DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE, INDIANA 47522-5000

IN REPLY REFER TO:

5090
Ser 095/0240
31 OCT 2000

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Illinois, Indiana, and Michigan Section
ATTN: Mr. Peter Ramanauskas (DW-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center (NAVSURFWARCENDIV Crane) submits enclosure (1) to finalize the Basewide (BW) Background (BG) Soils Investigation Work Plan and Field Sampling Plan Addendum. This enclosure contains the updated cover sheet, completed signature page, and the updated Figure 3-2. The permit required Certification Statement is provided as enclosure (2).

NAVSURFWARCENDIV Crane point of contact is Mr. Thomas J. Brent, Code 09510, telephone 812-854-6160.

Sincerely,

James M. Hunsicker
Director, Environmental
Protection Department
By direction of the Commander

Encl:
(1) Final Pages for the BW BG Addendum Plans
(2) Certification Statement

Copy to:
ADMINISTRATIVE RECORD
SOUTHNAVFACENGCOM (Code 1864) (w/o encl)
IDEM (Doug Griffin)
TTNUS (Keith Henn) (w/o encl)

Work Plan and Field Sampling Plan Addendum for Basewide Background Soil Investigation

Naval Surface Warfare Center Crane Division

Crane, Indiana

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0083

October 2000

TETRA TECH NUS, INC.
661 Andersen Drive ▪ Pittsburgh, Pennsylvania 15220-2745
(412) 921-7090 ▪ FAX (412) 921-4040 ▪ www.tetratech.com

PITT-10-0-094

October 26, 2000

Project Number 0087

Commander
Department of the Navy
SOUTHNAVFACENGCOM
ATTN: William H. Gates (Code 1864)
2155 Eagle Drive
North Charleston, South Carolina 29406

Reference: CLEAN Contract Number N62467-94-D-0888
Contract Task Order 0083

Subject: Work Plan/ Field Sampling Plan Addendum for Basewide Background Soil Investigation, Naval Surface Warfare Center Crane, Indiana

Dear Mr. Gates:

I have enclosed one copy of the updated cover sheet, completed signature page, and updated Figure 3-2 (per the EPA's request) for the Final Work Plan/ Field Sampling Plan Addendum Report for the Basewide Background Soil Investigation at the Naval Surface Warfare Center Crane at Crane Indiana.

Per your request on October 25, 2000, I have also sent Tom Brent five copies of these updates to distribute to the appropriate agency representatives at the U.S. Environmental Protection Agency and Indiana Department of Environmental Management.

If you have any questions, feel free to call me at (412) 921-8146.

Sincerely,

Keith W. Henn. P.G.
Task Order Manager

KWH/
Enclosure

c: Tom Brent, NSWC Crane (5 copies)
Debbie Wroblewski/DER (cover letter only)
Mark Perry/file (1 copy)
Tom Johnston (1 copy)
TtNUS NSWC Crane Library (1 copy)

WORK PLAN AND FIELD SAMPLING PLAN ADDENDUM FOR BASEWIDE BACKGROUND SOIL INVESTIGATION

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0083

SEPTEMBER 2000

Date 10/20/00
KEITH HENN, P.G.
TASK ORDER MANAGER
TETRA TECH NUS, INC.

Date 10/26/00
DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS, INC.

Date 9/21/00
BILL GATES
REMEDIAL PROJECT MANAGER
NAVAL FACILITIES ENGINEERING COMMAND

Date 10-20-00
PAUL V. FRANK
QUALITY ASSURANCE MANAGER
TETRA TECH NUS, INC.

Date 9-12-00
PETER RAMANAUSKAS
PERMITTING PROJECT MANAGER
U.S. EPA REGION 5

Date 9-12-00
ALLEN DEBUS
QUALITY ASSURANCE REVIEWER
U.S. EPA REGION 5

Date 9/15/00
TOM BRENT
SITE MANAGER
NSWC CRANE

TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS

ABC	Alluvial subsurface clay
BA1	Background Area 1
BA2	Background Area 2
BA3	Background Area 3
BGS	below ground surface
CLEAN	Comprehensive Long-Term Environmental Action Navy
CTO	Contract Task Order
DE	Depositional Environmental
FSP	Field Sampling Plan
ft	Foot; Feet
HASP	Health and Safety Plan
IDEM	Indiana Department of Environmental Management
NSWC	Naval Surface Warfare Center
PBS	Pennsylvanian subsurface sand
QAPP	Quality Assurance Project Plan
QA/QC	Quality assurance/quality control
SOP	standard operating procedure
TtNUS	TetraTech, NUS Inc.
USDA/SCS	United States Department of Agriculture/Soil Conservation Service
EPA	United States Environmental Protection Agency

1.0 INTRODUCTION

This combined Work Plan and Field Sampling Plan describes sampling and analyses to be performed in support of the Basewide Background Soil investigation at Naval Surface Warfare Center (NSWC) Crane, Crane, Indiana. This document is an addendum to the original Work Plan (Tetra Tech NUS, TtNUS, 2000a). The original Quality Assurance Project Plan (TtNUS, 2000b) is the basis for this project.

The original Work Plan established a goal of acquiring at least three background soil samples for each of 16 soil types. The samples were intended to represent background soil from all of NSWC Crane and were collected from surface and subsurface depths in four different representative soil depositional environments (DEs) at the NSWC Crane facility. The combination of DE, sampling depth (surface or subsurface), and grain size (sand, silt or clay) established the soil type of each soil sample collected. Sand, silt, and clay characteristics were determined based upon a geologist's observations in the field.

Three samples of a given soil type were sufficient to meet the minimum project objectives. However, it was anticipated that some soil types would be similar enough to other soil types that data from the similar soil types could be consolidated. This consolidation would provide greater statistical power when performing comparisons of site data to background data. Similarities and differences among soil types were based on metal concentrations and the geological characteristics of the samples. Metal concentrations were evaluated statistically using analysis of variance, and the geological characteristics were evaluated qualitatively.

Following the data evaluations and consolidations, nine different soil *groups* were formed from samples of the 16 *soil types*. Seven soil groups comprised at least five samples. The other two soil groups were each represented by a single soil sample of relatively unique metal concentration character. Those two groups are the Pennsylvanian Subsurface Sand (PBS) and Alluvial Subsurface Clay (ABC). The various soil groups and contributing soil types are depicted in Figure 4-1 of the Basewide Background Soil Investigation Report (TtNUS, 2000c).

The scarcity of PBS and ABC soil types (one sample each) obtained in the first sampling event provides the impetus behind this addendum. An attempt will be made in the upcoming sampling event to obtain at least four more PBS samples and at least two more ABC samples to yield a total of at least five samples and three samples in each of these two soil groups, respectively. The reasons for not striving to acquire four more samples of the ABC soil type are explained below and in Attachment 1.

This addendum strives to achieve a difficult goal, trying to find samples of specific soil types that are relatively scarce. A balance had to be reached between making a minimum effort to find the samples and making an unlimited effort. How this is achieved is described in the following sections.

Assuming that additional PBS and ABC samples can be obtained under the guidelines set forth in this document, the new chemical analytical results will be evaluated along with the existing background soil data to regenerate background soil groups. The data re-evaluation will follow the strategy described in the Basewide Background Soil Investigation Report (TtNUS, 2000c). The expectation is that the soil groupings will not change significantly after the new data are added to the existing data. Yet, the additional data may show that one or both of the PBS and ABC soil types can be consolidated with one of the other seven soil groups.

2.0 SAMPLING STRATEGY AND RATIONALE

All portions of the original Work Plan apply to this phase of the project, with the exceptions presented below.

2.1 PROBLEM STATEMENT AND DECISION RULE:

The problem statement remains the same as the original Work Plan (TtNUS, 2000a). The decision rule is slightly different because it incorporates a periodic re-evaluation of the costs associated with the acquisition of target samples. The decision rule is as follows:

> Acquire at least four samples of the PBS and two samples of the ABC soil types within established resource limitations. If, after installing a given *boring set* (described below), at least four PBS samples (or two ABC samples) have been acquired OR projected sampling costs exceed the established limit before all desired samples are acquired, stop sampling. Otherwise, continue sampling with periodic re-evaluation of costs to determine whether to continue sampling or to stop sampling.

Excluding mobilization costs, available resources are established as $10,000 for the Pennsylvanian DE and $8,000 for the Alluvial DE. The method used to derive these values is explained in Attachment 1. The mobilization cost is $4,000 for a single 10-day sampling shift. Sampling costs are $1,000 per day assuming an average of five soil borings are installed per day.

2.2 SAMPLING RATIONALE

The sampling rationale is the same as described in the original work plan (TtNUS, 2000a). It requires the collection of soil samples from 6-foot deep soil borings that represent “true” background conditions. The soil boring locations were chosen based on multiple criteria to meet this objective. Please refer to Section 4 of the original work plan for more details (TtNUS, 2000a).

