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Bench Scale Treatability Study

LABORATORY BENCH-SCALE TREATABILITY STUDY

Lehigh Valley Railroad Derailment

Site #8-19-014, Genesee County

JANUARY 1996

Prepared by: Division of Hazardous Waste Remediation

New York State Department of Environmental Conservation

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EXECUTIVE SUMMARY

The Lehigh Valley Railroad Derailment Site is the location of a 30,000 gallon trichloroethene (TCE) spill which was caused by a train derailment in 1970. Following the accident, in early 1970's, the Lehigh Valley Railroad conducted limited cleanup efforts. As part of the investigation of another Inactive Hazardous Waste Disposal site, sampling of private wells east of the spill site by the New York State Department of Health (NYSDOH) and local county health units in 1990, indicated numerous private wells contaminated with TCE. Acting on this information the New York State Department of Environmental Conservation (NYSDEC) listed the site on the Registry of Inactive Hazardous Waste Disposal Sites. Using state funds, the NYSDEC started a remedial investigation/ feasibility study (RI/FS) in 1992. In April 1993, the NYSDEC released a report which described the extent of the surface and subsurface soil contamination at the derailment site. Based on this report, it was decided to separate the site into two operable units in order to accelerate remediation of the spill area. Operable Unit #2, the focus of this treatability study, addresses the TCE contaminated soils. Operable Unit #1, evaluates the widespread groundwater contamination resulting from the spill and is presently in the remedial investigation stage.

The feasibility study (FS) report for Operable Unit #2 (surface soils) was focused on remediation of the TCE contaminated soils at the former spill site. The preliminary screening phase of the FS was designed to select an appropriate list of remedial alternatives for further evaluation in the detailed analysis section of the FS. As a basis for the remedial selection process, the NYSDEC utilized United State Environmental Protection Agency (USEPA) guidance on "Presumptive Remedies". The first phase FS report was released in December of 1994. Following the public release of the first phase of the FS, the report was peer-reviewed by parties both within and outside of the NYSDEC. Three outstanding concerns were noted during the peer-review process which required further attention. One, the railroad accident occurred over twenty years ago and volatilization/ natural attenuation processes should have degraded the TCE in the soils. However, extensive TCE contamination (>200 ppm) is still found in very shallow soils (<6") indicating a remarkable persistence of volatile compounds. Second, elevated levels of organic carbon in the site's soils (as high as 14%) could potentially impact TCE removal efficiencies. Finally, mechanical volatilization has been used successfully at other sites in New York to remediate TCE contaminated soil and it was suggested that this technology could be utilized for the site.

To address these concerns it was decided that additional information was necessary to properly evaluate the alternatives in the FS and survey additional remedial approaches. To collect this information, the NYSDEC developed and implemented a laboratory bench-scale treatability study. The study involved taking small volumes of site soils and subjecting it to processes which imitate remedial technologies including, thermal desorption, vacuum extraction, mechanical volatilization and size separation. The study was conducted at the NYSDEC, Division of Hazardous Waste Remediation laboratory at Saratoga, New York.

In general, the findings of the treatability study indicated that vacuum extraction and low temperature thermal desorption were effective at remediating site soils. Both technologies provided TCE removal efficiencies above the predetermined study goal of 50 % contaminant reduction. Mechanical volatilization did not meet the study contaminant reduction goals. Finally, size separation or soil sieving, did not produce a coarse grained material with TCE concentration below the site's soil clean up objectives and therefore, would not reduce the volume of material which would require further treatment.

The treatability study provided site-specific information necessary to aid in the selection of an appropriate and cost effective remedy for the Lehigh Valley Railroad Derailment site. The concerns raised after the release of the first phase FS were addressed and sufficient data was collected during the treatability study to assist the remedial alternative selection process. The treatability study provides a basis for the detailed analysis of the remaining alternatives in the second phase of the FS.

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LEHIGH VALLEY RAILROAD DERAILMENT SITE #8-19-014, GENESEE COUNTY LABORATORY BENCH-SCALE TREATABILITY STUDY REPORT

1.0 Introduction:

The Lehigh Valley Railroad Derailment Site ("the Site") is listed on the New York State Registry of Inactive Hazardous Waste Disposal Sites as a class two. A class 2 designation indicates that the New York State Department of Environmental Conservation (NYSDEC) has determined that the site poses a significant threat to the environment and/ or public health and remedial action is required. Previous site characterization data (reference #1) indicates surface and subsurface soils are contaminated with volatile organic compound (VOCs), in particular trichloroethene (TCE). Based on this information and the complexity of the groundwater problems the site was divided into two separate operable units (OPs). OP #1, is addressing the groundwater contamination found in a karst bedrock system and is presently in the remedial investigation phase. OP #2 address the surface and subsurface soils contaminated with TCE and is the focus of this report.

This report is the first part of a three-tiered approach to select an appropriate remedial technology which addresses the contaminated surface and subsurface soil. (OP #2). The approach consists of 1) laboratory bench-scale treatability study, 2) field-pilot scale testing, if necessary and 3) a final (second phase) feasibility study.

2.0 Treatability Study Goals:

The first phase feasibility study (FS) for the site (reference #2) described several alternative remedial strategies which survived the preliminary screening, including thermal desorption and vacuum extraction. Following the release of the FS report, a peer-review of the report noted three outstanding concerns which needed to be addressed. First, the railroad tanker spill occurred over twenty years ago and volatilization and natural degradation of TCE would be expected. However, extensive TCE soil contamination (up to 550 ppm) is found in extremely shallow soils (some as shallow as 6 inches) indicating a remarkable persistence of volatile compounds. As such, the ability to treat the site soils was questioned. Second, mechanical volatilization is considered by NYSDEC to be an innovative technology to remediate TCE contaminated soils and additional information on the technology's viability seems warranted. Finally, elevated organic carbon levels in the soils (as high as 14%) could potentially impact TCE removal efficiencies. To address these concerns, additional information was necessary to properly evaluate the remaining alternatives in the detailed analysis or second phase FS. The laboratory bench scale treatability study was designed to gather the necessary information.

