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REPORT ON THE BIOREMEDIATION STUDY OF UNDERGROUND STORAGE TANK (UST) SOIL CNC CHARLESTON SC

09/01/1997

ENVIRONMENTAL DETACHMENT CHARLESTON

REPORT ON THE BIOREMEDIATION STUDY OF UST SOIL

NAVAL BASE CHARLESTON CHARLESTON SC

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
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BIOREMEDIATION STUDY

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INTRODUCTION

Southern Division Naval Facilities Engineering Command (SOUTHDIV) tasked Supervisor of Shipbuilding, Conversion and Repair, USN, Portsmouth, VA, Environmental Detachment Charleston (DET) to conduct a study of the bioremediation of petroleum contaminated soil. The soil was excavated in small lots from various underground storage tank sites located at the Charleston Naval Base. The original plan was also to study different treatment methods by having several lots of soil for each treatment method. Delays in the start of the project, however, limited the number of lots to only four.

All lots contain small amounts of heating fuel with benzo(a)anthracene, benzo(b)fluoranthene and chrysene being the long term chemicals of concern. Results to date for these lots are:

LOT	Method	Months of treatment	Status
A	tilling	1.5	complete
B	tilling and moisture control	5.5	ongoing
C	same as B	4	ongoing
D	tilling,moisture control and nutrients	3.5	ongoing

A timeline type summary for the four lots is provided as Table 1.

BACKGROUND

DET was tasked to remove a large number of petroleum tanks as part of the Charleston Naval Base remediation program. During this removal process a significant amount of soil was to be excavated. The proposed methods of disposition of the soil were based on established pass/fail levels and/or the known presence of non-petroleum contaminants, and were:

(a) less than the established levels and no known non-petroleum contaminants -- no remediation required, return to the excavation

(b) more than the established levels and no known non-petroleum contaminants -- bioremediate to less than the levels and reuse

(c) known non-petroleum contaminants exceeding an applicable limit, or if (a) or (b) is not desirable -- transfer to a contractor for disposal.

The level originally considered was Total Petroleum Hydrocarbons(TPH) of one hundred parts per million (ppm). After discussion with South Carolina

Department of Health and Environmental Control (SCDHEC), this criterion was changed to the risk based screening levels (RBSL's). These levels are outlined in the SCDHEC "Risk Based Corrective Action For Petroleum Releases" (RBCA) dated June 1995. A Corrective Action Plan, PLAN FOR EXCAVATED SOIL FROM PETROLEUM TANK SITES, (Appendix A-1) was then submitted to SCDHEC via SOUTHDIV on 28 June 1996. As a result of SCDHEC comments (dated 17 October 1996) (Appendix A-2) concerning polynuclear aromatic hydrocarbons(PAH) not included in the SCDHEC "Risk Based Corrective Action For Petroleum Releases", the levels were required to be reevaluated.

The Installation Restoration team at SOUTHDIV was contacted in an effort to establish either RBSL's or soil screening levels (SSL's) for the remaining PAH's. It was determined that SSL's for an expanded list of PAH's have already been established and were outlined in the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) documents. These values, based on the Environmental Protection Agency Region III Risk-Based Concentration Table, were proposed by letter Ser 252, dated 4 December 1996 (Appendix A-3). In a letter dated 15 January 1997(Appendix A-4), SCDHEC approved the incorporation of the proposed SSL's into the Soil Correction Action Plan (SCAP).

A revised SCAP(Appendix A-5) was then sent on 29 January 1997 via SOUTHDIV for final SCDHEC approval after which the project started in late February using the SSL's in Enclosure (1) of Appendix A-5 as the bioremediation goals. However additional SCDHEC comments, dated 2 September, 1997 required a change to this goals. The comments, Appendix A-6, required the use of Table B3 (Risk-Based Corrective Action for Proteleum Releases, SCDHEC June 20,1997) Risk-Based Screening Levels (RBSL) for those (contained therein) chemical of concern. This includes BTEX, naphthalene and the PAH's benzo(a)anthracene, benzo(b)fluoranthene benzo(k)fluoranthene, chrysene, and dibenzo(a,h)anthracene. The SSL's were applicable for the remaining PAH's. Therefore the current following levels were established as the bioremediation goal:

TABLE A - BIOREMEDIATION GOAL LEVELS

	BTEX (ppb)					NAPHTHALENE	
	benzene	ethylbenzene	toluene	xylenes		Method 8260	
	*7**	*1500**	*1700**	*44K**		*200* ppb*	
PAH (ppb)							
acenaph-thene	acenaph-thylene	anthra-cene	benzo (a) anthracene	benzo(a) pyrene	benzo(b) fluoranthene	benzo(ghi) perylene	benzo(k) fluoranthene
20k	*20k*	*430k*	*700**	*4000*	*660**	*96k*	*4600**
chrysene	dibenzo(a,h) anthracene	fluoran thene	fluorene	indeno(1,2,3,-c,d)pyrene	naphthalene	phenanthrene	pyrene
*660**	*2600**	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*
* Based on Table B3 (Risked-Based corrective Action for Petroleum Releases,SCDHEC June 20, 1997) Risk-Based Screening Levels. Other values based on the RFI SSL (See Appendix A-5).							

During the SCAP approval process, scheduling of tank removals could not be delayed to support the bioremediation project. Generally, tank site soil was returned to the excavation with additional clean fill soil added as required. Details for each site are provided in the individual site Closure Reports. By the time this project was approved and during the period thereafter, soil from only seven tank sites was available. The soil from three of the sites was required to be mixed with soil from another site to obtain a minimum lot size of ten cubic yards.

DISCUSSION

General

To minimize runoff problems, the bioremediation has been performed in Building 1601. This building is a well ventilated, fully enclosed, 80,000 square foot warehouse. A concrete floor is constructed such that portions of the foundation will serve as a sufficient berm. Soil from one or more sites was mixed to provide a more homogeneous soil matrix and a minimum size of ten cubic yards. If necessary, adjustments to soil conditions and initial testing were then performed followed by additional mixing. The lots were then placed in windrows for treatment by one of these methods:

Method A: tilling at least once per month

Method B: tilling at least once per month and maintaining moisture control (based on visual inspection or sampling)

Method C: same as method B plus the monitoring and adjustment of various soil conditions which may include nutrients content, pH, microbial population and/or others.

The four lots are shown in Figures 1 and 2.

Equipment

Appendix C provides a list of the equipment used for this project. Standard equipment was used for the measurement of pH, temperature, and oxygen. However, special oxygen collectors (See Appendix C sketch), buried in the soil, were used. Each collector was fabricated using strainers that were filled with gravel and had several feet of ¼ inch hose attached with suitable fittings. Two instruments were tried for determining moisture content. A tensiometer was found not suitable for this application. Looseness of the soil from tilling resulted in insufficient soil to ceramic tip contact to give reliable readings. A resistance meter and gypsum blocks gave better readings but required removal for each tilling. After tilling, blocks were required to be reburied in a slurry. Two to three days were then required before representative readings could be obtained. For tilling, a 66 inch commercial tiller and a 45hp tractor were used. For improved depth control, modifications were made to the tiller as described in the discussion on tilling. Other equipment used, but not listed in Appendix C, included backhoes, front-end loaders, and a tractor with a rake attachment. These were utilized during mixing and other soil movement operations.

Sampling/monitoring

Laboratory Sampling

Laboratory sampling was done for BTEX, naphthalene, PAH and TPH. A summary of results for TPH and selected PAH's is contained in Table 2. Complete results are contained in Appendix B. For all lots, initial BTEX and naphthalene levels were well below the Table A limits. As further discussed for the applicable lot, some inconsistencies appear in the subsequent results for TPH and PAH. Whether a sampling problem, analysis problem or variability of sampling is questionable.

Immunoassay Testing

Immunoassay test results for TPH tracked reasonably well with lab results for lots B and C but were consistently low when compared to Lot D lab results. The method used by the laboratory was EPA 9071A as required by SCDHEC regulations. After obtaining lab results more than 500% of Immunoassay test value, the sample was resubmitted to the laboratory for reanalysis per EPA 9071A as well as two other methods -- EPA 8015 mod (CA method) and EPA 418.1 mod. All results are as follows:

Sample date	Analysis date	Method	TPH(ppm)
7/14	7/15	Immunoassay	<200
	7/21	9071	1510
	7/31	Immunoassay	>75, <300
	8/11	CA method	260
	8/12	418.1mod	388
	8/12	9071	1140

Per discussion with the manufacturer of the immunoassay testing kits, the tests most closely correspond to the CA method. Both of these only measure hydrocarbons for a specific petroleum product (i.e., diesel/heating fuel). Other petroleum hydrocarbons may be present but not detected.

Air Monitoring

Air monitoring of similarly petroleum contaminated soil had already indicated that air emissions would not be a problem. For verification, several types of monitoring were performed during initial operations. A gas monitor showed no drop in oxygen, zero ppm carbon monoxide and hydrogen sulfide, and a zero lower explosion level (LEL) adjacent to the soil. Samples taken adjacent to the exhaust of operating equipment (dump truck, backhoe, etc.) indicated some carbon monoxide (12 ppm max). Organic vapor badge monitoring (*Advanced Chemical Sensor, Inc*) results of personnel during soil moving operations were $<5 mg/m^3$. A flame ionization detector (FID) indicated <5 ppm volatile organics for lot A, <15 ppm for lot B, and zero for lots C and D when measured directly at the soil.

Brief Summary of Lots

Lot A

Soil from two sites was mixed to form a sandy loam lot and placed in an 11'x42' windrow. The lot volume had increased approximately 20% during mixing. This held true for all lots. Sample results were satisfactory except for benzo(a)arthracene, benzo(b)fluoranthene and chrysene in one of two sample locations. After four tillings and seven weeks, sample results were satisfactory, well below the limits.

Lot B

Soil from the largest and smallest sites was combined to form this sandy clay loam lot. Initial sample results revealed excessive benzo(a)arthracene, benzo(b)fluoranthene and chrysene at three of three locations and also benzo(a)pyrene at location #2 (See Figure 2). By week 9, immunoassay testing showed a 75% reduction in TPH at location #2. Subsequent lab results showed a 60-75% reduction in the above PAH's and was below the Table A limit for benzo(a)pyrene.

The latest results show location #1 to be less than all Table A limits except for benzo(b)fluoranthene. Little progress in additional reduction has occurred at location #2 based on testing results. Location #2 latest results actually show an increase which is highly suspect. A split duplicate sample of the last #2 sample is currently being analyzed by two independent laboratories.

Lot C

After mixing soil from two sites into a sandy loam lot, FID readings were zero -- unlike those for lots A and B as noted in the air monitoring section. Based on these zero readings, a single PAH sample was taken which indicated the lot was not contaminated above any SSL. However, one of two confirmation samples showed high benzo(a)anthracene and chrysene. The lot was then placed in a 14'x47' windrow.

Nutrient addition was originally scheduled for this lot. However, due to the low (60 ppm)TPH level, nutrient addition was delayed for a later lot. After 16 weeks of tilling and moisture control, the levels were reduced below the SSL limits and treatment was secured. However based on Appendix A-6, the soil exceeded the RBSL for benzo(b)fluoranthene and chrysene.

Lot D

The clay soil for this lot was from a single site. The soil had more clay (almost 45%) than the other lots. Mixing was delayed almost two weeks due to excessive moisture. The exact contamination status was unknown due to unacceptably high detection limits for the site lab samples. After mixing, a single (from three locations) sample was analyzed for PAH with satisfactory results based on the SSL. However, confirmation sampling showed one of two locations (See Figure 2) with very high levels of benzo(a)arthracene and chrysene, as well as, benzo(a)pyrene and benzo(b)fluoranthene. A retest of the same sample showed considerably lesser levels with benzo(a)pyrene within the Table A limits. Despite the high clay content and unusual lab result the decision to continue was made.

As the last source of soil for this study, nutrients were also added to this lot. Calculations for the amount of nitrogen, phosphorus and potassium were performed using a worksheet provided in Reference 1 and are included as Appendix D.

Three weeks later another sample from the same area showed a slight increase and the return of unsatisfactory benzo(a)pyrene. Another sample five weeks later was even worse.

A significant difference in TPH test results (immunoassay verse's lab) continued for the next several weeks. As noted in the immunoassay section, this may have been an indication of other hydrocarbons which are not constituents of concern normally associated with #2 heating fuel. Additional immunoassay therefore was not performed for this lot. The latest lab results show considerable improvement in both TPH and PAH's with unacceptable levels of benzo(a)arthracene, benzo(b)fluoranthene and chrysene only. A sample at previously untested location #3 showed similar results.

Tilling

A manufacturer's representative provided onsite advice for using the tiller which resulted in several changes to the original plan. The original tilling plan was to have a windrow height of 12-14 inches and use a till, plow and retill technique. By reducing the height to 10 inches or less, a single tiller pass would suffice. The original tractor was replaced with a lower geared one so the tiller could run at optimum rotating speed without exceeding optimum forward speed. A third change involved replacement of the adjustable depth control runners. These runners were designed to run on top of hardened ground and limited the tilling depth to 7 inches. In the loose soil of this application, sometime the runner remained on top thus limiting the tilling depth to 7 inches. Other times the runner would dig into the dirt for greater but inconsistent tilling depth and had the potential for allowing the blades to contact the concrete floor. Both runners were replaced with a steel plate designed to knife through the soil. An adjustable plastic wear plate, designed to ride on the concrete, was attached to the bottom edge of the steel plates such that the blades would remain ¼ " to ½ " above the concrete.

Significant amount of debris in the soil, despite some removal during initial mixing, caused some problems during tilling. Most significant was the time required to stop the tractor, raise the tiller, inspect for damage, remove the debris and restart tilling. Some damage to the tiller did result but none required repairs.

Soil Parameters

Moisture

Water was added to all lots except Lot A. A moisture level of 40-80% of the field capacity was desired. The moisture blocks/meter gave readings representing resistance in ohms which corresponded to soil suction in bars (one bar = one atmosphere). Graphs supplied by the manufacturer provided bars to percent moisture for different general soil textures. Due to the very general nature of the graphs the feel and appearance of the soil were also considered. Water was generally added when the moisture readings were in the 70's. Readings for all lots, including Lot A, and water additions are shown in Table 3 for each lots first 100 (41 for Lot A) days.

Oxygen

The expected depletion of oxygen did not occur. In a 20.8-20.9 % environment, initial(after tilling) soil readings of 20.5-20.6 % dropped ½ % or less during the tilling cycle. Various cycle lengths from a week to a month were used. Concerned that this was an indication of the process not working, the situation was discussed with Dr. Henry Cox of *Biosystems Technology Inc.* In his opinion, the lack of a depletion in the soil oxygen would be expected due to passive oxygen transfer that would occur when the soil depth is less than one foot.

Temperature

With a minimum of 61^0F and maximum of 82^0F being observed, the temperature of all the lots remained well within the target range of 50-100^0F. The lots remained within 2 degrees of one another from day to day. A temperature buildup in the windrows did not occur. The absence of the buildup is attributed to the shallow depth of the windrows which allowed the heat to dissipate as it was generated. As shown in Table 4, all lots followed (to a lesser degree) the general warming of the average ambient temperature that occurs between March and August. Temperature readings were not taken at a certain time each day as initial soil readings were not affected by daily ambient changes. From March 3-5, soil readings taken at times ranging between 8:30 AM and 12:30 PM with the ambient ranging between 66^0F and 81^0F did not change. Also from March 10-12, readings taken at the same time with 64-78^0F ambient temperatures did not change.

Microorganisms

Method C of treatment included increasing the microbial population if less than 100,000 cells/gram. Laboratory test showed that all lots had a minimum of greater than ten times that amount. Therefore no additional organisms were added.

pH

The target range for pH was 6 to 7.5. The average pH for the lots was 8, 7, 6.5 and 8 respectively. The slightly high pH for Lots A and D was not adjusted as it was within other published acceptable ranges for satisfactory bacteria function and might serve as method of comparison.

CONCLUSIONS

Determining the most cost effective method (A-tilling, B-tilling and moisture control, or C-tilling, moisture control and the addition of nutrients and microorganism) was to be based on the results of these methods for several lots each. As noted earlier, sequencing of the removal of the UST's and the period of this project did not allow a sufficient number of lots to be formed in order to make this determination. Even with additional lots, the influence of varying soil conditions may have been too great to normalize results sufficiently to accurately compare methods under the conditions.

Except for Lot A, the duration of the cleanup period was longer than had been anticipated. The reason(s) for the slow reduction in the contamination levels for both B and C is unknown. The slow progress of Lot D is attributed to, as a minimum, the high percentage of clay.

A shallow windrow depth has both advantages and disadvantages. Excellent tilling can be accomplished using low cost (approximately $2,000 tiller) equipment. Since the tilling zone includes the total depth, a compacted zone from the tractor tires does not remain. Two normal indicators of the bioremediation process working properly, oxygen depletion and heat buildup, did not appear. The lack of depth apparently allows the soil to continuously draw in oxygen to a certain degree and generated heat to dissipate to the atmosphere.

Physical screening of the soil would have been beneficial. In addition to debris removal which would have reduced tilling time, screening would have broken up the soil prior to mixing operations. This would most probably result in more efficient mixing.

BTEX and other volatile organic compounds (VOC) does not appear to be an area of concern in bioremediation of soil with this type of contamination. For sites where contamination has occurred over a long period of time from minor leaks and spills of diesel or #2 heating fuel, virtually all remaining VOC's volatilize during digging and transport. However, as was done in this study, case by case verification would be required.

RECOMMENDATIONS

The first recommendation is to extend the treatment period an additional three months for the two lots, B and D, and restart treatment of Lot C. Such an extension would allow sufficient time for a satisfactory reduction of the contamination levels or at least a better insight as to the progress that was made. An updated report would be submitted for this extension period.

In parallel with the additional treatment of Lots B, C and D, DET recommends consultations with Naval Facilities Engineering Service Center of Port Hueneme, California. The purpose of such consultations would be to:

(a) review results of this study to determine any additional conclusions/recommendations

(b) determine a primary method of treatment based on (a) and information obtained during the extension period.

