PERFORMANCE EVALUATION OF USAID'S ENVIRONMENTAL REMEDIATION AT DANANG AIRPORT

October 2018

This publication was produced at the request of the United States Agency for International Development. It was prepared independently by Integra LLC under the Learning, Evaluation, and Analysis project (LEAP III).

FINAL EVALUATION REPORT

PERFORMANCE EVALUATION OF USAID'S ENVIRONMENTAL REMEDIATION AT DANANG AIRPORT

Contract Title:	LEAP III: Learning, Evaluation, and Analysis Project
Contract Number:	GS-10F-083CA / 7200AA18M0004
Activity Number:	LEAP III 2018-01
Submitted:	Final Version – October 25, 2018
Contractor:	Integra Government Services International LLC 1100 Vermont Avenue NW, Suite 750 Washington, DC 20005
	Limestone Analytics LLC (Subcontractor)
USAID Office:	USAID Office of Economic Growth, Education and Environment (E3), Office of Economic Policy
	USAID/Vietnam
COR:	Yoon Lee

ABSTRACT

The Performance Evaluation of USAID's Environmental Remediation at Danang Airport Project answered five evaluation questions on project goals, cost effectiveness of the project's chosen remediation technology, economic benefits, stakeholder perceptions, and lessons learned. The evaluation looked at prevailing literature on dioxin contamination, recent economic development surrounding Danang Airport, comparable remediation technologies, and conducted key informant interviews to formulate findings for each evaluation question. The evaluation found that the project achieved its high-level goal of remediating dioxin contaminated areas, and made recommendations for improvements in the areas of Project Planning, Soil Characterization, Communication, Stakeholder Involvement, and Demobilization. The lessons learned will inform USAID efforts in the upcoming Dioxin Remediation efforts at Bien Hoa airport.

TABLE OF CONTENTS

ACRONYMS

AAD	Activity Approval Document
ADAFC	Air Defense – Air Force Command
BCD	Based Catalyzed Decomposition
CC	Chemical Command
CDM	CDM International
CDCS	Country Development and Cooperation Strategy
CEA	Cost-Effectiveness Analysis
CMU	Concrete Masonry Unit
COP	Chief of Party
COR	Contracting Officer's Representative
DONRE	Provincial Departments of Natural Resources and Environment
EA	Environmental Assessment
EDSO	Office of Environment and Social Development
EIA	Environmental Impact Assessment
EOP	End of Project
EQ	Evaluation Question
EVSA	Excess Volume Storage Area
FCR	Findings, Conclusions, and Recommendations
GVN	Government of Vietnam
H&S	Health and Safety
IPTD	In-Pile Thermal Desorption
ISTD	In-Situ Thermal Desorption
kg	Kilograms
KII	Key Informant Interview
LWIC	Lightweight Insulating Concrete
m^2	Square Meter
m^3	Cubic Meter
M&E	Monitoring and Evaluation
MIS	Multi-Incremental Sampling

MND	Ministry of National Defense
MONRE	Ministry of Natural Resources and Environment
MOU	Memorandum of Understanding
O&M	Operations and Maintenance
PCB	Polychlorinated Biphenyl
pg/g	Picograms per Gram
PPT	Parts per Trillion
SOW	Statement of Work
TCDD	Tetrachlorodibenzo-p-dioxin
TEQ	Toxic Equivalent
USAID	United States Agency for International Development
USD	United States Dollar
USD/t	United States Dollars per Ton
USG	United States Government
VND	Vietnamese Dong
WHO	World Health Organization

1. EXECUTIVE SUMMARY

1.1 OVERVIEW OF THE PROJECT

The "Environmental Remediation of Dioxin Contamination at Danang Airport" Project (hereafter referred to as the Project) is a 10-year (2009-2018), $103.5 million project "to characterize, remove and contain dioxin contaminated soil and sediment from hotspots at Danang Airport".[1] The Project has three implementing partners: CDM International (CDM), Tetra Tech, and TerraTherm, with all activities implemented by USAID/Vietnam's Environment and Social Development Office (ESDO).

The Project's original purpose was to dispose of contaminated soil excavated from the airport into a secure landfill. However, based on the Project's Environmental Assessment (EA), USAID and the Government of Vietnam (GVN), through the Ministry of National Defense (MND), decided to treat the dioxin contaminated soil and sediment using In-Pile Thermal Desorption (IPTD). The IPTD process heats soil to 635°F (335°C), causing dioxin compounds to break down into non-toxic components.

The Project was designed to excavate and treat approximately 73,000 cubic meters (m^3) of contaminated soil and sediment identified in the EA. The Project expanded to include excavation, treatment, and containment of additional soil and sediment that was identified during implementation, increasing its funding from $7.35 million to $103.5 million.[2]

1.2 EVALUATION PURPOSE

The purpose of this end of project performance evaluation is to:

- Obtain independent, third-party review and evaluation of the overall effectiveness of the project in addressing legacy dioxin-contaminated soil and sediment;
- Document the benefits of USAID and MND cooperation on the remediation of Danang Airport to the region, and the suitability of using this work as a model for collaboration;
- Develop recommendations for future cooperative efforts addressing legacy dioxin contamination at Bien Hoa Airport.[3]

1.3 METHODOLOGY

The Project was conducted in two phases which consisted of desk and literature review, key informant interviews (KIIs) and site visits. Phase 1 focused on the overall effectiveness of the Project with field visits that provided the evaluation team opportunities to meet project contractors and GVN officials. Phase 2 focused on broader stakeholder perspectives, economic analysis of impacts, and lessons learned.

---

[1] USAID/Vietnam (2015) Action Memorandum for the Mission Director, Dec 16, 2015

[2] The Project contributes to the Vietnam Mission's Country Development Coordination Strategy's Special Objective Intermediate Result 1.1 Reduced Dioxin Contamination. This feeds into the Mission's Special Objective: Legacies addressed to advance the U.S. - Vietnam Partnership and US Congress' efforts to address the legacy of the Vietnam-American war.

[3] USAID/Vietnam, (2018), Statement of Work, Performance Evaluation of USAID's Environment Remediation at Danang Airport

1.4 EVALUATION RESULTS

The Project was successful in achieving its higher-level purpose of treating dioxin and improving relationships between the Governments of the United States and Vietnam. The project excavated 162,567 m^3, treated 94,593 m^3, and contained 67,974 m^3 of contaminated soil in landfills. Additionally, it trained GVN officials in monitoring, sampling, and on remediation technologies such as IPTD. It also trained GVN staff and local Vietnamese workers in safety measures for working with hazardous materials and educated the local communities and workers on health and safety measures in and around dioxin contaminated areas.

"15-20 years ago, no one would have thought we could have such a project because dioxin was so sensitive. We didn't think the United States Government (USG) was willing to participate in the project and you can see what has happened since then. I strongly believe that the project has helped strengthen the relationship between the two countries."

- Quote from project stakeholder

Results indicate that the project was cost effective—treating large amounts of dioxin and contaminated materials at a low per unit cost and in a short time. Specifically, the treatment cost 669 USD per ton of soil, which compares to costs ranging from 337 - 5,205[4] USD for similar on-site measures. Within Phase II of IPTD, the heating was reduced from 10 months to 6 months which is a shorter time than in other dioxin treatment projects.

Further benefits of the project include:

- Remediated land can now be repurposed for productive uses and specifically, for the expansion of the airport into territory that could not previously have been built upon. This project remediated 29.9 hectares of land; the value of this remediated land is estimated to be roughly $15 million.[5]
- GVN and local contractor staff have advanced knowledge and experience in how to work safely in highly contaminated environments;
- GVN staff have more experience in sampling techniques, preparing them to better address dioxin and other pollutants.

1.5 FINDINGS, LESSONS, AND CONCLUSIONS

Evaluation Question 1: To what degree did the project achieve its purpose of characterizing, removing and containing dioxin contaminated soil and sediment from hotspots at Danang airport?

Findings	The project was a resounding success in treating dioxin contaminated soil and sediments, with resulting post-treatment dioxin levels well below the required limits. However, gaps in planning and testing hindered project performance relating to soil characterization, which in turn led to delays and higher project costs.
Conclusions	From the point of view of the higher-level goal of treating dioxin contaminated areas, the project was a success.
Recommendations	Employ a combination of soil sampling techniques to improve characterization, and strengthen planning. Explicitly state all assumptions.

[4] This highest unit cost refers to the project in Neratovice, Czech Republic, but cannot be verified from open sources.

[5] This is based on an approximation provided by Savills Research Consultancy, a firm specializing in providing analysis of real estate markets in Vietnam.

Evaluation Question 2: How cost effective was using thermal destruction of dioxin (IPTD) at the Danang Airport compared to similar and/or alternative solutions used in comparable remediation projects elsewhere in the world?

Findings	The Project cost 669 USD per ton to treat the material compared to similar methods which ranged from 337 – 5,205 USD per ton. The Danang project treated roughly 7.8 times more material than did the lowest cost project.
Conclusions	The project was cost effective, being the third least expensive project examined out of 10 technologies The agreed selection criteria for reference projects included: Definitive (not temporary) solution; Full scale method, able to remediate > 90,000 m^3 of highly contaminated soil; Verified method, able to reach the target values; On-site remediation; and compliance with Vietnamese regulations.
Recommendations	Cost per unit treated is not the only factor that should be considered when making the decision on technology choice. Other factors must be considered such as duration of treatment, site conditions and local standards and norms. It is necessary to improve reporting consistency, including a breakdown of the costs as well as summaries of incurred costs until the date of reporting. The system of monitoring and of calculating mass balance must be included in the design of the project.

Evaluation Question 3: What are the economic benefits for Vietnam and the local community that can be linked to the project results?

Findings	The removal of dioxin from the airport is directly linked to three main economic benefits: (1) repurposed land can now be used for productive purposes, (2) reduced potential for human exposure to dioxin, and, (3) increased capacity for Vietnamese private sector and experts in health and safety, as well as environmental remediation.
Conclusions	The most immediate benefits are linked to the expansion at the airport; Danang would not be able to fully capitalize on the economic dividend from the surge in tourism without the expansion of the airport. The capacity and knowledge of GVN authorities to manage contamination in a manner protective of human health and the environment is increased. Because the volume of dioxin contamination has been reduced below the clean-up goals, people living and working at the airport will also benefit immediately from reduced potential for exposure to dioxin, as will generations of Vietnamese into the future.
Recommendations	Allow for baseline and endline data collection to measure outcome data resulting from the project at Bien Hoa. This will allow for a more precise measure of benefits, as well as help in guiding public health messaging following the project.

Evaluation Question 4: How do program stakeholder organizations view the degree to which the project met expectations for the clean-up of dioxin?

Findings	When asked to rate numerous project activities, where 5 represents "just met expectations", 10 represents "exceeds expectations significantly" and 0 represents "significantly below expectations", the average score is above 7.4.
Conclusions	The project has exceeded expectations in all areas. As this evaluation shows, there is still room for improvement.
Recommendations	Improve communications Plan to encourage greater involvement of stakeholders

Evaluation Question 5: What are the lessons learned from the Project that can be used to remediate dioxin at other sites, such as Bien Hoa?

Findings	While the project has been very successful, there is still room for improvement in several areas aspects of project delivery.
Conclusions	The main areas where lessons can be learned are: Project Planning, Soil Characterization, Communication, Stakeholder Involvement, and Demobilization
Recommendations	See above

2. PROJECT BACKGROUND

2.1 OVERVIEW OF THE PROJECT

The "Environmental Remediation of Dioxin Contamination at Danang Airport" Project is a 10-year (2009-2018), $103.5 million project "to characterize, remove and contain dioxin contaminated soil and sediment from hotspots at Danang Airport".[6] The Project has three implementing partners: CDM, Tetra Tech, and TerraTherm, with all activities implemented by USAID/Vietnam's Environment and Social Development Office (ESDO).

The Project was originally designed to excavate and treat approximately 73,000 cubic meters of contaminated soil and sediment identified in the EA in two phases of work. The two phases each focused on excavating and treating contaminated soil from the Northern, and Southern parts of the site. The Project expanded to include excavation and treatment of additional soil and sediment that was identified during Project implementation. Some of this soil and sediment was placed in an excess volume storage area (EVSA). The Project's funding also expanded from $7.35 million to $103.5 million, due to the change in approach and additional contaminated soil and sediment handled.

The Project contributes to the Vietnam Mission's Country Development Coordination Strategy's Special Objective Intermediate Result 1.1 Reduced Dioxin Contamination. This feeds into the Mission's Special Objective: Legacies addressed to advance the U.S.-Vietnam Partnership and US Congress' efforts to address the legacy of the Vietnam-American war.

2.2 DEVELOPMENT HYPOTHESIS

The Project is part of the United States Government (USG) efforts to carry out Agent Orange/dioxin health and remediation activities in Vietnam, in close collaboration with the GVN[7]. The purpose of USG participation in dioxin remediation is to address the legacy of the American-Vietnam war through the reduction of dioxin contamination. This is measured at a high level by: 1) Cubic meters of dioxin-contaminated soil and sediment excavated and treated, 2) Increased GVN knowledge of environmental assessment and remediation methodologies and best practices, 3) Public outreach and stakeholder engagement in the site remediation process, and 4) Training in the areas of Health and Safety (H&S) and environmental assessment and remediation provided to representatives of various GVN ministries.

Beyond the remediation efforts at Danang Airport, the USAID has completed capacity building activities with the GVN to further their understanding of environmental assessment and remediation work. Furthermore, USAID and the GVN-MND are in the planning stages of another remediation project at Bien Hoa Airbase. This performance evaluation will provide lessons learned from clean-up efforts at Danang Airport to inform the future clean-up of Bien Hoa Airbase.

---

[6] USAID/Vietnam (2015) Action Memorandum for the Mission Director, Dec 16, 2015

7 This project is part of a larger USG response to dioxin. "In 2007, the U.S. Congress appropriated $3 million to carry out Agent Orange/dioxin- related health and remediation activities in Vietnam. Of this amount, $1 million was used for dioxin related health activities" that are outside the scope of the project being evaluated. Source: USAID AAD 2009.

3. EVALUATION PURPOSE AND QUESTIONS

3.1 EVALUATION PURPOSE

The purpose of this end-of-project performance evaluation is to:

1. Obtain independent, third-party review and evaluation of the overall effectiveness of the project in addressing legacy dioxin-contaminated soil and sediment.
2. Document the benefits of USAID/MND cooperation on remediation of Danang Airport to the region, and extend the work as a model for future collaboration.
3. Develop recommendations for future cooperative efforts addressing legacy dioxin contamination at Bien Hoa Airport.[8]

The primary audiences for this evaluation are the GVN, MND, National Steering Committee on Overcoming Post-War Consequences of Unexploded Ordnances and Toxic Chemicals in Vietnam (Committee 701), USG, and USAID. Secondary audiences include key partner GVN ministries, including the Air Defense – Air Force Command (ADAFC), Ministry of Natural Resources and Environment (MONRE), Provincial Departments of Natural Resources and Environment (DONRE) as well as the consultants and contractors, specifically CDM, Tetra Tech, and TerraTherm, responsible for implementation of the technical work activities. Evaluation findings will be used to shape the design and implementation of future dioxin remediation activities, including those at the Bien Hoa Airbase.[9]

3.2 EVALUATION QUESTIONS

The evaluation was framed around five primary evaluation questions (EQs):

1. To what degree did the project achieve its purpose of characterizing, removing, and containing dioxin contaminated soil and sediment from hotspots at Danang airport?
2. How cost effective was using thermal destruction of dioxin (IPTD) at the Danang Airport compared to similar and/or alternative solutions or comparable remediation projects elsewhere in the world?
3. What are the economic benefits for Vietnam and the local community that can be linked to the project results?[10]
4. How do program stakeholder organizations view the degree to which the project met expectations for the clean-up of dioxin? (Including communications and information transfer/training on choice of

---

[8] USAID/Vietnam, (2018), Statement of Work, Performance Evaluation of USAID's Environment Remediation at Danang Airport

[9] Ibid.

[10] This evaluation question was revised in coordination with USAID to remove the "return on investment" terminology. This was due to doubts by the evaluation team that the direct benefits from this project could be accurately valued (specifically the health benefits); thereby making it a challenge to compare costs to benefits in a way that would yield a reasonable measure of return on investment.

remedial alternative, health and safety controls, and environmental monitoring, and furthering a collaborative relationship between the USAID and GVN).

5. What are the lessons learned from the Danang Remediation Project that can be used to remediate dioxin at other sites, such as Bien Hoa, in terms of: alignment with international norms and standards for project delivery, such as the Project Management Institute framework; mitigating schedule and cost risks and managing change, and improving stakeholder communication and coordination.

The five evaluation questions were addressed in two phases with Phase I aligning with Project close-out events, giving the evaluation team opportunities to meet with the project contractors and GVN officials attending the closeout activities. It addressed primarily EQs 1 and 2. Phase II took place after the team had requested additional information and reviewed and processed the project materials. This phase dealt mainly with EQs 3, 4, and 5.

Figure 1: Photo from environmental remediation project site

Photo Credit: Richard Nyberg, USAID

4. EVALUATION METHODS AND LIMITATIONS

4.1 DATA COLLECTION METHODS

DESK AND LITERATURE REVIEW

The evaluation team reviewed as many Project documents as were made available, including but not limited to: annual and quarterly reports, work plans, monitoring and evaluation reports, activity completion reports, the EA, and other project documents. Additionally, the team conducted a literature review of scientific articles, studies in Danang that might have established baseline conditions or analyzed how environmental and health conditions changed over a relevant timeline, guidance documents related to dioxin, as well as relevant USAID and GVN policies and guidance documents. Annex 3 contains a complete list of the documents reviewed.

The evaluation team used baseline data from internal sources, such as the Activity Monitoring & Evaluation Plan, and external sources, such as published literature, third party reporting and open databases, to establish objective baseline conditions of the project's operating environment. The evaluation team reviewed relevant documentation, literature and expert sources to develop the types and sources of information to be used for quantitative and qualitative analysis to answer the evaluation questions.

The desk and literature review was used to gather both qualitative and quantitative data, the latter consisting largely of monitoring data and environmental and health conditions.

KEY INFORMANT INTERVIEWS (KIIs)

Integra conducted KIIs with over 24 different stakeholder entities that provided insight and perspective to the project's management, implementation and performance. The interviews also explored critical success factors, challenges or barriers to success, results at both the project and policy levels, as well as gender issues. The KIIs were semi-structured in nature, enabling the team to gather data related to the evaluation questions, while also allowing flexibility to add probing questions based on respondents' answers. Most KIIs were conducted in-person, though several were conducted over the phone and one was carried out in writing.

Most KIIs lasted no longer than 90 minutes, including time required for translation, to respect respondents' other daily obligations. Prior to each interview, the team identified the highest priority questions to cover with that respondent to ensure that it collected the most pertinent data, considering data already collected. Furthermore, the evaluation team split up to so that government stakeholders in Danang and Hanoi could be interviewed concurrently during the same field visit timeframe. See Annex 4 for the list of entities interviewed.

4.2 DATA ANALYSIS METHODS

Integra took detailed written notes of all interviews with the interviewees explicit consent so that the team could generate transcriptions and translations, if necessary, for coding. The coded responses allowed us to transform qualitative data into quantitative tabulations where possible and appropriate.

Each question in each KII protocol had a direct link to an evaluation question, or component of an evaluation question, and was categorized according to those linkages during data analysis. The findings generated through these methods were interpreted in the context of those generated through other qualitative and quantitative methods described above and triangulated accordingly.

In addition to the KII responses, the Evaluation Team reviewed reports and visited the site for verification. Thus, we used a combination of content, contribution, descriptive, qualitative and quantitative analysis as appropriate. The analytical technique used for each question are presented alongside the EQs in the Evaluation Design Matrix in Annex 5. Responses from the KIIs were also used as illustrative support. Conclusions were drawn on the preponderance of responses for each evaluation question and are clearly stated to reflect the logic that supports them. Similarly, recommendations were drawn from those conclusions, along with the expert counsel of the Evaluation Team.

The underlying logic supporting the conclusions and recommendations is presented and organized by question, later in the report, so that readers can trace these to the evaluation findings and expert inputs.

4.3 ASSUMPTIONS AND LIMITATIONS

This evaluation methodology has several underlying assumptions and limitations as described below.

***EQ 1*. To what degree did the project achieve its purpose of characterizing, removing and containing dioxin contaminated soil and sediment from hotspots at Danang airport?**

Integra assumed that the degree to which the project met its purpose could be measured quantitatively - for example, the goal was to treat soils and sediments to 150 parts per trillion (ppt). To the extent that the treatment results were below or above this defines the degree to which the purpose was met. This EQ did not seek to answer if the project could have achieved its goals better or more cost effectively. If evidence and expert opinion highlighted that aspects of the project could have been done differently to achieve better results, these were noted under the Findings, Conclusions and Recommendations (FCRs) for EQ5, which deals with lessons learned.

***EQ 2*. How cost effective was using thermal destruction of dioxin (IPTD) at the Danang Airport compared to similar and/or alternative solutions or comparable remediation projects elsewhere in the world?**

Cost-effectiveness analysis (CEA)

CEA is a quantitative method used to determine the most cost-effective remediation technology/solutions. The team used data from Project records and publicly available information on other treatment methods. To assess cost-effectiveness, the team reviewed cost-related data for similar technology as what was used in Danang, as well as cost-related data for alternative remediation technologies with the same or very similar objectives to the Project (if feasible). Integra conducted a literature review to identify other treatment technologies that aim to *reduce dioxin to the levels required for this Project.*

A cost-effectiveness analysis (CEA – see text box) was used to compare per unit Project costs related to dioxin remediation with per unit costs for similar remediation efforts. Developing comparable cost data is challenging because of the differences in site conditions and differences in the way the costs of different studies are expressed. For example, it was very difficult to know if cost data from other projects included training, management, health and safety procedures, etc. In the absence of this information, Integra took a conservative approach and included all expenses related to management, health and safety training and procedures, blood sampling, and design in the estimate of the cost-effectiveness of the Project. The only costs that were removed from the Project's contract costs were those related to excavation and landfilling of the soil placed in the EVSA, since this soil was not treated as the concentrations of dioxins did not exceed the set limits. Additionally, costs for GVN and USAID staff time and oversight costs were also not included in the Project's cost estimate.

Finally, to calculate the costs for the CEA ratios, source documents with cost data were used that in some cases did not identify the years in which costs accrued or in what year the costs were reported. In these cases, the evaluation team assumed that the costs accrued in the final year listed within a range of dates provided for the project. Using this assumption, costs were adjusted so that they could all be presented in real terms (2018 dollars).

CEA alone is an imperfect guide to choosing or rating technologies when other parameters come into play that cannot be measured by cost, for example, the difference in time it takes to treat the same amount of soil. It is difficult to compare data from different sources and databases as the system of reporting is not consistent. The evaluator identified the following key problems in this regard:

- The composition of contaminants on reference sites is sometimes not clearly specified (especially in summary reviews). The requirements on remediation of dioxins are more demanding than for other volatile organic compounds and depend also on the local hydrogeological situation and applied norms and standards. Therefore, the unit costs for reference sites might be lower than for Danang with extreme dioxin concentrations.
- In some cases, the reported total costs do not include all directly related costs, e.g., design, excavation (and transportation), refilling, post-treatment and residue disposal, health & safety measures, project supervision, or analytical costs (see also Annex 6).
- In some cases, the volume of contaminated soil or other contaminated media is not specified either. The extent of contamination is a very important factor for calculating costs of any remediation project.
- All remediation projects deal with complex issues and must often use a combination of diverse methods – besides the treatment of the soil, the remediation project must also include the treatment of water and air emission, and complex waste management. Remediation projects are also expected to assess and prevent the health risks related to the operation of remediation technologies and techniques.

There have been also inconsistencies in reporting the Danang Project, both in financial reporting, where quarterly reports do not include the total incurred costs to-date, and in technical details, where different summary reports present differing values for treated soil and sediments.

The above limitations have been considered in the CEA for the Danang remediation project. In this case, all the related costs (except for landfilling at EVSA) were compared with the total reported and verified volume of the soil and sediments treated by IPTD, but this was not the case for some reference projects or compendia reviews, where only the direct costs associated with implementation of the remediation technology were included (see the second bullet above). The CEA figure for Danang is therefore a conservative estimate, may overstate the costs somewhat relative to other CEA figures.

***EQ 3.* What are the economic benefits for Vietnam and the local community that can be linked to the project results?**

There are several limitations to valuing the economic benefits of a remediation project. The most direct benefit is certainly the impact on the health of the population. The linkage between exposure to dioxin and health outcomes, and especially the health implications after a reduction in chronic exposure, is not well documented in the literature. During an extensive literature review, the evaluation team was unable to find sufficient published scientific data to allow for an economic valuation of this benefit. In any case, an estimation of value of the reduced risk would require detailed health risk assessments conducted prior to and post remediation – this was not done by the Project and data was not available to complete such assessments as part of this evaluation. Finding an estimate of the potential population exposed to dioxin is also not possible since no probabilistic samples have been collected on how many people may be consuming dioxin-contaminated food or the number of people with elevated levels of dioxin in their tissues.

Secondary benefits associated with this Project primarily relate to the expansion of the airport made possible by the remediated land. The most defensible approach would be to measure the expected transportation cost savings for passengers and cargo, which would be feasible given the right data. The evaluation team, however, was unable to find data on historical tariff prices for flights into and from Danang to measure whether there was a change because of the airport expansion. Another approach may have been to calculate the mitigated coping costs associated with managing an airport that was operating over capacity before the expansion – such as the costs of parking planes at other regional airports. This data, however, was also not available to the evaluation team.

In those cases where sufficient data was not available to quantify or monetize the benefits to Vietnam because of this project, several assumptions were made. The evaluation team clearly identified all assumptions, and assumptions were based heavily on the literature review and always checked with experts, before presenting a conservative or lower-bound, and defensible case for the benefits of this project. The biggest assumption is that the conditions at the airport will remain static moving forward and dioxin will no longer migrate from Danang airport in the future.

***EQ 4.* How do program stakeholder organizations view the degree to which the project met expectations for the clean-up of dioxin? (Including communications and information transfer/training on choice of remedial alternative, health and safety controls, and environmental monitoring, and furthering a collaborative relationship between the USAID and GVN).**

The key assumption for this EQ was that key informants speak freely. To promote openness and the air of privacy and confidentiality of KIIs, the evaluation team ensured that interviews took place in a reasonably private location where interviewees were comfortable responding openly. Verbal informed consent was obtained prior to the start of the interview to ensure respondents understood: 1) the team's independent role in the evaluation, 2) the voluntary nature of the interview, and 3) their right to refuse to answer specific questions and/or to stop the interview early. Respondents were also informed that their names and job titles would not be referenced in any reporting, and quotes that would serve to identify them would not be used in reporting.

Further, to ensure respondent comfort during interviews, interviews were not audio recorded. The evaluation team took detailed notes and transcribed these notes in full, electronically, following the interviews. After reporting and dissemination was completed, the evaluation team disposed of hand-written notes, which included names, job titles, or contact information. Transcribed interview notes were saved in project folders accessible only by project team members.

***EQ 5.* What are the lessons learned from the Danang Remediation Project that can be used to remediate dioxin at other sites, such as Bien Hoa, in terms of: alignment with international norms and standards for project delivery, such as the Project Management Institute framework; mitigating schedule and cost risks and managing change, and improving stakeholder communication and coordination.**

There were no assumptions or limitations in the team's approach to answering this EQ.

4. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The higher-level goals of the remediation project were to: (1) improve relations between the USG and the GVN, and (2) treat dioxin hotspots at the Danang airport at or below the agreed on standard. The EQs sought to address these goals and answer other important aspects that will inform the design of the Bien Hoa project. The following section presents the findings, conclusions and, when appropriate, the recommendations for the five evaluation questions.

EQ 1. TO WHAT DEGREE DID THE PROJECT ACHIEVE ITS PURPOSE OF CHARACTERIZING, REMOVING[11] AND CONTAINING[12] DIOXIN CONTAMINATED SOIL AND SEDIMENT FROM HOTSPOTS AT DANANG AIRPORT?

FINDINGS

The evaluation question is based on the original Project purpose as stated in USAID's May 6, 2009 Activity Approval Document (AAD). However, the project's purpose changed over time to reflect changes in understanding of what was feasible at Danang Airport. In March 14, 2011, the Project's purpose was updated to read:

> *"The original AAD had <u>containment</u> of Agent Orange as the purpose of the project; this amendment changes the purpose to <u>remediation or treatment</u> of Agent Orange. 77,000 cubic meters of dioxin-contaminated soil and lake sediment around Danang Airport will be remediated, bringing dioxin levels below Government of Vietnam clean-up goals, and resulting in unrestricted land use of the currently contaminated areas."*

Accordingly, while assessing containment, we focus on the higher-level purpose which has not changed: to treat the dioxin contaminated hotspots and to improve relationships between the two countries.

The three dimensions of this question (characterizing, removing, and containing) are related. Proper characterization identifies the volume of soil and sediment that needs to be excavated, treated, or contained. As the evaluation team notes below, poor characterization early on led to inadequate targets for excavation and treatment, and did not identify a need for the EVSA. These target volumes during the planning phase became the metrics for measuring USAID's success against this purpose. **Naturally, if characterization had been more appropriately done in the beginning, USAID would have had fewer problems in dealing with excess volumes of contaminated soil and certainly reduced expenses in resolving the associated unforeseen issues.** Even so, USAID and its

---

[11] "Removing means excavating and treating by either thermal desorption or by containment (landfill/capping), such the potential human and environmental risks are mitigated." USAID, June 6, 2018.

