INTERNATIONAL COLLABORATION ON ADDRESSING DIOXIN CONTAMINATION IN VIETNAM

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Abstract

The Governments of Vietnam (GVN) and United State Governments (USG) agreed to use the Danang Airport as an example site which contains hotspots in the proximity of human settlement. From 2002 through 2007, EPA-funded project sought to provide technical support and analyze dioxin concentrations at the airport and test and evaluate low-cost soil sampling and remediation technologies in locations where there is a high probability of off-site dioxin contamination. To date, EPA and Vietnamese partner agencies have collected about 175 soil and sediment samples from the area, including some from an adjacent pond. More than 100 samples were analyzed using the Chemical Activated Luciferase Gene Expression (CALUX®) assay. A proportion was analyzed at the Vietnamese Academy of Science and Technology (VAST) using laboratory equipment, laboratory supplies and analytical materials, including a gas chromatograph/mass spectrometer (GC/MS), provided in-kind by the EPA and the Department of Health and Human Services (HHS). Preliminary results indicate that areas of the airfield as well as sediment in the nearby pond used by local farmers exhibit potentially significant levels of dioxin, which require interim containment and long-term remediation. Interim containment measures for the known hotspots have been designed for construction before the monsoon of 2007. A comprehensive strategy for complete site and human exposure assessment, and implementation of the final remedy is forth coming.

Introduction

Ten years after the United States and the Socialist Republic of Vietnam normalized diplomatic relations, the legacy of the defoliant, Agent Orange (AO) and its contaminant, 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin), remains an environmental issue. Over the past two decades, the dioxin issue created significant barriers to attaining a fully normalized bilateral relationship between the two countries. There is an opportunity to advance the bilateral relationship through the development of a joint environmental remediation project in one of the dioxin contaminated sites and therein take a crucial, necessary step toward full reconciliation between Vietnam and the United States.

Former U.S. bases, from which Operations Ranch Hand and Pacer Ivy to deploy AO were staged, have soil dioxin concentrations higher than recommended by the U. S. Environmental Protection Agency (EPA) and World Health Organization. On March 22, 2002, The United States Government (USG) and the Government of Vietnam (GVN) officials signed a Memorandum of Understanding (MOU) to promote joint scientific research on health and environmental effects of AO in Vietnam. The MOU promotes scientific experiments that would assist Vietnamese scientists in developing dioxin analytical capabilities using several bioassay/immunoassay procedures. Use of these cost-effective procedures allows Vietnamese scientists to identify and assess areas containing toxic levels of dioxin contamination. The EPA and United States National Institute of Environmental Health Sciences (NIEHS) entered into an Inter-Agency Agreement that would support a pilot study evaluating the suitability of bioassay and immunoassay methods compared to traditional high resolution gas chromatography/low resolution mass spectrometry (HRGC/LRMS).

In September 2005, field screening and laboratory analytical capabilities were enhanced to supported site characterization at the Danang Airport. Hot spots north of the airport were delineated for interim containment measures.

Materials and Methods

Soil samples collected by Vietnamese scientists from an area of the former U.S. military base in Danang, Vietnam were analyzed using the Strategic Diagnostics Inc. (SDI) EnviroGard™ and the Chemical Activated Luciferase Gene Expression (CALUX®) assay at the Vietnam Academy of Science and Technology (VAST) in Hanoi, VN in June 2002. The same samples were shipped to the State of Hawaii (HI) Department of Health

(DOH) Laboratory Facility for subsequent dioxin analysis using the SDI EnviroGard™ and Cape Technologies DF1 High Performance Dioxin/Furan Immunoassay Kits. Chemists from the EPA split and forwarded the same samples to a NIEHS-contracted laboratory for dioxin analysis by HRGC/LRMS. In addition, analyses for polyaromatic hydrocarbons (PAHs) by gas chromatography/mass spectrometry (GC/MS), and total petroleum hydrocarbons (TPHs) as diesel range organics (DROs) and coplanar polychlorinated biphenyl (PCB) congeners 77, 126 and 169 by gas chromatography (GC) were determined to evaluate possible interferences with the bioassay/immunoassay procedures. Herbicides were analyzed to determine if 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were present along with their degradation products, 2,4-dichlorophenol and 2,4,5-trichlorophenol.

