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NCBC GULFPORT
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LETTER REPORT ON SOIL AND SEDIMENT DIOXIN TRIPLICATE STUDY NCBC GULFPORT MS

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ABB ENVIRONMENTAL

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February 8, 1996

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SUBJECT: Soil and Sediment Dioxin Triplicate Study, Naval Construction Battalion Center (NCBC), Gulfport, Mississippi, Contract Number N62467-89-D-0317/096

INTRODUCTION

This dioxin detection level study was conducted during the period April 6 through June 6, 1995, to determine if it was technologically feasible to reproducibly measure dioxin at the Mississippi State Department of Environmental Quality's (MSDEQ's) cleanup level of 4.7 parts per trillion (ppt). The economic impact of dioxin removal in soil or sediment above 4.7 ppt could be significant due to potential remediation costs or the high analytical costs of confirmatory sampling. Further, if there is significant variability in the analytical results at concentrations around MSDEQ's cleanup level, additional data may not prove helpful in establishing either the presence or absence of dioxin. Therefore, determining the variability and reproducibility of dioxin measurements around 4.7 ppt in the soil and sediments at NCBC Gulfport is of critical importance.

This study examines the analytical results of soil and sediment samples collected at NCBC Gulfport. The samples, five sediment and one surface soil, were split into triplicates for 18 samples and submitted individually for laboratory analyses. The five sediment samples were collected from drainage ditches and canals exiting from the northern part of the base. The surface soil sample was collected along the 28th Street right-of-way, which runs along the northern border of the base. Total dioxins and furans were measured using a high resolution gas chromatography and mass spectrometry (GC/MS) method capable of detecting compounds in the low ppt range. For some samples total organic carbon (TOC) and grain-size analyses were also performed.

A statistical analysis of the analytical results was conducted to determine the intrasample variability (the scatter between the results of the triplicate samples) at dioxin concentrations both below and above MSDEQ's cleanup level of 4.7 ppt. Intrasample variability in dioxin concentrations was examined graphically. Variability was also compared to sample TOC to determine if this parameter affected detected concentrations.

FIELD SAMPLING PROGRAM

The triplicate samples in this study were collected during a field effort to characterize dioxin and furan levels in the area of a proposed roadway construction project along 28th Street in Gulfport, Mississippi. The details of the field program are outlined in the Sample Strategy Removal Action Letter written to the Mississippi Department of Environmental Quality, Hazardous Waste Division (ABB Environmental

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Mississippi Department of Environmental Quality, Hazardous Waste Division (ABB Environmental Services, Inc. [ABB-ES], 1995a). The sediment and soil triplicate samples were collected during the period from April 6 to April 12, 1995.

The soil and sediment sample locations are shown on Figure 1 (Attachment A). All samples were collected in the interval between 0 and 12 inches below land surface. The sample identification codes on Figure 1 uniquely identify the sample location and describe the sample characteristics. The sample identification code uses the following pattern: the letter "G" indicates the sample was collected from NCBC Gulfport, the second character designates the sampling round (the samples were collected in sampling round 3), the third character designates media type with "D" for sediment and "S" for surface soil, the next three characters designate the sample number, and the next three characters the sample depth in inches. Some samples also bear the suffix "D1" or "D2" indicating that they were the first or second duplicates, respectively. A sample plus its two duplicate splits make up a triplicate sample group.

Each sediment or surface soil sample was collected using a stainless-steel hand auger. The soil sample was then transferred to a Pyrex™ bowl using a stainless-steel spoon and was thoroughly stirred to ensure a homogeneous mixture. One third of the sample in the bowl was transferred to one of the three appropriately labeled sample jars. The sample jars were labeled using the identification code described above.

All augers, mixing bowls, spoons, and other sample collection equipment were decontaminated prior to use. The decontamination procedure included an equipment wash with an Alconox™ deionized water solution followed by deionized water rinse. Next, a 10 percent nitric acid solution rinse for the Pyrex™ pieces, or an isopropanol rinse for metal equipment, was utilized with a final deionized water rinse. Decontaminated equipment was placed on polyethylene plastic, allowed to air dry, visually inspected, and wrapped in aluminum foil.

Investigation-derived waste included only expendable materials such as gloves and paper towels. These were double-bagged in plastic bags and disposed of in an NCBC Gulfport solid waste facility. No extraneous sediments or surface soils were removed from the sampling locations, and no additional investigation-derived waste was generated.

LABORATORY ANALYTICAL PROCEDURES

All samples collected were properly preserved, placed in coolers, and packed with bagged ice immediately after collection. The samples remained in the custody of the field operations leader until delivery to the courier service providing overnight shipment to Quanterra Laboratories in California. All samples were shipped, complete with chain-of-custody forms, to the analytical laboratory within 24 hours of collection for analysis.

Upon arrival at the laboratory, the chain of custody and preservation of the samples were compared to the contents of each cooler by laboratory personnel. After verification, the chain-of-custody form was signed by laboratory personnel and the samples accepted for analysis.

