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Technology Demonstration Summary

Design and Development of a Pilot-Scale Debris Decontamination System

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Metallic, masonry, and other solid debris that may be contaminated with hazardous chemicals litter numerous hazardous waste sites in the United States. Polychlorinated biphenyls (PCBs), pesticides, lead, or other metals are some of the contaminants of concern. In some cases, cleanup standards have been established (e.g., no greater than 10 µg PCBs/100 cm² for surfaces to which humans may be frequently exposed). If decontaminated, this debris could be returned to the site as "clean" fill or, in the case of metallic debris, sold to a metal smelter.

This project involves the development and demonstration of a technology intended specifically for onsite decontamination of debris. Both bench-scale and pilot-scale versions of a debris washing system (DWS) have been designed, constructed, and demonstrated. The DWS entails application of an aqueous solution during a high-pressure spray cycle, followed by turbulent wash and rinse cycles. The aqueous cleaning solution is recovered and reconditioned for reuse concurrently with the debris-cleaning process, which minimizes the quantity of process water required to clean the debris.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the SITE program demonstration that is fully documented in a separate report of the same title (see ordering information at back).

Introduction

Numerous sites in the United States are contaminated with hazardous waste, and the cleanup of these sites is a top environmental priority of the decade. Currently, more than 1200 sites are included on the National Priorities List (NPL), and many more have been proposed for inclusion on the list. A typical hazardous waste site contains toxic organic and/or inorganic chemical residues that are frequently intermingled with remnants of razed structures (e.g., wood, steel, concrete block, bricks) as well as contaminated soil, gravel, concrete, and sometimes metallic debris (e.g., machinery and equipment, transformer casings, and miscellaneous scrap metal). Decontamination of these materials is important to prevent the spread of contamination offsite and to facilitate the disposal of the debris in an environmentally safe manner. Because most of the contaminated debris at Superfund sites has no potential for reuse, the purpose of a debris decontamination system would be to decontaminate the material sufficiently to permit its return to the site as "clean" fill or to allow its disposal in a Subtitle D sanitary landfill or municipal incinerator rather than a Resource Conservation and Recovery Act (RCRA) Subtitle C hazardous waste landfill or incinerator.

Objectives

The project was conducted in two phases. The objectives of Phase I were:

- to evaluate a hydromechanical cleaning system, an innovative approach for decontaminating debris,

- to conduct bench-scale testing with a portable module for the decontamination of debris, and
- based on bench-scale results, to develop a pilot-scale experimental debris decontamination module (EDDM).

The objectives of Phase II were:

- to continue development of the EDDM into a proven technology for removing various contaminants from debris found on hazardous waste sites,
- to conduct bench-scale tests to optimize the process,
- to design and construct a transportable pilot-scale DWS,
- to field-test the pilot-scale DWS at two hazardous waste sites where various types of debris are present, and

to prepare a conceptual design of a full-scale DWS.

This report is presented in two volumes. Volume I describes the design and development of the Phase I and II pilot-scale debris decontamination systems and presents the results of the decontamination demonstrations conducted at three hazardous waste sites. Volume II contains copies of the analytical data submitted by the various laboratories involved in the project.

Phase I: Development and Testing of Experimental Modules

During Phase I of the project, a hydromechanical cleaning system, an innovative approach to decontaminating debris, was developed and evaluated. A bench-scale, portable module consisting of an enclosure where debris was placed and a closed-loop solvent-delivery system was tested. Based on the bench-scale results, a pilot-scale EDDM was developed and field-tested.

A 300-gal-capacity pilot-scale EDDM was designed, assembled, installed (on a 48-ft semitrailer), and tested at the Carter Industrial Superfund Site in Detroit, MI. This site contained large quantities of different types of PCB-contaminated debris, including scrap metal, 55-gal metal drums, tools, equipment, and some furniture items.

Two 200-lb batches of metallic debris were cleaned in the system. Before and after treatment, surface-wipe samples were obtained to determine the contaminant removal efficiency of the system. The percentage reduction of PCBs achieved during cleaning ranged from 33% to 87% (average reduction of 58%) for Batch 1 and from 66% to 99% (average reduction of 81%) for Batch 2.

