0.4440	38	0.0765
13	0.4150	39	0.0715
14	0.3878	40	0.0668
15	0.3624	41	0.0624
16	0.3387	42	0.0583
17	0.3166	43	0.0545
18	0.2959	44	0.0509
19	0.2765	45	0.0476
20	0.2584	46	0.0445
21	0.2415	47	0.0416
22	0.2257	48	0.0389
23	0.2109	49	0.0363
24	0.1971	50	0.0339
25	0.1842		

Notes:

[1] Annual discount factors were calculated using the formulas and guidance presented in Section 4.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

[2] The real discount rate of 7.0% was obtained from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000, Page 4-5 for non-Federal facilities.

Project Alternative **2**

Passive Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: The Passive Landfill Alternative will consist of excavating contaminated soil from the MLA and SA hotspots and contaminated sediments from the drainage ditch and Sen Lake, dewatering the contaminated material and transporting it to a constructed landfill located in the southwestern area of the Airport property.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Passive	1	LS	$5,578,903	$5,578,903	Includes subgrade fill and preparation, liners, leachate collection system, waste placement, and cover.
SUBTOTAL				$5,578,903	
Contingency (Scope and Bid)	25%			$1,394,726	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$6,973,629	
Project Management	5%			$348,681	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$557,890	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$418,418	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,046,044	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$9,344,662	
TOTAL with VAT (assumed 10%)	10%			$10,279,128	
TOTAL CAPITAL COST				**$10,279,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$10,279,000	**$5,139,500**	Annual capital cost over the assumed duration.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Disposal	1	LS	$6,243,038	$6,243,038	Includes site clearing/preparation, excavation, decontamination, dewatering, hauling, backfilling, site restoration, and UXO screening and clearing of excavation and landfill areas. Excludes demolition of munitions bunkers at landfill site.
SUBTOTAL				$6,243,038	
Contingency (Scope and Bid)	25%			$1,560,760	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$7,803,798	
Project Management	5%			$390,190	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$624,304	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$468,228	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,170,570	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$10,457,090	
TOTAL with VAT (assumed 10%)	10%			$11,502,799	
TOTAL CAPITAL COST				**$11,503,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$11,503,000	**$5,751,500**	Annual capital cost over the assumed duration.

Project Alternative 2

Passive Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client: USAID Vietnam
Site: Da Nang Airport
Location: Da Nang, Vietnam
Phase: Environmental Assessment of Project Alternatives
Level of Project Definition: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2010 (FY10)
Date: February 8, 2010

Description: The Passive Landfill Alternative will consist of excavating contaminated soil from the MLA and SA hotspots and contaminated sediments from the drainage ditch and Sen Lake, dewatering the contaminated material and transporting it to a constructed landfill located in the southwestern area of the Airport property.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-LANDFILL MAINTENANCE (Years 3 through 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Passive Landfill O&M	1	LS	$35,466	$35,466	Includes annual landfill O&M; assume 0.3% of landfill construction capital costs.
SUBTOTAL				$35,466	
Contingency (Scope and Bid)	25%			$8,867	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$44,333	
Project Management	10%			$4,433	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	15%			$6,650	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$6,650	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$62,066	
TOTAL with VAT (assumed 10%)	10%			$68,273	
TOTAL ANNUAL O&M COST				**$68,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 3 THROUGH 50)	48	YR	$68,000	**$3,264,000**	Annual O&M Cost over the assumed duration.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MONITORING (Years 1 through 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Environmental Mitigation and Monitoring Plan (EMMP) Implementation	1	LS	$118,220	$118,220	Includes sampling and analysis required by the EMMP; assume 1% of landfill construction capital costs.
SUBTOTAL				$118,220	
Contingency (Scope and Bid)	25%			$29,555	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$147,775	
Project Management	8%			$11,822	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	10%			$14,778	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$22,166	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$196,541	
TOTAL with VAT (assumed 10%)	10%			$216,195	
TOTAL ANNUAL O&M COST				**$216,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 1 THROUGH 50)	50	YR	$216,000	**$10,800,000**	Annual O&M Cost over the assumed duration.

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	O&M	Operations and Maintenance
LS	Lump Sum	QTY	Quantity
NA	Not Applicable	UXO	Unexploded Ordinance

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Project Alternative **2**
Passive Landfill

Client: USAID Vietnam
Site: Da Nang Airport
Location: Da Nang, Vietnam
Phase: Environmental Assessment of Project Alternatives
Level of Project Definition: 10% (Conceptual)
Base Year (Year 2nd Quarter, Fiscal Year 2010 (FY10)
Date: February 8, 2010

Year[1]	Capital Costs (Landfill Passive)[2]	Capital Costs (Landfill Disposal)[2]	Annual O&M Costs (Maintenance)[2]	Annual O&M Costs (Monitoring)[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$5,139,500	$5,751,500	$0	$216,000	$11,107,000	0.9346	$10,380,602
2	$5,139,500	$5,751,500	$0	$216,000	$11,107,000	0.8734	$9,700,854
3	$0	$0	$68,000	$216,000	$284,000	0.8163	$231,829
4	$0	$0	$68,000	$216,000	$284,000	0.7629	$216,664
5	$0	$0	$68,000	$216,000	$284,000	0.7130	$202,492
6	$0	$0	$68,000	$216,000	$284,000	0.6663	$189,229
7	$0	$0	$68,000	$216,000	$284,000	0.6227	$176,847
8	$0	$0	$68,000	$216,000	$284,000	0.5820	$165,288
9	$0	$0	$68,000	$216,000	$284,000	0.5439	$154,468
10	$0	$0	$68,000	$216,000	$284,000	0.5083	$144,357
11	$0	$0	$68,000	$216,000	$284,000	0.4751	$134,928
12	$0	$0	$68,000	$216,000	$284,000	0.4440	$126,096
13	$0	$0	$68,000	$216,000	$284,000	0.4150	$117,860
14	$0	$0	$68,000	$216,000	$284,000	0.3878	$110,135
15	$0	$0	$68,000	$216,000	$284,000	0.3624	$102,922
16	$0	$0	$68,000	$216,000	$284,000	0.3387	$96,191
17	$0	$0	$68,000	$216,000	$284,000	0.3166	$89,914
18	$0	$0	$68,000	$216,000	$284,000	0.2959	$84,036
19	$0	$0	$68,000	$216,000	$284,000	0.2765	$78,526
20	$0	$0	$68,000	$216,000	$284,000	0.2584	$73,386
21	$0	$0	$68,000	$216,000	$284,000	0.2415	$68,586
22	$0	$0	$68,000	$216,000	$284,000	0.2257	$64,099
23	$0	$0	$68,000	$216,000	$284,000	0.2109	$59,896
24	$0	$0	$68,000	$216,000	$284,000	0.1971	$55,976
25	$0	$0	$68,000	$216,000	$284,000	0.1842	$52,313
26	$0	$0	$68,000	$216,000	$284,000	0.1722	$48,905
27	$0	$0	$68,000	$216,000	$284,000	0.1609	$45,696
28	$0	$0	$68,000	$216,000	$284,000	0.1504	$42,714
29	$0	$0	$68,000	$216,000	$284,000	0.1406	$39,930
30	$0	$0	$68,000	$216,000	$284,000	0.1314	$37,318
31	$0	$0	$68,000	$216,000	$284,000	0.1228	$34,875
32	$0	$0	$68,000	$216,000	$284,000	0.1147	$32,575
33	$0	$0	$68,000	$216,000	$284,000	0.1072	$30,445
34	$0	$0	$68,000	$216,000	$284,000	0.1002	$28,457
35	$0	$0	$68,000	$216,000	$284,000	0.0937	$26,611
36	$0	$0	$68,000	$216,000	$284,000	0.0875	$24,850
37	$0	$0	$68,000	$216,000	$284,000	0.0818	$23,231
38	$0	$0	$68,000	$216,000	$284,000	0.0765	$21,726
39	$0	$0	$68,000	$216,000	$284,000	0.0715	$20,306
40	$0	$0	$68,000	$216,000	$284,000	0.0668	$18,971
41	$0	$0	$68,000	$216,000	$284,000	0.0624	$17,722
42	$0	$0	$68,000	$216,000	$284,000	0.0583	$16,557
43	$0	$0	$68,000	$216,000	$284,000	0.0545	$15,478
44	$0	$0	$68,000	$216,000	$284,000	0.0509	$14,456
45	$0	$0	$68,000	$216,000	$284,000	0.0476	$13,518
46	$0	$0	$68,000	$216,000	$284,000	0.0445	$12,638
47	$0	$0	$68,000	$216,000	$284,000	0.0416	$11,814
48	$0	$0	$68,000	$216,000	$284,000	0.0389	$11,048
49	$0	$0	$68,000	$216,000	$284,000	0.0363	$10,309
50	$0	$0	$68,000	$216,000	$284,000	0.0339	$9,628
TOTALS:	$10,279,000	$11,503,000	$3,264,000	$10,800,000	**$35,846,000**		$23,487,272
TOTAL PRESENT VALUE OF ALTERNATIVE 2[5]							**$23,487,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on Table CS-2.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Annual Discount Rate Factors Table

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project Definition:	**10% (Conceptual)**
Base Year (Year 0):	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Discount Rate (Percent): 7.0

Year	Discount Factor[1,2]	Year	Discount Factor[1,2]
0	1.0000	26	0.1722
1	0.9346	27	0.1609
2	0.8734	28	0.1504
3	0.8163	29	0.1406
4	0.7629	30	0.1314
5	0.7130	31	0.1228
6	0.6663	32	0.1147
7	0.6227	33	0.1072
8	0.5820	34	0.1002
9	0.5439	35	0.0937
10	0.5083	36	0.0875
11	0.4751	37	0.0818
12	0.4440	38	0.0765
13	0.4150	39	0.0715
14	0.3878	40	0.0668
15	0.3624	41	0.0624
16	0.3387	42	0.0583
17	0.3166	43	0.0545
18	0.2959	44	0.0509
19	0.2765	45	0.0476
20	0.2584	46	0.0445
21	0.2415	47	0.0416
22	0.2257	48	0.0389
23	0.2109	49	0.0363
24	0.1971	50	0.0339
25	0.1842		

Notes:

[1] Annual discount factors were calculated using the formulas and guidance presented in Section 4.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

[2] The real discount rate of 7.0% was obtained from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000, Page 4-5 for non-Federal facilities.

USAID
Soil and Sedimentation Remeidation Landfill Disposal
Opinion of Probable Construction Cost, 10% Design, April 2010

Project name	Landfill Disp 4-22-2010
Estimator	Dodge
Labor rate table	2010-Vietnam rev1
Equipment rate table	00 092H R Equip Rate
Estimating Office:	Cambridge
CDM DB Version:	Database: 7.0
ENR 20 City CCI:	April 2010 : 8676
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: Quantities by engineer. Bid Items use metric quantities. Assembly costing is by foot pound measure. No rock excavation is required Dewatering Of Ponds - Using Bladder Dikes. Hazardous Soils Handled Per Specifications Based on a 40 hour work week with no overtime. MOPO (Maintenance of Plant Operation) is not included Exchange rate used, 18470 VND/USD. This job is sales tax exempt.
Report format	Sorted by 'Area/Bid Item/Assembly' 'Detail' summary Allocate addons

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
01.0			**Mobilization / Demobilize**							
	01		**Site Preparation**							
		01000-0301	**UXO Screening and Disposal**							
			UXO Screening and Disposal	41.00 ac	-	-	6,575.00	-	6,575.00 /ac	269,575
			UXO Screening and Disposal	**48,891.00 sm**			**5.51**		**5.51 /sm**	**269,575**
		01000-0301	**Decon Stations - 2 ea**							
			Precast Concrete Holding Tank - 5,000 ga (10' x 17' x 7')	2.00 ea	403.92	6,200.00	-	1,984.84	8,588.76 /ea	17,178
			Manhole Castings	2.00 ea	19.59	335.00	-		354.59 /ea	709
			HDPE Liner 40 mils	64,000.00 sf	-	-	0.38	-	0.38 /sf	24,320
			ASTM D448 #357 Stone (2.00- No. 4) - 64000 sf x 8" = 1,600 cy	2,240.00 tn	-	11.20	6.40	-	17.60 /tn	39,424
			PVC Schd. 40 Pipe, 12"	100.00 lf	1.41	30.86	-	-	32.27 /lf	3,227
			Polycast Trench Drain	80.00 lf	0.77	45.00	-	-	45.77 /lf	3,661
			Decon Stations - 2 ea	**1,152.00 sm**	**0.91**	**38.93**	**33.56**	**3.45**	**76.84 /sm**	**88,519**
		01000-0301	**Traffic Control - Haul Rd - 4.6 mi**							
			Temporary Traffic Signing - (4' x 4') x 10 sets x 4 ea	640.00 sf	-	-	18.00	-	18.00 /sf	11,520
			Self Propelled Pavement Broom 96" 85HP - 103 cd/22 = 5 mo	20.00 wk	244.80	-	-	986.00	1,230.80 /wk	24,616
			Traffic Control - Haul Rd - 4.6 mi	**7.40 km**	**661.62**		**1,556.76**	**2,664.87**	**4,883.24 /km**	**36,136**
		01000-0301	**Maintain Decon Stations**							
			On-Highway Water Truck 2500 Gallons	74.00 wk	244.80	-	-	1,537.20	1,782.00 /wk	131,868
			Maintain Decon Stations	**1.00 ls**	**18,115.20**			**113,752.80**	**131,868.00 /ls**	**131,868**
		01000-0301	**Sampling/H&S - During Excavation**							
			Sampling & H/S During Excavation	1.00 ls	-	-	250,000.00	-	250,000.00 /ls	250,000
			Sampling/H&S - During Excavation	**1.00 ls**			**250,000.00**		**250,000.00 /ls**	**250,000**
		02230-005	**Site Clearing - Treatment - Landfill - Decon Areas & Storage Areas**							
			Clear & Grub Heavy Trees, 5ac - 20ac	12.30 ac	293.76	-	-	1,173.12	1,466.88 /ac	18,043
			Site Clearing - Treatment - Landfill - Decon Areas & Storage Areas	**4.98 ha**	**725.55**			**2,897.47**	**3,623.02 /ha**	**18,043**
		02310-01-5	**Construct - Soil and Sediment Storage & Dewatering Areas**							
			Place Fill from Import- Dozer D6/CP323 Compactor	29,000.00 cy	0.20	-	-	2.10	2.30 /cy	66,735
			Import Common Earth	29,000.00 cy	-	7.00	4.10	-	11.10 /cy	322,016
			Fine Grade- Grader G12	25,100.00 sy	0.07	-	-	0.47	0.54 /sy	13,614
			ASTM D448 # 57 Stone (1.00- No. 4) - 89,000 sf @ 12"	3,300.00 cy	-	12.80	6.40	-	19.20 /cy	63,360
			HDPE Liner 40 mils	89,000.00 sf	-	-	0.38	-	0.38 /sf	33,820
			PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	4,200.00 lf	0.29	2.48	-	-	2.76 /lf	11,607
			PVC Schd. 40 Pipe, 12"	500.00 lf	1.41	30.86	-	-	32.27 /lf	16,134
			PVC Sch 40, Cross , 12"	14.00 ea	24.05	355.32	-	-	379.37 /ea	5,311
			Construct - Soil and Sediment Storage & Dewatering Areas	**22,172.00 cm**	**0.45**	**12.45**	**7.85**	**3.27**	**24.02 /cm**	**532,598**
			01 Site Preparation	**1.00 ls**	**37,681.37**	**320,887.68**	**743,707.00**	**224,462.20**	**1,326,738.25 /ls**	**1,326,738**
	04		**Site Restoration**							
		02310-01-3	**Replace Excavated Storage/Mixing & Loading Areas**							
			Cut/Fill- Dozer D6/CP323 Compactor	50,300.00 cy	0.31	-	-	3.15	3.45 /cy	173,627
			Haul Cut to Fill 18cy Rear Dump (2ea)	50,300.00 cy	0.41	-	-	4.95	5.36 /cy	269,440
			Articulated Wheel Loader Cat 966 220HP 4.75cy - Load From Soil & Sedimedt Areas	50,300.00 cy	0.10	-	-	1.19	1.29 /cy	64,853
			Import Gravel Fill	1,300.00 cy	-	9.10	5.60	-	14.70 /cy	19,110
			Replace Excavated Storage/Mixing & Loading Areas	**50,300.00 cy**	**0.82**	**0.24**	**0.15**	**9.28**	**10.48 /cy**	**527,031**
		02740-100-01	**Bituminous Paving 1.5" Overlay Of Haul Route - 30' wide**							

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
		02740-100-01	Bituminous Paving 1.5" Overlay Of Haul Route - 30' wide							
			Roadway Surface/Wearing Course	6,831.00 ton	0.74	60.00	15.00	5.79	81.54 /ton	556,962
			Roadway Tack Coat - 0.05 ga/sy	4,050.00 ga	-	4.00	2.57	-	6.57 /ga	26,601
			Bituminous Paving 1.5" Overlay Of Haul Route - 30' wide	80,960.00 sy	0.06	5.26	1.39	0.49	7.21 /sy	583,564
		02920-030	Loam and Seed Soil Abatement Areas							
			Spread Loam	10,175.93 cy		8.00	-		8.00 /cy	81,407
			Machine Rake	1,099,000.00 sf	-	-	0.04	-	0.04 /sf	43,960
			Hand Rake	1,099,000.00 sf	-	-	0.05	-	0.05 /sf	54,950
			Hydroseeding	1,099,000.00 sf	-	-	0.04	-	0.04 /sf	43,960
			Mulch - Hay	1,099,000.00 sf	-	-	0.01	-	0.01 /sf	10,990
			Loam and Seed Soil Abatement Areas	122,108.00 sy		0.67	1.26		1.93 /sy	235,267
			04 Site Restoration	1.00 ls	46,112.16	519,297.41	274,006.28	506,446.34	1,345,862.19 /ls	1,345,862
			01.0 Mobilization / Demobilize	**1.00 ls**	**83,793.53**	**840,185.09**	**1,017,713.28**	**730,908.54**	**2,672,600.44 /ls**	**2,672,600**
01.1			**Former Loading & Mixing Area/Pacer and Eastern Hot Spot**							
	02		Excavation							
		02310-01-2	Former Loading & Mixing Area/Pacer and Eastern Hot Spot							
			Cut to Stockpile- Dozer D-5	28,000.00 cy	0.12	-	-	1.20	1.32 /cy	36,904
			Fine Grade- Grader G12	63,475.00 sy	0.07	-	-	0.47	0.54 /sy	34,429
			Articulated Wheel Loader Cat 966 220HP 4.75cy	28,000.00 cy	0.07	-	-	0.79	0.86 /cy	24,068
			Haul To Stockpile Area	28,000.00 cy	0.20	-	-	2.47	2.68 /cy	74,993
			Former Loading & Mixing Area/Pacer and Eastern Hot Spot	28,000.00 cy	0.56			5.53	6.09 /cy	170,394
			02 Excavation	21,400.00 cm	0.73			7.23	7.96 /cm	170,394
			01.1 Former Loading & Mixing Area/Pacer and Eastern Hot Spot	**53,000.00 sm**	**0.30**			**2.92**	**3.22 /sm**	**170,394**
02.1			**Former Storage Area**							
	02		Excavation							
		02310-01-2	Former Storage Area							
			Cut to Stockpile- Dozer D-5	22,750.00 cy	0.12	-	-	1.20	1.32 /cy	29,985
			Fine Grade- Grader G12	58,657.00 sy	0.07	-	-	0.47	0.54 /sy	31,816
			Articulated Wheel Loader Cat 966 220HP 4.75cy	22,750.00 cy	0.07	-	-	0.79	0.86 /cy	19,555
			Haul To Stockpile Area	22,750.00 cy	0.20	-	-	2.47	2.68 /cy	60,932
			Former Storage Area	22,750.00 cy	0.58			5.67	6.25 /cy	142,287
			02 Excavation	17,400.00 cm	0.76			7.41	8.18 /cm	142,287
			02.1 Former Storage Area	**49,000.00 sm**	**0.27**			**2.63**	**2.90 /sm**	**142,287**
03.1			**Wetlands Areas: Sen Lake**							
	02		Excavation							
		01000-0301	F&I Two - 6' Aqua Dam Bladders							
			Furnish 6' Bladder	2,800.00 lf	-	-	77.25	-	77.25 /lf	216,300
			Install 6' Bladder	2,800.00 lf	0.98	-		6.08	7.06 /lf	19,754
			Tech Support To Install 6' Aqua Dam	2,800.00 lf	-	-	4.29	-	4.29 /lf	12,000
			Fill 6' Bladder @ 650 g/lf	1,820.00 mg	0.65	-		2.11	2.76 /mg	5,018
			F&I Two - 6' Aqua Dam Bladders	850.00 m	4.61		268.59	24.54	297.73 /m	253,071
		02310-01-2	Pond Excavation To Stockpile @ Shore							
			Cut to Stockpile- Dozer D6 - 3 ea	30,200.00 cy	0.37	-	-	5.68	6.05 /cy	182,613

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
		02310-01-2	Pond Excavation To Stockpile @ Shore							
			Load Excavation	30,200.00 cy	0.15	-	-	5.12	5.27 /cy	159,232
			Haul Spoil To Dewatering Area - Off HWY 35 cy Tks	30,200.00 cy	0.31	-	-	6.65	6.95 /cy	209,920
			Pond Excavation To Stockpile @ Shore	30,200.00 cy	0.83			17.44	18.27 /cy	551,765
			02 Excavation	23,089.00 cm	1.25		9.89	23.72	34.86 /cm	804,837
			03.1 Wetlands Areas: Sen Lake	**10.12 ha**	**2,852.82**		**22,559.29**	**54,117.21**	**79,529.32 /ha**	**804,837**
04.1			**Haul Route**							
	03		Load and Haul							
		02310-01-2	Dewatered Excavation - Load /Haul to Landfill							
			Load From Stockpile	80,500.00 cy	0.25	-	-	3.99	4.24 /cy	341,109
			Haul To Landfill - 18 cy Trucks - 2 hrs/cycle	80,500.00 cy	0.82	-	-	9.90	10.71 /cy	862,423
			Dewatered Excavation - Load /Haul to Landfill	80,500.00 cy	1.06			13.89	14.95 /cy	1,203,532
			03 Load and Haul	4.60 mi	18,564.70			243,072.67	261,637.36 /mi	1,203,532
			04.1 Haul Route	**7.40 km**	**11,540.22**			**151,099.22**	**162,639.44 /km**	**1,203,532**

Estimate Totals

Description	Amount	Totals	Hours		Rate	
Labor	227,047		37,505	hrs		
Material	840,185					
Subcontract	1,246,013					
Equipment	2,680,405		34,453	hrs		
Other						
	4,993,650	**4,993,650**				
Indirect Cost:						
Building Permits % total cost	24.972				0.40	%
Sales Tax (MEO)						
Builders Risk Ins % total cost	15.608				0.25	%
Gen Liability Ins % total cost	124.861				2.00	%
GC Bonds % total cost	62.430				1.00	%
-						
Subtotal Prior to OH&P	**227,871**	**5,221,521**				
GC Field General Conditions	499.365				10.00	%
GC Indirects. OH & Profit	522.152				10.00	%
-						
Subtotal	**1,021,517**	**6,243,038**				
Construction Contingency						
-						
Subtotal Cost, Today's Dollars		**6,243,038**				
Escalation to Mid Point of Construction. Based on 2%/year January 10 to January 11						
Total Construction Cost		**6,243,038**				

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

USAID
Soil Remediation Landfill - Passive
Opinion of Probable Construction Cost, 10% Design, April 2010

Project name	Landfill Passive 4-22-10
Estimator	Dodge
Labor rate table	2010-Vietnam rev1
Equipment rate table	00 092H R Equip Rate
Estimating Office:	Cambridge
CDM DB Version:	Database: 7.0
ENR 20 City CCI:	January 2010 : 8660

Notes

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM does not guarantee that this opinion will not vary from actual cost, or contractor's bids.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.

The total cost shown is valid to only two significant figures

Assumptions:

Item quantities by engineer.
No rock excavation is required
Only nominal dewatering is needed
No consideration for contaminated soils or hazardous materials (i.e. asbestos, lead)
Amunition area and UXO by others.
Based on a 40 hour work week with no overtime.
MOPO (Maintenance of Plant Operation) is not included
Labor rates are that of Vietnameese labor.
Exchange rate used, 0.00005414 USD/VND or 18,470 VND/USD.

This job is tax exempt.

Report format	Sorted by 'Area/Element/Bid Item/Assembly' 'Detail' summary Allocate addons

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
02				**Passive Landfill**							
	01			**Landfill Construction**							
		01		**Soil Compaction Testing**							
			01000-0301	**Soil Compaction Testing**							
				Compaction Testing - (115,000 cy @ 250 cy)	460.00 ea	12.24	-		-	12.24 /ea	5,630
				Soil Compaction Testing	**460.00 ea**	**12.24**				**12.24 /ea**	**5,630**
				01 Soil Compaction Testing	**115,000.00 cy**	**0.05**				**0.05 /cy**	**5,630**
		02		**Clear & Grub**							
			02230-005	**Site Clearing**							
				Clear & Grub Light Trees, 1ac - 5ac	5.00 ac	68.00	-	-	514.22	582.22 /ac	2,911
				Site Clearing	**5.00 ac**	**68.00**			**514.22**	**582.22 /ac**	**2,911**
				02 Clear & Grub	**5.00 ac**	**68.00**			**514.22**	**582.22 /ac**	**2,911**
		03		**Demo Of Munitions Bunkers**							
			01000-0301	**Demo Of Munitions Bunkers**							
				Demo Munitions Bunkers	***1.00 ls***	***-***	***-***	***0.00***	***-***	***0.00 /ls***	***0***
		04		**UXO Screening & Disposal**							
			01000-0301	**UXO - Screening and Disposal**							
				UXO Screening and Disposal	5.00 ac	-	-	6,575.00	-	6,575.00 /ac	32,875
				UXO - Screening and Disposal	**1.00 ls**			**32,875.00**		**32,875.00 /ls**	**32,875**
				04 UXO Screening & Disposal	**1.00 ls**			**32,875.00**		**32,875.00 /ls**	**32,875**
		05		**Bring Above Flood Plane**							
			02310-01-5	**Fill From Borrow - 2m Above Flood Plane**							
				Place Fill from Import- Dozer D6/CP323 Compactor	55,000.00 cy	0.25	-	-	3.19	3.43 /cy	188,876
				Import Common Earth	55,000.00 cy	-	9.10	4.10	-	13.20 /cy	726,220
				Fill From Borrow - 2m Above Flood Plane	**55,000.00 cy**	**0.25**	**9.10**	**4.10**	**3.19**	**16.64 /cy**	**915,096**
				05 Bring Above Flood Plane	**55,000.00 cy**	**0.25**	**9.10**	**4.10**	**3.19**	**16.64 /cy**	**915,096**
		06		**Common Fill For Longitudinal Slope**							
			02310-01-5	**Fill For Longitudinal Slope**							
				Place Fill from Import- Dozer D6/CP323 Compactor	10,200.00 cy	0.33	-	-	4.25	4.58 /cy	46,704
				Import Sand Fill	10,200.00 cy	-	18.00		-	18.00 /cy	183,600
				Fill For Longitudinal Slope	**10,200.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**230,304**
				06 Common Fill For Longitudinal Slope	**10,200.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**230,304**
		07		**Saw Tooth With Common Fill**							

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-5	**Saw Tooth - Sand**							
				Place Fill from Import- Dozer D6/CP323 Compactor	6,900.00 cy	0.33	-	-	4.25	4.58 /cy	31,594
				Import Sand Fill	6,900.00 cy	-	18.00		-	18.00 /cy	124,200
				Saw Tooth - Sand	**6,900.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**155,794**
				07 Saw Tooth With Common Fill	**6,900.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**155,794**
		08		**6" Processed Sand**							
			02310-01-5	**6" Processed Sand**							
				Place Fill from Import- Dozer D6/CP323 Compactor	4,200.00 cy	0.33	-	-	4.25	4.58 /cy	19,231
				Import Sand Fill	4,200.00 cy	-	18.00	5.60	-	23.60 /cy	99,120
				6" Processed Sand	**4,200.00 cy**	**0.33**	**18.00**	**5.60**	**4.25**	**28.18 /cy**	**118,351**
				08 6" Processed Sand	**4,200.00 cy**	**0.33**	**18.00**	**5.60**	**4.25**	**28.18 /cy**	**118,351**
		09		**Anchor Berm**							
			02310-01-3	**Anchor Berm (From On Site Fill)**							
				Cut/Fill- Dozer D6/CP323 Compactor	14,500.00 cy	0.39	-	-	5.10	5.50 /cy	79,671
				Anchor Berm (From On Site Fill)	**14,500.00 cy**	**0.39**			**5.10**	**5.50 /cy**	**79,671**
				09 Anchor Berm	**14,500.00 cy**	**0.39**			**5.10**	**5.50 /cy**	**79,671**
		10		**Excavate Anchor Trench**							
			02310-01-3	**Anchor Trench (Cut To Fill)**							
				Cut/Fill- Dozer D6/CP323 Compactor	730.00 cy	0.83	-	-	10.86	11.69 /cy	8,534
				Anchor Trench (Cut To Fill)	**730.00 cy**	**0.83**			**10.86**	**11.69 /cy**	**8,534**
				10 Excavate Anchor Trench	**1,772.00 lf**	**0.34**			**4.47**	**4.82 /lf**	**8,534**
		11		**Grade Subbase**							
			02310-01-3	**Grade Subbase**							
				Fine Grade- Grader G12	226,000.00 sf	0.01	-	-	0.07	0.08 /sf	18,940
				Grade Subbase	**226,000.00 sf**	**0.01**			**0.07**	**0.08 /sf**	**18,940**
				11 Grade Subbase	**25,111.00 sy**	**0.10**			**0.66**	**0.75 /sy**	**18,940**
		12		**Install GCL Liner**							
			01000-0301	**Install GCL Liner**							
				HDPE Liner 40 mils	226,000.00 sf	-	-	0.38	-	0.38 /sf	85,880
				Install GCL Liner	**226,000.00 sf**			**0.38**		**0.38 /sf**	**85,880**
				12 Install GCL Liner	**25,111.00 sy**			**3.42**		**3.42 /sy**	**85,880**
		13		**Install Secondary 60 Mil HDPE Liner**							
			01000-0301	**Install 60mil Secondary Liner**							
				HDPE Liner 60 mils	226,000.00 sf	-	-	0.51	-	0.51 /sf	115,260
				Install 60mil Secondary Liner	**226,000.00 sf**			**0.51**		**0.51 /sf**	**115,260**

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				13 Install Secondary 60 Mil HDPE Liner	25,111.00 sy			4.59		4.59 /sy	115,260
		14		Install Geocomposite (LDS)							
			01000-0301	Install Geocomposite (LDS)							
				Geocomposite- 250 mils	226,000.00 sf	-	0.11	0.32	-	0.43 /sf	97,180
				Install Geocomposite (LDS)	226,000.00 sf		0.11	0.32		0.43 /sf	97,180
				14 Install Geocomposite (LDS)	25,111.00 sy		0.99	2.88		3.87 /sy	97,180
		15		Install Primary 60 Mil HDPE Liner							
			01000-0301	Install Primary 60 mil HDPE Liner							
				HDPE Liner 60 mils	226,000.00 sf	-	-	0.51	-	0.51 /sf	115,260
				Install Primary 60 mil HDPE Liner	226,000.00 sf			0.51		0.51 /sf	115,260
				15 Install Primary 60 Mil HDPE Liner	25,111.00 sy			4.59		4.59 /sy	115,260
		16		Install Geocomposite (LCS)							
			01000-0301	Install Geocomposite (LCS)							
				Geocomposite- 250 mils	226,000.00 sf	-	0.11	0.32	-	0.43 /sf	97,180
				Install Geocomposite (LCS)	226,000.00 sf		0.11	0.32		0.43 /sf	97,180
				16 Install Geocomposite (LCS)	25,111.00 sy		0.99	2.88		3.87 /sy	97,180
		17		Protective Sand 2 '							
			02310-01-5	Protective Sand Layer (2')							
				Place Fill from Import- Dozer D6/CP323 Compactor	23,450.00 cy	0.33	-	-	4.25	4.58 /cy	107,373
				Import Sand Fill	23,450.00 cy	-	18.00	5.60	-	23.60 /cy	553,420
				Protective Sand Layer (2')	23,450.00 cy	0.33	18.00	5.60	4.25	28.18 /cy	660,793
				17 Protective Sand 2 '	23,450.00 cy	0.33	18.00	5.60	4.25	28.18 /cy	660,793
		18		6" HDPE Perforated (Lateral Collection)							
			01000-0301	6" HDPE Perforated (Lateral Collection)							
				HDPE Perforated, Sch 40, 6"dia	2,100.00 lf	0.29	2.48	-	-	2.76 /lf	5,804
				6" HDPE Perforated (Lateral Collection)	2,100.00 lf	0.29	2.48			2.76 /lf	5,804
				18 6" HDPE Perforated (Lateral Collection)	2,100.00 lf	0.29	2.48			2.76 /lf	5,804
		19		Install Gravel							
			02310-01-5	Install Gravel (Road)							
				Place Fill from Import- Dozer D6/CP323 Compactor	525.00 cy	0.17	-	-	2.18	2.35 /cy	1,235
				Import Gravel Fill	525.00 cy	-	9.10	5.60	-	14.70 /cy	7,718
				Install Gravel (Road)	525.00 cy	0.17	9.10	5.60	2.18	17.05 /cy	8,952