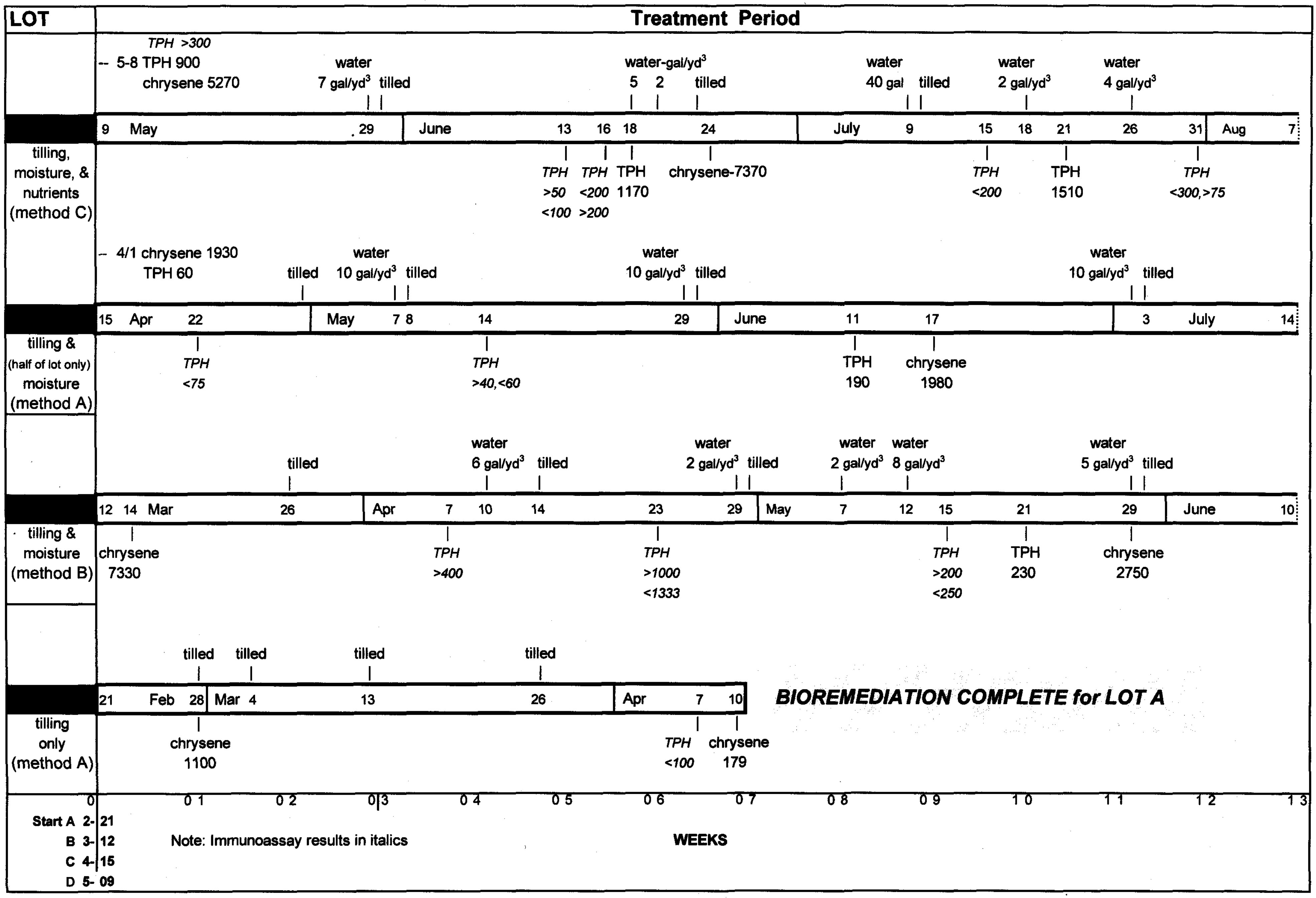
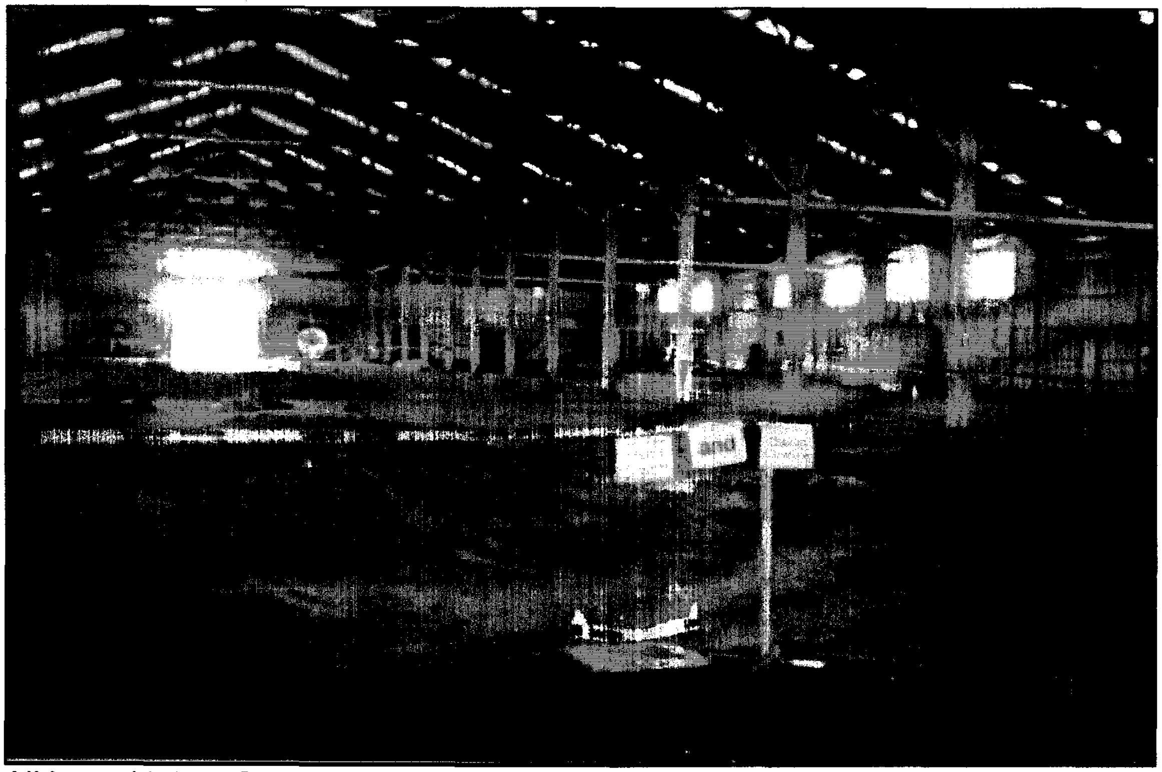


Table 1 - **Bioremediation Timeline**

LOT	Treatment Period
[redacted] tilling, moisture, & nutrients (method C)	Above the timeline: water-gal/yd^3: 3, 5, 5 and tilled; water-gal/yd^3: 5, 5; water 8 gal/yd^3; tilled Timeline: Aug 11, 21, 25 | 3, 5 Below the timeline: 11 – TPH 1140; 21 – TPH 680; 25 – chrysene 2860
[redacted] tilling & (half of lot only) moisture (method B)	Above the timeline: water 2 gal/yd^3; water 5 gal/yd^3 Timeline: 15, 18 Jul, 26, 31 | 3 Below the timeline: *TPH <50*; TPH 76; TPH 20; chrysene 778 **_BIOREMEDIATION SECURED_** (based on SSL)
[redacted] tilling & moisture (method B)	Above the timeline: water-25 gal; water 5 gal/yd^3; tilled; water 1 gal/yd^3; water 6 gal/yd^3; water-gal/yd^3: 7, 3, 2 and tilled; water 5 gal/yd^3; water 8 gal/yd^3; tilled Timeline: 12 Jun, 18, 20, 24 | 3 July, 15, 18, 26 | Aug 8, 11, 22, 25 | 3, 5 Below the timeline: *TPH <200,>100*; TPH 630; chrysene 2170; *TPH <200*; TPH 194; TPH 120; chrysene 7140?
13	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26
Start B 3- C 4- D 5-	12 Note: Immunoassay results in italics 15 **WEEKS** 09

Table 1 - **Bioremediation Timeline** (cont'd)

Lots A (background) and B in the treatment area.



All lots with lots C and D (foreground) in mixing areas in the center of the building.

Figure 1 - Lot Photographs

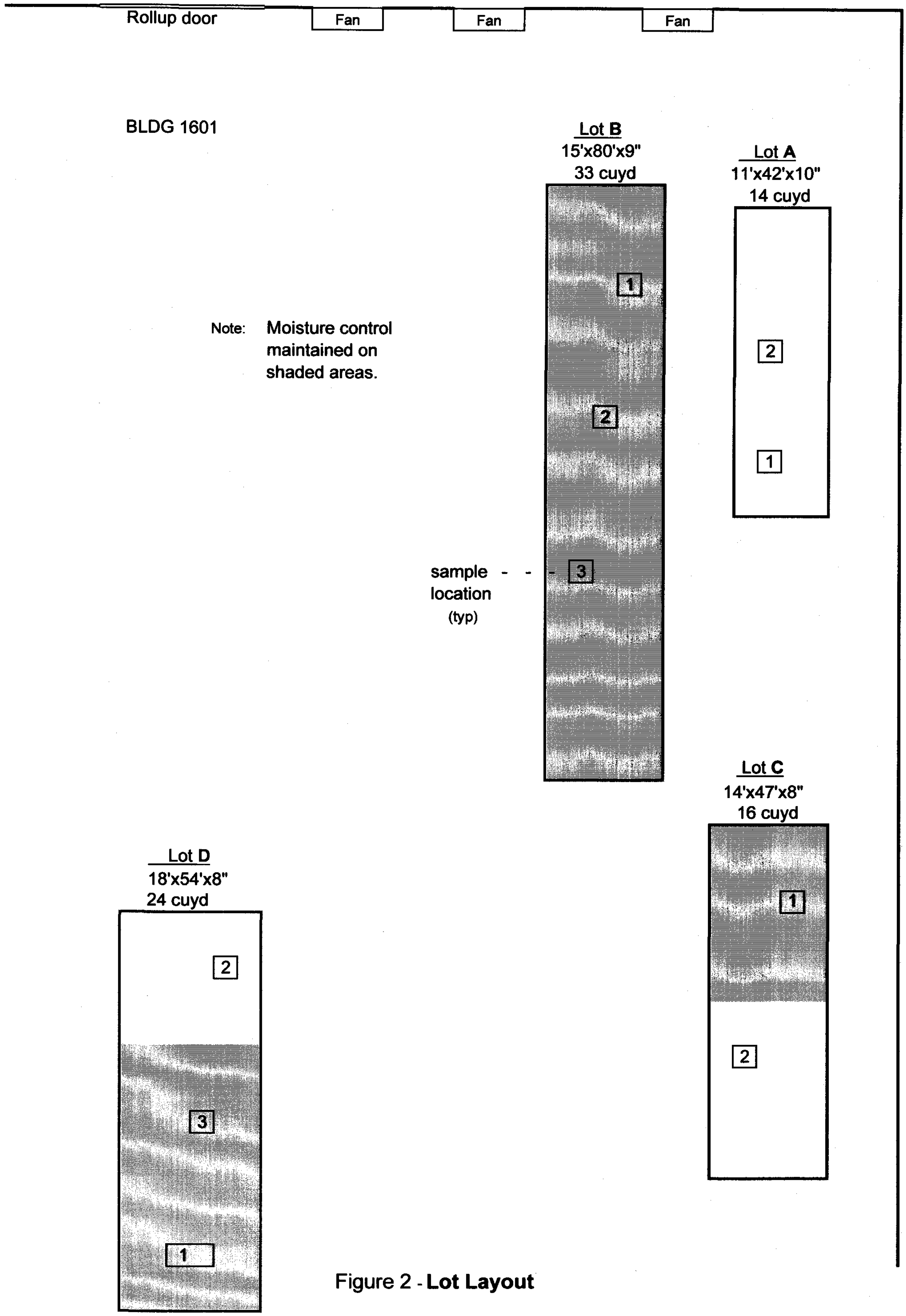


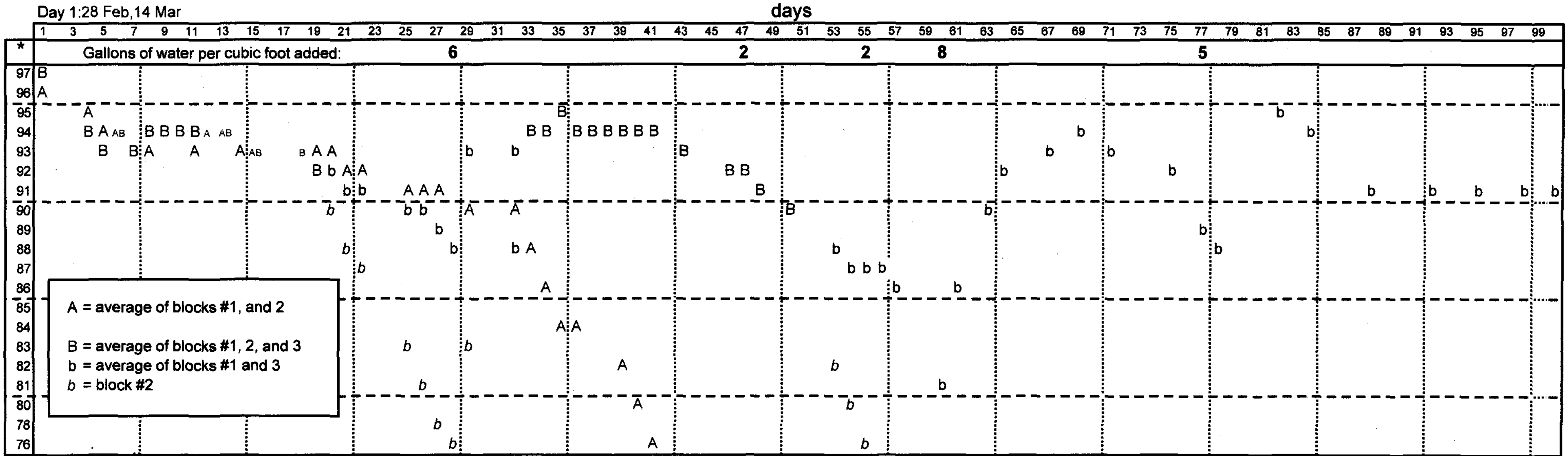
Figure 2 - **Lot Layout**

DATE	TPH immuo assay	TPH EPA 9071	PAH benzo (a) anthracene	PAH chrysene	PAH total	TPH immuo assay	TPH EPA 9071	PAH benzo (a) anthracene	PAH chrysene	PAH total	TPH immuo assay	TPH EPA 9071	PAH benzo (a) anthracene	PAH chrysene	PAH total
	SAMPLE AREA A-1					**SAMPLE AREA A-2**									
5-Mar								1110	1110	8475					
6-Mar			165	248	2364										
7-Apr						<100									
10-Apr								0(<331)*	179	1079					
	SAMPLE AREA B-1					**SAMPLE AREA B-2**					**SAMPLE AREA B-3**				
17-Mar													1030	1090	11706
18-Mar								6730	7330	67240					
21-Mar			1320	1550	16049										
7-Apr	>400														
23-Apr						<1333, >1000					<1000, >400				
15-May						<250, >200					<250, >200				
21-May							230								
28-May								1650	2750	20403					
18-Jun							*630*								
24-Jun								1630	2170	21353					
15-Jul						<200									
21-Jul							194								
22-Aug		310					120								
25-Aug			561	276	7723			*4720*	*7140*	*71130*					
	SAMPLE AREA C-1					**SAMPLE AREA C-2**									
7-Apr								318	341	2660					
8-Apr			2010	1930	27524										
11-Apr		60													
22-Apr	<75														
14-May	<60, >40														
11-Jun		190													
17-Jun			1880	1980	18358										
15-Jul	<50														
21-Jul		76													
31-Jul		20													
3-Aug			634	778	6896										
	SAMPLE AREA D-1					**SAMPLE AREA D-2**					**SAMPLE AREA D-3**				
20-Apr			25700	30200	322870			688	802	7263					
30-Apr	<300														
1-May		790													
7-May			4010	5030	47538										
12-May			5610	5270	57000										
13-May		900													
18-Jun		1170 1040													
24-Jun			5860	7320	70700										
15-Jul	<200														
21-Jul		*1510*													
31-Jul	<300, >75														
11-Aug		260**													
12-Aug		388** 1140													
21-Aug		680										450			
25-Aug			2690	2860	36515								2260	2730	31271

*detection level in ( ) for zero values ** method other than 9071 used

Table 2 - **Sample Results Summary**

LOTS A and B



LOTS C and D

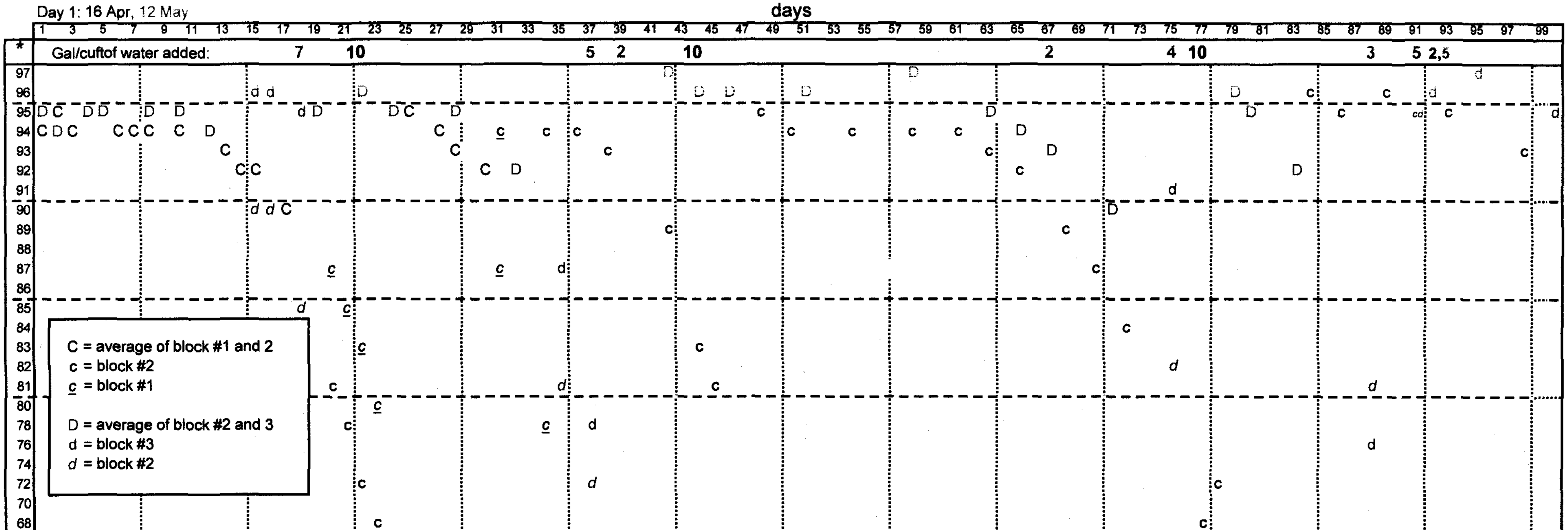


Table 3 - **MOISTURE**

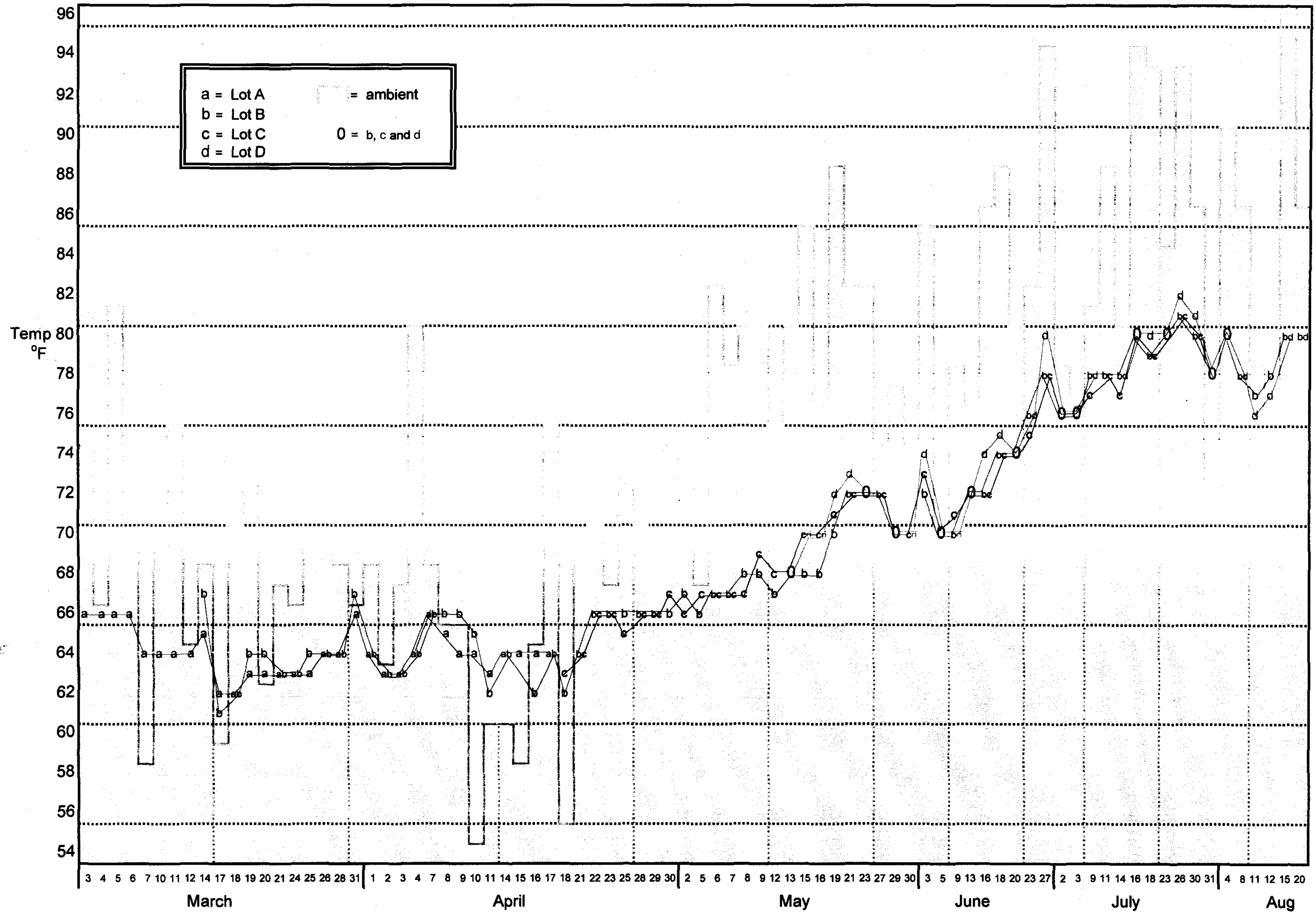


Table 4 - **TEMPERATURE**

Appendix A-1

Original Corrective Action Plan (6/96)