The quality assurance and quality control (QA/QC) samples collected during the field effort for the 28th Street soil and sediment samples were also used for the soil and sediment samples collected for this study. These QA/QC samples included duplicates, matrix spike and matrix spike duplicate (MS/MSD), rinsates, and field blanks. One duplicate sample was collected for every 10 samples of a single matrix. One set of MS/MSD samples was collected for every 20 samples of each matrix. One field blank was collected from the source of deionized, organic-free water. One equipment rinsate was collected following every other decontamination event.

Sediment and surface soil samples were analyzed in accordance with U.S. Environmental Protection Agency (USEPA) SW-846 methods (USEPA, 1986) and Naval Energy and Environmental Support Activity (NEESA) Level C documentation (NEESA, 1988). Dioxins and furans were analyzed using the USEPA high resolution mass spectrometry Method 8290 and TOC using USEPA Method 415.1. Grain-size and hydrometer analyses were conducted on select samples.

DIOXIN TOXIC EQUIVALENCY FACTOR (TEF) METHODOLOGY

While USEPA Method 8290 is specifically designed to detect tetra- through octa-chlorinated dioxin and furan congeners in soil and sediment, the dioxin and furan congeners of toxicologic importance are those with chlorine substitutions at molecular positions 2, 3, 7, and 8. Some of these 2,3,7,8-substituted dioxins and furans are far more toxic than others, and a simple presentation of the detected concentrations of all congeners is insufficient to adequately assess the potential toxicological effects associated with exposure to a complex mixture of these compounds (USEPA, 1989).

To address this problem, the USEPA developed a method that reasonably estimates the toxicity of each congener by assigning a TEF based upon the toxicological data and structure-activity studies on the toxic mechanism of dioxin (USEPA, 1989). These studies showed 2,3,7,8-tetrachloro-p-dibenzodioxin (TCDD) to be the most toxic of all the different congeners, and it was assigned a TEF of 1. All other 2,3,7,8-substituted congeners were less toxic and were assigned a TEF relative to TCDD. Those congeners without substitutions at molecular positions 2, 3, 7, and 8 were not considered toxic, at least in terms of carcinogenic potency, and were assigned a TEF of zero. The TEFs for the various dioxin and furan congeners are provided in Table 1 (Attachment B).

Applying the TEF to the analytical results of the various dioxin and furan congeners provides an expression of an equivalent amount of 2,3,7,8-TCDD. This is termed the TCDD toxic equivalency (TEQ). For example, the TCDD TEQ for a sample with 100 picograms per gram (pg/g) of 2,3,7,8-pentachloro-p-dioxin (2,3,7,8-PeCDD) is 50 pg/g since the TEF for congener is 0.5 ($100 \times 0.5 = 50$). This process is repeated for all 2,3,7,8-substituted dioxin and furan congeners detected in a sample, and the sum of all these values is called the total TCDD TEQ.

ANALYTICAL RESULTS

The complete dioxin and furan analytical results for each of the samples in this study are presented in Attachment C. Also presented in this attachment are the congener-specific TEFs, TCDD TEQs for each congener, and the total TCDD TEQ for each sample. If a TOC or grain-size analysis was conducted on the sample, these data are also presented in Attachment C.

A summary of the data presented in Attachment C, providing the total TCDD TEQs for each sample, is provided in Table 2 (Attachment B). Also provided is the arithmetic mean TCDD TEQ concentration and standard deviation for each sample group. Another statistic of each sample group provided in Table 2 is the normalized standard deviation that is found along the bottom row in italicized print. Because the size of standard deviation of a group is directly dependent upon the magnitude of the numbers in that group, a direct comparison with this statistic is not valid. To make a valid comparison, the group standard deviations are divided by their respective arithmetic mean concentration, resulting in the normalized standard deviation. Since the object of this study is to compare the variability of sample groups with different dioxin concentrations, the normalized standard deviation is used.

Total TCDD TEQs in the individual samples were detected below and above MSDEQ's target cleanup level of 4.7 ppt (Table 2). These values ranged from 1.01 ppt in sample G3S004D2 to 30.52 ppt in sample G3D003006. Arithmetic mean concentrations for the sample groups also bracketed the 4.7 cleanup level with concentrations ranging from 2.11 ppt at sampling location G3S004 to 25.35 ppt at sampling location G3D003006.

The TOC concentrations detected in the triplicate samples are provided in Table 3 (Attachment B). TOC ranged from 3,000 in sample G3D017006D1 to 13,000 milligrams per kilogram (mg/kg) in sample G3D003006. Generally, there was good agreement among the TOC concentrations within the sample groups. However, an exception was in sample group G3D017006, which ranged from 8,100 to 3,000 mg/kg.

Although limited by the small number of samples in this study, the comparison between the data in Tables 2 and 3 indicates a relationship between sample TOC concentration and its TCDD TEQ (Figure 2, Attachment A). This relationship was also observed for the remainder of soil and sediment samples collected during this sampling event and has been noted in other dioxin studies (ABB-ES, 1995; USEPA, 1995). A regression analysis of the data indicates a best fit line using the least squares regression exponential equation $y = ce^{bx}$. The values for c and b are constants and are provided on Figure 2, and *e* is the base of the natural logarithm. The correlation index R^2, a measure of the variability in TCDD TEQs in each sample as it relates to sample TOC, is also provided on Figure 2.