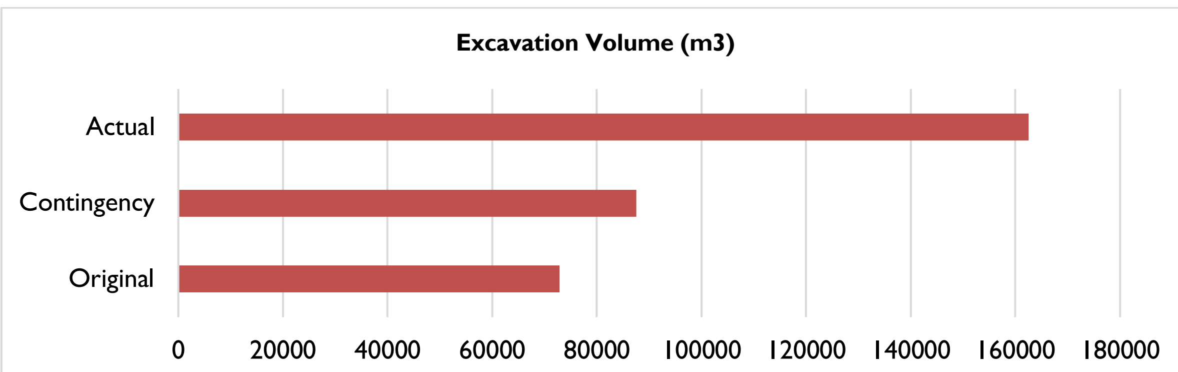
[12] "Containment refers to the Excess Volume Stockpile Area constructed to contain the excess volume… of primarily sediment with dioxin concentrations between 150 and 1,000 ppt TEQ" USAID, June 6, 2018.

contractors demonstrated remarkable flexibility and problem-solving to manage the excess volumes of contaminated soil.

Characterization – The project has performed worse than planned. Original characterization of soil and sediment was less than desirable and resulted in increased project cost and delay[13].

The quality of soil characterization in this project is defined as 'the difference between planned excavation and actual excavation volumes, where the larger the difference, the poorer the quality of characterization'. The EA was the project's first attempt to characterize the soil, estimating that 61,602 m^3 would be excavated[14]. At the time of the Final Design Report, Dig and Haul Component, the project planned to excavate and treat 72,900 m^3. By the end of Phase II, the project excavated a total of 162,567 m^3, 89,667 m^3 more than was planned. Both the total amount of contaminated soil and the amount of soil to be treated were underestimated. While the contractor built a contingency of about 20 percent around the originally estimated 72,900 m^3 volume for the pile design for additional volume, the excess volume was still significant, as shown in Figure 2.

Figure 2: Quality of Soil characterization



Removal – The Project was a success in treating dioxin contaminated soil and sediments, although excavation and treatment were greater than planned.

USAID defined removal as excavation and treatment.

Excavation: The Project has removed (excavated) 162,567 m^3, of which approximately 67,974 m^3 was low concentration dioxin soil that was excavated but not treated and bound for the EVSA. This greatly exceeds the original target goal for excavation in the monitoring and evaluation plan of 70,959 m^3. Thus, the project has performed less than desirable against its target excavation quantities.

Treatment: Treatment has two parameters, the volume treated and the treatment level (i.e. ppt). On volume treated, the project treated almost 30 percent more material than was planned. While this is good in the sense of attempting to treat all contaminated material, it shows a deficiency in that the project ended up treating significantly more material than was planned for, and this resulted in cost and time

---

[13] This is discussed later in EQ4.

[14] USAID, Environmental Assessment, June 2010, Appendices 2, pages A 2.8 and A 2.9.

implications. However, the project treated material to 8.9 ppt in Phase 1 and to levels equal to or less than 1 ppt in Phase II, which is substantially better than planned. From the point of view of those interviewed, hotspots were treated and actionable material[15] was treated to or below the standard of 150 ppt for sediment and 1,000 ppt for soil, resulting in the Project's success in treating dioxin contaminated soil and sediments.

While the initial target volumes for excavation and treatment were too low due to issues with the early characterization of the site, the USAID contractors had designed for contingencies and were still able to treat identified soil that exceeded the 1,000 ppt threshold and sediment above the 150 ppt threshold. Improvements in characterization were made in direct response to lessons learned from Phase I of the Project, which led to effective adaptive management during project Phase II implementation that helped the contractors satisfactorily remove the unexpected volumes of contaminated soil and sediment.

Containment – As containment was not originally envisaged, the project performed worse than expected.

As the project evolved, containment was not considered an option. Contaminated material above the actionable level would be treated. As stated in the March 14, 2011 AAD, treatment would be such that it would result "in unrestricted land use of the currently contaminated areas," implying no EVSA. In the Final Design Report, Dig and Haul, it was stated that the project would treat (using IPTD) all excavated volumes. So, considering that EVSA was not contemplated at the onset of the project, the target for containment was 0 m^3, while the actual amount contained was 67,974 m^3. The project exceeded the target of 0 m^3 of containment and this means the project performed worse than expected Figure 3 below presents the performance of the project in the parameters measuring characterization, removal and containment.

Figure 3: Project performance in characterization, removal, and containment

Purpose	Parameter	Design Values or Targets	Results	Performance
Characterization	Excavation Volume	72,900[16] m^3	162,567 m^3	Worse than planned*
Removal	Treatment Volume	72,900[17] m^3	94,593[18] m^3	Worse than planned*
	Treatment Level	≤ 150 ppt	8.9 ppt Phase 1, < 1ppt Phase II	Better than Planned
Containment	Containment Volume	0	67,974 m^3	Worse than planned*

**Note that exceeding a target does not necessarily equate to better performance. For example, the project planned to for 0 m^3 of containment but ended up with over 67,000 m^3. This resulted in greater costs and time than planned and thus performance was worse than planned.*

[15] Actionable material is comprised of soils exceeding 1,000 ppt and sediments above 150 ppt.

[16] USAID, Final Design Report, Dig and Haul Component. Table 1, March 2011.

[17] The original expected treatment volume was equal to the volume excavated. According to ACR 2, the ECC contractor built the pile 20% "larger than primary design" in case of overages. However, the design or intended treatment was 72,900 m^3.

[18] Activity Completion Report 4.

CONCLUSIONS

The project's treatment of dioxin contaminated soil and sediment is a success, although an underestimation of soil and sediment volumes requiring treatment added to Project implementation costs. Areas identified as hotspots were excavated and contaminated material[19] was treated well below the accepted standard. However, it was done so at greater cost and time expenditure than might otherwise have been had soil characterization been better and consequently, had the project accounted for excess volumes during planning. As Appendix 2 of the Environmental Impact Assessment (EIA) so aptly states, *"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."* Moreover, the same appendix points out that there is uncertainty in the final estimates.[20]

Despite the experience of improved characterization through additional sampling and the acknowledgement that confirmation sampling is likely to identify additional volumes, future reports did not assume any potential for excess volume until it happened. This failure to openly acknowledge and address the possibility of excess volume during the planning stages, particularly of soils below the 1,000 ppt level, caused delays in implementation as the GVN and USAID worked out how to address these quantities. This point was raised numerous times in the KIIs by Vietnamese interviewees. Part of the problem of the EVSA was that it was not contemplated in planning and adjusting to unplanned events during implementation is, according to the KII respondents, a "herculean effort." The issue of not addressing alternatives or possibilities in the planning stage was also raised by the contractors in their lessons learned session in June 2018.

To assume that excavated soil quantities would exactly match the quantities estimated during site characterization is naïve. However, the failure to consider that site characterization could be incomplete, and that excess volumes of material needing treatment could be encountered, is less than ideal planning. The implications of this are discussed later in EQ4 and EQ5.

RECOMMENDATIONS

See lessons learned, EQ 5.

EQ2: HOW COST EFFECTIVE WAS USING THERMAL DESTRUCTION OF DIOXIN (IPTD) AT THE DANANG AIRPORT COMPARED TO SIMILAR AND/OR ALTERNATIVE SOLUTIONS OR COMPARABLE REMEDIATION PROJECTS ELSEWHERE IN THE WORLD?

FINDINGS

1. The cost for treating dioxin contaminated soil/sediment at Danang site using IPTD was calculated to be 669 USD/ton (USD/t), respectively 1,137 USD/m^3, as described below.

- **The total costs used for CEA for Danang project is 99,606,926 USD** (in nominal terms). Adjusting for inflation over the project, the cost was 107,540,026 USD (in 2018 dollars). This is the

[19] Contaminated in this context refers to material at or above the project action levels of 1,000 ppt for soil and 150 ppt for sediment.

[20] Environmental Impact Assessment, USAID/Vietnam, (2018).

cost that is most directly analogous to the projects scrutinized for comparison. The costs do not include pre-remedial investigation, landfilling of soil/sediments below the remediation limit at the EVSA, use or treatment of some contaminated materials left on site (e.g. concrete masonry unit, or CMU blocks) and post-remedial site restoration.

- **The total volume of 94,593 m^3 of soil and sediment is considered for treatment.** A smaller volume is reported after the soil has been in the pile. The rationale behind using the volume excavated is that the volume of the treated soil must be considered before compaction (under natural conditions), while the reported numbers in summary reports for Phase I and Phase II refer to the compacted volume in the pile. For the comparability reasons, an average dry density of 1.7 g/cm^3 has been used for recalculation from m^3 to tons and vice versa for all compared locations.

2. In comparison with other remediation methods for dioxin contamination like on-site incineration or Base Catalyzed Decomposition (BCD) in combination with thermal desorption, the costs for IPTD at Danang Airport were relatively low. Costs of similar IPTD/ In-Situ Thermal Desorption (ISTD) projects (including summary review in US EPA Reference guide, 2010) range from 337 – 1,012 USD/t (in 2018 dollars), costs for on-site incineration range from 649 – 4,967 USD/t (in 2018 dollars), and costs for soil/waste treatment using BCD in combination with thermal desorption are between 2,320 – 5,205 USD/t (in 2018 dollars). In addition, the BEM System, Inc. report (2007) and FRTR Remediation Technologies Screening Matrix and Reference Guide, Version 4.0 (2000) were considered with the reported range of 72 - 715 USD/t. However, the reported costs in these guides do not include all related costs (see details in Annex 6).

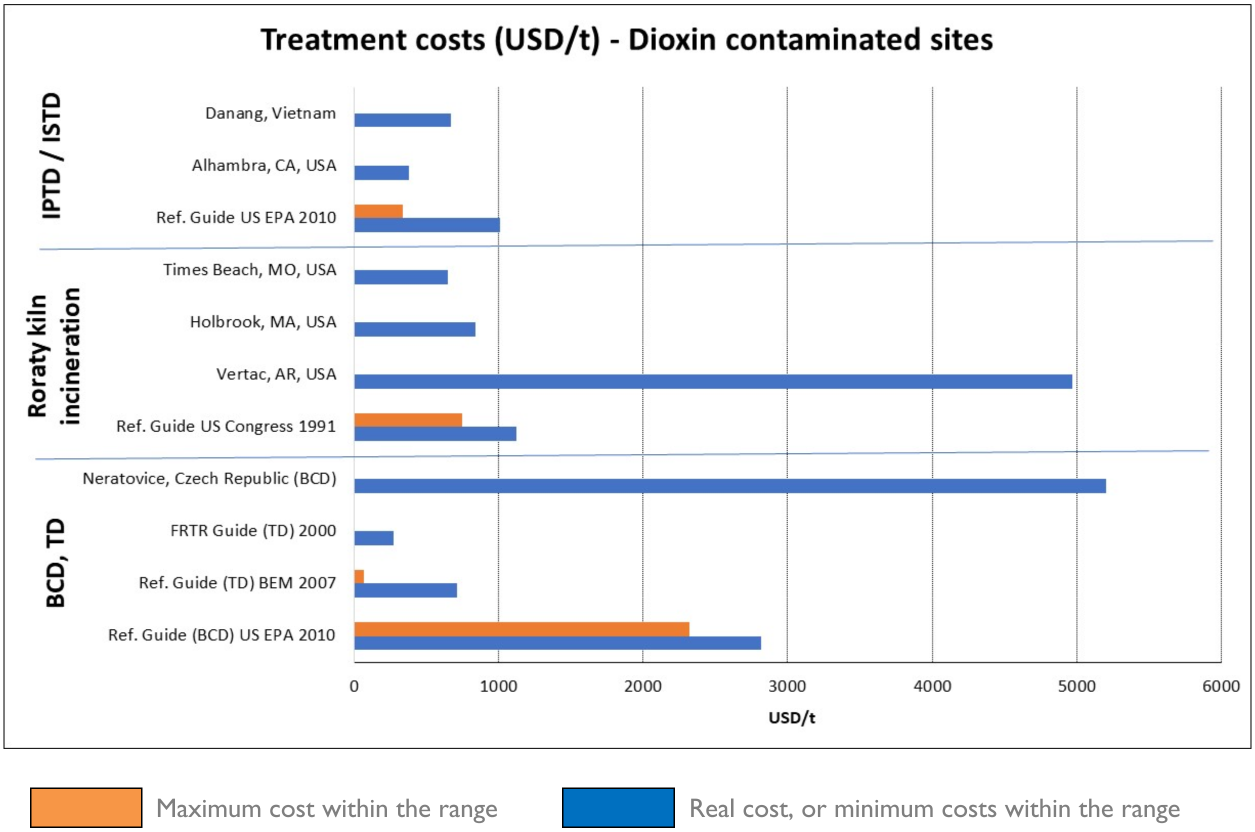
Figure 4 on the next page presents a comparison of cost per ton treated by technology type, while the detailed information on technology screening and costs appear in Annex 6.

CONCLUSIONS

The Danang Project is not the most expensive dioxin treatment project, nor the least expensive one. The cost for treatment of dioxin contaminated soil and sediment at Danang site using IPTD was calculated to be 669 USD/t, and 1,137 USD/m^3 respectively. These costs are in the range of other reference dioxin remediation projects where IPTD/ISTD method was applied, between 337 – 1,012 USD/t (in 2018 dollars). In addition, the costs of the reference projects seem to be underestimated as they most probably do not include all directly related costs (as also documented in Annex 6).

Integra's remediation specialists conclude that IPTD (or ISTD) is a cost-effective remediation technology for dioxin-contaminated sites where on-site treatment of large volumes and a definitive solution are required, as in Danang. In comparison with other remediation methods like on-site incineration or BCD in combination with thermal desorption, the costs for IPTD at Danang Airport were relatively lower. Costs for on-site incineration range from 649 – 4,967 USD/t (in 2018 dollars), and costs for soil/waste treatment using BCD in combination with thermal desorption are between 2,320 – 5,205 USD/t (in 2018 dollars).

Figure 4: Cost Comparison of Treatment Technologies



RECOMMENDATIONS

In choosing the appropriate technology for Bien Hoa and considering the selection criteria agreed during the first phase of evaluation[21], IPTD is likely to be cost-effective technology.

Due to high groundwater level and its direct communication with surface water (i.e. water streams, ponds and rainfalls) at Bien Hoa, in situ methods cannot be effectively applied there. In addition to the CEA, other factors such as time, remediation target concentrations (set limits) and prevention of health risks for both the workers at site and citizens in the environs will also be important criteria to the decision and should be discussed as well.

EQ 3: WHAT ARE THE ECONOMIC BENEFITS FOR VIETNAM AND THE LOCAL COMMUNITY THAT CAN BE LINKED TO THE PROJECT RESULTS?

FINDINGS

As has been highlighted above, the Project has successfully achieved its overall objective of identifying and removing, or containing soil and sediment that has been contaminated with dioxin. As a result, the removal of dioxin from the airport is directly linked to three main economic benefits for Vietnam and the local

[21] Definitive (not temporary) solution; Full scale method, able to remediate > 90,000 m^3 of highly contaminated soil; Verified method, able to reach the target values; On-site remediation (off site incineration not feasible); and compliance with Vietnamese regulations.

community: (1) repurposed land, (2) reduced potential for human exposure to dioxin, and (3) capacity building. Each of these benefits are briefly described below and in-depth evidence is provided in Annex 7.

Finding 1. Remediated land on the airport will be (and has been) repurposed for other economic uses.

The most immediate benefit to this project is that remediated land can now be repurposed for productive uses and specifically, for the expansion of the airport into territory that could not previously have been built upon. This project remediated 29.9 hectares of land, of which the value of this remediated land is estimated to be roughly $15 million.[22]

The remediated land is planned to be used for an expansion at the airport. The airport plays an important role in Danang's economy. Given the location of Danang in the center of the country, the airport is a main transportation corridor for passengers and approximately 90 percent of international tourists enter Danang through the airport.[23] The airport's limited capacity has been a transport bottleneck for Danang's economy. Local experts have credited much of the expansion of the economy in Danang to the boom in domestic and international tourists; the Danang Department of Tourism determined that the tourism industry generated 186,770 jobs in 2017 and grossed over 19.5 trillion VND (854.1 million USD) in revenues.[24] In the first five months of 2018, the Danang Department of Tourism indicated that tourism receipts had increased by 53 percent compared to the same period a year before,[25] which coincides with the period just before the new international terminal became operational. Danang would not have been able to fully capitalize on this economic dividend without the expansion of the airport onto the recently remediated land.

Economic benefits of the Project

- Value of the 29.9 hectares of remediated land is estimated to be $15 million;
- The land has already allowed the airport authorities to expand, including building a new terminal with an additional design capacity of 4 million passengers;
- The recent and future investments at the airport will allow Danang to further capitalize on the recent boom in tourism that is boosting the city's economy.

The 2015/2016 airport expansion on remediated land has already been able to accommodate increasing demand for passenger traffic transiting Central Vietnam. Before the recent expansion that included the new international terminal, Danang International Airport was already operating beyond the design capacity of its only terminal at the time, which was six million passengers. The new international terminal increased the design capacity to 10 million total passengers and is estimated to manage 13.5 million passengers in 2018 (see Figure 5). While demand from international and domestic tourism is growing throughout Vietnam.

[22] This is based on an approximation provided by Savills Research Consultancy, a firm specializing in providing analysis of real estate markets in Vietnam. It was estimated that a large amount of remediated land in the center of Danang could sell for roughly $50 per square meter, or about 25 percent of the value of similar land along stretches of the beach in Danang, for large unaffected land ready for future development assuming comfortable land use, zoning, and controls. While this is not the case since the land is zoned for the airport – this is a technique to estimate the market rate for this land.

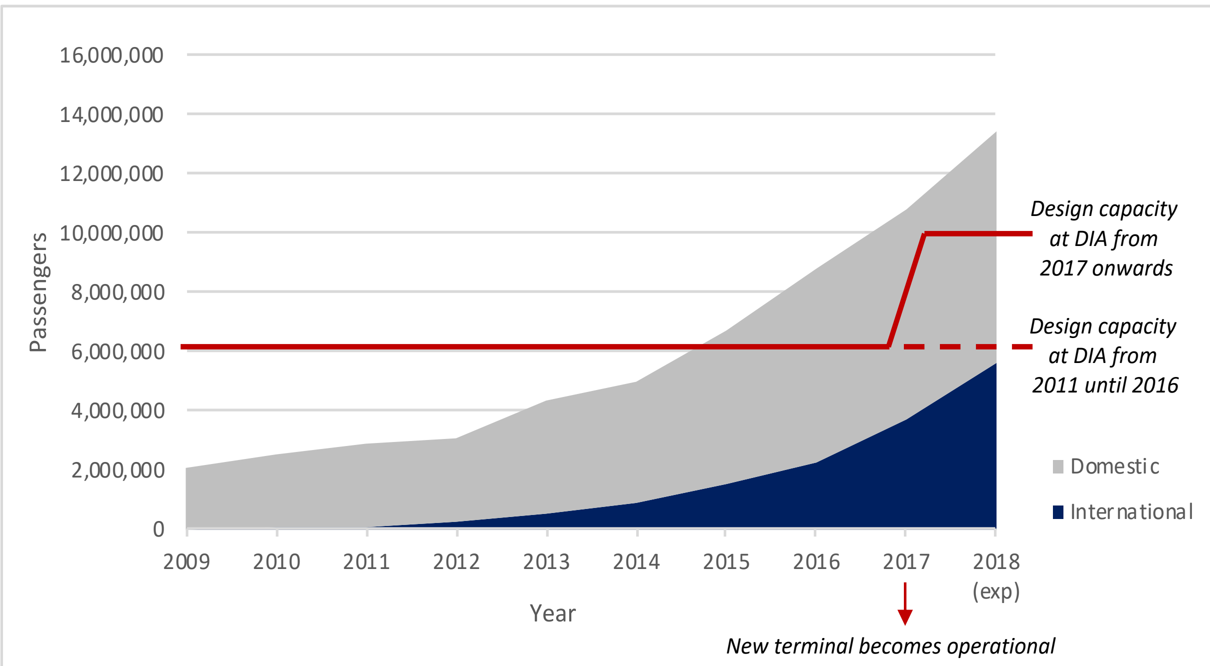
[23] Nhan Tam (2018).

[24] Rong Viet Securities (2017), page 69.

[25] Voice of Vietnam (2018).

Similarly, DIA is operating at over-capacity to accommodate cargo traffic to and from Danang; cargo transit volume has increased by 16.9 percent year-on-year since 2009. Officially, there is no cargo terminal at DIA but a temporary structure is managing the cargo volume, which has been designed for 20,000 tons per year. However, over 37,000 tons are expected to transit DIA this year. The next phase of expansion onto the remediated land will include a $20 million new cargo terminal, which is expected to be operational in the next three years and envisioned to handle 80,000 tons of cargo per year. While air freight contributes a small amount to Vietnam's trade by volume, it represents around 25 percent of Vietnam's trade by value.[26] Danang's investment in a cargo terminal on remediated land will directly increase air cargo trading with regional and international partners, which is a valuable source of trade income.

Figure 5: Passenger Volume at Danang, 2009 - 2018



Without the Project, it seems very likely that the airport expansion would have been significantly delayed by about 10-20 years, which would certainly have restricted the number of passengers and cargo that it could have accommodated into the medium-term.

[26] IATA (2014).

Finding 2. Potential for human exposure to dioxin in and near the Danang airport will likely be reduced over time.

After a series of studies, Danang airport was recognized as a dioxin hotspot due to large amounts of Agent Orange and other herbicides stored, handled, and spilled there during the Vietnam War.[27] This was confirmed due to the high levels of dioxin present in the soil and sediment in specific areas, primarily in the northern part of the airport. While the airport is the only known hotspot in Danang, evidence also suggests that the dioxin-contaminated soil and sediment has migrated from the hotspot into the surrounding communities, likely via a drainage ditch away from the airport and through the air as soil particles became airborne.[28]

Although much of dioxin was removed and contained, it is not possible to quantify reduction in human health risk without post-remediation samples of the environment. **However, with the removal of a large mass, construction of containment, and fishing bans, potential exposure to dioxin will likely be reduced for people who live and work near the northern part of the airport.** Experts have confirmed that this is associated with a likely reduction in the risks associated with the migration of dioxin-contaminated soil and sediment away from the airport into the surrounding communities.

> **Reduced potential human exposure to dioxin**
>
> Future generations in Danang will continue to benefit from this project since a large mass of dioxin at the hotspot was removed, and the remaining dioxin is capped in a manner that minimizes the potential for off-site migration;
>
> The local population has already benefited from increased optimism, a feeling of personal safety and well-being, and confidence in the future and will likely continue, especially for those living and working at the airport.

Additionally, possible improvements in the personal well-being of these sub-populations are likely, and for the populations who live and work on the airport. During interviews with local experts, it was clear that the USAID-GVN Project has directly contributed to decreased levels of distress about personal safety and concern for the health of people's families. Reportedly, fewer residents have raised concerns about their potential exposure to dioxin over the years since the USAID-GVN project was initiated and organizations involved with families living with disabilities have expressed increased optimism about the future due to the project. While these benefits cannot be measured, increased optimism, a feeling of personal safety and well-being, and confidence in the future are notable benefits of this project.

Finding 3: Capacity has been improved for Vietnamese experts and partners to support and continue further environmental assessment and remediation activities.

The support for the Vietnamese private sector, experts, and specialists has been two-fold: (1) Direct support was provided to the Vietnamese private sector, and (2) Capacity building and training programs increased the ability and confidence of Vietnamese laborers and specialists in applying their improved capacities in other remediation contexts.

---

[27] CDM (2010).

[28] CDM (2010).

Direct support to the Vietnamese private sector.

Nearly $40 million of the project funding was allocated to Vietnamese subcontractors[29] or otherwise spent in Vietnam. Vietnamese sub-contractors did purchase foreign goods and services, so not all these funds were ultimately spent in Vietnam. Channeling funds through Vietnamese sub-contractors, however, does support these business operations and expands their network and trade with foreign companies. Correspondence with one Vietnamese sub-contractor noted that their participation in this project garnered attention from other potential domestic and foreign business partners, led to increased employment, and directly impacted upstream industries. Otherwise, these funds were spent on labor, site electricity and water costs, miscellaneous equipment and supplies, office support costs, travel costs, per diems and other in-country expenses for the international staff, etc. These costs also supported at least 520 Vietnamese laborers who were employed by the USAID contractors at various points throughout the duration of the project; these individuals were employed for an estimated 1 million hours of labor on this project.[30]

> **Capacity building of the Vietnamese experts and the private sector**
>
> Nearly $40 million (41 percent) of the project funding was allocated to Vietnamese sub-contractors;
>
> At least 520 Vietnamese were employed by the USAID contractors, and benefitted from extensive health and safety training as well as on-the-job training over the duration of the project;
>
> All government of Vietnam counterparts interviewed reported that the capacity building activities were useful in enhancing their awareness and confidence for engaging in future remediation activities.

Capacity Building and Training.

Vietnamese labor additionally benefitted from an extensive health and safety training program, that was administered to all estimated 520 employees, as well as extensive on-the-job training and day-to-day oversight and knowledge transfer with the project staff. Significant resources were spent on health and safety training: according to the project's latest monitoring indicators, 24,482 hours of training were spent on health and safety of the on-site workers as well as GVN counterparts.

The obvious immediate benefit of the health and safety training program was to protect the health of the project staff - 94 percent of the monitored employees never had total dioxin concentrations in their blood measure above the project guidelines of 30 pg/g.[31] One USAID contractor indicated that there was a noticeable shift in the project staff embracing prevention measures throughout the duration of the project. Based on the feedback from key stakeholders involved in remediation activities, there is convincing

---

[29] This number is an estimate – all contractors noted that precise numbers for expenditures inside Vietnam were quite difficult to disaggregate from their expenditure data.

[30] This number is also a rough estimate – all contractors noted that it would be virtually impossible to derive an accurate estimate for this figure.

[31] Data as of April 2018. There were 29 individuals who did measure with total dioxin concentrations above 30 pg/g, though exact causes for these dioxin levels are not known. The USAID contractors indicated that in some instances, this dioxin exposure could also have originated off-site. Regardless, many interviewees did highlight these 29 individuals as a concern of the project. The evaluation team believes the health and safety program will result in benefits for the local community, including the majority of individuals who did not have elevated levels of dioxin, but certainly acknowledge that improvements in safety measures may have been possible in these instances.

evidence that health and safety standards will be improved at future sites because of the health and safety training program at the Danang project site.

CDM also led a capacity building program to contribute towards achieving USAID/Vietnam's Country Development and Cooperation Strategy (CDCS)[32] sub-intermediate result to improve the capacity of the Vietnamese government in addressing dioxin contamination. The evaluation team conducted KII with nearly all organizations who were involved in the certification program, these interviews were conducted either directly with the participants or with the supervising authorities. In interviews with these organizations, the majority reported that they had already applied at least some skills learned in the training course. Primarily, skills learned in multi-incremental sampling (MIS) methodology have reportedly been applied to other remediation sites in Vietnam, including Bien Hoa, by four separate organizations that participated in the training.[33] USAID also confirmed that DONRE Dong Nai also applied the MIS sampling techniques and procedures learned in the course and conducted an independent evaluation of their work, confirming that Dong Nai did adjust their sampling strategy after the training course and noted that the MIS sampling method helped reduce the data variability that they had observed while using the 5-point composite sampling method.[34]

Lastly, USAID contractors established productive technical and management relationships with their GVN counterparts over the duration of this project. Interviewees reported considerable knowledge transfer to the GVN counterparts. CDM reported "GVN partners have demonstrated a notable increase in understanding of hazardous waste remediation implementation, including overall project management, community engagement, and environmental sampling and analysis, through their exposure and engagement on the project with USAID and its contractors."[35] These sentiments were echoed by the other USAID contractors during key informant interviews. Similarly, interviews directly with the GVN partner organizations participating in the project management and other activities confirmed that they felt they learned from the partnership with the USAID contractor team, particularly in project management.

CONCLUSIONS

The removal of dioxin from the Danang Airport is directly linked to three main economic benefits for Vietnam and the local community: (1) repurposed land, (2) reduced potential human exposure to dioxin, and (3) capacity building.

The most immediate benefits are certainly linked to the expansion at the airport, which is now able to use the remediated land for productive purposes.

