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The Determination of Inorganic Anions in Water by Ion Chromatography (EPA Method 300.0)

Scope and Application

This method covers the determination of the following inorganic anions:

chloride
fluoride
dissolved fluoride
nitrate-N
nitrite-N
dissolved orthophosphate-P
sulfate

This is an ion chromatographic (IC) method applicable to the determination of the anions listed above in drinking water, surface water, and mixed domestic and industrial wastewater.

Summary of Method

A small volume of sample, typically 2-3 ml, is introduced into an ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, separator column, suppressor column, and conductivity detector.

Interferences

Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or spiking can be used to solve most interference problems.

The water dip or negative peak that elutes near and can interfere with the fluoride peak can be eliminated by the addition of the equivalent of 1 ml of concentrated eluent (100x) to 100 ml of each standard and sample.

Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baseline in ion chromatograms.

Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.2 microns require filtration to prevent damage to instrument columns and flow systems.

Apparatus and Materials

Balance - analytical, capable of accurately weighing to the nearest 0.0001 g.
Ion chromatograph - analytical system complete with ion chromatograph and all required accessories including syringes, analytical columns, compressed air, detector, and stripchart recorder. A data system is

recommended for peak integration.
Anion guard column: 4 x 50mm, Dionex P/N 030825, or equivalent
Anion separator column: 4 x 250 mm, Dionex P/N 030827, or equivalent
Anion suppressor column: fiber, Dionex P/N 35350, or equivalent
Detector - Conductivity cell: approximately 6 ul volume, Dionex, or equivalent

Reagents and Consumable Materials

Sample bottles: Glass or polyethylene of sufficient volume to allow replicate analyses of anions of interest
Reagent water: Distilled or deionized water, free of the anions of interest. Water should contain particles no larger than 0.20 microns
Eluent solution: Sodium bicarbonate 0.003 M, sodium carbonate 0.0024 M. Dissolve 1.0081 g sodium bicarbonate ($NaHCO_3$) and 1.0176 g of sodium carbonate (Na_2CO_3) in reagent water and dilute to 4 liters.
Regeneration solution (fiber suppressor): Sulfuric acid 0.025 N. Dilute 2.8 ml conc. sulfuric acid (H_2SO_4) to 4 liters with reagent water.
Stock standard solutions, 100 mg/l (1 mg/ml): Stock standard solutions may be purchased as certified solutions or prepared from ACS reagent grade materials (dried at 105°C for 30 min.) as listed below:

Chloride (Cl^-) 1000 mg/l: Dissolve 1.6485 g sodium chloride in reagent water and dilute to 1 liter.

Fluoride (F^-) 1000 mg/l: Dissolve 2.2100 g sodium fluoride in reagent water and dilute to 1 liter.

Nitrate (NO_3^--N) 1000 mg/l: Dissolve 6.0679 g sodium nitrate in reagent water and dilute to 1 liter.

Nitrite (NO_2^--N) 1000 mg/l: Dissolve 4.9257 g sodium nitrite in reagent water and dilute to 1 liter.

Phosphate ($PO_4^=$-P) 1000 mg/l: Dissolve 4.3937 g potassium phosphate in reagent water and dilute to 1 liter.

Sulfate ($SO_4^=$-P) 1000 mg/l: Dissolve 1.8141 g potassium sulfate in reagent water and dilute to 1 liter.

Calibration and Standardization

Establish ion chromatographic operating parameters equivalent to those indicated in Table 1.

For each analyte of interest, prepare calibration standards at a minimum of three concentration levels and a blank by adding accurately measured volumes of one or more stock standards to a volumetric flask and diluting to volume with reagent water. If the working range exceeds the linear range of the system, a sufficient number of standards must be analyzed to allow an accurate calibration curve to be established. One of the standards should be representative of a concentration near, but above, the method detection limit if the system is operated on an applicable attenuator range. The other standards should correspond to the range of concentrations expected in the sample or should define the working range of

ALKALINITY, Titrimetric, pH 4.5
(EPA Method 310.1)

Scope and Application

This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes.
The method is suitable for all concentration ranges of alkalinity; however, appropriate aliquots should be used to avoid a titration volume greater than 50 ml.
Automated titrimetric analysis is equivalent.