The surfactant solution in the EDDM was sampled twice during the actual cleaning process, and PCB concentrations of 928 and 420 µg/L were found. Upon completion of the debris-washing experiment, the cleaning solution was pumped through a series of particulate filters and finally through activated carbon. The PCB concentration was reduced to 5.4 µg/L during this treatment. Most municipalities allow water containing a PCB concentration of <1µg/L to be sewered, and this level was achieved by recycling the process water through carbon a second time.

Phase II: Design, Construction, and Demonstration of a Transportable Debris-Washing System

Phase II of this project was directed toward further development of debris washing into a proven technology for removing various contaminants from debris found on hazardous waste sites in preparation for full-scale demonstrations at Superfund and. other hazardous waste sites. An initial series of bench-scale tests were performed in a controlled environment to optimize the newlydesigned debris washing system. After the bench-scale evaluation, a transportable pilot-scale version of the DWS was designed, constructed, and demonstrated at actual hazardous waste sites.

Based on experience gained during the Carter site field test, a bench-scale (20 gal of surfactant solution capacity) debris washing unit was designed, constructed, and assembled. This system consisted of a spray tank, wash tank, oil-water separator, and ancillary equipment (i.e., heater, pumps, strainers, metal tray, etc.). This bench-scale DWS was developed to determine the ability of the system to remove contaminants from debris and to facilitate selection of the most efficient surfactant solution.

During these bench-scale experiments, surface-wipe samples of the six pieces of control debris were taken before and after treatment and analyzed for oil and grease. Based on the results, a nonionic surfactant solution was selected as the solution best suited for cleaning oily metal parts and debris.

As part of the continuing investigation into the performance of the DWS, the representative pieces of debris were spiked with a mixture of spiking material (used motor oil, grease, topsoil, and sand) containing representative contaminants (DDT, lindane, PCBs, and lead sulfate) and washed in the DWS with the selected surfactant solution. Three trials were performed. Surface wipe samples of debris from the first two trials were analyzed for PCBs, lindane, and DDT; the surface wipe samples from the third trial were analyzed for total lead.

Table 1 summarizes the quantities of PCBs and pesticides on the surface of each piece of debris before and after cleaning (Trial 2). Table 2 summarizes the quantities of lead found before and after treatment (Trial 3). The average overall reductions of PCBs and pesticides achieved during Trials 1 and 2 were greater than 99% and 98%, respectively. The overall reduction of lead was greater than 98%.

After completion of the bench-scale debris-washing experiments, the cleaning solution was neutralized to a pH of 8 and then pumped through a series of particulate filters and finally through activated carbon. During this treatment, the PCB, lindane. and DDT concentrations were reduced to <2.0, 0.03, and 0.33 µg/L, respectively. The concentration of lead was reduced to 0.2 mg/L after treatment.

Design, Fabrication, and Demonstration of Pilot-Scale DWS

Based on the results obtained from bench-scale studies, a Phase II 300gal capacity pilot-scale DWS was designed and constructed. The process flow diagram of the pilot-scale system is presented in Figure 1.

The pilot-scale DWS was assembled in a warehouse in Cincinnati, OH, and several tests were conducted. After the warehouse testing, the DWS was disassembled, loaded onto a 48-ft semitrailer, and transported to the Gray PCB site in Hopkinsville. KY, which was selected for the field demonstration. The entire DWS was reassembled on a 25-ft x 24-ft concrete pad. A temporary enclosure (approximately 25 ft high) was built on the concrete pad to enclose the DWS and to protect the equipment and the surfactant solution from rain and cold weather. The Gray PCB site contained between 70 and 80 burned out transformer casings and other large amounts of scrap metal. The demonstration took place in December 1989, and ambient temperatures were at or below freezing during the entire operation.