Expansions have already been completed on this land with clear linkages to economic benefits from Danang's growing tourism industry. The removal and containment of a large mass of dioxin accompanied by fishing bans, potential exposure to dioxin will likely be reduced for people who live and work near the

---

[32] The CDCS covers the period from 2014-2019. Source: USAID/Vietnam, Country Development and Cooperation Strategy (CDCS) (2013), page 24.

[33] Three interviewees reported that the MIS sampling technique had been applied, and documentation was available confirming this application (see next paragraph).

[34] CDM International, Inc (2018). Assessment of Dong Nai Department of Natural Resources and Environment (DONRE) Sampling Program, page 10.

[35] CDM International, Inc (2017). FY 2018 Implementation Plan.

northern part of the airport. Finally, the capacity and knowledge of GVN authorities has increased and experts are already applying improved skills to other remediation sites, likely providing benefits to other communities affected by dioxin hotspots in other parts of Vietnam.

RECOMMENDATIONS

Consider baseline and endline data collection to measure outcome data at Bien Hoa.

Given that substantial resources have been committed to this project by both Governments, this would be useful for tracking all potential benefits of the project. These benefits including health benefit are potentially quite large and methods exist for estimating how much risk is reduced due to changes in exposure scenarios before and after an intervention. Collecting data on the *dioxin levels in the environment, food, and human body*, before and after the project's conclusion would help USAID and MND assess the extent to which potential for human exposure to dioxin has decreased. Any such activity could be coordinated with staff from the DONRE if they are involved in downstream monitoring of the nearby communities. It would also be instrumental for informing a public health messaging strategy after the conclusion of any project at Bien Hoa as efforts to protect the public from potential exposure to dioxin may need to continue beyond the length of any remediation project. Understanding where the risks persist would be helpful for sustaining the benefits of a remediation project in reducing the potential exposure to dioxin into the future.

EQ4: HOW DO PROGRAM STAKEHOLDER ORGANIZATIONS VIEW THE DEGREE TO WHICH THE PROJECT MET EXPECTATIONS FOR THE CLEAN-UP OF DIOXIN?

FINDINGS

On meeting expectations, the evaluation team asked seven specific questions during the KIIs, and participants were asked if they had other areas of expectations. None reported any additional areas of expectations and not each KII answered each area. Respondents were asked to rate the degree to which their expectations were met:

- Ratings of 10 - meant that results significantly exceeded expectations;
- Ratings of 5 - meant that the results just met expectations;
- Ratings of 1- meant that results were significantly below expectations.

On average, the project met and exceeded expectations in all seven areas with the highest degree of satisfaction in the treatment of dioxin (one of the project's main objectives) and the lowest in the communication among all parties (Figure 6).

Figure 6: Degree to which the project met stakeholder expectations

Did the project meet expectations in	Average Score	Range	Number responding
The treatment of dioxin?	8.4	3 - 10	12
Training for health and safety?	8.0	5 - 10	7
Addressing the health and safety of workers?	7.9	6 – 10	7
Communications among all parties?	7.4	5 - 10	10
Cooperation between the GVN and USG?	7.9	7 - 9	10
Training in environmental monitoring and remediation?	7.9	5 - 10	10
Training on choices of remedial technologies for dioxin?	Not usable		5

Treatment of Dioxin - Score: 8.4

USAID, USAID's contractors and most GVN entities stated that the treatment exceeded their expectations in meeting the treatment standard for dioxin of at or below 150 ppt for actionable material. The two exceptions to this line of reasoning cited cost and time as their reasons as to why their major expectations in the treatment of dioxin were unmet. The other interviewees spoke of three main areas of concern for exposure during implementation.

- The first area of concern was that there were possible incidents of exposure during implementation. The concern is partly based on Phase 1 treatment, during which time steam (vapor) from the IPTD was observed to escape the treatment structure and the results of worker blood monitoring that indicated dioxin levels increased in certain workers during their employment, although the reason for the increase was not confirmed. Some interviewees mentioned possibility of contaminated dust during project implementation as well. All acknowledged that the safety record was very good but their reference point was zero risk.
- The second area of concern was the EVSA. They were concerned about possible exposure from the EVSA. Additionally, they stated that since the EVSA was not in the original EIA and design, some interviewees had concerns about the long run disposition[36]. They said because this has not been included in the earlier plans makes it difficult to obtain approvals and slowed the implementation because the GVN needed more time to study the proposal and reach concurrence[37]. The EVSA is symptomatic of potential sources of dioxin during and after the project. Other KIIs, in addition to

---

36 The EVSA was unanticipated but the details of construction, maintenance and ownership were worked out between the GVN and USAID. This covered all environmental concerns and if the EVSA is maintained per the agreement, there is no risk of exposure. This issue here, as in many other issues, is that communications between USAID and GVN are not being circulated among the project stakeholders.

37 While not a risk of exposure concern, this comment does underlie contractor concerns about deviations from plans and how to address uncertainty (see lessons learned for more on addressing uncertainty). In other words, contractors stated that because of the time and difficulty involved when changes or additions are made to the project, that more care needs to be taken in upfront planning for possible alternatives.

mentioning the EVSA, mentioned the CMU blocks and the lightweight insulating concrete (LWIC) as additional potential sources of dioxin exposure.

- The third area of concern was whether soil characterization was conducted thoroughly considering land use changes that might escape official records. Some of the interviewees mentioned that the GVN is investigating the possibility that previously unidentified hot spots exist at the Danang airport. It was stated that the soil characterization did not consider changes in land use at or near the site that were not part of official records, which records are often not themselves complete. These land use changes could mean migration of actionable materials, or actionable materials being deeper than model predictions based on inaccurate land use patterns. Those that did not cite Danang cited changes in land use and migration of contaminated material at Bien Hoa. They recommend involving the local community in the early process to address potential land use changes that might have escaped official records.

Training for health and safety - Score: 8

Worker health and safety (H&S) were major concerns on this project, and the starting point for addressing this was in H&S training. The project trained both its workers and those of GVN entities such as Chemical Command and VRTC in a variety of H&S areas. Seven entities answered this question, with all entities responding that it either met or exceeded their expectations.

> *"Training was very professional and the contractors 100% complied to regulations. We have changed our way of working on other projects based on this training."*

This quote is typical of those that experienced the training. The one KII for which the training just met expectations was a training provider, and their concern was that the benefit of the training may not extend past the Project period of performance because of the relatively low status of safety for local workers and their companies.

Addressing the health and safety of workers - Score: 7.9

The result of H&S training can be measured by the health and safety of workers on the job. There was not one serious incident or work stoppage from injury.

This area was rated slightly less than training, with all KIIs indicating that the results exceeded their expectations. The project took blood samples before, during and after employment. The two observations of note were that (1) the results of the blood samples were not made available and (2) that in a few cases, the dioxin levels in the workers' blood were higher than beginning blood levels, suggesting that there was exposure.

Communications among all parties - Score: 7.4

All interviewees indicated that communication was better than expected. For example, one interviewee noted:

> *"The two governments paid special attention to the project. Communications with very high-level leaders and operations was very good. Given the legal framework and standards, I don't see any way it could be improved. Most of time we reached consensus."*

However, at the lower level, among operational entities, communications started off rigidly and improved with time. There are no communications procedures or procedures detailing how and when information is to be shared among project participants according to the GVN interviewees.

> *"At the beginning, we did not understand communication regulations among the parties. There were no procedures."*

> *"There was more communication than was expected; started poorly and finished up great."*

> *"At the technical level, it was good but when we need[ed] information at a higher level from management entities, it was delayed. One reason is that each party has different regulations on communications. We need a task force with all bodies represented and we need a communications plan."*

This idea of a task force or a stakeholder-wide body for coordination and communication appeared in many interviews.

Cooperation between the Government of Vietnam and the United States Government - Score: 7.9

Even before the KIIs, stakeholders that the evaluation team met during the Phase I closeout meetings and subsequent briefing with the GVN reported that one of the major benefits of this project was significant improvement in the cooperation between the GVN and USG. When the work began, some KIIs reported distrusting the information they were given by the US side. Now that the project has been a success, there is mutual respect and trust.

> *"15-20 years ago, no one would have thought we could have such a project because dioxin was so sensitive. We didn't think the USG was willing to participate in the project and you can see what has happened since then. I strongly believe that the project has helped strengthen the relationship between the two countries."*

Training in environmental monitoring and remediation - Score 7.9

All KIIs answering this question indicated that the training exceeded their expectations. Each KII had favorable comments on training and how they have been able to use it. Two quotes illustrate the opinions:

> *"The training was very good and we applied it in other places. We applied multi-incremental sampling (MIS) to identify the area and then we combine it with other methods to get higher level of confidence."*

> *"We are very happy with all the training, even that in technical writing. We had an opportunity to visit other countries to learn about the technology."*

Training on choices of remedial technologies for dioxin - Unscored

There were two types of training on choices of remedial technologies. The first was formal training on different technologies and how to screen them. The second was study tours where senior-level GVN officials traveled abroad to see the technologies in application. The formal training with a workshop in March 2010 was about the same time that the draft EA was released. Subsequent workshops followed in May, October, and November of 2010 that presented the IPTD technology and discussed it in the context of the EIA and implementation. In 2016, between April 6th and 8th, training was provided for mid-level GVN staff on remediation technologies and evaluation alternatives.

More than for any other question, the KIIs did not answer the question asked. Rather, they answered about the actual choice of technology and not the training. Therefore, we have not scored this question because the answers do not address the subject. However, the answers provide important feedback on the issues of communication and inclusive stakeholder involvement.

The main issue that most KIIs reported was that they, the GVN, did not feel that they had any say in the choice of technology. The evaluation team could not get correspondence or information that would allow for a conclusive answer to this issue of technology choice. It appears that the selection criteria for screening technology choices for Danang was developed in concert with representatives of the GVN. There are records of attendance for the pre- and post-EA workshops that show GVN attendance. The EA put forward three alternatives: passive landfill, active landfill and ISTD/IPTD. It is our understanding that both the GVN and USAID turned down the option of landfills and this left only ISTD/IPTD. What is unclear is the extent to which the individuals questioned in this evaluation participated in the earlier work or whether the process had been thoroughly communicated. Better and wider circulation of key project decisions would benefit all parties and provide for more inclusive decision making.

CONCLUSIONS

The KIIs reflect the view that the project was successful. The interviews show that stakeholders recognize that the project has had key successes that contributed to the immediate problem of reducing potential exposure to dioxin at the Danang Airport, and improving relationships between the USG and GVN. It has built the capacity of the GVN and contractors to implement other dioxin remediation projects. This project has performed above the expectations of all interviewees as evidenced by the scores reported above. There was one KII that reported a rating less than 5 on one question.

While KII respondents viewed the project as a success, the responses point to room for improvement in the areas of communications, soil characterization, and planning. Communication was consistently mentioned throughout the interviews, that it was good but needed to be improved. Respondents mentioned that there were no established communication procedures or policies, and some answered that they were unaware of worker blood test results, even as the evaluation team determined that the blood test results had been communicated to the GVN counterpart. Some of the misperceptions about this issue appear to indicate the need for wider dissemination of project communications, results, agreements, and reports.

RECOMMENDATIONS

The principal recommendation coming out of these interviews is that USAID help to improve communication by supporting a stakeholder-wide body such as Office 701 in developing a project/program specific communication plan. Additionally, it is recommended that USAID provide periodic assistance, for example, having the implementation contractors provide routine updates for Office 701 to share with other stakeholders.

Other recommendations will appear in lessons learned, EQ5.

EQ5: WHAT ARE THE LESSONS LEARNED FROM THE DANANG REMEDIATION PROJECT THAT CAN BE USED TO REMEDIATE DIOXIN AT OTHER SITES, SUCH AS BIEN HOA.

The lessons learned have been ordered according to frequency in which they appeared in the team's interviews. In general terms, the main lessons learned that can be drawn from this project are linked to Soil Characterization, Communication, Project Planning, Piloting, and Reporting. Annex 8 contains the lessons learned by contractors that support and add detail to the general lessons learned that are presented here.

LESSON1 – SOIL CHARACTERIZATION

FINDINGS

As has been discussed in the EQ1, the volumes of soil to be treated and excavated were significantly different from what was estimated during soil characterization. Early estimates of soil volumes were based on discrete (grab) samples and on land use records that were outdated. This might also influence the decision on clean-up targets. During implementation, the project soon discovered that soil characterization was suboptimal. Initial estimates were that 72,900[38] m^3 were to be excavated, but actual excavation levels reached 162,567 m^3. Similarly, treated volumes were estimated to be 72,900[39] m^3 while 94,593[40] m^3 were finally treated. The difference in volumes between treated soils and total excavations had to be placed in the EVSA[41]. As the USAID contractors noted, "Use of grab samples did not give high level of accuracy. High concentrations could render the entire area (unnecessarily) characterized as contaminated before Multi Incremental Sampling.[42]"

Danang EA samples showed 97 percent variability between the discrete samples collected. At Bien Hoa, where mixed methods were applied, variability was 31 percent indicating that mixed methods can lead to better decisions.

Both the difference in volumes and the creation of the EVSA caused problems during implementation, and as the lessons learned session echoed, "*The grab sample approach led to huge schedule delay.*[43]"

In addition to the problems arising from using only one method of sampling for site characterization, the GVN KIIs indicated that **potential hotspots may have been missed at Danang**. The GVN concluded that this may have been the result of using old land use records. Local stakeholder communities are aware of how land use has changed over time since they are often the "users," or living there, they observe changes in land use.

---

[38] Source: USAID, Final Design Report, Dig and Haul Component. Table 1, March 2011.

[39] The original expected treatment volume was equal to the volume excavated. According to ACR 2, the ECC contractor built the pile 20% "larger than primary design" in case of overages. However, the design or intended treatment was the 72,900 m^3.

[40] Activity Completion Report 4.

[41] The fact that the early planning documents concluded that all excavated volumes would be treated meant that no preparation was made for either a landfill to hold volumes that were below the action level or for land use of excess material. (See the lesson learned in planning for more detail).

[42] MIS was not accepted by the USEPA before 2012.

[43] Lessons learned from USAID Contractors, June 2018.

CONCLUSIONS

High levels of uncertainty at the start of remediation influenced both the time schedule and the overall costs of the project. Although it is difficult to confirm the precise volumes of contaminated soil and sediments before the start of excavation/remediation works, the pre-remediation survey was significantly underestimated.

RECOMMENDATIONS

More in-depth site characterization is needed before implementation of such complex remediation projects, including verification of survey results by means of combination of sampling methods. Based on the experience of Danang in soil characterization, the following lessons learned are deemed appropriate for Bien Hoa:

- Monitoring plan (including analytical methods) must be agreed in advance. MSI should be used instead of discrete sampling. The same sampling techniques should be used for confirmation data as for excavation.
- Consider the link to mass balance and confirmation of sampling approaches before start of the remediation.
- Meet with local stakeholders to determine land use pattern changes that may not appear in official records.

LESSON 2 – COMMUNICATION

FINDINGS

There were several instances, as discussed above in EQ4, where lack of adequate communication was specifically mentioned by almost all KIIs. Two KIIs reported, for example, not knowing the results of worker blood tests even though USAID had shared them with MND. Similarly, most GVN KIIs indicated that their expectation of the project was to achieve zero risk of exposure during implementation, as well as meet the mandated standard for treatment. Most notably, when asked about the training on technology, most respondents expressed concern that they were not involved in the selection of the treatment technology. Further investigation showed that the GVN had been involved from the beginning in establishing the criteria that would guide technology selection and would ultimately lead to the decision that IPTD was the only viable choice. How it was ultimately communicated and the history that would inform new people to the Project, is not clear.

CONCLUSIONS

Several Project issues or problems were likely symptoms of a lack of adequate communication processes.

RECOMMENDATIONS

Committee 701 has been established as a project management unit for future dioxin projects. It is recommended that USAID support this office in the development of project communications plans and with periodic support for implementation. Contractors, for example, can provide routine fact sheets and progress updates to Committee 701 in a format that is easily shared with other stakeholders. In any case, a Project Management Unit should be established, with clear roles and responsibilities (including contact points).

The goal of the project must be clearly communicated. Risk assessment (before and after) should be included and remediation targets should be linked to exposure scenarios according to the actual and foreseen use of the site.

The key criteria for treatment technology selection should include:

- Definitive (not temporary) solution;
- Full scale method, able to remediate > 90,000 m^3 of highly contaminated soil;
- Verified method, able to reach the target values;
- On-site remediation; and
- Compliance with Vietnamese regulations.

LESSON 3 – GENERAL PROJECT PLANNING

FINDINGS

Several important aspects of project implementation were missing in the planning documents. For example, there was no discussion about demobilization, or it was treated as an implicit assumption that all excavated volumes would be treated and that there would be no excess volumes. In both the KIIs and in Contractor Lessons Learned, the need to have better planning, or to spend more time in the planning stage was discussed. This included: pilot testing, assessing alternative approaches, adding the EVSA into the EIA, explicitly discussing how excess volumes below the cleanup levels (if generated) will be addressed, and demobilization plans.

During the interviews, it was mentioned that the treated soil was not suitable for construction purposes and that there were no plans to deal with the EVSA and with the CMU. The Vietnamese party claims that additional costs are necessary to complete the demobilization and that they were not prepared for these potential costs.

KIIs noted that there were numerous instances where plans for actions were not implemented and unplanned actions were implemented. For example, originally it was planned that an oxidizer would be used in treatment and it was assumed that granular activated carbon (GAC) could be destroyed in a cement kiln in Vietnam (i.e., incineration)"[44]. An oxidizer was not used and the GAC could not be destroyed in Vietnam. As one contractor stated, "*CDM tried to get someone in Vietnam to be licensed for dioxin contaminated carbon. It wasn't easy – would take more time than entire project to get that done.*" Granular activated carbon and other waste material had to be sent from Vietnam to Switzerland and France for incineration. This high quantity of GAC sent to incineration was because the oxidation unit to treat the emissions was not approved[45].

---

[44] Meeting Minutes: ISTD/IPTD Technical Workshop, Presentation of January 2010 Sampling Results, and Danang Airport Site Visit, May 18, 2010 (Melia Hotel, Ha Noi, Vietnam) and May 20, 2010 (Green Plaza Hotel, Danang, Vietnam).

[45] This is also linked with the lack of piloting because the quantity of GAC could have been better predicted and/or the oxidation unit could have been added. Even for use of GAC, better planning could have saved money and time. Japan is a signatory country of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal near Vietnam and during the year of 2017 approved 139 out of 184 received applications for the import of hazardous waste for disposal in their territory

CONCLUSIONS

While implementation in terms of treatment levels, treatment time, and worker health and safety was outstanding, there were problems that arose that increased cost and caused delays that could have been avoided through better planning. Some of these may have been caused by time pressures at Danang which are not present at Bien Hoa. Other issues, such as the failure to plan demobilization or to consider the possibility of excess volumes, are not understandable.

RECOMMENDATIONS

Assumptions should be explicitly stated and there should be open discussion about what happens if these assumptions do not hold. Piloting will reduce the potential for upset during full-scale implementation (time and cost) and needs to be adequately planned and incorporated into the project time line. Lessons learned from contractors include:

- Build in adequate time for program design. Provide schedule flexibility to address issues and make system improvements.
- More market research upfront and facilitate capacity building if a potential partner has technical capacity but needs to scale.
- During the planning stage of the project, the final use of the land and of the treated material must be clearly established. A proper handover/demobilization protocol or procedures must be agreed in advance (including the requirements on necessary verification analyses).
- More throughout assessment of potential disposal options abroad is necessary in case that the wastes cannot be treated or recycled locally. If the option to export hazardous materials is considered (or needed) for the next projects, an expert on Basel Convention and Transboundary Shipments of Waste should be recruited.

LESSON 4 – PILOTING

FINDINGS

During Phase I of the Project, some delays were experienced related to the fact that the technology was only tested in a laboratory setting, and not as a proper pilot. This was acknowledged by the US Contractors in the lessons learned exercise of Phase I and confirmed when comparing the implementation time of Phase I and Phase II. Based on the experience from Phase I, Phase II was significantly shorter and more efficient. "*(We) need to do the full-scale pilot test. (If we) Get an idea of when the contamination is heated, we will know what will come off… to really understand the full system and how it reacted, get the operational information (moisture content, interactions with the components).*"

CONCLUSIONS

Piloting the technology properly could optimize Project design, helping reduce risk, and avoid costs and other issues over time. Having proper results from a pilot may have allowed USAID to detect problems in Phase I rather than later. If a proper pilot cannot be implemented, there is a need to design treatment system for the worst-case scenario.

RECOMMENDATIONS

The remediation technology should be tested in real conditions to confirm its efficiency and viability for the Project. This testing can be partially replaced by field experience at sites with similar conditions. Other lessons learned from contractor notes include:

- Provide schedule flexibility to address issues and make system improvements.
- Provide enough time and resources for a pilot test.

LESSON 5 – REPORTING

FINDINGS

During this assessment, several inconsistencies in the data provided by the project reports have been identified. For instance, the data on the treated volume of soil and sediments were different in different reports (likely due to a change in the way a Monitoring and Evaluation (M&E) indicator was defined):

- 43,348 m^3 of contaminated soil/sediment was treated in Phase I, as reported in IPTD Final Report – Phase I of March 18, 2016.
- For Phase II, a total of 49,073 m^3 (page 2) or 49,703 m^3 (page 90) of contaminated soil/sediment was excavated and hauled for placement in the pile structure; due to shrinkage from compaction, the in-placed compacted volume in the pile structure is 43,660 m^3, as reported in IPTD Final Report – Phase 2 of November 30, 2017.
- The report on Dioxin Mass Balance for Phase II IPTD Treatment of June 7, 2018 claimed that there were successfully treated approximately 94,593 m^3 (see page 8) of soil and sediment via two batches (or phases) of IPTD and that the estimated dry soil volume in the Phase I pile was 44,100 m^3 with maximum soil density determined to be 1,821 kg/m^3 (see page 69) and for Phase II 43,660 m^3 (with maximum soil density determined to be 1,697 kg/m^3 (see table on page 31). The summary number thus does not correspond with the volumes reported for individual phases.

An issue with the calculation of the mass balance was identified during the June 2018 lessons learned meeting between the USAID and contractors. Based on the provided explanations, the final volumes were confirmed as follows:

- 1st Phase: 45,520 m^3
- 2nd Phase: 49,073 m^3
- EVSA: 67,974 m^3
- Total: 162,567 m^3

Although these numbers confirm the final reported volume of 94,593 m^3 treated by IPTD, they do not fully correspond with the numbers provided for both phases in the above reports.

Another problematic issue is mixed reporting of dioxin concentrations in ppt and pg TEQ/g, without confirming the composition of dioxins and furans in the analyzed media and thus without verifiable calculations of toxicity equivalent. Some degree of uncertainty of these calculations is admitted also in the report on Dioxin Mass Balance for Phase II IPTD Treatment of June 7, 2018 (page 9).

The surface concentrations reported in ng TCDD/m^2 can be well used as "intervention" values during implementation but cannot be used for mass calculations.

CONCLUSIONS

The Project reports could not be used as reliable single sources of information on project implementation and results. The provided information had to be verified from other secondary and primary sources. The final reports on any remediation project should include the correct and verifiable numbers, especially when the results are used for mass balance calculations, for specifying the unit costs for the treatment, or for calculating the residual risks. From that point of view, the concentrations of contaminants in concern were not monitored and reported consistently in the same scale and using the same units, and the method for calculating the mass balance was not specified in advance.

RECOMMENDATIONS

Clear reporting requirements must be set in the contracts and must be fulfilled (see for example the requirement in the TerraTherm contract that the updates must include actual progress versus scheduled progress for each task, percent complete by each task, remaining duration, and total float). A system for monitoring and calculation of the mass balance and other results must be included already in the design of the project and must be consistent for all phases of the remediation process.

ANNEX 1. EVALUATION SCOPE OF WORK

PURPOSE OF THE EVALUATION

USAID/Vietnam wants to evaluate its "Environment Remediation at Da Nang Airport" Project. The project is a joint effort between USAID and the Vietnam Ministry of National Defense (MND). The evaluation has three main objectives:

1. Obtain independent, third-party review and evaluation of the overall effectiveness of the project in addressing legacy dioxin-contaminated soil and sediment.
2. Document the benefits of USAID/MND cooperation on remediation of Da Nang Airport to the region, and extent the work is a model for future collaboration.
3. Develop recommendations for future cooperative efforts addressing legacy dioxin contamination at Bien Hoa Airport.

These objectives will be accomplished in two evaluation phases designed to align with planned project close-out events and the start of a new, similar project at Bien Hoa Air Base which is planned to begin in late 2018.

The primary audiences for this evaluation are the GVN, MND, National Steering Committee on Overcoming Post-War Consequences of Unexploded Ordnances and Toxic Chemicals in Vietnam (Department 701), USG, and USAID. Secondary audiences include key partner GVN ministries, including the Air Defense – Air Force Command (ADAFC), Ministry of Natural Resources and Environment (MONRE), Provincial Departments of Natural Resources and Environment (DONRE) as well as the consultants and contractors, specifically CDM International, Inc. (CDM), Tetra Tech, Inc., and TerraTherm responsible for implementation of the technical work activities. Evaluation findings will be used to shape the design and implementation of future dioxin remediation activities.

SUMMARY INFORMATION

The "Environment Remediation of Dioxin Contamination at Da Nang Airport" Project is a 10 year (2009-2018), $110 million project to characterize, remove and contain dioxin contaminated soil and sediment from hotspots at Da Nang Airport. The geographic region covered by this project is the site of the Da Nang Airport only. The project contributes to the Mission's Country Development Coordination Strategy's Special Objective Intermediate Result 1.1 Reduced Dioxin Contamination. This feeds into the Mission's Special Objective: Legacies addressed to advance the U.S. - Vietnam Partnership.

The project has been implemented by three partners: CDM International, TETRA TECH, and TERRATHERM. All activities were run by USAID/Vietnam Office of Environment and Social Development. Annex 1 of this document for more detailed information on each implementer's role in the project.

BACKGROUND

Description of the Problem and Development Hypothesis(es)

Da Nang Airport is one of three dioxin hot-spots identified through studies completed in the 1990's by the GVN with support from several partner government and non-government organizations. Da Nang Airport, along with Phu Cat and Bien Hoa, were used by the US military for the import, storage, and loading of Agent Orange and other herbicides and defoliants (collectively referred to as Agent Orange) between 1961 and 1971. Dioxin, a contaminant associated with Agent Orange, is present in soil at concentrations exceeding GVN regulatory standards. To mitigate potential human exposure, the GVN completed studies and implemented select remedial measures at all three airports in the early 2000's. Since 2000, USG agencies have engaged with their Vietnamese counterparts to work on the complex Agent Orange/dioxin issue, notably through a bilateral Joint Advisory Committee on Agent Orange/dioxin that was created to coordinate collaborative research on this issue.

In 2007, the U.S. Congress began appropriating money to carry out Agent Orange/dioxin health and remediation activities in Viet Nam, much of which has been programmed for environmental remediation at Da Nang Airport. The purpose of USG participation in dioxin remediation is to address the legacy of the American-Viet Nam war through reduction of dioxin contamination as measured by:

- Cubic meters of dioxin-contaminated soil and sediment excavated and treated,
- Increased GVN knowledge of environmental assessment and remediation methodologies and best practices,
- Public outreach and stakeholder engagement in the site remediation process, and
- Training in the areas of Health and Safety and environmental assessment and remediation provided to representatives of various GVN ministries.

The Da Nang project has increased the familiarity of USAID and GVN with environmental remediation work in general and dioxin clean up in particular. USAID has completed capacity building activities with the GVN to further their understanding of environmental assessment and remediation work over the duration of the Da Nang project. Several key regulatory and remedial issues for Da Nang were resolved during the implementation phase. USAID is working to establish a risk-based, evidence-driven decision making framework with the GVN for use during planning and remedial implementation on future remediation projects.

USAID and the GVN-MND are in the early planning stages of remediation of Bien Hoa Air Base. Bien Hoa is the remaining dioxin hot-spot and is estimated to contain four times the volume of contaminated soil and sediment present at Da Nang. Additionally, the soil and sediment contamination is present both inside and outside the boundaries of the airbase. Completion of this performance evaluation will provide lessons learned from clean-up efforts at Da Nang Airport to inform the clean-up of Bien Hoa Airbase.

Description of the Project to be Evaluated

Overview

The project was designed and implemented to respond to the Government of Vietnam's request to the U.S. Government to complete the environmental remediation, or cleanup, of the Da Nang Airport due to high dioxin concentrations in soil and sediment remaining from the U.S.-Vietnam War.[46] The extent of the contamination at Da Nang Airport is summarized in the Environmental Assessment (EA) (USAID, 2010) and the Environmental Impact Assessment (EIA) (GVN, 2012) prepared as part of the project approval process by the USG and GVN, respectively.

In 2010, USAID completed an Environmental Assessment of the Da Nang Airport that estimated the volume of dioxin contaminated soil and sediment at the airport and evaluated multiple remediation strategies. In 2011, USAID and the Vietnamese Ministry of National Defense (MND) agreed to jointly implement the Da Nang Airport Remediation Project, which aims to clean up the dioxin contamination, eliminating the risk of dioxin exposure to the surrounding community, while developing Vietnamese capacity for environmental assessment and remediation activities.