As noted above, the normalized standard deviation of each group is used to compare variability. A plot of each group's normalized standard deviation as a function of the arithmetic mean is presented on Figure 3 (Attachment A). The sample identifiers are presented next to each plotted point. For these data, the best fit curve was a least squares power equation of the general form $y = cx^b$ where c and b are constants. The values for b and c are provided on Figure 3 along with R^2 value for the curve. The arrow indicates MSDEQ's dioxin cleanup level of 4.7 ppt.

The plot on Figure 3 indicates increasing intrasample variability in TCDD TEQ measurements as its concentration decreases. Intrasample variability increases dramatically at TEQ concentrations below MSDEQ's cleanup level of 4.7 ppt (the arrow on the curve). Intrasample variability is also highly inconsistent at concentrations above 4.7 ppt. Variability in TCDD TEQs does not stabilize until mean TCDD TEQ concentrations between 15 and 20 ppt are achieved.

DISCUSSION

The results of this study indicate that there is considerable uncertainty in measuring TCDD TEQ in soil and sediment at NCBC Gulfport at concentrations near MSDEQ's cleanup level of 4.7 ppt. Further, this uncertainty does not resolve until TCDD TEQ concentrations are detected at concentrations between 15 and 20 ppt. There are two potential sources of this uncertainty: (1) experimental error due to the sampling and analysis procedures, or (2) normal sample variation associated with measuring dioxin and furan congeners at low ppt concentrations.

To reduce experimental error in this study, all samples were collected in as similar a manner as possible. The samples were all collected during the period April 6 to 12, 1995, by the same field personnel using the same equipment. Samples were uniformly homogenized as practical for environmental field sampling investigations, and field personnel used care to minimize differences between the triplicate sample groups. All samples were labeled, packaged, and shipped in identical circumstances with complete chains of custody.

Each sample was analyzed by the same laboratory in a manner as identical as practically possible by a commercial, environmental analytical laboratory following standard USEPA Contract Laboratory program (CLP) guidelines. In addition, external data validation by a subcontractor not affiliated with either ABB-ES or Quanterra Laboratory confirmed that standard USEPA CLP guidelines were followed by the laboratory.

While some experimental error can always be introduced in a field sampling procedure, for the proposes of this study, it is reasonable to assume that no experimental error leading to significant differences in sample variability was introduced due to sampling methodology, packaging, transportation, or analytical practices. Considerable care was taken to minimize any differences in these practices, both between individual samples and between sample groups, and any experimental error would be characteristic of any well-controlled environmental sampling studies and would not be expected to change significantly between sampling efforts. Therefore, it is unlikely that experimental error was responsible for the uncertainty observed in this study at low dioxin concentrations.

The most likely source of the uncertainty associated with dioxin analysis at low ppt concentrations, normal sample variability, has two components that need further discussion. These components are: (1) the TCDD TEQ methodology used to calculate dioxin levels, and (2) site-specific sample conditions.

Dioxin data expressed using the TCDD TEQ methodology are not the analytical results of a single chemical, but are a population of 2,3,7,8-substituted dioxins and furans with the appropriate congener-specific TEF applied. Since each dioxin and furan congener is a unique chemical, with different properties, normal sample-specific variations in extraction efficiency and method detection level add inherent uncertainty to TCDD TEQ values. This can result in sample groups with different detected congeners and significantly different variabilities but with comparable TCDD TEQs.

The importance of this is demonstrated by comparing the variability of the three sample groups with TCDD TEQs around MSDEQ's cleanup level of 4.7 ppt: locations G3D008006, G3D024006, and G3D017006 (Figure 3). Variability in these three samples is neither consistent nor is it related to TEQ concentration. An analysis of the data in Attachment C indicates that the variability in these three sample groups is mostly due to differences in detected 2,3,7,8-substituted congeners with those samples without TCDD in one subset and those with TCDD in another. Further, the results plotted on Figure 3 demonstrate that this intrasample variability does not reach a constant value, indicating reproducibility, until sample TCDD TEQs approach 15 to 20 ppt.

Normal intrasample variability can also be affected by site-related conditions such as sample TOC. Figure 2 and other studies have shown that TOC is correlated to sample TCDD TEQ (ABB-ES, 1995b; USEPA, 1994). However, Figure 2 also shows that at TCDD TEQ concentrations near MSDEQ's cleanup level, TOC concentrations can range from less that 2,000 to greater than 6,000 mg/kg.

The significance of this can be demonstrated by comparing the TCDD TEQ results of samples G3D017006 and G3D017006D1 (Table 2). A single sample collected at this location could be considered either clean (i.e., below the 4.7 ppt) if the analytical results were similar to G3D017006D1 or possibly requiring remediation if the analytical results were similar to G3D017006. This variability between these split samples is probably due to differences in TOC since G3D017006 has both a higher TOC and a higher TCDD TEQ than sample G3D017006D1 (Tables 2 and 3). However, these were well-homogenized split samples showing this level of variability, and even now it is unclear whether this sampling location will require remediation. Since the economic consequences of the differences between samples G3D017006 and G3D017006D1 could be large, it is important to consider site-related conditions such as TOC and other factors when establishing a site-specific TCDD cleanup goal.