Summary of Method

An unaltered sample is titrated to an electrometrically determined end point of pH 4.5. The sample must not be filtered, diluted, concentrated, or altered in any way.

Apparatus

pH meter or electrically operated titrator that used a glass electrode and can be read to 0.05 pH units. Standardize and calibrate according to manufacturer's instructions. If automatic temperature compensation is not provided, make titration at 25±2°C.
Use an appropriate sized vessel to keep the air space above the solution at a minimum.
Use a rubber stopper fitted with holes for the glass electrode, reference electrode (or combination electrode) and buret.
Magnetic stirrer, pipets, flasks and other standard laboratory equipment.
Burets, Pyrex 50, 25, and 10 ml.

Reagents

Sodium carbonate solution, approximately 0.05 N: Place 2.5 ± 0.2 g (to nearest mg) Na_2CO_3 (dried at 250°C for 4 hours and cooled in desiccator) into a 1 liter volumetric flask and dilute to the mark.
Standard acid, sulfuric, 0.1 N: Dilute 3.0 ml conc. H_2SO_4 to 1 liter with distilled water. Standardize versus 40.0 ml of 0.05 N Na_2CO_3 solution with about 60 ml distilled water by titrating potentiometrically to pH of about 5. Lift electrode and rinse into beaker. Boil solution gently for 3-5 minutes under a watch glass cover. Cool to room temperature. Rinse cover glass into beaker. Continue titration to the pH inflection point. Calculate normality using:

$$N = \frac{A \times B}{53.00 \times C}$$

Where: A = g Na_2CO_3 weighed into 1 liter
B = ml Na_2CO_3 solution
C = ml acid used to inflection point

Standard acid, sulfuric, 0.02 N: Dilute 200.0 ml of 0.1000 N standard acid to 1 liter with distilled water. Standardize by potentiometric titration of 15.0 ml 0.05 N Na_2CO_3 solution as above.

Procedure

Sample size

1. Use a sufficiently large volume of titrant (>20 ml in a 50 ml buret) to obtain good precision while keeping volume low enough to permit sharp end point.
2. For <1000 mg $CaCO_3$/l use 0.02 N titrant
3. For >1000 mg $CaCO_3$/l use 0.1 N titrant
4. A preliminary titration is helpful.

Potentiometric titration

1. Place sample in flask by pipetting with pipet tip near bottom of flask
2. Measure pH of sample
3. Add standard acid, being careful to stir thoroughly but gently to allow needle to obtain equilibrium.
4. Titrate to pH 4.5. Record volume of titrant.

Potentiometric titration of low alkalinity

1. For alkalinity of <20 mg/l titrate 100-200 ml as above using a 10 ml microburet and 0.02 N acid solution.
2. Stop titration at pH in range of 4.3-4.7, record volume and exact pH. Very carefully add titrant to lower pH exactly 0.3 pH units and record volume.

Calculations

Potentiometric titration to pH 4.5.

$$\text{Alkalinity, mg/l } CaCO_3 = \frac{A \times N \times 50{,}000}{\text{ml of sample}}$$

where: A = ml standard acid
N = normality of standard acid

Potentiometric titration of low alkalinity:

$$\text{Total Alkalinity, mg/l } CaCO_3 = \frac{(2B - C) \times N \times 50{,}000}{\text{ml of sample}}$$

where: B = ml titrant to first recorded pH
C = total ml titrant to reach pH 0.3 units lower
N = normality of acid

Reference: Method 310.1, Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinatti, OH 45268

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Fluoride
Ion Selective Electron

Scope of Application

This method is applicable to the measurement of fluoride in drinking, surface and saline waters, domestic and industrial wastes.