Table 1. Summary of Bench-Scale Results of Controlled Debris Analyzed for PCBs and Pesticides (Trial 2)

Controlled Debris	Contaminant	Pretreatment (μg/100 cm²)	Posttreatment • (μg/100 cm*)		Percent Reduction	Average Reduction
Metal	Lindane	11,800	0.13	U	100	
	4.4' DDT	9320	2.32		99.97	
	PCB- 1260	1770	2.0	u	299.89	
Metal	Lindane	8180	0.31	u	100	
	4.4' DDT	7540	4.8		99.94	≥99.91,
	PCB- 1260	1780	2.79		99.84	for metal
Metal	Lindane	6150	0.41		99.99	
	4.4' DDT	5840	2.61		99.95	
	PCB- 1260	1450	2.0	u	>99.86	
Brick	Lindane	5810	3.49		99.94	
	4.4' DDT	5660	10.5		99.81	99.80
	PCB- 1260	1220	4.1		99.66	
Concrete Block	Lindane	6440	397		93.83	
	4,4' DDT	6610	389		94.11	94.39
	PCB- 1260	1390	66.1		95.24	
Plastic	Lindane	10,300	52		99.49	
	4.4' DDT	8400	223		97.34	98.22
	PCB- 1260	1620	35		97.84	

• U indicates that the target compound was not detected at this level.

Table 2. Summary of Bench-Scale Results of Controlled Debris Analyzed for Lead (Trial 3)

Controlled Debris	Contaminant	Pretreatment (μg/100 cm²)	Posttreatment (μg/100 cm²)	Percent Reduction
Metal	Lead	876	6.0	99.31
Metal	Lead	414	6.0	98.55
Metal	Lead	450	<3.0	>99.33
Brick	Lead	508	<3.0	>99.41
Concrete Block	Lead	414	<3.0	>99.27
Plastic	Lead	446	<3.0	>99.33

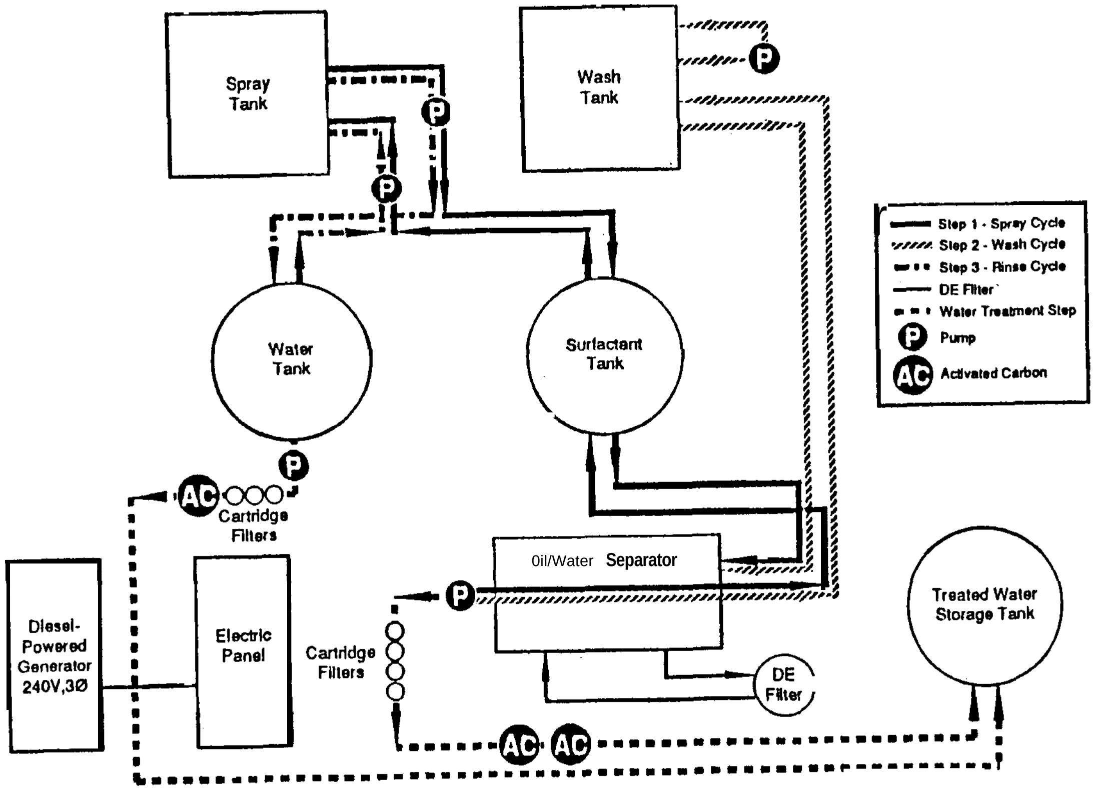

Figure 1. Schematic of Pilot - Scale Debris Washing System.