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				19 Install Gravel	525.00 cy	0.17	9.10	5.60	2.18	17.05 /cy	8,952
		20		Install Geotextile							
			01000-0301	Install Geotextile Wrap - Drain Pipe							
				Geotextile Fabric	33,600.00 sf	0.03	0.11	-	-	0.14 /sf	4,621
				Install Geotextile Wrap - Drain Pipe	33,600.00 sf	0.03	0.11			0.14 /sf	4,621
				20 Install Geotextile	33,600.00 sf	0.03	0.11			0.14 /sf	4,621
		21		8" HDPE LCS Manifold							
			01000-0301	Install 8" 8" LCS Manifold							
				Install 8" HDPE Pipe	328.00 lf	-	-	45.00	-	45.00 /lf	14,760
				Install 8" 8" LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
				21 8" HDPE LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
		22		8" HDPE LCS Manifold							
			01000-0301	8" HDPE LCS Manifold							
				Install 8" HDPE Pipe	328.00 lf	-	-	45.00	-	45.00 /lf	14,760
				8" HDPE LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
				22 8" HDPE LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
		23		8" HDPE Cleanouts							
			01000-0301	8" HDPE Cleanouts (140 ea @ ')							
				Install 8" HDPE Pipe	420.00 lf	-	-	45.00	-	45.00 /lf	18,900
				PE (B&S) Sewer Pipe Cap/Plug, 8"	140.00 ea	0.61	105.00	-	-	105.61 /ea	14,786
				PE (B&S) Drainage Pipe Wye, 8"	140.00 ea	3.06	24.00	-	-	27.06 /ea	3,788
				8" HDPE Cleanouts (140 ea @ ')	140.00 ea	3.67	129.00	135.00		267.67 /ea	37,474
				23 8" HDPE Cleanouts	420.00 lf	1.22	43.00	45.00		89.22 /lf	37,474
		24		LCS Pipe Penetration							
			01000-0301	LCS Pipe Penetration							
				Install Pipe penetrations	1.00 ea		-	5,000.00	-	5,000.00 /ea	5,000
				LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
				24 LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
		25		LCS Pipe Penetration							
			01000-0301	LCS Pipe Penetration							
				Install Pipe penetrations	1.00 ea		-	5,000.00	-	5,000.00 /ea	5,000
				LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
				25 LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
		26		LCS 10" HDPE From Sump To Manhole							
			15245-0210 9t	10" HDPE - LCS - Sump To MH							
				Plastic Pipe Equipment- Cat 325 Excavator	2.52 ch	6.12	-	-	130.18	136.30 /ch	343
				HDPE IPS, Butt-Fused Pipe, DR 9, 10"	70.00 lf	1.10	18.91	-	-	20.01 /lf	1,401

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			15245-0210 9t	**10" HDPE - LCS - Sump To MH**							
				Trenching- Backhoe/Loader 95HP Average Exc.	25.71 cy	0.41	-	-	4.12	4.53 /cy	116
				Trench Bedding-Backhoe/Loader C446 95HP	3.67 cy	1.23	-	-	5.00	6.22 /cy	23
				3/8 Stone Bedding/Zone/Engineered Fill Material	3.67 cy	-	30.94	-	-	30.94 /cy	114
				Trench Pipe Zone Backfill-Backhoe/Loader 95HP	12.05 cy	2.45	-	-	7.08	9.53 /cy	115
				3/8 Stone Bedding/Zone/Engineered Fill Material	12.05 cy	-	30.94	-	-	30.94 /cy	373
				Trench Native Backfill-Backhoe/Loader 95HP	8.57 cy	0.68	-	-	3.80	4.48 /cy	38
				10" HDPE - LCS - Sump To MH	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
				26 LCS 10" HDPE From Sump To Manhole	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
		27		**LDS 10" HDPE From Sump To Manhole**							
			15245-0210 9t	**10" HDPE - LDS - Sump To MH**							
				Plastic Pipe Equipment- Cat 325 Excavator	2.52 ch	6.12	-	-	130.18	136.30 /ch	343
				HDPE IPS, Butt-Fused Pipe, DR 9, 10"	70.00 lf	1.10	18.91	-	-	20.01 /lf	1,401
				Trenching- Backhoe/Loader 95HP Average Exc.	25.71 cy	0.41	-	-	4.12	4.53 /cy	116
				Trench Bedding-Backhoe/Loader C446 95HP	3.67 cy	1.23	-	-	5.00	6.22 /cy	23
				3/8 Stone Bedding/Zone/Engineered Fill Material	3.67 cy	-	30.94	-	-	30.94 /cy	114
				Trench Pipe Zone Backfill-Backhoe/Loader 95HP	12.05 cy	2.45	-	-	7.08	9.53 /cy	115
				3/8 Stone Bedding/Zone/Engineered Fill Material	12.05 cy	-	30.94	-	-	30.94 /cy	373
				Trench Native Backfill-Backhoe/Loader 95HP	8.57 cy	0.68	-	-	3.80	4.48 /cy	38
				10" HDPE - LDS - Sump To MH	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
				27 LDS 10" HDPE From Sump To Manhole	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
		28		**Lechate Man Hole**							
			01000-0301	**Precast Concrete Leachate Manhole (10,000 ga)**							
				Septic Tanks 10,000 gal.	1.00 ea	244.80	8,750.00	-	1,041.44	10,036.24 /ea	10,036
				Manhole Castings	3.00 ea	24.48	335.00	-		359.48 /ea	1,078
				Precast Concrete Leachate Manhole (10,000 ga)	**1.00 ea**	**318.24**	**9,755.00**		**1,041.44**	**11,114.68 /ea**	**11,115**
				28 Lechate Man Hole	**1.00 ea**	**318.24**	**9,755.00**		**1,041.44**	**11,114.68 /ea**	**11,115**

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				01 Landfill Construction							2,852,191
	02			Landfill Operation							
		40		Spread & Compact Contaminated Soil							
			02310-01-5	Spread & Compact Contaminated Soils							
				Place Fill from Import- Dozer D6/CP323 Compactor	50,300.00 cy	0.41	-	-	3.74	4.15 /cy	208,671
				Spread & Compact Contaminated Soils	**50,300.00 cy**	**0.41**			**3.74**	**4.15 /cy**	**208,671**
				40 Spread & Compact Contaminated Soil	50,300.00 cy	0.41			3.74	4.15 /cy	208,671
		41		Spread & Compact Sediment							
			02310-01-5	Spread & Compact Sediment							
				Place Fill from Import- Dozer D6/CP323 Compactor	30,200.00 cy	0.41	-	-	3.74	4.15 /cy	125,286
				Spread & Compact Sediment	**30,200.00 cy**	**0.41**			**3.74**	**4.15 /cy**	**125,286**
				41 Spread & Compact Sediment	30,200.00 cy	0.41			3.74	4.15 /cy	125,286
		42		Spread & Compact LCM							
			02310-01-5	Spread & Compact LCM							
				Place Fill from Import- Dozer D6/CP323 Compactor	5,700.00 cy	0.82	-	-	7.48	8.30 /cy	47,293
				Import Sand Fill	5,700.00 cy	-	18.00	5.60	-	23.60 /cy	134,520
				Spread & Compact LCM	**5,700.00 cy**	**0.82**	**18.00**	**5.60**	**7.48**	**31.90 /cy**	**181,813**
				42 Spread & Compact LCM	5,700.00 cy	0.82	18.00	5.60	7.48	31.90 /cy	181,813
		45		Leachate Treatment							
			01000-0301	Leachate Treatment							
				Leachate Treatment	1.00 ls	-	-	75,000.00	-	75,000.00 /ls	75,000
				Leachate Treatment	**1.00 ls**			**75,000.00**		**75,000.00 /ls**	**75,000**
				45 Leachate Treatment	1.00 ls			75,000.00		75,000.00 /ls	75,000
		46		Monitoring Well Network							
			01000-0301	Monitoring Well Network							
				Deep Monitoring Wells -	5.00 ea			376.00	-	376.00 /ea	1,880
				Shallow Monitoring Well -	5.00 ea	-	-	94.00	-	94.00 /ea	470
				Monitoring Well Network	**1.00 ls**			**2,350.00**		**2,350.00 /ls**	**2,350**
				46 Monitoring Well Network	1.00 ls			2,350.00		2,350.00 /ls	2,350
				02 Landfill Operation							593,120
	03			Landfill Closure							
		30		Intermediate Cover 12"							
			02310-01-5	12" Intermediate Cover							

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-5	**12" Intermediate Cover**							
				Place Fill from Import- Dozer D6/CP323 Compactor	8,400.00 cy	0.41	-	-	3.74	4.15 /cy	34,848
				Import Sand Fill	8,400.00 cy	-	18.00	5.60	-	23.60 /cy	198,240
				12" Intermediate Cover	**8,400.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**233,088**
				30 Intermediate Cover 12"	**8,400.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**233,088**
		31		**Install GCL Liner**							
			01000-0301	**Install GCL Liner**							
				HDPE Liner 40 mils	226,000.00 sf	-	-	0.38	-	0.38 /sf	85,880
				Install GCL Liner	**226,000.00 sf**			**0.38**		**0.38 /sf**	**85,880**
				31 Install GCL Liner	**25,111.00 sy**			**3.42**		**3.42 /sy**	**85,880**
		32		**Install 40 Mil LLDPE Liner**							
			01000-0301	**40 mil LLDPE Liner**							
				HDPE Liner 40 mils	226,000.00 sf	-	-	0.38	-	0.38 /sf	85,880
				40 mil LLDPE Liner	**226,000.00 sf**			**0.38**		**0.38 /sf**	**85,880**
				32 Install 40 Mil LLDPE Liner	**25,111.00 sy**			**3.42**		**3.42 /sy**	**85,880**
		33		**Install Geocomposite**							
			01000-0301	**Install Geocomposite**							
				Geocomposite- 250 mils	226,000.00 sf	-	0.10	0.32	-	0.42 /sf	94,920
				Install Geocomposite	**226,000.00 sf**		**0.10**	**0.32**		**0.42 /sf**	**94,920**
				33 Install Geocomposite	**25,111.00 sy**		**0.90**	**2.88**		**3.78 /sy**	**94,920**
		34		**Protective Sand**							
			02310-01-5	**Protective Sand - 2'**							
				Place Fill from Import- Dozer D6/CP323 Compactor	16,800.00 cy	0.41	-	-	3.74	4.15 /cy	69,695
				Import Sand Fill	16,800.00 cy	-	18.00	5.60	-	23.60 /cy	396,480
				Protective Sand - 2'	**16,800.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**466,175**
				34 Protective Sand	**16,800.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**466,175**
		35		**Sodding**							
			01000-0301	**Sodding**							
				Sod In Place	226,000.00 sf	-	-	0.50	-	0.50 /sf	113,000
				Sodding	**226,000.00 sf**			**0.50**		**0.50 /sf**	**113,000**
				35 Sodding	**25,111.00 sy**			**4.50**		**4.50 /sy**	**113,000**
				03 Landfill Closure							**1,078,943**
				02 Passive Landfill							**4,524,254**

Estimate Totals

Description	Amount	Totals	Hours		Rate	
Labor	93,402		15,270	hrs		
Material	1,979,526					
Subcontract	1,543,305					
Equipment	908,021		9,071	hrs		
Other						
	4,524,254	**4,524,254**				
Indirect Cost:						
Building Permits % total cost	22.316				0.40	%
Sales Tax (MEO)						
Builders Risk Ins % total cost	13.947				0.25	%
Gen Liability Ins % total cost	111.578				2.00	%
GC Bonds % total cost	55.789				1.00	%
-						
Subtotal Prior to OH&P	**203,630**	**4,727,884**				
GC Field General Conditions	472.788				10.00	%
GC Indirects. OH & Profit	378.231				8.00	%
-						
Subtotal	**851,019**	**5,578,903**				
Construction Contingency						
-						
Subtotal Cost, Today's Dollars		**5,578,903**				
Escalation to Mid Point of Construction. Based on 2%/year December 09 to December 10						
Total Construction Cost		**5,578,903**				

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.

Estimate Totals

There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Project Alternative 3

Active Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client: USAID Vietnam
Site: Da Nang Airport
Location: Da Nang, Vietnam
Phase: Environmental Assessment of Project Alternatives
Level of Project Definition: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2010 (FY10)
Date: February 8, 2010

Description: While no proven dioxin bioremediation technology currently exists (CDM International 2010, Appendix A5), the Active Landfill Alternative nevertheless considers a general Project configuration that could potentially accommodate a bioremediation technology.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Active	1	LS	$8,557,266	$8,557,266	Includes subgrade fill and preparation, liners, leachate collection system, waste placement, cover, and air distribution wells. Excludes bioremediaition distribution system.
SUBTOTAL				$8,557,266	
Contingency (Scope and Bid)	25%			$2,139,317	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$10,696,583	
Project Management	5%			$534,829	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	6%			$641,795	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$641,795	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,604,487	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$14,119,489	
TOTAL with VAT (assumed 10%)	10%			$15,531,438	
TOTAL CAPITAL COST				**$15,531,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$15,531,000	**$7,765,500**	Annual capital cost over the assumed duration.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Landfill Disposal	1	LS	$6,243,038	$6,243,038	Includes site clearing/preparation, excavation, decontamination, dewatering, hauling, backfilling, site restoration, and UXO screening and clearing of excavation and landfill areas. Excludes demolition of munitions bunkers at landfill site.
SUBTOTAL				$6,243,038	
Contingency (Scope and Bid)	25%			$1,560,760	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$7,803,798	
Project Management	5%			$390,190	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$624,304	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$468,228	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$1,170,570	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$10,457,090	
TOTAL with VAT (assumed 10%)	10%			$11,502,799	
TOTAL CAPITAL COST				**$11,503,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$11,503,000	**$5,751,500**	Annual capital cost over the assumed duration.

Project Alternative 3

Active Landfill

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client: USAID Vietnam
Site: Da Nang Airport
Location: Da Nang, Vietnam
Phase: Environmental Assessment of Project Alternatives
Level of Project Definition: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2010 (FY10)
Date: February 8, 2010

Description: While no proven dioxin bioremediation technology currently exists (CDM International 2010, Appendix A5), the Active Landfill Alternative nevertheless considers a general Project configuration that could potentially accommodate a bioremediation technology.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MAINTENANCE (Years 3 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Active Landfill O&M	1	LS	$44,401	$44,401	Includes annual landfill O&M; assume 0.3% of landfill construction direct capital costs.
SUBTOTAL				$44,401	
Contingency (Scope and Bid)	25%			$11,100	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$55,501	
Project Management	10%			$5,550	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	15%			$8,325	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$8,325	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$77,701	
TOTAL with VAT (assumed 10%)	10%			$85,471	
TOTAL ANNUAL O&M COST				**$85,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 3 THROUGH 10)	8	YR	$85,000	**$680,000**	Annual O&M Cost over the assumed duration.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MONITORING (Years 1 through 11)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Environmental Mitigation and Monitoring Plan (EMMP) Implementation	1	LS	$148,004	$148,004	Includes sampling and analysis required by the EMMP; assume 1% of landfill construction direct capital costs.
SUBTOTAL				$148,004	
Contingency (Scope and Bid)	25%			$37,001	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$185,005	
Project Management	8%			$14,800	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	10%			$18,501	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$27,751	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$246,057	
TOTAL with VAT (assumed 10%)	10%			$270,663	
TOTAL ANNUAL O&M COST				**$271,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 1 THROUGH 11)	11	YR	$271,000	**$2,981,000**	Annual O&M Cost over the assumed duration.

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	O&M	Operations and Maintenance
LS	Lump Sum	QTY	Quantity
NA	Not Applicable	UXO	Unexploded Ordinance

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Project Alternative **3**
Active Landfill

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project Definition:	**10% (Conceptual)**
Base Year (Year	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Year[1]	Capital Costs (Landfill Active)[2]	Capital Costs (Landfill Disposal)[2]	Annual O&M Costs (Maintenance)[2]	Annual O&M Costs (Monitoring)[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$7,765,500	$5,751,500	$0	$271,000	$13,788,000	0.9346	$12,886,265
2	$7,765,500	$5,751,500	$0	$271,000	$13,788,000	0.8734	$12,042,439
3	$0	$0	$85,000	$271,000	$356,000	0.8163	$290,603
4	$0	$0	$85,000	$271,000	$356,000	0.7629	$271,592
5	$0	$0	$85,000	$271,000	$356,000	0.7130	$253,828
6	$0	$0	$85,000	$271,000	$356,000	0.6663	$237,203
7	$0	$0	$85,000	$271,000	$356,000	0.6227	$221,681
8	$0	$0	$85,000	$271,000	$356,000	0.5820	$207,192
9	$0	$0	$85,000	$271,000	$356,000	0.5439	$193,628
10	$0	$0	$85,000	$271,000	$356,000	0.5083	$180,955
11	$0	$0	$0	$271,000	$271,000	0.4751	$128,752
12	$0	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$15,531,000	$11,503,000	$680,000	$2,981,000	**$30,695,000**		$26,914,138
TOTAL PRESENT VALUE OF ALTERNATIVE 3[5]							**$26,914,000**

Notes:

[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.

[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on Table CS-3.

[3] Total annual expenditure is the total cost per year with no discounting.

[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.

[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Annual Discount Rate Factors Table

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project Definition:	**10% (Conceptual)**
Base Year (Year 0):	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Discount Rate (Percent): 7.0

Year	Discount Factor[1,2]	Year	Discount Factor[1,2]
0	1.0000	26	0.1722
1	0.9346	27	0.1609
2	0.8734	28	0.1504
3	0.8163	29	0.1406
4	0.7629	30	0.1314
5	0.7130	31	0.1228
6	0.6663	32	0.1147
7	0.6227	33	0.1072
8	0.5820	34	0.1002
9	0.5439	35	0.0937
10	0.5083	36	0.0875
11	0.4751	37	0.0818
12	0.4440	38	0.0765
13	0.4150	39	0.0715
14	0.3878	40	0.0668
15	0.3624	41	0.0624
16	0.3387	42	0.0583
17	0.3166	43	0.0545
18	0.2959	44	0.0509
19	0.2765	45	0.0476
20	0.2584	46	0.0445
21	0.2415	47	0.0416
22	0.2257	48	0.0389
23	0.2109	49	0.0363
24	0.1971	50	0.0339
25	0.1842		

Notes:

[1] Annual discount factors were calculated using the formulas and guidance presented in Section 4.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

[2] The real discount rate of 7.0% was obtained from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000, Page 4-5 for non-Federal facilities.

USAID
Soil and Sedimentation Remeidation Landfill Disposal
Opinion of Probable Construction Cost, 10% Design, April 2010

Project name	Landfill Disp 4-22-2010
Estimator	Dodge
Labor rate table	2010-Vietnam rev1
Equipment rate table	00 092H R Equip Rate
Estimating Office:	Cambridge
CDM DB Version:	Database: 7.0
ENR 20 City CCI:	April 2010 : 8676
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: Quantities by engineer. Bid Items use metric quantities. Assembly costing is by foot pound measure. No rock excavation is required Dewatering Of Ponds - Using Bladder Dikes. Hazardous Soils Handled Per Specifications Based on a 40 hour work week with no overtime. MOPO (Maintenance of Plant Operation) is not included Exchange rate used, 18470 VND/USD. This job is sales tax exempt.
Report format	Sorted by 'Area/Bid Item/Assembly' 'Detail' summary Allocate addons

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
01.0			**Mobilization / Demobilize**							
	01		**Site Preparation**							
		01000-0301	**UXO Screening and Disposal**							
			UXO Screening and Disposal	41.00 ac	-	-	6,575.00	-	6,575.00 /ac	269,575
			UXO Screening and Disposal	**48,891.00 sm**			**5.51**		**5.51 /sm**	**269,575**
		01000-0301	**Decon Stations - 2 ea**							
			Precast Concrete Holding Tank - 5,000 ga (10' x 17' x 7')	2.00 ea	403.92	6,200.00	-	1,984.84	8,588.76 /ea	17,178
			Manhole Castings	2.00 ea	19.59	335.00	-		354.59 /ea	709
			HDPE Liner 40 mils	64,000.00 sf	-	-	0.38	-	0.38 /sf	24,320
			ASTM D448 #357 Stone (2.00- No. 4) - 64000 sf x 8" = 1,600 cy	2,240.00 tn	-	11.20	6.40	-	17.60 /tn	39,424
			PVC Schd. 40 Pipe, 12"	100.00 lf	1.41	30.86	-	-	32.27 /lf	3,227
			Polycast Trench Drain	80.00 lf	0.77	45.00	-	-	45.77 /lf	3,661
			Decon Stations - 2 ea	**1,152.00 sm**	**0.91**	**38.93**	**33.56**	**3.45**	**76.84 /sm**	**88,519**
		01000-0301	**Traffic Control - Haul Rd - 4.6 mi**							
			Temporary Traffic Signing - (4' x 4') x 10 sets x 4 ea	640.00 sf	-	-	18.00	-	18.00 /sf	11,520
			Self Propelled Pavement Broom 96" 85HP - 103 cd/22 = 5 mo	20.00 wk	244.80	-	-	986.00	1,230.80 /wk	24,616
			Traffic Control - Haul Rd - 4.6 mi	**7.40 km**	**661.62**		**1,556.76**	**2,664.87**	**4,883.24 /km**	**36,136**
		01000-0301	**Maintain Decon Stations**							
			On-Highway Water Truck 2500 Gallons	74.00 wk	244.80	-	-	1,537.20	1,782.00 /wk	131,868
			Maintain Decon Stations	**1.00 ls**	**18,115.20**			**113,752.80**	**131,868.00 /ls**	**131,868**
		01000-0301	**Sampling/H&S - During Excavation**							
			Sampling & H/S During Excavation	1.00 ls	-	-	250,000.00	-	250,000.00 /ls	250,000
			Sampling/H&S - During Excavation	**1.00 ls**			**250,000.00**		**250,000.00 /ls**	**250,000**
		02230-005	**Site Clearing - Treatment - Landfill - Decon Areas & Storage Areas**							
			Clear & Grub Heavy Trees, 5ac - 20ac	12.30 ac	293.76	-	-	1,173.12	1,466.88 /ac	18,043
			Site Clearing - Treatment - Landfill - Decon Areas & Storage Areas	**4.98 ha**	**725.55**			**2,897.47**	**3,623.02 /ha**	**18,043**
		02310-01-5	**Construct - Soil and Sediment Storage & Dewatering Areas**							
			Place Fill from Import- Dozer D6/CP323 Compactor	29,000.00 cy	0.20	-	-	2.10	2.30 /cy	66,735
			Import Common Earth	29,000.00 cy	-	7.00	4.10	-	11.10 /cy	322,016
			Fine Grade- Grader G12	25,100.00 sy	0.07	-	-	0.47	0.54 /sy	13,614
			ASTM D448 # 57 Stone (1.00- No. 4) - 89,000 sf @ 12"	3,300.00 cy	-	12.80	6.40	-	19.20 /cy	63,360
			HDPE Liner 40 mils	89,000.00 sf	-	-	0.38	-	0.38 /sf	33,820
			PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	4,200.00 lf	0.29	2.48	-	-	2.76 /lf	11,607
			PVC Schd. 40 Pipe, 12"	500.00 lf	1.41	30.86	-	-	32.27 /lf	16,134
			PVC Sch 40, Cross , 12"	14.00 ea	24.05	355.32	-	-	379.37 /ea	5,311
			Construct - Soil and Sediment Storage & Dewatering Areas	**22,172.00 cm**	**0.45**	**12.45**	**7.85**	**3.27**	**24.02 /cm**	**532,598**
			01 Site Preparation	**1.00 ls**	**37,681.37**	**320,887.68**	**743,707.00**	**224,462.20**	**1,326,738.25 /ls**	**1,326,738**
	04		**Site Restoration**							
		02310-01-3	**Replace Excavated Storage/Mixing & Loading Areas**							
			Cut/Fill- Dozer D6/CP323 Compactor	50,300.00 cy	0.31	-	-	3.15	3.45 /cy	173,627
			Haul Cut to Fill 18cy Rear Dump (2ea)	50,300.00 cy	0.41	-	-	4.95	5.36 /cy	269,440
			Articulated Wheel Loader Cat 966 220HP 4.75cy - Load From Soil & Sedimedt Areas	50,300.00 cy	0.10	-	-	1.19	1.29 /cy	64,853
			Import Gravel Fill	1,300.00 cy	-	9.10	5.60	-	14.70 /cy	19,110
			Replace Excavated Storage/Mixing & Loading Areas	**50,300.00 cy**	**0.82**	**0.24**	**0.15**	**9.28**	**10.48 /cy**	**527,031**
		02740-100-01	**Bituminous Paving 1.5" Overlay Of Haul Route - 30' wide**							

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
		02740-100-01	Bituminous Paving 1.5" Overlay Of Haul Route - 30' wide							
			Roadway Surface/Wearing Course	6,831.00 ton	0.74	60.00	15.00	5.79	81.54 /ton	556,962
			Roadway Tack Coat - 0.05 ga/sy	4,050.00 ga	-	4.00	2.57	-	6.57 /ga	26,601
			Bituminous Paving 1.5" Overlay Of Haul Route - 30' wide	80,960.00 sy	0.06	5.26	1.39	0.49	7.21 /sy	583,564
		02920-030	Loam and Seed Soil Abatement Areas							
			Spread Loam	10,175.93 cy		8.00	-		8.00 /cy	81,407
			Machine Rake	1,099,000.00 sf	-	-	0.04	-	0.04 /sf	43,960
			Hand Rake	1,099,000.00 sf	-	-	0.05	-	0.05 /sf	54,950
			Hydroseeding	1,099,000.00 sf	-	-	0.04	-	0.04 /sf	43,960
			Mulch - Hay	1,099,000.00 sf	-	-	0.01	-	0.01 /sf	10,990
			Loam and Seed Soil Abatement Areas	122,108.00 sy		0.67	1.26		1.93 /sy	235,267
			04 Site Restoration	1.00 ls	46,112.16	519,297.41	274,006.28	506,446.34	1,345,862.19 /ls	1,345,862
			01.0 Mobilization / Demobilize	**1.00 ls**	**83,793.53**	**840,185.09**	**1,017,713.28**	**730,908.54**	**2,672,600.44 /ls**	**2,672,600**
01.1			**Former Loading & Mixing Area/Pacer and Eastern Hot Spot**							
	02		Excavation							
		02310-01-2	Former Loading & Mixing Area/Pacer and Eastern Hot Spot							
			Cut to Stockpile- Dozer D-5	28,000.00 cy	0.12	-	-	1.20	1.32 /cy	36,904
			Fine Grade- Grader G12	63,475.00 sy	0.07	-	-	0.47	0.54 /sy	34,429
			Articulated Wheel Loader Cat 966 220HP 4.75cy	28,000.00 cy	0.07	-	-	0.79	0.86 /cy	24,068
			Haul To Stockpile Area	28,000.00 cy	0.20	-	-	2.47	2.68 /cy	74,993
			Former Loading & Mixing Area/Pacer and Eastern Hot Spot	28,000.00 cy	0.56			5.53	6.09 /cy	170,394
			02 Excavation	21,400.00 cm	0.73			7.23	7.96 /cm	170,394
			01.1 Former Loading & Mixing Area/Pacer and Eastern Hot Spot	**53,000.00 sm**	**0.30**			**2.92**	**3.22 /sm**	**170,394**
02.1			**Former Storage Area**							
	02		Excavation							
		02310-01-2	Former Storage Area							
			Cut to Stockpile- Dozer D-5	22,750.00 cy	0.12	-	-	1.20	1.32 /cy	29,985
			Fine Grade- Grader G12	58,657.00 sy	0.07	-	-	0.47	0.54 /sy	31,816
			Articulated Wheel Loader Cat 966 220HP 4.75cy	22,750.00 cy	0.07	-	-	0.79	0.86 /cy	19,555
			Haul To Stockpile Area	22,750.00 cy	0.20	-	-	2.47	2.68 /cy	60,932
			Former Storage Area	22,750.00 cy	0.58			5.67	6.25 /cy	142,287
			02 Excavation	17,400.00 cm	0.76			7.41	8.18 /cm	142,287
			02.1 Former Storage Area	**49,000.00 sm**	**0.27**			**2.63**	**2.90 /sm**	**142,287**
03.1			**Wetlands Areas: Sen Lake**							
	02		Excavation							
		01000-0301	F&I Two - 6' Aqua Dam Bladders							
			Furnish 6' Bladder	2,800.00 lf	-	-	77.25	-	77.25 /lf	216,300
			Install 6' Bladder	2,800.00 lf	0.98	-		6.08	7.06 /lf	19,754
			Tech Support To Install 6' Aqua Dam	2,800.00 lf	-	-	4.29	-	4.29 /lf	12,000
			Fill 6' Bladder @ 650 g/lf	1,820.00 mg	0.65	-		2.11	2.76 /mg	5,018
			F&I Two - 6' Aqua Dam Bladders	850.00 m	4.61		268.59	24.54	297.73 /m	253,071
		02310-01-2	Pond Excavation To Stockpile @ Shore							
			Cut to Stockpile- Dozer D6 - 3 ea	30,200.00 cy	0.37	-	-	5.68	6.05 /cy	182,613

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
		02310-01-2	Pond Excavation To Stockpile @ Shore							
			Load Excavation	30,200.00 cy	0.15	-	-	5.12	5.27 /cy	159,232
			Haul Spoil To Dewatering Area - Off HWY 35 cy Tks	30,200.00 cy	0.31	-	-	6.65	6.95 /cy	209,920
			Pond Excavation To Stockpile @ Shore	30,200.00 cy	0.83			17.44	18.27 /cy	551,765
			02 Excavation	23,089.00 cm	1.25		9.89	23.72	34.86 /cm	804,837
			03.1 Wetlands Areas: Sen Lake	**10.12 ha**	**2,852.82**		**22,559.29**	**54,117.21**	**79,529.32 /ha**	**804,837**
04.1			**Haul Route**							
	03		Load and Haul							
		02310-01-2	Dewatered Excavation - Load /Haul to Landfill							
			Load From Stockpile	80,500.00 cy	0.25	-	-	3.99	4.24 /cy	341,109
			Haul To Landfill - 18 cy Trucks - 2 hrs/cycle	80,500.00 cy	0.82	-	-	9.90	10.71 /cy	862,423
			Dewatered Excavation - Load /Haul to Landfill	80,500.00 cy	1.06			13.89	14.95 /cy	1,203,532
			03 Load and Haul	4.60 mi	18,564.70			243,072.67	261,637.36 /mi	1,203,532
			04.1 Haul Route	**7.40 km**	**11,540.22**			**151,099.22**	**162,639.44 /km**	**1,203,532**

Estimate Totals

Description	Amount	Totals	Hours		Rate	
Labor	227,047		37,505	hrs		
Material	840,185					
Subcontract	1,246,013					
Equipment	2,680,405		34,453	hrs		
Other						
	4,993,650	**4,993,650**				
Indirect Cost:						
Building Permits % total cost	24.972				0.40	%
Sales Tax (MEO)						
Builders Risk Ins % total cost	15.608				0.25	%
Gen Liability Ins % total cost	124.861				2.00	%
GC Bonds % total cost	62.430				1.00	%
-						
Subtotal Prior to OH&P	**227,871**	**5,221,521**				
GC Field General Conditions	499.365				10.00	%
GC Indirects. OH & Profit	522.152				10.00	%
-						
Subtotal	**1,021,517**	**6,243,038**				
Construction Contingency						
-						
Subtotal Cost, Today's Dollars		**6,243,038**				
Escalation to Mid Point of Construction. Based on 2%/year January 10 to January 11						
Total Construction Cost		**6,243,038**				

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

USAID
Soil Remediation Landfill - Active
Opinion of Probable Construction Cost, 10% Design, April 2010

Project name	Active Landfill 4-22-10
Estimator	Dodge
Labor rate table	2010-Vietnam rev1
Equipment rate table	00 092H R Equip Rate
Estimating Office:	Cambridge
CDM DB Version:	Database: 7.0
ENR 20 City CCI:	April 2010 : 8676

Notes

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM does not guarantee that this opinion will not vary from actual cost, or contractor's bids.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.