Environmental Remediation Process

The Da Nang Airport Remediation Project uses both thermal treatment and containment remediation approaches. The thermal treatment strategy involves three major steps: building an enclosed, above ground treatment structure; excavating and placing the dioxin-contaminated soil and sediment into the structure; and heating the contaminated soil and sediment to a high temperature (approximately 335°C) to destroy the dioxin. Following treatment, the soil and sediment is tested by both USAID and MND scientists to ensure it meets the approved GVN treatment goal. The treated material is then cooled, removed from the treatment structure and used as fill material on site to advance the Da Nang Airport's expansion plans. In addition to thermal treatment, USAID and MND are nearing completion of the land-filling of approximately 60,000 cubic meters of low concentration, dioxin-contaminated sediments. USAID, MND and the Vietnamese Ministry of Natural Resources and Environment agreed that containing these sediments was the appropriate means for preventing human health and environment impact over the long-term.

In October 2008, USAID awarded a contract to CDM International, Inc. (CDM) to complete "Environmental Remediation at Da Nang Airport: Assessments and Engineering Designs and Plans for Dioxin Contamination" (the Project). USAID subsequently awarded contracts to Tetra Tech and TerraTherm, respectively, to implement the approved engineering designs. CDM was retained to provide construction oversight services.

Project work began in 2009 and site remediation was substantially complete in 2017. The Project is in the final close-out phase, which includes disposal of excess construction materials and waste products, and completing planned training on aspects of environmental assessment and site remediation, to facilitate the GVNs on-going environmental programs. Completion of this performance evaluation is an important element of project close-out.

The EA and EIA include a description of the remediation methods used at Da Nang Airport. These included a form of ex-situ thermal conductive heating, to destroy dioxins in soil and sediment above the GVN

[46] Soil and sediment at Danang Airport contained dioxin at concentrations above GVN standards and that posed both human health and ecological risks. Dioxin is a persistent environmental pollutant. Humans are exposed to dioxin primarily through ingestion of contaminated food, such as fish and mollusks, present in ponds and lakes containing contaminated sediment

standard for human health. Soil containing dioxin at concentrations below human health criteria but above sediment criteria was isolated in a capped land disposal unit constructed on GVN managed land at the airport. Soil was treated in two phases. The U.S. and Vietnam announced the successful completion of the first phase of remediation at Da Nang in May 2016. Treatment of the second and final batch of dioxin-contaminated soil and sediment began in November 2016 and was substantially completed in 2017. Current activities include equipment and material demobilization and site restoration. These activities are anticipated to be completed in 2018.

Maintaining Health and Safety

All remediation activities occur entirely within the military portion of the Da Nang Airport. Measures are in place to ensure that contaminated soil, sediment, dust and water do not leave the project area. International safe work practices for hazardous waste sites are followed for all remediation activities, including worker monitoring and health and safety training. The project has achieved over one million accident-free work hours through more than 20,000 hours of worker training, building sustainable local capacity for best construction practices.

Results to Date

In May 2015, USAID and MND confirmed successful treatment of approximately 45,000 cubic meters of dioxin-contaminated material. The GVN officially accepted the first phase of treated land and treated soil in May 2016. The second and final phase of treatment was completed in June 2017, successfully treating almost 50,000 additional cubic meters of dioxin–contaminated material, also to be utilized for beneficial reuse by the Airport. USAID completed dioxin treatment at Da Nang in 2017 and expects full site restoration and project closure by mid-2018.

Project Monitoring and Planning Documents

USAID will provide the evaluation consultant copies of contract work scopes, key project deliverables, including planning documents, environmental mitigation plans, and summary reports to complete the evaluation. Similarly, USAID will make detailed cost information available to the evaluation consultant as available and needed for consultant to complete their work. The information will be shared in electronic format using google docs or similar software.

USAID entered into contracts with three firms to implement the Da Nang Environmental Remediation project. Each contract included several deliverables. Key elements of these contracts are summarized in Annex 1 (Tables 1 through 3). In conformance with USAID internal procedure, CDM was tasked with developing and implementing an Environmental Mitigation and Monitoring Plan outlining activities to address impacts during remedial construction. Additionally, as USAIDs construction oversight firm, CDM identified and documented issues and problems during construction. These are generally summarized in CDMs project activity reports. Budgeted costs for the above referenced contracts are summarized in the Annex 2 Table 4. The Office of Inspector General completed an audit of the project in 2014. The results of the audit are included in Audit Report No. 5-440-15-001-P, dated November 12, 2014, and titled Audit of USAID/Vietnam's Environmental Assessments and Remediation Project (***see Annex 3***).

EVALUATION QUESTIONS

The evaluation questions for this end-of-project performance evaluation are:

1. To what degree did the project achieve its purpose of characterizing, removing and containing dioxin contaminated soil and sediment from hotspots at Da Nang airport?
2. How cost effective was using thermal destruction of dioxin (IPTD) at the Da Nang Airport compared to similar and/or alternative solutions or comparable remediation projects elsewhere in the world?
3. What are the economic benefits and return on investment for Viet Nam and the local community that can be linked to the project results?
4. How do program stakeholders view the degree to which the project met expectations for the clean-up of dioxin? (Including communications and information transfer/training on choice of remedial alternative, health and safety controls, and environmental monitoring, and furthering a collaborative relationship between the USAID and GVN).
5. What are the lessons learned from the Da Nang Remediation Project that can be used to remediate dioxin at other sites, such as Bien Hoa, in terms of: Alignment with international norms and standards for project delivery, such as the Project Management Institute (PMI) framework; Mitigating schedule and cost risks and managing change, and Improving stakeholder communication and coordination.

EVALUATION DESIGN AND METHODOLOGY

This performance evaluation should be multi-phased to align with planned project close-out events and the start of a new, similar project at Bien Hoa Air Base which is planned to begin in late 2018:

- Phase 1 will primarily be a desk and literature review to address the first evaluation objective, which is to obtain independent, third-party review and evaluation of the overall effectiveness of the project in addressing legacy dioxin-contaminated soil and sediment. An interim report will be issued which will address the first three evaluation questions and quantify the degree to which the work met USAID and GVN goals for reduction of dioxin contamination, and how the project compares to similarly-sized efforts completed elsewhere in the world.
- Phase 2 will require in-county review and data collection to answer questions four and five. It will build on the results of the desk review and the interim report produced, will be a study of the project execution in order to respond to the second and third evaluation objectives, to document the benefits of USAID/MND cooperation on remediation of Da Nang Airport to the region, and extent the work is a model for future collaboration; and, to develop recommendations for future cooperative efforts addressing legacy dioxin contamination at Bien Hoa Airport.

The evaluation team, in collaboration with USAID, will finalize the overall evaluation methodology before fieldwork begins. USAID expects that, at a minimum, the evaluation team will:

- Review and analyze the existing performance information/data;
- Conduct site visits [when applicable and feasible];
- Meet and interview USAID project beneficiaries, partners, and host government counterparts at appropriate levels;
- Interview USAID staff and a representative number of experts working in the sector;

- Before arrival, the team members shall familiarize themselves with documentation about the project. USAID will ensure that this documentation is available to the team prior to their arrival in the region.

The desk review includes at a minimum:

- The Statement of Works and the Activity Approval Document;
- The project materials: Annual and Quarterly Reports, Annual Work Plan, Sector Assessments, trip reports, performance report, and miscellaneous thematic reports from other sources such as the relevant Inspector General Audit; and
- A finalized interim report to be delivered to USAID, addressing the first three evaluation questions.

Deliverables and Reporting Requirements

The following describes the minimum required deliverables to be provided by the consultant evaluation team. It is anticipated that the key members of the consultant team will perform a portion of the work scope in Viet Nam and that supporting staff will be remotely located.

All deliverables will be provided to USAID in electronic format as both pdf and editable formats. Final documents will be prepared using common office software such as Word, Excel, PowerPoint, and Adobe Acrobat. Deliverables will be prepared in English and when approved by USAID, Consultant will have the document translated into Vietnamese. USAID will review and approve translations prior to issuance to the GVN representatives as final documents.

Schedule for Evaluation of Da Nang Remediation Project Deliverables				
Deliverable	Planning Date 2018	Estimated Hours	Estimated Days	Estimated Cost 2 $600/Day or $75/Hour Ave.
Phase 1				
1. Preliminary Work Plan and Evaluation Design Document	May 4	40	5	3,000
2. Kick-Off Meeting	May 11	24	3	1,800
3. Final Work Plan and Evaluation Design Document	May 18	40	5	3,000
4. Background Data Review Briefing	June 1	16	2	1,200
5. Participation in Da Nang Project Close Out Meeting and Phase 1 In-Country Presentation	June 11- June 22	200	25	15,000
Phase 2				
6. Preliminary Work Plan and Evaluation Design Document	July 20	80	10	6,000

Schedule for Evaluation of Da Nang Remediation Project Deliverables				
Deliverable	Planning Date 2018	Estimated Hours	Estimated Days	Estimated Cost 2 $600/Day or $75/Hour Ave.
7. Kick-Off Meeting	July 31	32	4	2,400
8. Final Work Plan and Evaluation Design Document	August 7	60	7.5	4,500
9. In-Country Interviews and Exit Briefing	August 13 – August 24	240	30	18,000
10. Draft Evaluation Report	September 28	240	30	18,000
11. Draft Evaluation Report Review Meeting	October 10	36	4.5	2,700
12. Final Evaluation Report	October 31	80	10	6,000
13. Final Evaluation Work Shop	TBD - November	80	10	6,000

Description of Deliverables

Phase 1

Evaluation Design: The evaluation team must submit to the Contracting Officer's Representative (COR) an evaluation design (which will become an annex to the Evaluation Report). The evaluation design will include: (1) a detailed evaluation design matrix that links the Evaluation Questions from the SOW (in their collaboratively finalized form) to data sources, methods, and the data analysis plan; (2) draft questionnaires and other data collection instruments or their main features; (3) the list of potential interviewees and sites to be visited and proposed selection criteria and/or sampling plan (must include calculations and a justification of sample size, plans as to how the sampling frame will be developed, and the sampling methodology); (4) known limitations to the evaluation design; and (5) a dissemination plan (designed collaboratively with USAID). The evaluation consultant will be provided an opportunity to update the Phase 1 Work Plan and Evaluation Design Document prior to initiating Phase 2 as described below. The preliminary work plan and evaluation design document will be provided to USAID at least one week prior to a scheduled Phase 1 project kick-off meeting.

Participation in a Phase 1 Kick-Off Meeting: The evaluation consultant will participate with USAID representatives in a project kick-off meeting. The goals of the meeting include: (1) review and confirmation of both Phase 1 and Phase 2 evaluation objectives and goals; and (2) overview of consultants' Work Plan and Evaluation Design Document. Consultant will prepare summary meeting minutes following the kick-off meeting that will identify action items and the person and organization responsible for the action item. The minutes will be submitted to USAID for review. Once accepted by USAID, Consultant will translate the meeting minutes into Vietnamese and submit to USAID. USAID will send the minutes to representatives of the GVN following its review.

Phase I Background Data Review Briefing: Following its review of background data, the evaluation consultant will lead a review meeting with USAID to present its preliminary findings relative to the Phase 1 objective.

Phase I Final Work Plan and Evaluation Design Document: A final work plan and evaluation design document will be prepared following the kick-off meeting and will address comments received as appropriate. The document is anticipated to have minimal text and present evaluation methodology in tabular fashion. Consultant will address comments received on the draft submittal as appropriate, in the Final Work Plan and Evaluation Design Document.

Participation in Da Nang Project Team Closeout Meeting: A final project close out meeting is anticipated to occur in June 2018 in Da Nang. The evaluation consultant will participate in that meeting as an observer following its review of background information. The goal of consultant participation is to introduce themselves to key team members that maybe subsequently interviewed as part of phase 2, observe staff interaction, and collect additional information in order to prepare the phase 2 Work Plan and Evaluation Design Document.

Phase I Project Presentation: Consultant will organize and lead an all-day workshop, format to be determined, at which it will present the findings of the Phase 1 evaluation. The workshop will occur in Hanoi and will have an estimated attendance of 50 people representing various stakeholder groups. Presentation materials will be submitted to USAID and GVN for review and comment. Consultant will finalize materials to incorporate agreed upon comments and edits.

Phase 2

Phase 2 Preliminary and Final Work Plan and Evaluation Design Documents: The evaluation consultant will update the Phase 1 Work Plan and Evaluation Design Document to incorporate Phase 2 activities, including consultant work tasks, durations, data needs and dependencies, anticipated level of effort, and foreseeable constraints. The consultant will provide USAID a copy of the Preliminary Work Plan and Evaluation Design Document one week in advance of a schedule review meeting.

Participation in a Phase 2 Kick-Off Meeting: The evaluation consultant will participate with USAID and GVN representatives in a Phase 2 kick-off meeting. The goals of the meeting include: (1) Review of the Phase 2 Preliminary Work Plan and Evaluation Design Document; (2) Coordination of communications with project stakeholders, confirmation of communication methods, and scope discussion; and (3) Discussion of project deliverables including the draft and final evaluation reports, and presentation materials. Consultant will prepare summary meeting minutes following the Phase 2 review meeting that will identify action items and the person and organization responsible for the action item. The minutes will be submitted to USAID for review. Once accepted by USAID, Consultant will translate the meeting minutes into Vietnamese and submit to USAID. USAID will send the minutes to representatives of the GVN following its review.

Final Exit Briefing: The evaluation team is expected to hold a final exit briefing prior to leaving the country to discuss the status of data collection and preliminary findings. This presentation will be scheduled as agreed upon during the phase 2 kick-off meeting.

Preliminary Presentation: The evaluation team is expected to hold a preliminary presentation in person/by virtual conferencing software to discuss the summary of findings and conclusions with USAID and to collaboratively draft any requested recommendation. This presentation will be scheduled as agreed upon during the phase 2 kick-off meeting.

Final Presentation: The evaluation team is expected to hold a final presentation in person/by virtual conferencing software to discuss the summary of findings and conclusions, and recommendations (if applicable) with USAID. This presentation will be scheduled as agreed upon during the phase 2 kick-off meeting.

Draft Evaluation Report: The draft evaluation report should be consistent with the guidance provided in Section IX, Final Report Format. The report will address each of the questions identified in the SOW and any other issues the team considers to have a bearing on the objectives of the evaluation. Any such issues can be included in the report only after consultation with USAID. The submission date for the draft evaluation report will be determined in the evaluation work plan. Once the initial draft evaluation report is submitted, USAID/Vietnam will have **[*number*]** business days in which to review and comment on the initial draft, after which point the COR will submit the consolidated comments to the evaluation team. The evaluation team will then be asked to submit a revised final draft report **[*number*]** business days hence, and again the USAID/Vietnam will review and send comments on this final draft report within **[*number*]** business days of its submission**.**

Final Evaluation Report: The evaluation team leader will then submit the final report to the COR. Per USAID policy (ADS 201 and the Evaluation Policy) the Contractor must submit evaluation final reports and their summaries to the Development Experience Clearinghouse (DEC) within three months of final approval by USAID. Per USAID ADS 579 and the Evaluation Policy, the Contractor must also submit to the COR and the Development Data Library (DDL), at www.usaid.gov/data, in a machine-readable, non-proprietary format, a copy of any Dataset created or obtained in performance of this award The Dataset should be organized and documented for use by those not fully familiar with the intervention or evaluation.

EVALUATION TEAM COMPOSITION

The evaluation team will be composed of two to three international experts in environmental remediation project delivery, environmental remediation technology, and economics in addition to support staff. One of the experts will serve as the team leader and will be the primary contact with USAID during the evaluation. It is anticipated that two of the consultant experts will make a minimum of two trips to Viet Nam.

The team will have expertise in monitoring, evaluation, and learning (MEL) reviews. To avoid perception of bias, it is preferred the team leader and specialist not be currently engaged by the American or Viet Nam government. All project deliverables will be provided in American English and Vietnamese. Consultant is expected to provide translation services.

The designated Team Leader will lead the team, finalize the evaluation design, organize work activities, prepare a schedule, consolidate individual input from team members, and coordinate the assembly of the final findings and recommendations. S/he will be responsible for the overall technical quality of the evaluation. S/he will be the primary point of contact for USAID and its implementing partners regarding the technical aspects of the evaluation. S/he shall also lead the preparation and presentation of key evaluation findings and recommendations to the USAID team and key partners.

The environmental remediation technical specialist will participate in fieldwork, perform data analysis, and contribute to writing project deliverables. In addition, s/he will work closely with the team leader in drafting a detailed assessment plan, developing data collection tools, and documenting lessons learned. S/he is expected to provide the team expert knowledge in environmental remediation technology and technology application, and make sound recommendations for their effectiveness in Viet Nam considering the physical and economic environment and level of environmental regulation.

The expert in economics will be experienced in international development cost/benefit analysis. S/he will be responsible for research and data analysis necessary to quantify the economic benefits realized from remediation of Da Nang Airport and contributes to writing the report.

<u>Staff qualifications include:</u>

- Senior independent consultants with experience leading and conducting performance evaluations on complex environmental remediation projects
- Experience with standardized project delivery frameworks incorporating monitoring and evaluation work phases and change management
- Experience with providing technical services to USAID programs, project implementation and administration, financing, and management procedures,
- Experience with international environmental remediation projects, with experience in the Southeast Asian region, a plus
- Excellent oral and written skills required
- Strong English language oral and written skills required
- Critical thinking skills with high analytical capacity
- Proficient in qualitative assessments.

The contractor must provide information about the selected evaluation team members, including their CVs, and explain how they meet the requirements set forth in the evaluation SOW. Submissions of writing samples, preferably samples or links to past evaluation final reports and related deliverables substantially composed by proposed team members, are highly desirable. All team members are required to provide to USAID a signed statement attesting to a lack of conflict of interest in relation to the activity being evaluated (a COI form).

Proposed personnel are expected to be the people who execute the work of this contract. Any substitutes to the proposed team must be vetted and approved by the COR before they begin work. USAID may request an interview with any of the proposed evaluation team member/s via conference call/Skype or any other means available.

USAID may delegate one or more staff members to work full-time with the evaluation team or to participate in the field data collection activities. The evaluation COR will inform the contractor about any full-time/part-time USAID delegates no later than **[*number*]** working days after the submission of a *draft/updated* evaluation work plan. All costs associated with the participation of full-time/part-time USAID delegates in the evaluation will be covered by USAID.

EVALUATION SCHEDULE

Estimated Timeframe for Evaluation

Planned Date	Proposed Activities	Important Considerations/Constraints
Phase 1		
May 4	Preliminary Work Plan and Evaluation Design Document	
May 11	Kick-Off Meeting	
May 18	Final Work Plan and Evaluation Design Document	
June 1	Background Data Review Briefing	
June 11- June 22	Participation in Da Nang Project Close Out Meeting and Phase 1 In-Country Presentation	
Phase 2		
July 20	Preliminary Work Plan and Evaluation Design Document	
July 31	Kick-Off Meeting	
August 7	Final Work Plan and Evaluation Design Document	
August 13 – August 24	In-Country Interviews and Exit Briefing	
September 28	Draft Evaluation Report	
October 10	Draft Evaluation Report Review Meeting	
October 31	Final Evaluation Report	
TBD - November	Final Evaluation Report Workshop	

FINAL REPORT FORMAT

The evaluation final report (e.g. 30 pages) should include an abstract; executive summary; background of the local context and the strategies/projects/activities being evaluated; the evaluation purpose and main evaluation questions; the methodology or methodologies; the limitations to the evaluation; findings, conclusions, and recommendations (if applicable). For more detail, see the USAID Evaluation Toolkit for the How-To Note on Preparing Evaluation Reports and ADS 201mah, USAID Evaluation Report Requirements. An optional Evaluation Report Template is also available in the Evaluation Toolkit.

The abstract (of not more than 250 words) should briefly describing what was evaluated, evaluation questions, methods, and key findings or conclusions. The executive summary should be 2–5 pages in length and summarize the purpose, background of the project being evaluated, main evaluation questions, methods, findings, and conclusions as well as recommendations and lessons learned. This document must be translated into Vietnamese and shared with all evaluation stakeholders.

The evaluation methodology shall be explained in the report in detail. Limitations to the evaluation shall be disclosed in the report, with particular attention to the limitations associated with the evaluation methodology (e.g., selection bias, recall bias, unobservable differences between comparator groups, etc.)

The annexes to the report shall include:

- The Evaluation SOW;
- Any statements of difference regarding significant unresolved differences of opinion by funders, implementers, and/or members of the evaluation team;
- All data collection and analysis tools used in conducting the evaluation, such as questionnaires, checklists, and discussion guides;
- All sources of information/data, properly identified and listed; and
- Signed disclosure of conflict of interest forms for all evaluation team members, either attesting to a lack of conflicts of interest or describing existing conflicts of.
- Any "statements of difference" regarding significant unresolved differences of opinion by funders, implementers, and/or members of the evaluation team;
- Summary information about evaluation team members, including qualifications, experience, and role on the team.

CRITERIA TO ENSURE THE QUALITY OF THE EVALUATION REPORT

Per ADS 201maa, Criteria to Ensure the Quality of the Evaluation Report, draft and final evaluation reports will be evaluated against the following criteria to ensure the quality of the evaluation report:

- Evaluation reports should represent a thoughtful, well-researched, and well-organized effort to objectively evaluate the strategy, project, or activity.
- Evaluation reports should be readily understood and should identify key points clearly, distinctly, and succinctly.
- The Executive Summary of an evaluation report should present a concise and accurate statement of the most critical elements of the report.
- Evaluation reports should adequately address all evaluation questions included in the SOW, or the evaluation questions subsequently revised and documented in consultation and agreement with USAID.
- Evaluation methodology should be explained in detail and sources of information/data properly identified.
- Limitations to the evaluation should be adequately disclosed in the report, with particular attention to the limitations associated with the evaluation methodology (selection bias, recall bias, unobservable differences between comparator groups, etc.).
- Evaluation findings should be presented as analyzed facts, evidence, and data and not based on anecdotes, hearsay, or simply the compilation of people's opinions.
- Findings and conclusions should be specific, concise, and supported by strong quantitative or qualitative evidence.
- If evaluation findings assess person-level outcomes or impact, they should also be separately assessed for both males and females.
- If recommendations are included, they should be supported by a specific set of findings and should be action-oriented, practical, and specific.

OTHER REQUIREMENTS

All quantitative data collected by the evaluation team must be provided in machine-readable, non-proprietary formats at www.usaid.gov/data as required by USAID's Open Data policy (**see** **ADS 579, USAID Development Data**). The data should be organized and fully documented for use by those not fully familiar with the project or the evaluation. USAID will retain ownership of all survey and datasets developed.

All modifications to the required elements of the SOW of the contract/agreement, whether in technical requirements, evaluation questions, evaluation team composition, methodology, or timeline, need to be agreed upon in writing by the COR. Any revisions should be updated in the SOW that is included as an annex to the Evaluation Report.

LIST OF ANNEXES

1. Annex 1 - Tables of Implementer Roles and Key Deliverables in Da Nang Airport Environmental Remediation Project
2. Annex 2 – Summary of Project Costs
3. Annex 3 – The Audit of USAID/Vietnam's Environmental Assessments and Remediation Project

ANNEX 2. KII PROTOCOLS

EVALUATION QUESTION 4. KEY INFORMANT INTERVIEW QUESTIONS IN ENGLISH

These questions are guidance and used to probe the interviewee. Probe deeper: Why, how could it be done differently, why do you think it was not done that way?

In this interview, we want to understand the degree to which the clean-up of dioxin at the Danang airport project met your organization's expectations in several areas. These include:

- The quantity of soil and sediment treated and the treatment level,
- Worker health and safety,
- Communications among the parties,
- Cooperation between the Government of Vietnam and the United States Government in completing the project
- Furthering a collaborative relationship between the Government of Vietnam and the United States Government,
- Training in health and safety,
- Training in environmental monitoring and remediation of dioxins,
- Training on choices of remedial technologies for dioxin,
- Other expectations.

Question 1. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations for the treatment of dioxin?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Question 2. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations training for health and safety?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Question 3. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations in addressing the health and safety of its workers?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Question 4. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations in communications among all involved parties?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Question 5. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations in cooperation between the Government of Vietnam and the United States Government in completing the project?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Question 6. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations in training in environmental monitoring and remediation of dioxins?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Question 7. On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations in training on choices of remedial technologies for dioxin?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

Are there are other areas where you had expectations about the project that were not covered here and if so, what are they? (add each one in a separate listing below. After the interviewee is completed, then move to each aspect to ask if the project met expectations in that area).

On a scale of 1 to 10 with 10 being significantly exceeded expectations, 5 just met expectations, and 1 being substantially below expectations, did the project meet your expectations ____?

1	2	3	4	5	6	7	8	9	10

If not "5" then ask them, can you please explain why you answered as you did? What happened or did not happen to make you say this?

If less than "5", then ask what could have been done differently to make it meet your expectations?

EVALUATION QUESTION 5. KEY INFORMANT INTERVIEW QUESTIONS IN ENGLISH

These questions are guidance and used to probe the interviewee. Probe deeper. Why

Read: In this interview, we want to ask about lessons learned from the work that was conducted at Danang that can benefit future dioxin remediation projects.

1. What should be done over or differently in Danang remediation Project in the following areas?
    a. Planning
    b. Execution (Construction, Remediation, Sampling, Monitoring and Health and Safety)
    c. Capacity Building
    d. Stakeholder Engagement
    e. Improved relationships between the Government of Vietnam and United States.
    f. Closeout
2. Are there other lessons learned that we did not cover? What are these lessons learned?
3. Are there project events/situations that arose during implementation?
4. How can **these** unanticipated events/situations be avoided in Bien Hoa remediation project?

ANNEX 3. REFERENCES

BEM System, Inc. (2007): Mitigating the Impact of Dioxin-Contaminated „Hot Spots" in Vietnam, Assessment of Alternative Remediation Technologies and Work Plan for a Future Feasibility Study for Da Nang Airport.

Bernucci, I., Bertazzi, P.A., Brambilla, G., et al. (1998), The Seveso studies on early and long-term effect of dioxin exposure: a review, 1998, retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1533388/

Betraud, N. (2011), Da Nang's Urban Structure: Spatial Development Issues and Potential, Mimeo, 2011, retrieved from: http://alainbertaud.com/wp-content/uploads/2013/07/AB_report_Danang_Graphs_rev.pdf

Bimbaum, L., White, S. (2009), An Overview of the Effects of Dioxins and Dioxin-like Compounds on Vertebrates, as Documented in Human and Ecological Epidemiology, 2009, retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2788749/

Boivin, T., Son LK, Dwernychuk W, Tran MH, Bruce GS, Minh NH, Tran NT, Trinh KS, Phung TD, Moats, D, Allan JA, Borton L and Davies M. (2007). Agent Orange dioxin contamination in the environment and human population in the vicinity of Danang Airbase, Vietnam. Organohalogen Compounds Vol. 69, p. 576-579.

Boivin, T., Minh H.T. (2015). Evaluation of Dioxin Project - Impact to Environment and People. Global Environment Facility and United Nations Development Programme. Retrieved from: http://www.vn.undp.org/content/vietnam/en/home/library/environment_climate/evaluation_of_dioxin_project_impact_to_environment_and_people.html

CDM Int. (2010), Environmental Remediation at Danang Airport Environmental Assessment, USAID, June 2010.

CDM Int. (2011), Final Remediation Work Plan, USAID, March 18, 2011.

CDM Int. (2011), Final Site-Wide Sampling and Analysis Plan, USAID, March 18, 2011.

CDM Int. (2012), Preliminary Environmental Mitigation and Monitoring Plan, USAID, April 20, 2012.

CDM Int. (2012), Environmental Protection Plan, USAID, April 20, 2012.

CDM Smith (2014), Activity Completion Report No. 1, USAID, January 2014.

CDM Smith (2014), FY 2014 and FY 2015 Implementation Plan Update September 2014, USAID, September 2014.

CDM Smith (2016), Activity Completion Report No. 2, USAID, February 2016.

CDM Smith (2016), Activity Completion Report No. 3, USAID, July 2016.

CDM Smith (2016), FY 2016/2017 Implementation Plan, USAID, 2016.

CDM Smith (2017), Activity Completion Report No. 4, USAID, December 2017.

CDM Smith (2017), FY 2018 Implementation Plan, USAID, October 2017

CDM International, Inc. (2018). Assessment of Dong Nai Department of Natural Resources and Environment (DONRE) Sampling Program. USAID/Vietnam. May 18, 2018.