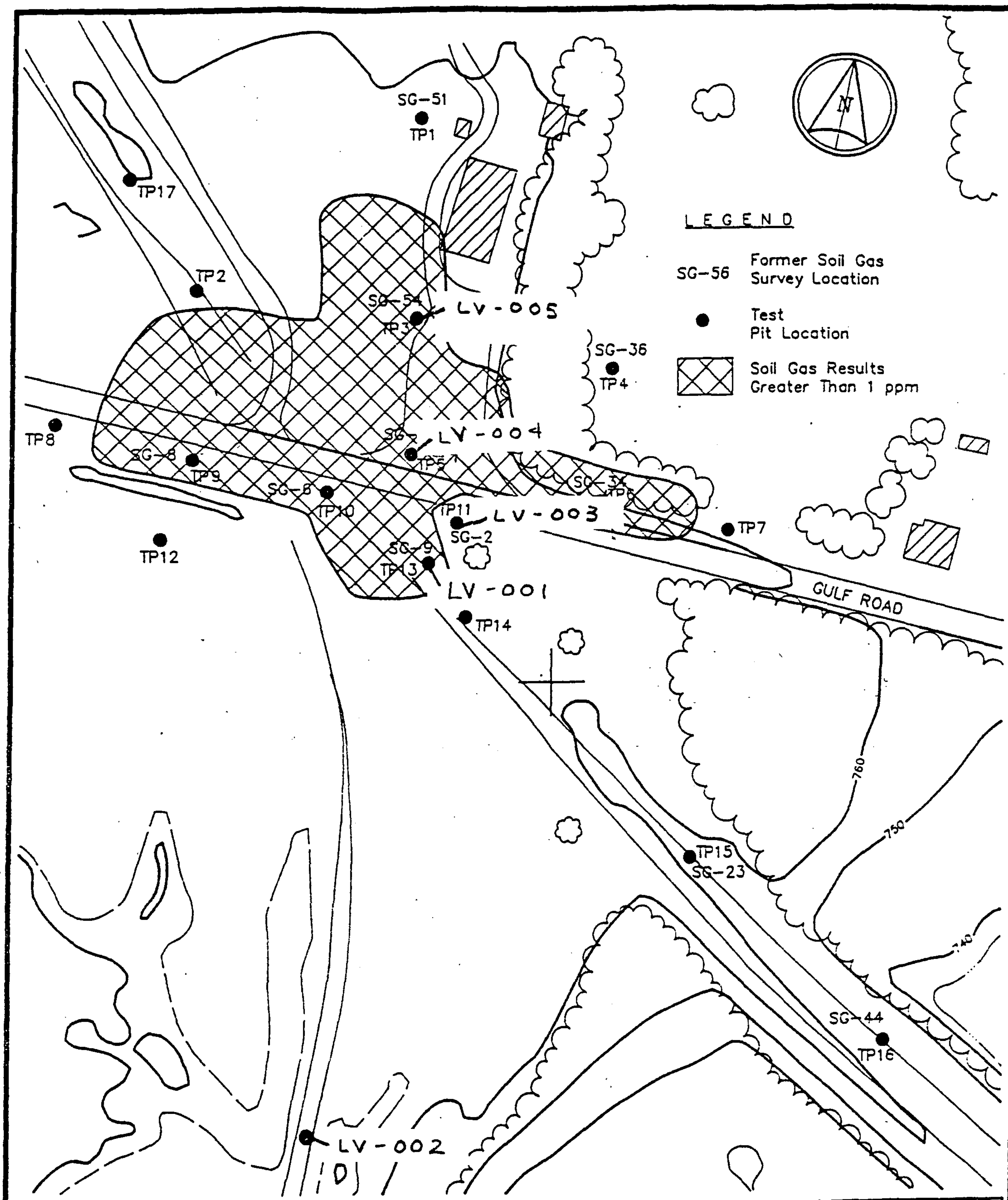
Previous site characterization indicates elevated organic carbon levels in some soil samples, as high as 14.3 % (reference #3). Because of elevated organic carbon content of the site soils there are concerns that TCE will not be liberated via the volatilization, vacuum or thermal processes. This study was designed to provide insight into the viability of several remediation processes in meeting the treatability project goals.

The laboratory bench-scale treatability test was designed to determine the viability of four remedial technologies to remediate Lehigh Valley Railroad Derailment Site soils: 1) mechanical volatilization, 2) size separation, 3) vapor extraction and 4) low temperature thermal desorption. As suggested by USEPA guidance (reference #4) the predetermined performance goal to evaluate the validity of a technology was a contaminant reduction in soil of 50%. If the performance goal was met, the technology was then compared to the anticipated soil cleanup criteria for the site (see below).

An additional evaluation of a technology's effectiveness was to compare results to the soil clean up objective as determined by NYSDEC, Division of Hazardous Waste Remediation, Technical and Administrative Guidance Memorandum # 4046, "Determination of Soil Clean Up Objectives" (DHWR-TAGM # 4046). The TAGM-4046 utilizes partitioning theory to estimate soil concentrations which are considered protective of groundwater resources. Appendix A presents the calculation of cleanup objectives for TCE in site soils. In general, at a one percent soil organic carbon level, the site soil cleanup objective for trichloroethene (TCE) would be approximately 0.5 ppm. The site wide soil organic carbon level was estimated at 3.5% (reference # 3). Utilizing the TAGM-4046, procedure a soil cleanup objective for TCE of 1.75 ppm is calculated. Soils collected for the treatability study had an average soil organic carbon content of 8.5%. This would produce a soil clean up goal of 4.25 ppm.

3.0 Treatability Study Procedures:

On May 25, 1995, contaminated soil was collected from the TCE source area, north of Gulf Road. The samples were collected at the approximate location of Test Pit #5 and soil sample location LV-004 (see figure #1). Past site characterization (reference #1 & 3) indicates the TCE concentrations of these soils ranged from 100-200 ppm. The soil collected on May 25th was described as a dark grey mixture of silt, sand and angular gravel, possibly fill. Some black cinders and coal bottom ash were observed. The sample was collected approximately 2 to 2.5 feet below grade and there were significant photoionization detector readings from the soil (approximately 100 ppm) at the time of the sampling. Five quart sized jars were collected, transported on ice and stored at 4° C at the NYSDEC Laboratory in Saratoga until the treatability tests were conducted.