Before the cleaning process began, the transformer casings (ranging from 5 gal to 100 gal in size) were cut in half with a metal-cutting partner saw. A pretreatment sample was obtained from one-half of each of the transformer casings by a surface-wipe technique. The transformer halves were placed into a basket and lowered into the spray tank, which was equipped with multiple water jets that blast loosely adhered contaminants and dirt from the casings. After the spray cycle, the basket of casings was removed and transferred to the wash tank, where the debris was washed with a high-turbulence wash. Each batch of debris was cleaned for a period of 1 hr in the spray tank and 1 hr in the wash tank. During both the spray and wash cycles, a portion of the cleaning solution was cycled through a closed-loop system in which the oil/PCB-contaminated cleaning solution was passed through an oil/water separator, and the cleaned solution was then recycled into the DWS. After the wash cycle, the basket containing the casings was returned to the spray tank, where it was rinsed with fresh water.

On completion of the cleaning process, posttreatment wipe samples were obtained from each of the transformer pieces to assess the post-decontamination PCB levels. The average PCB concentrations on the internal surfaces of the transformer casings before and after cleaning are summarized in Table 3. The before-treatment concentrations ranged from 0.1 to 98 $\mu g/100\ cm^2$. The after-treatment analyses showed that all the cleaned transformers had a PCB concentration lower than the acceptable level of 10 $\mu g/100\ cm^2$.

After treatment of all the transformers at the site, the surfactant solution and the rinse water were placed in the water treatment system, where they were passed through a series of particulate filters, then through an activated-carbon drum, and finally through an ion-exchange column. The before- and after-treatment water samples were collected and analyzed for PCBs and selected metals (cadmium, copper, chromium, lead, nickel and arsenic).

The water treatment system reduced the PCB concentration in the water to below the detection limit. The concentrations of each of the metals (except arsenic) were reduced to the allowable discharge levels set by the city of Hopkinsville. On receipt of the analytical results, the treated water was pumped into a plastic-covered 1 0,000-yd^3 pile of contaminated soil at the site.

During this site cleanup, 75 transformers were cleaned in the DWS. All of them are now considered clean and acceptable for sale to scrap metal dealers or to a smelter for reuse.

Demonstration at the Shaver's Farm Drum Disposal Site

In August 1990, a second demonstration of the DWS was conducted at the Shaver's Farm drum disposal site near Chickamauga, GA, where 55gal drums containing varying amounts of a herbicide, Dicamba (2-methoxy-3,6 dichlorobenzoic acid), and benzonitrile (a precursor in the manufacture of Dicamba) were buried. EPA Region IV had excavated more than 4000 drums from one location on this 5-acre site when this demonstration occurred.

The pilot-scale system was transported to this site on a 48-ft semitrailer and assembled on a 25x24 ft concrete pad. The temporary enclosure used at the Gray site was reassembled to protect the equipment from rain. Ambient temperature at the site during the demonstration ranged from 75° to 105° F.

The 55-gal herbicide-contaminated drums were cut into four sections, and pretreatment surface-wipe samples were obtained from each section. The drum pieces were first placed in the spray tank of the DWS for 1 hr of surfactant spraying, then in the wash tank for an additional hour of surfactant washing, and finally in the spray tank for 30 min of water rinsing. The drum pieces were then allowed to air-dry before the posttreatment surface-wipe samples were taken. Ten batches of 1 to 2 drums per batch were treated during this demonstration.

Tables 4 and 5 summarize the surface-wipe concentrations of benzonitrile and Dicamba, respectively, on the internal surfaces of the drums before and after cleaning. Pretreatment concentrations of benzonitrile in surface wipe samples ranged from 8 to 47,000 µg/100 cm^2 and averaged 4556 µg/100 cm^2; posttreatment samples ranged from below detection limit to 117 µg/100 cm^2 and averaged 10 µg/100 cm^2. Pretreatment Dicamba values ranged from below detection limit to 180 µg/100 cm^2 and averaged 23 µg/100 cm^2; posttreatment concentrations ranged from below detection limit to 5.2 µg/100 cm^2 and averaged 1 µg/100 cm^2.