CDM Int. (2018), Dioxin Mass Balance for Phase II In-Pile Thermal Desorption (IPTD) Treatment, USAID, June 2018

CDM Int. and Hatfield Consultants (2016), Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase, USAID, May 3, 2016

Commission Regulation (EU) No 1259/2011, amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non dioxin-like PCBs in foodstuffs

Cooke, R.J. (2013), Independent Evaluation of MCDTM Technology Demonstrated for Dioxin Contaminated Soil Destruction in Viet Nam, GEF/UNDP, 2013

Da Nang Today (2018). Real estate predicted to bounce back from current slowdown. 18 May 2018. Retrieved from: http://www.baodanang.vn/english/business/201805/real-estate-predicted-to-bounce-back-from-current-slowdown-2597283/

De May, Piet (2010), Disabilities and Health Assessment, USAID/Vietnam, 2010

Diem, T. P., Hang, M. N., Thomas, G. B., Anna, Z., Snehalata, V. H., & Harold, L. B. (2015). Predictors for dioxin accumulation in residents living in Da Nang and Bien Hoa, Vietnam, many years after Agent Orange use. Chemosphere, 118, 277–283. Retrived from: https://www.sciencedirect.com/science/article/pii/S0045653514011400?via%3Dihub

Dunne, M., Tenkate, T., Harden, F., Toms L., Tuyet-Hanh, T.T., Vu-Anh, L. (2013), Knowledge, Attitudes and Practices to Reduce Exposure Among Residents Living Near Danang Dioxin Hot Spot - 2.5 years after a Preventative Intervention, 2013, retrieved from: https://eprints.qut.edu.au/67423/1/8011.pdf

EPA (2000) Federal Remediation Technologies Roundtable: Abstracts of Remediation Case Studies, Volume 4. U.S. Environmental Protection Agency, Department of Defense (U.S. Air Force, U.S. Army, U.S. Navy), Department of Energy, Department of Interior, National Aeronautics and Space Administration, Tennessee Valley Authority, Coast Guard, June 2000 (www.frtr.gov)

GEF/UNDP (2013), Mid-Term Evaluation Report for Environmental Remediation of Dioxin Contaminated Hotspots in Vietnam Project, GEF/UNDP, 2013, retrieved from: http://procurement-notices.undp.org/view_file.cfm?doc_id=36458

GEF/UNDP,(2015), Evaluation of Dioxin Project - Impact to Environment and People, GEF/UNDP, 2015, retrieved from: http://www.vn.undp.org/content/vietnam/en/home/library/environment_climate/evaluation_of_dioxin_project_impact_to_environment_and_people.html

Global Health Action (2013), New strategy toward dioxin risk reduction for local residents surrounding sever dioxin hotspots in Vietnam, 2013, retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3689901/

Harden, F. (2013), Knowledge, Attitudes and Practices to Reduce Exposure Among Residents Living Near Danang Dioxin Hot Spot - 2.5 Years After a Preventive Intervention, 2013, retrieved from: https://eprints.qut.edu.au/67423/1/8011.pdf

Hatfield Consultants (2007). Assessment of Dioxin Contamination in the Environment and Human Population in the Vicinity of Da Nang Airbase, Vietnam – Report 3: Study Summary. Retrieved from: https://www.hatfieldgroup.com/services/contaminant-monitoring-agent-orange/hatfield-agent-orange-reports-and-presentations/

Hatfield Consultants, Office of the National Steering Committee 33 MONRE (2009). Comprehensive Assessment of Dioxin Contamination in Da Nang Airport, Viet Nam: Environmental Levels, Human Exposure and Options for Mitigating Impacts. Retrieved from: https://www.hatfieldgroup.com/services/contaminant-monitoring-agent-orange/hatfield-agent-orange-reports-and-presentations/

Hatfield and Office (2011), Comprehensive Assessment of Dioxin Contamination in Danang Airport, Viet Nam: Environmental Levels, Human Exposure and Options for Mitigating Impacts, 2009, retrieved from: https://www.hatfieldgroup.com/services/contaminant-monitoring-agent-orange/hatfield-agent-orange-reports-and-presentations/

Hue NT, Nam VD, Thuong NV, Huyen NT, Phuong NT, Hung NX, Tuan NH, Son LK, Minh NH. (2014). Determination of PCDD/Fs in breast milk of women living in the vicinities of Da Nang Agent Orange hot spot (Vietnam) and estimation of the infant's daily intake. Science of the Total Environment. Pages 212–218. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0048969714002289?via%3Dihub

International Air Transport Association (IATA). (2016). "IATA Forecasts Passenger Demand to Double Over 20 Years." October 18, 2016. Retrieved from: https://www.iata.org/pressroom/pr/Pages/2016-10-18-02.aspx

International Air Transport Association (IATA). "Strategic Opportunities for Vietnam Aviation." August 2014. Retrieved from: https://www.iata.org/pressroom/pr/Pages/2014-08-27-01.aspx

Lupi, C., Hoa N. K. (2013). Mid-Term Evaluation Report for Environmental Remediation of Dioxin Contaminated Hotspots in Vietnam Project. Global Environment Facility and United Nations Development Programme. Retrieved from: http://procurement-notices.undp.org/view_file.cfm?doc_id=36458

McDowall, R. and Office of the National Committee 22, MONRE (2009): Technology Review for Dioxin Contaminated Soils and Sludge, Vietnam, version 2. Faculty of Business & Economics, University of Auckland, New Zealand, MONRE, UNDP, February 2009

Nguyen, H.M., Nguyen, T.M.H, Nguyen, V.T., Tran, M.T, Tran, T.T.H., Tu, B.M. (2018), Bioaccumulation of PCDD/Fs in Foodstuffs Near Bien Hoa and Da Nang Airbases: Assessment of Sources, Environmental Distribution and Intake in Humans, Batelle Conference, 2018

Real Estate Vietnam (2017). Da Nang Land Prices Increased Rapidly To The Surface Of The Ancient City. Retrieved from: https://realestatevietnam.com.vn/da-nang-land-prices-increased-rapidly-to-the-surface-of-the-ancient-city/

Rong Viet Securities (2017). The Odds Favor the Bold: 2017 Analysis and Investment Advisory. Source: https://www.researchpool.com/download/?report_id=1223510&show_pdf_data=true

Savills Vietnam (2018). Report on Da Nang Real Estate Market H2 2017, 2017, retrieved from: https://www.savills.co.uk/insight-and-opinion/savills-news/159260-1/savills-vietnam-report-on-da-nang-real-estate-market-h22017?locale=

Tai, Pham The; Muneko Nishijo, Teruhiko Kido, Hideaki Nakagawa, Shoko Maruzeni, Rie Naganuma, Nguyen Thi Nguyet Anh, Yuko Morikawa, Hoang Van Luong, Tran Hai Anh, Nguyen Ngoc Hung, Le Ke Son, Kenji Tawara, and Hisao Nishijo, Dioxin Concentrations in Breast Milk of Vietnamese Nursing Mothers: A Survey Four Decades after the Herbicide Spraying, Environmental Science & Technology 2011 45 (15), 6625-6632.

Tam, Nhan (2018). International Arrivals in Danang surge by 50%, The Saigon Times, June 26, 2018, retrieved from: https://english.thesaigontimes.vn/60862/international-arrivals-in-danang-surge-by-50.html

TerraTherm Inc. (2013), Annual Implementation Plan, USAID, September 16, 2013.

TerraTherm Inc. (2014), Final Sampling and Analysis/Quality Assurance Project Plan (Phase 1), USAID, April 2014.

TerraTherm Inc, (2014), Annual Implementation Plan, USAID, September 5, 2014.

TerraTherm Inc. (2016), IPTD Final Report - Phase 1, USAID, March 18, 2016.

TerraTherm Inc. (2016), Annual Implementation Plan FY 2015 & 2016, USAID, May 23, 2016.

TerraTherm Inc. (2016), Final Sampling and Analysis/Quality Assurance Project Plan (Phase 2), USAID, October 2016.

TerraTherm Inc. (2016), Annual Implementation Plan FY 2017, USAID, November 3, 2016.

TerraTherm Inc. (2017), Annual Implementation Plan FY 2018, USAID, November 2, 2017.

TerraTherm Inc. (2017), IPTD Final Report - Phase 2, USAID, November 30, 2017.

Tetra Tech Inc. (2012), Component Specific Implementation Plan, USAID, February 2012.

Tetra Tech Inc. (2012), Environmental Protection Plan, USAID, USAID, October 19, 2012.

Tetra Tech Inc. (2017), Work Plan for Construction of a Sediment Pile in the Excess Volume Stockpile Area, May 3, 2017.

Tuyet-Hanh, T.T., Vu-Anh, L., Nguyen, N.B., Tenkate, T. (2010), Environmental Health Risk Assessment of Dioxin Exposure through Foods in a Dioxin Hot Spot - Bien Hoa City, Vietnam, 2010, retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2898056/

Tuyet Hanh, T.T., Nguyen, N.-B., & Le, V.-A. (2013). New strategy toward dioxin risk reduction for local residents surrounding severe dioxin hotspots in Vietnam. Global Health Action, 6, http://doi.org/10.3402/gha.v6i0.2110510.3402/gha.v6i0.21105.

Tuyet Hanh, T.T., Vu Anh, L., Dunne, P., Tenkate, T., Toms, M., Ngoc Bich, N., Harden, F. (2013). The effectiveness of an intervention to reduce risk of dioxin exposure in Da Nang: Changes in community knowledge, attitudes and prevention practices after 2.5 years. Vietnam Journal of Public Health, Volume 1(1), pages 12-21.

USAID/Vietnam (2009), Action Memorandum for the Mission Director, May 6, 2009

USAID/Vietnam (2011), Amendment 1, Action Memorandum for the Mission Director, March 14, 2011

USAID/Vietnam (2012), Amendment 2, Action Memorandum for the Mission Director, June 7, 2012

USAID/Vietnam (2013). Country Development and Cooperation Strategy (CDCS). Retrieved from: https://www.usaid.gov/sites/default/files/documents/1861/CDCS_Vietnam_2014-2019_final.pdf

USAID/Vietnam (2014), Amendment 3, Action Memorandum for the Mission Director, June 26, 2014

USAID/Vietnam (2014), Amendment 4, Action Memorandum for the Mission Director, November 3, 2014

USAID/Vietnam (2014), Office of Inspector General, Audit of USAID/Vietnam's Environmental Assessments and Remediation Project, November 12, 2014.

USAID/Vietnam (2015), Amendment 5, Action Memorandum for the Mission Director, December 28, 2015

USAID (2015): Meeting notes: Lessons learned from environmental remediation of dioxin contamination at Danang airport – Phase 1. Da Nang, April 2015

USAID/Vietnam (2018), Amendment 6, Action Memorandum for the Mission Director, March 15, 2018

USAID/Vietnam (2018), Statement of Work, Performance Evaluation of USAID's Environment Remediation at Danang Airport, April 2018

USAID (2018): Meeting notes: Lessons learned from environmental remediation of dioxin contamination at Danang airport – Phase 2. Da Nang, June 2018

US Army Corps of Engineers (2014): Design: In situ thermal remediation, Engineering Manual

U.S. Environmental Protection Agency (EPA) (2000). Federal Remediation Technologies Roundtable (2000): Remediation Technologies Screening Matrix and Reference Guide, Version 4.0.

U.S. Environmental Protection Agency (EPA) (2004). Example Exposure Scenarios Assessment Tool. Retrieved from: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=85843

U.S. Environmental Protection Agency (EPA) (2015). Guidance for Assessing Chemical Contaminant Data for Use if Fish Advisories, Volume 2 Risk Assessment and Fish Consumption Limits Third Edition. Retrieved from: https://www.epa.gov/sites/production/files/2015-06/documents/volume2.pdf

U.S. Congress, Office of Technology Assessment (1991): Dioxin Treatment Technologies + Background Paper, OTA-BP-O-93. U.S. Government printing Office, Washington, DC, November 1991

Van Dinh, T., Van Dong, H., Nguyen, T. C., Lee, A.H. (2013), Validity and Reliability of a Food Frequency Questionnaire to Assess Habitual Dietary Intake in Northern Vietnam, Vietnam Journal of Public Health, 2013, retrieved from: https://www.researchgate.net/publication/274734817_Validity_and_reliability_of_a_food_frequency_questionnaire_to_assess_habitual_dietary_intake_in_Northern_Vietnam

Vietnam Economic Times (2015). Da Nang land prices through the roof. October 20, 2015. Retrieved from: http://www.vneconomictimes.com/article/property/da-nang-land-prices-through-the-roof

Voice of Vietnam (2018). Da Nang welcomes more than 3.2 million visitors in 5 months. May 28, 2018. Retrieved from: https://english.vov.vn/travel/da-nang-welcomes-more-than-32-million-visitors-in-5-months-375688.vov

WHO (2016), Dioxins and their effect on human health, WHO, 2016, retrieved from: http://www.who.int/news-room/fact-sheets/detail/dioxins-and-their-effects-on-human-health

WHO (2010), Exposure to Dioxins and Dioxin-Like Substances: a Major Public Health Concern, WHO, retrieved from: http://www.who.int/ipcs/features/dioxins.pdf

ANNEX 4. LIST OF ENTITIES INTERVIEWED

Entity	Role or area of intersection with the project
Academy Military Science and Technology	GVN A&E firm, preparing EIA and Project Document
Air Defense – Air Force Command	Project Owner, Main counterpart of USAID
CDM Smith	Project management and Oversight contractor
Chemical Command	GVN technology oversight Site Monitoring Capacity building
Ministry of Natural Resources and Environment	Central Environmental Regulator
Military Science Department (MSD)	Ministry of National Defense Technical Advisor
Danang Department of Natural Resources and Environment	Recipient of the CDM Certification Program. Also responsible for monitoring the environment in Danang and was a stakeholder of the project.
Da Nang Institute for Socio-Economic Development	Closely monitoring real estate market in Danang and economic growth and social-wellbeing in Danang
Dioxin Laboratory, Centre for Environmental Monitoring, Vietnam Environment Administration	Research on health of the population surrounding Danang. Also involved in the training program and was active in monitoring during the project.
Dr. Son Formally with UNDP (and Office of the National Steering Committee 33)	Director of former-Office 33 and leading stakeholder throughout the duration of the project. Also actively involved in socio-economic surveys and environmental risk monitoring in Danang.
Hoà Khê Health Ward (Thanh Khê district)	Oversaw the first health examination of a total population (15,000) in 2010 in Hoà Khê commune. (Thanh Khê district).
The People's Committee of Hoà Khê commune (Thanh Khê district)	Local community on the airport perimeter, actively involved in the outreach activities with the project and working with populations with potential exposure to dioxin.
TerraTherm	In Pile Desorption Contractor

Hanoi University of Public Health	Research on dioxin contamination in Danang
Savills Vietnam	Real Estate Consultancy and Research active in research products of Danang real estate
Trabaco	In-country supplier of carbon for remediation project.
Tetra Tech	Dig and Haul Contractor
USAID Vietnam Currently	Project Oversight
Former USAID Vietnam	Project Oversight
USAID	Guidance on EIA
Vietnam Airport Company	Key Counterpart in Danang, Beneficiary of the Project
Vietnam Russian Tropical Center	GVN oversight Site Monitoring Capacity building
Vietnam Public Health Association	Research on dioxin contamination in Danang

ANNEX 5. EVALUATION DESIGN MATRIX

Evaluation questions	Data collection methods, e.g., records, structured observation, in-depth interviews, surveys		Analytical methods
	Source(s)	Method(s)	
Q1. To what degree did the project achieve its purpose of characterizing, removing and containing dioxin contaminated soil and sediment from hotspots at Danang airport?	Original logic model; monitoring data, baseline data, audit, Environmental Assessment (EA), Environmental Impact Assessment (EIA), and Reports and Annual Reports; Chief of Party (COP), Deputy Chief of Party (DCOP) and M&E Staff; Key Stakeholders.	Records review In-depth interviews	Descriptive Statistics Quantitative Analysis
Q2. How cost effective was using thermal destruction of dioxin (IPTD) at the Danang Airport compared to similar and/or alternative solutions or comparable remediation projects elsewhere in the world?	Project documents; External Literature analyzing dioxin remediation.	Records review Literature review	Descriptive Statistics Quantitative Analysis
Q3. What are the economic benefits and return on investment for Vietnam and the local community that can be linked to the project results?	Project documents and staff involved, Studies on the impact of dioxin on ecosystem services; Before and after measurements of dioxin levels in various samples if available, Scientific research papers, Health examination information from the community, if available Key community stakeholders, beneficiaries from the capacity building program	Records review In-depth interviews Literature review	Descriptive Statistics Quantitative Analysis Qualitative Analysis

Evaluation questions	Data collection methods, e.g., records, structured observation, in-depth interviews, surveys		Analytical methods
	Source(s)	**Method(s)**	
EQ4. How do program stakeholder organizations view the degree to which the project met expectations for the clean-up of dioxin?	Each stakeholder group and subgroup; COP, DCOP and M&E Staff; USAID Staff.	Desk Review In-depth interviews	Qualitative Analysis Content Analysis
EQ5. What are the lessons learned from the Danang Remediation Project that can be used to remediate dioxin at other sites, such as Bien Hoa, in terms of: alignment with international norms and standards for project delivery, such as the Project Management Institute framework; mitigating schedule and cost risks and managing change, and improving stakeholder communication and coordination.	Project documents; Each stakeholder group and subgroup; COP, DCOP and M&E Staff; USAID Staff.	Desk review In-depth Interviews	Qualitative Analysis Content Analysis

ANNEX 6. SELECTION OF REMEDIATION METHODS FOR DETAILED CEA

The key criteria for selection of similar/comparable reference projects were:

- Definitive (not temporary) solution – *Landfilling not accepted;*
- Operated full scale remediation (verified treatment able to remediate > 90,000 m^3 of highly contaminated soil) – Note: Reason is not to exclude innovative methods suitable for treatment of dioxins at Bien Hoa, but to use credible treatment costs for comparison (what pioneer methods do not offer) – *Mechanochemical dehalogenation (MCD) / Ball Milling rejected*;
- Verified method able to remediate highly contaminated soil (concentrations of dioxins above X0,000 ppt) and to reach VNG target values (< 150 ppt, respectively below the new standard of 21.5 ppt) – *Biological methods and solidification/stabilization rejected;*
- In situ or on-site remediation – Off-site incineration not feasible;
- Compliance with Vietnamese regulations.

The following methods have been selected for Cost-Effective Analysis (CEA):

- In-pile or in situ thermal desorption (IPTD / ISTD);
- On site incineration (rotary kiln incineration);
- On-site thermal desorption with secondary treatment of desorbed phase – for example BCD (Based Catalyzed Decomposition).

The selection of comparable methods was done in general agreement with the findings and conclusions of the Environmental Assessments completed for Danang (2010) and Bien Hoa (2016). Comments of Integra were added in case of pre-evaluation of selected remediation methods (right column).

Figure 7. Evaluation of potential remediation methods for Danang and Bien Hoa sites mentioned in Environmental Assessments

Method	**EA pre-selection of methods / EA conclusion**	**EA justification**	**Integra comment**
Potential methods – EA Danang 2010*			
No action	Not retained / not recommended	Does not meet objectives	OK
Incineration	Not retained / not recommended	Emissions, implementability not possible	On-site incineration should have been evaluated, however costs would be probably higher than IPTD (see below); there is still a question whether a permit for operation could be issued
BCD	Not retained / not recommended	By-products, would need landfill	Should have been evaluated. BCD is just a 2nd phase treatment for dioxins previously desorbed from soil/sediment; it is used in combination with thermal desorption as 1st phase; it was successfully applied in USA, Czech Republic
Ball Milling	Not retained / not recommended	Have not been demonstrated at large scale to treat dioxin below project clean up objective	OK, Pilot testing at Bien Hoa did not lead to reach 150 ppt limit in case of treatment highly contaminated soil**
ISTD / IPTD	Retained / recommended		OK
Geo-Melt	Not recommended	Never applied full-scale, does not meet objectives	OK
Passive landfill	Retained / not recommended	Effective for containment, not effective for long treatment, O&M 50 years	OK
Active landfill	Retained / uncertain	Effective for containment, not demonstrated for reaching objectives, not applied full-scale, O&M > 10 years	OK
Potential methods – EA Bien Hoa 2016***			
Passive landfill	Not retained / not recommended	Effective for containment, not effective for long treatment	OK

Active landfill	Not retained / not recommended	Not retained as a primary technology; technology is not mature (bioremediation is not yet well demonstrated)	OK
Capping	Not retained / not recommended	Not retained; technology is not acceptable to GVN (because of protectiveness)	OK
Solidification	Retained / not recommended	Effective for Containment, but Not Effective for Treatment	OK
In situ TCH****	Not retained / not recommended	Not retained; technology is mature (demonstrated for full-scale remediation)	OK
Ex situ TCH****	Retained / recommended	Effective for Treatment (demonstrated)	OK
Ex Situ Thermal Desorption	Retained / not evaluated	It may be feasible to combine this with other treatment technologies which would manage treatment of gaseous and liquid streams with dioxins	Should have been evaluated in more details in case this method will be considered for the remediation plan at Bien Hoa Airport
BCD	Not retained	Large quantity of wastes, not competitive	Should have been evaluated in more details in case this method will be considered for the remediation plan at Bien Hoa Airport
Incineration	Retained / not recommended	Effective for Treatment (demonstrated)	OK
MCD	Retained / not recommended	Effective for Treatment (demonstrated, but not to below all GVN standards)	OK, Pilot testing at Bien Hoa did not lead to reach 150 ppt limit in case of treatment highly contaminated soil*
Plasma Arc / Pyrolysis	Not retained	High energy requirements, not competitive	OK
Supercritical water treatment	Not retained / not recommended	Pre/post processing, not competitive	OK
Vitrification	Not retained / not recommended	High energy requirements, not competitive	OK
Soil washing	Not retained / not recommended	Not mature, solvents added, liquefied gas extraction, necessary post-washing treatment, limited effectiveness for clays and silts	OK

Gas-phase chemical reduction	Not retained / not recommended	High reagent needs, not competitive	OK
Bioremediation in situ	Not retained / not recommended	Not mature for dioxins in situ	OK
Ex-situ chemical reduction	Not retained / not recommended	Not mature, not cost-effective	OK
Advanced oxidation	Not retained / not recommended	Not mature, no full-scale remediation, pre/post processing for aqueous phase	OK
Biological/chemical hybrids, Solvated Electron technology, Copper-mediated destruction, In-situ photolysis, Steam distillation, Radiolytic degradation, Hydrothermal treatment, Non-thermal plasma, Phytoremediation, Mycoremediation…	Not retained / not recommended	Not mature, not demonstrated full-scale, not competitive	OK

** Cooke, R.J. (2013): Independent Evaluation of MCDTM Technology Demonstrated for Dioxin Contaminated Soil Destruction in Viet Nam, GEF/UNDP*

*** CDM Int. (2010): Environmental Remediation at Da Nang Airport – Environmental Assessment, USAID, June 2010*

**** CDM Int. and Hatfield Consultants (2016): Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase, USAID, May 3, 2016*

***** TCH – Ex situ Thermal Conductive Heating = IPTD*

FINDINGS – COMPARISON OF TREATMENT COSTS OF IPTD WITH OTHER SIMILAR PROJECT AND COMPARABLE REMEDIATION METHODS

Publicly available information on dioxin treatment projects is quite limited, mainly in terms of project/treatment costs. For this reason, costs spent for treatment of contaminated soil/sediments at Danang (using IPTD method) were analyzed in three levels:

1) Compared with similar reference projects (that present project/treatment costs) successfully completed in the world last 30 years.

2) Compared with unit treatment costs (USD/t or USD/m^3) stated in credible studies:

   - US EPA (2010): Reference Guide to Non-combustion Technologies for Remediation of Persistent Organic Pollutants in Soil, Second Edition
   - BEM System, Inc. (2007): Mitigating the Impact of Dioxin-Contaminated „Hot Spots" in Vietnam, Assessment of Alternative Remediation Technologies and Work Plan for a Future Feasibility Study for Danang Airport
   - U.S. Congress, Office of Technology Assessment, Dioxin Treatment Technologies+ Background Paper, OTA-BP-O-93. U.S. Government printing Office, Washington, DC, November 1991
   - FRTR Remediation Technologies Screening Matrix and Reference Guide, Version 4.0. Federal Remediation Technologies Roundtable, 2000

3) Costs for IPTD/ISTD technology were also compared with other similar methods for case of PCBs (contaminants with similar physico-chemical properties).

Although most of the reference projects use only "treatment" costs and not "project" costs, we included all the following remediation costs spent for Danang project as all directly related costs should be included and applied in CEA.

The "remediation" costs for Danang include:

- Assessment and engineering designs and plans for dioxin remediation
  - Total costs of CDM International: 4,542,276 USD
- Site preparatory works, excavation and construction services excluding EVSA costs:
  - Total costs of Tetra Tech: 30,901,421 USD – 3,916,634 USD (EVSA) = 26,984,787 USD
- In-pile Thermal Desorption design
  - Total costs of TerraTherm: 1,336,486 USD
- In-pile Thermal Desorption implementation – operational and maintenance costs
  - Total costs of TerraTherm: 47,404,672 USD
- Construction management oversight of remediation (incl. electricity costs, management, laboratory analyses, health & safety measures)
  - Total costs of CDM International: 19,338,705 USD

The costs do not include:

- Pre-remedial investigation
- Landfilling of soil/sediments below the remediation limit at EVSA
- Post-remedial site restoration

The total costs used for CEA for Danang project: 99,606,926 USD (in nominal terms). Adjusted for inflation over the project, the cost was 107,540,026 USD (in 2018 dollars).

We admit that used costs do not cover 100 % of all relevant costs (for example do not include costs for disposal of concrete blocks from IPTD construction).

Regarding the total volume of remediated soil and sediments, the provided data in the project reports are not consistent:

- The IPTD® Final Report – Phase I, of March 18, 2016 as well as the final report on Dioxin Mass Balance for Phase II IPTD Treatment of June 7, 2018 state that the total volume of treated soil after compaction was 39,690 m^3 which corresponds to 72,775,490 kg considering 1,821 kg/m^3 as dry bulk density of the soil.
- The IPTD® Final Report – Phase 2, of November 30, 2017 states the treated soil volume of 43,660 m^3, which corresponds to 64,398,500 kg, considering average dry density of 1.475 g/cm^3 (*evaluation team note: the density seems to be underestimated*) while the Final report on Dioxin Mass Balance for Phase II IPTD Treatment of June 7, 2018 states that „the project excavated all soil and sediment to the Vietnam National Standard (TCVN) 8183:2009 and successfully treated approximately 94,593 cubic meters (m^3) of soil and sediment via two batches (or phases) of IPTD".
- The latter provided number corresponds to data verified and justified by contractors during the evaluation mission in June 2018:

  1st phase: 45,520 m^3

  2nd phase: 49,073 m^3

  EVSA: 67,974 m^3

  Total: 162,567 m^3

As the total volume of 94,593 m^3 of soil and sediment was verified from two sources, this has been used for the CEA on IPTD technology applied in Danang. The rationale behind is that the volume of the treated soil must be considered before compaction (it means after excavation) while the reported numbers in summary reports for Phase I and Phase II refer to the compacted volume in the pile. For the comparability reasons, an average dry density of 1.7 g/cm^3 has been used for recalculation from m^3 to tons and vice versa for all locations, including Danang.

However, we think that for the CEA purpose, the above-mentioned simplifications are sufficient and appropriate, as other reference treatment costs are influenced by relatively high inaccuracy, like local standards, inflation rate, VAT issues, differences in dioxin content and soil characteristics, exclusion of some directly related costs, etc.

FINDINGS – COMPARISON OF THE COSTS FOR TREATMENT OF DIOXIN CONTAMINATED SITES

Figure 8 presents basic information on similar reference projects successfully applied for dioxin contaminated sites in the world. Second part of this table summarizes the treatment costs stated in credible studies. The costs are reported both in USD/t and USD/m^3, using the same average density of 1.7 g/cm^3 (1.7 t/m^3) for all reference projects and compendia results.

Figure 8: Comparison of "treatment" costs per ton – dioxin contaminated sites

Location	Year	Technology	Waste	Volume	Initial dioxin concentration level	Target values / After treatment level	Total treatment costs (USD) - nominal	Treatment costs per ton (USD)	Treatment costs per ton - adjusted for inflation*	Treatment costs per m^3 - adjusted for inflation*	Reference/Source
REFERENCE PROJECTS / CASE STUDIES RELATED TO DIOXINS											
Danang, Vietnam	2012-2018	In Pile Thermal Desorption (IPTD)	Soil and sediment	94,593 m^3	average 4,030 - 6,880 ppt (phase I); 2,461 ppt (phase II)	150 ppt / 0.243 - 2.5 ppt	99,606,926	620	669	1,137	USAID (2018): Dioxin Mass Balance for Phase II In-Pile Thermal Desorption (IPTD) Treatment, June 7, 2018
Alhambra, USA	2002-2005	In situ Thermal Desorption (ISTD)	Soil	12,385 m^3	194 µg/kg (max), 18 µg/kg (mean) TEQ	0.11 µg/kg TEQ		$500/$m^3$ (~$294/t)	382	649	Baker, R.S., et al. (2007): Completion of in situ thermal remediation of PAHs, PCP and dioxins and former wood treatment facility, IT3'07 Conference, May 14-18, 2007, Phoenix, AZ
Times Beach, Missouri, USA	1995-1997	On site rotary kiln Incineration	Soil and debris	265,000 tons	up to 1,800,000 ppt	0.02 mg/kg	110,000,000	415 *****	649 *****	1,103 *****	https://clu-in.org/
Holbrook, Massachusetts USA	1995-1997	On site rotary kiln Incineration	Soil and sediment	248,000 tons	up to 270,000 ppt	Not stated	133,000,000	536	838	1,425	https://clu-in.org/
Vertac, Arkansas, USA	1990-1994	On site rotary kiln Incineration	Waste and soil	10,831 tons	up to 400,000 ppt	(0.004 ppt in ash)	31,700,000	2,927	4,967	8,443	https://clu-in.org/
Neratovice, Czech Republic	2002-2009	Indirect thermal desorption + Base Catalyzed Decomposition (BCD)	Soil and concrete	35,000 tons	5-100 ng/g I-TEQ PCDD/F	1 ng/g I-TEQ PCDD/F	160,000,000	4,571 **	5,205 **	8,849 **	Czech Ministry of Finance

Location	Year	Technology	Waste	Volume	Initial dioxin concentration level	Target values / After treatment level	Total treatment costs (USD) - nominal	Treatment costs per ton (USD)	Treatment costs per ton - adjusted for inflation*	Treatment costs per m^3 - adjusted for inflation*	Reference/Source
LITERATURE REVIEW – REFERENCE GUIDES											
Four full-scale and two pilot-scale ISTD projects (dioxins or PCB)	1996-2005	In situ Thermal Desorption (ISTD)		222 - 16,200 cubic yards	3.2 - 19.4 µg/kg	0.003 - 0.11 µg/kg		$200 to $600 per cubic yard / $260-780/t	337 – 1,012	574 – 1,721	US EPA (2010): Reference Guide to Non-combustion Technologies for Remediation of Persistent Organic Pollutants in Soil, Second Edition
	Until 2007	Ex situ Thermal Desorption						$100 – $1000/$m^3$ (~$59-588/t); average $225/$m^3$ ***	72 – 715 ***	122 – 1,216 ***	BEM System, Inc. (2007): Mitigating the Impact of Dioxin-Contaminated "Hot Spots" in Vietnam, Assessment of Alternative Remediation Technologies and Work Plan for a Future Feasibility Study for Danang Airport
	Until 2004	Thermal desorption (TD) + Base Catalyzed Decomposition (BCD)						€1,400 – €1,700/ton; $1,630 – $1,980/t	2,320 – 2,818	3,944 – 4,791	US EPA (2010): Reference Guide to Non-combustion Technologies for Remediation of Persistent Organic Pollutants in Soil, Second Edition
	Until 2000	Thermal desorption	Soil					$110/$m^3$ (~$187/t)	275 ****	468 ****	FRTR Remediation Technologies Screening

Location	Year	Technology	Waste	Volume	Initial dioxin concentration level	Target values / After treatment level	Total treatment costs (USD) - nominal	Treatment costs per ton (USD)	Treatment costs per ton - adjusted for inflation*	Treatment costs per m^3 - adjusted for inflation*	Reference/Source
								****			Matrix and Reference Guide, Version 4.0. Federal Remediation Technologies Roundtable, 2000
	Until 1991	Rotary kiln incineration						400 – 600	750 – 1,126	1,276 – 1,914	U.S. Congress, Office of Technology Assessment, Dioxin Treatment Technologies + Background Paper, OTA-BP-O-93. U.S. Government printing Office, Washington, DC, November 1991

Notes:

Soil density of 1.7 t/m^3 is used for all locations and reference guides.