High Resolution Gas Chromatography/Low Resolution Mass Spectrometry. Soil samples were prepared, extracted, and analyzed using EPA Method 8280A, *The Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by High Resolution Gas Chromatography/Low Resolution Mass Spectrometry (HRGC/LRMS)* by a NIEHS-approved laboratory. This procedure uses HRGC/LRMS on extracts that have been subjected to a matrix-specific extraction and analyte-specific cleanup, and will provide the definitive concentrations for comparing the results obtained using the CALUX®, EnviroGard™, and Cape Technologies procedures.

Chlorinated Herbicides and Semivolatile Organics. Soil samples were prepared, extracted, and analyzed using EPA Method 8151, *Chlorinated Herbicides by GC Using Methylation or Pentafluorobenzylation Derivatization* and EPA Method 8270C, *Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)* by an EPA-approved laboratory.
Total Petroleum Hydrocarbons. The extracts prepared for semivolatile organics were also analyzed for total petroleum hydrocarbons (C_{10} to C_{28}) as DROs using modified EPA Method 8015A, *Nonhalogenated Organics Using GC/FID.*

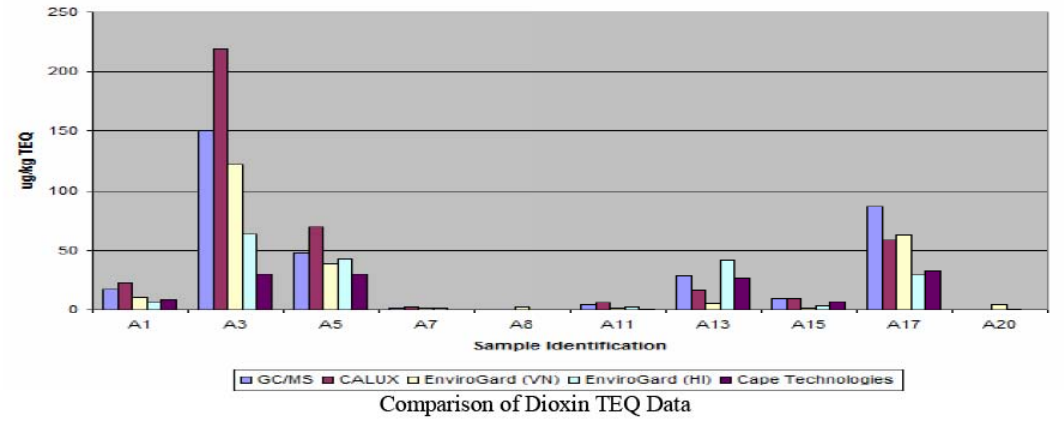
Coplanar PCB Congeners 77, 126 and 169. Soil samples were prepared, extracted, and analyzed using EPA Method 8082, *Polychlorinated Biphenyls (PCBs) by Gas Chromatograph.*

Hydraulic Modeling of storm run-off and flow/stress in Sen Lake.

Results and Discussion

Comparison of Field Screening Methods and Laboratory Analytical Capacity Building:

Regression analyses using a natural log transformation were developed to evaluate the correlation of each of the dioxin screening procedures with traditional HRGC/LRMS data.