2.3 SAMPLING STRATEGY

The sampling strategy for this phase is different from the original work plan. A periodic re-evaluation of sampling costs will occur after every fifth boring is installed. Every fifth boring provides a convenient re-evaluation point because five borings can be installed on a typical sampling day. A set of 5 sequential borings (defined as *boring sets*) was established, as follows:

- Several locations were identified throughout Background Areas 1 and 3 where PBS and ABC samples will be collected. See TtNUS (2000a) for a description of the background areas.

- Multiple groups of five borings identified as random numbers were drawn without replacement from the pool of identified boring locations using a uniform random number generator (Microsoft Excel 97, SR-1).

- A set of five borings were labeled to identify that they belong to the same boring set (Table 3-1).

Note: By requiring re-evaluation of sampling costs after every fifth boring rather than after each sampling day, the field crew may deviate from the installation rate of five borings per day without upsetting the randomization strategy.

Predetermined sampling cost estimates for this field event are based on four factors: (1) the sampling cost per day, (2) the number of days already spent sampling during this field event, (3) the number of borings that can be installed in a day, and (4) the probability of encountering a soil type of interest in a boring. Estimated daily sampling costs are based on the original background sampling event in November 1999 at NSWC Crane. The number of days spent sampling changes with each day in the field. The number of borings that can be installed in a day is assumed to be five until actual field work indicates otherwise. The probability estimates are based on NSWC Crane historical data, including the original basewide background field event and other site investigation data. The historical site investigation data are summarized in Attachment 2. The original background data can be found in the Basewide Background Investigation report (TtNUS, 2000c).

A few factors render the initial probability estimates uncertain. One factor is the scarcity of PBS and ABC samples obtained during initial background soil sampling. Another factor is that no other ABC data are available besides the initial background investigation sampling data. Finally, most PBS data in Table A2.1 (Attachment 2) are associated primarily at investigations with only two solid waste management units (SWMU), which presents a potentially biased view of the availability of PBS samples throughout NSWC Crane. Given this situation, a decision was made to use a periodic update model to estimate when sampling costs exceed established resources. The updates will reflect the changing probabilities of encountering a particular soil type as borings are installed and samples of the desired soil type either are or are not encountered. However, instead of requiring that the probabilities be computed in the field, all possible sampling outcomes have been anticipated in advance of sampling and the associated sampling costs have been computed (Attachment 1). Tables of stopping rules based on Tables A1.1 and A1.2

have been devised that allow the field crew to quickly and easily evaluate whether sampling should continue or be terminated at the re-evaluation points.

If more than one sample of the desired soil types is encountered in a boring, the sample selected for analysis will be determined in a random fashion to prevent vertical spatial bias. Only one sample will be acquired from each boring so that each boring location has equal representation in the data set.

Because resources (i.e., project funds) are not infinite, a limit has been placed on the number of sampling days that will be spent searching for and acquiring the appropriate number of samples of each soil type. This translates to a maximum dollar amount that will be spent searching for samples. Unless four or more PBS samples are acquired or two or more ABC samples are acquired within the first 14 borings, at least three sets of five borings (15 borings) will be installed in each DE. This ensures that a reasonable minimum effort will be expended before concluding that additional sampling is not cost effective. After the third set (15 borings) is installed in a given DE, attainment of one or more of the three conditions presented below will be reason for terminating sampling:

- The requisite number of soil samples has been acquired.
- Cost projections reveal that continuing the search for additional samples will be cost prohibitive ($10,000 limit for PBS and $8,000 limit for ABC will have been exceeded).
- The maximum number of boring sets have been installed (10 sets for PBS and 8 sets for ABC).

Once the sampling of a given boring set has begun, sampling must continue until all borings in the boring set have been installed. This renders it possible (though not very probable) that more than four PBS samples and more than two ABC samples will be collected by the end of the last sampling day. For example, the first sample of ABC soil could be encountered in the 15^{th} boring and another two ABC soil samples could be obtained in the 18^{th} and 20^{th} borings. Colleciton of more than the targeted number of samples per DE is an advantage because it provides slightly greater statistical power when comparing site data to background data. Yet, the costs associated with acquiring these extra samples are minimal.

It is possible that the minimum number of sampling days required to obtain the four PBS and two ABC samples is 2 days. For this to occur, four PBS samples would be collected in the first 5 PBS soil borings and two ABC samples would be collected in the first 5 ABC soil borings.

3.0 SAMPLING PLAN

Fifty boring locations in the Pennsylvanian DE have been grouped into randomly selected sets of five, with each set numbered PS1 through PS10. Forty boring locations in the Alluvial DE have been grouped into randomly selected sets of five, with each set numbered A1 through A8. Each group of five borings is called a "boring set." All borings are located in Background Areas 1 or 3 and are shown on Figures 3-1 and 3-2, respectively. Each boring in a given set is identified as belonging to that boring set (Table 3-1).

3.1 SAMPLE ACQUISITION PROCEDURE

The following procedure is to be used for acquiring the samples in each DE. Soil borings identified for this sampling event are tabulated on Table 3-1 and illustrated on Figures 3-1 and 3-2. The Pennsylvanian DE shall be sampled first, followed by the Alluvial DE. Text in bold typeface below should be replaced with Alluvial DE values when dealing with the Alluvial soil sampling. This is explained further in Step 6. A boring log shall be completed for each boring attempted.

Step Number — Procedure

1.0 Select the **Pennsylvanian** DE for boring installation.

2.0 Select the five **Pennsylvanian** DE boring locations in boring set "PS1" and install borings at those locations in any convenient sequence.
Note: Each boring will sampled in 1-foot increments to a depth of 6 feet below ground surface (bgs) or where refusal occurs, whichever is encountered first.

3.0 After each boring is installed in the **Pennsylvanian** DE:

3.1 Discard the top two 1-foot intervals (i.e., 0-2 feet) because those intervals represent surface soils, which are not part of this sampling campaign.

3.2 Characterize the soil type of each 1-foot interval sample below 2 feet according to grain size (see TtNUS, 2000a).

3.3 Using the grain size and DE information, classify each subsurface interval as **PBS** or not **PBS**. See original work plan (TtNUS, 2000a) for additional information.
Note: P = Pennsylvanian DE; B = subsurface soil; **S = sand**.

3.4 If no intervals matching the **PBS** soil type are detected in the soil boring, discard all the boring intervals and proceed to the next boring in the selected boring set.

3.5 If only one interval corresponds to the **PBS** soil type, select that interval for chemical analysis and proceed to the next boring in that boring set.

3.6 If more than one interval of the boring is a **PBS** soil type:

3.6.1 Number the four subsurface intervals from the boring as "3," "4," "5," and "6" with the number corresponding to the bottom depth of each soil boring interval.

3.6.2 Discard any intervals not matching the **PBS** soil type.

3.6.3 Roll a six-sided die with faces numbered 1, 2, 3, 4, 5, and 6.

3.6.4 If the upward die face does *not* correspond to one of the retained intervals of the **PBS** soil type, keep rolling the die until the upward face *does* correspond to one of those values.

3.6.5 When the upward die face corresponds to a retained boring interval of the **PBS** soil type, designate the corresponding soil boring interval for chemical analysis. Discard the remaining intervals from the boring and proceed to the next **Pennsylvanian** DE boring in the selected boring set.

Note: Using this procedure, it is possible to obtain more than four PBS soil samples from all of the boring sets sampled up to this point. This is acceptable, but only one **PBS** soil sample may be retained from each boring in a given boring set.

4.0 After characterizing every boring in a given boring set, use Table 3-2 to determine whether sampling for **PBS** soil should continue or be terminated. If sampling is to continue, proceed to Step 5.0; otherwise, proceed to Step 6.0.

5.0 Select the next boring set and repeat Steps 3.1 through 4.0 for the selected set.

6.0 After reaching a condition that requires termination of sampling for PBS soil samples:

6.1 Change each occurrence of "PBS" to "ABC" in Steps 3.3, 3.4, 3.5, 3.6, 3.6.2, 3.6.4, 3.6.5, 3.6.5 (Note), and 4.0.

6.2 Change "P = Pennsylvanian" to "A = Alluvial" in Step 3.3 (Note).

6.3 Change "Pennsylvanian" to "Alluvial" in Steps 1.0, 2.0, 3.0, and 3.6.5.

6.4 Change "S = Sand" to "C = Clay." in Step 3.3 (Note).
Replace the Note after Step 3.6.5 with the following: **Note:** Using this procedure, it is possible to obtain more than two ABC soil samples from all of the boring sets sampled up to this point. This is acceptable, but only one ABC soil sample should be retained from each boring in a given boring set.