DUNN GEOSCIENCE ENGINEERING CO., P.C.
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TEST PIT LOCATIONS
(WITH SOIL GAS POINTS WHERE APPLICABLE)

NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WORK ASSIGNMENT NUMBER: 0002520-15.1

LEHIGH VALLEY RR DERAILMENT SITE

PROJECT NO. 00296-02379	DATE 11/92	DWG. NO. A9181	SCALE 1"=100'	FIGURE NO. 1

Analytical results of the site soils collected on May 25th indicate TCE concentration ranging from 91 to 106 ppm with an average TCE concentrations of 98.7 ppm. This is in the range of previous site characterization results.

The initial soil characteristics for the soil tested are as follows:

Initial TCE concentration: (based on three samples)	Range; 91 - 106 ppm
	Study Average; 98.7 ppm
% Moisture:	10 %
Organic Carbon:	Range; 7.7 - 9.3 %
	Study Average; 8.5 %
Percent Total Solids:	Range; 83 - 86 %
	Study Average; 84.5 %
Soil Characteristics:	29.9% Gravel
	66.4 % Sand
	3.7 % Silt and clay

On June 1, 1995 and again on June 8, 1995, four specific batch treatability tests were conducted on possible remedial treatment alternatives. The tests included mechanical volatilization, grain-size separation, thermal desorption and vacuum extraction. The batch tests all involve small volumes of soil. Critical parameters measured included VOCs, percent moisture, organic carbon, temperature and reaction time.

For some of the tests the soil was "stockpiled" prior to the run. The stockpiling involved leaving the soil covered overnight under a fume hood. The purpose was to simulate actual field conditions of material handling and temporary storage of the material at the site.

3.1 Grain-Size Separation:

The intent of this test was to determine if the VOC contamination was related to soil particle size. A mechanical shaker table commonly used in soil engineering tests was used for the experiment. The duration of shaking was 5 minutes. A known weight of soil was sieved into coarse, medium and fine fractions. After sieving, the fractions were tested for VOCs, % moisture and organic carbon. The following flow chart represents the tests:

Weigh initial soil sample
[s]
↓
Sieve
↓ ↓ ↓
Fine Medium Coarse
[s] [s] [s]
(weigh each fraction)

[s] - indicates sample for VOCs, organic carbon and percent moisture, unless noted.

Two grain-size separation tests were conducted. The first was on soil taken directly out of cold storage. This test was run with a number 4 and #30 sieve.

A second test was run on soil that was "stockpiled" overnight. The intent of the second test was to simulate stockpiling of soil which is commonly done in the field during remedial projects. A number 4, 10 and 20 mesh sieves were used.

3.2 Standard Sieve Analysis:

To determine a grain-size distribution, a standard sieve analysis commonly used by soil engineers (reference # 5) was conducted on a sample dried in an oven, overnight at 103-105°C. No analytical samples were collected.

3.3 Mechanical Volatilization:

To determine the viability of mechanical volatilization a sample was agitated to simulate on-site aeration. A known weight of soil was placed in a bowl and attached to a mechanical mixer. Paddles were attached to the mechanical mixer which was operated at maximum speed. Soil samples were collected at 1, 5 and 10 minute intervals for analysis.

Weigh initial sample

[s]

↓

mechanical volatilization

↓

[s] - 1 minute; [s] - 5 minutes; [s] - 10 minute intervals

3.4 Low Temperature Thermal Desorption:

Low temperature thermal desorption (LTTD) treatment is considered by NYSDEC to be a proven technology and could likely be the preferred remedy if the other technologies proved ineffective. It was not anticipated that the high organic carbon content would prevent release of TCE from the soil, but it appears prudent to prove the effectiveness of thermal desorption.

A known weight of soil was place in a laboratory oven and heated without agitation or aeration, to 250° F. Soil samples were collected 5, 10, 30 and 60 minute intervals.

Weigh initial soil

[s]

↓

thermal

desorption

↓

[s] - 5 minutes, [s] - 10 minutes, [s] - 30 minute,

[S] - 60 minute intervals.

3.5 Vacuum Extraction:

A known weight of sample was placed in an Erlenmeyer flask and a strong vacuum of approximately 25 inches of mercury was applied by a vacuum pump. No air flow was induced through the sample. Only one soil sample was collected after 60 minutes.

4.0 Analytical Procedure:

Soil samples were collected and analyzed for volatile organic compounds (VOCs) and organic carbon content. The VOCs were analyzed at the NYSDEC laboratory in Saratoga and the organic carbon samples were analyzed via a NYSDEC contract laboratory (Ecology and Environment). The soil was analyzed for VOCs as per NYSDEC Analytical Service Protocol

(ASP), December 1992. The organic carbon analysis was conducted as per ASTM Method D-2974 as prescribed in the ASP. See Appendix B for the raw analytical results.

5.0 Findings and Results:

The test results were evaluated and compared to the stated goals of the treatability study. The findings and results of the various tests will be used for subsequent phases of the feasibility study.

5.1 Grain-Size Separation:

The intent of this test was to determine if the VOC contamination was related to soil particle size. Size separation could be used as a remedial technique to reduce the volume of material that would require further treatment. For example, a coarse-grained gravel could be screened out and placed back on-site without treatment if the TCE contamination is below the soil cleanup objectives. Two grain-size separation test were conducted.

Test #1: The first test was on soil taken directly out of cold storage. In general this test proved inconclusive because of material handling problems. Table 1 presents a summary of the analytical results. No soil passed the # 30 sieve; therefore, there was no fine fraction to test for chemistry. The coarse material (not passing the #4) represented 49 % of the total weight. The TCE concentration of the coarse fraction was 59 ppm which is well above the soil cleanup objective of 1.75 ppm. As such, sieving did not produce a coarse grained material which met soil cleanup objectives and therefore, did not reduce the volume of material which would require treatment. The medium fraction (the material which passed a #4 and did not pass the #30 sieve) appeared as small balls of soil. There appeared to be some type of binding agent, possibly high soil moisture (17%) and elevated organic carbon, which caused the soil to "ball up" and prevent the sieving of a fine fraction. The medium fraction had a TCE concentration of 143 ppm. The mass balance indicated that a majority of the contamination, over 81.5 %, is associated with this fraction.