Comparison of Dioxin TEQ Data

Interim Containment Measures:

In the workshop held in Hanoi during Feb 2007, several options for mitigating impacts of dioxin contamination in Danang airport were discussed. Since the workshop more EPA/VAST and Hatfield data has become available. The following map includes all data EPA has compiled from various sources up to date. A

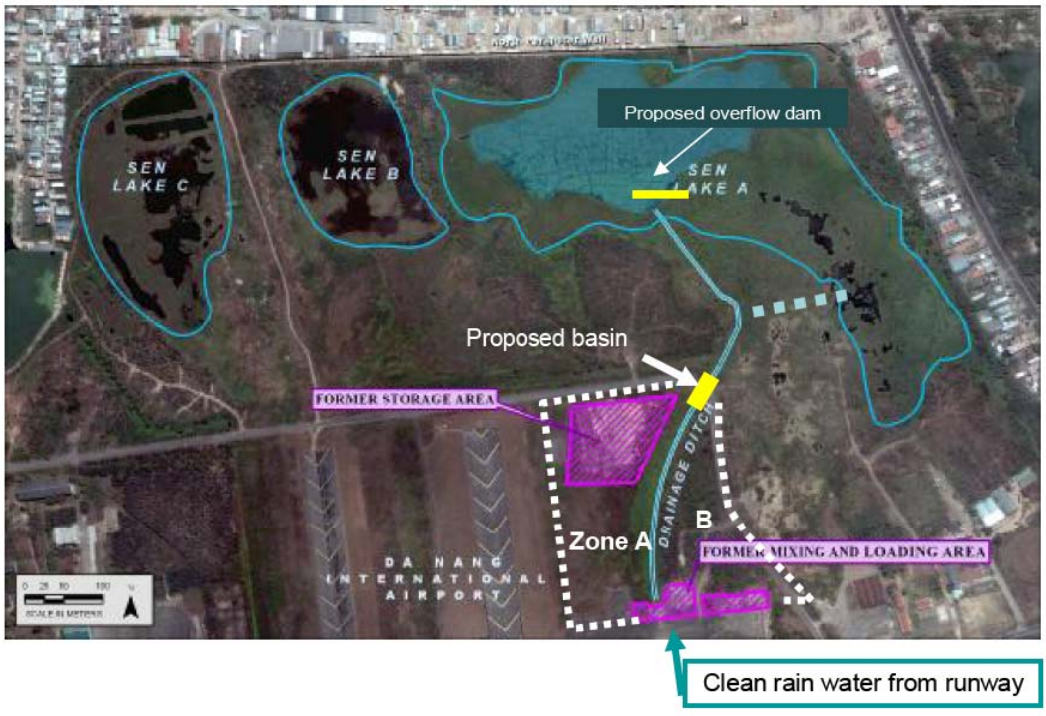
summary of the selected interim containment measures are summarized below. The design for engineering control measures are either completed or in the final stage. Construction is scheduled to take place in August and September, 2007 before the monsoon.

Former Mixing and Loading area: A portion of this area was covered by concrete in previous mitigating activities implemented by MoD, EPA/VAST site characterization data showed that the contaminated area is larger than the capped area (see map below). It was agreed among all parties to extend the impervious cap. The cap would consist of steel wire-reinforced concrete. Currently a concrete cap covers about 4200 sq meters. The new cap will extend west and northeast areas which are either known or suspected of being highly contaminated. The new total area to be capped will cover 6900 sq meters, an increase of 65% over the current capped area.