All site activities described in this document were governed by EPA-approved Health and Safety and Quality Assurance Plans.

Conclusions

Field-test results obtained with the pilot-scale DWS in demonstrations at two Region IV hazardous waste sites showed the unit to be both transportable and rugged. Extreme high and low temperatures had little effect on the operation of the equipment. The system successfully removed PCBs from transformer casing surfaces and herbicides and pesticides residues from drum surfaces.

The cleaning solution was recovered, reconditioned, and reused during the actual debris-cleaning process; this minimized the quantity of process water required for the decontamination procedure. The water treatment system was effective in reducing contaminant concentrations, with the exception of arsenic and possibly Dicamba, to below the detection limit.

Planned progression of this EPA-developed technology includes design, development, and demonstration of a full-scale, transportable version of the DWS unit.

The full report was submitted in fulfillment of EPA Contract No. 68-03-3413 by ITEP, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

TABLE 3. ***Results Obtained During Field Demonstration of DWS at Gray PCB Site***

Batch Number	Average PCB Concentration of Surfaces (µg/100 cm^2): Before Cleaning		After Cleaning	
	Average	Range	Average	Range
1.	19.7(N*=10)	< 0.1 - 94.0	1.5 (N=10)	<0.1 - 9.7
2.	9.9 (N=6)	4.8 - 17.0	1.5 (N=6)	<0.1 - 4.7
3.	6.6 (N=4)	5.0 - 9.9	1.4 (N=4)	<0.1 - 3.3
4.	4.1 (N=6)	<0.1 - 12.0	0.8 (N=6)	<0.1 - 4.1
5.	4.0 (N=8)	<0.1 -28.0	<0.1 (N=8)	<0.1 - <0.1
6.	2.0 (N=4)	<0.1 - 7.8	2.9 (N=4)	<0.1 - 10.0
7.	2.8 (N=2)	1.4 - 4.3	3.9 (N=2)	<0.1 - 7.7
6.	23.5 (N=5)	<0.1 -70.0	1.3 (N=5)	<0.1 - 3.8
9.	8.3 (N=4)	2.9 - 23.0	3.1 (N=4)	1.5 - 4.9
10.	5.2 (N=4)	<0.1 - 9.7	1.9 (N=4)	<0.1 - 2.8
11.	9.4 (N=4)	<0.1 - 17.0	3.0 (N=4)	<0.1 - 9.5
12.	48.8 (N=4)	2.3 - 98.0	1.1 (N=4)	<0.1 - 3.2
13.	12.3 (N=2)	9.6 - 15.0	5.1 (N=2)	<0.1 - 10.0
14.	16.7 (N=2)	8.7 - 25.0	<0.1 (N=2)	<0.1 - <0.1
15.	18.5 (N=4)	8.1 - 27.0	<0.1 (N=4)	<0.1 - <0.1
16.	11.3 (N=2)	8.6 - 14.0	2.0 (N=2)	1.5 - 2.5
17.	24.8 (N=4)	1.1 - 80.0	2.2 (N=4)	<0.1 - 8.4
18.	8.4 (N=5)	<0.1 - 19.0	3.4 (N=5)	<0.1 - 7.4
19.	8.3 (N=4)	<0.1 - 18.0	3.2 (N=4)	<0.1 - 5.3
20.	24.0 (N=3)	13.0 - 45.0	3.3 (N=3)	<0.1 - 9.8
21.	18.6 (N=8)	<0.1 - 44.0	0.4 (N=8)	<0.1 - 2.1
22.	25.0 (N=4)	12.0 - 35.0	<0.1 (N=4)	<0.1 - <0.1
23.	8.6 (N=4)	1.5 - 18.0	<0.1 (N=4)	<0.1 - <0.1
24.	6.8 (N=8)	<0.1 - 31.0	0.3 (N=8)	<0.1-1.4

• N indicates the number of samples.