TABLE #1
Lehigh Valley Railroad Derailment, Site #8-19-014
Soil Treatability Study
Grain-Size Separation

Test #1	Initial Soil	Coarse Fraction not Passing #4	Medium Fraction Passing #4 but not #30	Find Fraction Passing #30
Weight of Soil (grams)	150	73.9	76.7	0
Size Distribution % of Total	--	49.3	51.1	--
Volume Distribution % of Total	--	45.5	55.5	--
TCE Concentration (ppm)	91	59	143	--
TCE Mass in Fraction (grams)	0.0135	0.00436	0.011	--
%TCE in Fraction from Total	--	32.3	81.5	--
% Moisture	10	4	17	--

A volume measurement was conducted using a graduated cylinder filled with water to a known volume. The initial reading was 250 ml. When the coarse fraction was added, the level increased to 275 ml and when the fine fraction was added the level measurement was 305 ml. Therefore the coarse fraction represents 45 % of the overall volume and the medium fraction was 55 %.

Test #2: The second test was run on soil that was "stockpiled" overnight. The intent of the second test was to simulate stockpiling of soil in the field. A # 4, 10 and 20 mesh sieves were used. Table 2 presents the result of the second test. In general, the stockpiling of the soil made the soil more amenable to sieving. The fine fraction (passing # 20) was 12.7 % of the total sample weight. The largest percentage by weight was the coarse fraction (not passing #4) which was 37.5 %. The two medium fractions (passing a #4 but not #10 & passing a #10 but not a # 20) were 23.4 % and 24.2 % respectively.

The TCE appeared to be associated with the smaller particle size with over 48 % of the TCE mass found in the material passing a # 10 sieve. Further the fine fraction (passing a # 20 sieve) had the highest organic carbon content (20%) as compared to the course fraction (6%). Therefore the fine material had both a higher TCE concentration and elevated organic carbon content. The coarse fraction had a TCE concentration of 15 ppm which is considerable below the initial concentration of 57 ppm. The coarse soil fraction represents only 9.9 % of the total TCE mass but 37% of the total soil weight. However, the course material would still require some type of remediation to reach the clean up objective of 1.75 ppm or 4.25 ppm.

TABLE #2

Lehigh Valley Railroad Derailment, Site #8-19-014

Soil Treatability Study

Grain-Size Separation

Test #2	Initial Soil	Coarse Fraction not Passing #4	Medium Fraction		Find Fraction Passing #30
			Passing #4 but not #20	Passing #10 but not #20	
Weight of Soil (grams)	200	75.1	46.7	48.5	25.4
Size Distribution % of Total	--	37.5	23.4	24.2	12.7
TCE Concentration (ppm)	57.0	15	26	57	107
TCE Mass in Fraction (grams)	0.0114	0.00113	0.00121	0.00277	0.00272
TCE % in Fraction from Total	100	9.9	10.6	24.3	23.9
% Organic Carbon	7.7	6	10	10	20

Of interest was the low initial TCE soil concentration for test #2 which appears to be associated with soil stockpiling or possible sampling uncertainty. The study average initial soil TCE concentration was 98.7 ppm compared to the stockpiled initial concentration of 57 ppm. It is possible that volatilization occurred during the stockpiling. Further, the TCE mass balance for the grain-size distribution (test #2) indicated that 31.1% of the TCE was not accounted for in the sieved fractions and volatilization is considered the most probable mechanism for this removal. Assuming the study average initial TCE concentration of 98.7 ppm to simulate a mass balance, the stockpiling removed 42.2 % of the TCE mass and the combined process of sieving + stockpiling removed 60.3 % of the total TCE mass.

5.2 Sieve Analysis:

To determine a grain-size distribution a standard sieve analysis was conducted on an oven dried sample (reference #5). The results are summarized on Table 3. Figure 2 presents a graphical representation of the data which provides insight into the physical makeup of the sample. The sieve analysis indicated that 54.9 % of the sample consists of gravel size material larger then #10 sieve (2.0 millimeters), 41.4 % of the sample consists sand grains larger then 0.075 mm and only 3.7 % of the sample consists of silt or clay sized grains smaller then #200 sieve (0.075 mm). Of interest is the low percentage of a silt/clay fraction (only 3.7 %) which differs from field observations which described the soil as a silty sand (reference 1 & 3). This is possibly due to the predominance of fill material reported at the sampling location.

TABLE #3

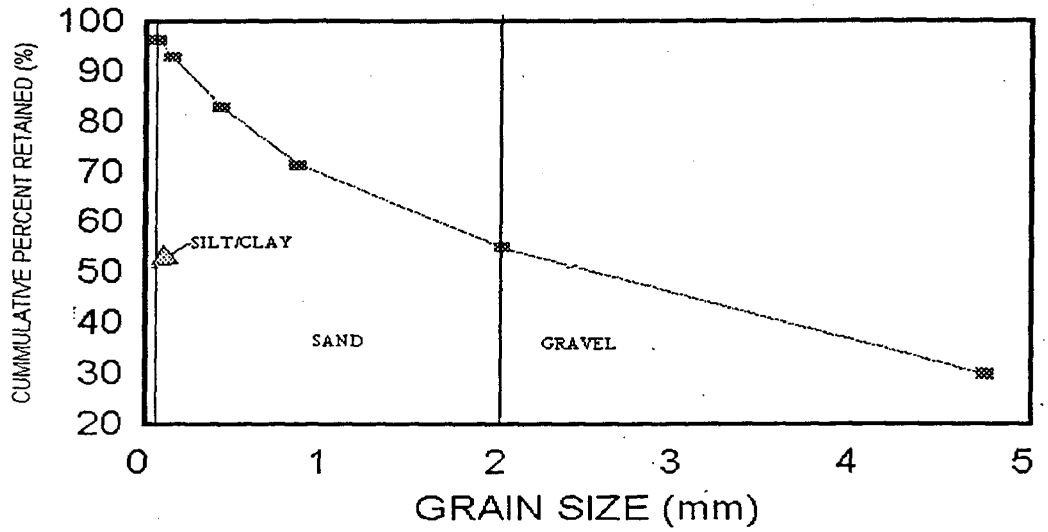
Lehigh Valley Railroad Derailment, Site #8-19-014