6.5 Change "Table 3-2" to "Table 3-3" in Step 4.0.

7.0 Repeat steps 1.0 through 6.5 for the Alluvial DE.

3.2 ANALYSIS SCHEDULE

After acquiring the appropriate PBS and ABC samples, submit the samples for chemical analysis according to the original Work Plan and QAPP (TtNUS, 2000a, 2000b).

Each sample shall be submitted for TAL metal analyses plus lithium, strontium, thorium, and tin.

Samples must be labeled, packaged, and shipped in accordance with the original Work Plan, and all appropriate chain of custody information must also be submitted with the samples. Samples identified for chemical analysis will be labeled according to the sample nomenclature on Table 3-4 and 3-5.

3.3 QUALITY CONTROL SAMPLES

Quality control (QC) samples shall be collected at the same rates as delineated in the original Work Plan and QAPP (TtNUS, 2000a, 2000b). The number of QC samples should be determined based upon the combined total number of samples sent for chemical analysis.

TABLE 3-1

BACKGROUND SOIL BORING SETS, AREAS 1 AND 3
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Pennsylvanian DE		Alluvial DE	
Boring Set	**Boring***	**Boring Set**	**Boring***
PS1	BG1SBP39	AB1	BG1SBA25
	BG1SBP42		BG1SBA28
	BG1SBP45		BG1SBA29
	BG3SBP01		BG1SBA38
	BG3SBP09		*BG3SBA07*
PS2	BG1SBP11	AB2	BG1SBA07
	BG1SBP22		BG1SBA24
	BG1SBP43		BG1SBA31
	BG1SBP44		BG1SBA34
	BG3SBP08		*BG3SBA11*
PS3	BG1SBP13	AB3	BG1SBA06
	BG1SBP16		BG1SBA10
	BG1SBP37		BG1SBA19
	BG1SBP40		BG1SBA37
	BG1SBP50		BG1SBA39
PS4	BG1SBP14	AB4	BG1SBA13
	BG1SBP21		BG1SBA33
	BG1SBP32		BG1SBA35
	BG1SBP35		BG1SBA36
	BG3SBP03		*BG3SBA08*
PS5	BG1SBP18	AB5	BG1SBA14
	BG1SBP27		BG1SBA22
	BG3SBP02		BG1SBA26
	BG3SBP04		BG1SBA32
	BG3SBP06		*BG3SBA06*
PS6	BG1SBP20	AB6	BG1SBA08
	BG1SBP24		BG1SBA09
	BG1SBP30		BG1SBA23
	BG1SBP31		BG1SBA30
	BG1SBP41		*BG3SBA10*
PS7	BG1SBP19	AB7	BG1SBA15
	BG1SBP23		BG1SBA17
	BG1SBP47		BG1SBA18
	BG1SBP49		BG1SBA21
	BG3SBP05		BG1SBA27
PS8	BG1SBP12	AB8	BG1SBA11
	BG1SBP17		BG1SBA12
	BG1SBP28		BG1SBA16
	BG1SBP48		BG1SBA20
	BG3SBP07		*BG3SBA09*
PS9	BG1SBP15		
	BG1SBP25		
	BG1SBP33		
	BG1SBP36		
	BG1SBP38		
PS10	BG1SBP26		
	BG1SBP29		
	BG1SBP34		
	BG1SBP46		
	BG3SBP10		

* Borings in Background Area 3 are italicized to distinguish them more easily from borings in Background Area 1.

TABLE 3-2

CRITERIA FOR DECIDING WHETHER TO CONTINUE OR TO STOP SAMPLING FOR PBS SAMPLES NAVAL SURFACE WARFARC ENTER CRANE, INDIANA

		Number of PBS Samples Acquired				
Boring Set Number	**Number of Borings Installed**	**0**	**1**	**2**	**3**	**4 or More**
PS1	5	Continue	Continue	Continue	Continue	Stop
PS2	10	Continue	Continue	Continue	Continue	Stop
PS3	15	Stop	Continue	Continue	Continue	Stop
PS4	20	NA	Continue	Continue	Continue	Stop
PS5	25	NA	Stop	Continue	Continue	Stop
PS6	30	NA	NA	Continue	Continue	Stop
PS7	35	NA	NA	Stop	Continue	Stop
PS8	40	NA	NA	NA	Continue	Stop
PS9	45	NA	NA	NA	Continue	Stop
PS10	50	NA	NA	NA	Stop	Stop

Notes:

NA Not Applicable

TABLE 3-3

CRITERIA FOR DECIDING WHETHER TO CONTINUE OR TO STOP SAMPLING FOR ABC SAMPLES NAVAL SURFACE WARFARC ENTER CRANE, INDIANA

		Number of ABC Samples Acquired		
Boring Set Number	**Number of Borings Installed**	**0**	**1**	**2 or More**
AB1	5	Continue	Continue	Continue
AB2	10	Continue	Continue	Continue
AB3	15	Continue	Continue	Continue
AB4	20	Stop	Continue	Continue
AB5	25	NA	Continue	Continue
AB6	30	NA	Continue	Continue
AB7	35	NA	Continue	Continue
AB8	40	NA	Continue	Continue

Notes:

NA Not Applicable

TABLE 3-4

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Sample Tracking Number	Coordinates		Depositional Environment[1]	Topographic Location	General Location	Crane Development Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMUs	Soil Classification[1,3]	
	Northing	Easting									Surface Soil[4]	Subsurface Soil[5]
Alluvium												
BG1SBA06	454461	559076	Silty alluvium derived from loess uplands	floodplains & lowlands	Southwest of Rocket Range	37	21	Wakeland	Wa	4	silt loam	silt loam
BG1SBA07	456878	556367	Silty alluvium derived from loess uplands	floodplains & lowlands	West of Rocket Range	37	20	Wakeland	Wa	4	silt loam	silt loam
BG1SBA08	460659	555847	Alluvium	floodplains & lowlands	South of Conservation Dam	33	16	Wilbur	Wr	NP	silt loam	silt loam
BG1SBA09	461721	562586	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	Northwest of Rocket Range	34	17	Burnside	Bu	4	loam	loam to channery loam
BG1SBA10	470982	553170	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	West of Pyrotechnic Area	28	12	Burnside	Bu	4	loam	loam to channery loam
BG1SBA11	472065	558899	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	South of Landfill	28	13	Burnside	Bu	4	loam	loam to channery loam
BG1SBA12	475076	565305	Alluvium	lowlands	East of Landfill	29	13	Haymond	Hd	3	silt loam	silt loam
BG1SBA13	470628	552326	Alluvium	lowlands	West of Pyrotechnic Area	28	12	Haymond	Hd	3	silt loam	silt loam
BG1SBA14	468794	554170	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	Northwest of Rocket Range	33	16	Burnside	Bu	4	loam	loam to channery loam
BG1SBA15	466253	553711	Silty alluvium derived from loess uplands	floodplains & lowlands	South of Landfill	33	16	Wakeland	Wa	4	silt loam	silt loam
BG1SBA16	462628	552867	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	North of JT-2	33	16	Burnside	Bu	4	loam	loam to channery loam
BG1SBA17	460628	552742	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	South of JT-2	33	16	Burnside	Bu	4	loam	loam to channery loam
BG1SBA18	460596	554086	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	South of JT-2	33	16	Burnside	Bu	4	loam	loam to channery loam
BG1SBA19	457982	555795	Alluvium	floodplains & lowlands	West of Rocket Range	37	20	Wilbur	Wr	NP	silt loam	silt loam
BG1SBA20	458961	556701	Silty alluvium derived from loess uplands	floodplains & lowlands	West of Rocket Range	37	16	Wakeland	Wa	4	silt loam	silt loam
BG1SBA21	455930	560263	Silty alluvium derived from loess uplands	floodplains & lowlands	Southwest of Rocket Range	37	21	Wakeland	Wa	4	silt loam	silt loam
BG1SBA22	455721	564336	Silty alluvium derived from loess uplands	floodplains & lowlands	Southwest of Rocket Range	38	21	Wakeland	Wa	4	silt loam	silt loam
BG1SBA23	460742	560211	Silty alluvium derived from loess uplands	floodplains & lowlands	West of Rocket Range	34	17	Wakeland	Wa	4	silt loam	silt loam
BG1SBA24	460846	563513	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	Northwest of Rocket Range	34	17	Burnside	Bu	4	loam	loam to channery loam
BG1SBA25	455909	556534	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 2500 feet southeast of storage bunker 1360	37	20	Wakeland	Wa	4	silt loam	silt loam
BG1SBA26	456346	557763	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 1000 feet southeast of storage bunker 1360	37	21	Wakeland	Wa	4	silt loam	silt loam