Finally, it may not be appropriate to use the results of this study to establish TCDD cleanup goals for other sites. It is important to consider many factors when establishing a cleanup goal that can have significant economic impact on the potential costs of remediation. These factors include sampling and analysis methodology, the dioxin and furan congeners present, dioxin source (chlorinated phenol source versus paper mill), media, and site-related conditions such as TOC. As demonstrated in this study, simple intrasample variability, as well as other site-specific factors, can have a significant impact on the practicality and feasibility of a dioxin cleanup standard.

RECOMMENDATIONS

The three recommendations concerning dioxin and furan cleanup levels in soil and sediment at NCBC Gulfport are listed below.

1. Variability in soil and sediment TCDD TEQ concentrations below 15 ppt are large enough to cast significant questions regarding the reproducibility of the analytical results. This variability is not due to sampling and analysis techniques but results from the inherent variability associated with dioxin and furan measurements. Therefore, based upon the results of this study indicating significant variability and uncertainty in analytical reproducibility and applicability of dioxin measurements at MSDEQ's present dioxin cleanup level of 4.7 ppt, the TCDD TEQ cleanup level at NCBC Gulfport should be raised to 15 ppt.

2. The conclusions presented in this report should also be consistent with the results of future dioxin soil and sediment investigations at NCBC Gulfport provided that they are conducted in a comparable manner.

3. It may not be appropriate to apply these recommendations to sites other than NCBC Gulfport without presenting support documentation on site-specific conditions that demonstrate comparability to the conditions described in this study.

Very truly yours,

ABB ENVIRONMENTAL SERVICES, INC.