Soil Treatability Study

Grain-Size Distribution

Sieve Size Opening (mm)	Cumulative Weight Retained (gm)	Cumulative Percentage Retained (%)
3/4 " (19)	0	0
#4 (4.75)	52.3	29.9
#10 (2.0)	96.1	54.9
#20 (0.85)	124.9	71.4
#40 (0.425)	145.0	82.9
#100 (0.150)	162.6	92.9
#200 (0.075)	168.6	96.3
Bottom Pan	175.7	100.4

FIGURE 2: GRAIN SIZE DISTRIBUTION



<u>AASHTO Soil Classification System (1970)</u>

Soil Type	Size Distribution (mm)
Gravel	2.0 - 75
Sand	0.075 - 2.0
Silt	0.002 - 0.075
Clay	0.001 - 0.002

Using AASHTO soil Classification to describe Lehigh Valley Soils

54.9%	Gravel
41.4%	Sand
3.7%	Silt & Clay

Note: AASHTO - American Association of State Highway Transportation Officials

5.3 Mechanical Volatilization:

Mechanical volatilization has been used successfully in New York to treat soils with low levels of TCE (reference #6). The intent of this part of the treatability test was to determine the viability of mechanical volatilization to treat site soils. As with the other tests, the elevated soil organic carbon content of site soils raises concerns with the ability of agitation to strip off TCE.

During the test, there appeared to be a build up of fine materials at the edges of the container used in the mixing experiment. The build up of fine material could have been caused by the excessive moisture of the site soils, a binding agent or because the soil temperature had not reached equilibrium with ambient conditions. The moisture content of the soil was approximately 10 % and the soil was cool after removal from cold storage of 4°C.

The results of the experiment indicated that the mechanical volatilization did not reduce VOC concentrations. Table 4 presents a summary of the test results. Of interest is the increase of contaminant concentrations with time in the mixing apparatus. Of course, this is not possible and is probably related to sampling error. Because of the build up of fine material in the sides of the mixing bowl, the sampling appeared to be biased towards fine materials. Further, the results did not replicate the apparent loss of TCE via volatilization that was observed during the grain-size distribution experiment. As discussed previously in section 5.1, both stockpiling the soil and agitation in the shaker table appeared to volatilize the TCE from the soil; however, this was not observed in the experiment designed to encourage volatilization.

TABLE #4

Lehigh Valley Railroad Derailment, Site #8-19-014

Soil Treatability Study

Mechanical Volatilization

	TCE Concentration (ppm)
Initial Soil	106
Shaker 1 Minute	117
5 Minutes	128
10 minutes	288

If future mechanical volatilization tests are considered, the mixing bowl should be redesigned to reduce packing of fine materials into the corners of the container and sampling efforts should be focused on collecting a soil with a more uniform size distribution. Further, a mixer which imparts higher energy to the soil, such as a kitchen blender, could be used. Finally, soil stockpiling possibly reduces moisture content and allows the soil temperature to reach equilibrium with ambient air conditions. Therefore, stockpiling may prevent the build up of fines and allows for better mixing of the soil matrix. The stockpiling experiment did appear to improve soil handling conditions during the grain-size separation study and may work for mechanical volatilization.

5.4 Low Temperature Thermal Desorption:

Low temperature thermal desorption (LTTD) has been used successfully at a number of sites in the State of New York for soil contaminated with VOCs and semi-VOCs. LTTD is no longer considered an innovative technology and therefore passed the initial screening in the FS. However, due to high organic carbon content of site soils, it appears prudent to prove the effectiveness of LTTD technology.

The test result are summarized in Table 5. As stated previously, a known weight of soil was placed in a laboratory oven and heated to 250°F. Soil samples were withdrawn at 5, 10, 30 and 60 minute intervals. At the end of 60 minutes, over half (54.5 %) of the TCE had volatilized. This indicates that thermal desorption was a viable technology to remove TCE from site soils. Of note, was the drop in the organic carbon content of the soil from 9.3 to 4.2

% during the hour low test period. This represents an organic carbon removal of 54.8% which was similar to the TCE removal rate. It appears that a high percentage of the organic carbon content of site soil was a material which was easily volatilized at relatively low temperatures. It is noted in the literature that organic carbon content of soil is not a homogeneous mass but a heterogeneous mixture of organic chemicals (reference #7). TCE can be preferential adsorbed to different organic chemicals that comprise the soil organic carbon content. It is possible that the TCE liberated in the experimented was adsorbed on the easily volatilized fraction of the soil organic carbon. Therefore, the ability to strip the TCE from the site soils may be associated with the ability to volatilize the organic carbon.

TABLE #5
Lehigh Valley Railroad Derailment, Site #8-19-014
Soil Treatability Study
Low Temperature Thermal Desorption

	TCE (ppm)	%TCE Removal	Organic Carbon %	Organic Carbon Removal %
Initial	99	--	9.3	--
Thermal Desorption (TD) - 5 Minutes	68	31.3	--	--
TD - 10 Minutes	73	26.3	--	--
TD - 30 Minutes	62	37.4	--	--
TD - 60 Minutes	45	54.5	4.2	54.8

Note: Removal Efficiency = $\frac{(\text{Initial} - \text{Observed})}{\text{Initial}}$ 100

5.5 Vapor Extraction:

To determine the viability of vapor extraction, 200 grams of soil was subjected to a strong vacuum. For this specific test no initial soil sample was not collected and the study average initial TCE concentration of 98.7 ppm was used to evaluate the removal efficiency.

The final soil concentration after the hour test was 45 ppm. The calculated removal efficiency for the hour long test was 54.4%. This indicates that vacuum treatment provided similar treatment as the LTTD.

6.0 Conclusions:

All of the laboratory tests assumed that site contaminated soil would be excavated during remediation. No in-situ treatment technologies were evaluated. The following conclusions are presented.