TABLE 3-4

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Sample Tracking Number	Coordinates		Depositional Environment[1]	Topographic Location	General Location	Crane Development Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMUs	Soil Classification[1,3]	
	Northing	Easting									Surface Soil[4]	Subsurface Soil[5]
BG1SBA27	468690	552711	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 3000 feet west of storage bunker 1215	33	16	Wakeland	Wa	4	silt loam	silt loam
BG1SBA28	456399	565076	Loess and underlying alluvium	outwash terraces	App. 2500 feet southeast of the Rocket Range	38	21	Pekin	PeB	NP	silt loam	silt loam to silty clay loam
BG1SBA29	465982	564055	Alluvium derived from loess uplands	floodplains & lowlands	App. 1000 feet north of storage bunker 1289	34	17	Wilbur	Wr	NP	silt loam	silt loam
BG1SBA30	474076	565909	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 2500 feet north-northwest of the Pyrotechnic Test Area	29	13	Wakeland	Wa	4	silt loam	silt loam
BG1SBA31	469065	565670	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 2500 feet southeast of Pyrotechnic Test Area	34	13	Wakeland	Wa	4	silt loam	silt loam
BG1SBA32	475971	563117	Silty alluvium	lowlands	App. 1300 feet northeast of storage bunker 1003	29	13	Haymond	Hd	3	silt loam	silt loam
BG1SBA33	471930	552232	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	App. 1200 feet west of storage bunker 1160	28	12	Burnside	Bu	4	loam	loam to channery loam
BG1SBA34	458784	559128	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 7500 feet west of the Rocket Range	37	21	Wakeland	Wa	4	silt loam	silt loam
BG1SBA35	455128	560899	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 1700 feet southeast of storage bunker 1350	38	21	Wakeland	Wa	4	silt loam	silt loam
BG1SBA36	466336	556961	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	App. 750 feet southeast of storage bunker 1210	33	16	Burnside	Bu	4	loam	loam to channery loam
BG1SBA37	464180	554545	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 1500 feet west-northwest of storage bunker 1278	33	16	Wakeland	Wa	4	silt loam	silt loam
BG1SBA38	464336	566086	Alluvium derived from loess uplands	floodplains & lowlands	App. 5500 feet north of the Rocket Range	34	17	Wilbur	Wr	NP	silt loam	silt loam
BG1SBA39	462274	556420	Alluvium derived from loess uplands	floodplains & lowlands	App. 100 feet south of storage bunker 1276	33	16	Wilbur	Wr	NP	silt loam	silt loam
Residual Soil from Pennsylvanian Bedrock/Colluvium												
BG1SBP11	472253	559492	material weathered from ss, siltstone, shale.	top of slope	West of Pyrotechnic Area	28	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP12	473399	562742	material weathered from ss, siltstone, shale.	top of ridge	Northwest of Pyrotechnic Area	29	13	Wellston-Gilpin complex	WnE	6	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP13	472649	564180	material weathered from ss, siltstone, shale.	sideslope	Northwest of Pyrotechnic Area	29	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP14	469742	559326	material weathered from ss, siltstone, shale.	top of slope	Southeast of Landfill	33	13	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP15	473617	564701	material weathered from ss, siltstone, shale.	sideslope in uplands	Southwest of Pyrotechnic Area	34	13	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP16	467836	564045	material weathered from ss, siltstone, shale.	sideslope	Northwest of Rocket Range	34	17	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP17	468107	555315	loess and material weathered from ss, siltstone, shale.	ridgetop	South of landfill	33	16	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP18	466492	560242	material weathered from ss, siltstone, shale.	sideslope	West of Annex	34	17	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam

TABLE 3-4

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Sample Tracking Number	Coordinates		Depositional Environment[1]	Topographic Location	General Location	Crane Development Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMUs	Soil Classification[1,3]	
	Northing	Easting									Surface Soil[4]	Subsurface Soil[5]
BG1SBP19	464096	555388	material weathered from ss, siltstone, shale.	ridgetop	North of Conservation Dam	33	16	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP20	463117	557253	material weathered from ss, siltstone, shale.	sideslope near ridgetop	Northeast of Conservation Dam	33	16	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP21	461763	561274	material weathered from ss, siltstone, shale.	ridgetop	West of Rocket Range	34	17	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP22	459649	553888	loess and material weathered from ss, siltstone, shale.	sideslope of ridge	West of Rocket Range	37	16	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP23	460242	562451	loess and material weathered from ss, siltstone, shale.	ridgetop	West of Rocket Range	34	17	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP24	459534	561701	material weathered from ss, siltstone, shale.	sideslope of ridge	West of Rocket Range	38	17	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP25	457732	561274	loess and material weathered from ss, siltstone, shale.	top of ridge	Southwest of Rocket Range	38	21	Zanesville	ZaC3	2	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP26	457315	564045	material weathered from ss, siltstone, shale.	ridgetop	Southwest of Rocket Range	38	21	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP27	455888	563305	material weathered from ss, siltstone, shale.	sideslope near ridgetop	Southwest of Rocket Range	38	21	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP28	455638	559690	loess and material weathered from ss, siltstone, shale.	top of ridge	Southwest of Rocket Range	37	21	Zanesville	ZaC3	2	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP29	454888	558180	loess and material weathered from ss, siltstone, shale.	top of ridge	Southwest of Rocket Range	37	20	Zanesville	ZaC3	2	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP30	456711	553576	material weathered from ss, siltstone, shale.	sideslope	West of Rocket Range	37	20	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP31	458680	553399	loess and material weathered from ss, siltstone, shale.	sideslope of ridge	West of Rocket Range	37	20	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP32	459878	556326	material weathered from ss, siltstone, shale.	ridgetop	South of Conservation Dam	37	16	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP33	462117	554534	loess and material weathered from ss, siltstone, shale.	sideslope of ridge	West of Conservation Dam	33	16	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP34	463982	552690	loess and material weathered from ss, siltstone, shale.	top of ridge	North of JT-2	33	16	Zanesville	ZaC3	2	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP35	459180	559774	material weathered from ss, siltstone, shale.	sideslope near ridgetop	West of Rocket Range	37	17	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP36	462492	559784	material weathered from ss, siltstone, shale.	sideslope near ridgetop	Northwest of Rocket Range	34	17	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP37	464013	559420	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Rocket Range	34	17	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP38	466461	558055	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Rocket Range	33	16	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP39	468263	557951	material weathered from ss, siltstone, shale.	sideslope near ridgetop	Northwest of Rocket Range	33	16	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP40	470107	556211	material weathered from ss, siltstone, shale.	sideslope near ridgetop	South of Landfill	28	12	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam

TABLE 3-4

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Sample Tracking Number	Coordinates		Depositional Environment[1]	Topographic Location	General Location	Crane Development Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMUs	Soil Classification[1,3]	
	Northing	Easting									Surface Soil[4]	Subsurface Soil[5]
BG1SBP41	471742	553065	material weathered from ss, siltstone, shale.	sideslope	South of Landfill	28	12	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP42	472951	560503	material weathered from ss, siltstone, shale.	sideslope	West of Pyrotechnic Area	29	13	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam
BG1SBP43	469607	561138	material weathered from ss, siltstone, shale.	ridgetop	Southeast of Landfill	34	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP44	470544	562545	material weathered from ss, siltstone, shale.	ridgetop	Southwest of Pyrotechnic Area	34	13	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP45	469096	562461	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Pyrotechnic Area	29	13	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP46	465690	561680	material weathered from ss, siltstone, shale.	ridgetop	Southwest of Annex	34	17	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP47	463930	564430	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Rocket Range	34	17	Wellston	WeD3	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP48	461919	564972	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Rocket Range	34	17	Wellston	WeD3	5	silt loam	silt loam, silty clay loam, to channery loam
BG1SBP49	457659	559742	material weathered from ss, siltstone, shale.	sideslope near ridgetop	West of Rocket Range	37	21	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
BG1SBP50	473930	560482	loess and material weathered from ss, siltstone, shale.	sideslope of ridge	Northwest of Pyrotechnic Area	29	13	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam

Notes:
SS - Sandstone
NP - Not present
SWMU - Solid Waste Management Unit
1 Information taken from (McElrath, G., Jr., 1998, Soil Survey of Martin County, Indiana, Soil Conservation Service, United States Department of Aqriculture.
2 No depth specified for surface soil samples
3 United States Department of Agriculture (USDA) classification system
4 Surface soil is from 0 to 12 inches below ground surface (bgs).
5 Subsurface soil is between 12 to 70 inches bgs or to the top of bedrock.