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Attachments

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ATTACHMENT A

FIGURES

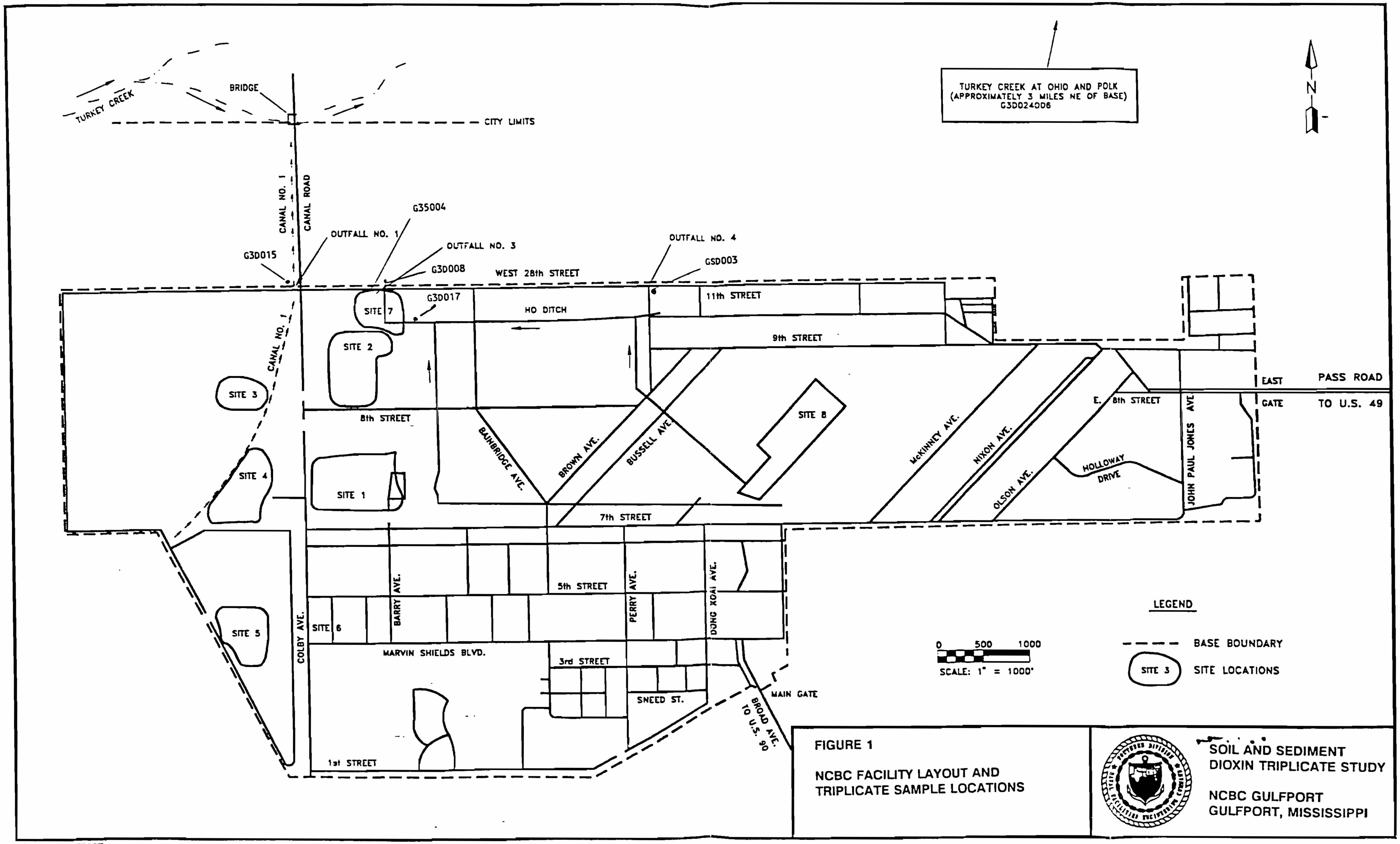

FIGURE 1

NCBC FACILITY LAYOUT AND TRIPLICATE SAMPLE LOCATIONS

SOIL AND SEDIMENT DIOXIN TRIPLICATE STUDY

NCBC GULFPORT
GULFPORT, MISSISSIPPI

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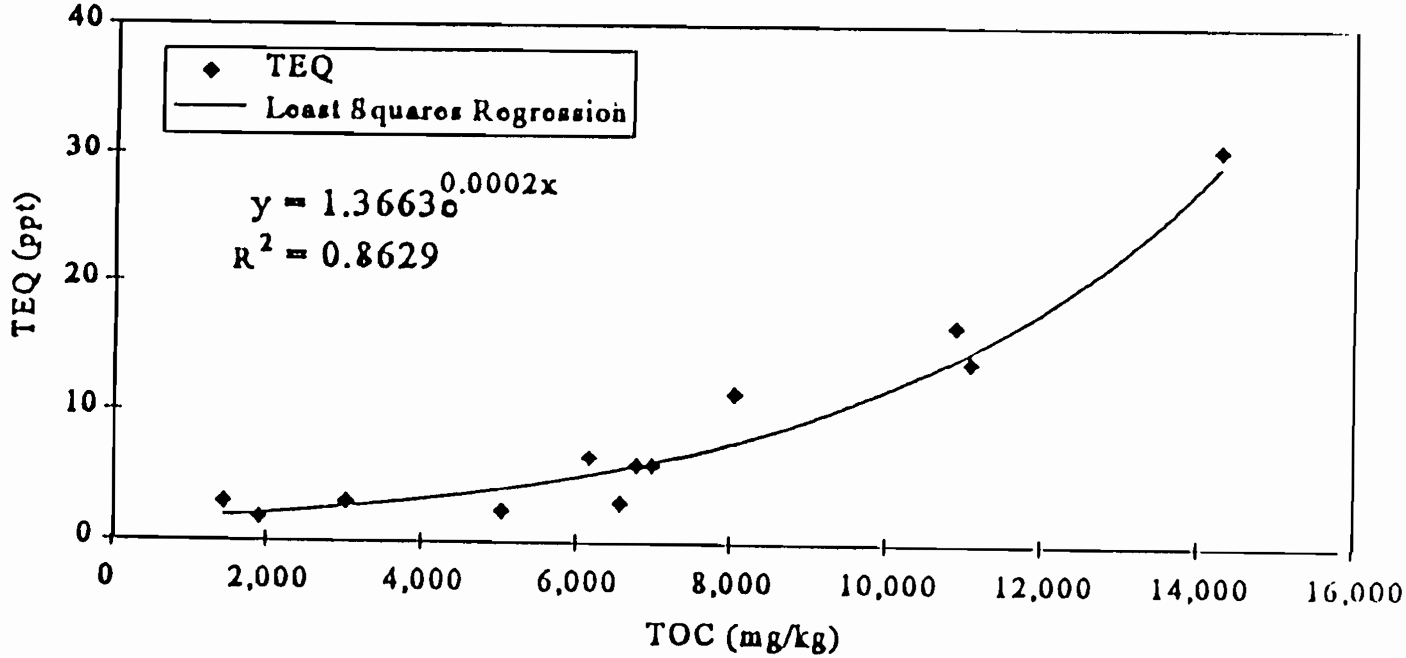

FIGURE 2

TOTAL ORGANIC CARBON (TOC) VERSUS TCDD TOXIC EQUIVALENT (TEQ)