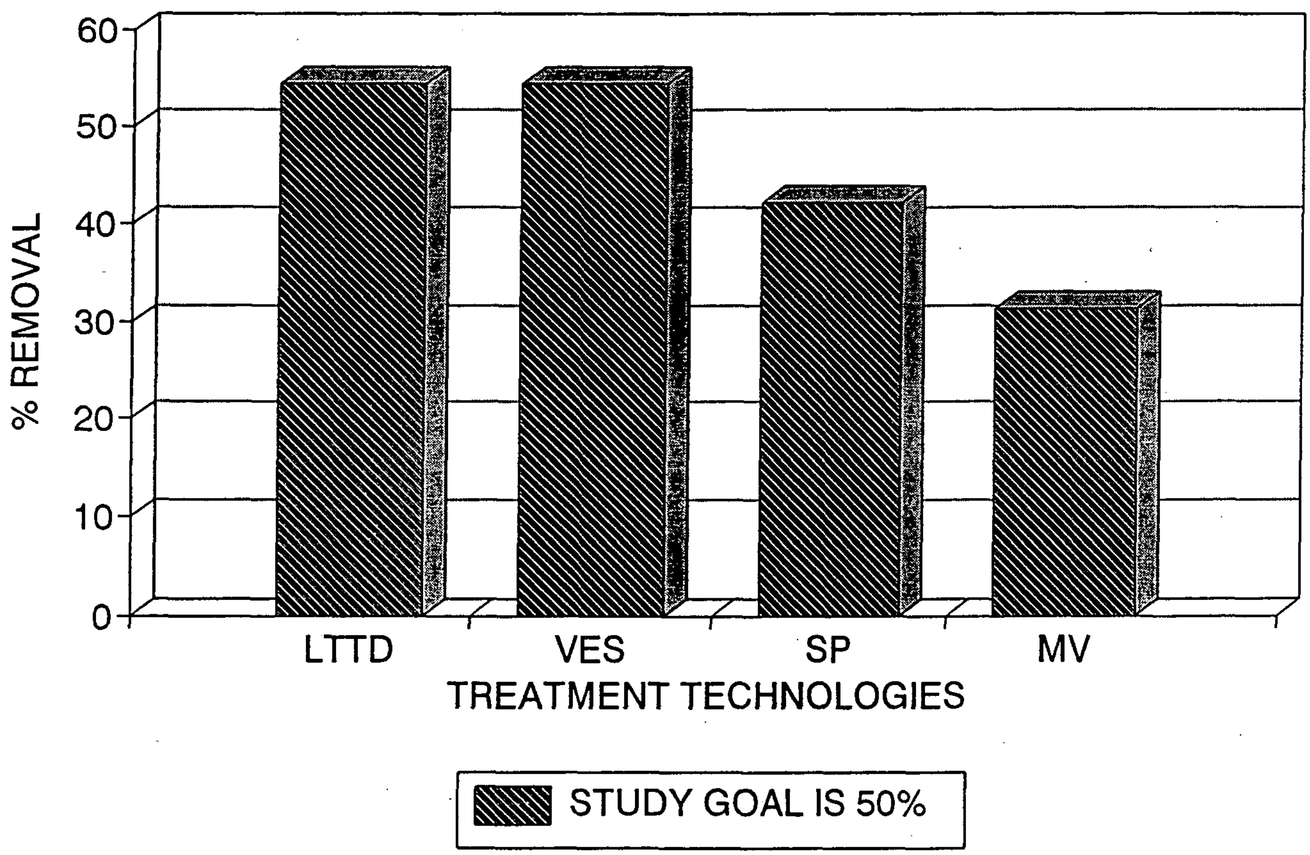
1. Soil sieving of the "raw" soil (not stockpiled overnight) proved difficult due to either excessive soil moisture, low soil temperature, or some type of binding agent in the soil. Possibly the combination of the soil moisture (10%) and the elevated organic carbon content (8.5 %) combined to produce the material handling problems.

2. Stockpiling of the soil reduced TCE concentrations from an initial study average of 98.7 to 57 ppm. This produced a significant TCE reduction of 42.2 %. However, duplication of this reduction would not be expected in actual field conditions because a stockpile would have a large volume of soil and a relatively small surface area exposed to the air.

3. Soil that was stockpiled by standing overnight produced a material that was easier to work and at a lower TCE concentration. It appears that if ex-situ technologies are selected to remedy the site, material preparation prior to treatment (e.g. stockpiling or drying) would be appropriate.

4. Figure 3 shows a comparison of the technology's removal efficiencies. The study indicated that thermal desorption and vacuum extraction are viable technologies to treat the Lehigh Valley Railroad Derailment soils. The two technologies had removal efficiencies over the study goals of 50%.

FIGURE # 3
REMOVAL EFFICIENCY



LTTD: Low Temperature Thermal Desorption
VES: Vapor Extraction
SP: Stockpilling
MV: Mechanical Volatilization

5. Mechanical volatilization proved ineffective at treating the TCE in site soils but there were some concerns with the testing methodology. If the grain-size distribution mass balance is used to estimate the removal efficiency of mechanical volatilization, the reduction is 31.3%, which is below the study goal.

6. The coarse fraction had lower TCE concentrations then the initial soil and it appears that a majority of the contamination is associated with the medium and fine fractions. However, sieving alone did reduce the volume of material which would require further treatment because the coarse soil fraction still had TCE concentrations above soil clean up objectives.

7. Low temperature thermal desorption (LTTD) proved effective at removing the TCE. However, at a slower rate then was expected. It was expected that the majority of the contamination would have quickly volatilized but a significant amount of the TCE mass 45.5% remained after one hour. It should be noted that a review of the LTTD technologies evaluated by the EPA SITE program indicate that temperatures of thermal desorption systems tend to be higher then that used in this study. Four vendors evaluated by the SITE program (reference # 8) had thermal desorption system temperatures between 400 - 1200 °F as compared to the 250 °F used for this experiment. Therefore, it could be anticipated that use of higher temperatures would be more effective at releasing TCE from the site's soils.

8. Vapor extraction experiment produced adequate removal of TCE from site soils and the removal efficiencies were comparable to thermal desorption. Due to the design of the experiment, no flow of air was induced over or through the soil. Therefore it is likely that removal efficiencies for a system designed to produce an air flow through the soil could be much higher.