TABLE 3-5

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 3
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Sample Tracking Number	Coordinates: Northing	Coordinates: Easting	Depositional Environment[1]	Topographic Location	General Location	Crane Development Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[4,5]	Present at # of SWMUs	Soil Classification[1,3]: Surface Soil[4]	Soil Classification[1,3]: Subsurface Soil[5]
Alluvium												
BG3SBA06	508070	599584	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	Upper Suilfur Creek: northwest intersection btwn JT-9 & H-162	12	3	Burnside	Bu	4	loam	loam to channery loam
BG3SBA07	507276	599846	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	Upper Suilfur Creek: northwest intersection btwn JT-9 & H-162	12	3	Burnside	Bu	4	loam	loam to channery loam
BG3SBA08	508563	601159	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	East of JT-9; north of iontersection btwn Jt-9 & H-162	13	3	Burnside	Bu	4	loam	loam to channery loam
BG3SBA09	506382	612515	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	Boone Hollow; West of PT-10A	14	3	Burnside	Bu	4	loam	loam to channery loam
BG3SBA10	507151	611102	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	Boone Hollow; app. 1800 feet north of storage bunker 1659	14	3	Burnside	Bu	4	loam	loam to channery loam
BG3SBA11	510301	611109	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	App. 3300 feet north of BG3SBA10	14	3	Burnside	Bu	4	loam	loam to channery loam
Residual Soil from Pennsylvanian Bedrock/Colluvium												
BG3SBP01	510720	609427	Loess and material weathered from ss, siltstone, shale	ridgetop	East of JT-10 and JT-10A intersection	6	3	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam to sandy clay loam
BG3SBP02	510170	608559	Loess and material weathered from ss, siltstone, shale	ridgetop	South of JT-10 and JT-10A intersection	6	3	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam to sandy clay loam
BG3SBP03	509770	607884	Loess and material weathered from ss, siltstone, shale	sideslope of ridgetop	Southwest of JT-10 and JT-10A intersection	13	3	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam to sandy clay loam
BG3SBP04	511420	607971	Loess and material weathered from ss, siltstone, shale	ridgetop/ sideslope	Northwest of JT-10 and JT-10A intersection	6	3	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam to sandy clay loam
BG3SBP05	511182	607152	Loess and material weathered from ss, siltstone, shale	sideslope	South of PT-9 and JT-10 intersection	6	3	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam to sandy clay loam
BG3SBP06	509820	601684	Loess and material weathered from ss, siltstone, shale	sideslope	App. 900 feet southeast of JT-9 and PT-9 intersection	13	3	Wellston-Berks-Gilpin Complex	WgG	5	silt loam to channery silt loam	silt loam,silty clay loam to channery loam
BG3SBP07	509963	601246	Loess, colluvium, and material weathered from ss, siltstone, shale	sideslope	App. 400 feet southeast of JT-9 and PT-9 intersection	13	3	Wellston-Ebal	WID	NP	silt loam	silt loam,silty clay loam to channery loam
BG3SBP08	508563	600346	Loess and material weathered from ss, siltstone, shale	sideslope	App. 1600 feet southest of JT-9 and PT-8 intersection	13	3	Wellston-Berks-Gilpin Complex	WgG	5	silt loam to channery silt loam	silt loam,silty clay loam to channery loam
BG3SBP09	509807	599315	Loess, colluvium, and material weathered from ss, siltstone, shale	sideslope	App. 1600 feet west of JT-9 and PT-8 intersection	5	3	Wellston-Ebal	WID	NP	silt loam	silt loam,silty clay loam to channery loam
BG3SBP10	511263	598840	Loess and material weathered from ss, siltstone, shale	sideslope	App. 1800 feet east of Robert's Cemetary	10	3	Wellston-Berks-Gilpin Complex	WgG	5	silt loam to channery silt loam	silt loam,silty clay loam to channery loam

Notes:
SS - Sandstone
NP - Not present
SWMU - Solid Waste Management Unit
1 Information taken from (McElrath, G., Jr., 1998, Soil Survey of Martin County, Indiana, Soil Conservation Service, United States Department of Aqriculture.
2 No depth specified for surface soil samples
3 United States Department of Agriculture (USDA) classification system
4 Surface soil is from 0 to 12 inches below ground surface (bgs).
5 Subsurface soil is between 12 to 70 inches bgs or to the top of bedrock.

NO.	DATE	REVISIONS	BY	CHKD	APPD

NO.	REFERENCES

NO.	RELEASED FOR	BY	DATE

DRAWN BY J. LAMEY DATE 2/25/00
CHECKED BY K. HENN DATE 9/5/00
COST/SCHEDULE-AREA
SCALE AS NOTED

Tetra Tech NUS, Inc.

SAMPLING LOCATION MAP
BACKGROUND AREA 1
WORK PLAN/FIELD SAMPLING PLAN ADDENDUM
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. 0087
OWNER NO. 0083
APPROVED BY K. HENN DATE 9/5/00
APPROVED BY DATE
DRAWING NO. FIGURE 3-1 REV. 0

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	NO.	RELEASED FOR	BY	DATE

DRAWN BY	DATE
J. LAMEY	2/25/00
CHECKED BY	DATE
K. HENN	9/5/00
COST/SCHEDULE-AREA	
SCALE	AS NOTED

Tetra Tech NUS, Inc.

SAMPLE LOCATION MAP
BACKGROUND AREA 3
WORK PLAN/FIELD SAMPLING PLAN ADDENDUM
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO.	OWNER NO.
0087	0083
APPROVED BY	DATE
K. HENN	9/5/00
APPROVED BY	DATE
___	___
DRAWING NO.	REV.
FIGURE 3-2	0

REFERENCES

Tetra Tech NUS, Inc., 2000a, Work Plan (including Field Sampling Plan and Health and Safety Plan), Basewide Background Soil Investigation, NSWC Crane. Final Report.

Tetra Tech NUS, Inc., 2000b, Quality Assurance Project Plan, Basewide Background Soil Investigation, NSWC Crane. Final Report.

Tetra Tech NUS, Inc., 2000c, Basewide Background Soil Investigation Report, NSWC Crane. Draft Report.

ATTACHMENT 1
COST PROJECTIONS

1.0 GENERAL APPROACH

During the original sampling event for this project, the PBS soil type was encountered in only one of the 10 borings installed in the Pennsylvanian DE (TtNUS, 2000c). The same is true of the ABC soil type in the Alluvial DE (TtNUS, 2000c). This leads to an initial probability estimate of encountering one sample per 10 borings for each of these two soil types. This can be expressed as $P(e)_{PBS} = P(e)_{ABC} = 0.10$, where $P(e)$ is the probability of encounter and the subscripts identify the respective soil types.

However, an independent estimate of $P(e)_{\mathrm{PBS}}$ is available from sampling data obtained at six NSWC Crane SWMUs, namely SWMUs 10/15, 05/03, 09/05, 06/09, 10/15, and 04/02. These data are tabulated in Attachment 2, Table A2.1. No such independent sampling data are available for the ABC soil type. From the independent PBS data, the frequency of encountering the PBS soil type in soil borings is estimated to be 23 samples per 100 borings, or $P(e)_{\mathrm{PBS}} = 0.23$. The independent data are summarized in the following table to show how this $P(e)_{\mathrm{PBS}}$ value was computed:

Statistics on the Number of Samples Exhibiting Zero and Non-Zero Percent PBS Characteristic at Previously Sampled SWMUs in the Pennsylvanian DE.

MEASURED OR CALCULATED PARAMETER	VALUE
Number of Borings with 0% PBS Characteristic:	146
Number of Borings with Non-0% PBS Characteristic	43
Total Number of Borings:	189
Fraction of Borings with Non-Zero PBS Characteristic ($P(e)$):	0.23 (= 43/189)

These probability estimates may be used to estimate the number of borings needed and, in turn, the cost incurred to acquire additional samples of the PBS and ABC soil types. It is assumed that the true probability of acquiring a PBS sample per boring lies between the two estimates of 0.23 and 0.10 as identified above. The reason for this is that most of the SWMU samples yielding a PBS soil type were clustered in just two of the SMWUs (i.e., SWMUs 04/02 and 05/03). The other four SWMUs yielded almost no PBS samples. Because it is not known which of these two probability estimates is more accurate, a value of 0.15 is assumed as an initial estimate of $P(e)_{PBS}$.

Sampling in the Pennsylvanian DE will occur first, followed by sampling in the Alluvial DE. Sampling will continue until all borings in a given boring set are installed, regardless of how many samples of each soil type have been acquired. Failure to comply with this requirement could result in an unwanted bias of sampling locations, depending on the sequence in which borings are installed. The field crew has freedom to install borings of a given boring set in any sequence.

After all samples in a given boring set have been acquired, an evaluation will be performed to determine whether sample acquisition goals have been achieved and, if not, whether continued sampling is cost effective. This maximizes the opportunity for acquiring samples of the two soil types within the allotted resources without making the sampling process overly difficult for field implementation. The method by which costs were balanced against available resources is described in the following paragraphs.

One important consideration was the ease of implementing this sampling plan. There was a desire to provide accurate cost estimates with the strongest possible technical basis, but only to the extent that implementation is not confusing for the field crew. The rationale for this is that collection of fewer than the targeted number of samples could be a costly error, especially if remobilization to collect additional samples is required.