DEPARTMENT OF THE NAVY
SUPERVISOR OF SHIPBUILDING, CONVERSION AND REPAIR, USN
PORTSMOUTH, VIRGINIA, DETACHMENT ENVIRONMENTAL CHARLESTON
1899 NORTH HOBSON AVENUE, BUILDING 30
NORTH CHARLESTON, SOUTH CAROLINA 29408-2106

IN REPLY REFER TO:

Memo Ser: 076
28 June 1996

MEMORANDUM

From: Director, Supervisor of Shipbuilding, Conversion and Repair, USN, Portsmouth Environmental Detachment Charleston, SC (SPORTENVDETCHASN)

To: Southern Division Naval Facilities Engineering Command (Code 1849 - Gabriel Magwood)

Subj: PLAN FOR EXCAVATED SOIL FROM PETROLEUM TANK SITES.

1. Please find attached the Detachment's Underground Storage Tank (UST) excavation soil corrective action plan. Included in the plan is the bioremediation pilot project. Both the disposal plan and the bioremediation project have been updated to reflect the use of risk based screening levels (RBSLs) instead of TPH for making soil disposal and reuse decisions. Any questions or concerns with this matter should be addressed to J. T. Amey, Environmental Detachment, at 743-6777, ext 17.

Respectfully,

J. K. Tunstall
by E. R. Dearhart

Copy to:
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PLAN FOR EXCAVATED SOIL FROM PETROLEUM TANK SITES

Supervisor of Shipbuilding, Conversion and Repair, USN, Portsmouth, VA, Environmental Detachment Charleston (DET) has been tasked to remove a large number of petroleum tanks as part of the Charleston Naval Base remediation program. During this removal process a significant amount of soil will be excavated. The proposed methods of disposition of the soil are based on the the risk based screening levels (RBSLs) which are outlined in the South Carolina Department of Health and Environmental Control (DHEC) "Risk Based Corrective Action For Petroleum Releases" (RBCA) dated June 1995.
Soils from the tank excavation will be sampled for the following chemicals of concern (COCs)as listed in RBCA, Table 6: BTEX - benzene, toluene, ethylbenzene, xylenes; naphthalene; and the polynuclear aromatic hydrocarbons (PAH)- benzo(a)anthracene, benzo(b)flouranthene, benzo(k)flouranthene, chrysene, and dibenz(a,h)anthracene . Generally, the sample results will be compared to the RBCA, Table 6, RBSLs using the "< 5ft depth to ground water" column concentrations as an action level for the excavated soils. For some sites, RBSLs may also be determined, using the appropriate "Risk Based Screening Levels Look-up Tables" based on site conditions.
The following actions will be taken based on the COC concentrations in the excavated soils:

(a) All COCs below the RBSLs and no known non-petroleum contaminants -- no remediation required, soil will be returned to the excavation.

(b) Any COCs above the RBSLs and no known non-petroleum contaminants -- bioremediate to levels below the RBSLs and reuse.

(c) Known non-petroleum contaminants exceeding an applicable limit or if option (a) or (b) is not desirable -- transfer to a contractor for disposal as waste.

Soils excavated from waste oil UST sites will not be considered for bioremediation. If the COCs are below the RBSLs and all metals are below RCRA limits, the soil be returned to the excavation. If any COCs are above the RBSL, or one or more metals are above the RCRA limits, the soil will be disposed of as waste per South Carolina Code of Regulations (R.) 61-79.261.

Excavated soils which are determined to be waste will be accumulated on site in containments at Building 1601 prior to disposal. These waste soils will be segregated based on the type of contamination. Soils that are contaminated with petroleum products (BTEX, and PAHs) will be separated from soils that are contaminated with RCRA (hazardous) constituents. All waste soils will be properly disposed of at a DHEC permitted treatment or disposal facility.

For the bioremediation phase of this plan, DET proposes using a unique approach. A standard bioremediation plan requires a detailed treatment method for an excavation site based on predetermined contamination and soil conditions, as well as other site specific information. Due to the number of sites, the small quantities (as little as a few cubic feet) of soil from most sites, and the nonavailability of most site specific data until after tank removal, normal procedures for establishing a bioremediation plan would prohibit bioremediation as a feasible treatment. Therefore the following plan is submitted.

The major elements of this plan include:

PURPOSE:

Determine the feasibility of the bioremediation of petroleum contaminated soil excavated in small lots from various sites to a cleanup level of at least the RBSLs of the RBCA.

SOIL:

Only petroleum contaminated soil not known or suspected of other contamination would be treated. Soil meeting this requirement may also be rejected based on some characteristic (i.e., clay content, concentration level, etc.). Waste or used oil impregnated soil would not be treated based on the probability of other contamination being present (i.e., heavy metals). Gasoline contaminated soil may be excluded depending on the effect of the increased volatile organic compound (VOC) rate on monitoring and ventilation.

SITE:

To minimize runoff problems, the bioremediation will be done in Building 1601, a well ventilated fully enclosed 80,000 sqft warehouse. The building has a concrete floor and is constructed such that portions of the foundation will serve as a sufficient berm.

Site preparations will include:

(a) removal of deteriorated lead based paint from the ceiling and interior walls
(b) operational testing of the ventilation system
(c) inspection/repair of any obvious floor cracks
(d) installation of overhead irrigation system

Due to site construction a liner is not considered necessary and, where tilling operations are proposed, would not be practical. Any runoff/leachate will be collected using a simple vacuum process.

The existing ventilation system will produce a ground level discharge which is considered acceptable. Also, based on expected VOC levels being less than 1000 lbs/month, an air permit is not considered to be required. No other permits are considered applicable.

PROCESS:

Initial Screening - Each lot (minimum of 20 cubic yards from one or more sites) will be sampled (if not already done during excavation) to determine contamination levels and soil conditions.

Mixing/Initial Treatment - based on the above results, pH may be adjusted and other soil condition improvements made. These could include adding nutrients, water, and/or compost (manure, wood chips, or other material). The treated lot will be mixed to obtain a more homogeneous soil matrix.

Treatment - use any method below after starting a windrow/pile or increasing height, width and/or length of an existing one. Planned size of a windrow/pile: up to two foot deep with width and length to suit. A minimum of one windrow/pile for each method used will be established.

Method A: tilling at least once per month

Method B: tilling at least once per month and maintaining moisture control (based on visual inspection or sampling)

Method C: same as method B plus the monitoring and adjustment of various soil conditions which may include nutrients content, pH, microbial population and/or others.

Method D: (OPTIONAL) same as method C except air will be supplied to/extracted from the windrow without tilling. This will be accomplished using a piping system within the windrow/pile connected to an appropriately sized blower assembly.

SAMPLING/MONITORING:

Safety - The levels of volatile and semi-volatile compound concentrations are not expected to present any hazards or require any personal protection equipment (PPE). However, appropriate PPE will be used until air monitoring performed during initial operations prove otherwise.

Soil -Prior to starting the treatment period, a minimum of one composite sample will be taken of the new lot and analyzed for RBCA Table 6 COCs.
During treatment, immunoassy technology will be used to monitor for total petroleum hydrocarbons (TPH). This method of testing will be used due to the significant cost reduction of testing to provide an indication of the bioremediation progress. Optional sampling/monitoring for soil nutrient conditions, pH, oxygen/ carbon dioxide, moisture, and microbial population may be done dependent on the method and other factors. Also for method D, the extracted air may be monitored for various conditions (i.e., oxygen, carbon dioxide, etc.).
For final testing of the soil, a minimum of one composite sample will be taken from each windrow / pile. For those exceeding 10 cubic yards, an addition sample will be taken for each additional ten cubic yards. Final testing will be analyzed for RBCA Table 6 COCs by a state certified laboratory.
Soil at or less than the Table 6, "< 5ft depth to ground water" column levels will be considered acceptable for unrestricted reuse. For soil not meeting these levels additional bioremediation will the performed and the soil retested or the soil may be reused in restricted applications. The restriction would exclude reuse at Table 6, "< 5ft depth to ground water" column sites, but would allow reuse at any other sites of Table 6 or the sandy sites of Table 5 provided the bioremediated soil meets the requirements for that type soil.

DURATION:

Up to six months, during and after which the results will be evaluated to determine the best methodology, is considered necessary. Based on this evaluation a new plan for continued and/or expanded operation will be submitted.

Appendix A-2

SCDHEC Comments (10/96)

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201-1708

Promoting Health, Protecting the Environment

Mr. Gabriel L. Magwood
Southern Division NFEC
P.O. Box 190010
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

Re: Document: Proposed Soil Corrective Action Plan (SCAP)
for Contaminated Soil at the Charleston Naval Complex,
dated July 18, 1996
CNB (general)
Charleston County

Date: October 17, 1996

Dear Mr. Magwood:

The author has completed technical review of the referenced submittal. It is recognized that the intent of the document is to provide a general task statement for the handling of soils resultant from tank removals at the facility. Although the proposal to utilize Risk-Based Screening Levels (RBSL) as a Pass/Fail criteria for excavated soils disposition appears reasonable, several concerns have been identified with the proposal as submitted. In this regard, the following comments and/or recommendations are provided for your consideration:

- The requirement for investigation and remediation of known releases is covered under Title 48 (Environmental Protection and Conservation), Chapter 1 (Pollution Control Act, PCA). Further, facilities with known or suspected releases from underground storage systems (i.e. tanks) must comply with R.61-92, Part 280 (Underground Storage Tank Control Regulations) Subpart F (Release response and corrective action...). In consideration to the above, appropriate assessments of the excavation should be conducted to determine the extent and severity, if any, of potential residual contamination. The document as submitted does not provide procedures and methodologies for the assessment(s) noted above, either directly or through reference. It seems appropriate to consider the condition of the tank excavation bottom (i.e. impacted or no impacts) in determining final disposition for excavated materials.

- Consistent with the above, the document fails to provide a decision matrix for determining the extent of soils excavation required to justify closure of each tank pit under the USTCR or PCA, as appropriate.

- The proposed sampling list for chemicals of concern should incorporate all polyaromatic hydrocarbons (PAH) identified in the Drinking Water Regulations and Health Advisories, as published by the Environmental Protection Agency.

- The document fails to provide for appropriate reporting and/or documentation technically justifying a choosen course of action for each site.

- The document fails to provide for appropriate sampling/analysis and disposal of collected leachate, if any, generated during remedial endeavors.

- The facility must provide an adequate demonstration that the volatile organic compound (VOC) emmission rate will not exceed one thousand (1000) pounds per month.

Provided the facility appropriately addresses the above concerns, the proposed soil corrective action plan may be implemented. Responses should be submitted to this office on or before November 29, 1996. Please be aware that additional assessments and/or sampling may be required as information and data is developed during the course of this demonstration.

Should you have any questions, please contact me at (803) 734-5328.

Sincerely,

Paul L. Bristol, Hydrogeologist
Groundwater Assessment and Development Section
Bureau of Water

cc: Trident District EQC

Appendix A-3

DET Ltr (12/96)

DEPARTMENT OF THE NAVY
SUPERVISOR OF SHIPBUILDING, CONVERSION AND REPAIR, USN
PORTSMOUTH, VIRGINIA, DETACHMENT ENVIRONMENTAL CHARLESTON
1899 NORTH HOBSON AVENUE, BUILDING 30
NORTH CHARLESTON, SOUTH CAROLINA 29405-2106

IN REPLY REFER TO:

Ser: 252
December 4, 1996

South Carolina Department of Health
and Environmental Control
Bureau of Water, Groundwater
Assessment and Development Section
2600 Bull Street
Columbia South Carolina 29201-1708

Re: Comments on the Proposed Soil Corrective Action Plan (SCAP) for Petroleum Contaminated Soil at the Charleston Naval Complex, dated October 17, 1996.

Dear Mr. Bristol:

We have reviewed your comments on the proposed Soil Corrective Action Plan (SCAP) for petroleum contaminated soil at the Charleston Naval Complex. We have added further references and information which should answer any of your initial concerns. One area that may need clarification involves your third bullet comment which states:

> "The proposed sampling list for chemicals of concern should incorporate all polyaromatic hydrocarbons (PAH) identified in the Drinking Water Regulations and Health Advisories, as published by the Environmental Protection Agency."

As you noted, the proposed SCAP referenced only the six PAH's from the SCDHEC, Risk-Based Corrective Action for Petroleum Releases, along with their associated risk based screening levels (RBSL) from the look-up tables. In addressing the remaining PAH's, we contacted members of the Installation Restoration (IR) team at Southern Division Naval Facilities Engineering and Command (SOUTHDIV) in an effort to establish either RBSL's or soil screening levels (SSLs) for the remaining PAH's.

When we met with members of the IR team, we found that SSL's had already been established for an expanded list of PAH's. The PAH's along with their SSL's are outlined in the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) documents. The RFI tables of chemicals and SSL's are based on the Environmental Protection Agency Region III Risk-Based Concentration Table.

The RFI Groundwater Protection SSL Tables for NAVBASE Charleston, Zone H is enclosed for your consideration. Our intent is to use these SSL's as a pass/fail criteria for excavated soil. Further risk assessment and/or action will be performed for chemicals with concentrations above the SSL's.

If the use of the SSL's for PAH's from the enclosed tables meets with your approval, it will be incorporated in the SCAP. The revised SCAP will then be resubmitted for your review.

Sincerely,

Earl R. Dearhart
Director, Supervisor of Shipbuilding, Conversion and Repair,
USN, Portsmouth, Va, Environmental Detachment Charleston, SC

Encl: RFI Groundwater Protection SSL Tables for NAVBASE Charleston, Zone H

cc: Paul Bergstrand, SCDHEC, Bureau of Solid and Hazardous Waste
Johnny Tapia, SCDHEC, Bureau of Solid and Hazardous Waste
Gabriel Magwood, SOUTHDIV
Tony Hunt, SOUTHDIV

Table 5.2.1
Fate and Transport Properties and Screening Levels for
Constituents Detected in Soil and Groundwater
NAVBASE-Charleston, Zone H