The total cost shown is valid to only two significant figures

Assumptions:

Item quantities by engineer.
No rock excavation is required
Only nominal dewatering is needed
No consideration for contaminated soils or hazardous materials (i.e. asbestos, lead)
Amunition area and UXO by others.
Based on a 40 hour work week with no overtime.
MOPO (Maintenance of Plant Operation) is not included
Labor rates are that of Vietnameese labor.
Exchange rate used, 0.00005414 USD/VND or 18,470 VND/USD.

This job is tax exempt.

Report format	Sorted by 'Area/Element/Bid Item/Assembly' 'Detail' summary Allocate addons

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
01				**Active Landfill**							
	01			**Landfill Construction**							
		01		**Soil Compaction Testing**							
			01000-0301	**Soil Compaction Testing**							
				Compaction Testing - (150,000 cy @ 250 cy)	600.00 ea	12.24	-		-	12.24 /ea	7,344
				Soil Compaction Testing	**600.00 ea**	**12.24**				**12.24 /ea**	**7,344**
				01 Soil Compaction Testing	**120,113.00 cy**	**0.06**				**0.06 /cy**	**7,344**
		02		**Clear & Grub**							
			02230-005	**Site Clearing**							
				Clear & Grub Light Trees, 1ac - 5ac	7.00 ac	68.00	-	-	514.22	582.22 /ac	4,076
				Site Clearing	**7.00 ac**	**68.00**			**514.22**	**582.22 /ac**	**4,076**
				02 Clear & Grub	**7.00 ac**	**68.00**			**514.22**	**582.22 /ac**	**4,076**
		03		**Demo Of Munitions Bunkers**							
			01000-0301	**Demo Of Munitions Bunkers**							
				Demo Munitions Bunkers	***1.00 ls***	***-***	***-***	***0.00***	***-***	***0.00 /ls***	***0***
		04		**UXO Screening & Disposal**							
			01000-0301	**UXO Screening and Disposal**							
				UXO Screening and Disposal	7.00 ac	-	-	6,575.00	-	6,575.00 /ac	46,025
				UXO Screening and Disposal	**7.00 ac**			**6,575.00**		**6,575.00 /ac**	**46,025**
				04 UXO Screening & Disposal	**1.00 ls**			**46,025.00**		**46,025.00 /ls**	**46,025**
		05		**Bring Above Flood Plane**							
			02310-01-5	**Fill From Borrow - 2m Above Flood Plane**							
				Place Fill from Import- Dozer D6/CP323 Compactor	70,700.00 cy	0.25	-	-	3.19	3.43 /cy	242,791
				Import Common Earth	70,700.00 cy	-	9.10	4.10	-	13.20 /cy	933,523
				Fill From Borrow - 2m Above Flood Plane	**70,700.00 cy**	**0.25**	**9.10**	**4.10**	**3.19**	**16.64 /cy**	**1,176,314**
				05 Bring Above Flood Plane	**70,700.00 cy**	**0.25**	**9.10**	**4.10**	**3.19**	**16.64 /cy**	**1,176,314**
		06		**Common Fill For Longitudinal Slope**							
			02310-01-5	**Fill For Longitudinal Slope**							
				Place Fill from Import- Dozer D6/CP323 Compactor	18,500.00 cy	0.33	-	-	4.25	4.58 /cy	84,708
				Import Sand Fill	18,500.00 cy	-	18.00	-	-	18.00 /cy	333,000
				Fill For Longitudinal Slope	**18,500.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**417,708**
				06 Common Fill For Longitudinal Slope	**18,500.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**417,708**
		07		**Saw Tooth With Common Fill**							

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-5	**Saw Tooth - Sand**							
				Place Fill from Import- Dozer D6/CP323 Compactor	8,800.00 cy	0.33	-	-	4.25	4.58 /cy	40,293
				Import Sand Fill	8,800.00 cy	-	18.00	-	-	18.00 /cy	158,400
				Saw Tooth - Sand	**8,800.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**198,693**
				07 Saw Tooth With Common Fill	**8,800.00 cy**	**0.33**	**18.00**		**4.25**	**22.58 /cy**	**198,693**
		08		**6" Processed Sand**							
			02310-01-5	**6" Processed Sand**							
				Place Fill from Import- Dozer D6/CP323 Compactor	5,400.00 cy	0.33	-	-	4.25	4.58 /cy	24,726
				Import Sand Fill	5,400.00 cy	-	18.00	5.60	-	23.60 /cy	127,440
				6" Processed Sand	**5,400.00 cy**	**0.33**	**18.00**	**5.60**	**4.25**	**28.18 /cy**	**152,166**
				08 6" Processed Sand	**5,400.00 cy**	**0.33**	**18.00**	**5.60**	**4.25**	**28.18 /cy**	**152,166**
		09		**Anchor Berm**							
			02310-01-3	**Anchor Berm (From On Site Fill)**							
				Cut/Fill- Dozer D6/CP323 Compactor	17,300.00 cy	0.39	-	-	5.10	5.50 /cy	95,056
				Anchor Berm (From On Site Fill)	**17,300.00 cy**	**0.39**			**5.10**	**5.50 /cy**	**95,056**
				09 Anchor Berm	**17,300.00 cy**	**0.39**			**5.10**	**5.50 /cy**	**95,056**
		10		**Excavate Anchor Trench**							
			02310-01-3	**Anchor Trench (Cut To Fill)**							
				Cut/Fill- Dozer D6/CP323 Compactor	860.00 cy	0.83	-	-	10.86	11.69 /cy	10,054
				Anchor Trench (Cut To Fill)	**860.00 cy**	**0.83**			**10.86**	**11.69 /cy**	**10,054**
				10 Excavate Anchor Trench	**2,100.00 lf**	**0.34**			**4.45**	**4.79 /lf**	**10,054**
		11		**Grade Subbase**							
			02310-01-3	**Grade Subbase**							
				Fine Grade- Grader G12	290,700.00 sf	0.01	-	-	0.07	0.08 /sf	24,362
				Grade Subbase	**290,700.00 sf**	**0.01**			**0.07**	**0.08 /sf**	**24,362**
				11 Grade Subbase	**32,300.00 sy**	**0.10**			**0.66**	**0.75 /sy**	**24,362**
		12		**Install GCL Liner**							
			01000-0301	**Install GCL Liner**							
				HDPE Liner 40 mils	290,700.00 sf	-	-	0.38	-	0.38 /sf	110,466
				Install GCL Liner	**290,700.00 sf**			**0.38**		**0.38 /sf**	**110,466**
				12 Install GCL Liner	**32,300.00 sy**			**3.42**		**3.42 /sy**	**110,466**
		13		**Install Secondary 60 Mil HDPE Liner**							
			01000-0301	**Install 60mil Secondary Liner**							
				HDPE Liner 60 mils	290,700.00 sf	-	-	0.51	-	0.51 /sf	148,257
				Install 60mil Secondary Liner	**290,700.00 sf**			**0.51**		**0.51 /sf**	**148,257**

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				13 Install Secondary 60 Mil HDPE Liner	32,300.00 sy			4.59		4.59 /sy	148,257
		14		Install Geocomposite (LDS)							
			01000-0301	Install Geocomposite (LDS)							
				Geocomposite- 250 mils	290,700.00 sf	-	0.11	0.32	-	0.43 /sf	125,001
				Install Geocomposite (LDS)	290,700.00 sf		0.11	0.32		0.43 /sf	125,001
				14 Install Geocomposite (LDS)	32,300.00 sy		0.99	2.88		3.87 /sy	125,001
		15		Install Primary 60 Mil HDPE Liner							
			01000-0301	Install Primary 60 mil HDPE Liner							
				HDPE Liner 60 mils	290,700.00 sf	-	-	0.51	-	0.51 /sf	148,257
				Install Primary 60 mil HDPE Liner	290,700.00 sf			0.51		0.51 /sf	148,257
				15 Install Primary 60 Mil HDPE Liner	32,300.00 sy			4.59		4.59 /sy	148,257
		16		Install Geocomposite (LCS)							
			01000-0301	Install Geocomposite (LCS)							
				Geocomposite- 250 mils	290,700.00 sf	-	0.11	0.32	-	0.43 /sf	125,001
				Install Geocomposite (LCS)	290,700.00 sf		0.11	0.32		0.43 /sf	125,001
				16 Install Geocomposite (LCS)	32,300.00 sy		0.99	2.88		3.87 /sy	125,001
		17		Protective Sand 2 '							
			02310-01-5	Protective Sand Layer (2')							
				Place Fill from Import- Dozer D6/CP323 Compactor	30,100.00 cy	0.33	-	-	4.25	4.58 /cy	137,822
				Import Sand Fill	30,100.00 cy	-	18.00	5.60	-	23.60 /cy	710,360
				Protective Sand Layer (2')	30,100.00 cy	0.33	18.00	5.60	4.25	28.18 /cy	848,182
				17 Protective Sand 2 '	30,100.00 cy	0.33	18.00	5.60	4.25	28.18 /cy	848,182
		18		6" HDPE Perforated (Lateral Collection)							
			01000-0301	6" HDPE Perforated (Lateral Collection)							
				HDPE Perforated, Sch 40, 6"dia	2,660.00 lf	0.29	2.48	-	-	2.76 /lf	7,351
				6" HDPE Perforated (Lateral Collection)	2,660.00 lf	0.29	2.48			2.76 /lf	7,351
				18 6" HDPE Perforated (Lateral Collection)	2,660.00 lf	0.29	2.48			2.76 /lf	7,351
		19		Install Gravel							
			02310-01-5	Install Gravel (Road)							
				Place Fill from Import- Dozer D6/CP323 Compactor	610.00 cy	0.17	-	-	2.18	2.35 /cy	1,435
				Import Gravel Fill	610.00 cy	-	9.10	5.60	-	14.70 /cy	8,967
				Install Gravel (Road)	610.00 cy	0.17	9.10	5.60	2.18	17.05 /cy	10,402

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				19 Install Gravel	610.00 cy	0.17	9.10	5.60	2.18	17.05 /cy	10,402
		20		Install Geotextile							
			01000-0301	Install Geotextile Wrap - Drain Pipe							
				Geotextile Fabric	38,300.00 sf	0.03	0.11	-	-	0.14 /sf	5,268
				Install Geotextile Wrap - Drain Pipe	38,300.00 sf	0.03	0.11			0.14 /sf	5,268
				20 Install Geotextile	38,300.00 sf	0.03	0.11			0.14 /sf	5,268
		21		8" HDPE LCS Manifold							
			01000-0301	Install 8" 8" LCS Manifold							
				Install 8" HDPE Pipe	328.00 lf	-	-	45.00	-	45.00 /lf	14,760
				Install 8" 8" LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
				21 8" HDPE LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
		22		8" HDPE LCS Manifold							
			01000-0301	8" HDPE LCS Manifold							
				Install 8" HDPE Pipe	328.00 lf	-	-	45.00	-	45.00 /lf	14,760
				8" HDPE LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
				22 8" HDPE LCS Manifold	328.00 lf			45.00		45.00 /lf	14,760
		23		8" HDPE Cleanouts							
			01000-0301	8" HDPE Cleanouts (140 ea @ ')							
				Install 8" HDPE Pipe	420.00 lf	-	-	45.00	-	45.00 /lf	18,900
				PE (B&S) Sewer Pipe Cap/Plug, 8"	140.00 ea	0.61	105.00	-	-	105.61 /ea	14,786
				PE (B&S) Drainage Pipe Wye, 8"	140.00 ea	3.06	24.00	-	-	27.06 /ea	3,788
				8" HDPE Cleanouts (140 ea @ ')	140.00 ea	3.67	129.00	135.00		267.67 /ea	37,474
				23 8" HDPE Cleanouts	420.00 lf	1.22	43.00	45.00		89.22 /lf	37,474
		24		LCS Pipe Penetration							
			01000-0301	LCS Pipe Penetration							
				Install Pipe penetrations	1.00 ea		-	5,000.00	-	5,000.00 /ea	5,000
				LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
				24 LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
		25		LCS Pipe Penetration							
			01000-0301	LCS Pipe Penetration							
				Install Pipe penetrations	1.00 ea		-	5,000.00	-	5,000.00 /ea	5,000
				LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
				25 LCS Pipe Penetration	1.00 ea			5,000.00		5,000.00 /ea	5,000
		26		LCS 10" HDPE From Sump To Manhole							
			15245-0210 9t	10" HDPE - LCS - Sump To MH							
				Plastic Pipe Equipment- Cat 325 Excavator	2.52 ch	6.12	-	-	130.18	136.30 /ch	343
				HDPE IPS, Butt-Fused Pipe, DR 9, 10"	70.00 lf	1.10	18.91	-	-	20.01 /lf	1,401

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			15245-0210 9t	**10" HDPE - LCS - Sump To MH**							
				Trenching- Backhoe/Loader 95HP Average Exc.	25.71 cy	0.41	-	-	4.12	4.53 /cy	116
				Trench Bedding-Backhoe/Loader C446 95HP	3.67 cy	1.23	-	-	5.00	6.22 /cy	23
				3/8 Stone Bedding/Zone/Engineered Fill Material	3.67 cy	-	30.94	-	-	30.94 /cy	114
				Trench Pipe Zone Backfill-Backhoe/Loader 95HP	12.05 cy	2.45	-	-	7.08	9.53 /cy	115
				3/8 Stone Bedding/Zone/Engineered Fill Material	12.05 cy	-	30.94	-	-	30.94 /cy	373
				Trench Native Backfill-Backhoe/Loader 95HP	8.57 cy	0.68	-	-	3.80	4.48 /cy	38
				10" HDPE - LCS - Sump To MH	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
				26 LCS 10" HDPE From Sump To Manhole	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
		27		**LDS 10" HDPE From Sump To Manhole**							
			15245-0210 9t	**10" HDPE - LDS - Sump To MH**							
				Plastic Pipe Equipment- Cat 325 Excavator	2.52 ch	6.12	-	-	130.18	136.30 /ch	343
				HDPE IPS, Butt-Fused Pipe, DR 9, 10"	70.00 lf	1.10	18.91	-	-	20.01 /lf	1,401
				Trenching- Backhoe/Loader 95HP Average Exc.	25.71 cy	0.41	-	-	4.12	4.53 /cy	116
				Trench Bedding-Backhoe/Loader C446 95HP	3.67 cy	1.23	-	-	5.00	6.22 /cy	23
				3/8 Stone Bedding/Zone/Engineered Fill Material	3.67 cy	-	30.94	-	-	30.94 /cy	114
				Trench Pipe Zone Backfill-Backhoe/Loader 95HP	12.05 cy	2.45	-	-	7.08	9.53 /cy	115
				3/8 Stone Bedding/Zone/Engineered Fill Material	12.05 cy	-	30.94	-	-	30.94 /cy	373
				Trench Native Backfill-Backhoe/Loader 95HP	8.57 cy	0.68	-	-	3.80	4.48 /cy	38
				10" HDPE - LDS - Sump To MH	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
				27 LDS 10" HDPE From Sump To Manhole	**70.00 lf**	**2.04**	**25.86**		**8.15**	**36.05 /lf**	**2,523**
		28		**Lechate Man Hole**							
			01000-0301	**Precast Concrete Leachate Manhole (10,000 ga)**							
				Septic Tanks 10,000 gal.	1.00 ea	244.80	8,750.00	-	1,041.44	10,036.24 /ea	10,036
				Manhole Castings	3.00 ea	24.48	335.00	-		359.48 /ea	1,078
				Precast Concrete Leachate Manhole (10,000 ga)	**1.00 ea**	**318.24**	**9,755.00**		**1,041.44**	**11,114.68 /ea**	**11,115**
				28 Lechate Man Hole	**1.00 ea**	**318.24**	**9,755.00**		**1,041.44**	**11,114.68 /ea**	**11,115**

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				01 Landfill Construction							3,753,137
	02			Landfill Operation							
		40		Spread & Compact Contaminated Soil							
			02310-01-5	Spread & Compact Contaminated Soils							
				Place Fill from Import- Dozer D6/CP323 Compactor	50,300.00 cy	0.41	-	-	3.74	4.15 /cy	208,671
				Spread & Compact Contaminated Soils	**50,300.00 cy**	**0.41**			**3.74**	**4.15 /cy**	**208,671**
				40 Spread & Compact Contaminated Soil	50,300.00 cy	0.41			3.74	4.15 /cy	208,671
		41		Spread & Compact Sediment							
			02310-01-5	Spread & Compact Sediment							
				Place Fill from Import- Dozer D6/CP323 Compactor	30,200.00 cy	0.41	-	-	3.74	4.15 /cy	125,286
				Spread & Compact Sediment	**30,200.00 cy**	**0.41**			**3.74**	**4.15 /cy**	**125,286**
				41 Spread & Compact Sediment	30,200.00 cy	0.41			3.74	4.15 /cy	125,286
		42		Spread & Compact LCM							
			02310-01-5	Spread & Compact LCM							
				Place Fill from Import- Dozer D6/CP323 Compactor	5,700.00 cy	0.82	-	-	7.48	8.30 /cy	47,293
				Import Sand Fill	5,700.00 cy	-	18.00	5.60	-	23.60 /cy	134,520
				Spread & Compact LCM	**5,700.00 cy**	**0.82**	**18.00**	**5.60**	**7.48**	**31.90 /cy**	**181,813**
				42 Spread & Compact LCM	5,700.00 cy	0.82	18.00	5.60	7.48	31.90 /cy	181,813
		43		Spread & Compact Bulking Material							
			02310-01-5	Spread & Compact Bulking Material							
				Place Fill from Import- Dozer D6/CP323 Compactor	17,500.00 cy	0.82	-	-	7.48	8.30 /cy	145,199
				Import Sand Fill	17,500.00 cy	-	18.00	5.60	-	23.60 /cy	413,000
				Spread & Compact Bulking Material	**17,500.00 cy**	**0.82**	**18.00**	**5.60**	**7.48**	**31.90 /cy**	**558,199**
				43 Spread & Compact Bulking Material	17,500.00 cy	0.82	18.00	5.60	7.48	31.90 /cy	558,199
		44		Bioremediation Distribution System Installed							
			01000-0301	Bioremediation System Distribution System							
				Boiremediation Distribution System	1.00 ls	-	-	650,000.00	-	650,000.00 /ls	650,000
				Bioremediation System Distribution System	**1.00 ls**			**650,000.00**		**650,000.00 /ls**	**650,000**

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				44 Bioremediation Distribution System Installed	1.00 ls			650,000.00		650,000.00 /ls	650,000
		45		Leachate Treatment							
			01000-0301	Leachate Treatment							
				Leachate Treatment	1.00 ls	-	-	75,000.00	-	75,000.00 /ls	75,000
				Leachate Treatment	**1.00 ls**			**75,000.00**		**75,000.00 /ls**	**75,000**
				45 Leachate Treatment	1.00 ls			75,000.00		75,000.00 /ls	75,000
		46		Monitoring Well Network							
			01000-0301	Monitoring Well Network							
				Shallow Well - (6 shallow and 6 deep)	6.00 ea	-	-	94.00	-	94.00 /ea	564
				Deep Well -	6.00 ea	-	-	376.00	-	376.00 /ea	2,256
				Monitoring Well Network	**1.00 ls**			**2,820.00**		**2,820.00 /ls**	**2,820**
				46 Monitoring Well Network	1.00 ls			2,820.00		2,820.00 /ls	2,820
				02 Landfill Operation							1,801,789
	03			Landfill Closure							
		30		Intermediate Cover 12"							
			02310-01-5	12" Intermediate Cover							
				Place Fill from Import- Dozer D6/CP323 Compactor	10,800.00 cy	0.41	-	-	3.74	4.15 /cy	44,804
				Import Sand Fill	10,800.00 cy	-	18.00	5.60	-	23.60 /cy	254,880
				12" Intermediate Cover	**10,800.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**299,684**
				30 Intermediate Cover 12"	10,800.00 cy	0.41	18.00	5.60	3.74	27.75 /cy	299,684
		31		Install GCL Liner							
			01000-0301	Install GLC Liner							
				HDPE Liner 40 mils	290,700.00 sf	-	-	0.38	-	0.38 /sf	110,466
				Install GLC Liner	**290,700.00 sf**			**0.38**		**0.38 /sf**	**110,466**
				31 Install GCL Liner	32,300.00 sy			3.42		3.42 /sy	110,466
		32		Install 40 Mil LLDPE Liner							
			01000-0301	40 mil LLDPE Liner							
				HDPE Liner 40 mils	290,700.00 sf	-	-	0.38	-	0.38 /sf	110,466
				40 mil LLDPE Liner	**290,700.00 sf**			**0.38**		**0.38 /sf**	**110,466**
				32 Install 40 Mil LLDPE Liner	32,300.00 sy			3.42		3.42 /sy	110,466
		33		Install Geocomposite							
			01000-0301	Install Geocomposite							
				Geocomposite- 250 mils	290,700.00 sf	-	0.10	0.32	-	0.42 /sf	122,094
				Install Geocomposite	**290,700.00 sf**		**0.10**	**0.32**		**0.42 /sf**	**122,094**
				33 Install Geocomposite	32,300.00 sy		0.90	2.88		3.78 /sy	122,094
		34		Protective Sand							

Area	Element	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-5	**Protective Sand - 2'**							
				Place Fill from Import- Dozer D6/CP323 Compactor	21,500.00 cy	0.41	-	-	3.74	4.15 /cy	89,193
				Import Sand Fill	21,500.00 cy	-	18.00	5.60	-	23.60 /cy	507,400
				Protective Sand - 2'	**21,500.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**596,593**
				34 Protective Sand	**21,500.00 cy**	**0.41**	**18.00**	**5.60**	**3.74**	**27.75 /cy**	**596,593**
		35		**Sodding**							
			01000-0301	**Sodding**							
				Sod In Place	290,700.00 sf	-	-	0.50	-	0.50 /sf	145,350
				Sodding	**290,700.00 sf**			**0.50**		**0.50 /sf**	**145,350**
				35 Sodding	**32,300.00 sy**			**4.50**		**4.50 /sy**	**145,350**
				03 Landfill Closure							**1,384,654**
				01 Active Landfill							**6,939,579**

Estimate Totals

Description	Amount	Totals	Hours		Rate	
Labor	124,392		20,333	hrs		
Material	2,913,463					
Subcontract	2,687,768					
Equipment	1,213,957		12,069	hrs		
Other						
	6,939,580	**6,939,580**				
Indirect Cost:						
Building Permits % total cost	34.229				0.40	%
Sales Tax (MEO)						
Builders Risk Ins % total cost	21.393				0.25	%
Gen Liability Ins % total cost	171.145				2.00	%
GC Bonds % total cost	85.573				1.00	%
-						
Subtotal Prior to OH&P	**312,340**	**7,251,920**				
GC Field General Conditions	725.192				10.00	%
GC Indirects. OH & Profit	580.154				8.00	%
-						
Subtotal	**1,305,346**	**8,557,266**				
Construction Contingency						
-						
Subtotal Cost, Today's Dollars		**8,557,266**				
Escalation to Mid Point of Construction. Based on 2%/year December 09 to December 10						
Total Construction Cost		**8,557,266**				

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.

Estimate Totals

There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Project Alternative 4

Thermal (ISTD / IPTD)

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: In this alternative, contaminated soil from the MLA and the SA, as well as contaminated sediments from the drainage ditch and Sen Lake, would be excavated, stockpiled, and thermally treated to below regulatory limits. Figure 2 outlines the general location of each of the major components of the ISTD/IPTD thermal alternative. It is expected that the ISTD/IPTD alternative will also be implemented over a 2-year period.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Thermal Alternative	1	LS	$16,789,205	$16,789,205	Includes permitting, mobilization/demobilization of system from overseas, system construction and installation, power, commissioning, operation, monitoring, effluent/GAC treatment.
SUBTOTAL				$16,789,205	
Contingency (Scope and Bid)	0%			$0	20% scope and bid contingency included in treatment subcontractor estimate.
SUBTOTAL				$16,789,205	
Project Management	5%			$839,460	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	6%			$1,007,352	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$1,007,352	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$2,518,381	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$22,161,750	
TOTAL with VAT (assumed 10%)	10%			$24,377,925	
TOTAL CAPITAL COST				**$24,378,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$24,378,000	**$12,189,000**	Annual capital cost over the assumed duration.

CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Years 1 and 2)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
ISTD/IPTD Alternative	1	LS	$4,760,183	$4,760,183	Includes site clearing/preparation, excavation, decontamination, dewatering, hauling, backfilling, permanent stockpiling of treated soil/sediment, site restoration, and UXO screening and clearing of excavation areas.
SUBTOTAL				$4,760,183	
Contingency (Scope and Bid)	25%			$1,190,046	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$5,950,229	
Project Management	5%			$297,511	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	8%			$476,018	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	6%			$357,014	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$892,534	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$7,973,306	
TOTAL with VAT (assumed 10%)	10%			$8,770,637	
TOTAL CAPITAL COST				**$8,771,000**	Total capital cost is rounded to the nearest $1,000.
CAPITAL COST PER YEAR (YEARS 1 THROUGH 2)	2	YR	$8,771,000	**$4,385,500**	Annual capital cost over the assumed duration.

Project Alternative **4**

Thermal (ISTD / IPTD)

COST ESTIMATE SUMMARY
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Client:	USAID Vietnam
Site:	Da Nang Airport
Location:	Da Nang, Vietnam
Phase:	Environmental Assessment of Project Alternatives
Level of Project Definition:	10% (Conceptual)
Base Year (Year 0):	2nd Quarter, Fiscal Year 2010 (FY10)
Date:	February 8, 2010

Description: In this alternative, contaminated soil from the MLA and the SA, as well as contaminated sediments from the drainage ditch and Sen Lake, would be excavated, stockpiled, and thermally treated to below regulatory limits. Figure 2 outlines the general location of each of the major components of the ISTD/IPTD thermal alternative. It is expected that the ISTD/IPTD alternative will also be implemented over a 2-year period.

ANNUAL OPERATIONS AND MAINTENANCE (O&M) COSTS-MONITORING (Years 1 through 3)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Environmental Mitigation and Monitoring Plan (EMMP) Implementation	1	LS	$107,747	$107,747	Includes sampling and analysis required by the EMMP; assume 0.5% of treatment and disposal direct capital costs.
SUBTOTAL				$107,747	
Contingency (Scope and Bid)	25%			$26,937	15% Scope, 10% Bid (Low end of recommended range in EPA 540-R-00-002).
SUBTOTAL				$134,684	
Project Management	8%			$10,775	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Construction Management	10%			$13,468	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Technical Support	15%			$20,203	Middle value of the recommended range in EPA 540-R-00-002 was used.
TOTAL				$179,130	
TOTAL with VAT (assumed 10%)	10%			$197,043	
TOTAL ANNUAL O&M COST				**$197,000**	Total O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST (YEARS 1 THROUGH 3)	3	YR	$197,000	**$591,000**	Annual O&M Cost over the assumed duration.

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each
GAC	Granular Activated Carbon
LS	Lump Sum
NA	Not Applicable
O&M	Operations and Maintenance
QTY	Quantity
UXO	Unexploded Ordinance

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Project Alternative **4**
Thermal (ISTD / IPTD)

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project Definition:	**10% (Conceptual)**
Base Year (Year	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Year[1]	Capital Costs (Thermal Alternative)[2]	Capital Costs (ISTD/IPTD Alternative)[2]	Annual O&M Costs (Monitoring)[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	1.0000	$0
1	$12,189,000	$4,385,500	$197,000	$16,771,500	0.9346	$15,674,644
2	$12,189,000	$4,385,500	$197,000	$16,771,500	0.8734	$14,648,228
3	$0	$0	$197,000	$197,000	0.8163	$160,811
4	$0	$0	$0	$0	0.7629	$0
5	$0	$0	$0	$0	0.7130	$0
6	$0	$0	$0	$0	0.6663	$0
7	$0	$0	$0	$0	0.6227	$0
8	$0	$0	$0	$0	0.5820	$0
9	$0	$0	$0	$0	0.5439	$0
10	$0	$0	$0	$0	0.5083	$0
11	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	0.0339	$0
TOTALS:	$24,378,000	$8,771,000	$591,000	**$33,740,000**		$30,483,683
TOTAL PRESENT VALUE OF ALTERNATIVE 4[5]						**$30,484,000**

Notes:

[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.

[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on Table CS-4.

[3] Total annual expenditure is the total cost per year with no discounting.

[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.

[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

PRESENT VALUE ANALYSIS
ENVIRONMENTAL ASSESSMENT OF PROJECT ALTERNATIVES

Annual Discount Rate Factors Table

Client:	**USAID Vietnam**
Site:	**Da Nang Airport**
Location:	**Da Nang, Vietnam**
Phase:	**Environmental Assessment of Project Alternatives**
Level of Project Definition:	**10% (Conceptual)**
Base Year (Year 0):	**2nd Quarter, Fiscal Year 2010 (FY10)**
Date:	**February 8, 2010**

Discount Rate (Percent): 7.0

Year	Discount Factor[1,2]	Year	Discount Factor[1,2]
0	1.0000	26	0.1722
1	0.9346	27	0.1609
2	0.8734	28	0.1504
3	0.8163	29	0.1406
4	0.7629	30	0.1314
5	0.7130	31	0.1228
6	0.6663	32	0.1147
7	0.6227	33	0.1072
8	0.5820	34	0.1002
9	0.5439	35	0.0937
10	0.5083	36	0.0875
11	0.4751	37	0.0818
12	0.4440	38	0.0765
13	0.4150	39	0.0715
14	0.3878	40	0.0668
15	0.3624	41	0.0624
16	0.3387	42	0.0583
17	0.3166	43	0.0545
18	0.2959	44	0.0509
19	0.2765	45	0.0476
20	0.2584	46	0.0445
21	0.2415	47	0.0416
22	0.2257	48	0.0389
23	0.2109	49	0.0363
24	0.1971	50	0.0339
25	0.1842		

Notes:

[1] Annual discount factors were calculated using the formulas and guidance presented in Section 4.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

[2] The real discount rate of 7.0% was obtained from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000, Page 4-5 for non-Federal facilities.