9. The grain-size analysis indicated that the percent of small grain-sized particles (silt and clay) was only 3.7 % of the total sample. This result is different from geologic field observations (see reference # 1 & 3) which implied a silty-sand matrix. Of note, was the high organic carbon content of the fine fraction found during the size separation experiment (20%). This helps explain the test results of the grain-size distribution test #2 were the material passing a # 20 sieve (fine fraction) was only 12.7% of the total weight but one-quarter of the total TCE mass.

7.0 Recommendation:

The following alternatives are presented for evaluation followed by a recommendation for future action.

7.1 Alternatives:

1. Conduct further laboratory bench testing - Additional test to consider are as follows:

   a. Improve the mechanical volatilization experiment by redesigning the mixing apparatus to prevent the build up of fine materials. Also a kitchen blender, or similar mixer could be used to impart more energy on the system.

   b. Run the thermal desorption experiment at a higher temperature (say, 600°F). This would be more consistent with the operating temperature of present thermal desorption technologies. Increased temperatures would be expected to increase the rate of TCE removal and provide for a better removal efficiency.

   c. Re-design the vacuum extraction experiment to allow for air flow over and through the soil. This should enhance removal efficiencies.

d. Double check the grain-size distribution experiment to verify the lack of silt and clay sized material in the site's soils. Collect samples from other locations at the site to derive a site average soil distribution.

2. Conduct field treatability testing of mechanical volatilization and vacuum extraction. It may be appropriate to conduct a mechanical volatilization experiment on-site using mixing technology more closely associated with a pugmill mixer. This would allow for a better determination of the technology viability and allow for the evaluation of air emission impacts. In addition, an in-situ vacuum extraction pilot test would assist in determining the viability of this in-situ remedial technology.

3. Continue with the feasibility study on the site surface soils. By continuing the FS it is assumed that sufficient information is available to properly screen alternatives in a second phase feasibility study (FS).

7.2 Proposed Action:

It is recommended that the FS for the Lehigh Valley Railroad Derailment Operable Unit #2 (surface soils), go forward. It appears that sufficient information has been obtained on the technologies that passed the preliminary screening in the first phase to allow for the continuation of the FS. The technologies evaluated (thermal desorption, vacuum extraction, grain-size separation and mechanical volatilization) have been compared to both the study goals and the soil cleanup objectives and sufficient information is available to determine the viability of the technologies to remediate the site's soils. The findings and conclusions in this report are sufficient to allow for selection of a final remedy for the site in the second phase of the FS.

References:

1. Dunn Geoscience, Spill Site Soil Investigation Report, Lehigh Valley Railroad Derailment Site RI/FS, April 1993.

2. NYSDEC, Lehigh Valley Railroad Derailment, Operable Unit #2 (Surface Soils), First Phase Feasibility Study, December 1994.

3. NYSDEC, Lehigh Valley Railroad Derailment, Field Sampling report, March 1995.

4. USEPA, Guide for Conducting Treatability Studies under CERCLA, Interim Final, EPA/540/2-89/058, December 1989.

5. Driscoll, F., Groundwater and Wells, 2nd ed, 1986.

6. O'Brien and Gere Technical Services, Soil Remediation Activities Interim Remedial Measures, Accurate Die Casting Site, October 1994.

7. Dragun, J., The Soil Chemistry of Hazardous Materials, 1988.

8. USEPA, Superfund Innovative Technology Evaluation Program, Technology Profiles, Seventh Edition, November 1994.

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APPENDICES

15 (12-75)

New York State Department of Environmental Conservation

MEMORANDUM

TO: David A. Crosby, BWRA
FROM: Ajay Shroff, Technology Section, BPM
SUBJECT: Lehigh Valley Site, Operable Unit #2, # 8-19-014

DATE: JUN 15 1994

This is in response to your memo of June 7, 1994 requesting soil cleanup levels at the referenced site. A brief review of the SCFS submitted with the memo has been completed. As you know, the normal procedure for determining a cleanup level is that the Technology Section first recommends a cleanup objective. The feasibility of attaining this cleanup objective is then evaluated in detail during the feasibility study, resulting in a cleanup level in the selected remedy.

As indicated in the TAGM # 4046, correction factor accounts for various mechanisms such as volatility, sorption and desorption, leaching and diffusion, transformation and degradation, and change in concentration (dilution) of contaminants after reaching and/or mixing with the groundwater surface. A correction factor of 100 is used for the contaminated soil not very close to the groundwater table. However if the contaminated soil is very close (<3'-5') to the groundwater table or in the groundwater, a correction factor of 100 may not be justified. As indicated in the SCFS for the site, a part of the contamination at the site is in groundwater. Based on the review of the site's SCFS, the Technology Section recommends correction factors of 65 for the volatile contaminants and 55 for the semivolatile contaminant as specified in the SCFS. This is based on the assumption of a normal groundwater flow underneath the site.

Based on the submitted information and using the above recommended correction factors, the attached Table 1 provides soil cleanup objectives for organic contaminants at the referenced site. Also, the attached Table 2 provides the soil cleanup objective for Mercury. Although the remedial goal of the New York State Department of Environmental Conservation for waste sites in New York State is to return the environmental to pre-disposal conditions, the alternative more realistic cleanup objectives which are protective of both health and environment are provided in Table 1 and Table 2. The proposed cleanup objectives are based on the revised ground water standards (TOGS 1.1.1 dated September 25, 1990), and the revised TAGM #4046. Also, as the contaminated soil is in or very close to groundwater, only the groundwater protection goal and not the USEPA health based goal (which is more stringent) has been recommended as the soil cleanup objective for Benzo(a)pyrene. The Technology Section (TS) has considered the following in developing soil cleanup objectives; (a) environmental concentrations which would be protective of groundwater quality; and (b) contract required quantitation limits. Water/soil partitioning is used to determine soil cleanup objectives which would be protective of groundwater quality for its best use.

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Soil cleanup objectives for the organic contaminants are determined to be protective of New York State groundwater quality. It is my recommendation that you review these cleanup objectives with the Department of Health (DOH).

An average soil background value is recommended as soil cleanup objective for the heavy metal contaminant, as shown in the attached TABLE 2. For determining site-specific soil background concentration for Mercury, the soil background samples should be free from the influences of this and any other hazardous waste site(s); ideal background samples may be obtained from uncontaminated upgradient and upwind locations.