Parameter	Vapor Pressure (mm Hg)	Density (g/cm3)	Solubilit (mg/L)	Henry's Law Constant (atm-m3/ mole)	Organic Carbon Water Part. Coeff. (L/kg)	Salt Water Chronic WQC ! (ug/L)	Tap Water RBC or UTL *	Water Units		Ground Water Protection SSL or UTL **	Soil Units	
Acenaphthene	1.6E-03	1.0E+00	3.5E+00	1.70E-04	1.78E+01	NDA	220	UG/L	a	20000	UG/KG	a,b
Acenaphthylene	2.9E-02	9.0E-01	3.9E+00	2.00E-04	3.97E+01	NDA	220	UG/L	c	20000	UG/KG	c
Acetone	2.7E+02	7.9E-01	1.0E+06	3.97E-05	3.70E-01	NDA	370	UG/L	a	800	UG/KG	a,b
Acetonitrile	8.8E+01	7.9E-01	NDA	2.93E-05	4.80E-01	NDA	22	UG/L	a	70	UG/KG	n
Acrylonitrile	1.0E+02	8.0E-01	7.9E+04	1.10E-04	7.40E-02	NDA	0.12	UG/L		0.04	UG/KG	n
Aldrin	6.0E-06	1.7E+00	2.7E-02	2.67E-05	4.07E+02	NDA	0.004	UG/L		5	UG/KG	
Aluminum	NA	NA	NA	NA	NA	NDA	3700	UG/L	a	46180	MG/KG	d
Ammonia	NDA	NDA	NDA	NDA	NDA	NDA	34	MG/L		NDA		
Anthracene	2.0E-04	1.3E+00	4.5E-02	6.50E-05	1.86E+04	NDA	1100	UG/L	a	430000	UG/KG	a,b
Antimony	NA	NA	NA	NA	NA	NDA	1.5	UG/L	a	NDA		
Aroclor-1248	4.9E-04	1.4E+00	5.4E-02	3.50E-03	4.37E+05	0.03	0.0087	UG/L		8200	UG/KG	
Aroclor-1254	7.7E-05	1.5E+00	5.0E-02	2.70E-03	4.31E+05	0.03	0.0087	UG/L		8200	UG/KG	
Aroclor-1260	4.1E-05	1.6E+00	8.0E-02	7.10E-03	8.22E+05	0.03	0.0087	UG/L		8200	UG/KG	
Arsenic	NA	NA	NA	NA	NA	36	27.99	UG/L	d	35.52	MG/KG	d
Azobenzene	NDA	NDA	NDA	NDA	NDA	NDA	0.61	UG/L		NDA		
beta-BHC	2.8E-07	1.9E+00	2.4E-01	2.30E-07	2.48E+03	NDA	0.037	UG/L		2	UG/KG	
alpha-BHC	2.5E-05	1.9E+00	1.6E+00	5.30E-06	1.82E+03	NDA	0.011	UG/L		0.4	UG/KG	
delta-BHC	1.7E-05	1.9E+00	3.1E-01	2.50E-07	1.50E+03	NDA	0.052	UG/L	e	6	UG/KG	e
gamma-BHC (Lindane)	6.7E-05	1.6E+00	7.5E+00	3.25E-06	1.21E+03	NDA	0.052	UG/L		6	UG/KG	
Barium	NA	NA	NA	NA	NA	NDA	323	UG/L	d	43.8	MG/KG	d
Benzene	9.5E+01	8.7E-01	1.8E+03	5.40E-03	5.00E+01	NDA	0.36	UG/L		20	UG/KG	
Benzidine	5.0E-04	1.3E+00	4.0E+02	3.88E-11	3.98E+01	NDA	0.00029	UG/L		0.0011	UG/KG	
Benzo(g,h,i)perylene	1.0E-10	NDA	2.6E-04	1.40E-07	7.76E+06	NDA	150	UG/L	f	98000	UG/KG	f
Benzo(a)pyrene Equivalents	5.6E-09	1.4E+00	3.9E-03	2.40E-06	1.77E+06	NDA	0.0092	UG/L		4000	UG/KG	
Benzoic acid	1.0E+00	1.3E+00	3.4E+03	7.02E-07	1.82E+02	NDA	15000	UG/L	a	28000	UG/KG	a,b
Beryllium	NA	NA	NA	NA	NA	NDA	0.016	UG/L		180	MG/KG	
Bromomethane	1.6E+03	1.7E+00	1.3E+04	2.00E-01	8.32E+01	NDA	0.87	UG/L	a	10	UG/KG	a,b
4-Bromophenyl-phenylether	1.5E-03	1.4E+00	NDA	1.00E-04	8.71E+04	NDA	210	UG/L	a	36600	UG/KG	
2-Butanone (MEK)	7.8E+01	8.1E-01	2.7E+05	4.66E-05	1.23E+00	NDA	190	UG/L	a	570	UG/KG	n
Butylbenzylphthalate	8.6E-06	1.1E+00	2.8E+00	1.30E-06	1.51E+02	NDA	730	UG/L	a	6800	UG/KG	a,b
Cadmium	NA	NA	NA	NA	NA	9.3	1.8	UG/L	a	6	MG/KG	h
Carbon disulfide	3.0E+02	1.3E+00	2.1E+03	1.33E-02	2.95E+02	NDA	2.1	UG/L	a	1400	UG/KG	a,b
alpha-Chlordane	1.0E-05	1.6E+00	5.6E-02	4.80E-05	4.95E+04	0.004	0.052	UG/L		2000	UG/KG	
gamma-Chlordane	1.0E-05	1.6E+00	5.6E-02	4.80E-05	4.95E+04	NDA	0.052	UG/L		2000	UG/KG	
Chlorobenzene	1.0E+01	1.1E+00	4.9E+02	3.93E-03	1.73E+02	NDA	3.9	UG/L	a	60	UG/KG	a,b
Chlorobenzilate	2.2E-06	NDA	1.3E+01	7.24E-08	1.07E+03	NDA	0.25	UG/L		0.6	UG/KG	n
Chloroethane	1.0E+03	9.0E-01	5.7E+03	1.00E-02	3.47E+00	NDA	860	UG/L	a	3300	UG/KG	a,b
bis(2-Chloroethyl)ether	1.2E+00	1.2E+00	1.0E+04	1.30E-05	1.41E+01	NDA	0.0092	UG/L		0.3	UG/KG	
Chloroform	1.6E+02	1.5E+00	8.0E+03	3.23E-03	4.60E+01	NDA	0.15	UG/L		300	UG/KG	
Chloromethane	3.8E+03	9.2E-01	7.3E+03	8.82E-03	2.51E+01	NDA	1.4	UG/L		6.6	UG/KG	
4-Chloro-3-methylphenol	5.0E-02	NDA	3.9E+03	1.78E-06	7.76E+02	NDA	NDA			NDA		
2-Chlorophenol	1.4E+00	1.3E+00	2.8E+04	8.28E-06	3.63E+02	NDA	18	UG/L	a	200	UG/KG	a,b
Chromium	NA	NA	NA	NA	NA	50	18	UG/L	a	85.65	MG/KG	d
Cobalt	NA	NA	NA	NA	NA	NDA	220	UG/L	a	14.88	MG/KG	d
Copper	NA	NA	NA	NA	NA	2.9	140	UG/L	a	31.62	MG/KG	d
Cyanide	NA	NA	NA	NA	NA	1	75	UG/L	a	NDA		
2,4-D	1.1E-02	1.4E+00	6.8E+02	1.37E-10	1.58E+00	NDA	6.1	UG/L	a	1700	UG/KG	h
2,4-DB	NDA	NDA	NDA	NDA	NDA	NDA	29	UG/L	a	1000	UG/KG	r
4,4'-DDD	1.0E-06	1.5E+00	2.0E-02	2.16E-05	4.37E+04	NDA	0.28	UG/L		700	UG/KG	
4,4'-DDE	6.5E-06		4.0E-02	2.34E-05	2.45E+05	NDA	0.2	UG/L		500	UG/KG	
4,4'-DDT	1.9E-07	1.6E+00	5.0E-03	4.89E-05	3.87E+05	0.001	0.2	UG/L		1000	UG/KG	
DCAA	NDA	NDA	NDA	NDA	NDA	NDA	NDA			NDA		
Dibenzofuran	NDA	1.1E+00	1.0E+01	NDA	1.00E+04	NDA	15	UG/L	a	12000	UG/KG	a,b
Dibromochloromethane	7.6E+01	2.5E+00	4.0E+03	9.90E-04	8.32E+01	NDA	NDA			38	UG/KG	p

Table 5.2.1
Fate and Transport Properties and Screening Levels for
Constituents Detected in Soil and Groundwater
NAVBASE-Charleston, Zone H

Parameter	Vapor Pressure (mm Hg)	Density (g/cm3)	Solubilit (mg/L)	Henry's Law Constant (atm-m3/ mole)	Organic Carbon Water Part. Coeff. (L/kg)	Salt Water Chronic WQC ! (ug/L)	Tap Water RBC or UTL *	Water Units		Ground Water Protection SSL or UTL **	Soil Units	
Di-n-butylphthalate	1.0E-05	1.0E+00	1.3E+01	6.30E-05	1.38E+03	NDA	370	UG/L	a	12000	UG/KG	a,b
1,2-Dichlorobenzene	1.0E+00	1.3E+00	1.0E+02	1.90E-03	1.82E+02	NDA	27	UG/L	a	600	UG/KG	h
1,4-Dichlorobenzene	6.0E-01	1.2E+00	7.9E+01	3.10E-03	5.11E+02	NDA	0.44	UG/L		1000	UG/KG	h
1,3-Dichlorobenzene	2.3E+00	1.3E+00	1.2E+02	3.60E-03	1.70E+02	NDA	54	UG/L	a	600	UG/KG	g
1,2-Dichloroethane	6.4E+01	1.3E+00	8.7E+03	9.80E-04	1.41E+01	NDA	0.12	UG/L		10	UG/KG	
1,1-Dichloroethane	1.8E+02	1.2E+00	5.5E+03	5.45E-03	3.40E+01	NDA	81	UG/L	a	1100	UG/KG	
1,2-Dichloroethene (total)	3.0E+02	NDA	3.5E+03	5.00E-03	2.30E-02	NDA	5.5	UG/L	a	300	UG/KG	h,i
1,1-Dichloroethene	5.9E+02	1.2E+00	2.3E+03	1.80E-02	6.50E+01	NDA	0.044	UG/L		30	UG/KG	h
2,4-Dichlorophenol	8.9E-02	1.4E+00	4.5E+03	6.66E-06	8.71E+02	NDA	11	UG/L	a	50	UG/KG	a,b
Dieldrin	1.8E-07	1.8E+00	2.0E-01	2.00E-05	1.34E+04	0.0019	0.0042	UG/L		1	UG/KG	
Diethylphthalate	2.0E-03	1.1E+00	9.0E+02	8.46E-07	6.92E+01	NDA	2900	UG/L	a	11000	UG/KG	a,b
7,12-Dimethybenz(a)anthracene	NDA	NDA	NDA	NDA	NDA	NDA	NDA			700	UG/KG	q
2,4-Dimethylphenol	9.8E-02	9.7E-01	6.2E+03	6.55E-06	1.18E+02	NDA	73	UG/L	a	300	UG/KG	a,b
2,4-Dinitrotoluene	5.1E-03	1.4E+00	2.7E+02	8.67E-07	6.17E+01	NDA	7.3	UG/L	a	20	UG/KG	a,b
Di-n-octylphthalate	1.4E-03	9.8E-01	3.0E+00	1.41E-12	9.77E+08	NDA	73	UG/L	a	1E+08	UG/KG	a,b
Dioxin (TCDD TEQ)	NDA	NDA	NDA	NDA	3.30E+06	NDA	0.5	PG/L		280	PG/G	s
Diphenylamine	NDA	NDA	NDA	NDA	NDA	NDA	91	UG/L	a	NDA		
Endosulfan I	1.0E-05	1.7E+00	5.3E-01	1.01E-04	2.04E+03	0.0087	22	UG/L	j	400	UG/KG	a,b,j
Endosulfan II	1.0E-05	1.7E+00	2.8E-01	1.91E-05	2.34E+03	0.0087	22	UG/L	j	400	UG/KG	a,b,j
Endosulfan sulfate	NDA	NDA	1.2E-01	NDA	2.34E+03	NDA	22	UG/L	j	400	UG/KG	a,b,j
Endrin	7.0E-07	1.7E+00	2.3E-01	5.00E-07	8.32E+03	0.0023	1.1	UG/L	a	400	UG/KG	h
Endrin aldehyde	2.0E-07	NDA	2.6E-01	3.86E-07	2.69E+04	NDA	1.1	UG/L	k	400	UG/KG	k
Ethylbenzene	7.1E+00	8.7E-01	1.5E+02	6.60E-03	1.87E+02	NDA	130	UG/L	a	5000	UG/KG	h
bis(2-Ethylhexyl)phthalate (BEHP	2.0E-07	9.9E-01	3.0E-01	1.10E-05	1.00E+05	NDA	4.8	UG/L	a	11000	UG/KG	a,b
Fluoranthene	5.0E-06	1.3E+00	2.4E-01	1.69E-02	4.17E+04	NDA	150	UG/L	a	98000	UG/KG	a,b
Fluorene	7.0E-03	1.2E+00	1.7E+00	2.10E-04	5.01E+03	NDA	150	UG/L	a	16000	UG/KG	a,b
Heptachlor	3.0E-04	1.7E+00	1.8E-01	2.30E-03	2.69E+04	0.0036	0.0023	UG/L		60	UG/KG	h
Heptachlor epoxide	2.6E-06	NDA	3.5E-01	3.20E-05	2.09E+04	0.0036	0.0012	UG/L		30	UG/KG	h
Hexachlorobenzene	1.1E-05	1.6E+00	6.0E-03	1.70E-03	3.89E+03	NDA	0.0066	UG/L		800	UG/KG	h
Hexachlorobutadiene	1.5E-01	1.6E+00	3.2E+00	1.03E-02	4.68E+03	NDA	0.14	UG/L		100	UG/KG	h
Hexachlorocyclopentadiene	8.1E-02	1.7E+00	1.1E+00	1.60E-02	4.27E+03	NDA	0.015	UG/L	a	10000	UG/KG	h
Hexachloroethane	2.1E-01	NDA	5.0E+01	2.80E-03	3.10E-01	NDA	0.61	UG/L	a	200	UG/KG	
Isodrin	NDA	NDA	NDA	NDA	NDA	NDA	NDA			NDA		
Kepone	3.0E-07	NDA	7.6E+00	2.50E-08	2.45E+03	NDA	0.0037	UG/L		NDA		
Lead	NA	NA	NA	NA	NA	8.5	15	UG/L	o	118	MG/KG	d
Manganese	NA	NA	NA	NA	NA	NDA	3391	UG/L	d	1412	MG/KG	d
Mercury	NA	NA	NA	NA	NA	0.025	1.1	UG/L	a	3	MG/KG	h
Methoxychlor	1.4E-06	1.4E+00	4.0E-02	1.58E-05	7.94E+04	NDA	18	UG/L	a	62000	UG/KG	h
Methyl parathion	9.6E-06	NDA	5.0E+01	1.00E-07	6.34E+01	NDA	0.91	UG/L	a	4.1	UG/KG	a,b
4-Methyl-2-Pentanone (MIBK)	1.5E+01	8.0E-01	1.7E+04	1.49E-05	6.17E+00	NDA	290	UG/L	a	910	UG/KG	n
Methylene chloride	3.5E+02	1.3E+00	2.0E+04	2.00E-03	2.30E+01	NDA	4.1	UG/L		10	UG/KG	
2-Methylnaphthalene	NDA	1.0E+00	2.5E+01	NDA	8.51E+03	NDA	150	UG/L	l	3000	UG/KG	l
2-Methylphenol	2.4E-01	1.0E+00	2.5E+04	1.23E-06	2.19E+01	NDA	180	UG/L	a	600	UG/KG	a,b
4-Methylphenol	4.0E-02	1.0E+00	2.3E+04	7.92E-07	4.90E+01	NDA	18	UG/L	a	600	UG/KG	m
Naphthalene	5.4E-02	1.1E+00	3.0E+01	4.60E-04	7.92E+02	NDA	150	UG/L	a	3000	UG/KG	a,b
Nickel	NA	NA	NA	NA	NA	8.3	73	UG/L	a	33.38	MG/KG	d
4-Nitrophenol	1.0E-04	1.5E+00	1.3E+04	3.00E-05	2.14E+02	NDA	230	UG/L	a	1670	UG/KG	n
N-Nitroso-di-n-propylamine	4.0E-01	9.2E-01	9.9E+03	6.92E-06	1.02E+01	NDA	0.0096	UG/L		0.02	UG/KG	
N-Nitrosodiphenylamine	NDA	NDA	NDA	NDA	NDA	NDA	14	UG/L		200	UG/KG	
Parathion	9.7E-06	NDA	6.5E+00	5.65E-07	6.61E+02	NDA	22	UG/L	a	390	UG/KG	a,b
Pentachlorophenol	1.1E-04	2.0E+00	2.0E+01	2.10E-06	4.09E+02	7.9	0.56	UG/L		200	UG/KG	
Phenanthrene	6.8E-04	1.2E+00	1.0E+00	3.90E-05	2.29E+04	NDA	150	UG/L	f	98000	UG/KG	f
Phenol	2.0E-01	1.1E+00	8.2E+04	2.70E-07	2.69E+01	NDA	2200	UG/L	a	4900	UG/KG	a,b
Pyrene	2.5E-06	1.3E+00	1.4E-01	1.09E-05	6.46E+04	NDA	110	UG/L	a	140000	UG/KG	a,b

Table 5.2.1
Fate and Transport Properties and Screening Levels for
Constituents Detected in Soil and Groundwater
NAVBASE-Charleston, Zone H

Parameter	Vapor Pressure (mm Hg)	Density (g/cm3)	Solubilit (mg/L)	Henry's Law Constant (atm-m3/ mole)	Organic Carbon Water Part. Coeff. (L/kg)	Salt Water Chronic WQC ! (ug/L)	Tap Water RBC or UTL *	Water Units		Ground Water Protection SSL or UTL **	Soil Units	
Selenium	NA	NA	NA	NA	NA	71	18	UG/L	a	3	MG/KG	h
Silver	NA	NA	NA	NA	NA	NDA	18	UG/L	a	NDA		
2,4,5-T	7.5E-07	1.4E+00	2.8E+02	8.68E-08	2.04E+02	NDA	37	UG/L	a	260	UG/KG	n
2,4,5-TP (Silvex)	5.2E-06	NDA	1.4E+02	1.31E-07	2.57E+03	NDA	29	UG/L	a	1580	UG/KG	n
Total Petroleum Hydrocarbons (IR	NDA	NDA	NDA	NDA	NDA	NDA	NDA			NDA		
Tetrachloroethene	1.4E+01	1.6E+00	1.5E+02	1.53E-02	2.64E+02	NDA	1.1	UG/L		40	UG/KG	
Tetrahydrofuran	1.6E+02	8.9E-01	NDA	9.63E-03	1.95E+00	NDA	NDA			NDA		
Thallium	NA	NA	NA	NA	NA	NDA	7.66	UG/L	d	1.3	MG/KG	d
Tin	NA	NA	NA	NA	NA	NDA	2200	UG/L	a	NDA		
Toluene	2.2E+01	8.7E-01	5.2E+02	6.70E-03	1.29E+02	NDA	75	UG/L	a	5000	UG/KG	h
Toxaphene	3.3E-05	1.6E+00	7.4E-01	6.30E-02	1.51E+03	0.0002	0.061	UG/L		40	UG/KG	h
1,2,4-Trichlorobenzene	4.0E-01	1.5E+00	3.0E+01	2.32E-03	1.56E+03	NDA	19	UG/L	a	2000	UG/KG	h
1,1,1-Trichloroethane	1.0E+02	1.3E+00	1.6E+03	1.62E-02	1.28E+02	NDA	130	UG/L	a	900	UG/KG	h
Trichloroethene	5.8E+01	1.5E+00	1.1E+03	9.10E-03	8.70E+01	NDA	1.6	UG/L		20	UG/KG	h
Trichlorofluoromethane	6.9E+02	1.5E+00	1.1E+03	1.10E-01	1.59E+02	NDA	130	UG/L	a	1300	UG/KG	a,b
2,4,5-Trichlorophenol	NDA	1.7E+00	NDA	NDA	NDA	NDA	370	UG/L	a	12000	UG/KG	a,b
2,4,6-Trichlorophenol	1.7E-02	1.5E+00	8.0E+02	9.07E-08	1.07E+03	NDA	6.1	UG/L		50	UG/KG	
1,2,3-Trichloropropane	3.1E+00	1.4E+00	1.8E+03	3.44E-04	7.24E+01	NDA	0.0015	UG/L		0.006	UG/KG	
Vanadium	NA	NA	NA	NA	NA	NDA	26	UG/L	a	131.6	MG/KG	d
Vinyl chloride	2.6E+03	9.1E-01	1.1E+03	1.22E+00	1.10E+01	NDA	0.019	UG/L		10	UG/KG	h
Xylene (total)	8.7E+00	8.8E-01	2.0E+02	7.10E-03	2.34E+02	NDA	1200	UG/L	a	74000	UG/KG	h
Zinc	NA	NA	NA	NA	NA	86	1100	UG/L	a	4200	MG/KG	

* - Ground water screening concentration which is the greater of:
1. Tap water risk-based concentration as presented in EPA Region III tables (1/31/95)
2. Background upper tolerance limit for shallow groundwater; NAVBASE Charleston - Zone H

** - Soil screening concentration which is the greater of:
1. Soil screening levels which governs soil to water transfer as presented in EPA Region III risk-based concentration tables (1/31/95)
2. Background upper tolerance limit for surface or subsurface soil; NAVBASE Charleston - Zone H

(Risk based screening concentrations assume a target risk of 1E-06, a target hazard index of 0.1, and a dilution attenuation factor of 10)

! - Salt Water Chronic Water Quality Criteria as provided in EPA (1993) Quality Criteria for Water
NA - Not applicable
NDA - No data available
a - based on target hazard index of 0.1
b - target soil leachate concentration based on the tap water RBC
c - acenaphtene used as a surrogate
d - background upper tolerance limit
e - gamma-BHC used as a surrogate
f - fluoranthene used as a surrogate
g - 1,2-dichlorobenzene used as a surrogate
h - target leachate soil concentration based on a MCL
i - value for trans - 1,2-dichloroethene
j - endosulfan used as a surrogate
k - endrin used as a surrogate
l- naphthalene used as a surrogate
m - 2-methylphenol used as a surrogate
n - Calculated using Soil Screening Guidance (EPA 12/94) using contaminant specific values
o - Treatment technique action level for water
p - based on the MCL for total trihalomethanes of 0.08 mg/L
q - benzo(a)anthracene used as a surrogate
r - estimated to be greater than 1000 ug/kg based on structural similarities to 2,4-D
s - Dioxin (TCDD TEQ) soil screening value based on the tap water RBC and site specific soil parameters