Table 4. Results of Surface Wipe Samples Analyzed for Benzonitrile, 2,4-Dichlorophenol, 2, 6-Dichlorophenol, and 1,2,4-Trichlorobenzene During Field Demonstration of DWS at Shaver's Farm Site (µg/100cm²)

		Benzonitrile		2,4-Dichlorophenol		2,6 Dichlorophenol		1,2,4-Tricholorbenzene	
Batch Number	Sample Number	Pre-treatment	Post-treatment	Pre-treatment		Pre-treatment	Post-treatment	Pre-teatment	Post-treatment
1	1	180*(50)≠	ND§	ND(50)	ND	ND(50)	ND	ND (50)	ND
	2	130*(50)	ND	ND(50)	ND	ND(50)	ND	ND (50)	ND
2	1	125	117	34	ND	ND	ND	ND	ND
	2	90	7.8*(5)	43	ND	ND	ND	ND	ND
3	1	43	ND	ND	16*(5)	ND	ND	ND	ND
	2	28	ND	ND	14*(5)	ND	ND	ND	ND
4	1	4400	ND	NAΔ	NA	NA	NA	NA	NA
	2	2700	N D	N A	NA	NA	NA	NA	NA
5	1	4700	10*(5)	ND	ND	ND	ND	ND	ND
	2	2200	7.9*(5)	ND	ND	ND	ND	ND	ND
6	1	10*(5)	ND	ND	ND	ND	ND	ND	ND
	2	8 *(5)	ND	ND	ND	ND	ND	ND	ND
7	1	200	ND	ND	ND	ND	ND	ND	ND
	2	320	10*(5)	ND	ND	ND	ND	ND	ND
8	1	1400	28	ND	ND	ND	ND	ND	ND
9	1	3000	ND	ND	ND	ND	ND	ND	ND
	2	3500	7*(5)	ND	ND	ND	ND	ND	ND
10	1	22*(5)	ND	ND	ND	ND	ND	ND	ND
	2	1400	ND	ND	ND	ND	ND	ND	ND

. Estimated result less than 5 times detection limit.
≠ Numbers in parenthesis indicate the minimum detectable concentration of the analyte.
§ None detected in excess of the minimum detectable concentration of 5 µg/100cm² unless otherwise specified.
A Not analyzed.

Table 5. Results of Surface Wipe Samples Analyzed for Dicamba, 2,4-D, and 2,4,5-T During Field Demonstration of DWS at Shaver's Farm Site (µg/1 OOcm2)

		Dicamba		2.4-D		2,4,5-T	
Batch Number	Sample Number	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
4	1	1.9	0.63*(0.27)≠	ND§	ND	ND	ND
	2	3.4	ND	NAΔ	NA	NA	NA
5	1	ND	ND	ND	ND	ND	ND
	2	ND	2.6	ND	ND	ND	ND
6	1	ND(2.7)	ND	ND(12)	ND	ND(2.0)	ND
	2	ND(2.7)	ND(2.7)	ND(12)	ND(12)	ND(2.0)	ND(2.0)
7	1	7.3*(2.7)	1.8	ND	ND	ND	ND
	2	15	2.3	ND(12)	ND	ND(2.0)	ND
8	1	55	5.7*(2.7)	ND(12)	ND(12)	ND(2.0)	ND(2.0)
	2	13	0.62*(0.27)	ND	ND	ND	ND
9	1	1.7	0.63*(0.27)	ND	ND	ND	ND
	2	ND(2.7)	ND	ND(12)	ND	ND(2.0)	ND
10	1	41	0.30*(0.27)	ND(12)	ND	ND(2.0)	ND
	2	180	0.34*(0.27)	ND(12)	ND	ND(2.0)	ND

* Estimated result less than 5 times detection limit.
≠ Numbers in parenthesis indicate the minimum detectable concentraiton of the **analyte.**
§ **None** detected in excess of minimum detectable concentration of\Dicamba at 0.27: 2,4-D at 1.2; and 2.4.5-T at 0.20 unless otherwise specified.
A Not analyzed.

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The complete report, entitled "Technology Evaluation Report: Design and Development of a Pilot-Scale Debris Decontamination System," consists of two volumes:
"Volume I"(Order No. PB91-231456AS; Cost: $19.00, subject to change) discusses the development, demonstration, and evaluation of the debris decontamination system.
"Volume II" (Order No. PB91-231464AS; Cost: $35.00, subject to change) contains copies of the analytical data submitted by the various laboratories involved in the project.
Both volumes of this report will be available from:

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