Concentration of fluoride from 0.1 up to 1000 mg/liter may be measured.

For Total or Total Dissolved Fluoride, the Bellack distillation is required for NPDES monitoring but is not required for SDWA monitoring.

Summary of Method

The fluoride is determined potentiometrically using a fluoride electrode in conjunction with a standard single junction sleeve-type reference electrode and a pH meter having an expanded millivolt scale or a selective ion meter having a direct concentration scale for fluoride.

The fluoride electrode consists of a lanthanum fluoride crystal across which a potential is developed by fluoride ions. The cell may be represented by Ag/Ag Cl, Cl^-(0.3), F^-(0.001)LaF/test solution/SCE/.

Interferences

Extremes of pH interfere; sample pH should be between 5 and 9. Polyvalent cations of Si^{+4}, Fe^{+3} and Al^{+3} interfere by forming complexes with fluoride. The degree of interferences depends upon the concentration of the complexing cations, the concentration of fluoride and the pH of the sample. The addition of a pH 5.0 buffer (described below) containing a strong chelating agent preferentially complexes aluminum (the most common interference), silicon and iron and eliminates the pH problem.

Apparatus

Electrometer (pH meter), with expanded mv scale, or a selective ion meter such as the Orion 400 Series.
Fluoride Ion Activity Electrode, such as Orion No. 94-09[1].
Reference electrode, single junction, sleeve-type, such as Orion No.90-01, Beckman No. 40454, or Corning No. 476010.
Magnetic Mixer, Teflon-coated stirring bar.
Bellack distillation apparatus (if needed).

Reagent

Buffer solution: TISAB III with CDTA buffer solution made by Orion. This buffer is ten times more concentrated than the buffer listed in EPA 340.2. Therefore the sample/standard volume to buffer volume is changed from 50 ml:50 ml to 50 ml:5 ml.

Sulfuric Acid Conc. (if Total F^- needed).

Sodium fluoride, stock solution: 1.0 ml = 1.0 mg F. Dissolved 2.210 g of sodium fluoride in distilled water and dilute to 1 liter in a volumetric

flask. Store in chemical-resistant glass or polyethylene.
Sodium fluoride, standard solution: 1.0 ml = 0.1 mg F. Dilute 100.0 ml of sodium fluoride stock solution (6.2) to 1000 ml with distilled water.

Procedure

1. Preliminary distillation (if needed)
   Place 200 ml distilled water in the distilling flask.
   Carefully add 100 ml conc. H_2SO_4 an swirl until contents are homogenous.
   Add 25 to 35 glass beads, connect the apparatus (Figure 1) making sure all joints are tight.
   Heat slowly at first, then as rapidly as the efficiency of the condenser will permit (distillate must be cool) until the temperature of the flask contents reaches exactly 180°C. Discard the distillate. This process removes fluoride contamination and adjusts the acid-water ratio for subsequent distillations.
   Cool to 120°C or below.
   Add 150 ml sample, mix thoroughly, distill as in 6.1.4 until temperature reaches 180°C. Do not heat above 180°C to prevent sulfate carryover.
   Add Ag_2SO_4 (5.2) at a rate of 5 mg/mg Cl when high chloride samples are distilled.
   Use the sulfuric acid solution in the flask repeatedly until the contaminants form the samples accumulate to such an extent that recovery is affected or interferences appear in the distillate. Check periodically by distilling standard fluoride samples. High fluoride samples may require that the still be flushed by using distilled water and combining distillates.