USAID
Soil and Sedimentation Remeidation ISTD/IPTD Thermal Disposal
Opinion of Probable Construction Cost, 10% Design, April 2010

Project name	ISTD/IPTD QTYS 4-22-10
Estimator	Dodge
Labor rate table	2010-Vietnam rev1
Equipment rate table	00 092H R Equip Rate
Estimating Office:	Cambridge
CDM DB Version:	Database: 7.0
ENR 20 City CCI:	April 2010 : 8676
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: Quantities by engineer. Bid Items use metric quantities. Assembly costing is by foot pound measure. No rock excavation is required Dewatering Of Ponds - Using Bladder Dikes. Hazardous Soils Handled Per Specifications Based on a 40 hour work week with no overtime. MOPO (Maintenance of Plant Operation) is not included Exchange rate used, 18,470 VND/USD. This job is sales tax exempt.
Report format	Sorted by 'Area/Bid Item/Assembly' 'Detail' summary Allocate addons

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
01.0			**Mobilization / Demobilize**							
	01		**Site Preparation**							
		01000-0301	**UXO Screening and Disposal**							
			UXO Screening and Disposal	45.00 ac	-	-	6,575.00	-	6,575.00 /ac	295,875
			UXO Screening and Disposal	**48,891.00 sm**			**6.05**		**6.05 /sm**	**295,875**
		01000-0301	**Decon Stations - 1 ea**							
			Precast Concrete Holding Tank - 5,000 ga (10' x 17' x 7')	1.00 ea	403.92	6,200.00	-	1,984.84	8,588.76 /ea	8,589
			Manhole Castings	1.00 ea	19.58	335.00	-		354.58 /ea	355
			HDPE Liner 40 mils	32,000.00 sf	-	-	0.38	-	0.38 /sf	12,160
			ASTM D448 #357 Stone (2.00- No. 4) - 64000 sf x 8" = 1,600 cy	1,120.00 tn	-	11.20	6.40	-	17.60 /tn	19,712
			PVC Schd. 40 Pipe, 12"	50.00 lf	1.41	30.86	-	-	32.27 /lf	1,613
			Polycast Trench Drain	40.00 lf	0.77	45.00	-	-	45.77 /lf	1,831
			Decon Stations - 1 ea	**2,974.00 sm**	**0.18**	**7.54**	**6.50**	**0.67**	**14.88 /sm**	**44,259**
		01000-0301	**Maintain Decon Stations**							
			On-Highway Water Truck 2500 Gallons	26.00 wk	244.80	-	-	1,537.20	1,782.00 /wk	46,332
			Maintain Decon Stations	**1.00 ls**	**6,364.80**			**39,967.20**	**46,332.00 /ls**	**46,332**
		01000-0301	**Sampling / H&S During Excavation**							
			Sampling/H&S During Excavation	1.00 ls	-	-	250,000.00	-	250,000.00 /ls	250,000
			Sampling / H&S During Excavation	**1.00 ls**			**250,000.00**		**250,000.00 /ls**	**250,000**
		02230-005	**Site Clearing - Treatment - Decon Areas & Storage Areas**							
			Clear & Grub Heavy Trees, 5ac - 20ac	12.30 ac	293.76	-	-	1,173.12	1,466.88 /ac	18,043
			Site Clearing - Treatment - Decon Areas & Storage Areas	**4.98 ha**	**725.55**			**2,897.47**	**3,623.02 /ha**	**18,043**
		02310-01-5	**Construct - Soil and Sediment Storege & Dewatering Areas**							
			Place Fill from Import- Dozer D6/CP323 Compactor	29,000.00 cy	0.20	-	-	2.10	2.30 /cy	66,735
			Import Common Earth	29,000.00 cy	-	7.00	4.10	-	11.10 /cy	322,016
			Fine Grade- Grader G12	25,100.00 sy	0.07	-	-	0.47	0.54 /sy	13,614
			ASTM D448 # 57 Stone (1.00- No. 4) - 89,000 sf @ 12"	3,300.00 cy	-	12.80	6.40	-	19.20 /cy	63,360
			HDPE Liner 40 mils	89,000.00 sf	-	-	0.38	-	0.38 /sf	33,820
			PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	4,200.00 lf	0.29	2.48	-	-	2.76 /lf	11,607
			PVC Schd. 40 Pipe, 12"	500.00 lf	1.41	30.86	-	-	32.27 /lf	16,134
			PVC Sch 40, Cross , 12"	14.00 ea	24.05	355.32	-	-	379.37 /ea	5,311
			Construct - Soil and Sediment Storege & Dewatering Areas	**22,000.00 cm**	**0.46**	**12.55**	**7.91**	**3.30**	**24.21 /cm**	**532,598**
			01 Site Preparation	**1.00 ls**	**20,510.48**	**298,465.68**	**739,159.00**	**128,971.76**	**1,187,106.92 /ls**	**1,187,107**
	04		**Site Restoration**							
		02310-01-3	**Replace Excavated Storage/Mixing & Loading Areas**							
			Cut/Fill- Dozer D6/CP323 Compactor	50,300.00 cy	0.31	-	-	3.15	3.45 /cy	173,627
			Haul Cut to Fill 18cy Rear Dump (2ea)	50,300.00 cy	0.41	-	-	4.95	5.36 /cy	269,440
			Articulated Wheel Loader Cat 966 220HP 4.75cy - Load From Soil & Sedimedt Areas	47,800.00 cy	0.10	-	-	1.19	1.29 /cy	61,630
			Replace Excavated Storage/Mixing & Loading Areas	**50,300.00 cy**	**0.81**			**9.22**	**10.03 /cy**	**504,698**
		02920-030	**Loam and Seed Soil Abatement Areas**							
			Spread Loam	10,175.93 cy		8.00	-		8.00 /cy	81,407
			Machine Rake	1,099,000.00 sf	-	-	0.04	-	0.04 /sf	43,960
			Hand Rake	1,099,000.00 sf	-	-	0.05	-	0.05 /sf	54,950
			Hydroseeding	1,099,000.00 sf	-	-	0.04	-	0.04 /sf	43,960
			Mulch - Hay	1,099,000.00 sf	-	-	0.01	-	0.01 /sf	10,990
			Loam and Seed Soil Abatement Areas	**122,108.00 sy**		**0.67**	**1.26**		**1.93 /sy**	**235,267**
			04 Site Restoration	**1.00 ls**	**40,789.80**	**81,407.41**	**153,860.00**	**463,907.88**	**739,965.09 /ls**	**739,965**

Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			01.0 Mobilization / Demobilize	**1.00 ls**	**61,300.28**	**379,873.09**	**893,019.00**	**592,879.64**	**1,927,072.01 /ls**	**1,927,072**
01.1			**Former Loading / Mixing & Storage /Pacer Ivy /Eastern Hot Spot Areas**							
	02		**Excavation**							
		02310-01-2	**Former Loading & Mixing Area/Pacer Ivy/Eastern Hot Spot**							
			Cut to Stockpile- Dozer D-5	50,300.00 cy	0.12	-	-	1.20	1.32 /cy	66,295
			Fine Grade- Grader G12	50,300.00 cy	0.07	-	-	0.47	0.54 /cy	27,283
			Articulated Wheel Loader Cat 966 220HP 4.75cy	50,300.00 cy	0.07	-	-	0.79	0.86 /cy	43,236
			Haul To Stockpile Area	50,300.00 cy	0.20	-	-	2.47	2.68 /cy	134,720
			Former Loading & Mixing Area/Pacer Ivy/Eastern Hot Spot	**50,300.00 cy**	**0.47**			**4.93**	**5.40 /cy**	**271,534**
			02 Excavation	**50,300.00 cm**	**0.47**			**4.93**	**5.40 /cm**	**271,534**
			01.1 Former Loading / Mixing & Storage /Pacer Ivy /Eastern Hot Spot Areas	**38,457.00 cm**	**0.61**			**6.45**	**7.06 /cm**	**271,534**
03.1			**Wetlands Areas: Sen Lake - B - C**							
	02		**Excavation**							
		01000-0301	**F&I Two - 6' Aqua Dam Bladders**							
			Furnish 6' Bladder	2,800.00 lf	-	-	77.25	-	77.25 /lf	216,300
			Install 6' Bladder	2,800.00 lf	0.98	-		6.08	7.06 /lf	19,754
			Tech Support To Install 6' Aqua Dam	2,800.00 lf	-	-	4.29	-	4.29 /lf	12,000
			Fill 6' Bladder @ 650 g/lf	1,820.00 mg	0.65	-		2.11	2.76 /mg	5,018
			F&I Two - 6' Aqua Dam Bladders	**850.00 m**	**4.61**		**268.59**	**24.54**	**297.73 /m**	**253,071**
		02310-01-2	**Pond Excavation To Stockpile @ Shore**							
			Cut to Stockpile- Dozer D6 - 3 ea	30,200.00 cy	0.37	-	-	5.68	6.05 /cy	182,613
			Load Excavation	30,200.00 cy	0.15	-	-	5.12	5.27 /cy	159,232
			Haul Spoil To Dewatering Area - Off HWY 35 cy Tks	30,200.00 cy	0.31	-	-	6.65	6.95 /cy	209,920
			Pond Excavation To Stockpile @ Shore	**30,200.00 cy**	**0.83**			**17.44**	**18.27 /cy**	**551,765**
			02 Excavation	**23,089.00 cm**	**1.25**		**9.89**	**23.72**	**34.86 /cm**	**804,837**
			03.1 Wetlands Areas: Sen Lake - B - C	**10.12 ha**	**2,852.82**		**22,559.29**	**54,117.21**	**79,529.32 /ha**	**804,837**
04.1			**Haul Route/Place**							
	03		**Load and Haul / Place - ISTD/IPTD Alternative**							
		02310-01-2	**Dewatered Excavation - Load /Haul to Permanent Stockpile**							
			Load From Stockpile	80,500.00 cy	0.16	-	-	2.66	2.83 /cy	227,406
			Haul To Permanent Stockpile - 18 cy Trucks - 1/2 hr per cycle	80,500.00 cy	0.20	-	-	2.47	2.68 /cy	215,606
			Dewatered Excavation - Load /Haul to Permanent Stockpile	**61,547.00 cm**	**0.48**			**6.72**	**7.20 /cm**	**443,012**
		02310-01-5	**Site Fill**							
			Place Fill from Import- Dozer D6/CP323 Compactor	80,500.00 cy	0.33	-	-	3.36	3.68 /cy	296,397
			Fine Grade- Grader G12	536,782.00 sf	0.02	-	-	0.10	0.12 /sf	64,700
			Site Fill	**61,547.00 cm**	**0.57**			**5.30**	**5.87 /cm**	**361,098**
			03 Load and Haul / Place - ISTD/IPTD Alternative	**1.00 mi**	**64,597.23**			**739,511.85**	**804,109.08 /mi**	**804,109**
			04.1 Haul Route/Place	**1.60 km**	**40,373.27**			**462,194.91**	**502,568.17 /km**	**804,109**

Estimate Totals

Description	Amount	Totals	Hours		Rate	
Labor	178,300		29,540	hrs		
Material	379,873					
Subcontract	1,121,319					
Equipment	2,128,059		27,246	hrs		
Other						
	3,807,551	**3,807,551**				
Indirect Cost:						
Building Permits % total cost	19,041				0.40	%
Sales Tax (MEO)						
Builders Risk Ins % total cost	11,900				0.25	%
Gen Liability Ins % total cost	95,204				2.00	%
GC Bonds % total cost	47,602				1.00	%
-						
Subtotal Prior to OH&P	**173,747**	**3,981,298**				
GC Field General Conditions	380,755				10.00	%
GC Indirects. OH & Profit	398,130				10.00	%
-						
Subtotal	**778,885**	**4,760,183**				
Construction Contingency						
-						
Subtotal Cost, Today's Dollars		**4,760,183**				
Escalation to Mid Point of Construction. Based on 2%/year January 10 to January 11						
Total Construction Cost		**4,760,183**				

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
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The total cost shown is valid to only two significant figures.

USAID
Da Nang Air Base - Soil/Sediment Remediation - Thermal Alternative
Opinion of Probable Construction Cost, 10% Design, April 2010

Project name	Thermal ALT 4-9-10
Estimator	Dodge
Labor rate table	2010-Vietnam rev1
Equipment rate table	00 092H R Equip Rate
Estimating Office:	Cambridge
CDM DB Version:	Database: 7.0
ENR 20 City CCI:	April 2010 : 8676

Notes

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The total cost shown is valid to only two significant figures

Assumptions:

Quantities by engineer.
No rock excavation is required
Only nominal dewatering is needed
No consideration for contaminated soils or hazardous materials (i.e. asbestos, lead)
Based on a 40 hour work week with no overtime.
MOPO (Maintenance of Plant Operation) is not included
Vietnameese labor rates baised upon exchange rate of
VND = 0.00005414 USD or 18,470 VND/USD.

This job is tax exempt.

Report format	Sorted by 'System/Area/Bid Item/Assembly' 'Detail' summary Allocate addons Paginate

System	Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
01				ISTD/IPTD (Thermal) Alternative						
	01			Design and Installation						
		010		Design and Permitting						
			01000-0301	Design and Permitting						
				Design and Permitting	1.00 ls	-	367,000.00	-	367,000.00 /ls	367,000
				Design and Permitting	**1.00 ls**		**367,000.00**		**367,000.00 /ls**	**367,000**
				010 Design and Permitting	1.00 ls		367,000.00		367,000.00 /ls	367,000
		011		Procurement and Mobilization						
			01000-0301	Procurement and Mobilization						
				Procurement and Mobilization	1.00 ls	-	935,000.00	-	935,000.00 /ls	935,000
				Procurement and Mobilization	**1.00 ls**		**935,000.00**		**935,000.00 /ls**	**935,000**
				011 Procurement and Mobilization	1.00 ls		935,000.00		935,000.00 /ls	935,000
		012		Power Drop and Transformer						
			01000-0301	Power Drop and Transformer						
				Power Drop and Transformer	1.00 ls	-	246,000.00	-	246,000.00 /ls	246,000
				Power Drop and Transformer	**1.00 ls**		**246,000.00**		**246,000.00 /ls**	**246,000**
				012 Power Drop and Transformer	1.00 ls		246,000.00		246,000.00 /ls	246,000
		017		Drill and Install Wells - Two Basins						
			02520-100-000	Drill and Install Wells - Two Basins 55,744 sf /ea						
				Survey & Stake Well Locations	1,486.00 ea	4.27	-	-	4.27 /ea	6,338
				Mobilize/Demobilize Drilling Crew	2.00 ea	-	50,000.00	-	50,000.00 /ea	100,000
				Drill/Develop Install Heater Boring /Vapor Extraction / Air Inlet - Wells	1,486.00 ea	171.37	500.00	879.68	1,551.05 /ea	2,304,863
				Drill and Install Wells - Two Basins 55,744 sf /ea	**1,486.00 ea**	**175.64**	**567.30**	**879.68**	**1,622.61 /ea**	**2,411,201**
				017 Drill and Install Wells - Two Basins	1,486.00 ea	175.64	567.30	879.68	1,622.61 /ea	2,411,201
		018		Vapor Cover Installation						
			01000-0301	Vapor Cover Installation						
				Vapor Cover Installation	2.00 ea	-	482,000.00	-	482,000.00 /ea	964,000
				Vapor Cover Installation	**2.00 ea**		**482,000.00**		**482,000.00 /ea**	**964,000**
				018 Vapor Cover Installation	2.00 ea		482,000.00		482,000.00 /ea	964,000
		019		Electrical Consumption						
			01000-0301	Electrical Work						
				Electrical	1.00 ls	-	838,500.00	-	838,500.00 /ls	838,500

System	Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				Electrical Work	**1.00 ls**		**838,500.00**		**838,500.00 /ls**	**838,500**
				019 Electrical Consumption	**1.00 ls**		**838,500.00**		**838,500.00 /ls**	**838,500**
		020		**Mechanical Construction**						
			01000-0301	**Mecanical Construction**						
				Mechanical	1.00 ls	-	913,000.00	-	913,000.00 /ls	913,000
				Mecanical Construction	**1.00 ls**		**913,000.00**		**913,000.00 /ls**	**913,000**
				020 Mechanical Construction	**1.00 ls**		**913,000.00**		**913,000.00 /ls**	**913,000**
		021		**ISTD Power Equipment**						
			01000-0301	**ISTD Power Equipment**						
				Power Equipment	1.00 ls	-	695,000.00	-	695,000.00 /ls	695,000
				ISTD Power Equipment	**1.00 ls**		**695,000.00**		**695,000.00 /ls**	**695,000**
				021 ISTD Power Equipment	**1.00 ls**		**695,000.00**		**695,000.00 /ls**	**695,000**
		022		**Effulent Treatment System**						
			01000-0301	**Effulent Treatment System**						
				Effulent Treatment System	1.00 ls	-	995,000.00	-	995,000.00 /ls	995,000
				Effulent Treatment System	**1.00 ls**		**995,000.00**		**995,000.00 /ls**	**995,000**
				022 Effulent Treatment System	**1.00 ls**		**995,000.00**		**995,000.00 /ls**	**995,000**
		023		**Commissioning**						
			01000-0301	**Commissioning**						
				Commissioning	1.00 ls	-	653,000.00	-	653,000.00 /ls	653,000
				Commissioning	**1.00 ls**		**653,000.00**		**653,000.00 /ls**	**653,000**
				023 Commissioning	**1.00 ls**		**653,000.00**		**653,000.00 /ls**	**653,000**
				01 Design and Installation	**1.00 ls**	**260,996.30**	**7,449,500.00**	**1,307,204.48**	**9,017,700.78 /ls**	**9,017,701**
	02			**Operation**						
		125		**Maintence and Hardware**						
			01000-0301	**Maintence and Hardware**						
				Maintance and Hardware	1.00 ls	-	582,000.00	-	582,000.00 /ls	582,000
				Maintence and Hardware	**1.00 ls**		**582,000.00**		**582,000.00 /ls**	**582,000**
				125 Maintence and Hardware	**1.00 ls**		**582,000.00**		**582,000.00 /ls**	**582,000**
		126		**Labor Travel Per Diem**						
			01000-0301	**Labor, Travel, Per Diem**						
				Labor/Travel, per Diem	1.00 ls	-	694,000.00	-	694,000.00 /ls	694,000
				Labor, Travel, Per Diem	**1.00 ls**		**694,000.00**		**694,000.00 /ls**	**694,000**
				126 Labor Travel Per Diem	**1.00 ls**		**694,000.00**		**694,000.00 /ls**	**694,000**
		127		**Process Monitoring, Sampling & Analysis**						
			01000-0301	**Process, Monitoring, Sampling & Analysis**						

System	Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			01000-0301	**Process, Monitoring, Sampling & Analysis**						
				Process Monitoring & Analysis	1.00 ls	-	230,000.00	-	230,000.00 /ls	230,000
				Process, Monitoring, Sampling & Analysis	**1.00 ls**		**230,000.00**		**230,000.00 /ls**	**230,000**
				127 Process Monitoring, Sampling & Analysis	**1.00 ls**		**230,000.00**		**230,000.00 /ls**	**230,000**
		128		**Waste and GAC Disposal (By Others)**						
			01000-0301	**Waste and GAC Disposal (By Others)**						
				Waste & GAC Disposal	1.00 ls	-	729,000.00	-	729,000.00 /ls	729,000
				Waste and GAC Disposal (By Others)	**1.00 ls**		**729,000.00**		**729,000.00 /ls**	**729,000**
				128 Waste and GAC Disposal (By Others)	**1.00 ls**		**729,000.00**		**729,000.00 /ls**	**729,000**
		129		**Rental and Fees**						
			01000-0301	**Rental and Fees**						
				Rental and Fees	1.00 ls	-	130,000.00	-	130,000.00 /ls	130,000
				Rental and Fees	**1.00 ls**		**130,000.00**		**130,000.00 /ls**	**130,000**
				129 Rental and Fees	**1.00 ls**		**130,000.00**		**130,000.00 /ls**	**130,000**
				02 Operation	**1.00 ls**		**2,365,000.00**		**2,365,000.00 /ls**	**2,365,000**
	03			**Demob & Other**						
		230		**Demobilization**						
			01000-0301	**Demobilization**						
				Demobilization	1.00 ls	-	798,000.00	-	798,000.00 /ls	798,000
				Demobilization	**1.00 ls**		**798,000.00**		**798,000.00 /ls**	**798,000**
				230 Demobilization	**1.00 ls**		**798,000.00**		**798,000.00 /ls**	**798,000**
		232		**Reporting**						
			01000-0301	**Reports**						
				Reports	1.00 ls	-	124,000.00	-	124,000.00 /ls	124,000
				Reports	**1.00 ls**		**124,000.00**		**124,000.00 /ls**	**124,000**
				232 Reporting	**1.00 ls**		**124,000.00**		**124,000.00 /ls**	**124,000**
		234		**Power (Paid By Client)**						
			01000-0301	**Power Costs - (Paid By Client)**						
				Power Costs	42,260,192.00 kwh	-	0.07	-	0.07 /kwh	2,958,213
				Power Costs - (Paid By Client)	**1.00 ls**		**2,958,213.44**		**2,958,213.44 /ls**	**2,958,213**
				234 Power (Paid By Client)	**1.00 ls**		**2,958,213.44**		**2,958,213.44 /ls**	**2,958,213**

System	Area	Bid Item	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				03 Demob & Other	1.00 ls		3,880,213.44		3,880,213.44 /ls	3,880,213
				01 ISTD/IPTD (Thermal) Alternative	**60,111.00 cm**	**4.34**	**227.82**	**21.75**	**253.91 /cm**	**15,262,914**

Estimate Totals

Description	Amount	Totals	Hours		Rate	
Labor	260,996		42,644	hrs		
Material						
Subcontract	13,694,713					
Equipment	1,307,204		6,151	hrs		
Other						
	15,262,913	**15,262,913**				

Indirect Cost:

Building Permits % total cost						
Sales Tax (MEO)						
Builders Risk Ins % total cost						
Gen Liability Ins % total cost						
GC Bonds % total cost						
-						
Subtotal Prior to OH&P		**15,262,913**				
GC Field General Conditions	763.146				5.00	%
GC Indirects. OH & Profit	763.146				5.00	%
-						
Subtotal	**1,526,292**	**16,789,205**				
Construction Contingency						
-						
Subtotal Cost, Today's Dollars		**16,789,205**				
Escalation to Mid Point of Construction. Based on 2%/year December 09 to December 10						
Total Construction Cost		**16,789,205**				

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.

Estimate Totals

There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

APPENDIX A4

BASELINE DATA TABLES

Table A41. Particle Size, Physical Qualities and Carbon Content in Soil and Sediment, March 29, Lake-Phu Loc River Catchment

			Particle Size				Physical Qualities			Carbon Content	
Sample ID	**Location**	**Matrix**	**% Gravel (>2 mm)**	**% Sand (2.0 mm to 0.063 mm)**	**% Silt (0.063 mm to 4 µm)**	**% Clay (<4 µm)**	**% Moisture**	**Conductivity (EC)**	**pH**	**Total Organic Carbon (%)**	**Inorganic Carbon (%)**
Airbase											
06VN063	MLA	Soil	3	73	20	4	16	-	-	<0.1	0.3
SAP605.2	MLA	Soil	7	75	10	8	13	-	8.21	<0.10	-
06VN075	SA (surface)	Soil	-	-	-	-	4.84	-	-	0.30	<0.1
06VN079	SA (10 cm depth)	Soil	<1	80	8	12	10.8	-	-	0.6	<0.1
SAP601-3	SA	Soil	<1	82	6	11	12.1	-	4.14	0.12	-
Lakes											
06VN030	Sen Lake	Sediment	<1	95	2	3	0.58	-	-	0.60	<0.1
06VN040	Sen Lake	Sediment	<1	11	63	25	84	0.44	6.6	15	0.50
06VN052	Sen Lake	Sediment	<1	12	40	48	-	-	-	14.8	0.3
SAP501-1	Sen Lake	Sediment	<1	85	2	13	27.3	-	5.45	1.19	-
SAP504-1	Sen Lake	Sediment	<1	28	46	26	65.1	-	5.36	7.59	-
SAP521-1	Sen Lake	Sediment	<1	79	5	16	26.9	-	5.20	0.98	-
06VN024	Lake B	Sediment	<1	58	27	15	-	-	-	2.5	<0.1
06VN023	Lake C	Sediment	<1	69	23	8	-	-	-	2	<0.1
06VN062-1	Core 1	Sediment	-	-	-	-	-	-	5.42	-	-
06VN062-2	Core 2	Sediment	-	-	-	-	-	-	5.02	-	-
06VN062-3	Core 3	Sediment	-	-	-	-	-	-	4.44	-	-
06VN062-4	Core 4	Sediment	-	-	-	-	-	-	4.58	-	-
06VN062-5	Core 5	Sediment	-	-	-	-	-	-	4.75	-	-
06VN062-6	Core 6	Sediment	-	-	-	-	-	-	4.24	-	-
06VN062-11	Core 11	Sediment	-	-	-	-	-	-	5.08	-	-
Other Areas on Airbase											
06VN003	Between Storage Area/Sen Lake	Soil	<1	92	6	3	-	-	-	0.5	<0.1
06VN027	Home Garden southwest of Airport	Soil	<1	81	10	9	-	-	-	1.1	<0.1
Outside Airbase											
06VN093	March 29 Lake	Sediment	<1	57	25	18	-	-	-	6.1	1.1

Data from Hatfield/Office 33 (2007); data collected in December 2006. Data from Hatfield / CDM (2010) collected January 2010. See Figure 15 for sample locations.

Table A4.2. Concentrations of PCBs in Soil and Sediment Samples, March 29, Lake-Phu Loc River Catchment

PCB/TEQ Value	Units	06VN040 Sen Lake-Inlet	06VN062-1 Sen Lake-West	06VN062-2 Sen Lake-West	06VN062-3 Sen Lake-West	SAP501-1 E Wetland A	SAP504-1 Sen Lake Inlet	SAP521-1 E Wetland D	06VN063 MLA	SAP605-2 MLA	06VN075 SA	SAP601-3 SA
		Seds (grab)	Seds (0-2 cm)	Seds (2-4 cm)	Seds (4-6 cm)	Seds	Seds	Seds	Soil	Soil	Soil	Soil
CL4-PCB-77	pg/g	5,910	1,080	221	12	-	-	-	221	-	15	-
CL4-PCB-81	pg/g	84	8	3	< 0.382	-	-	-	3	-	< 0.998	-
CL5-PCB-105	pg/g	10,200	1,670	350	33	-	-	-	185	-	64	-
CL5-PCB-114	pg/g	437	58	11	1	-	-	-	2	-	4	-
CL5-PCB-118	pg/g	**40,600**	9,050	1,780	138	-	-	-	312	-	137	-
CL5-PCB-123	pg/g	558	94	19	NDR 1.83	-	-	-	13	-	2	-
CL5-PCB-126	pg/g	154	46	NDR 9.81	< 0.752	-	-	-	7	-	2	-
CL6-PCB-156/157	pg/g	4,900	800	148	13	-	-	-	47	-	24	-
CL6-PCB-167	pg/g	1,950	351	67	6	-	-	-	18	-	10	-
CL6-PCB-169	pg/g	< 16.7	< 10.0	< 2.20	< 1.82	-	-	-	< 1.46	-	< 0.721	-
CL7-PCB-170	pg/g	7,370	1,320	270	21	-	-	-	113	-	80	-
CL7-PCB-180/193	pg/g	17,800	3,000	616	45	-	-	-	240	-	183	-
CL7-PCB-189	pg/g	344	57	11	< 2.34	-	-	-	4	-	5	-
Total PCBs	pg/g	**90,307**	17,534	3,496	268	<50	<100	<50	1166	<50	525	<50
% Moisture	pg/g	73.5	67.4	61.3	45.2	27.3	65.1	26.9	17.3	13	5.9	12.1
TEQ (WHO 1998) ND=0	pg/g	23.9	6.22	0.319	0.0251	-	-	-	0.779	-	0.221	-
TEQ (WHO 1998) ND=1/2DL	pg/g	23.9	6.27	0.378	0.072	-	-	-	0.786	-	0.225	-
TEQ (WHO 2005) ND=0	pg/g	17.8	5.06	0.0945	0.00686	-	-	-	0.721	-	0.194	-
TEQ (WHO 2005) ND=1/2DL	pg/g	18	5.21	0.176	0.0719	-	-	-	0.742	-	0.205	-
Aroclor 1016	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Aroclor 1221	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Aroclor 1232	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Aroclor 1248	pg/g	-	-	-	-	<10	48	<10	-	<10	-	<10
Aroclor 1254	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Aroclor 1260	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Aroclor 1262	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Aroclor 1268	pg/g	-	-	-	-	<10	<20	<10	-	<10	-	<10
Surrogate; Decachlorobiphenyl	%	-	-	-	-	93	94	87	-	75	-	87

Data from Hatfield/Office 33 (2007), data collected in December 2006. Data from Hatfield / CDM (2010) collected January 2010.
Units are in pg/g.
Non detectable values represented as "<" with detection limit.
NDR = Peak detected but did not meet quantification criteria.
Note: CCME (2002) sediment quality guidelines for the protection of freshwater aquatic life are 34,000 pg/g of total PCBs.
Bold: samples exceed this standard.
See Figure 15 for sample locations.

Table A4.3. Concentrations of Organochlorine Pesticides in Soil and Sediment Samples, March 29 Lake-Phu Loc River Catchment

Variable	Standard	Sample Location and Type (ng/g)			
		06VN040	06VN063	06VN075	06VN099
		Sen Lake Sediment	MLA Soil	SA Soil	Thanh Khe (Site 18) Soil
delta-HCH	-	NDR 0.019	< 0.0172	NDR 0.050	0.02
Heptachlor-Epoxide	-	< 0.0071	< 0.0080	0.02	NDR 0.004
alpha-Endosulphan	0.01[a]	< 0.0636	< 0.0582	< 0.0428	NDR 0.011
Dieldrin	0.01	**0.973**	< 0.0188	**0.876**	**2.03**
Endrin	0.01	< 0.0400	< 0.0206	< 0.174	NDR 0.013
beta-Endosulphan	0.01[a]	< 0.119	< 0.113	< 0.0829	< 0.0161
Endosulphan-Sulphate	0.01[a]	< 0.109	< 0.103	< 0.0759	***0.039***
Endrin-Aldehyde	-	< 0.0700	< 0.0543	< 0.193	< 0.0092
Endrin-Ketone	-	< 0.0188	NDR 0.730	NDR 0.540	NDR 0.008
Methoxychlor	-	NQ	< 0.0441	< 0.0322	< 0.0162
Hexachlorobenzene	0.01	**0.152**	**0.155**	**0.298**	**0.067**
alpha-HCH	-	NDR 0.086	NDR 0.016	NDR 0.083	0.05
beta-HCH	-	0.065	0.037	0.127	0.102
gamma-HCH (Lindane)	-	0.074	NDR 0.014	0.142	0.023
HEPTACHLOR	-	NQ	< 0.0126	NDR 0.410	NDR 0.004
ALDRIN	0.01	**2.04**	**0.034**	< 0.0250	**0.852**
OXYCHLORDANE	-	<0.0454	< 0.0335	< 0.0380	< 0.0058
t-CHLORDANE	0.01[a]	***0.858***	NDR 0.033	***18.7***	***0.194***
c-CHLORDANE	0.01[a]	***0.817***	***0.026***	***19.9***	***0.155***
t-NONACHLOR	-	0.317	0.039	6.32	0.108
c-NONACHLOR	-	0.331	NDR 0.034	2.97	0.093
o,p-DDD	-	2.67	0.083	0.332	1.52
p,p-DDD	-	11.9	0.155	1.6	8.69
o,p-DDE	-	1.93	0.069	0.117	0.172
p,p-DDE	-	41	0.506	3.01	5.73
o,p-DDT	0.01[a]	NQ	***0.131***	***2.83***	***0.432***
p,p-DDT	0.01[a]	NQ	***0.543***	***12.8***	***1.96***
MIREX	-	0.196	NDR 0.010	< 0.0153	0.048
% Moisture	-	73.5	17.3	5.9	39.7

Data from Hatfield/Office 33 (2007); data collected in December 2006.
Units are ng/g (dry weight basis).
Guidelines are from QCVN 15: 2008/BTNMT; [a] These guidelines do not differentiate speciation (i.e., standard is for Chlordane, DDT, Endosulphan).
Bold: standard is exceeded.
***Bold*:** standard for non-speciated form is exceeded.
NQ = Not quantifiable.
NDR = Peak detected but did not meet quantification criteria.
See Figure 15 for sample locations.