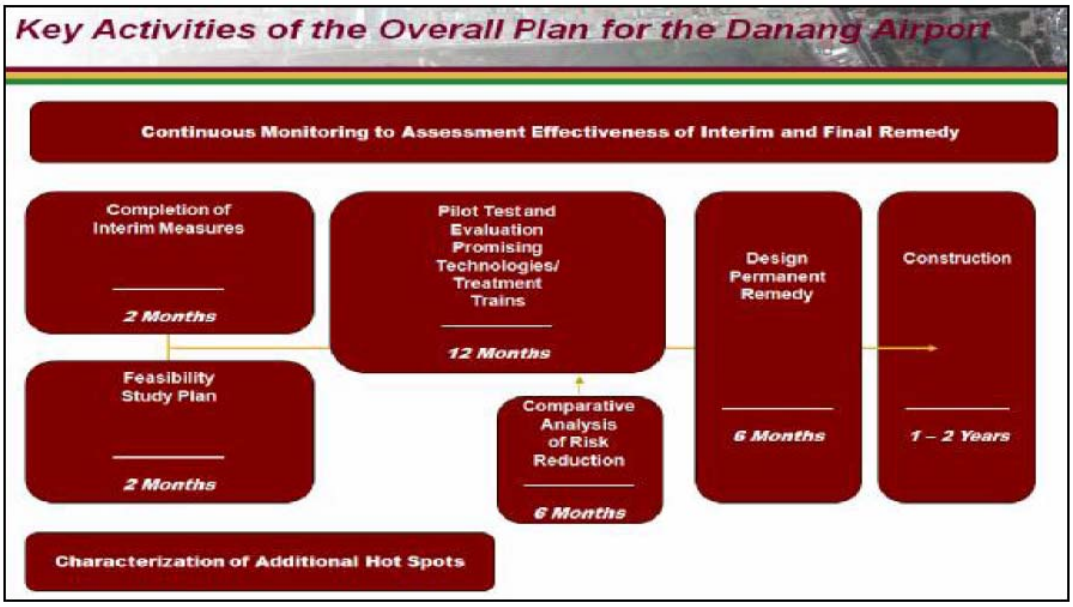
Former Storage Area: The option of sedimentation/filtration basin is preferred as it can be effective in dioxin-contaminated sediment in the runoff during significant rain events both as short-term measure and long-term solution. During future remediation, the basin will provide means to prevent contaminated soil from excavation and treatment areas. The sedimentation basin will gather all runoff water from zone A and B as indicated in the map below and remove dioxin-contaminated particles. "Clean" water from the runway and taxi way of the airport will be diverted away the contaminated areas.

Sen Lake and Drainage Ditch: An Overflow Dam will be constructed at the end of the existing ditch to slow down the storm water hence minimize the impact to the Sen Lake. Engineering design enhancements such as steps and baffles can also reduce the amount of contaminated sediment from entering into the lake. The Sen Lake serves as reservoir for runoff water flowing over the contaminated areas during rain and flood events. [The contaminated areas include the Former Mixing/Loading/Washing area where aircrafts were loaded with herbicides and washed after spraying missions and the Former Storage Area where herbicide and other chemicals were staged.] The December 2006 C33-Hatfield report discusses the public health risk caused by consumption of contaminated food. The community living near the Sen Lake harvests aquatic products containing dioxin.

Mitigation measures for the mixing loading and the former storage area



Overall Plan and Feasibility Study:
A comprehensive overall plan for complete site and human exposure assessment and implementation of the final remedy is forth coming. A flow chart of activities leading to the construction of the final remedy and a list of technologies being considered as possible remedies are presented below.



Long-Term Remediation Technologies

Technology	Definition	Status
Thermal	High temperatures breakdown the dioxin molecule into carbon dioxide, water, and chlorine gas (which must be managed by a scrubber unit).	PROVEN, $$$$
Solidification/ Stabilization	Mixtures immobilize the dioxin in a matrix that can withstand erosion and migration.	PROVEN; $; easy to implement
Physical/Chemical	Chemicals detoxify the dioxin by removing the chlorine molecules or act to separate it from the contaminated media.	PILOTED with success
Bioremediation	Use microorganisms to breakdown dioxin into non-toxic waste products.	UNPROVEN; $; promising pilots underway
Containment	Physical barriers to sequester contaminated soils; Regular monitoring	PROVEN $$

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2. Hatfield Consultants, Vietnam Office of the National Committee 33, and Ford Foundation Office for Vietnam & Thailand. 2007. Assessment of Dioxin Contamination in the Environment and human Population in the Vicinity of Da Nang Airbase, Vietnam. Report 3: Study Summary and Final Report