Another consideration was how often to re-evaluate projected sampling costs. Although technically possible to re-evaluate costs after each boring is installed, it is believed that requiring such a frequent cost re-evaluation is too cumbersome. It is estimated that five borings can be installed on an average day of sampling. Therefore, an assumption was made that cost estimate re-evaluations would only be performed after complete boring sets of five borings each were installed.

A third consideration was how to randomize the sample acquisition to eliminate or minimize bias in spatial coverage of NSWC Crane but still generate a sampling plan that could be implemented easily. The decision was made to establish boring locations and to group them into sets of five borings each. The boring locations within each set of five borings were randomly selected from the available boring locations within the DE. That way, the borings of a given set may be installed in any sequence and will allow the field crews to minimize travel time among boring locations while in the field by not requiring them to install the borings in a random sequence. The only constraint is that all borings in each boring set must be installed.

This sampling campaign incurs a mobilization cost per 10-day sampling shift that includes travel to the site and transport of sampling equipment. This mobilization cost is incurred regardless of the number of days spent in sampling. The mobilization cost for this project for two samplers is $4,000. Added to the mobilization cost is a *per diem* cost of collecting samples. This cost is $1,000/day.

There is a range of conditions over which continued sampling generates a benefit that is worth its cost. On the other hand, conditions also exist where additional sampling does not generate a benefit worth the cost. It also means that a disproportionate number of soil borings would have to be installed in order to encounter the given soil type. This, in turn, means that collection of samples of the given soil type is disproportionately costly. An important question to answer is: “How much should be spent to locate the desired number of background soil samples of a given type if the probabilities of encounter are as stated above?".

It was assumed that a reasonable cost limit to acquire additional samples would be approximately 10% of the initial project budget for each of the DEs. This is computed as follows:

$$L_{PBS} = Round\left[0.10 * InitialBudget * \frac{\frac{1}{P(e)_{PBS}}}{\left(\frac{1}{P(e)_{PBS}} + \frac{1}{P(e)_{ABC}}\right)}\right]$$

$$= Round\left[0.10 * \$250{,}000 * \frac{7}{(7+10)}\right]$$

$$= \$10{,}000$$

Where L_{PBS} = the upper limit on expenditures for acquiring additional samples in the Pennsylvanian DE. The round function rounds the computed value to the nearest $1,000.

Similarly,

$$L_{ABC,initial} = Round\left[0.10 * InitialBudget * \frac{\frac{1}{P(e)_{ABC}}}{\left(\frac{1}{P(e)_{PBS}} + \frac{1}{P(e)_{ABC}}\right)}\right]$$

$$= Round\left[0.10 * \$250,000 * \frac{10}{(7+10)}\right]$$

$$= \$15,000$$

However, one more factor was considered. A much greater percentage of the facilty is covered by Pennsylvanian DE versus Alluvial DE based upon a review of Figure 2-4 in the Basewide Background Soil Investigation Report (TtNUS, 2000c). Also, several SWMUs lie in the Pennsylvanian DE, whereas the number of SWMUs and the area in the Alluvial DE is rather limited. This means that PBS soil data will be more likely needed for background comparisons than ABC data. Furthermore, the indications obtained from the initial background soil data analyses was that ABC soil may be similar to the other Alluvial subsurface soil group so that, upon further analysis, the ABC soil samples are more likely to be consolidated into that soil group than PBS samples into another soil group. Therefore, the amount of resources spent looking for PBS soil samples should be greater than for ABC samples. Based on these considerations, it was decided that striving to obtain only two ABC samples would be sufficient, whereas an effort would still be made to find at least four PBS samples. Two ABC samples would still meet the minimum project requirements of obtaining three samples of ABC soil type (one from previous sampling and two from this campaign). Limiting the ABC soil search to two samples effectively halves the dollar limit on spending, which equals $8,000 when rounded to the nearest $1,000. Thus

$$L_{ABC} = \$8,000$$

The total sampling limit for two mobilizations is then $8,000 for the mobilization costs plus $10,000 for PBS sampling and $8,000 for ABC sampling, to yield a total additional project sampling cost of $26,000. Using this cost information and the probability estimate above, $P(e)_{PBS}$ = 0.15, a cost function was generated to show the total cost of sampling to collect four samples of the PBS soil type. Excluding for the moment the mobilization cost, the total cost of sampling in the Pennsylvanian DE is the cost expended to date (for this field event only) plus the projected cost:

$$C_{PBS} = Cost\,incurred\,to\,date + Projected\,remaining\,cost$$

This can be expressed mathematically as:

$$C_{PBS} = \frac{\$1{,}000}{day}\left\{Round\left[D_{PBS} + \left(4 - n_{PBS}\right)\left(\frac{D_{PBS}}{B_{PBS}}\right)\left(\frac{7}{1}\right)\right]\right\}$$

Where:

D_{PBS} = # of days into sampling campaign

n_{PBS} = # of PBS samples acquired up to end of day #D

B_{PBS} = # of borings installed to a depth of 6 feet up to end of day #D

The first term in square brackets, D_{PBS}, yields the sampling cost to date. The other term in the square brackets determines the projected costs associated with additional samples. The number of additional samples necessary to achieve the project goal of four PBS samples is expressed by the ($4\text{-}n_{PBS}$) factor. If, for example, four PBS samples were to be acquired on the first day of sampling, this factor would be (4-4) = 0 and the *projected* sampling costs would be zero because the requisite number of PBS samples has been acquired. On the other hand, acquisition of fewer than four samples at any point in the project leaves additional samples to be acquired. Whether sampling continues depends on the projected cost of obtaining the desired samples.

The $\left(\frac{D_{PBS}}{B_{PBS}}\right)$ factor is designed to accommodate the potential for installing more, or fewer, than five borings in a single day. If more than five borings can be installed on an average sampling day, the likelihood of obtaining the requisite number of PBS samples in a given period of time increases and the sampling costs decrease. The opposite is true if fewer borings are installed on an average sampling day.

The last term, (7/1), approximates $1/P(e)_{PBS}$ =(1/0.15). This is the reciprocal of the initial estimated probability of encountering at least one PBS sample in a boring. Obtaining more than one PBS sample in any given boring is of no value because only one PBS sample may be retained from each boring. If the probability of encountering a PBS sample increases, the number of borings that must be installed to obtain the requisite number of PBS samples decreases. This initial probability estimate is relatively uncertain. However, as data are acquired, that probability estimate can be refined. This refinement is incorporated into the cost estimate to yield a self-adjusting equation:

$$C_{PBS} = \frac{\$1,000}{day}\left\{Round\left[D_{PBS} + (4 - n_{PBS})\left(\frac{D_{PBS}}{B_{PBS}}\right)\left(\frac{7 + B_{PBS}}{1 + n_{PBS}}\right)\right]\right\}$$

The computed probability of acquiring PBS samples at any time in the project, $P(e)_{PBS}$, is provided by $\left(\frac{7 + B_{PBS}}{1 + n_{PBS}}\right)$. At the beginning of the sampling campaign $B_{PBS} = n_{PBS} = 0$ and this term = 7/1. As new information is acquired this term is updated.

Note: The rounding function, *Round*, is used so that whole boring sets (five borings in a set) are computed for sampling in each DE.

A similar function was generated for the ABC soil type, but with an effort made to collect only two rather than four ABC samples:

$$C_{ABC} = \frac{\$1,000}{day}\left\{Round\left[D_{ABC} + (2 - n_{ABC})\left(\frac{D_{ABC}}{B_{ABC}}\right)\left(\frac{10 + B_{ABC}}{1 + n_{ABC}}\right)\right]\right\}$$

where:

D_{ABC} = # of days into sampling campaign

n_{ABC} = # of ABC samples acquired up to end of day #D

B_{ABC} = # of borings installed to a depth of 6' up to end of day #D

Using these two equations coupled with the $4,000 mobilization cost of sampling, a total cost equation can be generated for the entire sampling campaign:

$$C_{total} = C_{PBS} + C_{ABC} + \$4,000\left[Round\left(\frac{D_{PBS} + D_{ABC}}{10}\right)\right]$$

The last term in this equation accounts for the potential for having to mobilize more than once to complete the sample acquisition.

2.0 POTENTIAL SAMPLING OUTCOMES AND ASSOCIATED COSTS

Table A1.1 shows the various possible outcomes for all Pennsylvanian DE sampling scenarios up through sampling day 10 (assuming that five borings can be installed each day). Also shown is the cost of sampling to acquire the desired four PBS samples, C_{PBS}. Costs are computed using the last C_{PBS} equation shown above.

The right-most column of Table A1.1 indicates whether projected sampling costs are prohibitive for any combination of *D*, *B*, and *n*. If, at a given point in the sampling campaign the projected costs are prohibitive, sampling is terminated at that point with two exceptions. The first exception is that three sampling days will be expended in each DE unless the desired number of samples is acquired. This guarantees that a minimum level of effort is expended in search of the desired soil types before conceding that sampling is cost prohibitive.