SOIL AND SEDIMENT DIOXIN TRIPLICATE STUDY

NAVAL CONSTRUCTION BATTALION CENTER
GULFPORT, MISSISSIPPI

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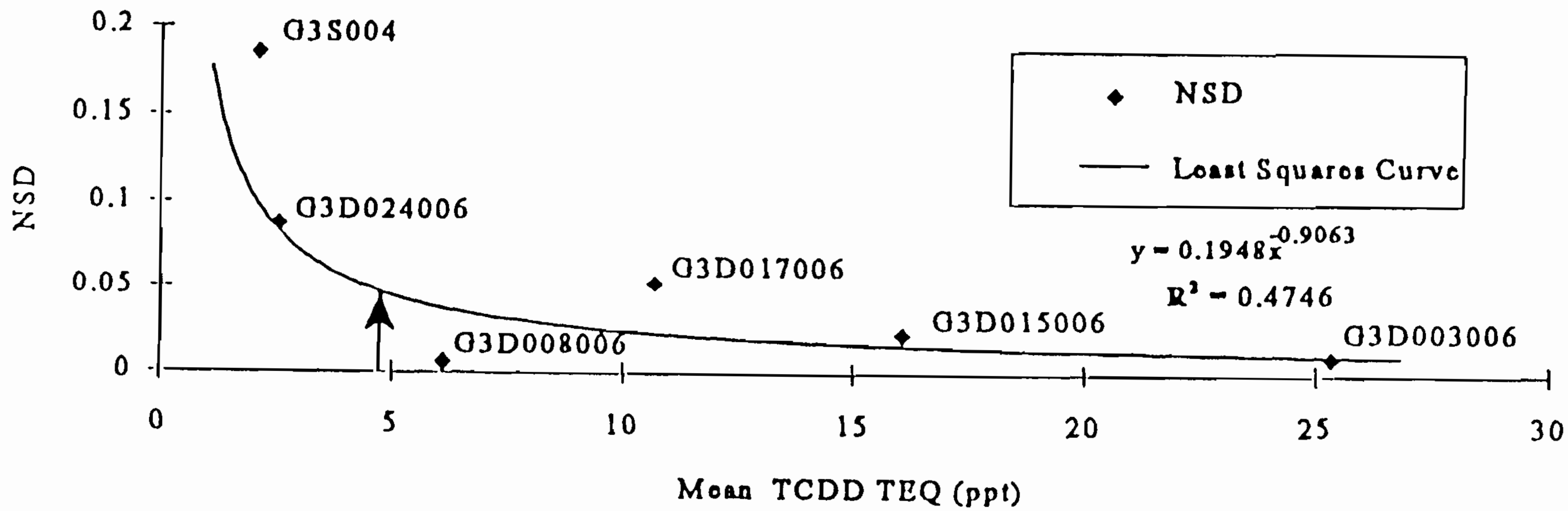

FIGURE 3

NORMALIZED STANDARD DEVIATION (NSD) VERSUS
MEAN TCDD TOXIC EQUIVALENTS (TEQs)

SOIL AND SEDIMENT DIOXIN TRIPLICATE STUDY

NAVAL CONSTRUCTION BATTALION CENTER
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ATTACHMENT B

TABLES

Table 1
U.S. Environmental Protection Agency (USEPA) Dioxin and Furan Toxic Equivalency Factors

Triplicate Study Letter Report
Naval Construction Battalion Center Gulfport
Gulfport, Mississippi

Congener	Toxic Equivalency Factor
Dioxins	
2,3,7,8 - Tetra chloro-p-dibenzodioxins (TCDDs)	1
Other TCDDs	0
2,3,7,8 - Pentachloro-p-dibenzodioxins (PeCDDs)	0.5
Other PeCDDs	0
2,3,4,7,8 - Hexachloro-p-dibenzodioxins (HxCDDs)	0.1
Other HxCDDs	0
1,2,3,4,6,7,8 - Heptachloro-p-dibenzodioxins (HpCDDs)	0.01
Other HpCDDs	0
Octachloro-p-dibenzodioxins (OCDDs)	0.001
Furans	
2,3,7,8 - Tetrachloro-p-dibenzofurans (TCDFs)	0.1
Other TCDFs	0
2,3,7,8 - Pentachloro-p-dibenzofurans (PeCDFs)	0 05
Other PeCDFs	0
2,3,7,8 - Hexachloro-p-dibenzofurans (HxCDFs)	0.1
Other HxCDFs	0
2,3,7,8 - Heptachloro-p-dibenzofurans (HpCDFs)	0.01
Other HpCDFs	0
Octachloro-p-dibenzofurans (OCDFs)	0.001

Source: USEPA, 1989, Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and -Dibenzofurans (CDDs and CDFs) and 1989 Update.

Table 2
2,3,7,8-TCDD Toxic Equivalency Concentrations in Triplicate Samples

Triplicate Study Letter Report
Naval Construction Battalion Center Gulfport
Gulfport, Mississippi

	Sample Identifier Code					
	G3S004	G3D024006	G3D008006	G3D017006	G3D015006	G3D003006
Sample 1 (pg/g or ppt)	3.00	1.74	6.44	11.31	13.90	30.52
Sample D1 (pg/g or ppt)	2.32	2.96	5.96	3.00	24.17	28.77
Sample D2 (pg/g or ppt)	1.01	2.93	5.95	17.77	10.11	16.76
Arithmetic Mean	2.11	2.54	6.11	10.69	16.06	25.35
Standard Deviation	0.83	0.57	0.23	6.04	5.94	6.11
Normalized Standard Deviation	0.19	0.09	0.01	0.05	0.02	0.01

Notes: pg/g = picogram(s) per gram.
ppt = parts per trillion.

Table 3
Total Organic Carbon Concentrations in Triplicate Samples

Triplicate Study Letter Report
Naval Construction Battalion Center Gulfport
Gulfport, Mississippi

	Sample Identifier Code					
	G3S004	G3D024006	G3D008006	G3D017006	G3D015006	G3D003006
Sample 1 (mg/kg or ppm)	6,600	1,900	6,800	8,100	11,000	13,000
Sample D1 (mg/kg or ppm)	5,100	1,400	6,100	3,000	12,000	ND
Sample D2 (mg/kg or ppm)	ND	ND	7,000	ND	ND	11,000

Notes: mg/kg = microgram(s) per kilogram.
ppm = parts per million.
ND = no data.