Table A4.4. Concentrations of PAHs in Soil and Sediment Samples, March 29, Lake-Phu Loc River Catchment

Variable	Standard	Sample Location and Type (ng/g)							
		06VN040 Sen Lake	SAP501-1 E Wetland A	SAP504-1 Sen Lake	SAP521-1 E Wetland D	06VN063 MLA	SAP605-2 MLA	06VN075 SA	SAP601-3 SA
		Sediment	Sediment	Sediment	Sediment	Soil	Soil	Soil	Soil
Naphthalene	34.6	**87.5**	2.16	15	4.22	1.11	-	1.2	1.2
Acenaphthylene	5.87	**6.43**	0.471	2.39	1.05	0.096	NDR 0.149	NDR 0.139	<0.048
Acenaphthene	6.71	**21**	0.116	2.53	1.03	NDR 0.176	<0.063	< 0.441	<0.462
Fluorene	21.2	**24.9**	0.322	5.49	1.86	< 0.087	0.117	< 0.356	<0.030
Phenanthrene	41.9	**97.8**	3.09	26.3	20.7	0.5	1.28	2.48	0.122
Anthracene	46.9	**20.1**	0.368	8.98	9.55	< 0.062	0.163	< 0.775	<0.026
Fluoranthene	111	**149**	5.41	**167**	29.4	0.42	1.6	NDR 3.14	0.143
Pyrene	53	**192**	5.54	**171**	41.4	0.463	2.48	1	NDR 0.054
Benz[a]anthracene	31.7	**53.9**	2.44	**67.7**	16.3	0.182	0.855	< 0.184	NDR 0.020
Chrysene	57.1	**132**	5.43	**125**	44.5	0.655	2.51	1.89	0.158
Benzo[b]fluoranthene	-	-	4.77	172	37.2	-	2.49	-	<0.029
Benzo[j,k]fluoranthenes	-	-	3.9	-	-	-	1.6	-	<0.029
Benzo[e]pyrene	-	105	3.41	82.1	19	0.456	1.69	0.914	NDR 0.043
Benzo[a]pyrene	31.9	**65.6**	3.33	**73**	12.8	0.244	1.37	< 0.264	<0.039
Perylene	-	131	3.71	459	5.71	NDR 0.129	0.722	< 0.261	<0.041
Dibenz[a,h]anthracene	-	13.4	0.784	14.6	2.92	< 0.185	0.288	< 0.205	<0.029
Indeno[1,2,3-c,d]-pyrene	-	66.5	NDR 3.77	68.4	NDR 11.5	0.479	1.54	0.513	NDR 0.062
Benzo[g,h,i]perylene	-	94.6	3.66	72.5	11.7	0.66	1.5	0.569	NDR 0.062
2-Methylnaphthalene	-	46.1	0.837	9.41	6.48	0.693	0.687	0.819	0.48
1-Methylnaphthalene	-	18.7	0.545	42.3	26.6	0.494	0.451	0.652	0.036
C1-Naphthalenes	-	64.9	-	-	-	1.19	-	1.47	-
C2-Naphthalenes	-	174	-	-	-	3.41	-	4.08	-
C3-Naphthalenes	-	123	-	-	-	1.52	-	7.25	-
2,3,5-Trimethylnaphthalene	-	29.3	1.04	24.1	24.9	NDR 0.193	1.36	1.08	<0.114
C4-Naphthalenes	-	187	-	-	-	1.33	-	11.4	-
C1-Fluorenes	-	86	-	-	-	0.882	-	8.01	-
C2-Fluorenes	-	95.8	-	-	-	0.608	-	3.26	-
C3-Fluorenes	-	211	-	-	-	1.52	-	15.9	-
C4-Fluorenes	-	96.5	-	-	-	2.62	-	21.3	-
Dibenzothiophene	-	17.1	0.388	7.16	11	NDR 0.090	0.202	NDR 1.04	NDR 0.015
C1-Dibenzothiophenes	-	91.8	-	-	-	0.119	-	8	-
C2-Dibenzothiophenes	-	433	-	-	-	2.76	-	32.2	-
C3-Dibenzothiophenes	-	585	-	-	-	4.53	-	32.7	-

Table A4.4. (cont.)

Variable	Standard	Sample Location and Type (ng/g)							
		06VN040 Sen Lake	SAP501-1 E Wetland A	SAP504-1 Sen Lake	SAP521-1 E Wetland D	06VN063 MLA	SAP605-2 MLA	06VN075 SA	SAP601-3 SA
		Sediment	Sediment	Sediment	Sediment	Soil	Soil	Soil	Soil
C1 Phenanthrenes/ Anthracenes	-	114	-	-	-	0.745	-	5.89	-
2,6-Dimethylphenanthrene	-	NDR 15.4	0.393	12.3	7.47	< 0.208	0.487	0.529	<0.261
1,5/1,7-Dimethylphenanthrene	-	23.8	-	-	-	NDR 0.255	-	1.08	-
C2 Phenanthrenes/ Anthracenes	-	182	-	-	-	1.56	-	7.11	-
C3-Phenanthrenes/ Anthracenes	-	232	-	-	-	2.35	-	14.7	-
Retene	-	185	-	-	-	< 0.440	-	< 1.75	-
C4-Phenanthrenes/ Anthracenes	-	469	-	-	-	5	-	34.1	-
C1-Fluoranthenes/Pyrenes	-	178	-	-	-	0.71	-	1.87	-
C2-Fluoranthenes/Pyrenes	-	145	-	-	-	0.792	-	5.58	-
C3-Fluoranthenes/Pyrenes	-	50.4	-	-	-	0.947	-	4.6	-
C4-Fluoranthenes/Pyrenes	-	6.14	-	-	-	< 0.117	-	2.72	-
% Moisture	-	74.9	24.7	69.8	25.8	16.6	12.3	4.82	10.9

Data from Hatfield/Office 33 (2007); data collected in December 2006. Data from Hatfield / CDM (2010) collected January 2010.
Units are ng/g (dry weight basis).
BOLD: CCME (2002) standard exceeded.
Non detectable values represented as "<" with detection limit.
NDR: Peak detected but did not meet quantification criteria.
See Figure 15 for sample locations.

Table A4.5. Concentrations of Volatiles and Hydrocarbons in Soil and Sediment Samples, March 29, Lake-Phu Loc River Catchment

Variable	Units	Sample Location and Type						
		06VN063 MLA	SAP605-2 MLA	SAP601-3 SA	06VN040 Sen Lake	SAP501.1 E Wetland A	SAP504-1 Sen Lake	SAP521-1 E Wetland D
		Soil	Soil	Soil	Sediment	Sediment	Sediment	Sediment
Non-Halogenated Volatiles								
Benzene	mg/kg dry wt	<0.005	<0.040	<0.040	<0.005	<0.040	<0.20	<0.040
EthylBenzene	mg/kg dry wt	<0.01	<0.050	<0.050	<0.01	<0.050	<0.25	<0.050
Toluene	mg/kg dry wt	<0.01	<0.050	<0.050	<0.01	0.240	<0.25	<0.050
Xylenes	mg/kg dry wt	<0.02	<0.050	<0.050	<0.02	<0.050	<0.25	<0.050
F1(C6-C10)	mg/kg dry wt	<5	-	-	<5	-	-	-
F1-BTEX	mg/kg dry wt	<5	-	-	<5	-	-	-
Toluene d8		104	-	-	61	-	-	-
Extractable Hydrocarbons								
F2 (C10-C16)	mg/kg dry wt	<5	-	-	<5	-	-	-
F3 (C16-C34)	mg/kg dry wt	27	-	-	2700	-	-	-
F4 (C34-C50)	mg/kg dry wt	36	-	-	2100	-	-	-
2-Bromobenzotrifluoride	%	90	-	-	85	-	-	-
Hexatriacontane	%	115	-	-	125	-	-	-

Data from Hatfield/Office 33 (2007); data collected in December 2006. Data from Hatfield / CDM (2010) collected January 2010.

Non detectable values represented as "<" with detection limit.

See Figure 15 for sample locations.

Table A4.5. Cont.

Variable	Units	Standard (Soil only)	Sample Location and Type				
			SAP605-2 MLA	SAP601-3 SA	SAP501-1 E Wetland A	SAP504-1 Sen Lake	SAP521-1 E Wetland D
			Soil	Soil	Sediment	Sediment	Sediment
Bromobenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Bromochloromethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Bromodichloromethand	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Bromoform	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Bromomethane	mg/kg	-	<0.10	<0.10	<0.10	<0.25	<0.10
n-Butylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.50	<0.050
sec-Butylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
tert-Butylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Carbon tetrachloride	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Chlorobenzene	mg/kg	1.0	<0.050	<0.050	<0.050	<0.25	<0.050
Dibromochloromethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Chloroethane	mg/kg	-	<0.10	<0.10	<0.10	<0.25	<0.10
Chloroform	mg/kg	-	<0.10	<0.10	<0.10	<0.50	<0.10
Chloromethane	mg/kg	-	<0.10	<0.10	<0.10	<0.50	<0.10
2-Chlorotoluene	mg/kg	-	<0.050	<0.050	<0.050	<0.50	<0.050
4-Chlorotoluene	mg/kg	-	<0.20	<0.20	<0.20	<0.25	<0.20
1,2-Dibromo-3-chloropropane	mg/kg	-	<0.050	<0.050	<0.050	<1.0	<0.050
1,2-Dibromoethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Dibromomethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,2-Dichlorobenzene	mg/kg	1.0	<0.050	<0.050	<0.050	<0.25	<0.050
1,3-Dichlorobenzene	mg/kg	1.0	<0.050	<0.050	<0.050	<0.25	<0.050
1,4-Dichlorobenzene	mg/kg	1.0	<0.050	<0.050	<0.050	<0.25	<0.050
Dichlorodiffluoromethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,1-Dichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,2-Dichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,1-Dichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
cis-1,2-Dichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
trans-1,2-Dichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Methylene chloride	mg/kg	-	<0.30	<0.30	<0.30	<0.25	<0.30
1,2-Dichloropropane	mg/kg	-	<0.050	<0.050	<0.050	<1.5	<0.050
1,3-Dichloropropane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
2,2-Dichloropropane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,1-Dichloropropane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
cis-1,3-Dichloropropane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
trans-1,3-Dichloropropene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Hexachlorobutadiene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Isopropylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
p-Isopropyltoluene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Naphthalene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
n-Propylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Styrene	mg/kg	5.0	<0.050	<0.050	<0.050	<0.25	<0.050
1,1,1,2-Tetrachloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,1,2,2-Tetrachloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Tetrachloroethene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,2,3-Trichlorobenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,2,4-Trichlorobenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,1,1-Trichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,1,2-Trichloroethane	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050

Table A4.5. Cont.

Variable	Units	Standard (Soil only)	Sample Location and Type				
			SAP605-2 MLA	SAP601-3 SA	SAP501-1 E Wetland A	SAP504-1 Sen Lake	SAP521-1 E Wetland D
			Soil	Soil	Sediment	Sediment	Sediment
Trichloroethene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Trichlorofluoromethane	mg/kg	-	<0.10	<0.10	<0.10	<0.50	<0.10
1,2,3-Trichloropropane	mg/kg	-	<0.020	<0.020	<0.020	<0.10	<0.020
1,2,4-Trimethylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
1,3,5-Trimethylbenzene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Vinyl chloride	mg/kg	-	<0.10	<0.10	<0.10	<0.50	<0.10
o-Xylene	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
M+p-Xylenes	mg/kg	-	<0.050	<0.050	<0.050	<0.25	<0.050
Surrogate: 4-Bromofluorobenzene	%	-	93	97	90	83	93

Data from Hatfield / CDM (2010) collected January 2010.
Non detectable values represented as "<" with detection limit.
See Figure 15 for sample locations.
Guidelines are from CCME 2002 Soil Quality Guidelines for the Protection of Environmental and Human Health for Residential / parkland use (soil only).

Table A4.6. Concentrations of Chlorophenols in Soil and Sediment Samples, March 29 Lake-Phu Loc River Catchment

Variable	Sample Location and Type			
	06VN063	**06VN075**	**06VN079**	**06VN040**
	MLA	**SA (0-10 cm)**	**SA (10-30 cm)**	**Sen Lake**
	Soil	**Soil**	**Soil**	**Sediment**
Tetrachlorocatechol	<0.0050	<0.060	<0.080	<0.0050
Tetrachloroguaiacol	<0.0050	<0.050	<0.050	<0.0050
3,4,5-Trichlorocatechol	<0.0050	<0.030	<0.0050	<0.0050
3,4,5-Trichloroguaiacol	<0.0050	<0.0050	<0.0050	<0.0050
2,3,4-Trichlorophenol	<0.0020	<0.20	<5.0	<0.0020
2,3,5-Trichlorophenol	<0.0020	<0.0020	<0.020	<0.0020
2,3,6-Trichlorophenol	<0.0030	<0.60	<0.10	<0.0050
2,4,5-Trichlorophenol	0.287	<3.0	<9.0	0.0043
2,4,6-Trichlorophenol	0.0113	<1.0	<2.0	<0.0020
2,3,4,5-Tetrachlorophenol	<0.0020	<0.40	<0.30	<0.0020
2,3,4,6-Tetrachlorophenol	<0.0020	<0.40	<0.080	<0.0020
2,3,5,6-Tetrachlorophenol	<0.0020	<0.40	<0.30	<0.0020
Pentachlorophenol	<0.0020	<0.40	<0.20	<0.0020

Data from Hatfield/Office 33 (2007); data collected in December 2006.

Units are mg/g.

Non detectable values represented as "<" with detection limit.

See Figure 15 for sample locations.

Table A4.7. Concentrations of Metals in Sen Lake sediments, March 29, Lake-Phu Loc River Catchment

Variable	Unit	Standard	Sample ID and Depth									
			06VN062-1	06VN062-2	06VN062-3	06VN062-4	06VN062-5	06VN062-6	06VN062-11	SAP501-1	SAP504-1	SAP521-1
			0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-14 cm	30-32 cm	E Wetland A	Sen Lake	E Wetland D
pH			5.42	5.02	4.44	4.58	4.75	4.24	5.08	5.45	5.36	5.20
Aluminum	mg/kg	-	-	-	-	-	-	-	-	4440	27700	9540
Antimony	mg/kg	-	23	<10	<10	<10	<10	<10	<10	0.61	15.2	0.84
Arsenic	mg/kg	5.9	**1230**	**180**	**15.3**	5.9	<5.0	<5.0	<5.0	5.5	**328**	**8.7**
Barium	mg/kg	-	202	94.1	57.4	51.1	59.4	81.9	79.8	22.1	115	30.9
Beryllium	mg/kg	-	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	0.56	<0.50	0.50	<0.50
Bismuth	mg/kg	-	-	-	-	-	-	-	-	<20	<20	<20
Cadmium	mg/kg	0.99	**12.8**	**1.3**	<0.50	<0.50	<0.50	<0.50	<0.50	0.23	**5.16**	0.33
Calcium	mg/kg	-	-	-	-	-	-	-	-	77	2420	222
Chromium	mg/kg	37.3	**62.4**	31.3	14.2	11.3	10.4	13.9	16.3	6.1	33.4	13.6
Cobalt	mg/kg	50	10.9	4	<2.0	<2.0	<2.0	2.8	2.5	<2.0	5.5	<2.0
Copper	mg/kg	31.6	**52.9**	15.1	6.2	4.6	3.5	5.4	6.4	5.5	**32.5**	12.9
Iron	mg/kg	-	-	-	-	-	-	-	-	2570	45200	14200
Lead	mg/kg	35.8	**169**	**46**	<30	<30	<30	<30	<30	25.8	**91.2**	28.6
Lithium	mg/kg	-	-	-	-	-	-	-	-	<2.0	17.3	3.2
Magnesium	mg/kg	-	-	-	-	-	-	-	-	144	812	398
Manganese	mg/kg	-	-	-	-	-	-	-	-	6.5	277	44.6
Mercury	mg/kg	0.174	**0.63**	0.167	0.0595	0.0471	0.0293	0.0359	0.0384	0.105	**0.372**	0.0596
Molybdenum	mg/kg	-	<8.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.30	2.58	0.45
Nickel	mg/kg	22.7	**25**	10.7	<5.0	<5.0	<5.0	<5.0	5.9	<5.0	10.8	<5.0
Phosphorus	mg/kg	-	-	-	-	-	-	-	-	68	381	216
Potassium	mg/kg	-	-	-	-	-	-	-	-	<200	780	320
Selenium	mg/kg	-	<4.0	<5.0	<2.0	<3.0	<2.0	<2.0	<4.0	0.14	1.86	0.31
Silver	mg/kg	0.50	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	0.46	<0.10
Sodium	mg/kg	-	-	-	-	-	-	-	-	<200	<200	<200
Strontium	mg/kg	-	-	-	-	-	-	-	-	1.47	12.5	2.64
Thallium	mg/kg	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.50	<0.50	<0.50
Tin	mg/kg	-	13	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	8.2	5.2	<5.0
Titanium	mg/kg	-	-	-	-	-	-	-	-	26.3	78.8	59.9
Vanadium	mg/kg	-	57.2	28.7	17	12.8	13.2	16	21.8	6.6	39.7	15.5
Zinc	mg/kg	121	**2300**	**265**	24.6	15.5	10.4	13.5	17	16.7	**540**	54.9

Data from Hatfield/Office 33 (2007); data collected in December 2006. Data from Hatfield / CDM (2010) collected January 2010.
Standards are from EPA Region V, except for arsenic and chromium which are from CCME (2002).
BOLD: standard is exceeded
Non-detectable represented as "<" with detection limit.
See Figure 15 for sample locations.

Table A4.8. Concentrations of Metals in SA and MLA soils, March 29, Lake-Phu Loc River Catchment

Variable	Unit	Standard	Sample ID and Depth	
			SAP601-3	SAP605-2
			SA	MLA
pH			4.14	8.21
Aluminum	mg/kg	-	11800	10400
Antimony	mg/kg	0.142	**0.64**	**0.59**
Arsenic	mg/kg	12	**257**	**151**
Barium	mg/kg	10.4	7.5	**25.2**
Beryllium	mg/kg	10.6	<0.50	<0.50
Bismuth	mg/kg	-	<20	<20
Cadmium	mg/kg	0.0022	<0.10	<0.10
Calcium	mg/kg	-	<50	5000
Chromium	mg/kg	64	14.3	16.9
Cobalt	mg/kg	0.14	<2.0	**3.1**
Copper	mg/kg	5.4	1.5	**18.2**
Iron	mg/kg	-	5500	8150
Lead	mg/kg	0.537	**4.0**	**6.6**
Lithium	mg/kg	-	3.0	3.9
Magnesium	mg/kg	-	162	557
Manganese	mg/kg	-	10.9	79.4
Mercury	mg/kg	6.6	0.0289	0.0271
Molybdenum	mg/kg	-	0.21	0.22
Nickel	mg/kg	13.6	<5.0	6.4
Phosphorus	mg/kg	-	<50	96
Potassium	mg/kg	-	260	520
Selenium	mg/kg	0.0276	0.28	0.24
Silver	mg/kg	4.04	<0.10	<0.10
Sodium	mg/kg	-	<200	<200
Strontium	mg/kg	-	<0.50	11.6
Thallium	mg/kg	0.0569	<0.50	<0.50
Tin	mg/kg	7.62	<5.0	<5.0
Titanium	mg/kg	-	48.2	116
Vanadium	mg/kg	1.59	**18.3**	**18.7**
Zinc	mg/kg	6.62	**6.9**	**14.4**

Data from Hatfield/CDM (2010) collected January 2010.
Standards are from EPA Region V, except for arsenic and chromium which are from CCME (2002).
BOLD: standard is exceeded.
Non-detectable represented as "<" with detection limit.
See Figure 15 for sample locations

Table A4.9. Sediment Characteristics, Phu Loc River

Variable	USEPA Region V Standard	Unit	Sample Location					
			B2-1	B2-2	B3-1	B3-2	B4-1	B4-2
pH	-	-	7.4	7.6	8	7.7	7.7	7.5
Salinity	-	$^{0}/_{00}$	0.4	0.35	2.38	2.06	2.96	2.26
Pb	35.8	mg/kg	**264**	**227**	**310**	**354**	23	27
Cu	31.6	mg/kg	**71**	**87**	**157**	**130**	25	34
Zn	121	mg/kg	**485**	**457**	**550**	**528**	87	65
Cd	0.99	mg/kg	**47**	**55**	**80**	**97**	**25**	**23**
Hg	0.174	mg/kg	**2.7**	**1.8**	**2.1**	**2.1**	Trace	Trace
Cr^{6+}	37.3	mg/kg	**188**	**210**	**325**	**347**	Trace	Trace
Total N	-	mg/kg	0.7	0.85	0.93	0.9	0.14	0.14
Total P	-	mg/kg	0.37	0.41	0.65	0.98	0.09	0.1

Data from PIIP-PMU (2007).
Standards are from EPA Region V, except for chromium standard which is from CCME (2002).
Bold: standard is exceeded.
See Figure 15 for sample locations.

Table A4.10. Soil Chemical Properties, West of Airport-Han River Catchment

Variable	Units	Standard	Sampling Location					
			D1	D2	D3	D4	D5	D6
pH	-	-	5.9	5.93	5.94	4.45	4.54	5.09
Organic Content	%	-	0.73	0.68	0.66	0.4	0.38	0.28
Fe_2O_3	%	-	4.93	3.46	0.44	0.64	0.34	1.33
MgO	%	-	0.403	0.179	0.162	0.063	0.063	0.194
CaO	%	-	0.177	0.157	0.143	0.055	0.111	0.17
SiO_2	%	-	93.5	82.45	82.05	91.67	91.92	93.47
Hg	mg/kg	0.174	**0.18**	0.15	0.16	**0.21**	**0.22**	**0.24**
As	mg/kg	5.9	1.87	1.59	1.61	1.68	1.63	1.91
Cu	mg/kg	31.6	29.22	23.63	23.62	4.22	3.11	5.44
Pb	mg/kg	35.8	30.33	26.82	26.96	9.46	9.59	15.05
Zn	mg/kg	121	51.29	49.44	49.42	14	12.95	14.66
Al^{3+}	meq/100g	-	0.006	0.005	0.005	0.193	0.102	0.858
Cation Exchange Capacity	meq/100g	-	10.6	11.1	11.2	4.2	4.4	4.3

Data from Office 33 (2008).
Standards are from EPA Region V.
See Figure 15 for sample locations.

Table A4.11. Groundwater Quality: Metals

Variable	Units	Vietnam Ground-water Quality Standards	USEPA Drinking Water Guidelines (MCL or TT)	Within Airport Property				March 29 Lake-Phu Loc River Catchment Outside Airport Property										
				March 29 Lake-Phu Loc River Catchment	West of Airport-Han River Catchment													
				DW1	DW2	DW3	SAP706	NN1	NN2	NN3	NN4	NN5	NN6	NN8	SAP708	SAP709	SAP710	SAP711
Groundwater Level [1]	m	-	-	0.6[1]	0.2[1]	0.8[1]	-	6	16	shallow	not reported	8	25	7	-	-	-	-
pH	-	5.5-8.5	6.5-8.5	**6.4**	**6.22**	6.66	-	7.25	**6.3**	7.89	**6.26**	7.67	7.17	6.6	-	-	-	-
Color	Cobalt	-	15	-	-	-	-	2	4	4	5	3	5	5	-	-	-	-
Smell	-	-	-	-	-	-	-	none	none	none	none	none	none	none	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	10	8	3	7	9	6	4	-	-	-	-
Hardness	mg/l	500	-	-	-	-	178	52.5	205	225	360	77.5	297	132	4	190	241	205
COD	mg/l	4	-	16	32	16	-	-	-	-	-	-	-	-	-	-	-	-
HCO_3^-	mg/l	-	-	183	85.4	36.6	-	-	-	-	-	-	-	-	-	-	-	-
SO_4^{2-}	mg/l	400	250	0	5.94	0	-	-	-	-	-	-	-	-	-	-	-	-
TDS	mg/l	1,500	-				-	176	377	422	883	563	558	141	-	-	-	-
Cl^-	mg/l	250	250	14.18	7.09	7.09	-	56	99	110	**365**	**319**	162	71	-	-	-	-
F^-	mg/l	1	4				-	0.25	0.5	0.27	0.25	0.35	0.18	0.47	-	-	-	-
Fe2+	mg/l	-	-	4.55	5	0	-	-	-	-	-	-	-	-	-	-	-	-
Fe3+	mg/l	-	-	0.22	0.1	0.015	-	0.19	0.25	0.13	0.36	0.12	0.34	0.46	-	-	-	-
NO_2^-	mg/l	1	1	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-
NO_3^-	mg/l	15	10	1.52	5.29	4.74	-	0.138	0.143	1.89	0.13	0.51	0.14	0.63	-	-	-	-
NH_4^+	mg/l	0.1	-	0.002	0.003	0.0015	-	-	-	-	-	-	-	-	-	-	-	-
PO_4^{3-}	mg/l	-	-	0.45	0.5	0.15	-	0.41	0.29	0.32	4.7	2.88	0.33	0.49	-	-	-	-
Arsenic	mg/l	0.05	0.01	0.00521	0.00827	0.00237	<0.0010	-	< 0.001	< 0.01	< 0.01	<0.0025	<0.001	<0.001	<0.00050	<0.00050	<0.00050	<0.0050
Lead	mg/l	0.01	0.015*	**0.97**	**0.015**	0.011	0.0015	-	-	-	-	-	-	-	<0.00050	<0.00050	<0.00050	0.00225
Zinc	mg/l	3.0	5	1.786	0.094	0.012	0.0573	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Cadmium	mg/l	0.005	0.005	-	-	-	0.00104	-	-	-	-	-	-	-	<0.000017	0.000025	<0.000017	<0.000017
Manganese	mg/l	0.5	0.05	0.024	**0.141**	0.011	**0.855**	0.04	0.02	**0.08**	**0.15**	**0.08**	**0.1**	**0.05**	0.00554	0.0867	0.150	**0.162**
Sodium	mg/l	-	-	3.41	6.93	6.17	115	-	-	-	-	-	-	-	7.3	86.0	58.8	88.6
Potassium	mg/l	-	-	3.98	1.92	1.77	18.3	-	-	-	-	-	-	-	2.5	38.5	27.1	9.4
Calcium	mg/l	-	-	10.02	5.01	45.09	28.5	-	-	-	-	-	-	-	0.88	54.4	71.4	61.4
Magnesium	mg/l	-	-	3.04	3.04	6.08	25.9	-	-	-	-	-	-	-	0.43	13.0	15.1	12.6
Total Coliform	MNP/100ml	3	-	-	-	-	-	17	-	45	-	33	-	-	-	-	-	-
Other Metals																		
Aluminum	mg/l	-	-	-	-	-	0.307	-	-	-	-	-	-	-	0.0057	0.0064	<0.0050	<0.0050
Antimony	mg/l	-	0.006	-	-	-	<0.0010	-	-	-	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Barium	mg/l	-	2	-	-	-	1.32	-	-	-	-	-	-	-	0.031	0.211	0.358	0.087
Beryllium	mg/l	-	0.004	-	-	-	<0.0020	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010
Boron	mg/l	-	-	-	-	-	<0.10	-	-	-	-	-	-	-	<0.10	<0.10	<0.10	<0.10
Chromium	mg/l	-	0.1	-	-	-	0.0103	-	-	-	-	-	-	-	0.0082	0.0110	0.0077	0.0067
Cobalt	mg/l	-	-	-	-	-	0.0480	-	-	-	-	-	-	-	<0.00030	0.00504	0.00082	0.00226
Copper	mg/l	-	-	-	-	-	<0.0020	-	-	-	-	-	-	-	<0.0010	0.0024	0.0014	<0.0010
Iron	mg/l	-	-	-	-	-	0.147	-	-	-	-	-	-	-	<0.030	<0.030	0.044	<0.030
Lithium	mg/l	-	-	-	-	-	0.011	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050
Mercury	mg/l	-	0.002	-	-	-	0.000067	-	-	-	-	-	-	-	<0.000020	<0.00001	<0.00001	<0.00001
Molybdenum	mg/l	-	-	-	-	-	<0.0020	-	-	-	-	-	-	-	<0.0010	<0.0010	0.0011	<0.0010
Nickel	mg/l	-	-	-	-	-	0.0091	-	-	-	-	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010
Selenium	mg/l	-	0.05	-	-	-	<0.0060	-	-	-	-	-	-	-	0.0015	<0.0020	<0.0010	<0.0020
Silver	mg/l	-	-	-	-	-	<0.00006	-	-	-	-	-	-	-	<0.00002	<0.00002	<0.00002	<0.000020
Thallium	mg/l	-	0.002	-	-	-	0.00046	-	-	-	-	-	-	-	<0.00020	0.00043	0.00069	<0.00020
Tin	mg/l	-	-	-	-	-	<0.0010	-	-	-	-	-	-	-	<0.00050	<0.00050	<0.00050	<0.00050
Titanium	mg/l	-	-	-	-	-	<0.010	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010
Uranium	mg/l	-	0.03	-	-	-	<0.00040	-	-	-	-	-	-	-	<0.00020	0.00042	0.00073	<0.00020
Vanadium	mg/l	-	-	-	-	-	<0.0020	-	-	-	-	-	-	-	<0.0010	<0.0010	0.0061	<0.0010

Sources: Office 33 (2008) for groundwater quality within Airport property and PIIP-PMU (2007) for groundwater quality outside Airport property but within March 29 Lake-Phu Loc River Catchment.
Data from Hatfield / CDM (2010) collected in January 2010.
[1] Groundwater levels were measured at well heads by Office 33 (2008) and are assumed to be relative to ground level.
Vietnam groundwater standards: QCVN 09:2009.
USEPA NRWQC – 2009 US EPA National Recommended Water Quality Criteria, 2009.
Bold: USEPA standard is exceeded; shaded: Vietnamese standard exceeded; Non detectable values represented as "<" with detection limit.
See Figure 15 for sample locations.

Table A4.12. Water Quality: Polychlorinated Biphenyls in ground water and surface water

Variable	Units	USEPA Drinking Water Guidelines (MCL or TT)	Within Airport Property	Surface Water			Groundwater			
			West of Airport-Han River Catchment	Sen Lake		Sen Lake Drainage Canal	March 29 Lake-Phu Loc River Catchment Outside Airport Property			
			SAP706	SAP701	SAP702	SAP703	SAP708	SAP709	SAP710	SAP711
Aroclor 1016	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1221	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1232	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1242	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1248	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1254	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1260	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1262	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Aroclor 1268	mg/l	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Total PCBs	mg/l	0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Surrogage: Decachlorobiphenyl	%	-	104	112	102	105	113	103	98	96

Data from Hatfield / CDM (2010) collected in January 2010

Non detectable values represented as "<" with detection limit.

USEPA NRWQC – 2009 US EPA National Recommended Water Quality Criteria, 2009.

Bold: USEPA standard is exceeded;

See Figure 15 for sample locations.