** All numbers were adjusted for inflation, and presented in 2018 dollars. Where precise annual data were available (for example with the Danang airport project), all costs were adjusted for each year of the project. For data that was presented within a range of dates, the evaluation team assumed that the costs were presented in the final year and were adjusted for inflation using that year. Inflation data for USD came from the World Bank Development Indicators.*

*** The treatment costs include also construction costs for building special sarcophagus for under-pressure treatment.*

**** The lower quoted value most probably do not include costs for secondary treatment of desorbed dioxins – gaseous and liquid streams.*

***** The data in Figure 8 correspond to Scenario D – Difficult conditions at large sites. Based on explanations in some included case studies, the calculations do not reflect the real level of dioxin contamination and the related target values (see also the temperature of only 100-150°C used for the treatment), and in some cases „the cost for full-scale operation does not include excavation, refilling, residue disposal, or analytical costs“ (Evaluator´s note: These costs can form a significant part of the total budget). Also, the recalculation from tons to m^3 in the summary table of Racer parameters seems to be incorrect (density of 1.32 t/m^3 is too low). From the above reasons this source of information cannot be considered sufficiently reliable.*

****** 800 USD/t reported in the case study; this does not correspond to the total costs (110,000,000 USD) and volume of treated soil (265,000 t).*

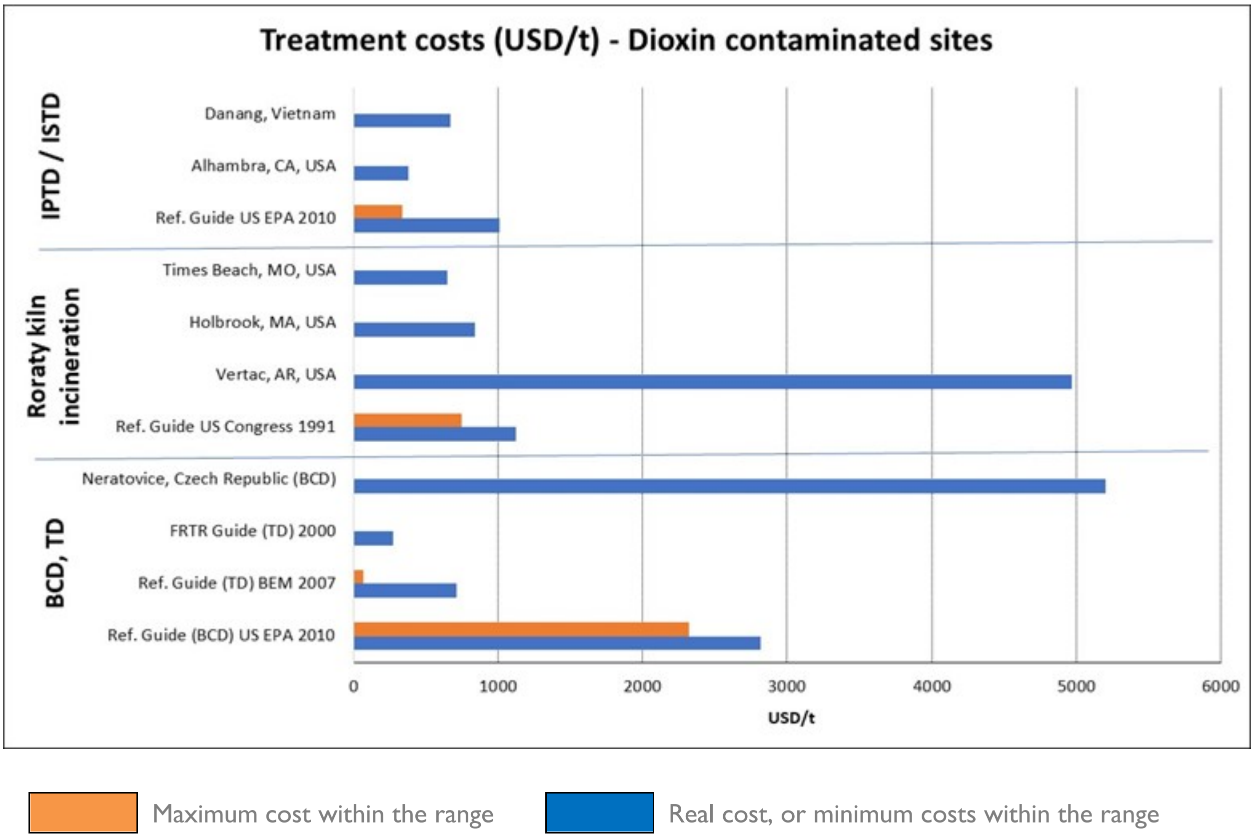
The cost for treatment dioxin contaminated soil/sediment at Danang site using IPTD method was calculated to be 669 USD/t, respectively 1,137 USD/m³.

These costs are in the range of other reference remediation projects where IPTD/ISTD method was applied, between 337 – 1,012 USD/t (in 2018 dollars).

In comparison with other remediation methods like on-site incineration or BCD in combination with thermal desorption, **the costs for IPTD at Danang Airport were relatively lower**. Costs for on-site incineration range from 649 – 4,967 USD/t (in 2018 dollars), costs for soil/waste treatment using BCD in combination with thermal desorption are between 2,320 – 5,205 USD/t (in 2018 dollars).

As a conclusion, IPTD can be reported as a cost-effective remediation technology for dioxin contaminated sites where on-site treatment and definitive solution are required.

Figure 9: Treatment costs (USD/t) – Dioxin Contaminated Sites



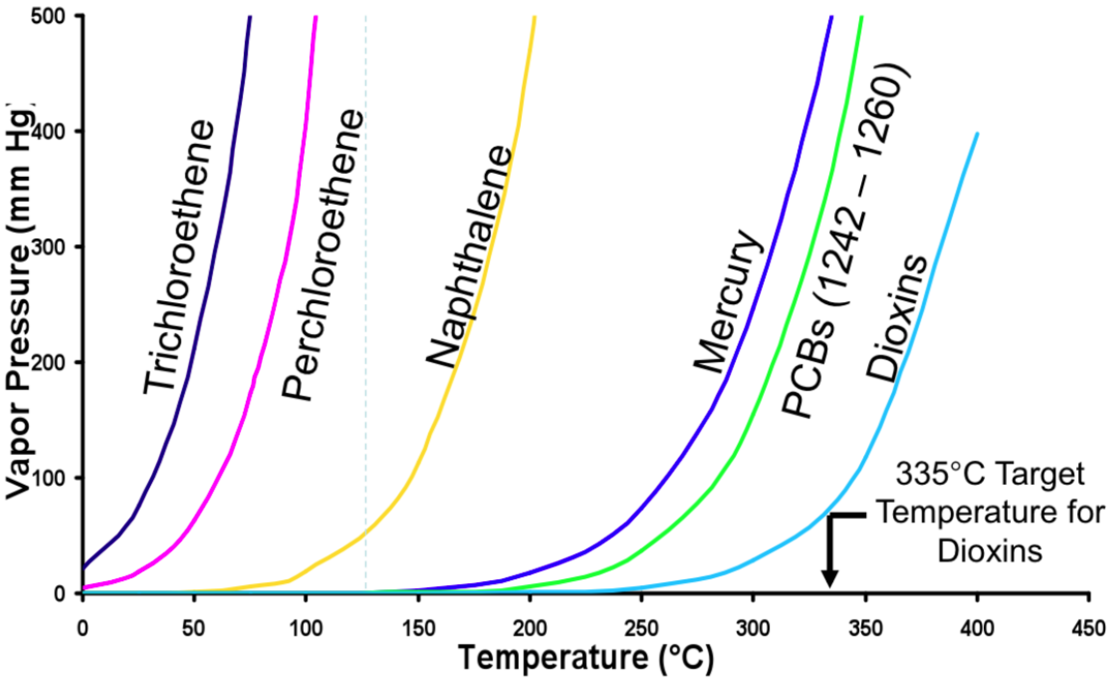
Visual comparison of treatment costs of similar remediation projects and comparable methods is depicted in Figure 9, above.

FINDINGS – COMPARISON OF THE COSTS FOR TREATMENT OF PCBS CONTAMINATED SITES

To support or refute the findings done for dioxin contaminated sites, similar comparative evaluation was performed for the sites contaminated with PCBs.

The reason was that PCBs are very similar contaminants in terms of physico-chemical properties and same/similar methods are commonly applied for full scale remediation. The main difference related to the treatment requirements is relatively higher temperature that needs to be used for dioxins (see graph below).

Figure 10: Vapor Pressures of Contaminants



The vapor pressures of contaminants increase exponentially due to thermal conduction heating during the IPTD® process.

Ref: Baker, R.S., et al. (2014): In-Pile Thermal Desorption (IPTD) of Dioxin Contaminated Soil and Sediment, Intersol, Lille, France.

Figure 10 summarizes the treatment costs (USD/t) stated for comparable reference projects that were successfully applied for PCBs contaminated sites in the USA/in the world.

Figure 11: Comparison of "treatment" costs per ton – PCBs contaminated sites

Location	Year	Technology	Waste	Volume	Initial level	After treatment level	DRE / DE efficiency	Total treatment costs (USD)	Treatment costs (USD/t)	Treatment costs (USD/t) - adjusted for inflation*	Reference/Source
REFERENCE PROJECTS / CASE STUDIES RELATED TO PCBs											
On site thermal desorption											
Outboard Marine Corporation Superfund Site / Waukegan, Illinois	1992	Thermal Desorption - Rotary kiln	Soil and sediment	12,755 tons	2,400 to 23,000 mg/kg PCBs	Below cleanup goal 0.4 - 8.9 mg/kg	DRE 99.9999%	3,374,000 **	265 **	476 **	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/
Wide Beach Development Superfund Site / Brant, New York	1990-1991	Thermal Desorption / Dehalogenation - Rotary kiln desorber	Soil	42,000 tons	68 mg/kg	Below 2 mg/kg		15,908,000 **	379 **	711 **	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/
Re-Solve, Inc. Superfund Site / North Dartmouth, Massachusetts	1993-1994	Thermal Desorption	Soil	36,200 cubic yards (44,000 tons)		Below cleanup goal 25 mg/kg		19,190,000 **	436 **	737 **	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/
Industrial Latex Superfund Site, Wallington, New Jersey	1999-2000	Thermal Desorption	Soil	53,685 cubic yards (69,777 tons)		Below cleanup goal 1.4 - 46 mg/kg		24,205,528	347	511	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/
New Bedford Harbor Superfund /	1996	Thermal Desorption / Gas Phase Chemical	Sediments	18,000 tons	Max. conc. more than	Between 28 to 77 mg/kg, with an	DE from 98.36 to 99.52%	11,114,000	617	993	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated

Location	Year	Technology	Waste	Volume	Initial level	After treatment level	DRE / DE efficiency	Total treatment costs (USD)	Treatment costs (USD/t)	Treatment costs (USD/t) - adjusted for inflation*	Reference/Source
New Bedford, Massachusetts		Reduction (GPCR)			200,000 mg/kg	average of 52 mg/kg					_biphenyls_(pcbs)/cat/Treatment_Technologies/
On site incineration											
Bridgeport Refinery and Oil Services Superfund Site / Logan Township, New Jersey	1991-1996	On-site Incineration (rotary kiln)	Sediments and sludge, debris,	172,000 tons			DRE 99.9999%	187,000,000	1,087	1,749	https://frtr.gov/costperformance/searchresult.cfm
Coal Creek Superfund Site / Chehalis, Washington, USA	1994	On-Site Incineration system	Soil	9,715 tons			DRE 99.9999%	8,100,000	834	1,415	https://frtr.gov/costperformance/searchresult.cfm
Rose Township, Holly, Michigan	1992-1993	Infrared incineration	Soil	34,000 t		1 -10 mg/kg	DRE 99.9999%	12,000,000	353	617	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/
Rose Disposal Pit Superfund Site / Lanesborough, Massachusetts	1994	On-site incineration	Soil	51,000 tons	Max. 440,000 mg/kg, average 500 mg/kg	13 mg/kg	DRE 99.9999%	Not available	N/A	N/A	https://frtr.gov/costperformance/searchresult.cfm
Vitrification											
Hanford Sites: 1. Richland, Washington 2. Oak Ridge, Tennessee	1997	In Situ Vitrification (ISV)	Soil, Sludge, and Debris	4,800 + 5,600 + 3,100 tons			DRE 99.9999%		375-425	586 – 664	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/

Location	Year	Technology	Waste	Volume	Initial level	After treatment level	DRE / DE efficiency	Total treatment costs (USD)	Treatment costs (USD/t)	Treatment costs (USD/t) - adjusted for inflation*	Reference/Source
New Bedford Harbor Superfund, New Bedford, Massachusetts	1996	Vitrification	Sediment	18,000 tons	Max. conc. more than 200,000 mg/kg		DRE 99.9905%	20,687,000	1,149	1,849	https://clu-in.org/contaminantfocus/default.focus/sec/polychlorinated_biphenyls_(pcbs)/cat/Treatment_Technologies/
In situ thermal desorption											
Naval Facility Centerville Beach / Ferndale, CA	1998-1999	ISTD		510 m^3	0.15 - 860 ppm	below 1 ppm	DRE 99.9999%	456,000 **	526 (894/m^3) **	791 **	US Army Corps of Engineers (2014): Design: In situ thermal remediation, Engineering Manual
Vallejo, CA	1997	ISTD		46.5 m^2				912,500 **	N/A	N/A	US Army Corps of Engineers (2014): Design: In situ thermal Remediation, Engineering Manual
Missouri Electric Works Site, Cape Girardeau, MO	1997	ISTD		2.59 ha (?)	782 ppm average	below 2 ppm		2,038,000 **	N/A	N/A	US Army Corps of Engineers (2014): Design: In situ thermal remediation, Engineering Manual
Tanapag Village, Saipan, Western Pacific	1997-1998	IPTD		1,858 m^2 / 765 m^3 (?)				2,805,000 **	N/A	N/A	US Army Corps of Engineers (2014): Design: In situ thermal Remediation, Engineering Manual

Notes:

** All numbers were adjusted for inflation, and presented in 2018 dollars. As the precise annual data were not available for projects presented within a range of dates, the evaluation team assumed that the costs were presented in the final year and were adjusted for inflation using that year. Inflation data for USD came from the World Bank Development Indicators.*

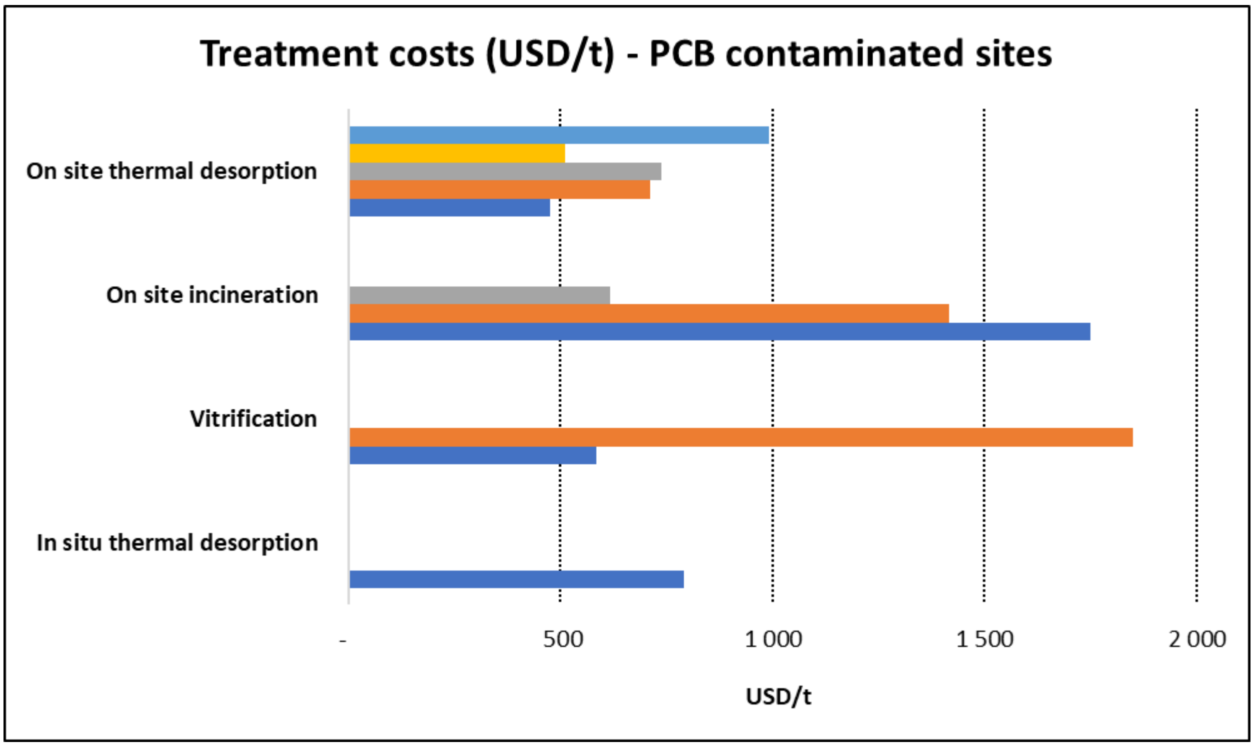
*** Total project costs.*

What is obvious from the comparison that the costs for on-site thermal desorption (476 – 993 USD/t; in 2018 dollars) and in situ thermal desorption (791 USD/t; in 2018 dollars) are relatively lower when comparing to the costs for on-site incineration (617 – 1,749 USD/t, in 2018 dollars) and vitrification (586 – 1,849 USD/t, in 2018 dollars).

The costs for treatment PCBs contaminated sites with ISTD method (only one relevant reference project) were 791 USD/t (in 2018 dollars). These costs are relatively higher when comparing to Danang treatment costs, what explains the small-scale site of the implemented PCB project.

Visual comparison of treatment costs of selected PCBs remediation methods (for projects referred in Figure 9) is depicted in the Graph below.

Figure 12: Treatment Cost (2018 USD/t) – PCB contaminated sites



ANNEX 7. DETAILED DISCUSSION OF ECONOMIC BENEFITS

EQ 3: WHAT ARE THE ECONOMIC BENEFITS FOR VIETNAM AND THE LOCAL COMMUNITY THAT CAN BE LINKED TO THE PROJECT RESULTS?

As has been highlighted above, the Project has successfully achieved its overall objective of identifying and removing, or containing soil and sediment that has been contaminated with dioxin. As a result, the removal of dioxin from the airport is directly linked to three main economic benefits for Vietnam and the local community: (1) repurposed land, (2) reduced potential for human exposure to dioxin, and (3) capacity building. Each of these benefits are described in more details below.

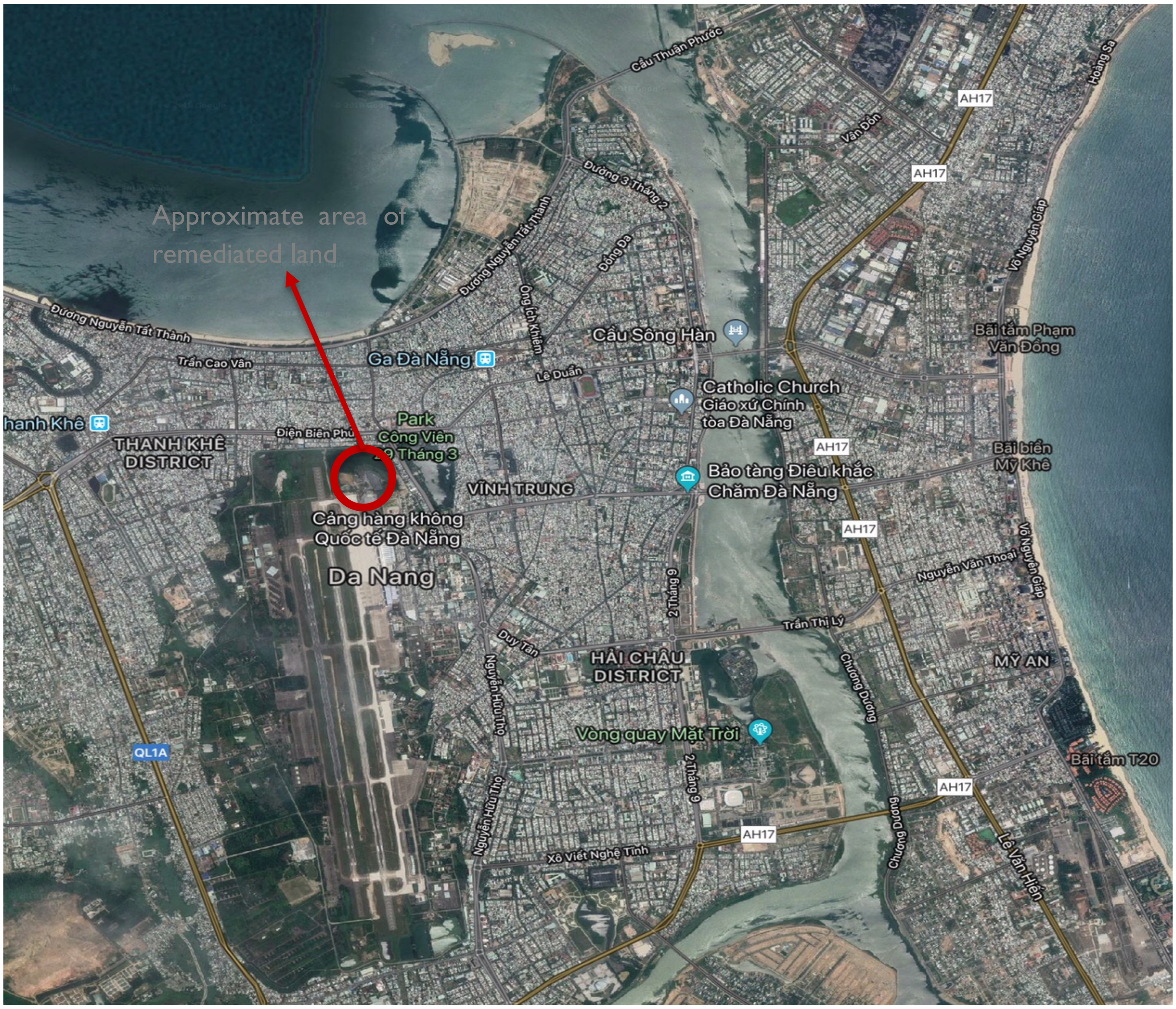
FINDING 1. REMEDIATED LAND ON THE AIRPORT WILL BE (AND HAS BEEN) REPURPOSED FOR OTHER ECONOMIC USES.

The most immediate benefit to this project is that remediated land can now be repurposed for productive uses and specifically, for the expansion of the airport into territory that could not previously have been built upon. This project remediated 29.9 hectares of land, of which 18.67 hectares have already been transferred to the DIA for its first airport expansion in 2015 and 2016. It is expected that up to 10 more hectares of land could further be transferred to the airport for another planned expansion in the coming years.

The value of this remediated land is estimated to be roughly $15 million.[47] The Danang real estate market has experienced unprecedented growth over the last ten years with valuable land, given its central location in the heart of Danang (see Figure 13 below).

[47] This is based on an approximation provided by Savills Research Consultancy, a firm specializing in providing analysis of real estate markets in Vietnam. It was estimated that a large amount of remediated land in the center of Danang could sell for roughly $50 per square meter, or about 25 percent of the value of similar land along stretches of the beach in Danang, for large unaffected land ready for future development assuming comfortable land use, zoning, and controls. While this is not the case since the land is zoned for the airport – this is a technique to estimate the market rate for this land.

Figure 13: Approximate Area of Remediated Land within Danang



By the time of this evaluation, airport authorities had already spent at least $154 million to expand the airport and build a new terminal in 2015 and 2016 onto part of the remediated land. This allowed for a significant increase in capacity and service quality of the airport and mitigates coping costs imposed by space limitations (for example, before the expansion the airport authority required aircraft to use a nearby airport or rented land from the Ministry of Defense for parking). On the remediated land, DIA invested in a new international terminal, an expansion of the apron to the north, and a new 3,000 square meter (m^2) taxiway, a VIP lounge, and office buildings for the airport, customs department, and the immigration police. Additional investment is planned for land that was remediated in Phase II of the Project. Specifically, future investments will include a new cargo terminal, additional vehicle and airplane parking, ground support equipment and maintenance area, a new hanger, additional office space, health and police facilities, an inflight catering center, a tool and equipment warehouse, and a waste treatment facility.

The airport plays an important role in Danang's economy. Given the location of Danang in the center of the country, the airport is a main transportation corridor for passengers and approximately 90 percent of international tourists enter Danang through the airport.[48] The airport's limited capacity has been a transport bottleneck for Danang's economy.

The evidence at hand highlights the importance of the airport expansion for Danang's economy. Local experts have credited much of the expansion of the economy in Danang to the boom in domestic and international tourists;[49] the Danang Department of Tourism determined that the tourism industry generated 186,770 jobs in 2017 and grossed over 19.5 trillion VND (854.1 million USD) in revenues.[50] Authorities in Danang have made a concerted effort to attract tourists to the city, which has included investments throughout the city and a dedicated marketing campaign. However, the surge in Danang's tourism industry has been facilitated by the expansion of the airport since the clear majority of these international tourists are entering Danang through the airport.[51] In the first five months of 2018, the Danang Department of Tourism indicated that tourism receipts had increased by 53 percent compared to the same period a year before,[52] which coincides with the period just before the new international terminal became operational. While it is not possible to measure the extent to which the airport directly contributed to this income stream, Danang would not have been able to fully capitalize on this economic dividend without the expansion of the airport onto the recently remediated land.

The 2015/2016 expansion has already been able to accommodate increasing demand for passenger and cargo traffic transiting Central Vietnam. In the past decade, passenger traffic to Danang has increased by an average of 23 percent year-on-year from just over 2 million passengers in 2009 to an estimated 13.5 million passengers in 2018 (see Figure 14 below). Before the recent expansion that included the new international terminal, Danang International Airport was already operating beyond the design capacity of its only terminal at the time, which was 6 million passengers. The new international terminal increased the design capacity to 10 million total passengers, which has already been quickly exceeded. In the nearly two years since the new terminal became fully operational in 2017, passenger traffic has grown by 53 percent from nearly 8.8 million passengers in 2016 to an estimated 13.5 million passengers in 2018. While demand from international and domestic tourism is growing throughout Vietnam,[53] Danang would not have been able to accommodate these additional passengers without the expansion of the airport onto the recently remediated land.