ATTACHMENT C

DATA

Analytical Results
G3S004D1

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3S004D1	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	36		0.01	0.36
	OCDD	470		0.001	0.47
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF	7.3	J	0.10	0.73
	1,2,3,4,6,7,8 - HpCDF	72		0.01	0.72
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	35		0.001	0.035
				TEQ =	2.315
			Ratio	TCDD/TEQ =	0%
	TOC (mg/kg)	5,100			

Analytical Results
G3S004D2

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3S004D2	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	26		0.01	0.26
	OCDD	390		0.001	0.39
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	34		0.01	0.34
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	20	J	0.001	0.02
				TEQ =	1.01
			Ratio	TCDD/TEQ =	0%

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Analytical Results
G3S004

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3S004	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	51		0.01	0.51
	OCDD	650		0.001	0.65
	Furans (pg/g)				
	2,3,7,8 - TCDF	1.3	J	0.10	0.13
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF	8.9	J	0.10	0.89
	1,2,3,4,6,7,8 - HpCDF	77		0.01	0.77
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	50		0.001	0.05
				TEQ =	3
			Ratio	CDD/TEQ	0%
	TOC (mg/kg)	6,600			
	Grain Size	**%**			
	> 4	0.3	Gravel		
	4-10	1.6	Coarse sand		
	10-40	9.8	Medium sand		
	40-200	75.7	Fine sand		
	< 200	12.6	Silt/clay		
	Total	**100.0**			

Analytical Results
G3008006D2

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D008006D2	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	5.4		1.00	5.4
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	26		0.01	0.26
	OCDD	250		0.001	0.25
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF		U	0.01	0
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	35		0.001	0.035
				TEQ =	5.945
			Ratio	TCDD/TEQ =	91%
	TOC (mg/kg)	7,000	J		

Analytical Results
G3008006D1

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D008006D1	Dioxins (pg/g)				
	2,3,7,8 - TCDD	5.1		1.00	5.1
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	35		0.01	0.35
	OCDD	390		0.001	0.39
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	7.0	J	0.01	0.07
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	48		0.001	0.048
				TEQ =	5.958
			Ratio	DD/TEQ	86%
	TOC (mg/kg)	6,800	J		

Analytical Results
GD008006

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D008006	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	4.6	J	1.00	4.6
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	66		0.01	0.66
	OCDD	890		0.001	0.89
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	16		0.01	0.16
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	130		0.001	0.13
				TEQ =	6.44
			Ratio	TCDD/TEQ =	71%
	TOC (mg/kg)	6,100	J		
	Grain Size	**%**			
	> 4	2.1	Gravel		
	4-10	1.5	Coarse sand		
	10-40	4.9	Medium sand		
	40-200	57.7	Fine sand		
	< 200	33.8	Silt/clay		
	Total	**100.0**			

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Analytical Results
G3D003006D2

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D003006D2	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	15		1.00	15
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	53		0.01	0.53
	OCDD	550		0.001	0.55
	Furans (pg/g)				
	2,3,7,8 - TCDF	5.5		0.10	0.55
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	10	J	0.01	0.1
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	35		0.001	0.035
				TEQ =	16.765
			Ratio	TCDD/TEQ =	89%
	TOC (mg/kg)	11,000			

Analytical Results
G3D003006D1

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D003006D1	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	23		1.00	23
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD	8.3	J	0.10	0.83
	1,2,3,4,6,7,8 - HpCDD	180		0.01	1.8
	OCDD	2000		0.001	2
	Furans (pg/g)				
	2,3,7,8 - TCDF	7.3		0.10	0.73
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	30		0.01	0.3
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	110		0.001	0.11
				TEQ =	28.77
			Ratio	TCDD/TEQ =	80%

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Analytical Results
G3D033006

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D033006	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	31		0.01	0.31
	OCDD	310		0.001	0.31
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF		U	0.01	0
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	15	J	0.001	0.015
				TEQ =	0.635
			Ratio	TCDD/TEQ =	0%
	TOC (mg/kg)	3,600			

Analytical Results
G3D024006D2

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D024006D2	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD	15		0.10	1.5
	1,2,3,4,6,7,8 - HpCDD	64		0.01	0.64
	OCDD	790		0.001	0.79
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF		U	0.01	0
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF		U	0.001	0
				TEQ =	2.93
			Ratio	TCDD/TEQ =	0%

Analytical Results
G3D024006D1

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D024006D1	Dioxins (pg/g)				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD	16		0.10	1.6
	1,2,3,4,6,7,8 - HpCDD	64		0.01	0.64
	OCDD	720		0.001	0.72
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF		U	0.01	0
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF		U	0.001	0
				TEQ =	2.96
			Ratio	TCDD/TEQ =	0%
	TOC (mg/kg)	1,400	J		

Analytical Results
G3D024006

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D024006	Dioxins (pg/g)				
	2,3,7,8 - TCDD		U	1.00	0
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD	9.0	J	0.10	0.9
	1,2,3,4,6,7,8 - HpCDD	37		0.01	0.37
	OCDD	470		0.001	0.47
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF		U	0.01	0
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF		U	0.001	0
				TEQ =	1.74
			Ratio	TCDD/TEQ =	0%
	TOC (mg/kg)	1,900	J		