Table A4.13. Water Quality: Polycyclic Aromatic Hydrocarbons in ground water and surface water

Variable	Units	Surface Water Guidelines (CCME)	Groundwater Guidelines	Within Airport Property	Surface Water			Groundwater			
				West of Airport-Han River Catchment	Sen Lake		Sen Lake Drainage Canal	March 29 Lake-Phu Loc River Catchment Outside Airport Property			
				SAP708	SAP701	SAP702	SAP703	SAP706	SAP709	SAP710	SAP711
Naphthalene	ng/l	1100	-	3.21	32.7	6.34	11.5	3.73	4.46	4.63	NDR 5.76
Acenaphthylene	ng/l	-	-	<0.101	NDR 2.18	NDR 1.15	NDR 0.511	<0.189	<0.184	NDR 0.522	NDR 0.267
Acenaphthene	ng/l	5800	-	<0.115	1.16	1.31	NDR 0.559	<0.309	<0.244	<0.245	< 0.282
Flourene	ng/l	3000	-	<0.161	1.86	1.29	0.578	<0.255	<0.265	0.441	4.89
Phenanthrene	ng/l	400	-	0.597	4.55	3.22	1.27	0.878	0.534	2.05	1.54
Anthracene	ng/l	12	-	<0.109	0.565	NDR 0.391	<0.213	<0.213	NDR 0.555	NDR 0.420	6.16
Fluoranthene	ng/l	40	-	0.311	0.279	2.29	1.13	0.683	NDR 0.586	NDR 1.13	0.57
Pyrene	ng/l	25	-	0.3	2.96	3.08	1.23	0.681	NDR 0.669	2.63	2.58
Benz[a]anthracene	ng/l	18	-	NDR 0.050	NDR 0.149	NDR 0.218	NDR 0.106	0.234	<0.063	<0.078	NDR 0.096
Chrysene	ng/l	-	-	0.104	0.582	0.994	0.887	0.348	<0.075	0.155	0.164
Benzo[b]fluoranthene	ng/l	-	-	<0.070	0.231	0.283	0.431	0.276	<0.081	<0.086	< 0.095
Benzo[j,k]fluoranthenes	Ng/l	-	-	<0.085	NDR 0.119	<0.122	0.277	NDR 0.162	<0.093	<0.103	NDR 0.145
Benzo[e]pyrene	Ng/l	-	-	<0.107	NDR 0.198	0.356	0.445	NDR 0.224	<0.138	<0.131	< 0.203
Benzo[a]pyrene	Ng/l	15	-	<0.120	<0.125	<0.161	NDR 0.204	NDR 0.304	<0.155	<0.147	< 0.227
Perylene	Ng/l	-	-	<0.120	<0.134	<0.165	<0.130	<0.153	<0.149	<0.151	< 0.216
Dibenz[a,h]anthracene	Ng/l	-	-	<0.125	<0.112	<0.149	<0.124	<0.154	<0.162	<0.128	< 0.189
Indeno[1,2,3-cd]pyrene	Ng/l	-	-	NDR 0.134	NDR 0.200	NDR 0.214	NDR 0.396	NDR 0.297	<0.135	<0.131	< 0.253
Benzo[ghi]perylene	Ng/l	-	-	NDR 0.163	NDR 0.210	NDR 0.311	NDR 0.379	NDR 0.351	<0.138	NDR 0.135	< 0.169
2-Methylnaphthalene	Ng/l	-	-	1.15	15.6	3.95	9.09	1.2	1.27	1.61	2.01
2,6-Dimethylnaphthalene	Ng/l	-	-	0.319	2.22	1.73	3.27	<0.506	0.407	0.729	0.855
2,3,5-Trimethylnaphthalene	Ng/l	-	-	<0.157	5.27	5.95	1.78	<0.265	NDR 0.609	NDR 0.965	NDR 1.18
1-Methylphenanthrene	Mg/l	-	-	0.158	0.843	1.05	0.228	<0.209	<0.218	0.373	0.368
Dibenzothiophene	Mg/l	-	-	<0.081	NDR 0.571	NDR 0.498	NDR 0.293	<0.191	<0.183	NDR 0.245	NDR 7.39

Data from Hatfield / CDM (2010) collected in January 2010
CCME 2007 Canadian Water Quality Guidelines for the Protection of Aquatic Life
Bold: CCME standard is exceeded;
Non detectable values represented as "<" with detection limit.
See Figure 15 for sample locations.

Table A4.14. Water Quality: Volatile Organic Compounds in Groundwater

Variable	Unit	USEPA Drinking water guidelines (MCL or TT)	World Health Organization	West of Airport-Han River Catchment	March 29 Lake-Phu Loc River Catchment Outside Airport Property			
				SAP708	SAP706	SAP709	SAP710	SAP711
Benzene	mg/l	0.005	0.01	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromobenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromochloromethane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromodichloromethane	mg/l	-	0.06	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromoform	mg/l	-	0.1	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bromomethane	mg/l	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
n-Butylbenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
sec-Butylbenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
tert-Butylbenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Carbon tetrachloride	mg/l	0.005	0.004	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chlorobenzene	mg/l	0.1	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dibromochloromethane	mg/l	-	0.1	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chloroethane	mg/l	-	-	<0.010	<0.010	<0.010	<0.010	<0.010
Chloroform	mg/l	-	0.3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chloromethane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.010
2-Chlorotoluene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
4-Chlorotoluene	mg/l	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
1,2-Dibromo-3-chloropropane	mg/l	-	0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2-Dibromoethane	mg/l	-	0.0004	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dibromomethane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2-Dichlorobenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,3-Dichlorobenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,4-Dichlorobenzene	mg/l	-	0.3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Dichlorodifluoromethane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1-Dichloroethane	mg/l	0.007	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2-Dichloroethane	mg/l	0.005	0.05	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1-Dichloroethene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
cis-1,2-Dichloroethene	mg/l	0.07	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
trans-1,2-Dichloroethene	mg/l	0.1	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Methylene chloride	mg/l	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
1,2-Dichloropropane	mg/l	0.005	0.04	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,3-Dichloropropane	mg/l	-	0.02	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
2,2-Dichloropropane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1-Dichloropropene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
cis-1,3-Dichloropropene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
trans-1,3-Dichloropropene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Ethylbenzene	mg/l	0.7	0.3	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Hexachlorobutadiene	mg/l	-	0.0006	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Isopropylbenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
p-Isopropyltoluene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Naphthalene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
n-Propylbenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Styrene	mg/l	0.1	0.02	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,1,2-Tetrachloroethane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,2,2-Tetrachloroethane	mg/l	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tetrachloroethene	mg/l	-	0.04	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Toluene	mg/l	1	0.7	<0.0010	<0.0010	<0.0010	0.0078	<0.0010
1,2,3-Trichlorobenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2,4-Trichlorobenzene	mg/l	0.07	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,1-Trichloroethane	mg/l	0.2	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,1,2-Trichloroethane	mg/l	0.005	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Thrichloroethene	mg/l	0.005	0.02	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Trichlorofluoromethane	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,2,3-Trichloropropane	mg/l	-	-	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
1,2,4-Trimethylbenzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
1,3,5-trimethyl benzene	mg/l	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vinyl chloride	mg/l	0.002	0.0003	<0.020	<0.020	<0.020	<0.020	<0.020
o-Xylene	mg/l	10	0.5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
m+p-Xylenes	mg/l	10	0.5	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Surrogage: 4-Bromofluorobenzene	%	-	-	101	100	104	98	100

Data from Hatfield / CDM (2010) collected in January 2010

WHO groundwater standards: Guidelines for Drinking Water Quality 2006.

USEPA NRWQC – 2009 US EPA National Recommended Water Quality Criteria, 2009.

Bold: WHO standard is exceeded; shaded: USEPA standard exceeded; not detectable represented as "<" with detection limit.

See Figure 15 for sample locations.

Table A4.15. Surface Water Quality: Metals in Sen Lake

Variable	Unit	Standards and Guidelines			Sen Lake 2009	Sen Lake 2010		Sen Lake Drainage Canal
		QCVN 08:2009		USEPA Freshwater (CCC)				
		Domestic Use	Non-Domestic Use			SAP701	SAP702	SAP703
pH		6-8.5	5.5-9	6.5-9	6.84	-	-	-
Hardness	mg/l	500	-	-	-	62.5	66.1	24.9
DO	mg/l	≥ 6	≥ 2	-	3.25	-	-	-
BOD_5	mg/l	<4	<25	-	12	-	-	-
COD	mg/l	<10	<50	-	15	-	-	-
SS	mg/l	20	100	-	17.6	-	-	-
Nitrite (in N)	mg/l	0.01	0.05	-	0.001	-	-	-
Nitrate (in N)	mg/l	2	15	-	0.3	-	-	-
NH_3	mg/l	0.1	1	-	0.23	-	-	-
Fluoride	mg/l	1	2	-	0.26	-	-	-
Manganese	mg/l	0.1	0.1	-	0.043	0.120	0.139	0.0639
Iron	mg/l	0.5	2	1	**1.13**	**1.04**	0.999	**3.16**
Cadmium	mg/l	0.005	0.01	0.00025	**0.000792**	0.000026	<0.000017	0.000045
Lead	mg/l	0.02	0.05	0.0025	0.00104	0.00096	0.00095	<0.00050
Copper	mg/l	0.1	1	-	0.0011	0.0013	<0.0010	<0.0010
Zinc	mg/l	0.5	2	0.12	0.00308	<0.0050	<0.0050	0.0090
Detergents	mg/l	0.1	0.5	-	0.035	-	-	-
Oil	mg/l	0.01	0.3	-	0.12	-	-	-
Coliform	MPN/100ml	2,500	10,000	-	750	-	-	-
Other Metals								
Aluminum	mg/l	-	-	0.087	-	**0.133**	0.0637	0.0386
Antimony	mg/l	-	-	-	-	<0.00050	<0.00050	<0.00050
Arsenic	mg/l	0.001	0.1	0.15	-	0.0187	0.0179	**0.257**
Barium	mg/l	-	-	-	-	0.048	0.049	0.043
Beryllium	mg/l	-	-	-	-	<0.0010	<0.0010	<0.0010
Boron	mg/l	-	-	-	-	<0.10	<0.10	<0.10
Calcium	mg/l	-	-	-	-	19.8	21.1	7.82
Chromium	mg/l	0.05	1	0.074	-	0.0194	0.0100	0.0119
Cobalt	mg/l	-	-	-	-	<0.00030	<0.00030	<0.00030
Lithium	mg/l	-	-	-	-	<0.0050	<0.0050	<0.0050
Magnesium	mg/l	-	-	-	-	3.15	3.27	1.31
Mercury	mg/l	0.001	0.002	0.00077	-	<0.00002	<0.00002	<0.00002
Molybdenum	mg/l	-	-	-	-	<0.0010	<0.0010	<0.0010
Nickel	mg/l	-	-	0.052	-	<0.0010	<0.0010	<0.0010
Potassium	mg/l	-	-	-	-	7.4	7.7	4.2
Selenium	mg/l	-	-	0.005	-	<0.0010	<0.0010	<0.0010
Silver	mg/l	-	-	-	-	<0.00002	<0.00002	<0.00002
Sodium	mg/l	-	-	-	-	21.1	19.8	9.4
Thallium	mg/l	-	-	-	-	<0.00020	<0.00020	<0.00020
Tin	mg/l	-	-	-	-	0.00487	<0.00050	<0.00050
Titanium	mg/l	-	-	-	-	<0.010	<0.010	<0.010
Uranium	mg/l	-	-	-	-	<0.00020	<0.00020	<0.00020
Vanadium	mg/l	-	-	-	-	<0.0010	<0.0010	<0.0010

Source: Da Nang Center for Environmental Technology (2009).
QCVN 08:2009 - Vietnam surface water quality standards.
USEPA NRWQC – 2009 US EPA National Recommended Water Quality Criteria.
Bold: USEPA standard is exceeded.
Shaded: QCVN 08:2009 standard exceeded.
See Figure 15 for sample locations.

Table A4.16. Water Quality: Volatile Organic Compounds in Sen Lake

Variable	Unit	CCME Surface Water Guideline	Sen Lake		Sen Lake Drainage Canal
			SAP701	SAP702	SAP703
Benzene	mg/l	0.37	<0.0010	<0.0010	<0.0010
Bromobenzene	mg/l	-	<0.0010	<0.0010	<0.0010
Bromochloromethane	mg/l	-	<0.0010	<0.0010	<0.0010
Bromodichloromethane	mg/l	-	<0.0010	<0.0010	<0.0010
Bromoform	mg/l	-	<0.0010	<0.0010	<0.0010
Bromomethane	mg/l	-	<0.010	<0.010	<0.010
n-Butylbenzene	mg/l	-	<0.0010	<0.0010	<0.0010
sec-Butylbenzene	mg/l	-	<0.0010	<0.0010	<0.0010
tert-Butylbenzene	mg/l	-	<0.0010	<0.0010	<0.0010
Carbon tetrachloride	mg/l	-	<0.0010	<0.0010	<0.0010
Chlorobenzene	mg/l	-	<0.0010	<0.0010	<0.0010
Dibromochloromethane	mg/l	-	<0.0010	<0.0010	<0.0010
Chloroethane	mg/l	-	<0.010	<0.010	<0.010
Chloroform	mg/l	-	<0.0010	<0.0010	<0.0010
Chloromethane	mg/l	-	<0.010	<0.010	<0.010
2-Chlorotoluene	mg/l	-	<0.0010	<0.0010	<0.0010
4-Chlorotoluene	mg/l	-	<0.0020	<0.0020	<0.0020
1,2-Dibromo-3-chloropropane	mg/l	-	<0.0010	<0.0010	<0.0010
1,2-Dibromoethane	mg/l	-	<0.0010	<0.0010	<0.0010
Dibromomethane	mg/l	-	<0.0010	<0.0010	<0.0010
1,2-Dichlorobenzene	mg/l	0.0007	<0.0010	<0.0010	<0.0010
1,3-Dichlorobenzene	mg/l	0.150	<0.0010	<0.0010	<0.0010
1,4-Dichlorobenzene	mg/l	0.026	<0.0010	<0.0010	<0.0010
Dichlorodifluoromethane	mg/l	-	<0.0010	<0.0010	<0.0010
1,1-Dichloroethane	mg/l	-	<0.0010	<0.0010	<0.0010
1,2-Dichloroethane	mg/l	0.10	<0.0010	<0.0010	<0.0010
1,1-Dichloroethene	mg/l	-	<0.0010	<0.0010	<0.0010
cis-1,2-Dichloroethene	mg/l	-	<0.0010	<0.0010	<0.0010
trans-1,2-Dichloroethene	mg/l	-	<0.0010	<0.0010	<0.0010
Methylene chloride	mg/l	-	<0.0050	<0.0050	<0.0050
1,2-Dichloropropane	mg/l	-	<0.0010	<0.0010	<0.0010
1,3-Dichloropropane	mg/l	-	<0.0010	<0.0010	<0.0010
2,2-Dichloropropane	mg/l	-	<0.0010	<0.0010	<0.0010
1,1-Dichloropropene	mg/l	-	<0.0010	<0.0010	<0.0010
cis-1,3-Dichloropropene	mg/l	-	<0.0010	<0.0010	<0.0010
trans-1,3-Dichloropropene	mg/l	-	<0.0010	<0.0010	<0.0010
Ethylbenzene	mg/l	0.09	<0.0010	<0.0010	<0.0010
Hexachlorobutadiene	mg/l	0.0013	<0.0010	<0.0010	<0.0010
Isopropylbenzene	mg/l	-	<0.0010	<0.0010	<0.0010
p-Isopropyltoluene	mg/l	-	<0.0010	<0.0010	<0.0010
Naphthalene	mg/l	0.0011	<0.0010	<0.0010	<0.0010
n-Propylbenzene	mg/l	-	<0.0010	<0.0010	<0.0010
Styrene	mg/l	0.072	<0.0010	<0.0010	<0.0010
1,1,1,2-Tetrachloroethane	mg/l	-	<0.0010	<0.0010	<0.0010
1,1,2,2-Tetrachloroethane	mg/l	-	<0.0050	<0.0050	<0.0050
Tetrachloroethene	mg/l	0.111	<0.0010	<0.0010	<0.0010
Toluene	mg/l	0.002	<0.0010	<0.0010	<0.0010
1,2,3-Trichlorobenzene	mg/l	0.008	<0.0010	<0.0010	<0.0010
1,2,4-Trichlorobenzene	mg/l	0.024	<0.0010	<0.0010	<0.0010
1,1,1-Trichloroethane	mg/l	-	<0.0010	<0.0010	<0.0010
1,1,2-Trichloroethane	mg/l	-	<0.0010	<0.0010	<0.0010
Thrichloroethene	mg/l	0.021	<0.0010	<0.0010	<0.0010
Trichlorofluoromethane	mg/l	-	<0.0010	<0.0010	<0.0010
1,2,3-Trichloropropane	mg/l	-	<0.0020	<0.0020	<0.0020
1,2,4-Trimethylbenzene	mg/l	-	<0.0010	<0.0010	<0.0010
1,3,5-trimethyl benzene	mg/l	-	<0.0010	<0.0010	<0.0010
Vinyl chloride	mg/l	-	<0.020	<0.020	<0.020
o-Xylene	mg/l	-	<0.0010	<0.0010	<0.0010
m+p-Xylenes	mg/l	-	<0.0010	<0.0010	<0.0010
Surrogate: 4-Bromofluorobenzene	%	-	102	103	103

Data from Hatfield / CDM (2010) collected in January 2010

CCME 2007 Canadian Water Quality Guidelines for the Protection of Aquatic Life

Bold: CCME standard is exceeded; shaded:

Non detectable values represented as "<" with detection limit.

See Figure 15 for sample locations.

Table A4.17. Water Quality in Phu Loc River

Parameter	Unit	QCVN 08:2009		USEPA Fresh water (CCC)	Phu Loc River					
					NM2		NM3		NM4	
		Domestic Use	Non-Domestic Use		Flood Tide	Ebb Tide	Flood Tide	Ebb Tide	Flood Tide	Ebb Tide
pH	-	6-8.5	5.5-9	6.5-9	7.66	7.54	8	8	8	8
BOD_5	mg/l	<4	<25	-	890	880	1,045	1,005	130	215
COD	mg/l	<10	50	-	1,540	1,630	1,900	1,990	420	465
DO	mg/l	≥ 6	≥ 2	-	4.12	4.63	4	4	4.4	4.52
Salinity	$^0/_{00}$	-	-	-	0.89	0.31	2	1	1.43	0.98
SS	mg/l	20	100	-	718	485	757	580	375	270
NO_3^-(as N)	mg/l	2	15	-	0.64	0.58	0.87	1.45	0.1	0.19
NH_4^+(as N)	mg/l	0.1	1	-	12.86	17.39	15.01	21.95	4.15	8.15
$P\text{-}PO_4^{3-}$	mg/l	0.1	0.5	-	2.98	2.09	5.3	2.19	0.11	1.06
Total Coliform	MNP/ 100ml	2,500	10,000	-	30,603	28,103	18,103	33,103	5,603	14,103
E. coli	MNP/ 100ml	20	200	-	-	-	-	-	-	-

Source: PIIP-PMU (2007).

QCVN 08:2009 – Vietnam surface water quality standards.

USEPA NRWQC – 2009 US EPA National Recommended Water Quality Criteria, 2009.

CCC = criterion continuous concentration (chronic).

Bold: USEPA standard is exceeded.

Shaded: QCVN 08:2009 domestic use standard exceeded.

See Figure 15 for sample locations.

Table A4.18. Water Quality at Phu Loc Bridge

Variable	Units	QCVN 08:2009		USEPA Freshwater (CCC)	2006			2007			2008									
		Domestic Use	Non-Domestic Use		July-Aug	Sept-Oct	Nov	July-Aug	Sept-Oct	Nov	March	March	May	May	July	July	Sept	Sept	Nov	Nov
Temperature	°C	-	-	-	28.1	28.2	28.2	30.5	30.7	25.6	23.7	28.8	30.4	31.2	33.6	34.2	29.6	31.5	22.1	26.5
pH	-	6-8.5	5.5-9	6.5-9	7.94	7.47	7.8	7.36	6.88	**6.46**	8.41	7.33	7.6	7.5	7.67	7.9	7.08	7.14	6.92	**6.47**
BOD_5	mg/l	<4	<25	-	685.2	400	49.5	86.3	83.4	57.3	6.3	98.4	93.7	82.3	42.9	70.7	61.2	63.4	62.1	51.3
COD	mg/l	<10	50	-	1508	1660	199	220	229	128	12	185	169	157	81	160	110	120	131	103
DO	mg/l	≥ 6	≥ 2	-	0.45	1.99	4.59	1.62	1.57	-	7.33	1.13	4.2	4	2.95	1.86	0.81	0.57	-	-
Sal	$^0/_{00}$	-	-	-	17	0.4	9.5	-	-	-	31.9	6.2	14.2	8.2	20.1	18.6	0.6	0.9	0.9	0.5
SS	mg/l	20	100	-	226	173	35	19.8	73.33	66.7	17.5	60	64.5	62.4	39.2	62.3	35.5	30.6	29.1	28.7
Turbidity	NTU	-	-	-	9.73	9	43.6	38	37	12	3636	41.81	30	29.09	16.36	72.72	34.54	39.09	16.36	14.54
NO_2	mg/l	0.01	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NO_3^-(as N)	mg/l	2	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NH_4^+(as N)	mg/l	0.1	1	-	3442	1432	0.552	4421	0.041	3789	0.642	7333	7.93	4.87	1763	3486	1343	1068	10.34	9.19
Total N	mg/l	-	-	-	10510	5.74	4200	25.24	22.73	3670	0.136	10510	0.46	0.51	0.415	2492	10.51	11.91	0.003	0.04
Total P	mg/l	-	-	-	1472	3.58	1.52	0.73	0.508	0.95	0.114	1310	10.59	9.74	6.28	8.15	0.088	0.087	7.54	7.01
H_2S	mg/l	-	-	-	-	-	-	-	-	-	0.004	0.024	0.003	0.006	0.02	0.035	0.009	0.01	0.004	0.008
F^-	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	mg/l	0.02	0.05	0.0025	**0.015**	0.0017	**0.0035**	**0.00834**	**0.01123**	**0.00829**	**0.00382**	**0.00464**	**0.00541**	**0.00398**	**0.00376**	**0.00614**	0.00065	0.00027	0.00153	0.00142
As	mg/l	0.01	0.1	0.15	-	-	-	-	-	-	-			-	-	-	-	-	-	-
Hg	mg/l	0.001	0.002	0.00077	0.00032	0.000541	**0.0013**	0.00042	0.00023	0.00016	0.00027	0.00036	0.00042	0.00042	0.00041	0.00038	**0.00316**	**0.00103**	**0.00214**	**0.00386**
Mn	mg/l	0.1	0.1	-	0.022	0.2296	0.0681	0.26153	0.16452	0.06186	0.24281	0.32894	0.28761	0.30258	0.15642	0.22764	0.18423	0.21763	0.14286	0.20728
Cr	mg/l	0.01	0.005	-	0.002	0.004	ND	0.005	0.002	0.003	0.003	0.005	0.006	ND	0.006	0.01	0.009	0.008	ND	ND
Fe	mg/l	0.5	2	1	0.561	**1374**	0.032	0.952	0.369	0.612	0.044	0.72	0.791	0.403	0.573	0.745	0.888	0.827	0.274	0.252
Cd	mg/l	0.005	0.01	0.00025	**0.00055**	ND	**0.1279**	**0.00031**	**0.00046**	**0.00046**	**0.00042**	**0.00067**	**0.00039**	**0.00064**	**0.00051**	**0.00076**	**0.00089**	**0.0075**	**0.00118**	**0.00649**
Zn	mg/l	0.5	2	0.12	0.01515	0.0426	0.0436	0.03762	0.04235	0.03485	0.06227	0.08271	0.06327	0.08071	0.07281	0.06583	0.0227	0.0845	0.02865	0.01286
CN	mg/l	0.005	0.01	0.0052	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol		0.005	0.02	-	-	-	-	ND	ND	ND	ND	ND	ND	ND	0.003	0.005	0.002	ND	ND	0.002
Oil	mg/l	0.01	0.3	-	-	0.2	0.1	0.18	0.24	0.46	0.2	0.29	0.2	0.2	0.25	0.31	3.72	4.01	4.61	4.82
Total Coliform	MNP/ 100ml	2,500	10,000	-	4,300	21,000	5,000	2,300,000	11,000	70,000	1,000	21,000	21,000	23,000	9,500	11,000	11,000	11,000	11,000	9,500

Source: Nguyen (2009b).

QCVN 08:2009 – Vietnam surface water quality standards.

USEPA NRWQC – 2009 US EPA National Recommended Water Quality Criteria, 2009.

CCC = criterion continuous concentration (chronic).

Bold: USEPA standard is exceeded.

Shaded: QCVN 08:2009 domestic use standard exceeded.

See Figure 15 for sample locations.

Table A4.19. Air Quality on Airport Property

Variable	Units	TCVN 5938: 2005	USEPA NAAQS	Sample Location					
				K1	K2	K3	K4	K5	K6
Temperature	^{0}C	-	-	34.4	34.4	35.6	35.7	35.7	36.5
Humidity	%	-	-	56	56	56	56	56	55
TSP	mg/m	0.3	-	0.07	0.09	0.12	0.11	0.171	0.28
SO_2	mg/m	0.35	1.3[1]	0.03	0.029	0.036	0.033	0.035	0.047
NO_2	mg/m	0.2	0.1[2]	0.026	0.024	0.032	0.027	0.03	0.041
CO	mg/m	30	10[3]	3.56	3.42	3.78	3.62	3.69	4.75
Hydrocarbons		5	-	1.12	1.09	1.35	1.24	1.27	2.85

Source: Da Nang Center for Environmental Technology (2009).

TCVN 5937:2005 – Vietnam Air Quality Standard.

USEPA NAAQS: National Ambient Air Quality Standards.

[1] 3-hour averaging of secondary standards (for the protection of public welfare).

[2] Annual mean for the primary standard (for the protection of human health).

[3] 8-hour exposure not to be exceeded once a year for the primary standard (for the protection of human health).

See Figure 15 for sample locations.

APPENDIX A5

DETAILED CALCULATIONS FOR ASSESSMENT OF PROJECT-AFFECTED WATER

Table A5.1 Project Affected Water – Passive Landfill.

	Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[2]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season 1970-2009 Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season 1998-2009 Max 24 hr Rainfall (mm)	Max 24 hr Volume (m^3)
A.	Operation of temporary storage and dewatering area	11	11	21,000	0.2	72.2	3,336	166.6	700
B.1	MLA Excavation + PISA	2	0.5	5,700	0.5	72.2	102.9	166.6	475
C.1	SA & Drainage Ditch Excavation	2	0.5	12,950	0.5	72.2	233.7	166.6	1,079
E.	Placement of contaminated material in landfill	4	1	5,250	0.2	72.2	75.8	166.6	175
TOTAL							**3,748**		**2,428**

	Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[2]	Total Duration (months)	Duration Exposed (days)[2]	Total Length of Open Excavation Perimeter[3] (m)	Proposed Excavation Depth Below Ground[4] (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[5]	K_{max} (m/d)[5]	dh/dl[6]	Q_{min} (m^3/d)[7]	Q_{max} (m^3/d)[7]	$Volume_{min}$ (m^3)	$Volume_{max}$ (m^3)
B.2	MLA Excavation & PISA	22,800	5,700	2	15	302	1.1	0	0	1.42	19	0.0004	0.00	0.00	0	0
C.2	SA Excavation & drainage ditch	51,800	12,950	2	15	455	1.6	0.1	46				0.026	0.35	0.39	5.19

	Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
D.	Sediment Excavation[8]	31,800	30%	11,130	3,339
TOTAL					**3,339**

	Activity	Lifespan (years)	Area (m^2) - excluding support facilities	Wet Season 1970-2009 Annual Average Rainfall (mm)	Annual Average Leachate (60% of Precipitation) (mm)	Total Lifespan Volume (m^3)	Wet Season 1998-2009 Max 24 hr Rainfall (mm)	Max 24 hr Leachate (60% of Precipitation) (mm)	Max 24 hr Volume (m^3)
G.	Operation of Landfill - leachate[9]	50	21,000	405	243	255,150	592.6	356	**7467**
TOTAL						**255,150**			**7467**

TOTAL VOLUME (m^3)	**262,242**

[1] Excavations occur during the dry season.
[2] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration
[3] Although groundwater flow is expected to flow primarily in a northerly direction, to calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter; excavation area is assumed to be a square
[4] Worst case expected dry season groundwater levels were taken into consideration (1.5 mbgs). Office 33, 2008 report indicates groundwater levels in the dry season are generally measured between 2.0 – 2.5 mbgs.
[5] Hydraulic conductivity (K) values for the shallow aquifer on the airport site are quoted in the range of 1.42 – 19 m/day. Note: these values have not been validated in terms of the location of wells tested or how the k values were calculated.
[6] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow topographic relief. MOD staff (pers. comm. 2009) indicates that there is a 2 m difference in topographic elevation from the southern to northern end of the Airport (4.5 km). An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004.
[7]

$$Q = \frac{dh}{dl} K A$$

Q is the total groundwater discharge (m^3/d)

[8] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35
[9] Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate (Visvanathan C., Trankler, P. Kuruparan, Q. Xiaoning 2003).
Rainfall data source - Nguyen Hoang Van 2009a

Table A5.2 Project Affected Water – Active Landfill.

	Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[2]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season 1970-2009 Monthly Average Rainfall (mm)	Wet Season 1970-2009 Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season 1998-2009 Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season 1998-2009 Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
A.	Operation of temporary storage and dewatering area - dry season	11	11	53,000	0.2	72.2	---	8,418.5	166.6	1,766	---	---
A.	Operation of temporary storage and dewatering area - wet season	4	4	53,000	0.7	---	402.9	59,790	---	---	592.6	31,408
B.1	MLA Excavation & PISA	2	0.5	5,700	0.5	72.2	---	102.9	166.6	475	---	---
C.1	SA & Drainage Ditch Excavation	2	0.5	12,950	0.5	72.2	---	233.7	166.6	1,079	---	---
E.	Placement of contaminated material in landfill	4	1	6,750	0.2	72.2	---	97.5	166.6	225	---	---
TOTAL								**68,643**		**3,544**		**31,408**

	Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[2]	Total Duration (months)	Duration Exposed (days)[2]	Total Length of Open Excavation Perimeter[3] (m)	Proposed Excavation Depth Velow Ground[4] (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[5]	K_{max} (m/d)[5]	dh/dl[6]	Q_{min} (m^3/d)[7]	Q_{max} (m^3/d)[7]	$Volume_{min}$ (m^3)	$Volume_{max}$ (m^3)
B.2	MLA Excavation & PISA	22,800	5,700	2	15	302	1.1	0	0	1.42	19	0.0004	0.00	0.00	0	0
C.2	SA Excavation & drainage ditch	51,800	12,950	2	15	455	1.6	0.1	46				0.026	0.35	0.39	5.19

	Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
D.	Sediment Excavation[8]	31,800	30%	11,130	3,339
TOTAL					**3,339**

	Activity	Lifespan (years)	Area (m^2) - excluding support facilities	Wet season 1970-2009 Annual Average Rainfall (mm)	Annual Average Leachate (60% of Precipitation) (mm)	Total Lifespan Volume (m^3)	Wet Season 1998-2009 Max 24 hr Rainfall (mm)	Max 24 hr Leachate (60% of Precipitation) (mm)	Max 24 hr Volume (m^3)
G.	Operation of Landfill - leachate[9]	10	27,000	405	243	65,610	592.6	356	**9,600**
TOTAL						**65,610**			**9,600**

TOTAL VOLUME (m^3)	**137,597**

[1] Excavations occur during the dry season.
[2] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration
[3] Although groundwater flow is expected to flow primarily in a northerly direction, to calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.
[4] Worst case expected dry season groundwater levels were taken into consideration (1.5 mbgs). Office 33, 2008 report indicates groundwater levels in the dry season are generally measured between 2.0 – 2.5 mbgs.
[5] Hydraulic conductivity (K) values for the shallow aquifer on the airport site are quoted in the range of 1.42 – 19 m/day. Note: these values have not been validated in terms of the location of wells tested or how the k values were calculated.
[6] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow topographic relief. MOD staff (pers. comm. 2009) indicates that there is a 2 m difference in topographic elevation from the southern to northern end of the Airport (4.5 km). An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004.
[7]

$$Q = \frac{dh}{dl} K A$$

Q is the total groundwater discharge (m^3/d)

[8] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35
[9] Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate (Visvanathan C., Trankler, P. Kuruparan, Q. Xiaoning 2003).
Rainfall data source (Nguyen Hoang Van 2009a)

Table A5.3 Project Affected Water – Thermal Desorption.

	Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[2]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season 1970-2009 Monthly Average Rainfall (mm)	Wet Season 1970-2009 Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season 1998-2009 Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season 1998-2009 Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
B.1	MLA Excavation	2	0.5	5,700	0.5	72.2	---	102.9	166.6	475	---	---
C.1	SA & Drainage Ditch Excavation	1	0.25	12,950	0.5	72.2	---	116.9	166.6	1,079	---	---
F.1	Soil Stockpile - Set-up & Maintenance (dry season)	1	1	7,300	0.05	72.2	---	26.4	166.6	61	---	---
F.1	Soil Stockpile - Treatment (dry season)	5	5	7,300	0.9	72.2	---	2,372	166.6	1,095	---	---
F.1	Soil Stockpile - Treatment (wet season)	1	1	7,300	0.9	---	402.9	2,647	---	---	592.6	3,893
F.2	Sediment Stockpile - Set-up & Maintenance (dry season)	3	3	8,100	0.05	72.2	---	87.7	166.6	67	---	---
F.2	Sediment Stockpile - temporary cap (wet season)	4	4	8,100	0.9	---	402.9	11,749	---	---	592.6	4,320
F.2	Sediment Stockpile - treatment (dry season)	6	6	8,100	0.9	72.2	---	3,158	166.6	1,215	---	---
TOTAL								**20,259**		**3,991**		**8,213**

	Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[2]	Total Duration (months)	Duration Exposed (days)[2]	Total Length of Open Excavation Perimeter[3] (m)	Proposed Excavation Depth Below Ground[4] (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[5]	K_{max} (m/d)[5]	dh/dl[6]	Q_{min} (m^3/d)[7]	Q_{max} (m^3/d)[7]	$Volume_{min}$ (m^3)	$Volume_{max}$ (m^3)
B.2	MLA Excavation & PISA	22,800	5,700	2	15	301.9933774	1.1	0	0	1.42	19	0.0004	0.00	0.00	0	0
C.2	SA Excavation & drainage ditch	51,800	12,950	2	15	455	1.6	0.1	46				0.026	0.35	0.39	5.19

	Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
D.	Sediment Excavation[8]	31,800	30%	11,130	3,339
TOTAL					**3,339**

TOTAL VOLUME (m^3)	**23,603**

[1] Excavations occur during the dry season.

[2] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[3] Although groundwater flow is expected to flow primarily in a northerly direction, to calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[4] Worst case expected dry season groundwater levels were taken into consideration (1.5 mbgs). Office 33, 2008 report indicates groundwater levels in the dry season are generally measured between 2.0 – 2.5 mbgs.

[5] Hydraulic conductivity (K) values for the shallow aquifer on the airport site are quoted in the range of 1.42 – 19 m/day. Note: these values have not been validated in terms of the location of wells tested or how the k values were calculated.

[6] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow topographic relief. MOD staff (pers. comm. 2009) indicates that there is a 2 m difference in topographic elevation from the southern to northern end of the Airport (4.5 km). An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004.

[7] $$Q = \frac{dh}{dl} K A$$ Q is the total groundwater discharge (m^3/d)

[8] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

[9] Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate (Visvanathan C., Trankler, P. Kuruparan, Q. Xiaoning 2003).

Rainfall data source - Nguyen Hoang Van 2009a

APPENDIX A6

DESCRIPTION OF MODEL OF POTENTIAL EXPOSURE TO DIOXIN, DUST, AND OTHER COPCS

APPENDIX A6. DESCRIPTION OF MODEL OF POTENTIAL EXPOSURE TO DIOXIN, DUST, AND OTHER COPCS

A6.1 INTRODUCTION AND BACKGROUND

This appendix describes a model developed to assess the potential environmental effects associated with a number of Project activities involving handling of dioxin-contaminated material, release of this material into the air, and potential exposure to this material by persons working and living on or near the Airport property.

The following cannot be stated strongly enough: *the purpose of this model is not to predict what the actual, quantitative exposure of persons living and working on the Airport property or in the vicinity of the Airport to dioxin will be as a result of the Project alternatives; this is not intended to be a formal risk assessment*. The purpose of this model is to provide a means of being able to quantitatively compare each of the Project alternatives with respect to potential environmental effects associated with handling of dioxin-contaminated material, release of this material into the air, and potential exposure to this material by persons working and living on or near the Airport property.

The model does not consider potential effects of handling dioxin-contaminated material on Project construction workers; these workers will be protected through various means that will be specified in the Component 3 Health and Safety Plan.

The indicator that the model described below calculates is relative cumulative potential exposure. Cumulative potential exposure is potential exposure from all sources of dioxin contamination considered in the model added together for each Project alternative. Relative potential exposure is defined in two ways:

- Relative contamination of the material being handled in each Project activity (described below); and
- The cumulative potential exposures for each Project alternative are scaled to the lowest cumulative potential exposure of any Project alternative (described below).

A6.2 MODEL DESCRIPTION

The Airport property and the surrounding area, a total area of approximately 18 km^2, was gridded into a series of 1 ha cells, 3.3 km from west to east and 5.4 km from south to north (Figure A6.1); each grid is 100 m on a side. The population of each of the grids was estimated using district-level population data and visual estimation of the amount of residential settlement in each grid cell on the satellite image (Figure A6.1). The Project activities in each Project alternative with potential sources of dioxin-contaminated material were mapped onto this grid.

The relative cumulative potential exposure, RTPE, for any given alternative is:

$$RTPE = \frac{TPE}{\min(TPE_{pl}, TPE_{al}, TPE_{th})}$$

where:

TPE_{pl} is the total potential exposure for the Passive Landfill alternative (pl);

TPE_{al} is the total potential exposure for the Active Landfill alternative (al); and

TPE_{th} is the total potential exposure for the Thermal Desorption alternative (th).

TPE, total cumulative potential exposure for a given Project alternative, is calculated as follows:

$$TPE = \sum_{i=1}^{33} \sum_{j=1}^{54} \frac{PE_{i,j} POP_{i,j}}{TPOP}$$

where:

$PE_{i,j}$ is the cumulative potential exposure in cell i,j;

$POP_{i,j}$ is the estimated population of residents in cell i,j; and

TPOP is the total estimated population of residents in the entire area being considered (Figure A6.1).

The calculation of $PE_{i,j}$, the cumulative potential exposure in any given location (cell), is based on a modified standard Gaussian air quality dispersion model:

$$PE_{i,j} = \sum_{k=1}^{nk} \sum_{a=1}^{33} \sum_{b=1}^{54} W_y \frac{RC_k DP_k T_k I_{k,a,b}}{2\pi\sigma_y\sigma_z} e^{-\frac{y^2}{2\sigma_y^2}}$$

where:

$PE_{i,j}$ is the cumulative potential exposure of residents in cell i,j;

nk is the total number of different potential sources of potential exposure to dioxin (varies with each Project alternative, Table A6.1);

y is the horizontal direction of cell i,j relative to cell a,b (radians);

W_y is the relative frequency with which wind direction is in the y direction (based on wind direction data summarized in the Affected Environment section of the EA);

σ_y is the horizontal standard deviation of the plume (assumes Pasquill stability class D – neutral conditions)

σ_z is the vertical standard deviation of the plume (assumes Pasquill stability class D – neutral conditions)

RC_k is the relative contamination of the material being handled in Project activity k, with RC_k for contaminated soils = 1, RC_k for contaminated sediments = 0.33, and RC_k for mixed contaminated soils and sediments = 0.67. These relative values are derived from scaling the average dioxin concentrations in contaminated soils and sediments reported in Appendix A2.

DP_k is "dispersion potential" for the contaminated material being handled in Project alternative k; that is, the ability of the particular contaminated material to be released into the air. This factor captures the fact that different contaminated materials have different moisture contents and therefore different susceptibilities to being released into the air from wind or simple disturbance during handling. For example, the dispersion potential of dry, dewatered soil or sediment is higher than wet, just-excavated soil, which in turn is higher than just-excavated sediment which would contain a relatively high proportion of water. Values of DP_k are estimated with professional judgment (Table A6.1).

$I_{k,a,b}$ is the proportion of the area of cell a,b over Project activity k is occurring.

Tk is the relative length of time for which Project activity k is scheduled (derived from the indicative implementation schedules).

Parameter values for these variables are provided in Table A6.1.

TABLE A6.1 MODEL PARAMETER VALUES

Potential Source of Dioxin-Contaminated Material	RC[1]	DP[2]	T[3]	I
All Project Alternatives				
Excavation of Contaminated Soils from Former Mixing and Loading Area	1	0.01	2	0.00003[4]
Excavation of Contaminated Material from Former Storage Area and Drainage Ditch	1	0.01	2	0.00003[4]
Excavation of Contaminated Sediments from Sen Lake	0.33	0.001	4	0.00003[4]
Passive Landfill Alternative				
Temporary Storage and Dewatering Area During Filling with Contaminated Soils	1	0.01	2	0.06[5]
Temporary Storage and Dewatering Area During Filling with Contaminated Sediments	0.33	0.001	2	0.06[5]
Temporary Storage and Dewatering Area During Loading of Dewatered Contaminated Soils onto Haul Trucks	1	1	2	0.06[5]
Temporary Storage and Dewatering Area During Loading of Dewatered Contaminated Sediments onto Haul Trucks	0.33	1	2	0.06[5]
Hauling Dewatered Contaminated Soils to Landfill	1	1	2	0.00003[4]
Hauling Dewatered Contaminated Sediments to Landfill	0.33	1	2	0.00003[4]
Placement of Contaminated Soil into Landfill	1	1	2	0.09[6]
Placement of Contaminated Sediments into Landfill	0.33	1	2	0.09[6]

TABLE A6.1 MODEL PARAMETER VALUES

Potential Source of Dioxin-Contaminated Material	RC[1]	DP[2]	T[3]	I
Active Landfill Alternative				
Temporary Storage and Dewatering Area During Filling with Contaminated Soils	1	0.01	2	0.06[5]
Temporary Storage and Dewatering Area During Filling with Contaminated Sediments	0.33	0.001	2	0.06[5]
Temporary Storage and Dewatering Area During Loading of Dewatered Contaminated Material onto Haul Trucks	0.67	1	5	0.06[5]
Hauling Dewatered Contaminated Soils to Landfill	1	1	2	0.00003[4]
Hauling Dewatered Contaminated Sediments to Landfill	0.33	1	2	0.00003[4]
Placement of Contaminated Materials into Landfill	1	1	5	0.18[7]
ISTD/IPTD Alternative				
Construction of Contaminated Soils Stockpile	1	0.01	2	0.15[8]
Construction of Contaminated Sediments Stockpile	.33	0.001	2	0.15[8]

[1] Derived from scaling the average dioxin concentrations in contaminated soils and sediments reported in Section 4

[2] Captures effect of different moisture contents of contaminated materials and therefore different susceptibilities to being released into the air from wind or simple disturbance during handling

[3] Set to the total number of months required to complete the Project activity – values obtained from indicative schedules for each Project alternative

[4] Represents hauling of contaminated soil, assuming 15 loaded trucks per hour, 8 hour workday, truck speed of 20 km/hr, and area of truck bed of 12 m^2

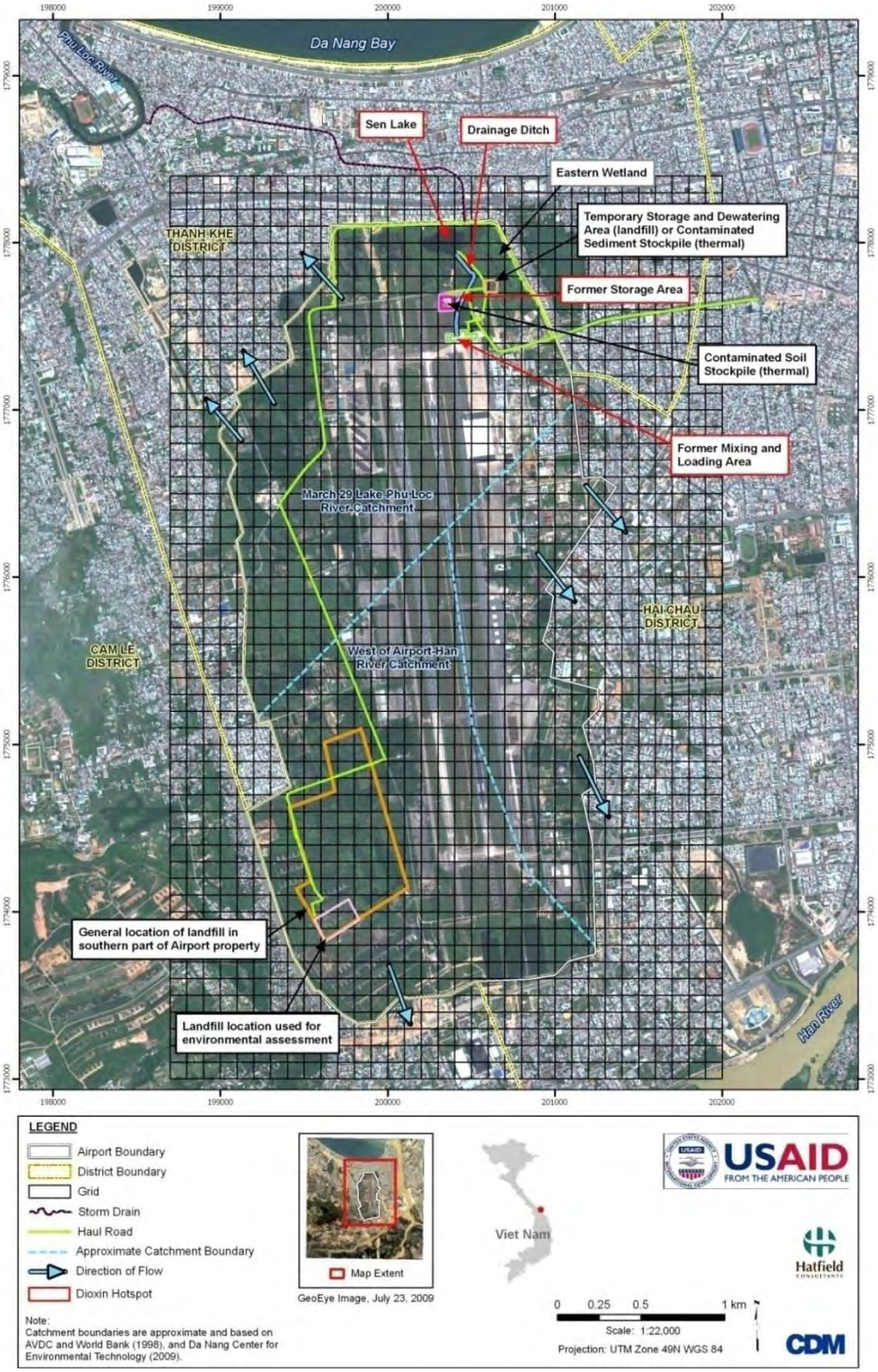
[5] Area of temporary storage and dewatering area is 2.1 ha (passive) 5.3 ha (active), 10% of facility assumed to be exposed during filling for 1/3 of the total time during filling (i.e., 8 hours per day)

[6] Assumes 1/8th of landfill area is open for 8 hours per day during filling and total landfill area is 2.1 ha

[7] Assumes ¼ of landfill area is open for 8 hours per day during filling and total landfill area is 2.7 ha

[8] Assumes total stockpile area is 1.54 ha and 1/3 of total stockpile area is exposed on average throughout the construction period.

Figure A6.1 Grid used for potential exposure model.



APPENDIX A7

DETAILED CALCULATIONS FOR ASSESSMENT OF GREENHOUSE GAS EMISSIONS

Table A7.1 GHG Calculations for Passive Landfill.

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[2]	Duration (mths)	Duration (hours)[2]	Total Fuel Usage (L)	LHV Diesel (MJ/L)[3]	kg CO_2/GJ[3]	t CO_2
A.	Construction of Temporary Storage & Dewatering Area	Dozer, Compactor, Grader	3	45	2	448	60480	37	74.1	165.8
A.	Operation of Temporary Storage & Dewatering Area	Dozer	1	45	11	2464	110880	37	74.1	304.0
F.	Construction of Decontamination Areas[1]	Dozer, Compactor, Grader	3	45	0.5	112	15120	37	74.1	41.5
B.	Road Upgrades [1]	Paver, 14 m^3 Truck	2	45	1	224	20160	37	74.1	55.3
C.	Landfill Construction - Establish subgrade & liner and leachate collection system	Dozer, Grader	2	45	5	1120	100800	37	74.1	276.4
J.	SA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	2	448	60480	37	74.1	165.8
K.	MLA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	2	448	60480	37	74.1	165.8
K.	PISA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	0.25	56	7560	37	74.1	20.7
L.	Sediment Excavation	3 Dozers	3	45	4	896	120960	37	74.1	331.6
M.	Backfilling Excavations	Dozer, Compactor	2	45	1	224	20160	37	74.1	55.3
O.	Landfill Capping[1]	Dozer, Compactor, Grader. Temporary Cap 1 month. Final Cap 3 months	3	45	4	896	120960	37	74.1	331.6
	TOTAL									**1913.8**

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per One-Way Trip (km)[4]	# of Full Loads[5]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[6]	Full Load + Truck Weight (t)	Emission Factor (kg CO2-e/ton-km)[7]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
C.	Landfill Construction - Establish subgrade & liner and leachate collection system	Haul trucks	75,000	14	15	5892.9	88392.9	5892.9	88392.9	1.8	20	45.2	0.159	281,089.3	635,261.8	916.4
F.	Construction of Decontamination Areas[1]	Haul trucks	1,200	14	15	94.3	1414.3	94.3	1414.3	1.8	20	45.2	0.159	4,497.4	10,164.2	14.7
A.	Import Fill for temporary storage & dewatering areas	Haul trucks	24,900	14	15	1956.4	29346.4	1956.4	29346.4	1.8	20	45.2	0.159	93,321.6	210,906.9	304.2
G.	Hauling soil from MLA and SA to Dewatering Area	Haul trucks	28,400	14	0.2	2434.3	486.9	2434.3	486.9	1.8	20	45.2	0.159	1,548.2	3,498.9	5.0
G.	Hauling soil from PISA to Dewatering Area	Haul trucks	1,400	14	7.5	120.0	900.0	120.0	900.0	1.8	20	45.2	0.159	2,862.0	6,468.1	9.3
G.	Hauling sediment from Sen Lake/Eastern Hotspot/Drainage Ditch to Dewatering Area	Haul trucks	23,300	27	0.4	1035.6	414.2	1035.6	414.2	1.8	35	83.6	0.159	2,305.1	5,506.0	7.8
I.	Hauling contaminated soil (MLA/SA) to landfill	Haul trucks	28,400	14	7.5	2434.3	18257.1	2434.3	18257.1	1.8	20	45.2	0.159	58,057.7	131,210.4	189.3
I.	Hauling contaminated soil (PISA) to landfill	Haul trucks	1,400	14	0.2	120.0	24.0	120.0	24.0	1.8	20	45.2	0.159	76.3	172.5	0.2
I.	Hauling contaminated sediment to landfill	Haul trucks	31,800	27	7.5	1413.3	10600.0	1413.3	10600.0	1.8	35	83.6	0.159	58,989.0	140,899.4	199.9
M.	Backfilling Excavation (MLA/SA/PISA)	Dump trucks	29,800	14	15	2341.4	35121.4	2341.4	35121.4	1.8	20	45.2	0.159	111,686.1	252,410.7	364.1
	TOTAL															**2,010.9**

TOTAL t CO_2	**3,925**

[1] Assumptions made by Hatfield as site specific data unavailable at time of analysis

[2] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers & Los Angeles Memorial Coliseum. Renovation Project, Draft Environmental Impact Report, 2003). Assume equipment runs 8 hours/day, 7 days/week.

[3] Economics of Greenhouse Gas Limitations - Vietnam. Hydrometeorological Service of Vietnam, Hanoi. 1999; Greenhouse Gas Protocol Initiative. 2005. Calculating CO2 Emissions from Mobile Sources v1.3. Accessed http://www.ghgprotocol.org Jan-10.

[4] Soil/gravel source assumed 7.5 km to the west based on Vietnamese topographical map, assuming exiting site from NE side (haul road 7.5 km)

[5] Volume expansion due to excavation - factor of 1.2 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill

[6] Based on Cat 770 Off Hwy Truck (www.cat.com)

[7] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 kg CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.

Table A7.2 GHG Calculations for Active Landfill.

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[2]	Duration (mths)	Duration (hours)[2]	Total Fuel Usage (L)	LHV Diesel (MJ/L)[3]	kg CO_2/GJ[3]	t CO_2
A.	Construction of Temporary Storage & Dewatering Area	Dozer, Compactor, Grader	3	45	2	448	60480	37	74.1	165.8
A.	Operation of Temporary Storage & Dewatering Area	Dozer	1	45	14	3136	141120	37	74.1	386.9
F.	Construction of Decontamination Areas[1]	Dozer, Compactor, Grader	3	45	0.5	112	15120	37	74.1	41.5
B.	Road Upgrades[1]	Paver, 14 m^3 Truck	2	45	1	224	20160	37	74.1	55.3
C.	Landfill Construction - Establish subgrade & liner and leachate collection system	Dozer, Grader	2	45	5	1120	100800	37	74.1	276.4
J.	SA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	2	448	60480	37	74.1	165.8
K.	MLA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	2	448	60480	37	74.1	165.8
K.	PISA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	0.25	56	7560	37	74.1	20.7
L.	Sediment Excavation	3 Dozers	3	45	4	896	120960	37	74.1	331.6
M.	Backfilling Excavations	Dozer, Compactor	2	45	1	224	20160	37	74.1	55.3
O.	Landfill Capping[1]	Dozer, Compactor, Grader. Final Cap 3 months	3	45	3	672	90720	37	74.1	248.7
	TOTAL									**1913.8**

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[4]	# of Full Loads[5]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[6]	Full Load + Truck Weight (t)	Emission Factor (kg CO2-e/ton-km)[7]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
C.	Landfill Construction - Establish subgrade & liner and leachate collection system	Haul trucks	100,000	14	15	7857.1	117857.1	7857.1	117857.1	1.8	20	45.2	0.159	374,785.7	847,015.7	1,221.8
F.	Construction of Decontamination Areas[1]	Haul trucks	1,200	14	15	94.3	1414.3	94.3	1414.3	1.8	20	45.2	0.159	4,497.4	10,164.2	14.7
A.	Import Fill for temporary storage & dewatering areas	Haul trucks	63,000	14	15	4950.0	74250.0	4950.0	74250.0	1.8	20	45.2	0.159	236,115.0	533,619.9	769.7
G.	Hauling soil from MLA and SA to Dewatering Area	Haul trucks	28,400	14	0.2	2434.3	486.9	2434.3	486.9	1.8	20	45.2	0.159	1,548.2	3,498.9	5.0
G.	Hauling soil from PISA to Dewatering Area	Haul trucks	1,400	14	7.5	120.0	900.0	120.0	900.0	1.8	20	45.2	0.159	2,862.0	6,468.1	9.3
G.	Hauling sediment from Sen Lake/Eastern Hotspot/Drainage Ditch to Dewatering Area	Haul trucks	23,300	27	0.4	1035.6	414.2	1035.6	414.2	1.8	35	83.6	0.159	2,305.1	5,506.0	7.8
N.	Importing bulking material[8]	Haul trucks	24,080	14	15	2064.0	30960.0	2064.0	30960.0	1.8	20	45.2	0.159	98,452.8	222,503.3	321.0
I.	Hauling contaminated soil (MLA/SA) to landfill	Haul trucks	28,400	14	7.5	2434.3	18257.1	2434.3	18257.1	1.8	20	45.2	0.159	58,057.7	131,210.4	189.3
I.	Hauling contaminated soil (PISA) to landfill	Haul trucks	1,400	14	0.2	120.0	24.0	120.0	24.0	1.8	20	45.2	0.159	76.3	172.5	0.2
I.	Hauling contaminated sediment to landfill	Haul trucks	31,800	27	7.5	1413.3	10600.0	1413.3	10600.0	1.8	35	83.6	0.159	58,989.0	140,899.4	199.9
M.	Backfilling Excavation	Dump trucks	29,800	14	15	2341.4	35121.4	2341.4	35121.4	1.8	20	45.2	0.159	111,686.1	252,410.7	364.1
	TOTAL															**3,102.8**

	Activities	Source of GHGs	Lifespan (years)	kWh/Year[9]	Total kWh	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[10]	VN Electricity from Natural Gas[10]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[3]	Natural Gas (kg CO_2/GJ)[3]	t CO_2 (Coal)	t CO_2 (Natural Gas)
Q.	Operation of Active Landfill	Electricity	10	33,200	332,000	3,600,000	1,195	14%	38%	167	454	98.3	56.1	16.4	25.5
	TOTAL														**41.9**

TOTAL t CO_2	**5,059**

[1] Assumptions made by Hatfield as site specific data unavailable at time of analysis
[2] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers & Los Angeles Memorial Coliseum. Renovation Project, Draft Environmental Impact Report, 2003). Assume equipment runs 8 hours/day, 7 days/week.
[3] Economics of Greenhouse Gas Limitations - Vietnam. Hydrometeorological Service of Vietnam, Hanoi. 1999; Greenhouse Gas Protocol Initiative. 2005. Calculating CO2 Emissions from Mobile Sources v1.3. Accessed http://www.ghgprotocol.org Jan-10.
[4] Soil/gravel source assumed 7.5 km to the west based on Vietnamese topographical map, assuming exiting site from NE side (haul road 7.5 km)
[5] Volume expansion due to excavation - factor of 1.2 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[6] Based on Cat 770 Off Hwy Truck (www.cat.com)
[7] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 kg CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[8] Assuming 40% of the total contaminated soil/sediment required, as per CDM correspondence
[9] Assumes two pumps and a blower running 4 hours per day
[10] http://web.worldbank.org, Vietnam & Energy: Meeting the Financing Needs in the Power Sector. Accessed 12-Jan-10.

Table A7.3 GHG Calculations for Thermal Desorption.

	Activities	Source of GHGs	t CO_2[1]
F.	Thermal Treatment System Construction	Equipment	276
	TOTAL		**276**

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[2]	Duration (mths)	Duration (hours)[2]	Total Fuel Usage (L)	LHV Diesel (MJ/L)[3]	kg CO_2/GJ[3]	t CO_2
G.	Construction of Decontamination Areas[1]	Dozer, Compactor,	3	45	0.25	56	7560	37	74.1	20.7
E.	Pile Construction	Dozer, Compactor,	3	45	5	1120	151200	37	74.1	414.5
J.	SA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	1	224	30240	37	74.1	82.9
K.	MLA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	2	448	60480	37	74.1	165.8
K.	PISA Excavation	Dozer, Grader, Art-Wheel Loader	3	45	0.25	56	7560	37	74.1	20.7
L.	Sediment Excavation	3 Dozers	3	45	4	896	120960	37	74.1	331.6
M.	Backfilling Excavations	Dozer, Compactor	2	45	1	224	20160	37	74.1	55.3
	TOTAL									**1091.6**

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[4]	# of Full Loads[5]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[6]	Full Load + Truck Weight (t)	Emission Factor (kg CO2-e/ton-km)[7]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
E.	Pile Construction - importing fill	Haul trucks	46,000	14	15	3614.3	54214.3	3614.3	54214.3	1.8	20	45.2	0.159	172,401.4	389,627.2	562.0
G.	Construction of Decontamination Areas[1]	Haul trucks	600	14	15	47.1	707.1	47.1	707.1	1.8	20	45.2	0.159	2,248.7	5,082.1	7.3
H.	Hauling soil from MLA to SA stockpile	Haul trucks	19,500	14	0.2	1671.4	334.3	1671.4	334.3	1.8	20	45.2	0.159	1,063.0	2,402.4	3.5
H.	Hauling contaminated soil (PISA) to stockpile	Haul trucks	1,400	14	7.5	120.0	900.0	120.0	900.0	1.8	20	45.2	1.159	20,862.0	47,148.1	68.0
H.	Hauling sediment from Sen Lake/Eastern Hotspot/Drainage ditch to stockpile	Haul trucks	31,800	14	0.4	2725.7	1090.3	2725.7	1090.3	1.8	20	45.2	0.159	3,467.1	7,835.7	11.3
M.	Backfilling Excavation	Dump trucks	29,800	14	15	2341.4	35121.4	2341.4	35121.4	1.8	20	45.2	0.159	111,686.1	252,410.7	364.1
P.	Stockpile Removal	Dump trucks	97,300	14	3	7645.0	22935.0	7645.0	22935.0	1.8	20	45.2	0.159	72,933.3	164,829.3	237.8
	TOTAL															**1,254.0**

	Activities	Source of GHGs	kWh/pile[9]	Total kWh (2 piles)	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[9]	VN Electricity from Natural Gas[19]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[3]	Natural Gas (kg CO_2/GJ)[3]	t CO_2 (Coal)	t CO_2 (Natural Gas)
Q.	Thermal Treatment System Operation	Electricity	21,000,000	42,000,000	3,600,000	151,200	14%	38%	21,168	57,456	98.3	56.1	2,080.8	3,223.3
	TOTAL													**5,304.1**

TOTAL t CO_2	**7,926**

[1] Assumptions made by Hatfield as site specific data unavailable at time of analysis; thermal system construction assumed to be equivalent to "landfill construction - establish subgrade and leachate collection system"
[2] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers & Los Angeles Memorial Coliseum. Renovation Project, Draft Environmental Impact Report, 2003). Assume equipment runs 8 hours/day, 7 days/week.
[3] Economics of Greenhouse Gas Limitations - Vietnam. Hydrometeorological Service of Vietnam, Hanoi. 1999; Greenhouse Gas Protocol Initiative. 2005. Calculating CO2 Emissions from Mobile Sources v1.3. Accessed http://www.ghgprotocol.org Jan-10.
[4] Soil/gravel source assumed 7.5 km to the west based on Vietnamese topographical map, assuming exiting site from NE side (haul road 7.5 km)
[5] Volume expansion due to excavation - factor of 1.2 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[6] Based on Cat 770 Off Hwy Truck (www.cat.com)
[7] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 kg CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[8] Based on Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010
[9] http://web.worldbank.org, Vietnam & Energy: Meeting the Financing Needs in the Power Sector. Accessed 12-Jan-10.

2005 Electricity Statistics
hydro - 39% natural gas - 38% coal - 14% oil - 5% diesel generators - 6%

APPENDIX A8

HOST GOVERNMENT STAKEHOLDER MEETING SUMMARIES

March 16, 2010

Presentation of the Draft Environmental Assessment

Ha Noi, Vietnam

Environmental Remediation at Da Nang Airport
Assessments and Engineering Planning and Design

Presentation of the Draft Environmental Assessment
March 16, 2010
Melia Hotel, Function Room 7
Hanoi, Vietnam
8:00-17:00

MEETING MINUTES

1.0 Introductions

The United States Agency for International Development (USAID) Mission Director, Mr. Francis A. Donovan opened the meeting stating the goal is to review the Draft Environmental Assessment (EA) findings and identify the most appropriate alternative for remediation of Da Nang Airport. He noted this as an example of the continuing partnership that has developed between USAID and Office 33. The Director of Office 33, Dr. La Minh Hien, welcomed participants and expressed his appreciation for the opportunity to review and discuss the findings of the EA. All meeting participants introduced themselves.

2.0 Meeting Purpose

The purpose of the meeting was:

2.1 To present the findings of the Draft EA for Dioxin Remediation at Da Nang Airport;

2.2 To obtain stakeholder input into the assumptions used for completing the EA;

2.3 To obtain consensus on the technology option to be selected as the "preferred" alternative for the EA, for which the Environmental Impact Assessment (EIA) and further designs, plans and specifications will be developed.

3.0 The Draft Environmental Assessment

The Draft EA evaluated four alternatives for addressing dioxin contamination at Da Nang Airport that were identified as part of the scoping process and evaluation of site conditions at the Airport. Although the full range methods for addressing dioxin site clean up were evaluated, only three technology options were considered appropriate for the Da Nang context. The CDM team presented a summary of each of these alternatives which included: 1) No Action; 2) Passive Landfill Containment; 3) Active Landfill Containment; and 4) In-Situ/In Pile Thermal Desorption (ISTD/IPTD) Destruction. Conceptual designs (i.e., 10% designs) were prepared for each alternative which were then evaluated for effectiveness, suitability for application at the Da Nang site, environmental impacts, and costs (estimates with range of -30% to +50% calculated in accordance with United States Environmental Protection Agency [USEPA] Superfund guidance). A summary of each of the alternatives was presented.

3.1 No Action:

No Action is not considered an appropriate alternative because current concentrations of dioxin substantially exceed USEPA's proposed preliminary clean up goals for dioxin in soil and the Government of Vietnam's (GVN's) national dioxin standards for soil and sediment.

3.2 Passive Landfill:

This alternative would involve construction of a secure onsite landfill on the airport premises and removal, dewatering, transport and deposition of contaminated material into the landfill. This approach would securely contain dioxin for 50 years, and is an approved option for addressing dioxin at contaminated sites in the United States. This would require construction of a large above ground landfill (2.5 football fields in area and 1.5 stories high), and hauling of approximately 5,000 truckloads of contaminated material through residential areas to the landfill site. A minimum of 50 years of operation and maintenance (O&M) and environmental monitoring and management would be necessary. At the end of this period, dioxin levels in soil contained in the landfill would remain significantly above clean up goals. Construction of a new landfill

or dioxin destruction would be necessary at that time, with an additional significant cost.