---

48 Nhan Tam (2018).

49 Confirmed in interviews with experts.

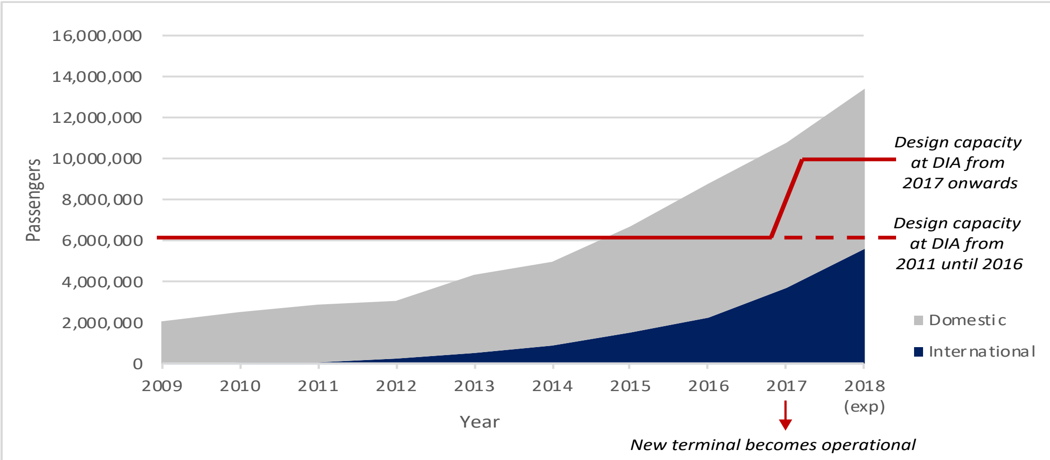
50 Rong Viet Securities (2017), page 69.

51 Tam (2018).

52 Voice of Vietnam (2018).

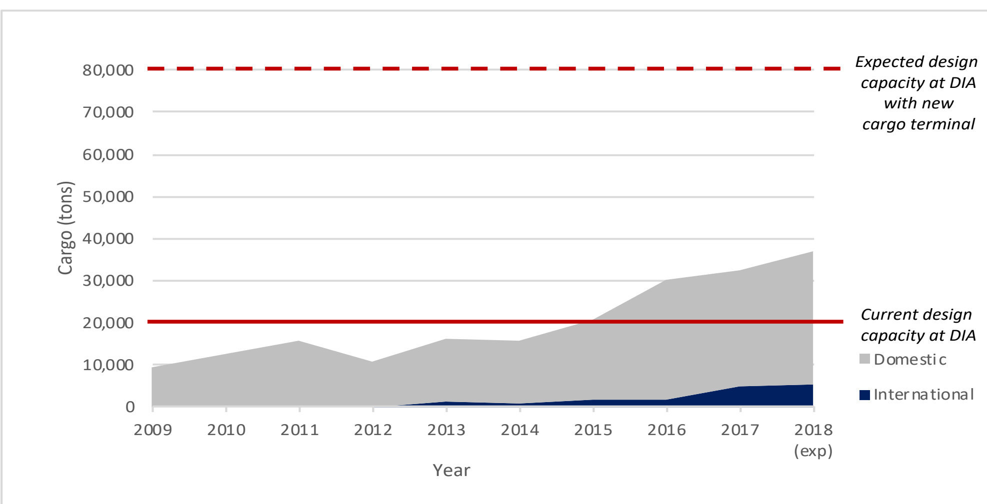
53 The International Air Transport Association predicts that Vietnam's aviation sector will grow 7.1 percent annually on average between 2016-2035, which is estimated to be the fifth fastest growing aviation market in the world measured by growth in passenger traffic. Source: International Air Transport Association (IATA) (2016).

Figure 14: Passenger Volume at Danang, 2009 - 2018



Similarly, DIA is operating at over-capacity to accommodate cargo traffic to and from Danang; cargo transit volume has increased by 16.9 percent year-on-year since 2009. Officially, there is no cargo terminal at DIA but a temporary structure is managing the cargo volume, which has been designed for 20,000 tons per year. However, over 37,000 tons are expected to transit DIA this year and authorities anticipate they will need at least to manage 100,000 tons per year in the coming years. The next phase of expansion onto the remediated land will include a $20 million new cargo terminal, which is expected to be operational in the next three years. The cargo terminal will be built on land remediated by USAID and is currently envisioned to handle 80,000 tons of cargo per year. While air freight contributes a small amount to Vietnam's trade by volume, it represents around 25 percent of Vietnam's trade by value.[54] Danang's investment in a cargo terminal on remediated land will directly increase air cargo trading with regional and international partners, which is a valuable source of trade income.

Figure 15: Cargo Volume at DIA, 2009 - 2018



[54] IATA (2014).

Airport authorities expressed that they already cannot meet the needs of their customers and are clearly beyond their capacity for passengers and cargo. The next phase of investments in the northern half of the airport on remediated land are designed to better meet quality standards for the passengers and allow for a significant increase in the amount of air freight that can transit through Danang.

The evaluation team tried to discern the alternatives for the airport expansion if the Project had not been possible (in economic terms, to identify the counterfactual scenario). Airport authorities suggested that it would have been prohibitively costly to rebuild the airport in another location outside of Danang that may have had sufficient land and therefore, this option was not considered feasible. Instead, the only possible alternative to expanding into the northern, unused part of the airbase would have been to expand south or west into areas that are currently owned and occupied by the MND. While this seemed to be the only viable alternative for the airport, stakeholders did not perceive that this would have been possible. Instead, without the project the airport authority would have most likely waited until the planned relocation of the MND to another base, which is not expected for another 10-20 years into the future. As such, without the Project it seems very likely that the airport expansion would have been significantly delayed, which would certainly have restricted the number of passengers and cargo that it could have accommodated into the medium-term.

There is no equivalent post-remediation data for dioxin-contamination in food sources in or near the Danang airport, to the knowledge of the evaluation team.

Other human exposure pathways on or near the airport may also include soil ingestion if people/children near contaminated soils inadvertently swallow small amounts of soil that adhere to their bodies, food, or crops, dermal absorption when soil or sediment contacts the skin for prolonged periods of time as might be the case for people wading through contaminated water during flooding or while fishing, and inhalation of dust when surface particles contaminated with dioxin are airborne due to wind erosion or as a result of the traffic at the airport.[55]

Samples taken throughout Danang over time have indeed confirmed elevated levels of dioxin in people who live in or near the Danang airport and those who work in the airport, and in particular high levels of TCDD, suggesting that Agent Orange is the origin for the dioxin detected in these samples.[56] Long-term exposure to dioxin has been linked to adverse health outcomes such as cancer, and impairment of the immune, endocrine, and reproductive systems as well as the nervous system.[57]

---

[55] Ibid, page 4-3.

[56] See for example: Boivin TG, et. al. (2007)

[57] WHO (2016).

FINDING 2. POTENTIAL FOR HUMAN EXPOSURE TO DIOXIN IN AND NEAR THE DANANG AIRPORT HAS BEEN REDUCED.[58]

MEASURING HUMAN EXPOSURE TO DIOXIN.

After a series of studies, Danang airport, was recognized as a dioxin hotspot due to large amounts of Agent Orange and other herbicides stored, handled, and spilled there during the Vietnam War.[59] This was confirmed due to the high levels of dioxin present in the soil and sediment in specific areas, primarily in the northern part of the airport. While the airport is the only known hotspot in Danang,[60] evidence also suggests that the dioxin-contaminated soil and sediment has migrated from the hotspot into the surrounding communities, likely via a drainage ditch away from the airport and through the air as soil particles became airborne.[61] Evidence also confirms there are other sources of dioxin in the surrounding community.[62]

The WHO recently estimated that more than 90 percent of human exposure to dioxin is through food, primarily meat and dairy products, fish, and shellfish.[63] Contaminated foodstuffs is very likely the main exposure pathway in Danang as well. Dioxins enter the food chain, accumulating primarily in the fatty tissues of animals, because of their exposure to contaminated soil and sediment. Prior to full remediation and containment at Danang airport, scientists have measured dioxin-contamination in local "high-risk" food sources (e.g. free-range chicken meat and eggs, ducks, freshwater fish, snail and beef) and have found total 2,3,7,8- TCDD concentrations in samples ranging from 0.3 pg/g (picogram per gram) to 15.3 pg/g in Danang.[64] TCDD was the main congener present in the Agent Orange mixture. The concentration of dioxins is usually expressed as toxic equivalents (TEQ); these TEQ of high-risk foods in Danang ranged from 3.8 pg TEQ/g to 86.6 pg TEQ/g. Vietnam does not currently set maximum levels of dioxin for consumption; for comparison, the standards set for maximum levels for human consumption of high-risk foods by the European Commission in 2011 include 3.5 pg TEQ/g for fresh water fish 2.5 pg TEQ/g for beef and chicken eggs. Similar post-remediation data has not been collected.

Working on the airport has been found to be correlated with blood TEQ and TCDD above average levels compared to surrounding communities and among the highest blood dioxin levels ever reported for Vietnam.[65] Similarly, studies have found that to the potential for exposure is high within 1 kilometer of the airport perimeter, with identified blood samples with TCDD concentrations above 10 pg/g in residents from Anh Khe Ward (Thanh Khe District), Thuan Tay and Chinh Gian Wards (Hai Chau District).[66]

---

58 Note: In the Evaluation Design Report and Work Plan, it was envisioned that the evaluation team might be able to create a model to estimate the potential exposure to dioxin before and after the project. This risk reduction scenario was, however, not possible due to a lack of adequate data for estimating potential for exposure after the project. We have made a recommendation below that collecting this data will allow for USAID to better estimate this impact for future projects.

59 CDM International Inc. (2010).

60 Confirmed in interviews with experts.

61 CDM International Inc. (2010).

62 Hatfield Consultants (2009).

63 World Health Organization (2016).

64 Tuyet-Hanh T.T. et al (2015), page 476.

65 Hatfield Consultants (2007).

66 Hatfield Consultants et al (2009).

Experts agree that a reduction in the dioxin levels found in foodstuffs is unlikely to be reduced in the near-term. As exposure via food consumption is the most common exposure pathway, the evaluation cannot definitively say if there is reduced potential for human exposure to dioxin until post-remediation data from food in markets and homes near the airport can be tested. However, exposure to dioxin from inhalation, absorption, or ingestion is possibly reduced as a result of the Project.

Additionally, possible improvements in the personal well-being of these sub-populations are likely, and for the populations who live and work on the airport. During interviews with local experts and community leaders in Danang, it was clear that the USAID-GVN project has directly contributed to decreased levels of distress about personal safety and concern for the health of people's families. Reportedly, fewer residents have raised concerns about their potential exposure to dioxin over the years since the USAID-GVN project was initiated and organizations involved with families living with disabilities have expressed increased optimism about the future due to the project. Workers at the airport also reportedly have an increased confidence in their ability to manage their personal safety because of the health and safety protocols that were in place for the duration of the project. While these benefits cannot be measured, increased optimism, a feeling of personal safety and well-being, and confidence in the future are notable benefits of this project.

FINDING 3: CAPACITY HAS BEEN IMPROVED FOR VIETNAMESE EXPERTS AND PARTNERS TO SUPPORT AND CONTINUE FURTHER ENVIRONMENTAL ASSESSMENT AND REMEDIATION ACTIVITIES.

The support for the Vietnamese private sector, experts, and specialists has been two-fold: (1) Direct support was provided to the Vietnamese private sector, and (2) Capacity building and training programs increased the ability and confidence of Vietnamese laborers and specialists in applying their improved capacities in other remediation contexts.

DIRECT SUPPORT TO THE VIETNAMESE PRIVATE SECTOR.

Nearly $40 million of the project funding was allocated to Vietnamese subcontractors[67] or otherwise spent in Vietnam. Vietnamese sub-contractors did purchase foreign goods and services, so not all these funds were ultimately spent in Vietnam. Channeling funds through Vietnamese sub-contractors, however, does support these business operations and expands their network and trade with foreign companies. Correspondence with one Vietnamese sub-contractor noted that their participation in this project garnered attention from other potential domestic and foreign business partners, led to increased employment, and directly impacted upstream industries. Otherwise, these funds were spent on labor, site electricity and water costs, miscellaneous equipment and supplies, office support costs, travel costs, per diems and other in-country expenses for the international staff, etc. These costs also supported at least 520 Vietnamese laborers who were employed by the USAID contractors at various points throughout the duration of the project; these individuals were employed for an estimated 1 million hours of labor on this project.[68]

---

[67] This number is an estimate – all contractors noted that precise numbers for expenditures inside Vietnam were quite difficult to disaggregate from their expenditure data.

[68] This number is also a rough estimate – all contractors noted that it would be virtually impossible to derive an accurate estimate for this figure.

CAPACITY BUILDING AND TRAINING.

Vietnamese labor additionally benefitted from an extensive health and safety training program, that was administered to all estimated 520 employees, as well as extensive on-the-job training and day-to-day oversight and knowledge transfer with the project staff. As can be seen in Table 5 below, significant resources were spent on health and safety training: ***according to the project's latest monitoring indicators, 24,482 hours of training were spent on health and safety of the on-site workers as well as GVN counterparts***.

Figure 16: Relevant M&E Indictors Measuring Benefits of Training and Capacity Building Programs

Intermediate Result	Reduced Dioxin Contamination	Indicators	Cumulative results as of March 2018
Sub-Intermediate Result	Government Capacity to Address Dioxin Contamination Increased (CDCS Statement) To build GVN capacity to conduct environmental assessments and remediation activities (M&E Goal Statement)	Number of person hours of training completed in the areas of (1) health and safety	24,482
		Number of person hours of training completed in the areas of (2) environmental assessment/remediation supported by USG assistance (output)	3,249
		Number of GVN officials with increased knowledge of environmental assessment and/or remediation because of USG assistance (outcome)	123*

** This double/triple/quadruple-counts individuals who participated in several trainings. See footnote.*

The obvious immediate benefit of the health and safety training program was to protect the health of the project staff - 94 percent of the monitored employees never had total dioxin concentrations in their blood measure above the project guidelines of 30 pg/g.[69] One USAID contractor indicated that there was a noticeable shift in the project staff embracing prevention measures throughout the duration of the project. Based on the feedback from key stakeholders involved in remediation activities, there is convincing evidence that health and safety standards will be improved at future sites because of the health and safety training program at the Danang project site. Several interviewees indicated that this was a lesson they have been applying to other sites (see text box).

[69] Data as of April 2018. There were 29 individuals who did measure with total dioxin concentrations above 30 pg/g, though exact causes for these dioxin levels are not known. The USAID contractors indicated that in some instances, this dioxin exposure could also have originated off-site. Regardless, many interviewees did highlight these 29 individuals as a concern of the project. The evaluation team believes the health and safety program will result in benefits for the local community, including the majority of individuals who did not have elevated levels of dioxin, but certainly acknowledge that improvements in safety measures may have been possible in these instances.

CDM International Inc. also led a capacity building program to contribute towards achieving USAID/Vietnam's Country Development and Cooperation Strategy (CDCS)[70] sub-intermediate result to improve the capacity of the Vietnamese government in addressing dioxin contamination. They designed a needs-based, four-part training and certification program as well as scientific writing and air sampling trainings. Fifty-one people participated in these trainings and completed 3,249 person hours of training (see Table 5). Of these participants, 28 received certificates from the four-part program. For all courses, improved knowledge was measured by a pre- and post-training survey asking participants to rate their current understanding of specific topics and report if the training had improved their knowledge overall during each course. Survey results following each of the various training courses show that the clear majority of participants reported an increased knowledge (after all courses, participants reported increased knowledge 123 times).[71]

"We've been doing remediation activities since 1995 which of course incorporated safety and prevention activities, but after the work at Danang we improved our awareness and are taking more preventative measures at other sites."

\- GVN representative

The evaluation team conducted KII with nearly all organizations who were involved in the certification program, these interviews were conducted either directly with the participants or with the supervising authorities. In interviews with these organizations, the majority reported that they had already applied at least some skills learned in the training course. Primarily, skills learned in multi-incremental sampling (MIS) methodology have reportedly been applied to other remediation sites in Vietnam, including Bien Hoa, by four separate organizations that participated in the training.[72] Participants also reported improved technical writing – one organization believes this course contributed to at least one case of a publication in an international journal.

Additionally, USAID took an opportunity to gather more objective evidence that the skills taught in the capacity building courses have been appropriately applied elsewhere. DONRE Dong Nai, which was not interviewed for this evaluation, participated in the four-part certification program and later applied the MIS sampling techniques and procedures learned in the course at the hotspot in Bien Hoa. When USAID learned of this, they discussed and agreed with DONRE Dong Nai that CDM International Inc. would review and assess DONRE's sampling activities to determine whether the specific protocols/procedures learned during the four-part training/certificate program had been applied. The results of this assessment concluded that DONRE Dong Nai:

- Demonstrated adjustments to their sampling strategy after participating in USAID's four-part training/certificate program
- Presented information on MIS techniques to other members of their organization

[70] The CDCS covers the period from 2014-2019. Source: USAID/Vietnam, Country Development and Cooperation Strategy (CDCS) (2013), page 24.

[71] There were only 51 individuals in all courses, many of whom were surveyed after each course they participated in. For example, and individual successfully completing the four-part certification course may have reported increased knowledge all four times. This figure does not mean that 123 individuals have increased knowledge, but that knowledge increased 123 times following capacity building courses.

[72] Three interviewees reported that the MIS sampling technique had been applied, and documentation was available confirming this application (see next paragraph).

- Had implemented MIS techniques in several areas at the Bien Hoa Airbase
- Noted that the MIS sampling method helped reduce the data variability that they had observed while using the 5-point composite sampling method.[73]

Beyond these hard skills, GVN counterparts also reported an increased awareness of remediation technologies or assessment activities, greater confidence in their abilities, as well as other unintended skills such as improved English abilities.

Lastly, in addition to health and safety training and the capacity building training, USAID contractors established productive technical and management relationships with their GVN counterparts over the duration of this project. Interviewees reported considerable knowledge transfer to the GVN counterparts. CDM International Inc. reported "GVN partners have demonstrated a notable increase in understanding of hazardous waste remediation implementation, including overall project management, community engagement, and environmental sampling and analysis, through their exposure and engagement on the project with USAID and its contractors."[74] These sentiments were echoed by the other USAID contractors during key informant interviews. Similarly, interviews directly with the GVN partner organizations participating in the project management and other activities confirmed that they felt they learned from the partnership with the USAID contractor team, particularly in project management.

Evidence of improved skills and knowledge from self-reports, observations from counterparts, and empirical measurements suggests that GVN counterparts have indeed increased their capacity because of the Project. Furthermore, several GVN organizations are in fact already applying skills they have learned to other sites, including Bien Hoa. I/t is reasonable to assume that increased technical knowledge and project management abilities will likely improve the remediation activities at other sites in Vietnam in the future.

[73] CDM International, Inc (2018). Assessment of Dong Nai Department of Natural Resources and Environment (DONRE) Sampling Program, page 10.

[74] CDM International, Inc (2017). FY 2018 Implementation Plan.

ANNEX 8. LESSONS LEARNED

<table>
<tr><td>Project Name: Environmental Remediation of Dioxin Contamination at Danang Airport</td><td>Date of Event: June 18-19, 2018</td></tr>
<tr><td>Venue: Grand Mercure Hotel, Danang</td><td>Number of Participants (Male/Female): 15/2</td></tr>
<tr><td colspan="2">List of Participants:
USAID facilitators: Eileen Fanelli and Anthony Kolb
USAID: Mahbub Hussain, Cuong Nguyen, and Nguyen Manh Phuc
CDM Smith: Jeff Bamer, Pete Chenevey, Alexis Lopez, and Karl Tilgner,
Tetra Tech: David Liu and Bobby Bobo
TerraTherm: Tim Burdett, Gorm Heron, and Rich Michalewich
Observers:
Integra: Matthew Addison, Kristen Schubert, and Daniel Svoboda</td></tr>
<tr><td colspan="2">Background.
The second phase of the “Environmental Remediation of Dioxin Contamination at Danang Airport Project” is coming to end and treatment has been completed. In order to generate lessons learned from Phase 2 to inform potential future remediation efforts, USAID/Vietnam organized a lessons learned workshop with its three main contractors, CDM Smith, Tetra Tech, and TerraTherm.
The information below summarizes the results of the workshop, including general workshop information, results of group discussions, and proposed follow up steps.</td></tr>
</table>

MEETING NOTES

Day 1 – June 18th

- Overview of Phase 1 Lessons Learned
- Summary of Phase 2 Operations

Pete Chenevey provided an overview of the Lessons Learned presentation planned for the Thursday meeting with GVN, including the Agenda, phase 2 operations, environmental compliance, demobilization, and the mass balance.

OPERATIONS

- Described Phase 2 relative to Phase 1 operations.
- Overview of Phase 1 lessons learned implemented in Phase 2.
- Phase 1 heating took 10 months, phase 2 heating took 6 months, the shorter time is attributed to changes in cover design and heater design, discussed during the Phase 1 lessons learned.

ENVIRONMENTAL COMPLIANCE:

- On site real time monitoring of the treatment system was conducted by Terra Term, with oversight by GVN Chemical Command.
- Vapor monitoring
- No exceedance of dioxin in Phase 2.
- VOCs in off-gas, with low odor-thresholds, lead to complaints from local residents.
- All workers used proper PPE (including full face respirators).
- Active monitoring, not passive.
- Liquid monitoring
- Arsenic was main chemical of concern
- No excursions detected in the Phase 2 monitoring, except at the very end, after treatment was complete at the end of quenching, when there was a release from the MPPE system, which was immediately taken offline and not used again.
- Ambient air monitoring
- Worker and community safety perspective.
- Monitoring perimeter of stack, on top of pile, etc.
- No excursions detected in the Phase 2 monitoring.
- Confirmation sampling
- When heating was complete, sample was collected from each 1 m depth, results were all below 0.25 ppt and well below treatment goal of 150 ppt.
    - Full PPE regardless of confidence that dioxin was gone.
    - PPE same in Phase 1 and Phase 2.
- Health and safety monitoring program
- Conducted 2-day working training.
- Required worker physical examinations prior to start of work, annually, and at end of employment.
- Big change in Phase 2 was implementation of an expanded blood monitoring program.
    - Baseline and periodic follow-up (annually, and at exit)
    - If blood dioxin exceeded 30 pg/g, follow-up sample collected in 6 months.
- Provided workers access to a doctor who would explain results.
- What happens if they had an elevated number?
    - – They were sent to a physician to understand what it meant, and the worker was retrained on proper PPE use, including respirators, etc.
    - – Workers were provided information explaining the testing process, what blood dioxin means, and how it relates to worker's life habits.
    - – Part of Phase 2 was extensive lifestyle questionnaire to see what they were doing off site (140 questions)
    - – 100% of workers participated, sampled >400 employees, over 800 samples analyzed
        - 30 workers identified over the 30 pg/g level
            - Sometimes their baseline samples were above that, not necessarily from the project
        - 13 still working on project, but they were no longer allowed to do intrusive work.

Participant Discussion:

- Potential success story.
- Health and safety in general is a major success story.
- Mass balance and this part will draw the most attention, we think health monitoring is "utterly unique"
- Topic for paper presentation, cross-cultural elements.
- Highlighted for the end of project evaluation team as it might be something interesting to focus on relative to overall success.
- – We invented it – there was no information on medical monitoring for dioxin, we went through a pretty extensive process to design the program.
- – Workers thought Agent Orange was a ghost that would hurt them. Talking with the physicians helped workers understand how to protect themselves.
- – Single women didn't want to work here originally (worried about having children because of the dioxin), but their attitude changed because their fundamental change in understanding agent orange and how you get exposed to it, they become much more comfortable (e.g. nurse). People outside still have this idea that it can't be controlled

DEMOBILIZATION

Described the 3 categories of items disposed of from Phase 2 based on the residual concentration of dioxin and/or arsenic or benzene.

- If it was low (< 25 ng/m^2 or <150 ppt) unrestricted use
- If it was medium – some restrictions (< 125 or <1,000 ppt), e.g. Heat exchanger, CMU blocks
- If it was high – sent to Europe for treatment as hazardous waste (> 125 ng/m^2 or >1,000 ppt), e.g. steel scrap, used HDPE liner, used cap materials

Participant Discussion:

- Noted that the project did not take hazardous waste from Danang to another place. Key message is that we did not generate waste that became a problem somewhere else.
- We recognize that we have different types of materials, so we want to identify the appropriate place to dispose based on its concentration, so we are trying to be conscientious about where this goes, and learning as we go along (e.g. we thought the CMU blocks would be low but found they were medium)
- If it was soil, gravel, sand measured by weight basis using PPT concentration
- Could include another item of beneficial reuse or recycling
- Saved money, important part of the story

MASS BALANCE

Presented a slide showing a simplified treatment process. Results of calculated mass balance:

- 72% dioxin destroyed in pile.
- 26% in NAPL (non-aqueous phase liquids).
- <0.01% discharge to Sen lake.
- DRE 99.992%, DE 72.8% (% efficiency).
- Starting mass (0.176 kg TEG), ending mass 0.048 (kg TEQ), 0.128 calculated by difference (destroyed in pile 72%).

Lessons Learned Methodology Review

- Successes are for the whole project
- Non-successes will be reviewed tomorrow specifically, so we are prepared to talk to GVN
- Also want to discuss lessons learned for the project as a whole

Root/cause analysis of an effect, keep asking why to drill down and find root causes – which are the key causes or factors.

[LUNCH]

PROJECT SUCCESSES

Survey Results – Project Success:

- Everyone said it was successful or exceeded expectations.
- Area of greatest success – implementation, then design.
- Main cause of that success:
    - Consistency and longevity of the team
    - Stakeholder engagement – USAID, GVN, the public, workers (and transparency)
    - Monitoring – capture results and put them in activity completion reports (we are on #5 from CDM)

GROUP 1 BREAKOUT:

Success statement and reasons for success: Reduced exceedances in treatment

- Series of changes along the liquid stream - getting rid of recirculation, cooling effects trickled down to control biological growth in Phase 1.
- Improved coordination between two contractors
- Lessons learned gatherings were really helpful to bring the issues to the forefront
    - Came out of trouble shooting in Phase I
    - Good working relationship between contractors
    - Possible because experienced operators in Phase I were involved
    - Pause in operations so the time pressure was removed to allow these changes to occur (which wasn't designed in but was an artefact of the staging)

Lessons learned

- Pause time was really important, build in time for program design (X expressed some concern that there isn't that time in USAID program cycle and planning for procurement).
- They used some of the most conservative and worse assumptions to create a schedule board.
- The lessons learned was really successful – everyone could think about solutions and speak freely and the exchange fed directly into improved Phase 2 design. In addition, there was time to implement improvements.
- Better partitioning of stages, not the liquid and vapor phase. It's easier to deal with dioxin in the vapor, never had an exceedance in the vapor stage. The changes to the pumps were critical. And did make improvements of oil and water separator to ensure they weren't churning it or agitating it. Ultimately it meant everything was kind of working right – not a bunch of little problems that were coming up all the time

- Best to schedule some time for pilots before going full-scale. Incorporate more pilots in design to confirm assumptions about risk.

GROUP 2 BREAKOUT:

Success statement and reasons for success: Project successfully treated all the soil below GVN standards

- M&E: good monitoring program in place, team spirit
- Execution: lessons learned process helped
- Initiating and planning: plan adapted to challenges that arose
- Resources/time/: experienced personnel, all contractors, and sufficient resources
- Technology worked
- In context: the US has around 1500 super fund sites and few have successfully completed treatment – it is not a given that we met the standards. This is important. Especially in a foreign context very differ
- In US, spend more time working with the regulatory agencies. Here we spend more time working on the process.

Lesson Learned:

- Be adaptable, be able to change, and adapt to challenges
- Get the right people.
- Put the right plan in place.
- Adapt to changing conditions accordingly.

GROUP 3 BREAKOUT:

Success statement and reasons for success: environmental exposure at the site was significantly reduced in Phase 2.

- Initiating/planning: TT started excavations early because we thought there would be excess volumes, allowing for segregation of material
- Executing/process: planned for and identified excess volume, then the success of the phase II treatment operations itself
- Design/process: we had designs in place, but there were methods in there to be flexible if needed. E.g. on TerraTherm, procedures in place where they had approved design, but if they find something better they had a process in place that it could be submitted and reviewed on
- M&E: all had eyes and ears on M&E to provide comments and ideas. Robust confirmatory sampling procedure in place – and on treatment side, confirmed that everything was met
- Management/integration: weekly team calls and follow-up on site with meetings so everyone on same page, lots of communications, planning
- Before monthly meeting with ADAFC everyone was on the same page
- Resources/time/material: project went much longer than expected, financial commitment from USAID to get additional funds to get it done and flexibility in terms of schedule
- Vietnamese contractors really took ownership

Lessons Learned:

- Flexibility (same as adapt with previous group). It's good to have plan in place but flexibility is important.
- how do you institutionalize this?

- Not just flexibility; it´s accountability. From beginning: when we work together, we knew we came from reputable companies and we wanted to be successful. Not only important for USAID – first remediation project in dealing with dioxin for US government – serious implications if not successful. USAID is an important client. Personal commitment. Put the best resources we could into this. Established communication process with CDM even though we have separate contract we made it clear to CDM that we are excavation contractor and we will report to you (CDM), and communicate through you then USAID. Because CDM will be the first to look at what we are going to do and comment on, another pair of eyes to tell us if we are right or wrong – better to work through that with a coherent voice.
- Institutionalize the process – there was a process to tweak the design all along, inherently flexible. All documents had a change form, so if something came up on site we could change the documents. Financially: contract modification process that was set up up-front. All processes allowed the team to be flexible.
- Tim: contract (cost +) was more flexible that TT's contract. Contract type was important and TT didn't have the same flexibility.
- Work on transparency and communication piece. Really needs to be a team effort.