Please note that these recommended cleanup objectives should be treated as cleanup goals. The economic and engineering feasibility of attaining the recommended cleanup objectives should be addressed during the screening and evaluation of remedial alternatives. Also, as most of the contaminated soil is underneath the facility, the economic and engineering feasibility of removing the volume of contaminated soil should also be evaluated in establishing final soil cleanup levels.

If you have any further questions, please contact me at 485-8792.

cc: J. Harrington
J. White

TABLE 1
Recommended soil cleanup objectives (mg/kg or ppm)
Lehigh Valley Site, # 8-19-014

Contaminant	Partition coefficient Koc	Groundwater Standards/ Criteria Cw ug/l or ppb.	a Allowable Soil conc. ppm. Cs	b ** Soil Cleanup objectives to Protect GW Quality (ppm)	USEPA Health Based (ppm) Carcinogens	Systemic Toxicants	CRQL (ppb)	Rec.soil Clnup Objct. (ppm)
Trichloroethene	126	5	0.007	0.5	64	N/A	5	0.5
1,2-Dichloroethene	59	5	0.003	0.20	N/A	2,000	5	0.20
Benzo(a)pyrene	5,500,000	0.002(ND)	0.110	6.0	0.0609	N/A	330	6.0*

a. Allowable Soil Concentration Cs = f x Cw x Koc
b. Soil cleanup objective = Cs x Correction Factor (CF)

As the contamination is in groundwater, only groundwater protection goal is considered.

Correction Factors (CFs) of 65 for volatile contaminants and 55 for semivolatile contaminants are used as the contamination is in or close to the groundwater.
: Soil clnup objectives are developed for soil organic carbon content (f) of 1.0 % , and should be adjusted for the actual soil organic carbon content if it is known.

TABLE 2

Recommended Soil Cleanup Objectives (mg/kg or ppm) for Heavy Metals
Lehigh Valley Site, # 8-19-014

Contaminants	Protect Water Quality ppm	Eastern USA Background ppm	* CRDL mg/kg or ppm	** Average Background Concentration (ppm)
Mercury	N/A	0.001 - 0.2	0.002	0.1

N/A is not available

* CRDL for soil is approx. 10 times the CRDL for water

** Average background concentration
as reported in a 1984 survey of reference maE. Carol McGovern, NYSDEC.

THE FOLLOWING DOCUMENTS WERE OF POOR QUALITY

IMAGE DATA
A Data Distributors Company

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

MOBILE LABORATORY VOLATILE ANALYSIS

LEIGHIGH VALLEY RAILROAD DERAILMENT

VOLATILE TEST ANALYSIS FOR TRICHLOROETHENE

DATE SUBMITTED: 06 08/95   DATE ANALYZED: [illegible] 09-12/95

FIELD ID	LABORATORY ID	TRICHLOROETHENE CONC (PPB)
SP-1	895-159-01	57,000*
SP-2 4 MESH	895-159-02	15,000
SP-3 10 MESH	895-159-03	26,000*
SP-4 20 MESH	895-159-04	57,000
SP-5 FINAL	895-159-05	107,000
TD-1	[illegible]	99,000
[illegible]	[illegible]	[illegible]
TD-3	[illegible]	[illegible]
TD-4	895-159-09	62,000
TD-5	895-159-10	45,000
[illegible]	895-159-13	45,000

DETECTION LIMIT = 2500 PPB

*DETECTION LIMIT FOR THESE TWO SAMPLES WAS 5000 PPB.

ecology and environment, inc.
International Specialists in the Environment

ANALYTICAL SERVICES CENTER
4493 Walden Avenue
Lancaster, New York 14086
Tel. (716) 685-8080, Fax: (716) 685-0852

July 17, 1995

LAB NAME: Ecology and Environment, Inc.

CASE NUMBER: RB095

SDG NUMBER: 0608

CONTRACT NUMBER: C003181

SAMPLE IN SDG: LVSP01 LVSP02 LVSP03 LVSP04
LVSP05 LVTD01 LVTD05

SDG NARRATIVE:

Enclosed are the analytical results for samples received at the Analytical Services Center on June 20, 1995. The samples were analyzed for Total Organic Carbon according to ASTM Method D2974 from the NYSDEC Analytical Services Protocol, September 1989, Revision 12/91.

Due to the level of organic carbon present, results have been reported as percent organic matter. Values have also been adjusted for sample dry weight.

I certify that this data package is in compliance with the terms and conditions of the contract, both technically and for completeness, for other than the conditions detailed above. Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or the Manager's designee, as verified by the following signature.

Gary Hahn

Gary Hahn - Manager
Analytical Services Center
July 17, 1995

TEST CODE :STOC 1

JOB NUMBER :9501.348
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : NEW YORK STATE DEC

RESULTS IN DRY WEIGHT

TEST NAME : TOC
UNITS : %
PARAMETER : Total Organic Carbon as % Organic Matter
CONTRACT # : C003181
CASE # : RB095
SDG # : 0608

SAMPLE ID	RESULTS	Q	QNT. LIMIT
EE-95-28094 LVSP01	7.7		1.2
EE-95-28095 LVSP02	6.0		1.0
EE-95-28096 LVSP03	10		1.1
EE-95-28097 LVSP04	10		1.2
EE-95-28098 LVSP05	20		1.2
EE-95-28099 LVTD01	9.3		1.2
EE-95-28100 LVTD05	4.2		1.0

QUALIFIERS: C = COMMENT
J = ESTIMATED VALUE
NA = NOT APPLICABLE
ND = NOT DETECTED

TEST CODE :STS 1

JOB NUMBER :9501.348
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : NEW YORK STATE DEC
TEST NAME : SOLIDS-TOTAL (GAC)
UNITS : %
PARAMETER : Solids-Total
CONTRACT # : C003181
CASE # : RB095
SDG # : 0608

SAMPLE ID	RESULTS	Q
EE-95-28094 LVSP01	86	
EE-95-28095 LVSP02	97	
EE-95-28096 LVSP03	92	
EE-95-28097 LVSP04	85	
EE-95-28098 LVSP05	85	
EE-95-28099 LVTD01	83	
EE-95-28100 LVTD05	100	

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE

li