Table 5.3.1
Chemicals Detected in Soil
Comparison to Groundwater Protection SSL or Background UTL
NAVBASE-Charleston, Zone H, SWMUs 9,19,20,121 and AOCs 649,650,654

Parameter	Units	SWMU 19		SWMU 20		SWMU 121		AOC 649,650,651		AOC 654		Ground-Water Protection SSL	Detected in Ground-water
		Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil		
Acenaphthene	ug/kg	217	360	210	ND	130	ND	ND	ND	ND	ND	20000	I,II
Acenaphthylene	ug/kg	ND	130	ND	ND	590	ND	ND	ND	ND	ND	20000	
Acetone	ug/kg	33	47	ND	ND	193.5	ND	25.2	ND	4000	1700 *	800	I,II
Acrylonitrile	ug/kg	ND	ND	ND	ND	34.5	ND *	36.9	ND *	ND	ND	0.04	
Aluminum	mg/kg	11900	8210	ND	ND	16000	15500	10900	3280	6890	6530	46180	I,II
Anthracene	ug/kg	357	670	450	170	610	ND	250	ND	ND	130	430000	
Antimony	mg/kg	726	1.4	ND	ND	7.3	ND	1.6	ND	ND	ND	NDA	I (x)
Aroclor-1248	ug/kg	ND	ND	ND	ND	160	37	52	30	ND	ND	8200	
Aroclor-1254	ug/kg	2300	ND	ND	ND	4300	82	407	30	ND	ND	8200	
Aroclor-1260	ug/kg	560	ND	ND	ND	1100	88	ND	ND	ND	ND	8200	
Arsenic	mg/kg	22.1	8.3	ND	ND	18.7	10.7	9.5	3	7.7	18.4	35.52	I,II (x)
delta-BHC	ug/kg	ND	ND	ND	ND	ND	ND	ND	ND	1.2	ND	6	
Barium	mg/kg	128	64.1 *	ND	ND	530	89.7 *	57.9	ND *	38.7	ND	43.8	I,II (x)
Benzene	ug/kg	64	ND *	ND	ND	ND	ND	ND	ND	ND	ND	20	I,II (x)
Benzo(g,h,i)perylene	ug/kg	215	600	250	ND	780	93	1100	ND	ND	ND	98000	
Benzo(a)pyrene	ug/kg	604	1400	820	430	1700	200	2000	ND	ND	ND	4000	
Benzo(a)anthracene	ug/kg	811	1700 *	950	580 *	1900	160 *	1900	ND *	ND	ND	700	
Benzo(b)fluoranthene	ug/kg	935	1700	1400	680	2700	200	4000	ND	ND	140	4000	
Benzo(k)fluoranthene	ug/kg	712	1200	660	400	2200	230	130	ND	110	ND	4000	
Chrysene	ug/kg	755	1600 *	940	610	2000	170 *	1900	ND *	ND	140	1000	
Dibenzo(a,h)anthracene	ug/kg	ND	250	100	ND	280	ND	390	ND	ND	ND	11000	
Indeno(1,2,3-cd)pyrene	ug/kg	240	590	260	ND	750	ND	910	ND	ND	ND	35000	
Benzoic acid	ug/kg	ND	ND	ND	ND	ND	ND	269	ND	ND	ND	28000	I
Beryllium	mg/kg	3	0.61	ND	ND	14.6	2.6	1.1	0.2	0.49	0.59	180	II (x)
2-Butanone (MEK)	ug/kg	ND	ND	ND	ND	37.1	ND	ND	ND	ND	ND	570	I
Butylbenzylphthalate	ug/kg	2300	150	190	430	2600	ND	1540	ND	ND	ND	6800	II
Cadmium	mg/kg	1.8	0.64	ND	ND	2.5	ND	0.39	ND	0.97	1.5	6	I,II
Carbon disulfide	ug/kg	9.9	ND	ND	ND	ND	ND	4.8	ND	ND	11	1400	I,II (x)
alpha-Chlordane	ug/kg	9.35	ND	ND	ND	ND	ND	11.6	2	69.1	ND	2000	
gamma-Chlordane	ug/kg	4	ND	ND	ND	4	ND	6	ND	41	ND	2000	
Chlorobenzene	ug/kg	64	ND *	ND	ND	ND	ND	5.18	ND	ND	ND	60	I,II (x)
Chloroform	ug/kg	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	300	
Chromium	mg/kg	49.2	20.7	ND	ND	210	50.8 *	24.4	12.3	53.3	70.7	85.65	I,II (x)
Cobalt	mg/kg	43.3	5.5 *	ND	ND	97.2	15.9 *	9.5	1.5	3.1	4.3	14.88	I,II
Copper	mg/kg	3040	309 *	ND	ND	4060	680 *	357	24.6 *	57.1	13.1 *	31.62	I,II (x)
Cyanide	mg/kg	ND	ND	ND	ND	9.9	ND	ND	ND	2	1	NDA	
2,4-D	ug/kg	41.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	1700	
4,4'-DDD	ug/kg	6	10	ND	ND	ND	ND	8	ND	ND	ND	700	II
4,4'-DDE	ug/kg	5	12	ND	ND	20.5	ND	10.2	3	6.15	ND	500	II
4,4'-DDT	ug/kg	16	ND	ND	ND	14	ND	7	ND	10	ND	1000	I
Dibenzofuran	ug/kg	124	200	220	ND	89	ND	56.5	ND	ND	ND	12000	I,II
Diethylphthalate	ug/kg	ND	ND	ND	ND	85.2	ND	ND	ND	ND	ND	11000	I
Di-n-butylphthalate	ug/kg	1100	ND	ND	ND	ND	ND	222	ND	ND	ND	12000	I,II

Appendix A-4

SCDHEC Ltr (1/97)

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201-1708

Promoting Health, Protecting the Environment

Mr. Earl R. Dearhart
Director, Supervisor of Shipbuilding, Conversion and Repair
USN Portsmouth, Virginia, Detachment Environmental Charleston
1899 North Hobson Avenue, Building 30
North Charleston, SC 29405-2106

Re: Response to Comments, Proposed Soils Corrective Action Plan (SCAP) for Petroleum Contaminated Soils dated December 4, 1996
Charleston Naval Complex (Site Identification # 15405- General)
Charleston Naval Base, SC
Charleston County

Date: January 15, 1997

Dear Mr. Dearhart:

The author has completed technical review of the referenced document. As submitted, the information addresses previous Department concerns regarding environmental sampling for chemicals of concern at potential petroleum release sites. As such, the author is amenable to having the referenced information incorporated into the Soils Corrective Action Plan.

Should you have any questions, please contact me at (803) 734-5328.

Sincerely,

Paul L. Bristol, Hydrogeologist
Groundwater Assessment and Development Section
Bureau of Water

cc: Trident District EQC

Appendix A-5

Revised Soil Corrective Action Plan (1/97)

Memo Ser: 327
29 Jan 1997

MEMORANDUM

From: Director, Supervisor of Shipbuilding, Conversion and Repair, USN, Portsmouth Environmental Detachment Charleston, SC (SPORTENVDETCHASN)

To: Southern Division Naval Facilities Engineering Command (Code 1849 - Gabriel Magwood)

Subj: REVISED PLAN FOR EXCAVATED SOIL FROM PETROLEUM TANK SITES.

1. Please find attached the Detachment's revised Underground Storage Tank (UST) excavation Soil Corrective Action Plan. This plan has been updated to incorporate comments of South Carolina Department of Health and Environmental Control (DHEC) letter dated October 17, 1996. For information, the Detachment's specific response to each DHEC comment is also attached. Included in the update is the replacement of the risk based screening levels with Soil Screening Levels as proposed by our letter Ser: 252 dated December 4, 1996 and accepted by SCDHEC letter dated January 15, 1997. Any questions or concerns with this matter should be addressed to J. T. Amey, Environmental Detachment, at 743-6777, ext 217.

Respectfully,

E. R. Dearhart

Copy to:
File

Response to DHEC Comments (dtd 10/17) on Bioremediation

comment #1

. . In consideration of the above (Environmental Regs)*, appropriate assessments of the excavation should be conducted to determine the extent and severity, if any, of potential residual contamination. The document as submitted does not provide procedures and methodologies for the assessment(s) noted above, either directly or through reference. It seems appropriate to consider the condition of the tank excavation bottom (i.e., impacted or no impacts) in determining the final disposition for excavated materials.*

All UST removals will be performed in accordance with South Carolina Department of Health and Environmental Control (DHEC) regulation R.61-92, Part 280 (Underground Storage Tank Control Regulations). The method for tank removal and assessment reporting will be as outlined in SC DHEC's "Underground Storage Tank Assessment Guidelines for Permanent Closure, Change-In-Owner and Change-In-Service," dated June, 1995.

comment #2

Consistent with the above (the first point)*, the document fails to provide a decision matrix for determining the extent of soils excavation required to justify closure of each tank pit under the USTCR or PCA, as appropriate.*

Currently, the only soil removed from each UST site is the amount needed to remove the tank. With the initiation of the soil corrective action plan , UST excavations will be evaluated for further removal of petroleum contaminated soil. Where no structural or physical obstacles limit the size of the excavation, the pit will be examined for evidence of petroleum releases based on sight, smell, or condition of the tank. Field sampling using an Organic Vapor Analyzer (OVA) for headspace analysis will determine if further soil needs to be removed from the excavation. OVA readings of greater than 250 parts per million will result in further excavation of the contaminated soil. Where feasible, the pit will be left open until laboratory analysis are obtained.

comment #3

The proposed sampling list for chemicals of concern should incorporate all polyaromatic hydrocarbons (PAH) identified in the Drinking Water Regulations and Health Advisories, as published by the Environmental Protection Agency.

An expanded list of PAH's and other chemicals of concerns have already had Soil Screening Levels (SSL's) established for the Charleston Naval Complex as described in our letter ser: 252 of 12/4/96. The referenced SSL information will be incorporated into the SCAP as addressed in your responce dated 15 Jan.

comment #4

The document fails to provide for appropriate reporting and/or documentation technically justifying a chosen course of action for each site.

The method for tank removal and assessment reporting will be as outlined in SC DHEC's "Underground Storage Tank Assessment Guidelines for Permanent Closure, Change-In-Owner and Change-In-Service," dated June, 1995.

comment #5

The document fails to provide for appropriate sampling/analysis and disposal of collected leachate, if any, generated during remedial endeavors.

Any collected leachate will be immediately returned to the soil being treated, based on moisture level, or temporarily stored and then returned. No sampling/analysis is considered necessary. In the event the stored leachate becomes excessive, sampling for compliance with National Pollutant Discharge Elimination System(NPDES) requirements will be performed. If the sample is in compliance, the leachate will be discharged to the North Charleston Publicly Owned Treatment Works. Otherwise, the leachate will be evaluated for alternate disposition.

comment #6

The facility must provide an adequate demonstration that the volatile organic compound (VOC) emission rate will not exceed one thousand (1000) pounds per month.

An estimate of the expected VOC emission rate will be added to the SCAP as an attachment and is considered an adequate demonstration that the rate will not exceed one thousand pounds per month.

SOIL CORRECTIVE ACTION PLAN FOR EXCAVATED SOIL FROM UNDERGROUND STORAGE TANKS (BIOREMEDIATION STUDY) NAVAL BASE CHARLESTON CHARLESTON SC

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON SC

Prepared by:

SUPERVISOR OF SHIPBUILDING, CONVERSION
AND REPAIR, USN, PORTSMOUTH
ENVIRONMENTAL DETACHMENT CHARLESTON
1899 NORTH HOBSON AVE.
NORTH CHARLESTON SC 29405-2106

January 28, 1997

PLAN FOR EXCAVATED SOIL FROM PETROLEUM TANK SITES

Enclosure (1) Soil Screening Levels Tables
Enclosure (2) Volatile Organic Compounds Estimates

Supervisor of Shipbuilding, Conversion and Repair, USN, Portsmouth, VA, Environmental Detachment Charleston (DET) has been tasked to remove a large number of petroleum tanks as part of the Charleston Naval Base remediation program. All UST removals will be performed in accordance with South Carolina Department of Health and Environmental Control (DHEC) regulation R.61-92, Part 280 (Underground Storage Tank Control Regulations). The method for tank removal and assessment reporting will be as outlined in SC DHEC's "Underground Storage Tank Assessment Guidelines for Permanent Closure, Change-In-Owner and Change-In-Service," dated June, 1995.

Currently, the only soil removed from each UST site is the amount needed to remove the tank. With the initiation of the soil corrective action plan , UST excavations will be evaluated for further removal of petroleum contaminated soil. Where no structural or physical obstacles limit the size of the excavation, the pit will be examined for evidence of petroleum releases based on sight, smell, or condition of the tank. Field sampling using an Organic Vapor Analyzer (OVA) for headspace analysis will determine if further soil needs to be removed from the excavation. OVA readings of greater than 250 parts per million will result in further excavation of the contaminated soil. Where feasible, the pit will be left open until laboratory analysis are obtained.

During the tank removal process, a significant amount of soil will be excavated. The proposed methods of disposition of the soil are based on Soil Screening Levels (SSL) previously established by Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) documents for the Charleston Naval Complex. The RFI tables of chemicals and SSL are based on the Environmental Protection Agency Region III Risked-Based Concentration Table dated March 1995. Soils from the tank excavation will be sampled for the following chemicals of concern (COC):

benzene, toluene, ethylbenzene, xylenes, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3,-c,d)pyrene, naphthalene, phenanthrene, and pyrene.

The sample results will be compared to SSL in Tables 5.2.1/5.3.1 of the RFI document for NAVBASE-Charleston, Zone H,(Enclosure 1).

The following actions will be taken based on the COC concentrations in the excavated soils:

(a) All COC below the SSL and no known non-petroleum contaminants – no remediation required, soil will be returned to the excavation.

(b) Any COC above the SSL and no known non-petroleum contaminants – bioremediate to levels below the SSL and reuse.

(c) Known non-petroleum contaminants exceeding an applicable limit or if option (a) or (b) is not desirable – transfer to a contractor for disposal as waste.

Soils excavated from waste oil UST sites will not be initially considered for bioremediation. If the COC are below the SSL and all metals are below RCRA limits, the soil be returned to the excavation. If any COC are above the SSL, or one or more metals are above the RCRA limits, the soil will be disposed of as waste per South Carolina Code of Regulations (R.) 61-79.261.

Excavated soils which are determined to be waste will be accumulated on site in containments at Building 1601 prior to disposal. These waste soils will be segregated based on the type of contamination. Soils that are contaminated with petroleum products (BTEX, and PAH) will be separated from soils that are contaminated with other RCRA constituents. All waste soils will be properly disposed of at a DHEC permitted treatment or disposal facility.

For the bioremediation phase of this plan, DET proposes using a unique approach. A standard bioremediation plan requires a detailed treatment method for an excavation site based on predetermined contamination and soil conditions, as well as other site specific information. Due to the number of sites, the small quantities (as little as a few cubic feet) of soil from most sites, and the nonavailability of most site specific data until after tank removal, normal procedures for establishing a bioremediation plan would prohibit bioremediation as a feasible treatment. Therefore the following plan is submitted.

The major elements of this plan include:

PURPOSE:

Determine the feasibility of the bioremediation of petroleum contaminated soil excavated in small lots from various sites to a cleanup level of at least the SSL identified in Enclosure (1).

SOIL:

Only petroleum contaminated soil not known or suspected of other contamination would be treated. Soil meeting this requirement may also be rejected based on some characteristic (i.e., clay content, concentration level, etc.). Waste or used oil impregnated soil would not be treated based on the probability of other contamination being present (i.e., heavy metals). Gasoline contaminated soil may be excluded depending on the effect of the increased volatile organic compound (VOC) rate on monitoring and ventilation.

SITE:

To minimize runoff problems, the bioremediation will be done in Building 1601, a well ventilated fully enclosed 80,000 sq ft warehouse. The building has a concrete floor and is constructed such that portions of the foundation will serve as a sufficient berm.

Site preparations will include:

(a) removal of deteriorated lead based paint from the ceiling and interior walls
(b) operational testing of the ventilation system
(c) inspection/repair of any obvious floor cracks
(d) installation of overhead irrigation system

Due to site construction a liner is not considered necessary and, where tilling operations are proposed, would not be practical. Any runoff/leachate will be collected using a simple vacuum process. Any collected leachate will be immediately returned to the soil being treated based on moisture level or temporarily stored and then returned. No sampling/analysis is considered necessary. In the event the stored leachate becomes excessive, sampling for compliance with National Pollutant Discharge Elimination System(NPDES) requirements will be performed. If the sample is in compliance, the leachate will be discharged to the North Charleston Publicly Owned Treatment Works. Otherwise, the leachate will be evaluated for alternate disposition.

The existing ventilation system will produce a ground level discharge which is considered acceptable. Also, based on expected VOC levels, Enclosure (2), being considerably less than 1000 lbs/month, an air permit is not considered to be required. No other permits are considered applicable.

PROCESS:

Initial Screening - Each lot (minimum of 10 cubic yards from one or more sites) will be sampled (if not already done during excavation) to determine contamination levels and soil conditions.

Mixing/Initial Treatment - based on the above results, pH may be adjusted and other soil condition improvements made. These could include adding nutrients, water, and/or compost (manure, wood chips, or other material). The treated lot will be mixed to obtain a more homogeneous soil matrix and then placed as a windrow/pile. Planned size of a windrow/pile: up to two foot deep with width and length to suit.

Treatment - use any method below after establishing the windrow/pile. A minimum of one windrow/pile for each method used will be established.

Method A: tilling at least once per month

Method B: tilling at least once per month and maintaining moisture control (based on visual inspection or sampling)

Method C: same as method B plus the monitoring and adjustment of various soil conditions which may include nutrients content, pH, microbial population and/or others.

Method D: (OPTIONAL) same as method C except air will be supplied to/extracted from the windrow without tilling. This will be accomplished using a piping system within the windrow/pile connected to an appropriately sized blower assembly.

SAMPLING/MONITORING:

Safety - The levels of volatile and semi-volatile compound concentrations are not expected to present any hazards or require any personal protection equipment (PPE). However, PPE will be used until air monitoring performed during initial operations prove otherwise.

Soil -Prior to starting the treatment period, a minimum of one composite sample will be taken of the new lot and analyzed for the COC.
During treatment, immunoassy technology will be used to monitor for total petroleum hydrocarbons (TPH) and/or PAH. This method of testing will be used due to the significant cost reduction of testing to provide an indication of the bioremediation progress. Optional sampling/monitoring for soil nutrient conditions, pH, oxygen/ carbon dioxide, moisture, and microbial population may be done dependent on the method and other factors. Also for method D, the extracted air may be monitored for various conditions (i.e., oxygen, carbon dioxide, etc.).

For final testing of the soil in each windrow/pile, a minimum of one composite sample per 10 cubic yards will be taken. Final testing will be analyzed for the COC by a state certified laboratory.
Soil at or less than the SSL will be considered acceptable for unrestricted reuse. For soil not meeting these levels, additional bioremediation will the performed and the soil retested or the soil may be transferred to a contractor for disposal as waste.

DURATION:

The duration for this project is for up to six months, during and after which the results will be evaluated to determine the best methodology. Based on this evaluation a new plan for continued and/or expanded operation will be submitted.