2. Calibrate meter according to instrument manual.

3. Standard curve, prepare a ug F^- vs mV curve by adding successive amounts of the standard F^- solution to 50 mls of D.I. water plus 5 mls of TISAB III. Record the mV valve between each addition.
   The following series may be used:

mls of Standard Sol added successively	mls of Standard Sol. Present in Solution	ug F^-
0.05	0.05	5.0
0.05	0.10	10
0.40	0.50	50
0.50	1.00	100
0.50	1.50	150
0.50	2.00	200

The standard curve should be plotted on semilogarithmic graph paper with the ugF^- on the log axis vs the mV on the linear axis.

The linear regression curve can be calculated by calculator by entering negative log concentrations vs mV.

Samples Analysis: To 50 mls of sample add 5 mls of TISAB III. Place electrodes into the sample (which a stir bar is mixing) and measure the mV

valve. Record the valve when the reading is table and doesn't change for at least as long as one minute.

Calculation

ug/ml F^- = ug F (for curve) - 50 mls (ml of sample)

To get ug F^- from curve (in calculator) change sign to positive and take the inverse log of the valve.

Reference: Method 340.2, Method for Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

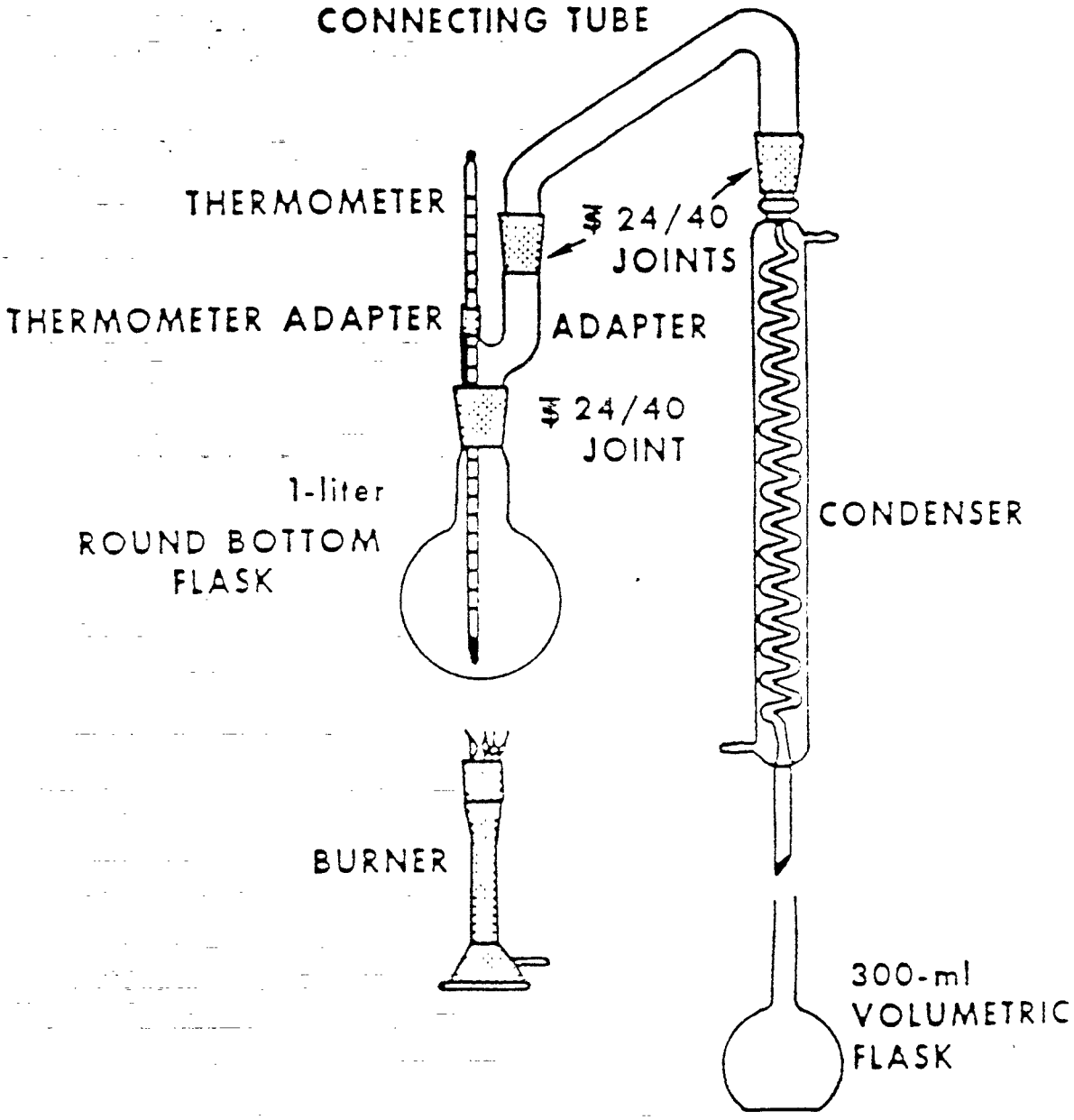

FIGURE 1 DIRECT DISTILLATION APPARATUS FOR FLUORIDE.

Hardness, Titrimetric EDTA

Scope and Application

This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes.
The method is suitable for all concentration ranges of hardness; however, in order to avoid large titration volumes, use a sample aliquot containing not more than 25 mg $CaCO_3$.
Automated titration may be used.

Summary of Method

Calcium and magnesium ions in the sample are sequestered upon the addition of disodium ethylenediamine tetraacetate (Na2EDTA). The end point of the reaction is detected by means of Eriochrome Black T indicator, which has a red color in the presence of calcium and magnesium and a blue color when the cations are sequestered.

Interferences

Excessive amounts of heavy metals can interfere. This is usually overcome by complexing the metals with cyanide.