The EA identifies a number of environmental impacts associated with the passive landfill alternative. The most significant include risks from unexploded ordnance (UXO), potential impacts on surface water quality, contaminated fugitive dust exposure to workers and area residents, noise impacts, impacts to natural resources due to the large size of the footprint, and potential impacts associated with long term operation of the landfill. The environmental impact of this alternative was found to be lower than the No Action and Active Landfill alternatives, but significantly greater than the ISTD/IPTD alternative. Mitigation measures were identified for all impacts.

3.3 Active Landfill (Bioremediation):

The Active Landfill alternative would provide the same containment benefit as the Passive Landfill alternative. However, under this alternative, additives would be mixed with contaminated material to facilitate growth of bacteria that would destroy dioxin. These "bulking agents" would add 40% to the volume of material to be contained in the landfill, resulting in a much larger landfill (4 football fields in size built 1.5 stories high) and require almost 6,000 truckloads of haul to the site. Bioremediation has not been applied on a commercial scale for dioxin destruction; therefore, how to design a large landfill to facilitate the bioremediation process is uncertain. As a result, it is difficult to predict whether an active landfill would result in dioxin destruction to meet clean up goals. How long this process might take is also unknown, and as a result, it is difficult to determine the need for long term O&M and environmental monitoring and management. The EA assumed a 10 year period of long term O&M and environmental monitoring in its cost estimation.

Environmental impacts of the Active Landfill alternative are incrementally greater than those of the Passive Landfill due to the need for a larger temporary storage and dewatering area, and the need for a larger landfill footprint to accommodate the 40% increase in total volume of material. Greater contact with contaminated material would be necessary to mix it with bulking agents to facilitate the biological reaction

process. As a result, the environmental impacts associated with UXO, potential impacts on surface water quality, contaminated fugitive dust exposure to workers and area residents, noise impacts, and impacts to natural resources are greater than those of the Passive Landfill and significantly greater than those of the ISTD/ISPD alternative. Mitigation measures were identified for all impacts. Thus, this alternative has lower environmental impacts than the No Action alternative, although impacts are greater than the Passive Landfill and significantly greater than the ISTD/ISPD alternative.

3.4 In Situ/In Pile Thermal Desorption:

ISTD/IPTD is a cutting edge dioxin destruction technology. Dig and haul operations for this alternative would be required only to create temporary stockpiles near hotspot sites. The stockpiles would then be heated to 500-700 °C to destroy 95% of the dioxins in the pile. The remaining dioxin would be drawn through an air treatment system which removes the rest, resulting in air emissions that are below regulatory limits. This technology has been demonstrated at a similarly-sized dioxin site in Alhambra, California which was granted unrestricted land use status after treatment. The Government of Japan conducted a carefully controlled pilot test of ISTD/IPTD which led to the technology being approved for dioxin destruction in Japan.

ISTD/IPTD is preferred to the landfill alternatives because it would not require large storage and dewatering operations, upgrade of the haul routing, long hauling distance, UXO clearance and bunker decommissioning of the landfill site, construction of the landfill, and deposition of contaminated material into the landfill. As a result, there is considerably less handling and transport of dioxin contaminated soil and sediment, and far less environmental risk associated with the ISTD/IPTD process. Furthermore, this alternative would result in destruction of dioxin to clean up goals. For these reasons, the ISTD/IPTD alternative has the lowest environmental impacts of all of the other alternatives, and is the EA's preferred alternative.

3.5 Cost Estimates

The EA includes cost estimates for each of the three alternatives based on 10% engineering designs and Superfund guidance. Although there is a -30 to + 50% range around these estimates, they can be used for making reliable cost comparisons. The estimates do not include cost of UXO removal. Mid-range to upper bound cost estimates for the three technology alternatives is in the same range: $24-36 million for Passive Landfill; $21-32 million for Active Landfill; and $22-33 million for ISTP/IPTD. The primary cost difference between the Passive and Active Landfill options is that the Active Landfill would cost $4 million more to construct, but the O&M and environmental monitoring period is 10 years instead of 50 years assumed for the Passive Landfill.

3.6 EA Findings Summary

The ISTD/IPTD alternative was found to have the highest treatment effectiveness, the highest feasibility, the lowest environmental impact, and a cost in the same range as the other alternatives. The Passive Landfill alternative was the most expensive option, ranked third in terms of environmental impact, was possibly feasible in the context of the Da Nang site, and, while effective for containment, does not provide a final remedy. The Active Landfill alternative was associated with the highest environmental impact, while its effectiveness for destroying dioxin to clean up goals is uncertain. It is possibly feasible in the context of the Da Nang site although it is unclear whether it would provide a final remedy. No Action is not considered a viable alternative due to the high levels of dioxin contamination present at the site.

4.0 Discussion

The following presents the questions, responses, and discussions of the participants regarding the general findings of the Draft EA.

4.1 GVN stakeholders noted that the “No Action” is not a viable alternative for the Da Nang Airport project and it should not be included in the EA. USAID noted that inclusion of this alternative is required under its environmental compliances regulations to establish the project baseline

and to justify further action. This would not be considered in the EA as a "preferred alternative."

4.2 GVN noted that the EA should include incineration, chemical destruction, and other thermal remediation alternatives in addition to ISTD/IPTD. CDM noted that the EA did consider these as alternatives but none of them demonstrated effective full-scale treatment of dioxin to the clean up levels required for the Da Nang Airport. Regarding other thermal options, conventional incineration is done at higher temperatures, but is problematic in terms of air emissions (dioxins can be formed in the process). Ex-situ thermal desorption is much more expensive, treats smaller volumes of soil using a shorter residence time at higher temperatures, and is therefore not as desirable as in-situ treatment. The ISTD/IPTD technology, with longer residence times and lower temperatures has been shown to be more effective in removing dioxins safely (with fewer air emissions concerns) than other thermal options.

4.3 GVN noted that the Vietnamese labor rates used in the EA cost estimates were not reasonable and do not include the required hazard pay additions required for work at contaminated sites.

4.4 Ministry of Defense (MOD) and Middle Airport Corporation (MAC) representatives stated the project must be undertaken in a manner which does not affect local communities, MOD activities, and airport operations.

4.5 GVN representatives noted that ISTD/IPTD is a new technology which has not been discussed in detail and CDM needs to confirm the technical basis for using this technology prior to moving forward. They noted that if ISTD/IPTD can meet the criteria of GVN and is environmentally safe and cost-effective, then the stakeholders should focus on this alternative. They explained that CDM must provide all relevant data and information on this alternative so that GVN can make an informed decision on the best alternative.

4.6 A number of GVN representatives expressed concern that the Japanese ISTD/IPTD pilot study and the Alhambra, California site were not directly comparable to the conditions in Vietnam and could not be used

as the full basis to ensure the ISTD/IPTD technology would work at the Da Nang Airport. They stated that a treatability study would need to be conducted at Da Nang Airport prior to full-scale implementation.

4.7 A number of GVN representatives expressed concern regarding the availability of power needed to support the ISTD/IPTD treatment system (24,000,000 kilowatt hours [kwh]) over 2 years and noted the Da Nang Power Company must be consulted to ensure their capacity to provide this level of power at the price included in the cost estimate.

4.8 Office 33, MOD, and MAC expressed concern regarding a proposed landfill site in the southwestern area of the Da Nang Airport property. They suggested the footprint of the landfill be reduced and the ammunition bunkers be avoided. The possibility of constructing more than one landfill should be explored to reduce the impact to future land use and alternative sites, including Lake C, should be investigated further. The possibility of constructing an alternate, shorter haul route should be considered; however, it must not impact airport operations or cause a safety hazard.

4.9 MOD representatives expressed concern over a 2 year implementation schedule for landfill construction. They noted the landfill at Bien Hoa landfill took 4 years to construct.

4.10 Several GVN representatives expressed concern about the effectiveness of the Active Landfill alternative. They suggested that there was no basis for the EA's assumption that the Active Landfill could be operated and maintained for 10 years (i.e. less than the 50 years required for a landfill per GVN regulations). They noted the pilot studies on bioremediation in Vietnam have not indicated that this remedial alternative is feasible and the environmental and economic risk of this alternative is too high. They requested that this alternative be excluded from the assessment.

5.0 Conclusions and Recommendations

5.1 GVN will fully support and agree on using the best technology for destroying dioxins at the Da Nang Airport. The ISTD/IPTD alternative has many merits. The ISTD/IPTD alternative costs are in the same

range as both of the landfill alternatives and the EA demonstrates that ISTD/IPTD is the preferred alternative.

5.2 GVN requested CDM to develop a plan to test the ISTD/IPTD alternative which reflects the actual field conditions of the Da Nang Airport. Discussions need to be held with GVN counterparts on how best to design, implement, and test the ISTD/IPTD technology.

5.3 The Passive Landfill is an acceptable alternative for dioxin containment and is used in other international contexts. However, the environmental risk of remediation using this approach is high. This alternative does not provide a final remedy for dioxin contamination.

5.4 The Active Landfill alternative has not been proven in other international contexts. GVN does not support further discussion of this alternative in the context of the Da Nang remediation effort.

5.5 CDM needs to continue to work with the Da Nang Power Company on the electricity issue and work with MOD on the costs and labor policy issues. Office 33 will work with CDM, MOD, and MAC to ensure we have a successful outcome.

Environmental Remediation at Da Nang Airport
Assessments and Engineering Planning and Design

Presentation of the Draft Environmental Assessment
March 16, 2010
Melia Hotel, Function Room 7
Hanoi, Vietnam
8:00-17:00

LIST OF PARTICIPANTS

Representatives from National Steering Committee 33 Science Advisory Committee	
Nguyễn Văn Minh, Consultant	Nguyễn Xuân Nết
Nguyen Duc Hue	
Representatives from Office 33	
Lai Minh Hien, Director	Vu Chien Thang, Deputy Director
Le Thi Hai Le, Department of International Relations	Nguyen My Hang, Department of Science, Technology and International Relation
Cao Thi Thu Huong	Mai Dinh Mui
Nguyen Thi Thanh Hoa	Nguyen Thanh Hai
Representatives from the Ministry of Defense	
Pham Ngoc Canh, Agency for Science, Technology and Environment	Tran Ngoc Tam , Agency for Science, Technology and Environment
Ngo Kien Cuong,, ADCC Company Air Force Command	Nguyen Hong Minh, ADCC Company Air Force Command
Nguyen Van Vi, High Command of Chemical Arms	Nguyen Manh That, High Command of Engineers Arms
Do Ngoc Lanh, Vietnam-Russia Tropical Centre	Vu Duc Hung, Strategy Department, General Staff
Tran Trong Hieu, Air Force and Air Defense Services	
Representatives from the Civil Aviation Agency of Vietnam	
Nguyen Ngoc Toan	Vu Thi Thanh

LIST OF PARTICIPANTS (CONTINUED)

Representative of the Middle Airport Corporation	
Le Van Tien	
Representatives of the Ministry of Natural Resources and Environment	
Nguyen Truong Huynh, General Department of Environment: Department for Waste Management	
Representatives from the United States Government	
Francis A. Donovan, Mission Director, USAID/Vietnam	Andrew Herrup, Environment, Health, Science, and Technology Officer, US Embassy/Vietnam
Barbara Britton, Environmental Health and Remediation Advisor, USAID/Vietnam	Richard Nyberg, Communications and Outreach Advisor, USAID/Vietnam
Representatives from USAID's Environmental Remediation at Da Nang Airport Project	
Randa Chichakli, Chief of Party, CDM International	Kent Sorenson, Lead Practitioner, CDM International (by teleconference)
Thomas Boivin, Senior Technical Advisor, Hatfield Consultants	Tam Diep Minh, Senior Technical Advisor, CDM International
Jeff Montera, Component 3 Leader, CDM International	Peter Chenevey, Component 2 Leader, CDM International
Peter McNamee, Component 1 Leader, Hatfield Consultants	John Gavin, Mobilization/Home Office Project Manager, CDM International
Peter Macy, Client Services Manager, CDM International	Dung Vu Thuy, Assistant, CDM International

Environmental Remediation at Da Nang Airport
Assessments and Engineering Planning and Design

Presentation of the Draft Environmental Assessment
March 16, 2010
Melia Hotel, Function Room 7
Hanoi, Vietnam
8:00-17:00

AGENDA

Registration -- Coffee and Tea	*8:00AM*
Welcoming Remarks (Francis A. Donovan, Mission Director USAID/Vietnam)	**8:30 AM**
Introductions (Dr. Hien, Office 33)	**8:40 AM**
Presentation of Draft Environmental Assessment (CDM):	**8:45 AM**
• Approach • Common Project Activities and Key Environmental Issues • Brief Description of Alternatives • Comparison of Alternatives • Summary of Environmental Assessment Findings	
Break	*10:00AM*
In-Situ/In-Pile Thermal Desorption (ISTD/IPTD) Presentation (CDM) and Discussion:	**10:30AM**
• Conceptual Design and Schedule • Effectiveness, Implementability, Environmental Impact • Cost Estimation	
Lunch (will be provided)	*12:00PM*
Passive Landfill Presentation (CDM) and Discussion:	**1:00PM**
• Conceptual Design and Schedule • Effectiveness, Implementability, Environmental Impact • Cost Estimation	
Active Landfill Presentation (CDM) and Discussion:	**2:00PM**
• Conceptual Design and Schedule • Effectiveness, Implementability, Environmental Impact • Cost Estimation	
Break	*3:00PM*
Selection of the Preferred Remedial Alternative	**3:30PM**
Adjourn	**5:00PM**

March 18, 2010

Presentation of the Draft Environmental Assessment

Da Nang, Vietnam

Environmental Remediation at Da Nang Airport
Assessments and Engineering Planning and Design

Presentation of the Draft Environmental Assessment
March 18, 2010
Saigontourane Hotel, Meeting Hall
Da Nang, Vietnam
8:00-11:30

MEETING MINUTES

1.0 Introductions

The Deputy Director of Office 33, Dr. Vu Chien Thang, opened the meeting stating the goal is to review the Draft Environmental Assessment (EA) findings for remediation of Da Nang Airport and receive input from Da Nang stakeholders. The Environment, Health, Science, and Technology Officer of the United States Embassy/Vietnam, Mr. Andrew Herrup, welcomed participants and expressed his appreciation for the meeting attendees' participation and involvement in the project. All meeting participants introduced themselves.

2.0 Meeting Purpose

The purpose of the meeting was:

2.1 To present the findings of the Draft EA for Dioxin Remediation at Da Nang Airport;

2.2 To obtain stakeholder input on the "preferred" alternative for the EA, for which the Environmental Impact Assessment (EIA) and further designs, plans and specifications will be developed.

3.0 The Draft Environmental Assessment

The Draft EA evaluated four alternatives for addressing dioxin contamination at Da Nang Airport that were identified as part of the scoping process and evaluation of site conditions at the Airport. Although the full range methods for

addressing dioxin site clean up were evaluated, only three technology options were considered appropriate for the Da Nang context. The CDM team presented a summary of each of these alternatives which included: 1) No Action; 2) Passive Landfill Containment; 3) Active Landfill Containment; and 4) In-Situ/In Pile Thermal Desorption (ISTD/IPTD) Destruction. Conceptual designs (i.e., 10% designs) were prepared for each alternative which were then evaluated for effectiveness, suitability for application at the Da Nang site, environmental impacts, and costs (estimates with range of -30% to +50% calculated in accordance with United States Environmental Protection Agency [USEPA] Superfund guidance). A summary of each of the alternatives was presented.

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No Action is not considered an appropriate alternative because current concentrations of dioxin substantially exceed USEPA's proposed preliminary clean up goals for dioxin in soil and the Government of Vietnam's (GVN's) national dioxin standards for soil and sediment.

3.2 Passive Landfill:

This alternative would involve construction of a secure onsite landfill on the airport premises and removal, dewatering, transport and deposition of contaminated material into the landfill. This approach would securely contain dioxin for 50 years, and is an approved option for addressing dioxin at contaminated sites in the United States. This would require construction of a large above ground landfill (2.5 football fields in area and 1.5 stories high), and hauling of approximately 5,000 truckloads of contaminated material through residential areas to the landfill site. A minimum of 50 years of operation and maintenance (O&M) and environmental monitoring and management would be necessary. At the end of this period, dioxin levels in soil contained in the landfill would remain significantly above clean up goals. Construction of a new landfill or dioxin destruction would be necessary at that time, with an additional significant cost.

The EA identifies a number of environmental impacts associated with the passive landfill alternative. The most significant include risks from unexploded ordnance (UXO), potential impacts on surface water quality,

contaminated fugitive dust exposure to workers and area residents, noise impacts, impacts to natural resources due to the large size of the footprint, and potential impacts associated with long term operation of the landfill. The environmental impact of this alternative was found to be lower than the No Action and Active Landfill alternatives, but significantly greater than the ISTD/IPTD alternative. Mitigation measures were identified for all impacts.

3.3 Active Landfill (Bioremediation):

The Active Landfill alternative would provide the same containment benefit as the Passive Landfill alternative. However, under this alternative, additives would be mixed with contaminated material to facilitate growth of bacteria that would destroy dioxin. These "bulking agents" would add 40% to the volume of material to be contained in the landfill, resulting in a much larger landfill (4 football fields in size built 1.5 stories high) and require almost 6,000 truckloads of haul to the site. Bioremediation has not been applied on a commercial scale for dioxin destruction; therefore, how to design a large landfill to facilitate the bioremediation process is uncertain. As a result, it is difficult to predict whether an active landfill would result in dioxin destruction to meet clean up goals. How long this process might take is also unknown, and as a result, it is difficult to determine the need for long term O&M and environmental monitoring and management. The EA assumed a 10 year period of long term O&M and environmental monitoring in its cost estimation.

Environmental impacts of the Active Landfill alternative are incrementally greater than those of the Passive Landfill due to the need for a larger temporary storage and dewatering area, and the need for a larger landfill footprint to accommodate the 40% increase in total volume of material. Greater contact with contaminated material would be necessary to mix it with bulking agents to facilitate the biological reaction process. As a result, the environmental impacts associated with UXO, potential impacts on surface water quality, contaminated fugitive dust exposure to workers and area residents, noise impacts, and impacts to natural resources are greater than those of the Passive Landfill and significantly greater than those of the ISTD/ISPD alternative. Mitigation

measures were identified for all impacts. Thus, this alternative has lower environmental impacts than the No Action alternative, although impacts are greater than the Passive Landfill and significantly greater than the ISTD/ISPD alternative.

3.4 In Situ/In Pile Thermal Desorption:

ISTD/IPTD is a cutting edge dioxin destruction technology. Dig and haul operations for this alternative would be required only to create temporary stockpiles near hotspot sites. The stockpiles would then be heated to 500-700 °C to destroy 95% of the dioxins in the pile. The remaining dioxin would be drawn through an air treatment system which removes the rest, resulting in air emissions that are below regulatory limits. This technology has been demonstrated at a similarly-sized dioxin site in Alhambra, California which was granted unrestricted land use status after treatment. The Government of Japan conducted a carefully controlled pilot test of ISTD/IPTD which led to the technology being approved for dioxin destruction in Japan.

ISTD/IPTD is preferred to the landfill alternatives because it would not require large storage and dewatering operations, upgrade of the haul routing, long hauling distance, UXO clearance and bunker decommissioning of the landfill site, construction of the landfill, and deposition of contaminated material into the landfill. As a result, there is considerably less handling and transport of dioxin contaminated soil and sediment, and far less environmental risk associated with the ISTD/IPTD process. Furthermore, this alternative would result in destruction of dioxin to clean up goals. For these reasons, the ISTD/IPTD alternative has the lowest environmental impacts of all of the other alternatives, and is the EA's preferred alternative.

3.5 Cost Estimates

The EA includes cost estimates for each of the three alternatives based on 10% engineering designs and Superfund guidance. Although there is a -30 to + 50% range around these estimates, they can be used for making reliable cost comparisons. The estimates do not include cost of UXO removal. Mid-range to upper bound cost estimates for the three technology alternatives is in the same range: $24-36 million for Passive

Landfill; $21-32 million for Active Landfill; and $22-33 million for ISTP/IPTD. The primary cost difference between the Passive and Active Landfill options is that the Active Landfill would cost $4 million more to construct, but the O&M and environmental monitoring period is 10 years instead of 50 years assumed for the Passive Landfill.

3.6 EA Findings Summary

The ISTD/IPTD alternative was found to have the highest treatment effectiveness, the highest feasibility, the lowest environmental impact, and a cost in the same range as the other alternatives. The Passive Landfill alternative was the most expensive option, ranked third in terms of environmental impact, was possibly feasible in the context of the Da Nang site, and, while effective for containment, does not provide a final remedy. The Active Landfill alternative was associated with the highest environmental impact, while its effectiveness for destroying dioxin to clean up goals is uncertain. It is possibly feasible in the context of the Da Nang site although it is unclear whether it would provide a final remedy. No Action is not considered a viable alternative due to the high levels of dioxin contamination present at the site.

4.0 Discussion

The following presents the questions, responses, and discussions of the participants regarding the general findings of the Draft EA.

4.1 A representative from the Ministry of Defense (MOD) summarized his review of the EA findings as follows: 1) No Action" is not a viable alternative for the Da Nang Airport project; 2) the Vietnamese process for ranking the alternatives uses stars rather than the numerical ranking procedure used in the Draft EA; 3) the total destruction of dioxins is a major advantage of the ISTD/IPTD alternative; however, electrical requirements, air emissions, and ultimate use of treated soils/sediments must be considered; and 4) key disadvantages of the landfill alternatives are the long haul road and that the landfills would remain in place for 20+ years.

4.2 A representative from the Middle Airport Corporation (MAC) stated the ISTD/IPTD alternative is the most suitable because it minimizes

impacts to the Airport planning and future land use; however, the dust, air emissions, and equipment obstructions to airport operations must be considered. He noted there are plans for future development of the airport 300 meters to the north, as well as planned developments in the south; therefore, it is impossible to construct landfills in these areas.

4.3 A representative from the Cam Le District explained there are three wards in Cam Le which are adjacent to the Da Nang Airport. He stated that treating soils in-situ is a more favorable alternative than transporting contaminated materials because it would pose less risk and fewer environmental impacts to the nearby residences.

4.4 MOD and Office 33 representatives stated the Vietnamese labor rates must be revised so they include the hazard pay additions required for work at contaminated sites (+20% special conditions, 4 hour work days for respirator work, and hazard working condition supplement). The incentives and compensation pay structure for hazard working conditions are confidential regulations and approval from the Prime Minister of Vietnam is required to release these pay rates. In addition, the power rates must be revised to reflect actual rates from the Da Nang Power Company.

4.5 A representative from MOD noted the EA provides a very good picture of potential environmental impacts from the hazardous waste perspective, specifically air emissions and other exposure risk; however, additional information is required regarding “non-waste” impacts such as psychological, land use, and airport operational impacts. It was clarified that in addition to addressing air emission impacts, the EA evaluated the impact to land use/land disturbance area. In addition, the EIA will be prepared to meet the requirements of the GVN to include non-environmental impacts.

4.6 MOD representatives stated MOD is willing and able to assist with UXO clearance to meet the project requirements for both the soil and sediment areas requiring clearance. UXO clearance costs are stipulated by the Prime Minister and MOD on a hectare basis and are typically 300,000,000 VND per hectare. MOD will need detailed information on the areas requiring UXO clearance including expected depth of excavation to provide an accurate cost estimate.

4.7 MOD discussed the importance of ensuring that ISTD/IPTD will treat soil to below the clean up levels (1000 parts per trillion [ppt] for soil and 150 ppt for sediment). A treatability study is necessary to demonstrate the ISTD/IPTD technology is effective at the Da Nang Airport. A technical seminar should be held with CDM, the ISTD/IPTD experts who would be implementing the technology at Da Nang, and GVN counterparts to discuss the details of the design and to develop a plan to test the effectiveness ISTD/IPTD alternative at the Da Nang Airport.

4.8 Representatives from MOD, Office 33, Cam Le District, MAC, and the Civil Aviation Agency of Vietnam (CAAV) expressed concern how the release of toxic by-products is prevented from the ISTD/IPTD system and whether ISTD/IPTD treated soil could be used to backfill the excavations or reused for some other purpose such as the foundation of a new runway.

4.9 A representative from Air Force Division 372 explained the Da Nang Airport property (including civil, commercial, and military portions) belongs to MOD and is under the administration of Air Force Division 372. The only areas available for a landfill are in the north and northwest portions of the property; the west and southwest portions of the airport property cannot be used for a landfill as these areas will be used for a cooperative program with European companies for airplane equipment.

5.0 Conclusions and Recommendations

5.1 GVN will fully support and agree on using the best technology for destroying dioxins at the Da Nang Airport. The ISTD/IPTD alternative has many merits. The ISTD/IPTD alternative costs are in the same range as both of the landfill alternatives and the EA demonstrates that ISTD/IPTD is the preferred alternative.

5.2 GVN requested CDM to develop a plan to test the ISTD/IPTD alternative which reflects the actual field conditions of the Da Nang Airport. Discussions need to be held with GVN counterparts on how best to design, implement, and test the ISTD/IPTD technology.

5.3 The extent and depth of contamination will be determined soon based on the recent sampling results.

5.4 A detailed EIA will be prepared according to GVN standards.

5.5 CDM needs to continue to work with the Da Nang Power Company on the electricity issue and work with MOD on the costs and labor policy issues. Office 33 will work with CDM, MOD, and MAC to ensure we have a successful outcome.

Environmental Remediation at Da Nang Airport
Assessments and Engineering Planning and Design

Presentation of the Draft Environmental Assessment
March 18, 2010
Saigontourane Hotel, Meeting Hall
Da Nang, Vietnam
8:00-11:30

LIST OF PARTICIPANTS

Representatives from Office 33	
Vu Chien Thang, Deputy Director	Nguyen My Hang, Department of Science, Technology and International Relation
Mai Dinh Mui	
Representatives from the Ministry of Defense	
Pham Ngoc Canh, Agency for Science, Technology and Environment	Tran Ngoc Tam , Agency for Science, Technology and Environment
Bui Quoc Hung, High Command of Engineers Arms	
Representatives from the Army Corps 372	
Nguyen Van Dinh, Agency for Science, Technology and Environment	
Representatives from the Civil Aviation Agency of Vietnam	
Nguyen Ngoc Toan	Vu Thi Thanh
Trinh Manh Hoa	
Representative of the Middle Airport Corporation	
Le Van Tien	
Representatives from District Governments Adjacent to the Airport	
Nguyen Hanh Xuan, Thank Khe District	Ho Manh Vinh, Hai Chau District
Tran Chi, Cam Le District	
Representatives from the United States Government	
Barbara Britton, Environmental Health and Remediation Advisor, USAID/Vietnam	Andrew Herrup, Environment, Health, Science, and Technology Officer, US Embassy/Vietnam
Representatives from USAID's Environmental Remediation at Da Nang Airport Project	
Randa Chichakli, Chief of Party, CDM International	Peter McNamee, Component 1 Leader, Hatfield Consultants
Thomas Boivin, Senior Technical Advisor, Hatfield Consultants	Peter Chenevey, Component 2 Leader, CDM International
Jeff Montera, Component 3 Leader, CDM International	John Gavin, Mobilization/Home Office Project Manager, CDM International
Tam Diep Minh, Senior Technical Advisor, CDM International	Dung Vu Thuy, Assistant, CDM International

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AGENDA

Registration/Coffee and Tea	*8:00AM*
Opening/Introductions, Dr. V.C. Thang, Deputy Director, Office 33	**8:30AM**
Purpose of the Environmental Assessment, Barbara Britton, USAID/Vietnam	**8:40 AM**
Presentation of Environmental Assessment, CDM	**8:50AM**
• Common Project Activities and Key Environmental Issues	
• Description of Alternatives	
• Comparison of Alternatives	
• Summary of Environmental Assessment Findings	
Break	*10:00AM*
Selection of the Preferred Remedial Alternative	**10:30AM**
Open Discussion and Questions	
Adjourn	**11:30AM**

March 18, 2010

Discussion of ISTD/IPTD Follow-Up Details

Da Nang, Vietnam

Environmental Remediation at Da Nang Airport
Assessments and Engineering Planning and Design

Discussion of ISTD/IPTD Follow-Up Details
March 18, 2010
Saigontourane Hotel, Meeting Hall
Da Nang, Vietnam
13:30-15:00

MEETING MINUTES

1.0 Meeting Purpose

The purpose of the meeting was:

1.1 To discuss the planned Scientific Roundtable on In-Situ/In-Pile Thermal Desorption (ISTD/IPTD);

1.2 To review the schedule for the next phase of the Da Nang remediation project;

1.3 To discuss cost assumptions for electricity rates and Vietnamese labor rates for implementation of the ISTD/IPTD technology at Da Nang;

1.4 To determine how to address the proposed landfill site in the Environmental Assessment (EA).

2.0 ISTD/IPTD Scientific Roundtable

CDM's technical expert, Dr. Kent Sorenson, and Terra Therm, the ISTD/IPTD contractor, will come to Vietnam in late April/early May to hold a Scientific Roundtable to discuss details of the ISTD/IPTD technology with Office 33 and the Ministry of Defense (MOD). Office 33 will invite relevant Vietnamese scientists who are working with this technology to the Scientific Roundtable.

CDM will provide any available relevant literature and details of the ISTD/IPTD treatability study (equipment, system configuration, soils/sediments to be included, size of the study) to the participants prior to the meeting.

3.0 Project Schedule

Under CDM's contract with the United States Agency for International Development (USAID), two additional tasks have been added to the project which were unexpected: 1) evaluation of the ISTD/IPTD alternative in the EA, and 2) conducting a treatability study of the ISTD/IPTD technology. Therefore, the CDM project will continue until at least the end of this year (instead of the originally expected end date of September 30, 2010) and USAID will amend the CDM contract accordingly.

CDM will develop a new schedule with a detailed project implementation schedule that will be provided to Office 33 via USAID. The assistance from Office 33 will be required to coordinate this schedule with the Middle Airport Corporation (MAC).

4.0 Cost Assumptions

CDM will provide details of the ISTD/IPTD power requirements to Office 33. Office 33 will forward these requirements to the Da Nang Power Company in an official letter, and CDM and Office 33 will meet with the relevant electrical authorities during the late April/early May meeting in Vietnam to continue discussions. MOD and Office 33 recommended that official documentation, perhaps a Memorandum of Understanding (MOU), should be obtained of any agreements made regarding electrical rates for the remedy implementation.

Vietnamese labor rates used in the EA cost estimates must follow standard GVN rates and must include the appropriate hazard pay supplements. CDM, USAID, and Office 33 must work together to acquire official GVN documentation to support the rates used in the EA.

5.0 Landfill Siting

MOD outlined the criteria for landfill site selection as follows, in order of importance: 1) The site must not interfere with national interests; 2) The site must not overlap with current airport structures; and 3) The site must meet environmental standards.

MOD explained the proposed site in the southwest portion of the airport property does not meet the first criterion, nor does it meet the second criterion

due to the presence of the ammunition bunkers. However, USAID noted the proposed areas in the northern portion of the airport property do not meet USAID safety requirements.

6.0 Conclusions and Recommendations

6.1 Based on the EA results, USAID's intent is to select ISTD/IPTD as the alternative for the Da Nang Airport and proceed with the full scale design and Environmental Impact Statement (EIA). If the treatability study shows that the ISTD/IPTD technology will not be effective at the Da Nang Airport, then the Passive Landfill will be selected as the most appropriate alternative for implementation. Office 33 agreed with this approach.

6.2 GVN will participate in a Scientific Roundtable to further discuss the ISTD/IPTD alternative.

6.3 CDM will work with Office 33 to develop the best approach to get the required information on electricity supply, unexploded ordnance (UXO) clearance, and Vietnamese labor rates.

6.4 All three landfill sites (two in the north and one in the southwest) will remain in the EA as options; the limitations of each site will be described in the EA, and if the landfill alternative is selected, then additional discussions will be held to identify the most appropriate site.

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