Table 5.2.1
Fate and Transport Properties and Screening Levels for
Constituents Detected in Soil and Groundwater
NAVBASE-Charleston, Zone H

Parameter	Vapor Pressure (mm Hg)	Density (g/cm3)	Solubilit (mg/L)	Henry's Law Constant (atm-m3/ mole)	Organic Carbon Water Part. Coeff. (L/kg)	Salt Water Chronic WQC ! (ug/L)	Tap Water RBC or UTL *	Water Units		Ground Water Protection SSL or UTL **	Soil Units	
Acenaphthene	1.6E-03	1.0E+00	3.5E+00	1.70E-04	1.78E+01	NDA	220	UG/L	a	20000	UG/KG	a,b
Acenaphthylene	2.9E-02	9.0E-01	3.9E+00	2.00E-04	3.97E+01	NDA	220	UG/L	c	20000	UG/KG	c
Acetone	2.7E+02	7.9E-01	1.0E+06	3.97E-05	3.70E-01	NDA	370	UG/L	a	800	UG/KG	a,b
Acetonitrile	8.8E+01	7.9E-01	NDA	2.93E-05	4.80E-01	NDA	22	UG/L	a	70	UG/KG	n
Acrylonitrile	1.0E+02	8.0E-01	7.9E+04	1.10E-04	7.40E-02	NDA	0.12	UG/L		0.04	UG/KG	n
Aldrin	6.0E-06	1.7E+00	2.7E-02	2.67E-05	4.07E+02	NDA	0.004	UG/L		5	UG/KG	
Aluminum	NA	NA	NA	NA	NA	NDA	3700	UG/L	a	46180	MG/KG	d
Ammonia	NDA	NDA	NDA	NDA	NDA	NDA	34	MG/L		NDA		
Anthracene	2.0E-04	1.3E+00	4.5E-02	6.50E-05	1.86E+04	NDA	1100	UG/L	a	430000	UG/KG	a,b
Antimony	NA	NA	NA	NA	NA	NDA	1.5	UG/L	a	NDA		
Aroclor-1248	4.9E-04	1.4E+00	5.4E-02	3.50E-03	4.37E+05	0.03	0.0087	UG/L		8200	UG/KG	
Aroclor-1254	7.7E-05	1.5E+00	5.0E-02	2.70E-03	4.31E+05	0.03	0.0087	UG/L		8200	UG/KG	
Aroclor-1260	4.1E-05	1.6E+00	8.0E-02	7.10E-03	8.22E+05	0.03	0.0087	UG/L		8200	UG/KG	
Arsenic	NA	NA	NA	NA	NA	36	27.99	UG/L	d	35.52	MG/KG	d
Azobenzene	NDA	NDA	NDA	NDA	NDA	NDA	0.61	UG/L		NDA		
beta-BHC	2.8E-07	1.9E+00	2.4E-01	2.30E-07	2.48E+03	NDA	0.037	UG/L		2	UG/KG	
alpha-BHC	2.5E-05	1.9E+00	1.6E+00	5.30E-06	1.82E+03	NDA	0.011	UG/L		0.4	UG/KG	
delta-BHC	1.7E-05	1.9E+00	3.1E-01	2.50E-07	1.50E+03	NDA	0.052	UG/L	e	6	UG/KG	e
gamma-BHC (Lindane)	6.7E-05	1.6E+00	7.5E+00	3.25E-06	1.21E+03	NDA	0.052	UG/L		6	UG/KG	
Barium	NA	NA	NA	NA	NA	NDA	323	UG/L	d	43.8	MG/KG	d
Benzene	9.5E+01	8.7E-01	1.8E+03	5.40E-03	5.00E+01	NDA	0.36	UG/L		20	UG/KG	
Benzidine	5.0E-04	1.3E+00	4.0E+02	3.88E-11	3.98E+01	NDA	0.00029	UG/L		0.0011	UG/KG	
Benzo(g,h,i)perylene	1.0E-10	NDA	2.6E-04	1.40E-07	7.76E+06	NDA	150	UG/L	f	98000	UG/KG	f
Benzo(a)pyrene Equivalents *	5.6E-09	1.4E+00	3.9E-03	2.40E-06	1.77E+06	NDA	0.0092	UG/L		4000	UG/KG	
Benzoic acid	1.0E+00	1.3E+00	3.4E+03	7.02E-07	1.82E+02	NDA	15000	UG/L	a	28000	UG/KG	a,b
Beryllium	NA	NA	NA	NA	NA	NDA	0.016	UG/L		180	MG/KG	
Bromomethane	1.6E+03	1.7E+00	1.3E+04	2.00E-01	8.32E+01	NDA	0.87	UG/L	a	10	UG/KG	a,b
4-Bromophenyl-phenylether	1.5E-03	1.4E+00	NDA	1.00E-04	8.71E+04	NDA	210	UG/L	a	36600	UG/KG	
2-Butanone (MEK)	7.8E+01	8.1E-01	2.7E+05	4.66E-05	1.23E+00	NDA	190	UG/L	a	570	UG/KG	n
Butylbenzylphthalate	8.6E-06	1.1E+00	2.8E+00	1.30E-06	1.51E+02	NDA	730	UG/L	a	6800	UG/KG	a,b
Cadmium	NA	NA	NA	NA	NA	9.3	1.8	UG/L	a	6	MG/KG	h
Carbon disulfide	3.0E+02	1.3E+00	2.1E+03	1.33E-02	2.95E+02	NDA	2.1	UG/L	a	1400	UG/KG	a,b
alpha-Chlordane	1.0E-05	1.6E+00	5.6E-02	4.80E-05	4.95E+04	0.004	0.052	UG/L		2000	UG/KG	
gamma-Chlordane	1.0E-05	1.6E+00	5.6E-02	4.80E-05	4.95E+04	NDA	0.052	UG/L		2000	UG/KG	
Chlorobenzene	1.0E+01	1.1E+00	4.9E+02	3.93E-03	1.73E+02	NDA	3.9	UG/L	a	60	UG/KG	a,b
Chlorobenzilate	2.2E-06	NDA	1.3E+01	7.24E-08	1.07E+03	NDA	0.25	UG/L		0.6	UG/KG	n
Chloroethane	1.0E+03	9.0E-01	5.7E+03	1.00E-02	3.47E+00	NDA	860	UG/L	a	3300	UG/KG	a,b
bis(2-Chloroethyl)ether	1.2E+00	1.2E+00	1.0E+04	1.30E-05	1.41E+01	NDA	0.0092	UG/L		0.3	UG/KG	
Chloroform	1.6E+02	1.5E+00	8.0E+03	3.23E-03	4.60E+01	NDA	0.15	UG/L		300	UG/KG	
Chloromethane	3.8E+03	9.2E-01	7.3E+03	8.82E-03	2.51E+01	NDA	1.4	UG/L		6.6	UG/KG	
4-Chloro-3-methylphenol	5.0E-02	NDA	3.9E+03	1.78E-06	7.76E+02	NDA	NDA			NDA		
2-Chlorophenol	1.4E+00	1.3E+00	2.8E+04	8.28E-06	3.63E+02	NDA	18	UG/L	a	200	UG/KG	a,b
Chromium	NA	NA	NA	NA	NA	50	18	UG/L	a	85.65	MG/KG	d
Cobalt	NA	NA	NA	NA	NA	NDA	220	UG/L	a	14.88	MG/KG	d
Copper	NA	NA	NA	NA	NA	2.9	140	UG/L	a	31.62	MG/KG	d
Cyanide	NA	NA	NA	NA	NA	1	75	UG/L	a	NDA		
2,4-D	1.1E-02	1.4E+00	6.8E+02	1.37E-10	1.58E+00	NDA	6.1	UG/L	a	1700	UG/KG	h
2,4-DB	NDA	NDA	NDA	NDA	NDA	NDA	29	UG/L	a	1000	UG/KG	r
4,4'-DDD	1.0E-06	1.5E+00	2.0E-02	2.16E-05	4.37E+04	NDA	0.28	UG/L		700	UG/KG	
4,4'-DDE	6.5E-06		4.0E-02	2.34E-05	2.45E+05	NDA	0.2	UG/L		500	UG/KG	
4,4'-DDT	1.9E-07	1.6E+00	5.0E-03	4.89E-05	3.87E+05	0.001	0.2	UG/L		1000	UG/KG	
DCAA	NDA	NDA	NDA	NDA	NDA	NDA	NDA			NDA		
Dibenzofuran	NDA	1.1E+00	1.0E+01	NDA	1.00E+04	NDA	15	UG/L	a	12000	UG/KG	a,b
Dibromochloromethane	7.6E+01	2.5E+00	4.0E+03	9.90E-04	8.32E+01	NDA	NDA			38	UG/KG	p

* see Pg 4 of 4 for BEQ specific levels

Table 5.2.1
Fate and Transport Properties and Screening Levels for
Constituents Detected in Soil and Groundwater
NAVBASE-Charleston, Zone H

Parameter	Vapor Pressure (mm Hg)	Density (g/cm3)	Solubilit (mg/L)	Henry's Law Constant (atm-m3/mole)	Organic Carbon Water Part. Coeff. (L/kg)	Salt Water Chronic WQC ! (ug/L)	Tap Water RBC or UTL *	Water Units		Ground Water Protection SSL or UTL **	Soil Units	
Di-n-butylphthalate	1.0E-05	1.0E+00	1.3E+01	6.30E-05	1.38E+03	NDA	370	UG/L	a	12000	UG/KG	a,b
1,2-Dichlorobenzene	1.0E+00	1.3E+00	1.0E+02	1.90E-03	1.82E+02	NDA	27	UG/L	a	600	UG/KG	h
1,4-Dichlorobenzene	6.0E-01	1.2E+00	7.9E+01	3.10E-03	5.11E+02	NDA	0.44	UG/L		1000	UG/KG	h
1,3-Dichlorobenzene	2.3E+00	1.3E+00	1.2E+02	3.60E-03	1.70E+02	NDA	54	UG/L	a	600	UG/KG	g
1,2-Dichloroethane	6.4E+01	1.3E+00	8.7E+03	9.80E-04	1.41E+01	NDA	0.12	UG/L		10	UG/KG	
1,1-Dichloroethane	1.8E+02	1.2E+00	5.5E+03	5.45E-03	3.40E+01	NDA	81	UG/L	a	1100	UG/KG	
1,2-Dichloroethene (total)	3.0E+02	NDA	3.5E+03	5.00E-03	2.30E-02	NDA	5.5	UG/L	a	300	UG/KG	h,i
1,1-Dichloroethene	5.9E+02	1.2E+00	2.3E+03	1.80E-02	6.50E+01	NDA	0.044	UG/L		30	UG/KG	h
2,4-Dichlorophenol	8.9E-02	1.4E+00	4.5E+03	6.66E-06	8.71E+02	NDA	11	UG/L	a	50	UG/KG	a,b
Dieldrin	1.8E-07	1.8E+00	2.0E-01	2.00E-05	1.34E+04	0.0019	0.0042	UG/L		1	UG/KG	
Diethylphthalate	2.0E-03	1.1E+00	9.0E+02	8.46E-07	6.92E+01	NDA	2900	UG/L	a	11000	UG/KG	a,b
7,12-Dimethybenz(a)anthracene	NDA	NDA	NDA	NDA	NDA	NDA	NDA			700	UG/KG	q
2,4-Dimethylphenol	9.8E-02	9.7E-01	6.2E+03	6.55E-06	1.18E+02	NDA	73	UG/L	a	300	UG/KG	a,b
2,4-Dinitrotoluene	5.1E-03	1.4E+00	2.7E+02	8.67E-07	6.17E+01	NDA	7.3	UG/L	a	20	UG/KG	a,b
Di-n-octylphthalate	1.4E-03	9.8E-01	3.0E+00	1.41E-12	9.77E+08	NDA	73	UG/L	a	1E+08	UG/KG	a,b
Dioxin (TCDD TEQ)	NDA	NDA	NDA	NDA	3.30E+06	NDA	0.5	PG/L		280	PG/G	s
Diphenylamine	NDA	NDA	NDA	NDA	NDA	NDA	91	UG/L	a	NDA		
Endosulfan I	1.0E-05	1.7E+00	5.3E-01	1.01E-04	2.04E+03	0.0087	22	UG/L	j	400	UG/KG	a,b,j
Endosulfan II	1.0E-05	1.7E+00	2.8E-01	1.91E-05	2.34E+03	0.0087	22	UG/L	j	400	UG/KG	a,b,j
Endosulfan sulfate	NDA	NDA	1.2E-01	NDA	2.34E+03	NDA	22	UG/L	j	400	UG/KG	a,b,j
Endrin	7.0E-07	1.7E+00	2.3E-01	5.00E-07	8.32E+03	0.0023	1.1	UG/L	a	400	UG/KG	h
Endrin aldehyde	2.0E-07	NDA	2.6E-01	3.86E-07	2.69E+04	NDA	1.1	UG/L	k	400	UG/KG	k
Ethylbenzene	7.1E+00	8.7E-01	1.5E+02	6.60E-03	1.87E+02	NDA	130	UG/L	a	5000	UG/KG	h
bis(2-Ethylhexyl)phthalate (BEHP	2.0E-07	9.9E-01	3.0E-01	1.10E-05	1.00E+05	NDA	4.8	UG/L	a	11000	UG/KG	a,b
Fluoranthene	5.0E-06	1.3E+00	2.4E-01	1.69E-02	4.17E+04	NDA	150	UG/L	a	98000	UG/KG	a,b
Fluorene	7.0E-03	1.2E+00	1.7E+00	2.10E-04	5.01E+03	NDA	150	UG/L	a	16000	UG/KG	a,b
Heptachlor	3.0E-04	1.7E+00	1.8E-01	2.30E-03	2.69E+04	0.0036	0.0023	UG/L		60	UG/KG	h
Heptachlor epoxide	2.6E-06	NDA	3.5E-01	3.20E-05	2.09E+04	0.0036	0.0012	UG/L		30	UG/KG	h
Hexachlorobenzene	1.1E-05	1.6E+00	6.0E-03	1.70E-03	3.89E+03	NDA	0.0066	UG/L		800	UG/KG	h
Hexachlorobutadiene	1.5E-01	1.6E+00	3.2E+00	1.03E-02	4.68E+03	NDA	0.14	UG/L		100	UG/KG	h
Hexachlorocyclopentadiene	8.1E-02	1.7E+00	1.1E+00	1.60E-02	4.27E+03	NDA	0.015	UG/L	a	10000	UG/KG	h
Hexachloroethane	2.1E-01	NDA	5.0E+01	2.80E-03	3.10E-01	NDA	0.61	UG/L	a	200	UG/KG	
Isodrin	NDA	NDA	NDA	NDA	NDA	NDA	NDA			NDA		
Kepone	3.0E-07	NDA	7.6E+00	2.50E-08	2.45E+03	NDA	0.0037	UG/L		NDA		
Lead	NA	NA	NA	NA	NA	8.5	15	UG/L	o	118	MG/KG	d
Manganese	NA	NA	NA	NA	NA	NDA	3391	UG/L	d	1412	MG/KG	d
Mercury	NA	NA	NA	NA	NA	0.025	1.1	UG/L	a	3	MG/KG	h
Methoxychlor	1.4E-06	1.4E+00	4.0E-02	1.58E-05	7.94E+04	NDA	18	UG/L	a	62000	UG/KG	h
Methyl parathion	9.6E-06	NDA	5.0E+01	1.00E-07	6.34E+01	NDA	0.91	UG/L	a	4.1	UG/KG	a,b
4-Methyl-2-Pentanone (MIBK)	1.5E+01	8.0E-01	1.7E+04	1.49E-05	6.17E+00	NDA	290	UG/L	a	910	UG/KG	n
Methylene chloride	3.5E+02	1.3E+00	2.0E+04	2.00E-03	2.30E+01	NDA	4.1	UG/L		10	UG/KG	
2-Methylnaphthalene	NDA	1.0E+00	2.5E+01	NDA	8.51E+03	NDA	150	UG/L	l	3000	UG/KG	l
2-Methylphenol	2.4E-01	1.0E+00	2.5E+04	1.23E-06	2.19E+01	NDA	180	UG/L	a	600	UG/KG	a,b
4-Methylphenol	4.0E-02	1.0E+00	2.3E+04	7.92E-07	4.90E+01	NDA	18	UG/L	a	600	UG/KG	m
Naphthalene	5.4E-02	1.1E+00	3.0E+01	4.60E-04	7.92E+02	NDA	150	UG/L	a	3000	UG/KG	a,b
Nickel	NA	NA	NA	NA	NA	8.3	73	UG/L	a	33.38	MG/KG	d
4-Nitrophenol	1.0E-04	1.5E+00	1.3E+04	3.00E-05	2.14E+02	NDA	230	UG/L	a	1670	UG/KG	n
N-Nitroso-di-n-propylamine	4.0E-01	9.2E-01	9.9E+03	6.92E-06	1.02E+01	NDA	0.0096	UG/L		0.02	UG/KG	
N-Nitrosodiphenylamine	NDA	NDA	NDA	NDA	NDA	NDA	14	UG/L		200	UG/KG	
Parathion	9.7E-06	NDA	6.5E+00	5.65E-07	6.61E+02	NDA	22	UG/L	a	390	UG/KG	a,b
Pentachlorophenol	1.1E-04	2.0E+00	2.0E+01	2.10E-06	4.09E+02	7.9	0.56	UG/L		200	UG/KG	
Phenanthrene	6.8E-04	1.2E+00	1.0E+00	3.90E-05	2.29E+04	NDA	150	UG/L	f	98000	UG/KG	f
Phenol	2.0E-01	1.1E+00	8.2E+04	2.70E-07	2.69E+01	NDA	2200	UG/L	a	4900	UG/KG	a,b
Pyrene	2.5E-06	1.3E+00	1.4E-01	1.09E-05	6.46E+04	NDA	110	UG/L	a	140000	UG/KG	a,b

Table 5.2.1
Fate and Transport Properties and Screening Levels for Constituents Detected in Soil and Groundwater
NAVBASE-Charleston, Zone H