Routine addition of sodium cyanide solution (Caution: deadly poison) to prevent potential metallic interference is recommended.

Apparatus

Standard laboratory titrimetric equipment.

Reagents

Buffer solution

1. If magnesium EDTA is available: Dissolve; 16.9 g NH_4Cl in 143 ml conc. NH_4OH in a 250 ml volumetric, add 1.25 g of magnesium salt of EDTA and dilute to the mark with distilled water. Then go to 6.1.3.

2. If magnesium EDTA is unavailable: Dissolve 1.179 g disodium EDTA (analytical reagent grade) and 780 mg $MgSO_4.7H_2O$ (or 644 mg $MgCl_2.6H_2O$) in 50 ml distilled water. Add this solution to a 250 ml volumetric flask containing 16.9 g NH_4Cl and 143 ml conc. NH_4OH with mixing and dilute to the mark with distilled water.

3. Store in a tightly stoppered plastic bottle; stable for approximately one month. Dispense with bulb operated pipet. Discard when 1 or 2 ml added to sample fails to produce a pH of 10.0 $\pm$ 0.1 at end point of Inhibitors: For most waters inhibitors are not necessary. If interfering ions are present use one of the following:

Inhibitors: For most waters inhibitors are not necessary. If interfering ions are present use one of the following:

1. Inhibitor I: NaCN powder. (Caution: extremely poisonous). Flush

solutions or sample containing this down drain using large quantities of water. Make sure no acids are present which might liberate HCN gas.

2. Inhibitor II: Dissolve 5.0 g $Na_2S9.H_2O$ or 3.7 g $Na_2S.5\ H_2O$ in 100 ml distilled water. Exclude air with tightly fitted rubber stopper. This gives sulfide precipitates which may obscure the end point if large quantities of heavy metals are present. Deteriorates rapidly through air oxidation.

3. Inhibitor III: Dissolve 4.5 g hydroxylamine hydrochloride in 100 ml of 95% ethanol or isopropanol.

Indicator: Use a commercially available indicator such as Calmagite indicator (Mallinckrodt) or one of the formulations described below:

1. Mix 0.5 g Eriochrome Black T with 4.5 g hydroxylamine hydrochloride. Dissolve in 100 ml of 95% ethanol or isopropanol.