GROUP 4 BREAKOUT:

Success statement and reasons for success: Completed within 6 years

- Including all legal constraints and problems, this is a big success
- Personal dedication of the people and engaged from the beginning to end, consistency
- A lot less administrative burden from EPA CERCLA process

Success: No accident

- In spite of # hours of work
- Good health and safety plan
- Repeated training
- Improved since the start

Success: Usage of lessons learned

- Best practice
- Accountable and wanting to improve

Lessons Learned:

- Waste disposal (28,000 blocks) must be included in the future design
- Health protection and prevention
- Training and capacity building must be continued
- M&E: better sampling
- Resources/time/material: break-down of budget, building trust with GVN
- Management: institutional memory and devotion have been very important
- Use of lessons learned is key success factor.
- Build in the lessons learned and build in time to address them in work planning
- Engage more with GVN

Participant Discussion:

- To evaluate further, need budget breakdown needed since there were many non-treatment activities.
- What happened to the 72% that was "treated"? What products did it become? It is not enough to simply say it is gone.
- 72% disappeared – herbicides had same by-products as dioxin so it was hard to determine which belonged to dioxin. 2,4-D and 2,4,5-T cannot track the unique daughter products and do a complete close analysis.
- Focus on results from the area, baseline and current risk scenarios, not just the pile.

[BREAK]

TEAM EXERCISE:

Each company spent 15-20 minutes drawing a picture of their worst nightmare of Phase 2, what kept them awake at night.

Tetra Tech Group:

Problem: Rain was our biggest concern (EVSA and filling the IPTD structure in Phase 2)

- Phase 2 successful because CDM and TT worked together to excavate sediment ahead of schedule, so sediment could sit in pile and dewater in advance.
- Sediment water content was much lower in Phase 2.
- When building Phase 2 pile, Tetra Tech had good material to work with. Also shaped the pile in a way that there wasn't a lot of infiltration to increase moisture content
- During phase I lessons learned team talked about how to protect the pile, Roof, cover with plastic, HDPE liner, etc.
- EVSA excess volume storage area
- Project excavated more contaminated material than the project anticipated
    - Not very high level of dioxin contaminated material
    - Exceeding sediment level but below soil clean-up goal
    - Close to 50,000 cubic meter of material that doesn't need to go into thermal treatment, now that material wasn't treated with IPTD but was taken to EVSA and compacted and had to condition it (reduce moisture content of compaction requirement of 85% or higher). Then we cover with geosynthetic drain material and liner and then put grass soil cap on top of it → environmental safe storage process.
- Phase II pile construction in 2016
- EVSA took place in 2017
- Weather factor is really the biggest concern.
- Once the sediment is wet – there is not a lot you can do with it.

CDM Smith Group

Problem Statement: VOCs and odors

- Phase II treatment – substantially more VOC than in Phase I, compounds with a low odor thresholds resulted in complaints from surrounding community.
- FTIR was online measuring VOCs and estimating the overall burden of VOCs in air.

- They were not dangerous.
- People's Committee complaint came in and we responded with a fact sheet.
- Shortly later a meeting with a few organizations and presented data. We met with DONRE, Chemical Command and others.
- After that, the odor began to dissipate because the treatment had burned off the VOCs.

USAID Group

Problem statement: Stop motion situation: getting the mouse tail in the hole. The demobilization – get that final stage finished.

TerraTherm Group:

Problem: Getting enough carbon on site

- Having high benzene in the vapor system, required additional granulated activated carbon (GAC),
- Couldn't ship in, had to find local vendor in Ho Chi Minh City to provide
- They stepped up to the plate
- Pretty hot weather and the project had to push the guys to get the carbon changed out quickly. We couldn't have changed it fast enough for a period of time that was all that we were doing.
- We were worried we would be shut down. And phase II was so much more successful that we didn't want to stop it
- In case TerraTherm couldn't change the carbon, they completed an air dispersion model (AECOM) which showed the risk due to benzene would be minimal.

Survey Results:

- Reviewed the survey results. Survey Results: everywhere, majority in execution

Where are best chances to improve (from survey results):

- Reduce turn-over rate of USAID personnel
- Flexibility: expect the unexpected
- Where do you do the flexibility: contingency planning, setting wider boundaries,
- Continuity,
- Planning –
- Demobilization
- Combine the mob and demobilization plans to force considerations for demobilization early in the planning process

[BREAK]

- Problem Statement Formulation

- Groups to come up with key problem statements for deeper dives tomorrow
- No lessons learned now, just problem identification
- Problem statement, try to narrow down – even if that means you come up with a lot of them.

[break-out groups]

(Bolded in blue are selected problems for day 2 discussion)

GROUP 1: DEMOBILIZATION:

- No specific clean-up standards for dioxin (we do have hazardous waste thresholds and we have steel pipe well below that, but we need to prove non-hazardous nature in order to have someone accept the waste)
- The non-hazardous waste that is a challenge: the scrap, the liner – there is no standard to say that its ok to go to a landfill.
  - We do not have a regulated procedure but we have regulation. It has to do with proving the tests.
  - There is a requirement to document but no procedure for documentation.
- No defined process/ procedure for disposition of non-hazardous materials containing dioxin contamination
- No standards for reuse.
- MONRE never responded to requests for information/guidance.
- We have possible lessons learned from actions ultimately taken, but when we started there were no standards.
  - Who in GVN has responsibility to certify that a waste is non-hazardous? It goes through a circle of approvals. And various GVN agencies are sitting on it without giving any decision.
- Stigma of dioxin and Agent Orange. Facilities not willing to accept things even if decontaminated.
- No in country disposition of imports.
- No process to easily manage with customs.
- Creating processes on the fly.
- Also relates to the stigma issue.
- Residual dioxin surprises that we didn't expect.
- Design elements, M&E, standards, did not anticipate the residual dioxin present.
- Donation/disposition challenges
- US policy against donating things to foreign militaries which limits options.
- Basal Convention Issues: transit countries do not need to provide approval in writing, just wait 30 days and that is tacit approval, but Vietnam does not accept that and requires approvals to be in writing, no exceptions.
- Need in writing Saudi Arabia and Djibouti that always does tacit approval and they want envelopes of cash to approve these things and we can't do that.
- Lagging response from MND/GVN.
- E.g.: last June a letter was sent on clean-up standards and it took until about December before a response was provided allowing further action (sat in limbo).
- E.g.: sampling of decontaminated items. Last July/August – asked for samples, nothing happened on that until January because no budget even though VRTC was ready to analyze the samples.
- Vietnam is in early stages of developing materials disposition processes.

If there were standards and procedures, the team could have worked through it. But we are creating these processes with Vietnam as we try to address issues. Need same players, but in 5-10 years, if the GVN ministry has new people, the team needs to educate them of the agreed upon process and hope they concur. Official procedures would help eliminate this inefficiency.

Assuming you will need to have new players: introducing it to GVN side earlier to allow for a lag time before the demobilization time. Can do a lot of lessons learned on this topic.

GROUP 2: TREATMENT

- What is the level of treatment?
- Nice we can achieve 99.992 destruction rate. Is this what is needed? Is it too strict? Since the objective was to treat to 150 ppt, it did not define rate. If project focuses on objective rather than rates, then costs may be reduced. For example:
- Impact of treating soil beyond requirements.
- OK it's nice that we achieve 99.9% but should we consider the objective is to prevent exposure.
- Maybe we don't have to be confined to one technology.
- Millions of dollars are spent on managing residual risk.
- What is the objective and what is the best way to reach it.
- Target is 150 and we got it to 1ppt. Was it too successful?
- Now that we know the temperature criteria was highly conservative - we could use that to adjust the criteria on the next project.
- What is the CBA, cutting the power a week earlier or two weeks, maybe $100,000 in power savings. Is that good insurance to ensure that its below 150 ppt.
- To go from 3,000 ppt to 150 ppt, still need 90%+ reduction rate.
- What type of sampling is appropriate for determining quantities for treatment?
- Using discrete sampling we couldn't characterize the full extent of contamination.
    - Lessons learned: discrete sampling cannot give you a precise estimate of contaminated volumes.
    - disagree. We need to think about the impacts of averaging.
    - We've had this question from lots of people: one other thing to think about: we want to reduce risk, calculate risk by exposure over a particular area –
        - MIS sampling is appropriate for looking at a risk in an area (human health and eco risk exposure)
        - Is that the appropriate method for characterizing soil for treatment?
        - There is a hybrid option, MIS plus additional sampling. MIS is good for overall evaluation.
        - If you are averaging everything, maybe you are missing something.
        - I want to identify different areas of contamination – if you look at main mechanism
        - Maybe we excavated too much because we took averages? How do we further characterize our DUs for excavation?
- Accurate estimation of off gas concentrations?
- Decision not to use oxidizer (because of the size based on assumptions at the time)
- So used "catcher's mitt": carbon
- We never changed carbon vessel because of dioxin.
- So our break-through was benzene, not dioxin.
- We went into this knowing that.
- CDM tried to get someone in Vietnam to be licensed for dioxin contaminated carbon
    - Wasn't easy – would take more time than entire project to get that done
    - There is a company that is working on this
    - We need to export dioxin contaminated carbon because it can't be destroyed in-country
- Off-gas treatment, supplemental technologies for other constituents.
- Appropriate characterization of off-gas concentrations so that it can be considered

- If we went from proof of concept to full scale pilot testing, would have caught the amount of benzene in the off-gas.
- Used large amounts of GAC.
- Lack of regeneration and disposal facilities in Vietnam.
- We weren't saying its bad or we did something wrong, but it was a problem.
- Arsenic Management
- 23 samples, and 16 had elevated levels of arsenic.
- We need to think ahead of time of what we do with arsenic even though it's not a contaminant of concern (COC).

GROUP 3: MONITORING

- Are we monitoring the right compounds? Don't know what the smell is from.
- No in country capacity in key areas.
- No lab in Vietnam able to do dioxin analysis on scale needed, so it took a few weeks from sample collection to obtain results because samples were sent overseas.
- Is dioxin analysis onsite worthwhile?
- Even though it's expensive, would we do that?
- Exposed to dioxin, no acute effects (can't smell, no alarm…) but time lag in analysis creates uncertainty and stress.
- Need plan for monitoring.
- Identify sources of odors (i.e., acetone).

Is the remediation contractor the appropriate place to do blood work or is it better to have third party with medical staff?

- Should a third-party monitor blood with medical staff, not the remediation contractor?
- Third party to manage blood monitoring and program.
- Using blood monitoring results (e.g. to show no additional exposure)
- 800 samples of worker's blood, not all samples were under 30 ppt.
- It would be good to discuss that it wasn't critical, not dangerous.
- Could we have prevented it with next-to-real-time monitoring

GROUP 4: MASS BALANCE

- Conducting

What is best method for characterizing soil?

- Challenge in small box attempt – fail
- Collect samples immediately from pile effluent
- "Larger box" increases uncertainty and complexities of data collected
- Presenting
    - How best to balance need to build trust with GVN (and the associated data needs) with need to present a simple message?
- Difficulties in proving the negative.
- Have to convince someone that you have looked everywhere and you did it well and it´s not there is hard.

- As opposed to finding degradation by-products.
- Balance the need to simplify and check all the boxes and answer all the questions.
- Trying to be comprehensive while also trying to provide a simple and easy to digest message.

Day 2 – June 19th

TREATMENT TOPIC AREA

Problem statement: We did not have accurate estimate of off gas.

Root cause analysis:

- Hadn't characterized soil accurately
- Not enough of a pilot study to accurately predict the composition and possible concentration of other constituents.
- We went from proof of concept to full scale without benefit of a pilot test. A business decision was to skip the pilot.
- Bench scale was done but for a small sample. Small sample not fully representative of entire area. – it was meant to prove that we could destroy the dioxin, not what off gas would be.
- We collected master sediment and master soil samples, but we hadn't characterized the sediment from the dump area, which was probably mixed with other contaminants. It was not representative.
- We did have Phase I data, and we knew there was benzene in off gas.
- Estimation is estimation – even then we were surprised in off-gas in Phase 2.

Participant Discussion:

Really need to characterize the input into the treatment system. Get flow data to measure VOCs, Dioxins, herbicides, etc. Representative volume, multiplied by flows, to multiply by full volume and then we know the concentrations to expect for the full volume.

- Need to do the full-scale pilot test
- Get an idea of when the contamination is heated, we will know what will come off
- And to really understand the full system and how it reacted, get the operational information (moisture content, interactions with the components)
- Try to simulate the full approach, off-gas is just a part of it
- Typically, 2-3 treatment systems to select from, if concentrations are high we can go with oxidizer, if there is indication that concentrations are low, we could go with carbon-based system.
- Additional chemical characterization of the soil would be helpful to understand what the breakdown products will be.

Pilot test or full scale? Decision on full scale... Can project automatize the process? possible for benzene content (or VOCs – mg/m^3), not possible for dioxins (much lower analytical threshold – pg/m^3).

Lessons Learned:

- Provide schedule flexibility to address issues and make system improvements.
- Create time for a **pilot test**, delay operations for several months.
- Could optimize design, to avoid cost and schedule problems down the road.
- Risk reduction.
- Maybe, if we ran a pilot in Phase I we wouldn't have been able to detect the problems in Phase 2.

- In a big batch operation, do we need a pilot for both batches
  - Batch II came from the dump area, which makes it fundamentally different than where they stored the tank.
- If cannot do pilot, need to design the treatment system for the worst-case scenario.
- Characterization is a must.
- We need a plan for collection of master soil and sediment samples so they are representative.
- The representation of the material that you use will really drive how successful your design will be.
- There will always be risk but there are ways to try to minimize that as much as possible.

Problem Statement: Optimizing amount of soil treated. (What type of sampling is appropriate for determining quantity of soil for treatment?)

Root cause analysis and participant discussion:

- Didn't see a problem with the evolution of efforts to accurately characterize soil for dioxin.
- Starting point was sampling that was highly variable, did not give a consistent picture.
- MIS provided a higher confidence at decision unit level. It was further refined over time with sub-units.
- Over-reliance on grab sampling, not enough depth information (ultimately characterized with MIS) and area specification was weak before MIS.
- Need to understand sampling context. MIS not accepted by EPA until recently. If you take grab sample, then you can define a larger area for remediation based on averages. MIS makes it more accurate.
- MIS added depth information
- Largely we maintained the original decision units slightly modified based on data results.
- Did do MIS on filled Phase 2 IPTD structure and for stock piles.
- The one component we don't know was the concentration in Phase I soil.
- With Phase 2 we had information MIS.
- Did pre-treatment samples in the IPTD pile.
- Did you look at the EA data to determine what went into treatment system?
  - No. Different sampling methodologies used.
  - EA – grab samples. Not MIS.
    - This was the vulnerability.
    - Could be that a lot of soil that was moved that maybe didn't need to be (but unlikely, we likely underestimated soil volumes using the grab sample data only.)
    - Based on most decision units, we were too narrow in what we excavated for treatment.
    - Would have saved time if we had used different sampling.
- MIS accepted by EPA in 2012
- Use of grab samples did not give high level of accuracy.
- High concentrations could render the entire area (unnecessarily) characterized as contaminated before MIS.
- MIS did not dilute high concentration hot spots.
- Revealed larger volumes requirement treatment than discrete samples did.
- In areas with high concentrations.
  - Grab and MIS difference is likely to be small
- In areas with low concentrations, grab and MIS difference is likely small.
- But if you have heterogeneity or high variability:

    - If you are collecting grab, might get a false positive OR false negative.
    - With grab, there is no spatial relationship other than at the macro-scale, can only say with confidence that it's this ISO concentration line around the decision unit.
    - Not based on a presumed flow from a release
- Issue is optimization
- Danang EA samples
- 97% variability between the discrete samples collected.
- Bien Hoa is 31% variability, can make better decisions.
- Mass Balance analysis was after-thought in Phase I. That's why we didn't collect samples from actual stock piles in the beginning
- Grab sample approach led to huge schedule delay
- Low quality information
- Learned that in Phase 1, nothing new in Phase 2.

Lessons Learned:

- Link decisions to the sample collection methods and development of decision units.
- Consider link to mass balance and confirmation sampling approaches.
- Look at sampling methodology to help with mass balancing and system optimization
- Fully utilize in-situ data to identify potential hot-spots within decision units.
- Use same sampling techniques for confirmation data as for excavation.

Project used a very conservative approach to ensure that it met the objectives because once you shut down to sample, you lose time and increase costs if you did not hit the mark

Problem Statement: In phase II, we treated to 1ppt, and goal was 150ppt. Is that too much treatment? (What is the level of treatment?)

Root cause analysis and participant discussion:

It was a conservative method to ensure that we met the objectives based on time and cost.

- We made decisions to get the dioxin level to 150 ppt. We could save a couple weeks of power shutting the system off sooner, but the risk would be a two-month delayed if we had to reheat the pile. We chose to over-treat.
- Going into Phase 2 we did change the treatment objective a bit.
- Lowered target in terms of temperature and time (3-4 criteria)
- Heated it in Phase 2 lower temperature, with better results (we had lower remaining concentrations following Phase 2 treatment).
- We don't have to go to 335, but if we get to 275 or 300 its worth sampling because we might be there. Would need to rely on interim sampling.

Lessons Learned:

- Understand what you are doing with your treated material, where is it going?
- At Danang we did everything at 150 ppt because we are mixing sediment, soil, etc
- Look at optimization based on end-use E.g. if you are at Bien Hoa, if you know treated material is going to industrial area, treating to 1,200 ppt might be sufficient, or if urban residential, 300 ppt.
    - Need to work with Vietnamese to not change the land use 5-10 years later.

- Not a realistic approach for US government.
  - Land use is changing rapidly, we don't know future but we know it will change.
  - We need to optimize in operational terms, these exogenous factors we cannot control.
  - Still a lesson learned but we may decide that given certain realities, we cannot utilize this lesson learned at Bien Hoa.
- Look at site specific materials, starting concentrations, target goals and maybe fine-tuning heating times based on that.
- Interim sampling can provide data mid-way through the heating process, to adjust heating times.

[BREAK]

Problem Statement: Residual dioxin surprises that we didn't expect.

Root cause analysis and participant discussion:

- Concrete, piping with surprises, CMU blocks, LWIC ….
- Driven by vapor-phase dioxin, which came out of the sides of the pile (especially for concrete)
- Samples were only collected from one part of vapor
- HDPE liner along the sides was compromised, maybe from hot air, cracking of LWIC, related to expansion during heating. Led to vapor coming out of the side
- Concrete and other porous materials, no coating on concrete in Phase I.
- We had thought of others but didn't necessarily have plans.

Lessons Learned:

- Material chosen for containment, how its protected.
- Secondary materials.
- Better liner on concrete to prevent exposure and contamination.
- Structure
- Look at ways to apply vacuum to side walls.
- Pile structure: account for thermal expansion and account for movement, or use different materials (LWIC on the side, maybe better to use fiberglass that is more yielding).
- Potentially some layering system on the outside.

Problem Statement: No defined process/ procedure for disposition for non-hazardous materials for dioxin contamination

Root cause analysis and participant discussion:

- Monitoring results came in fairly late.
- No well-defined process up-front.

Lessons Learned:

- Similar to lessons from last problem – planning up front.
- As part of capacity building, target a framework for a discussion on reuse options (EIA is vehicle for that).
- Maybe some SOPs for how we approach that analysis.
- Maybe MND could adopt some SOPs.

- Need to focus on demobilization and restoration would be a very good topic for a workshop or knowledge transfer with MND.
- 701, helping them get a bureaucratic or administrative role.
- Maybe taking it too far, perhaps just focus on MND
- Build agreements into the EIA.

Problem Statement: No in country disposition of imports / no process to easily manage with customs.

Root cause analysis and participant discussion:

- Market is not big enough to attract private sector to invest in hazardous waste disposal facility and maintenance. GVN has law:
- But enforcement of the law is weak
- So, market is just not big enough
- Psychology
- No one wants to take the waste because of the fear (the Ghost), even if they see that it could be profitable.
- Permission
- Not clear about the permission
- GVN has robust system for approval of hazardous waste management licenses.
    - But not sure if dioxin is included in this
    - Regulator doesn't want to take the risk to say if dioxin is included or not; dioxin not mentioned in the treatment code.

Lessons Learned:

- More market research upfront and may be facilitate building some facility if we find a partner that has technical capacity but needs to scale.
- Given limited capability to treat waste in-country, next project – we need to plan for removing waste out of country.

How to address the ghost of dioxin?

- PCB has been targeted by Vietnamese government in the last five years. If they lump that with dioxin together, will give them a much larger market to work with. If you can destroy PCB's, you can handle dioxin.
- Strategy: try to get to ghost by associating it with waste management processes that are evolving (e.g. laboratories)

[LUNCH]

MONITORING AND MASS BALANCE TOPIC AREAS

Problem Statement: Should a third-party monitor blood with medical staff, not the remediation contract?

Root cause analysis and participant discussion:

- Issues getting employees to go through monitoring program
- Turnaround time at the lab

- This is not what the implementing companies do; it is not their specialty.
- Phase I – realized lots of focus on that from GVN, it was set up to be interim to start
- We feel it's more appropriate to have medical sub-contractor to manage entire program
- Not TerraTherm's business model
- Confidentiality
- Takes administrative burden off contractors
- This evolved over time
- We are comfortable doing it now but maybe still not appropriate and not cost effective
- Documenting employees with higher blood dioxin levels was also an administrative burden (unexpected)
- Communicating with family medical practice, the lab, the program – lots of administrative burden
- Tracking and receiving the information was a problem for us
- Tracking employees who moved between Tetra Tech and CDM was a nightmare
- Family medical practice in Danang could have managed the program
- Wouldn't have had the confidentiality problem
- Using ALS instead of Axis – ALS could have provided a faster turnaround time, but we decided it wasn't worth switching labs between Phase 1 and Phase 2
- Medical monitoring company
- Lifestyle questionnaire, was supposed to help determine doses of the dioxin off-site
- Any contractor on site who comes in contact with the people who are being monitored, caused problems
- Transitional workers
- Even though you get baseline blood sample, couldn't find them for exit samples
- Phase 1 we were definitely not prepared for blood monitoring
- No questionnaire
- Not robust sampling protocol
- No procedures in place for what to do if they have elevated levels
- There was training on exposure pathways, one-time training wasn't enough
- Between phases
- We answered those questions and made policies and set minimal requirements for the contractors, and each contractor created their own program and met the minimal requirements
    - Multiple sub-contractors - messy

Lessons Learned

- Need better understanding the from the beginning of what the program should look like and establish the criteria for health and monitoring
- Perhaps a more comprehensive program to add credential and credibility to the program
- Have a third-party monitor company manage the health criteria and measurement
- Employees would trust a 3rd-party more maybe
- Removes bias and no potential manipulative
- Increases transparency and reduces moral hazard issues

Problem Statement: How do we optimize the mass balance between the big box and small box?

Root cause analysis and participant discussion:

- Expected to use the small box, and failed
- Lost the sample port, due to water backing up.
- Forced us to use the big box.
- Sampling error
- As we were collecting samples from numerous places, we were missing mass
- Larger box
- Does increase uncertainty, especially because we didn't sample all of our materials in a super robust way.
- We introduced uncertainty from the way the samples were done.
- Why did we even do mass balance?
- Largely political.
- Do we need to do it?
- Optimizing destruction [very technical conversation …]
- Having the NPP was crucial – maybe we didn't need two units.
- Huge cost associated with GAC and shipping to Europe.
- Expense was main factor for not going for oxidizer (oxidizer was about $20million estimated). If we had known we were targeting VOCs, we could have used something smaller.
- After Phase I – we wanted to make changes but it was prohibitively expensive and would have caused delays.
- Dependable natural gas supply – is this going to be practical? What happens if we lost the supply? Because we can't turn the power off.
- the only big problem in the whole project and both phases was we operated in the rainy season in Phase 1 which caused delays.
- GVN expectations evolved over time too.

Lessons Learned:

- Clearly identify the goals of the mass balance. Why is this being done and plan accordingly.
- Do mass balance at the pilot phase to optimize the system.
- So you can answer questions you get from GVN, in a much more controlled environment with more robust sampling.
- Fewer uncertainties.
- Pilot it first! More robust sampling, saving costs later. Plus improving the technology, itself.
- pilot could be incredibly ambitious because there were a lot of other things we needed to measure (e.g. thermal expansion, liner, etc.).
- Incorporate CBA application to the choice above.
- If we are going to do this again, re-design the sampling (especially sampling at the ports) and how it relates to small box. Small box is ideal, especially if you can get good samples coming out.
- Use small and large box, but prioritize them equally.

Problem Statement: Presenting (mistrust of engineering calculation and the messenger– too much or too little detail)

Root cause analysis and participant discussion:

- Dioxin ghost – began the project with distrust
- Highly technical
- People with different agendas. E.g. someone might have a particular interest in particular technology
- Complex treatment process (small and big box)

Lessons learned:

- Plan with end in mind.
- Initiation phase – understand level of proof GVN wants to see and make sure they understand the plan that is in place.
- Design: ensure you have flow meters, all the right equipment to allow mass balance to be done well, you can get all the samples that you want to get (maintaining sample port).
- M&E – in both phases we didn't analyze mass balance, added it at the end –characterize earlier to avoid issues E.g. for bag filters.
- Very clear opportunity for demobilization.

Problem Statement: No in country facility to test or dispose of dioxin

Root cause analysis and participant discussion:

It is the market. Market perceived as not big enough to attract private sector to build. Second root cause is phycology. People don't want to take the risk because of "fear" around dioxin. Treatment mission is not clear. GVN has robust system to approve who gets license (Hazmat) but dioxin is not discussed. Need explicitly mention of dioxin in treatment code. As a result of it not being there, people won't touch dioxin.

Communication Problems:

- We tried, but we never got info we needed from GVN or local vendors.
- Or they are there but have limited production capacity, cannot physically analyze sufficient material in a month.
- There are some Vietnam lab facilities, but the labs just do certain materials: food products, blood, etc.

Lessons Learned:

- Work with private sector to get all information needed for laboratory analysis (verifiable).
- See what can be done to increase their production capacity (staffing?) or other capabilities
- What would it take to expand to other materials if they are limited in their sampling?
- Arrange a courier service for their dioxin analysis (like TerraTherm did – and got the results fast)
- Arrangement with ALS in Canada
- TerraTherm – we did look at a lab in Taiwan. But there is appetite at SGS to expand their lab in Saigon.
- Maybe do a back of the envelope calculation for where to do a dioxin analysis (on-site lab would be pretty expensive)

SUMMARY

Identify key lessons learned in all areas

The project was good – could limit lessons learned in Phase 2 just to have a thermal oxidizer (especially given the non-characterization)

Treatment

1. Pilot test
    a. Off gas
    b. Mass balance
    c. Operational parameters
    d. Duration of treatment
    e. Process optimization
    f. (thermal oxidizer with scrubbers GAC polish) very important
2. Better characterization of the chemical constituents in the soil/sediment
    a. Additional analysis that could affect treatment
    b. Support the pilot test and design of the treatment system
    c. Identify other constituents affecting waste disposal
    d. Waste disposal / soil reuse
3. Pre-plan for waste (soil, construction materials) with residuals of dioxins and arsenic
    a. Pilot test optimize performance
4. Use consistent sampling / characterization methods (apples to apples)
    a. Pre- and post-excavation
    b. Pre- and post-treatment
5. Treat only to the level required based on risk
    a. [debate if this really was a lesson learned]
6. Treatment process works
    a. P2 > P1 results

Demobilization

7. Use EIA to manage demobilization and drive early approval
    a. Agree in advance on materials management during demobilization]
    b. Reuse, disposal, excess materials, treated soil, equipment
8. Part of 7: Pre plan for management of soil, sediment, and construction materials that have residual dioxin and arsenic that are going to be re-used
9. Promote in country establishment of hazardous waste treatment and disposal and lab analysis of dioxin ***[and/or monitoring issue]***
10. Refine designs to minimize residuals that need special, future management

Monitoring

11. Use third-party medical monitoring or surveillance contractor
12. Collect data on demobilization as early as possible
13. No systematic exceedances during monitoring
    a. In blood dioxin levels of the workers
    b. Environmental

Mass Balance

[mass balance seen as a good news story – but areas that can be improved moving forward]

14. Define objectives of the mass balance and design sampling accordingly

[BREAK]

Taglines

[see slides]

Global Lessons Learned

Coating?

- No coating in Phase 1
- Just asking because I hadn't heard from you on that

Given what we know about sensitivity to water from the rain, could we tweak process to be smaller batch operations rather than larger ones?

- Time/cost: how small is too small? How big is too big?
- If they are smaller batches, you will probably see more variability
- By the time you get your samples back, it's too late. Too many things have changed and you'd have to chase the old samples
- Uncertainty – each batch can be difficult
- Dust that is generated could lead to exposure
- Sustainability analysis – amount of gas/energy – might be more for a kiln style than IPTD
- If you have a robust treatment system then you don't have to worry about it for awhile
- Kiln style – if someone did a real analysis of that compared to IPTD
- Maybe because time to load was too long given the rain, or is there a way to load so that you don't worry about the rain
- If you had 5-10 years, you could make this more of a process and have two treatment sites, and work the soil through the process, less risk of rain.
- This is our largest IPTD site above ground
- Benefit of the pause between Phase 1 and Phase 2.
- Not extensive changes.
- Continuous operations would have been a problem.
- Significant costs to start up and shut down that argue for continuous operations.
    - Can't leave pumps and blowers off or they will seize up.
    - Continuous treatment is better for system overall.