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Analytical Results
G3D017006D2

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D017006D2	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	16		1.00	16
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	69		0.01	0.69
	OCDD	530		0.001	0.53
	Furans (pg/g)				
	2,3,7,8 - TCDF	3.8	J	0.10	0.38
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	11	J	0.01	0.11
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	56		0.001	0.056
				TEQ =	17.766
			Ratio	TCDD/TEQ =	90%

Analytical Results
G3D017006D1

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D017006D1	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	2.7	J	1.00	2.7
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	15		0.01	0.15
	OCDD	150		0.001	0.15
	Furans (pg/g)				
	2,3,7,8 - TCDF		U	0.10	0
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF		U	0.01	0
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF		U	0.001	0
				TEQ =	3
			Ratio	TCDD/TEQ =	90%
	TOC (mg/kg)	3,000			

Analytical Results
G3D017006

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D017006	**Dioxins (pg/g)**				
	2,3,7,8 - TCDD	9.7		1.00	9.7
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	63		0.01	0.63
	OCDD	570		0.001	0.57
	Furans (pg/g)				
	2,3,7,8 - TCDF	2.2	J	0.10	0.22
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	13	J	0.01	0.13
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	58		0.001	0.058
				TEQ =	11.308
			Ratio	TCDD/TEQ =	86%
	TOC (mg/kg)	8,100			
	Grain Size				
	> 4	0.1	Gravel		
	4-10	0.5	Coarse sand		
	10-40	1.5	Medium sand		
	40-200	58.2	Fine sand		
	< 200	39.7	Silt/clay		
	Total	100.0			

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Analtical Results
G3D015006D2

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D015006D2	Dioxins (pg/g)				
	2,3,7,8 - TCDD	7.4		1.00	7.4
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	94		0.01	0.94
	OCDD	1100		0.001	1.1
	Furans (pg/g)				
	2,3,7,8 - TCDF	3.9	J	0.10	0.39
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	20		0.01	0.2
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	75		0.001	0.075
				TEQ =	10.105
			Ratio	TCDD/TEQ =	73%

Analytical Results
G3D015006D1

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D015006D1	Dioxins (pg/g)				
	2,3,7,8 - TCDD	20		1.00	20
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	110		0.01	1.1
	OCDD	1600		0.001	1.6
	Furans (pg/g)				
	2,3,7,8 - TCDF	11		0.10	1.1
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	26		0.01	0.26
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	110		0.001	0.11
				TEQ =	24.17
			Ratio	TCDD/TEQ =	83%
	TOC (mg/kg)	12,000			

Sample Number	Analyte	Result	Qualifier	TEF	TCDD TEQ (ppt)
G3D015006	Dioxins (pg/g)				
	2,3,7,8 - TCDD	10		1.00	10
	1,2,3,7,8 - PeCDD		U	0.50	0
	1,2,3,4,7,8 - HxCDD		U	0.10	0
	1,2,3,6,7,8 - HxCDD		U	0.10	0
	1,2,3,7,8,9 - HxCDD		U	0.10	0
	1,2,3,4,6,7,8 - HpCDD	130		0.01	1.3
	OCDD	1600		0.001	1.6
	Furans (pg/g)				
	2,3,7,8 - TCDF	6.1		0.10	0.61
	1,2,3,7,8 - PeCDF		U	0.05	0
	2,3,4,7,8 - PeCDF		U	0.50	0
	1,2,3,6,7,8 - HxCDF		U	0.10	0
	1,2,3,7,8,9 - HxCDF		U	0.10	0
	1,2,3,4,7,8 - HxCDF		U	0.10	0
	2,3,4,6,7,8 - HxCDF		U	0.10	0
	1,2,3,4,6,7,8 - HpCDF	27		0.01	0.27
	1,2,3,4,7,8,9 - HpCDF		U	0.01	0
	OCDF	120		0.001	0.12
				TEQ =	13.9
			Ratio	TCDD/TEQ =	72%
	TOC (mg/kg)	11,000			
	Grain Size				
	> 4	21.0	Gravel		
	4-10	5.7	Coarse sand		
	10-40	10.7	Medium sand		
	40-200	52.9	Fine sand		
	< 200	9.7	Silt/clay		
	Total	*100.0*			

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ATTACHMENT D

GLOSSARY

GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
CLP	Contract Laboratory program
GC/MS	gas chromatography and mass spectrometry
mg/kg	milligrams per kilogram
MS/MSD	matrix spike and matrix spike duplicate
MSDEQ	Mississippi State Department of Environmental Quality
NCBC	Naval Construction Battalion Center
NEESA	Naval Energy and Environmental Support Activity
2,3,7,8-PeCDD	2,3,7,8-pentachloro-p-dioxin
pg/g	picograms per gram
ppt	parts per trillion
QA/QC	quality assurance and quality control
TCDD	tetrachloro-p-dibenzodioxin
TEF	toxic equivalency factor
TEQ	toxic equivalency
TOC	total organic carbon
USEPA	U.S. Environmental Protection Agency

ATTACHMENT E

REFERENCES

REFERENCES

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