Parameter	Vapor Pressure (mm Hg)	Density (g/cm3)	Solubilit (mg/L)	Henry's Law Constant (atm-m3/ mole)	Organic Carbon Water Part. Coeff. (L/kg)	Salt Water Chronic WQC ! (ug/L)	Tap Water RBC or UTL *	Water Units		Ground Water Protection SSL or UTL **	Soil Units	
Selenium	NA	NA	NA	NA	NA	71	18	UG/L	a	3	MG/KG	h
Silver	NA	NA	NA	NA	NA	NDA	18	UG/L	a	NDA		
2,4,5-T	7.5E-07	1.4E+00	2.8E+02	8.68E-08	2.04E+02	NDA	37	UG/L	a	260	UG/KG	n
2,4,5-TP (Silvex)	5.2E-06	NDA	1.4E+02	1.31E-07	2.57E+03	NDA	29	UG/L	a	1580	UG/KG	n
Total Petroleum Hydrocarbons (IR	NDA	NDA	NDA	NDA	NDA	NDA	NDA			NDA		
Tetrachloroethene	1.4E+01	1.6E+00	1.5E+02	1.53E-02	2.64E+02	NDA	1.1	UG/L		40	UG/KG	
Tetrahydrofuran	1.6E+02	8.9E-01	NDA	9.63E-03	1.95E+00	NDA	NDA			NDA		
Thallium	NA	NA	NA	NA	NA	NDA	7.66	UG/L	d	1.3	MG/KG	d
Tin	NA	NA	NA	NA	NA	NDA	2200	UG/L	a	NDA		
Toluene	2.2E+01	8.7E-01	5.2E+02	6.70E-03	1.29E+02	NDA	75	UG/L	a	5000	UG/KG	h
Toxaphene	3.3E-05	1.6E+00	7.4E-01	6.30E-02	1.51E+03	0.0002	0.061	UG/L		40	UG/KG	h
1,2,4-Trichlorobenzene	4.0E-01	1.5E+00	3.0E+01	2.32E-03	1.56E+03	NDA	19	UG/L	a	2000	UG/KG	h
1,1,1-Trichloroethane	1.0E+02	1.3E+00	1.6E+03	1.62E-02	1.28E+02	NDA	130	UG/L	a	900	UG/KG	h
Trichloroethene	5.8E+01	1.5E+00	1.1E+03	9.10E-03	8.70E+01	NDA	1.6	UG/L		20	UG/KG	h
Trichlorofluoromethane	6.9E+02	1.5E+00	1.1E+03	1.10E-01	1.59E+02	NDA	130	UG/L	a	1300	UG/KG	a,b
2,4,5-Trichlorophenol	NDA	1.7E+00	NDA	NDA	NDA	NDA	370	UG/L	a	12000	UG/KG	a,b
2,4,6-Trichlorophenol	1.7E-02	1.5E+00	8.0E+02	9.07E-08	1.07E+03	NDA	6.1	UG/L		50	UG/KG	
1,2,3-Trichloropropane	3.1E+00	1.4E+00	1.8E+03	3.44E-04	7.24E+01	NDA	0.0015	UG/L		0.006	UG/KG	
Vanadium	NA	NA	NA	NA	NA	NDA	26	UG/L	a	131.6	MG/KG	d
Vinyl chloride	2.6E+03	9.1E-01	1.1E+03	1.22E+00	1.10E+01	NDA	0.019	UG/L		10	UG/KG	h
Xylene (total)	8.7E+00	8.8E-01	2.0E+02	7.10E-03	2.34E+02	NDA	1200	UG/L	a	74000	UG/KG	h
Zinc	NA	NA	NA	NA	NA	86	1100	UG/L	a	4200	MG/KG	

* - Ground water screening concentration which is the greater of:
1. Tap water risk-based concentration as presented in EPA Region III tables (1/31/95)
2. Background upper tolerance limit for shallow groundwater; NAVBASE Charleston - Zone H

** - Soil screening concentration which is the greater of:
1. Soil screening levels which governs soil to water transfer as presented in EPA Region III risk-based concentration tables (1/31/95)
2. Background upper tolerance limit for surface or subsurface soil; NAVBASE Charleston - Zone H

(Risk based screening concentrations assume a target risk of 1E-06, a target hazard index of 0.1, and a dilution attenuation factor of 10)

! - Salt Water Chronic Water Quality Criteria as provided in EPA (1993) Quality Criteria for Water
NA - Not applicable
NDA - No data available
a - based on target hazard index of 0.1
b - target soil leachate concentration based on the tap water RBC
c - acenaphtene used as a surrogate
d - background upper tolerance limit
e - gamma-BHC used as a surrogate
f - fluoranthene used as a surrogate
g - 1,2-dichlorobenzene used as a surrogate
h - target leachate soil concentration based on a MCL
i - value for trans - 1,2-dichloroethene
j - endosulfan used as a surrogate
k - endrin used as a surrogate
l- naphthalene used as a surrogate
m - 2-methylphenol used as a surrogate
n - Calculated using Soil Screening Guidance (EPA 12/94) using contaminant specific values
o - Treatment technique action level for water
p - based on the MCL for total trihalomethanes of 0.08 mg/L
q - benzo(a)anthracene used as a surrogate
r - estimated to be greater than 1000 ug/kg based on structural similarities to 2,4-D
s - Dioxin (TCDD TEQ) soil screening value based on the tap water RBC and site specific soil parameters

Table 5.3.1
Chemicals Detected in Soil
Comparison to Groundwater Protection SSL or Background UTL
NAVBASE-Charleston, Zone H, SWMUs 9,19,20,121 and AOCs 649,650,654

BEQ specific levels

Parameter	Units	SWMU 19 Surface Soil	SWMU 19 Subsurface Soil	SWMU 20 Surface Soil	SWMU 20 Subsurface Soil	SWMU 121 Surface Soil	SWMU 121 Subsurface Soil	AOC 649,650,651 Surface Soil	AOC 649,650,651 Subsurface Soil	AOC 654 Surface Soil	AOC 654 Subsurface Soil	Ground-Water Protection SSL	Detected in Ground-water
Acenaphthene	ug/kg	217	360	210	ND	130	ND	ND	ND	ND	ND	20000	I,II
Acenaphthylene	ug/kg	ND	130	ND	ND	590	ND	ND	ND	ND	ND	20000	
Acetone	ug/kg	33	47	ND	ND	193.5	ND	25.2	ND	4000	1700 *	800	I,II
Acrylonitrile	ug/kg	ND	ND	ND	ND	34.5	ND *	36.9	ND *	ND	ND	0.04	
Aluminum	mg/kg	11900	8210	ND	ND	16000	15500	10900	3280	6890	6530	46180	I,II
Anthracene	ug/kg	357	670	450	170	610	ND	250	ND	ND	130	430000	
Antimony	mg/kg	726	1.4	ND	ND	7.3	ND	1.6	ND	ND	ND	NDA	I (x)
Aroclor-1248	ug/kg	ND	ND	ND	ND	160	37	52	30	ND	ND	8200	
Aroclor-1254	ug/kg	2300	ND	ND	ND	4300	82	407	30	ND	ND	8200	
Aroclor-1260	ug/kg	560	ND	ND	ND	1100	88	ND	ND	ND	ND	8200	
Arsenic	mg/kg	22.1	8.3	ND	ND	18.7	10.7	9.5	3	7.7	18.4	35.52	I,II (x)
delta-BHC	ug/kg	ND	ND	ND	ND	ND	ND	ND	ND	1.2	ND	6	
Barium	mg/kg	128	64.1 *	ND	ND	530	89.7 *	57.9	ND *	38.7	ND	43.8	I,II (x)
Benzene	ug/kg	64	ND *	ND	ND	ND	ND	ND	ND	ND	ND	20	I,II (x)
Benzo(g,h,i)perylene	ug/kg	215	600	250	ND	780	93	1100	ND	ND	ND	98000	
Benzo(a)pyrene	ug/kg	604	1400	820	430	1700	200	2000	ND	ND	ND	4000	
Benzo(a)anthracene	ug/kg	811	1700 *	950	580 *	1900	160 *	1900	ND *	ND	140	700	
Benzo(b)fluoranthene	ug/kg	935	1700	1400	680	2700	200	4000	ND	110	ND	4000	
Benzo(k)fluoranthene	ug/kg	712	1200	660	400	2200	230	130	ND	ND	140	4000	
Chrysene	ug/kg	755	1600 *	940	610	2000	170 *	1900	ND *	ND	ND	1000	
Dibenzo(a,h)anthracene	ug/kg	ND	250	100	ND	280	ND	390	ND	ND	ND	11000	
Indeno(1,2,3-cd)pyrene	ug/kg	240	590	260	ND	750	ND	910	ND	ND	ND	35000	
Benzoic acid	ug/kg	ND	ND	ND	ND	ND	ND	269	ND	ND	ND	28000	I
Beryllium	mg/kg	3	0.61	ND	ND	14.6	2.6	1.1	0.2	0.49	0.59	180	II (x)
2-Butanone (MEK)	ug/kg	ND	ND	ND	ND	37.1	ND	ND	ND	ND	ND	570	I
Butylbenzylphthalate	ug/kg	2300	150	190	430	2600	ND	1540	ND	ND	ND	6800	II
Cadmium	mg/kg	1.8	0.64	ND	ND	2.5	ND	0.39	ND	0.97	1.5	6	I,II
Carbon disulfide	ug/kg	9.9	ND	ND	ND	ND	ND	4.8	ND	ND	11	1400	I,II (x)
alpha-Chlordane	ug/kg	9.35	ND	ND	ND	ND	ND	11.6	2	69.1	ND	2000	
gamma-Chlordane	ug/kg	4	ND	ND	ND	4	ND	6	ND	41	ND	2000	
Chlorobenzene	ug/kg	64	ND *	ND	ND	ND	ND	5.18	ND	ND	ND	60	I,II (x)
Chloroform	ug/kg	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	300	
Chromium	mg/kg	49.2	20.7	ND	ND	210	50.8 *	24.4	12.3	53.3	70.7	85.65	I,II (x)
Cobalt	mg/kg	43.3	5.5 *	ND	ND	97.2	15.9 *	9.5	1.5	3.1	4.3	14.88	I,II
Copper	mg/kg	3040	309 *	ND	ND	4060	680 *	357	24.6 *	57.1	13.1 *	31.62	I,II (x)
Cyanide	mg/kg	ND	ND	ND	ND	9.9	ND	ND	ND	2	1	NDA	
2,4-D	ug/kg	41.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	1700	
4,4'-DDD	ug/kg	6	10	ND	ND	ND	ND	8	ND	ND	ND	700	II
4,4'-DDE	ug/kg	5	12	ND	ND	20.5	ND	10.2	3	6.15	ND	500	II
4,4'-DDT	ug/kg	16	ND	ND	ND	14	ND	7	ND	10	ND	1000	I
Dibenzofuran	ug/kg	124	200	220	ND	89	ND	56.5	ND	ND	ND	12000	I,II
Diethylphthalate	ug/kg	ND	ND	ND	ND	85.2	ND	ND	ND	ND	ND	11000	I
Di-n-butylphthalate	ug/kg	1100	ND	ND	ND	ND	ND	222	ND	ND	ND	12000	I,II

VOC ESTIMATES

for bioremedition of petroleum contaminated soil

	B cuyd / site x	C sites x	27 cuft / cuyd x	E lbs / cuft x	F ppm	x million / 10^6 part	x H % voc / period	= emissions subtotal	(lbs/month) total
diesel	*20*	*24*	27	*115*	*1600*	1E-06	*0.033*	***79***	
gasoline		*0*						***0***	
									79

B = average cubic yards per site

C = number of sites in 3 month period

E = soil density

F = average TPH (based on actual samples from several sites)

H = total % of TPH emitted as VOCs divided by a period of 3 months

It is assumed that input rate of the soil is such that when combined with the non linear decay rate, equal monthly emissions occur throughtout the period. Also, conservatively assumes no vocs emitted during digging/transport.

diesel: 6-7% total voc - assume .1 divided by 3 months

gas: 85-90% total voc - assume .9 divided by 3 months

% total voc obtained from Jeff O'Conner, PE at Southwest Division, Naval Facilities Engineering Command in San Diego, Calif on 4/8/96

Appendix A-6

SCDHEC Ltr (9/97)

D H E C

PROMOTE PROTECT PROSPER

2600 Bull Street
Columbia, SC 29201-1708

Supervisor of Shipbuilding, Conversion and Repair
USN, Portsmouth
Environmental Detachment Charleston
1899 North Hobson Avenue
North Charleston, SC 29405-2106
Attn. J.T. Amey

Re: Soil Corrective Action Plan/Response to Comments dated July 30, 1997
Charleston Naval Complex/Charleston Naval Base
Charleston, SC
Charleston County

Date: September 2, 1997

Dear Mr. Amey:

The author has completed technical review of the referenced document. The above responses have been provided to address Department concerns regarding the efficacy of the Soils Corrective Action Plan (SCAP) to determine appropriate levels of soils contamination below which would be protective of human health and the environment, as identified in correspondence dated April 18,1997 (Bristol to Amey). The intent of the SCAP document is to provide a Pass/Fail criteria for determining the extent of bioremediation necessary for contaminated soils generated during site closure activities. Concurrently, the author identifies the SCAP document as a tool by which the facility may determine the extent of soils excavation necessary during an UST/AST closure and reasonably identify sites which will potentially require additional assessments and/or remedial activities, as subsequently determined by the Department.

During review of the submitted responses, it was noted that wording utilized in reference to the current SCAP document is sufficient to significantly modify the soils concentrations proposed in the original document (dated July 18, 1996). The original document entitled "Plan For Excavated Soil From Petroleum Tank Sites" was presented as a SCAP for mitigating petroleum contaminated soils from UST site closures at the Charleston Naval Complex. The proposed methods of disposition for generated soils were based on the risk based screening levels (RBSL) Table 6 as outlined in the "Risk Based Corrective Action For Petroleum Releases" (RBCA) document (DHEC, June 1995). By correspondence dated October 17, 1996, (Bristol to Magwood) the author approved the above document with a request that petroleum compounds not identified by the RBCA document (specifically polynuclear aromatic hydrocarbons, PAH) be incorporated into the SCAP, with appropriate and reasonable concentrations for RBSL's. The facility provided an excerpt from the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) document, which provided proposed groundwater protection soil screening levels (SSL) for the remaining PAH compounds on December 6, 1996. By correspondence dated January 15, 1997, (Bristol to Dearhart) the author accepted the SSL's as proposed and agreed to incorporation with the previously approved SCAP. A revised SCAP document intended to detail the final approved version was submitted to the Department on February 6, 1997. This document refers to the RFI SSL's as the concentrations which the facility will utilize in the SCAP document, contrary to the original, approved document.

Based on the foregoing discussion, the author will initiate review of petroleum vessel closure reports as follows:

- Soil sample analytical results will be compared to Table B3 (Risk-Based Corrective Action for Petroleum Releases, DHEC June 20, 1997) Risk-Based Screening Levels (RBSL) for those chemical of concern (COC); remaining PAH compounds will be compared to the RFI SSL concentrations, as appropriate.

- As identified in the response to comments dated July 30, 1997, when Detection Limits (DL) are elevated and COC are reported as zero (0) or less than detection limit it will be assumed that the chemical constituents are equal to the elevated detection limit.

- As identified in the response to comments dated July 30, 1997, soil(s) with petroleum hydrocarbon compounds detected at or near the appropriate RBSL or SSL will not be placed (remain) within two (2) feet of the groundwater table.

With consideration to the SCAP for petroleum contaminated material, the Pass/Fail decision criteria for bioremediated soils will need to be consistent with the above comments. In this regard, the determination of when to cease soil bioremediation activities and declare the soils "ready for reuse" will incorporate the RBSL and SSL, as appropriate. Further, an appropriate tracking and reporting schedule should be developed which provides, at a minimum, the following information:

- Source and quantity of contaminated soils delivered to the remediation facility.
- Initial screening data.
- Initial mixing/treatment, as appropriate.
- Treatment process employed (air monitoring may be required for process "D").
- Final treatment analytical data.
- Final quantity and disposition of soil declared "ready for reuse".

It appears appropriate that a report describing the efficacy of the bioremediation process and incorporating the above information be submitted to my attention monthly during the duration of the demonstration period. Modification to this schedule may be considered subsequent to completion of the initial project duration.

Should you have any questions, please contact me at (803) 734-5328.

Sincerely,

Paul L. Bristol, Hydrogeologist
Groundwater Assessment and Development Section
Bureau of Water

cc: Trident District EQC

Appendix B

Sample Results

LOT ***A*** **Method** A

	DATE	FROM	Amount	Comments
Received	17 Jan	UST 28B	2 cuyd	
	18 Feb	UST 657	10 cuyd	
Mixed	20 Feb		12 cuyd	
	21 Feb			
Transferred	28 Feb		14 cuyd	

COC		BTEX (ppb) ben zene	ethyl ben zene	tol uene	xy lenes	TPH (ppm)	(ppb) Naph tha lene	PAH (ppb) ace naph thene	ace naph thy lene	anthra cene	benzo (a) anthrac ene	benzo (a)py rene	benzo (b)flu oran thene	benzo (ghi) pery lene	benzo (k)flu oran thene	chry sene	dibenz o(a,h) anthra cene	fluo ran thene	fluo rene	indeno (1,2,3,-c,d)py rene	naph tha lene	phen anth rene	py rene	total
SSL		*20*	*5000*	*5000*	*74k*			*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL		*7*	*1500*	*1700*	*44k*		*200*				*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																							
28B	006-3	250	4900	<20	2210		47k	<16k	<19k	<17k	<16k	<18k	<16k	<18k	<21k	<17k	<17k	<18k	<16k	<18K	33k	40k	<20k	
	DL	5	200	20	4000		4000	16k	19k	17k	16k	18k	16k	18k	21k	17k	17k	18k	16k	18k	16k	18k	~~20k~~	
657	218-3	0	0	0	0		186	1350	0	0	3270	2380	4030	858	0	3560	0	12.8k	0	990	0	2110	7660	
	DL		5				5								1650									
TANK SITE TEST RESULTS ABOVE ...........BIOREMEDITION TEST RESULTS BELOW																								
Mix 28 Feb location #1	365-1	0	0	0	0		0	0	0	0	165	281	413	172	0	248	0	323	0	0	0	0	762	2364
	DL		*1*				*1*								*165*									
Mix 28 Feb location #2	365-2	0	0	0	0		0	0	0	0	1110	715	1220	0	0	1110	0	0	0	0	0	1350	2970	8475
	DL		*1*				*1*								*662*									
Immunoassay 4/7	I-A1					<100																		
Mix 8 Apr location #2(4/10)	412-1	0	0	2	0		0	0	0	0	0	185	205	0	0	179	0	192	0	0	0	0	318	1079
	DL		*1*												*331*									

COMPLETE

General Notes

COC-chemicial of concern, *DL*-detection limit, ppb-parts per billion, k-thousand, [shaded box] -value above limit

SSL-soil creeening level, RBSL-SCDHEC Risk-Based-Screening-Level

LOT ***B*** **Method** B

	DATE	FROM	Amount	Comments
Received	24 Feb	UST 653	25 cuyd	
	3 Mar	UST Qtrs C	3 cuyd	
Mixed	3 Mar		28 cuyd	
	10 Mar			
Transferred	12 Mar		33 cuyd	

		BTEX (ppb)					(ppb)	PAH (ppb)																
COC		benzene	ethylbenzene	toluene	xylenes	TPH (ppm)	Naphthalene	acenaphthene	acenaphthylene	anthracene	benzo(a)anthracene	benzo(a)pyrene	benzo(b)fluoranthene	benzo(ghi)perylene	benzo(k)fluoranthene	chrysene	dibenzo(a,h)anthracene	fluoranthene	fluorene	indeno(1,2,3,-c,d)pyrene	naphthalene	phenanthrene	pyrene	total
SSL		*20*	*5000*	*5000*	*74k*			*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL		*7*	*1500*	*1700*	*44k*		*200*				*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																							
653 note 1	326-4	0	0	0	0		0	503	0	826	1170	734	658	375	721	855	0	2880	740	385	316	3360	2320	
	DL		*1*				*1*								*165*									
Quarters C	242-1	676	2690	1060	4680		3920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50.7k	0	
	DL	*20*	*40*	*20*	*40*		*40*								*41600*									
TANK SITE TEST RESULTS ABOVE ...........BIOREMEDITION TEST RESULTS BELOW																								
B-1 14 Mar (3/18,3/21)	377-1	0	0	0	0		0	0	0	0	1320	1120	1080	773	1280	1550	0	3890	0	746	0	2210	2080	16049
	DL		*1*				*1*								*666*									
B-2 14 Mar (3/18,3/18)	377-2	0	0	0	0		0	0	0	0	6730	4260	5330	0	4330	7330	0	16700	0	0	0	8860	13700	67240
	DL		*1*				*1*								*3300*									
B-3 14 Mar (3/18,3/17)	377-3	0	0	0	0		0	0	0	416	1030	753	932	613	989	1090	170	2150	0	653	0	1200	1710	11706
	DL		*1*				*1*								*167*									
Immunoassay 4/7	I-B1					>400																		
Immunoassay 4/22 and 4/23	I-B2					>1000 <1333																		
Immunoassay 4/22 and 4/23	I-B3					>400 <1000																		
Immunoassay 5/14 and 5/15	I-B2-2					>200 <250																		
Immunoassay 5/14 and 5/15	I-B3-2					>200 <250																		
Mix 15 May B-2A	446-1					230		221	0	467	1650	1750	2040	1030	1220	2750	351	2860	204	1090	0	2010	2760	20403
	DL					*10*									*167*									
Immunoassay 6/11	I-B2-3	TPH: <200, <150, <150, <100, <50, >100, >75, >50, >200, <150, <100, >200, <200, >100 (variance in TPH results from the same 8 0z jar)																						
Immunoassay 6/16	I-B2-4	TPH: >200, <200																						