The second exception deals with cases that are only borderline cost-prohibitive. If a given combination of *D*, *B*, and *n* indicates that projected sampling costs are prohibitive, but collecting one additional sample would reverse this “cost-prohibitive” status, then an extra day of sampling is scheduled. This essentially means an extra $1,000 has been committed to verifying whether it is prudent to terminate sampling at any given point in the sampling campaign. For example, if after sampling on day 4 (D=4) only one PBS sample has been acquired (after installing 20 borings), the projected total cost of acquiring four PBS samples (neglecting the $4,000 mobilization cost) is $12,100. This exceeds the $10,000 sampling limit. However, if one more boring set is installed and an additional PBS sample is acquired, the projected sampling costs to acquire all four PBS samples is $9,300. This value is less than the $10,000 limit, and suggests that it was prudent to have continued sampling. If no more PBS samples are acquired the next day (D=5), the projected sampling cost is $14,600, clearly indicating that continued sampling is much less prudent. When determining how to classify these borderline conditions in the “Cost Prohibitive?” column of Table A1.1, the following rule was used:

> Select the current *n* value, which exceeds $10,000. For the next highest boring set, select *n* + 1 and view the associated cost. If the cost exceeds $10,000, label *n* as “YES”; otherwise, label *n* as “No” in the “Cost Prohibitive?” column of Table A1.1.

Table A1.2 shows similar cost estimates for the ABC soil type. The cost values are computed using the last C_{PBS} equation of Section 1.0. Borderline cases were also evaluated similarly to PBS samples, but the $10,000 limit is replaced with $8,000.

Table A1.1. PBS Soil Sample Cost Estimates.

Sampling Day, *D*	Number of Borings, *B*	No. of Samples Acquired, *n*	Cost of Acquiring PBS Samples, C_{PBS}	Cost Prohibitive?
1	5	0	$10,600	No*
1	5	1	$4,600	No
1	5	2	$2,600	No
1	5	3	$1,600	No
1	5	4	$1,000	No
2	10	0	$15,600	No*
2	10	1	$7,100	No
2	10	2	$4,300	No
2	10	3	$2,900	No
2	10	4	$2,000	No
3	15	0	$20,600	**Yes**
3	15	1	$9,600	No
3	15	2	$5,900	No
3	15	3	$4,100	No
3	15	4	$3,000	No
4	20	0	$25,600	**Yes**
4	20	1	$12,100	No*
4	20	2	$7,600	No
4	20	3	$5,400	No
4	20	4	$4,000	No
5	25	0	$30,600	**Yes**
5	25	1	$14,600	**Yes**
5	25	2	$9,300	No
5	25	3	$6,600	No
5	25	4	$5,000	No
6	30	0	$35,600	**Yes**
6	30	1	$17,100	**Yes**
6	30	2	$10,900	No*
6	30	3	$7,900	No
6	30	4	$6,000	No
7	35	0	$40,600	**Yes**
7	35	1	$19,600	**Yes**
7	35	2	$12,600	**Yes**
7	35	3	$9,100	No
7	35	4	$7,000	No
8	40	0	$45,600	**Yes**
8	40	1	$22,100	**Yes**
8	40	2	$14,300	**Yes**
8	40	3	$10,400	No*
8	40	4	$8,000	No
9	45	0	$50,600	**Yes**
9	45	1	$24,600	**Yes**
9	45	2	$15,900	**Yes**
9	45	3	$11,600	No*
9	45	4	$9,000	No
10	50	0	$55,600	**Yes**
10	50	1	$27,100	**Yes**
10	50	2	$17,600	Yes
10	50	3	$12,900	Yes
10	50	4	$10,000	Yes

*Collection of one more boring set could render continued sampling to be cost effective, so this *n* value has been classified as "not cost prohibitive" even though it exceeds the cost limit.

Table A1.2. ABC Soil Sample Cost Estimates.

Sampling Day, *D*	**Number of Borings, *B***	**No. of Samples Acquired, *n***	***Cost of Acquiring ABC Samples, C_{ABC}***	**Cost Prohibitive?**
1	5	0	$7,000	No
1	5	1	$2,500	No
1	5	2	$1,000	No
2	10	0	$10,000	No
2	10	1	$4,000	No
2	10	2	$2,000	No
3	15	0	$13,000	No
3	15	1	$5,500	No
3	15	2	$3,000	No
4	20	0	$16,000	**Yes**
4	20	1	$7,000	No
4	20	2	$4,000	No
5	25	0	$19,000	**Yes**
5	25	1	$8,500	No
5	25	2	$5,000	No
6	30	0	$22,000	**Yes**
6	30	1	$10,000	No
6	30	2	$6,000	No
7	35	0	$25,000	**Yes**
7	35	1	$11,500	No
7	35	2	$7,000	No
8	40	0	$28,000	**Yes**
8	40	1	$13,000	No
8	40	2	$8,000	No

*Collection of one more boring set could render continued sampling to be cost effective, so this *n* value has been classified as “not cost prohibitive” even though it exceeds the cost limit.

ATTACHMENT 2

PENNSYLVANIAN RESIDUAL SUBSURFACE SOIL STATISTICS

Table A2.1. Pennsylvanian Residual Subsurface Soil Percent Sand, Silt and Clay

Boring Name	SWMU No.	% sand	% silt	% clay	total %
WES-10-23C-88	10/15	0%	0%	100%	100%
WES-10-24C-88	10/15	0%	0%	100%	100%
WES-10-25C-88	10/15	0%	0%	100%	100%
WES-10-26C-88	10/15	0%	25%	75%	100%
WES-10-27C-88	10/15	0%	0%	100%	100%
WES-10-28C-88	10/15	0%	0%	100%	100%
WES-10-29C-88	10/15	0%	0%	100%	100%
WES-10-32C-88	10/15	0%	0%	100%	100%
WES-10-30C-88	10/15	0%	0%	100%	100%
WES-10-31C-88	10/15	0%	0%	100%	100%
WES-10-33C-88	10/15	0%	0%	100%	100%
WES-10-34C-88	10/15	0%	0%	100%	100%
WES-10-35C-88	10/15	0%	0%	100%	100%
WES-10-36C-88	10/15	0%	0%	100%	100%
WES-10-37C-88	10/15	0%	0%	100%	100%
WES-10-38C-88	10/15	0%	0%	100%	100%
WES-10-39C-88	10/15	0%	0%	100%	100%
WES-10-40C-88	10/15	0%	0%	100%	100%
WES-10-41C-88	10/15	0%	0%	100%	100%
WES-10-42C-88	10/15	0%	0%	100%	100%
WES-10-43C-88	10/15	0%	0%	100%	100%
WES-10-44C-88	10/15	0%	0%	100%	100%
WES-10-45C-88	10/15	0%	0%	100%	100%
WES-10-46C-88	10/15	0%	0%	100%	100%
WES-10-47C-88	10/15	0%	0%	100%	100%
WES-10-48C-88	10/15	0%	0%	100%	100%
WES-10-49C-88	10/15	34%	0%	66%	100%
WES-10-50C-88	10/15	0%	0%	100%	100%
WES-10-51C-88	10/15	0%	0%	100%	100%
WES-10-52C-88	10/15	0%	0%	100%	100%
WES-10-53C-88	10/15	0%	0%	100%	100%
WES-10-54C-88	10/15	0%	0%	100%	100%
WES-10-55C-88	10/15	0%	0%	100%	100%
WES-10-56C-88	10/15	0%	0%	100%	100%
WES-10-57C-88	10/15	0%	0%	100%	100%
WES-10-58C-88	10/15	0%	0%	100%	100%