2. Dissolve 0.5 to 1.0 g Eriochrome Black T in an appropriate solvent such as triethanolamine or 2-methoxyethanol. Stable approximately one week.

3. Mix together 0.5 g Eriochrome Black T and 100 g NaCl.

Standard EDTA titrant, 0.02 N: Place 3.723 g analytical reagent grade disodium ethylenediamine tetraacetate dihydrate, $Na_2H_2C_{10}H_{12}O_8N_2.2H_2O$ in a 1 liter volumetric flask and dilute to the mark with distilled water. Check with standard calcium solution by titration. Store in Polyethylene. Check periodically because of gradual deterioration.

Standard calcium solution 0.02 N: Place 1.000 g anhydrous calcium carbonate (primary standard low in metals) in a 500 ml flask. And, a little at a time, 1 + 1 HCL until all of the $CaCO_3$ has dissolved. Add 200 ml distilled water. Boil for a few minutes to expel CO_2. Cool. Add a few drops of methyl red indicator and adjust to intermediate orange color by adding 3N NH_4OH or 1 + 1 HGl, as required. Quantitatively transfer to a 1 liter volumetric flask and dilute to mark with distilled water.

Standardization titration procedure: Place 10.0 ml standard calcium solution in vessel containing about 50 ml distilled water. Add 1 ml buffer solution. Add 1-2 drops indicator or small scoop of dry indicator. Titrate slowly with continuous stirring until the last reddish tinge disappears, adding last few drops at 3-5 second intervals. At end point the color is blue. Total titration duration should be 5 minutes from the time of buffer addition.

$$N \text{ of EDTA} = \frac{0.2}{\text{ml of EDTA}}$$

Hydrochloric acid solution, 1 + 1.

Methyl red indicator: dissolve 0.10 g methyl red in distilled water in a

100 ml volumetric flask and dilute to the mark.

Ammonium hydroxide solution, 3 N: Dilute 210 ml of conc. NH_4OH to 1 liter with distilled water.

Ammonium Hydroxide, 1N: Dilute 70 ml of conc. NH_4OH to 1 liter with distilled water.

Procedure

Titration of sample-normal to high hardness:

1. Sample should require <15 ml EDTA titrant and titration should be completed within 5 minutes of buffer addition.
2. Place 25.0 ml sample in titration vessels, neutralize with 1N ammonium hydroxide and dilute to about 50 ml.
3. Add 1 to 2 ml buffer solution.
4. If end point is not sharp (as determined by practice run) add inhibitor at this point (see section "To Correct for Interferences" below).
5. Add 1 to 2 drops indicator solution or small scoop of dried powder indicator formulation
6. Titrate slowly with continuous stirring with standard EDTA titrant, until last reddish tint disappears. Solution is normally blue at end point.

Titration of sample-low hardness (less than 5 mg/l)

1. Use a larger sample (100 ml).
2. Use proportionately larger amounts of buffer, inhibitor and indicator
3. Use a microburet and run a blank using redistilled, distilled or deionized water.

To correct for interferences:

1. Some metal ions interfere by causing fading or indistinct end points. Inhibitors reduce this. For 25.0 ml samples diluted to 50 ml, use one of the following inhibitors;

   Inhibitor I: Add 250 mg NaCN. Add sufficient buffer to achieve pH 10.0 $\pm$ 0.1 to offset alkalinity resulting from hydrolysis of sodium cyanide.

   Inhibitor II: Add 1 ml of inhibitor II

   Inhibitor III: Add 1 ml of inhibitor III

Calculations:

$$\text{Hardness (EDTA) mg } CaCO_3/l = \frac{A \times N \times 50{,}000}{\text{ml sample}}$$

where:
A = ml EDTA titrant (6.4)
N = normality of EDTA titrant.