LOT **B** Method B

COC	#	BTEX (ppb) ben zene	ethyl ben zene	tol uene	xy lenes	TPH (ppm)	(ppb) Naph tha lene	PAH (ppb) ace naph thene	ace naph thy lene	anthra cene	benzo (a) anthrac ene	benzo (a)py rene	benzo (b)flu oran thene	benzo (ghi) pery lene	benzo (k)flu oran thene	chry sene	dibenz o(a,h) anthra cene	fluo ran thene	fluo rene	indeno (1,2,3,-c,d)py rene	naph tha lene	phen anth rene	py rene	total
SSL		*20*	*5000*	*5000*	*74k*			*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL		*7*	*1500*	*1700*	*44k*		*200*				*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																							
Mix 16 Jun B2-4	463-1					630		0	0	0	1630	1650	2660	953	0	2170	0	4200	0	1100	0	3380	3610	21353
	DL					*10*									*654*									
Immunoassay 7/15	*Lot B*					<200																		
Mix 7/14 (7/21)						194																		
	DL					*25*																		
Mix 7/29@B-2 (7/31,8/1)	487-2					68		1750	0	3380	11000	7070	9280	4080	5160	9900	668	11800	754	4030	0	14200	17300	100372
						10									*664*									
Mix 7/29@B-1 (7/31,8/1)	487-3					219		0	0	0	0	1140	1610	0	0	0	0	2660	0	0	0	1120	1410	7940
						10									*658*									
Mix 8/20@B-1 (8/21,8/25)	498-4					310		81	0	786	651	516	825	308	462	276	0	1260	85	579	0	704	1190	7723
	DL					*10*									*67 max*									
Mix 8/20@B-2 (8/21,8/25)	498-3					120		957	0	2050	4720	4730	7490	2440	2930	7140	0	10500	1100	2810	363	10900	13000	71130
	DL					*10*									*67 max*									
498-3 retest (9/3)	503-1					198		273	0	756	1690	1580	2350	1020	585	2100	323	3310	295	1040	0	2800	3050	21172
	DL					*10*									*166*									

LOT **C** **Method B/A**

	DATE	FROM	Amount	Comments
Received	7 Mar	2517	10 cuyd	dirt pile(292-1) plus additional digging based on hole sample 292-3
	10 Mar	2522	3 cuyd	additional digging based on hole sample
Mixed	10 Mar		13 cuyd	
Transferred	15 Apr		16 cuyd	

		BTEX (ppb)					(ppb)	PAH (ppb)																
COC		benzene	ethylbenzene	toluene	xylenes	TPH (ppm)	Naphthalene	acenaphthene	acenaphthylene	anthracene	benzo (a) anthracene	benzo (a)pyrene	benzo (b)fluoranthene	benzo (ghi) perylene	benzo (k)fluoranthene	chrysene	dibenzo(a,h) anthracene	fluoranthene	fluorene	indeno (1,2,3,-c,d)pyrene	naphthalene	phenanthrene	pyrene	total
SSL		*20*	*5000*	*5000*	*74k*			*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL		*7*	*1500*	*1700*	*44k*		*200*				*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																							
2517	292-1	0	0	<1	0		3	281	0	645	1290	861	1340	367	569	1530	0	2970	394	410	0	2400	2820	
	292-3	0	0	2	0		2	0	1760	2060	13.2k	12.6k	15.0k	5940	8530	14.8k	2860	20.1k	0	6840	0	0	20.6k	
2522	297-9	0	0	0	0		0	0	0	0	17.6k	20.9k	27.6k	11.3k	10.0k	21.0k	4550	30.4k	0	13.2k	0	0	34.9k	
TANK SITE TEST RESULTS ABOVE ..........BIOREMEDITION TEST RESULTS BELOW																								
Mix 21 Mar	389-1							0	0	0	684	578	584	365	611	697	0	1700	0	332	0	1190	1380	8121
	DL														*166*									
Mix 1 Apr	404-1	0	0	0	0		0	444	0	1330	2010	1850	1820	1090	1590	1930	485	4940	545	1020	0	4770	3700	27524
	DL		*1*												*165*									
Mix 1 Apr	404-2	0	0	0	0		0	0	0	0	318	0	269	0	0	341	0	810	0	0	0	312	610	2660
	DL		*1*												*164*									
Mix 1 Apr, Note 1	9704031					60																		
Immunoassay 4/22	I-C1					<75																		
Immunoassay 5/14	I-C1-2	TPH: >40, <60																						
Immunoassay 6/6	1	TPH: >40, >40, >40																						
	2	TPH: <20, <20																						
Mix 9 Jun	457-1					190		0	0	484	1880	854	1270	0	1020	1980	0	3740	0	0	0	3450	3680	18358
	DL					*10*									*330*									
Immunoassay 7/15	Lot C	TPH: <75, <50																						
Mix 7/14 (7/21)	476-3					76																		
	DL					*25*																		
Mix 7/29 (7/31,8/3)	487-4					20		0	0	0	634	504	1070	0	0	778	0	1560	0	283	0	857	1210	6896
	DL					*10*									*167*									

1) TPH done on sample 404-1 after receiving high PAH results

SECURED 8/3

LOT ***D*** **Method C**

	DATE	FROM	Amount	Comments
Received	25 Mar	654	20 cuyd	
Mixed	27 Mar		20 cuyd	
	3 Apr			
Transferred	9 May		24 cuyd	

COC		BTEX (ppb) ben zene	ethyl ben zene	tol uene	xy lenes	TPH (ppm)	(ppb) Naph tha lene	PAH (ppb) ace naph thene	ace naph thy lene	anthra cene	benzo (a) anthrac ene	benzo (a)py rene	benzo (b)flu oran thene	benzo (ghi) pery lene	benzo (k)flu oran thene	chry sene	dibenz o(a,h) anthra cene	fluo ran thene	fluo rene	indeno (1,2,3,-c,d)py rene	naph tha lene	phen anth rene	py rene	total
SSL		*20*	*5000*	*5000*	*74k*			*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL		*7*	*1500*	*1700*	*44k*		*200*				*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																							
654	323-4	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	1710	0	0	0	0	0	
	DL		*10*				*10*								*1650*									
654 note 1	368-1							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	DL														*6580*									
654 note 2	378-1					1510																		
	DL					*10*																		
TANK SITE TEST RESULTS ABOVE ...........BIOREMEDITION TEST RESULTS BELOW																								
Immunoassay 4/7	I-D1					>100 <400																		
Mix 4/8 note 3 location - triprelim	412-2					990		0	0	0	659	626	679	406	579	793	0	1540	0	360	0	646	1330	7618
	DL					*10*									*333*									
Immunoassay 4/22	I-DX					>75 <300																		
Immunoassy 4/23	I-DXA					<150																		
Mix 4/17	424-1	0	0	0	0		0	8080	0	10.6k	25.7k	18.2k	31.0k	10.6k	3240	30.2k	3740	36.7k	5830	11.9k	2480	34.4k	90.2k	3E+05
	DL		*1*				*1*								*1660*									
	424-2	0	0	0	0		0	0	0	196	688	561	799	349	0	802	0	1370	0	391	0	887	1220	7263
	DL		*1*				*1*								*163*									
Immunoassay 4/30	#1					<300																		
#1, #4 near and #2	#2					<300																		
from 424-1 hole	#3					<300																		
#3 near 424-2 hole	#4					<300																		

1) Resampled based on high DL above, results worst

2) TPH taken on same sample

3) PAH analyzed 4/14, TPH 4/18

LOT **D** **Method** C

COC	#	BTEX (ppb) ben zene	ethyl ben zene	tol uene	xy lenes	TPH (ppm)	(ppb) Naph tha lene	PAH (ppb) ace naph thene	ace naph thy lene	anthra cene	benzo (a) anthrac ene	benzo (a)py rene	benzo (b)flu oran thene	benzo (ghi) pery lene	benzo (k)flu oran thene	chry sene	dibenz o(a,h) anthra cene	fluo ran thene	fluo rene	indeno (1,2,3,-c,d)py rene	naph tha lene	phen anth rene	py rene	total
SSL		*20*	*5000*	*5000*	*74k*			*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL		*7*	*1500*	*1700*	*44k*		*200*				*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																							
Mix 4/17	432-1					790		1560	0	2220	4010	3340	3340	1750	2850	5030	0	8870	0	1990	728	7150	4700	47538
note 4	*DL*					*10*									*1660*									
Immunoassy 5/7	P-1					<300																		
from 424-1 PAH	P-2					>300																		
Jar (P) and Btex/N	B/N-1					>300																		
Jar (B/N)	B/N-2					<300																		
Four Corner 5/8	437-1					900		1880	0	2710	5610	4470	5450	1900	2980	5270	0	8300	1520	1970	0	8350	6590	57000
	DL					*10*									*331*									
Immunoassy 5/28	p1,p2							Total PAH <50K, <10K																
	p3,p4							Total PAH <34K, >6.7K																
Immunoassy 6/11	I-DM1	TPH: <667, <400																						
	I-DM2	TPH: <667, <400, <300, <200, <300, <200, <100, <100, <75, <50																						
Immunoassy 6/13	I-D-A	TPH: <400																						
	I-D-B	TPH: <400, <200, <100, >50																						
	I-D-C	TPH: <400, <200, <100, >50																						
	I-D-D	TPH: <400																						
Immunoassy 6/16	I-D-E1					>200																		
	I-D-E2					<200																		
Mix 6/16	463-2					1170		1710	0	0	5860	5260	7110	2530	4080	7370	0	13100	0	2930	0	9550	11200	70700
	DL					*10*									*1660*									
Mix 6/16	463-3					1040																		
	DL					*10*																		
Immunoassy 7/15	Lot D	TPH: <400, <200																						
Mix 7/14 (7/21)	476-4					1510																		
	DL					*25*																		
Immunoassy 7/31		TPH: <1000,<300, >75																						
Mix 7/29	487-5					1020		0	0	0	577	593	974	0	0	607	0	1130	0	381	0	635	952	5849
	DL					*10*									*327*									
Mix 7/29	487-6					322		2460	0	0	6650	6150	10800	0	0	6870	0	13300	0	0	0	12600	13900	72730
	DL					*10*									*1650*									
Mix 7/14 same as 476-4	495-1					1140	TPH of 388 (EPA 418.1), 260 (CA)																	
	DL					*10*																		

4) Reanalysis (5/6) of 424-2

LOT **D** **Method** C

COC		ben zene	ethyl ben zene	tol uene	xy lenes	TPH (ppm)	Naph tha lene (ppb)
		BTEX (ppb)					
SSL		*20*	*5000*	*5000*	*74k*		
RBSL		*7*	*1500*	*1700*	*44k*		*200*
Sample	**#**						
Mix 8/20@D-1 (8/21,8/25)	498-1					680	
	DL					*10*	
Mix 8/20@D-3 (8/21,8/27)	498-2					450	
	DL						

COC		ace naph thene	ace naph thy lene	anthra cene	benzo (a) anthrac ene	benzo (a)py rene	benzo (b)flu oran thene	benzo (ghi) pery lene	benzo (k)flu oran thene	chry sene	dibenz o(a,h) anthra cene	fluo ran thene	fluo rene	indeno (1,2,3,-c,d)py rene	naph tha lene	phen anth rene	py rene	total
		PAH (ppb)																
SSL		*20k*	*20k*	*430k*	*700*	*4000*	*4000*	*96k*	*4000*	*1000*	*11k*	*98k*	*16k*	*35k*	*3000*	*96k*	*140k*	
RBSL					*700*		*660*		*4600*	*660*	*2600*							
Sample	**#**																	
Mix 8/20@D-1 (8/21,8/25)	498-1	925	0	978	2690	2380	3670	1020	1810	2860	0	6100	782	1820	0	5160	6320	36515
	DL								*165 max*									
Mix 8/20@D-3 (8/21,8/27)	498-2	686	20	1060	2260	2300	2580	845	2410	2730	394	6190	527	928	131	3750	4460	31271
	DL								*167 max*									

Appendix C

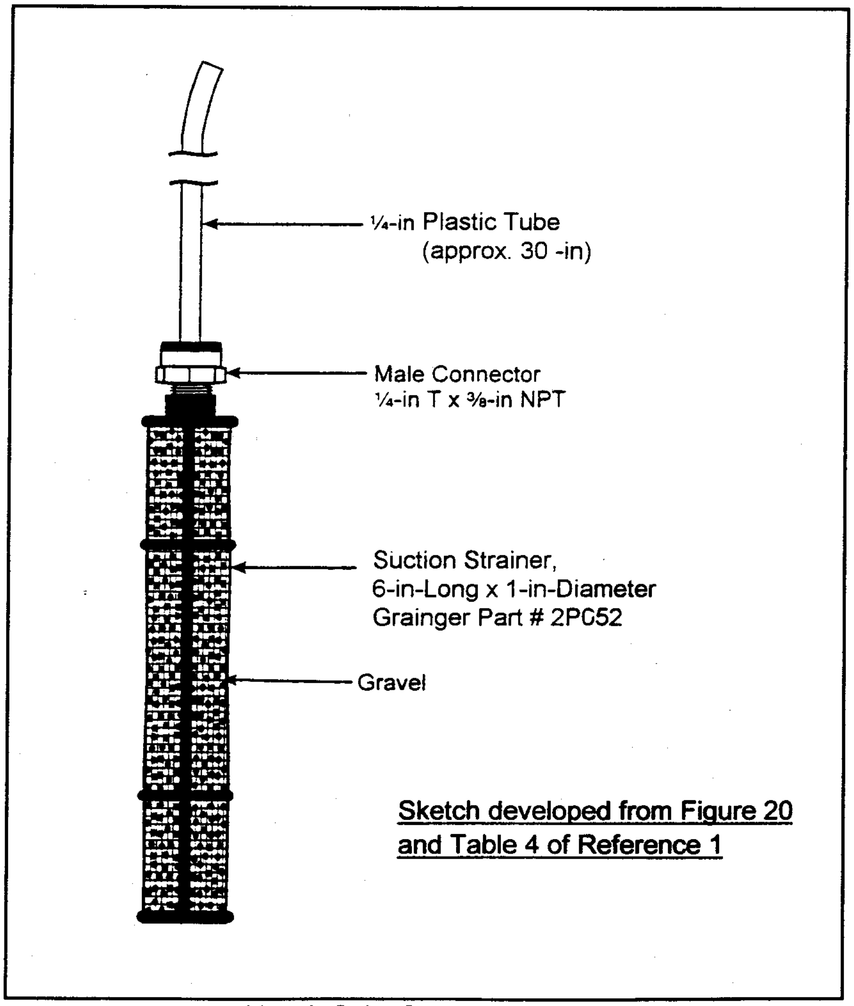
List of Equipment

Appendix C

List of Equipment

Table C-1

pH meter	*Accumet* Model AP 15 with electrode Model AP 20	- 1 - 1
thermometer	*Weksler Instruments*, 5" dia., 0-200^{0}F	- 4
O_2 meter	*MSA* MiniGard II used with collector similar to sketch	- 1 - 6
tensiometer	*Soilmoisture* Quick-Draw Model 290^{0}F1L	- 1
moisture meter	*Soilmoisture* resistance meter Model 5910A with gypsum blocks Model 5201	- 1 -10
tiller	*Befco* Model 266-232	- 1
tractor	*Case* Model 485, 45hp	- 1



Sketch C-1 - Oxygen Collector

Appendix D

Biopile Nutrient Addition Worksheet

Appendix D

BIOPILE NUTRIENT ADDITION WORKSHEET

1. Nutrient Source:
   a. Nitrogen source (e.g. urea) _*UREA*__ __*0.46*_ weight fraction nitrogen (urea = 0.46)[a]
   b. Phosphorus source (e.g. diammonium phosphate) _P_2O_5_ ___*0.45*__ weight fraction phosphorus
   c. Potassium source (e.g. potassium sulfate) _*POTASH*___ ____*0.60*___ weight fraction potassium

2. Total organic carbon content in soil: _*see 2b*_ mg/kg dry soil. Obtained from laboratory results. If unknown, calculate as below:
   a. Average concentration of hydrocarbon contamination in soil = ___*990*___ mg/kg dry soil
   b. Average carbon content in contamination = line 2a. x 0.8 = _____*792*__ mg carbon/kg dry soil

3. Desired C:N:P:K ratio. Determine by treatability tests, else use C:N:P:K = *100:15:1:1.*

4. Amount of nutrient to add per kg of dry soil. (If not known, assume negligible N,P,K content in soil prior to nutrient addition.)
   a. Nitrogen (N) needed to be added per kg dry soil = line 2b. x 0. 15 = ____*119*_ mg N/kg soil
   b. Phosphorus (P) needed to be added per kg dry soil = line 2b. x 0.01 = _____*8*_ mg P/kg soil
   c. Potassium (K) needed to be added per kg dry soil = line 2b. x 0.01 = ______*8*_ mg K/kg soil

5. Bulk density of soil = __*1400*__ kg/m^3[(b)] (Assume 1,400 kg/m^3 if unknown.)

6. Nutrients required per m^3 Of Soil:
   a. kg N/m^3 soil = line 4a. x line 5/1,000,000 = __*.17*___ kg N/m^3 soil
   b. kg P/m^3 soil = line 4b. x line 5/1,000,000 = __*.01*___ kg P/m^3 soil
   c. kg K/m^3 soil = line 4c. x line 5/1,000,000 = __*.01*__ kg K/m^3 soil

7. Pounds of nutrients required per cubic yards of soil
   a. lb N/yd^3 soil = line 6a. x 1.69 = ____*.28*___ lb N/yd^3 soil
   b. lb P/yd^3 soil = line 6b. x 1.69 = ____*.02*___ lb P/yd^3 soil
   c. lb K/yd^3 Soil = line 6c. x 1.69 = ____*.02*___ lb K/yd^3 soil

8. Total volume of soil to be treated by biopile: ____*24*__ yd^3

9. Pounds of nutrient source to be added per cubic yard of soil:
   line 7a./line la. = _____*.61*____ lb of N source required/yd^3Soil
   line 7b./line lb. = _____*.04*____ lb of P source required/yd^3 soil
   line 7c./line lc. = _____*.03*__ lb of K source required/yd^3 soil

10. Total pounds of nutrient sources required for the biopile:
    line 9a. x line 8 = ____*14.7*__ lb of N source[(c)] to be purchased
    line 9b. x line 8 = _____*1.0*__ lb of P source to be purchased
    line 9c. x line 8 = _____*0.8*___ lb of K source to be purchased

(a) Weight fraction = %/100.
(b) I kg/m^3 = 1.688 lb/yd^3.
(c) Assumes all N comes from a single source.
NA = not applicable.

Figure J-3. Biopile Nutrient Addition Worksheet. *(of Reference 1)*