Boring Name	SWMU No.	% sand	% silt	% clay	total %
WES-10-59C-88	10/15	46%	0%	54%	100%
WES-10-60C-88	10/15	0%	100%	0%	100%
WES-10-61C-88	10/15	0%	0%	100%	100%
05/03-01-90	05/03	56%	44%	0%	100%
05/03-02-90	05/03	100%	0%	0%	100%
05/03-03-90	05/03	44%	0%	56%	100%
05/03-04-90	05/03	0%	94%	6%	100%
05/03-05-90	05/03	0%	0%	100%	100%
05/03-06-90	05/03	91%	0%	9%	100%
05/03-07-90	05/03	0%	0%	100%	100%
05/03-08-90	05/03	0%	0%	100%	100%
05/03-09-90	05/03	0%	0%	100%	100%
WES-WT1P-86	09/05	0%	90%	100%	100%
WES-WT2P-86	09/05	0%	0%	100%	100%
WES-WT3P-86	09/05	0%	100%	0%	100%
WES-WT4P-86	09/05	0%	48%	52%	100%
WES-WT5P-86	09/05	0%	50%	50%	100%
WES-WT6P-86	09/05	0%	0%	100%	100%
09/05-1-92	09/05	0%	88%	12%	100%
09/05-2-92	09/05	0%	100%	0%	100%
09/05-3-92	09/05	0%	100%	0%	100%
09/05-4-92	09/05	9%	91%	9%	100%
09/05-5-92	09/05	0%	100%	0%	100%
09/05-6-92	09/05	0%	100%	0%	100%
09/05-7-92	09/05	0%	100%	0%	100%
09/05-8-92	09/05	0%	40%	60%	100%
09/05-9-92	09/05	0%	0%	100%	100%
09/05-10-92	09/05	0%	0%	100%	100%
09/05-11-92	09/05	0%	0%	100%	100%
09/05-12-92	09/05	0%	100%	0%	100%
09/05-13-92	09/05	0%	100%	0%	100%
09/05-14-92	09/05	0%	75%	25%	100%
09/05-15-92	09/05	0%	85%	15%	100%
WES-6-1A-81	06/09	0%	0%	100%	100%
WES-6-1B-81	06/09	0%	0%	100%	100%
WES-6-1C-81	06/09	0%	0%	100%	100%
WES-6-2-81	06/09	0%	0%	100%	100%
WES-6-3-81	06/09	0%	0%	100%	100%
WES-6-4-81	06/09	0%	0%	100%	100%
WES-6-5-81	06/09	0%	0%	100%	100%
WES-6-6-81	06/09	0%	0%	100%	100%
WES-6-7-81	06/09	0%	0%	100%	100%

Boring Name	SWMU No.	% sand	% silt	% clay	total %
WES-6-8-81	06/09	0%	0%	100%	100%
WES-6-9-81	06/09	100%	0%	0%	100%
WES-6-10-81	06/09	0%	0%	100%	100%
WES-6-11-81	06/09	38%	0%	62%	100%
WES-6-12-81	06/09	0%	0%	100%	100%
WES-6-13-81	06/09	0%	0%	100%	100%
WES-6-14-81	06/09	0%	0%	100%	100%
WES-6-15-81	06/09	100%	0%	0%	100%
WES-6-16-81	06/09	0%	100%	0%	100%
WES-6-17-81	06/09	0%	0%	100%	100%
WES-6-18-81	06/09	100%	0%	0%	100%
WES-6-19-81	06/09	0%	0%	100%	100%
WES-6-20-81	06/09	0%	100%	0%	100%
10/15-01-90	10/15	0%	100%	0%	100%
10/15-02-90	10/15	0%	0%	100%	100%
10/15-03-90	10/15	0%	0%	100%	100%
10/15-04-90	10/15	0%	0%	100%	100%
10/15-05-90	10/15	0%	0%	100%	100%
10/15-06-90	10/15	0%	0%	100%	100%
10/15-6A-90	10/15	0%	0%	100%	100%
10/15-07-90	10/15	0%	0%	100%	100%
10/15-08-90	10/15	0%	17%	83%	100%
10/15-09-90	10/15	0%	8%	92%	100%
10/15-10-90	10/15	0%	31%	69%	100%
10/15-11-90	10/15	0%	0%	100%	100%
10/15-12-90	10/15	0%	8%	92%	100%
10/15-13-90	10/15	0%	0%	100%	100%
04/02-01-90	04/02	6%	48%	46%	100%
04/02-1A-90	04/02	25%	0%	75%	100%
04/02-02-90	04/02	100%	0%	0%	100%
04/02-03-90	04/02	36%	38%	26%	100%
04/02-04-90	04/02	100%	0%	0%	100%
04/02-05-90	04/02	94%	0%	6%	100%
04/02-06-90	04/02	99%	1%	0%	100%
04/02-07-90	04/02	87%	13%	0%	100%
04/02-08-90	04/02	85%	0%	15%	100%
04/02-09-90	04/02	98%	0%	2%	100%
04/02-10-90	04/02	100%	0%	0%	100%
WES-4-1-81	04/02	68%	32%	0%	100%
WES-4-2-81	04/02	84%	16%	0%	100%
WES-4-3-81	04/02	100%	0%	0%	100%
WES-4-4-81	04/02	56%	14%	30%	100%

Boring Name	SWMU No.	% sand	% silt	% clay	total %
WES-4-5-81	04/02	58%	0%	42%	100%
WES-4-6-81	04/02	100%	0%	0%	100%
WES-10-1-81	10/15	100%	0%	0%	100%
WES-10-2-81	10/15	100%	0%	0%	100%
WES-9-1-81	09/05	80%	0%	20%	100%
WES-9-2-81	09/05	21%	0%	79%	100%
WES-9-3-81	09/05	67%	0%	33%	100%
WES-9-4-81	09/05	100%	0%	0%	100%
WES-9-5-81	09/05	100%	0%	0%	100%
WES-9-6-81	09/05	0%	100%	0%	100%
WES-9-7-81	09/05	0%	58%	42%	100%
WES-9-8-81	09/05	0%	0%	100%	100%
WES-9-9-81	09/05	0%	0%	100%	100%
WES-9-10-83	09/05	0%	0%	100%	100%
WES-9-11-83	09/05	0%	0%	100%	100%
WES-9-12-83	09/05	0%	0%	100%	100%
WES-9-13-83	09/05	0%	0%	100%	100%
WES-9-14A-83	09/05	0%	0%	100%	100%
WES-9-14B-83	09/05	0%	0%	100%	100%
WES-10-3-83	10/15	0%	0%	100%	100%
WES-10-4-83	10/15	0%	0%	100%	100%
WES-10-5-83	10/15	0%	0%	100%	100%
WES-10-6-83	10/15	0%	0%	100%	100%
WES-10-7-83	10/15	0%	0%	100%	100%
WES-10-8-83	10/15	0%	0%	100%	100%
WES-10-9-83	10/15	0%	0%	100%	100%
WES-10-10-83	10/15	0%	0%	100%	100%
WES-10-11-83	10/15	0%	0%	100%	100%
WES-10-12-83	10/15	0%	0%	100%	100%
WES-10-13-83	10/15	0%	0%	100%	100%
WES-10-14-83	10/15	0%	0%	100%	100%
WES-10-14A-83	10/15	0%	0%	100%	100%
WES-10-14B-83	10/15	0%	0%	100%	100%
WES-10-15-83	10/15	0%	0%	100%	100%
WES-10-16-83	10/15	100%	0%	0%	100%
WES-10-17-83	10/15	100%	0%	0%	100%
WES-10-18-83	10/15	0%	0%	100%	100%
WES-10-19-83	10/15	0%	0%	100%	100%
WES-10-20-83	10/15	0%	0%	100%	100%
WES-10-21-83	10/15	0%	0%	100%	100%
WES-10-22-83	10/15	0%	0%	100%	100%
WES-6-21-83	06/09	0%	0%	100%	100%

Boring Name	SWMU No.	% sand	% silt	% clay	total %
WES-6-22-83	06/09	100%	0%	0%	100%
WES-6-23-83	06/09	0%	0%	100%	100%
EPA-1-83	06/09	0%	0%	100%	100%
EPA-2-83	06/09	0%	0%	100%	100%
EPA-3-83	06/09	0%	0%	100%	100%
EPA-4-83	06/09	0%	0%	100%	100%
EPA-5-83	06/09	10%	0%	90%	100%
WES-6-1C-89	06/09	ALL SANDSTONE/SHALE			100%
WES-6-2C-89	06/09	0%	0%	100%	100%
WES-6-3C-89	06/09	0%	0%	100%	100%
WES-6-4C-89	06/09	0%	0%	100%	100%
WES-6-5C-89	06/09	0%	0%	100%	100%
WES-6-6C-89	06/09	0%	0%	100%	100%
WES-6-7C-89	06/09	0%	0%	100%	100%
WES-6-8C-89	06/09	0%	0%	100%	100%
WES-6-9C-90	06/09	0%	0%	100%	100%
WES-6-10C-90	06/09	0%	0%	100%	100%
WES-6-11C-90	06/09	0%	0%	100%	100%
WES-6-12C-90	06/09	0%	0%	100%	100%
WES-6-13C-90	06/09	0%	0%	100%	100%
WES-6-14C-90	06/09	14%	0%	86%	100%
WES-6-15C-90	06/09	0%	0%	100%	100%
WES-6-16C-90	06/09	0%	0%	100%	100%
WES-6-17C-90	06/09	0%	0%	100%	100%
WES-6-18C-90	06/09	15%	0%	85%	100%
06C19	06/09	0%	61%	39%	100%
06C13P2	06/09	54%	0%	46%	100%
	No. of Zero%:	146	151	35	
	No. of Non-Zero%:	43	38	154	
	Total Number:	189	189	189	
	Percent Non-Zero:	23%	20%	81%	

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

SIGNATURE

Environmental Protection Department Manager
TITLE

10/30/02
DATE