Reference: Method 130.2, Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

Determination of Nitrogen, Nitrate and Nitrite by Technicon AA II

Analyte: NO_{32}-N

Matrix: Aqueous Samples

Range: 10 ug/l to 200 ug/l, dilute sample if conc. exceeds range.

Summary of Method: A Sample is passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. The nitrite is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye which is measured colorimetrically. Separate, rather than combined nitrate-nitrite, valve are readily obtained by carrying out the procedure first with, and then without, the Cu-Cd reduction step.

Interferences:

1. Build up of suspended matter in the reduction column will restrict sample flow. Since nitrate-nitrogen is found in a soluble state, the sample may be prefiltered.

2. Low results might be obtained for sample that contain high concentrations of iron, copper, or other metals. EDTA is added to the samples to eliminate this interference.

3. Samples that contain large concentrations of oil and grease will coat the surface of the cadmium. This interference is eliminated by pre-extracting the sample with an organic solvent.

Apparatus

Technicon AutoAnalyzer II Consisting of the following Components:

1. Sampler
2. Manifold (AAI) or analytical cartridge (AAII)
3. Proportioning Pump
4. Colorimeter equipped with a 15 mm or 50 mm tubular flow cell and 540 mm filters.
5. Recorder

Reagents: Dilute hydrochloric acid, 6N: Dilute 50 ml conc. HCl to 100 ml with distilled water.
Copper sulfate solution: Dissolve 20 g of $CuSO_4 \cdot 5H_2O$ ml of distilled water and dilute to 1 liter.
Granulate cadmium: 40-60 mesh (MCB Reagents).
Copper-cadmium: The cadmium granules (new or used) are cleaned with dilute HCl and copperized with 2% solution of copper sulfate in the follower manner:
Wash the cadmium with HCl and rinse with distilled water. The color of the cadmium so treated should be silver.
Swirl 10 g cadmium in 100 ml portions of 2% solution of copper sulfate for five minutes or until blue color partially fades,

decant and repeat with fresh copper sulfate until a brown colloidal precipitate forms.
Wash the cadmium-copper with distilled water (at least 10 times) to remove all the precipitated copper. The color of the cadmium so treated should be black.

Color Reagent: To approximately 800 ml of distilled water, add, while stirring, 100 ml conc. phosphoric acid, 40 g sulfanilamide, and 2 g N-1-naphthylethylenediamine dihydrochloride. Stir until dissolved and dilute to 1 liter. Store in brown bottle and keep in the dark when not in use. This solution is stable for several months.

Ammonium chloride-EDTA solution: Dissolve 85 g of reagent grade ammonium chloride and 0.1 g of disodium ethylenediamine tetracetate in 900 ml of distilled water. Adjust the pH to 8.5 with conc. ammonium hydroxide and dilute to 1 liter. Add 1/2 ml Brij-35 (available from Technicon Corporation).

Preparation of the reduction column; take approximately 25 cm of 0.110 inch tubing and fill it with D-I H_2O. Holding both ends of the tube, making a U shape, place a cut eppendorf tip in one end of the tube making the tip act as a funnel. Fill the tube with copper-cadmium granules, one side of the U shape at a time. After the tub is about 80% filled, place a glass wool plug in each end of the tube. Take care not to allow any air to be trapped in the column. The cadmium reduction column should not be allowed to dry out.

Stock nitrate solution: Dissolve 7.218 g KNO_3 and dilute to 1 liter in a volumetric flask with distilled water. Preserve with 2 ml of chloroform per liter. Solution is stable for 6 months 1 ml = 1.0 mg NO_3-N.

Stock nitrate solution: Dissolve 6.072 g KNO_2 in 500 ml of distilled water and dilute to 1 liter in a volumetric flask. Preserve with 2 ml of chloroform and keep under refrigeration. 1.0 ml = 1.0 mg NO_2-N.

Standard nitrate solution: Dilute 1.0 ml of stock nitrite solution (100 ml, 1.0 ml = 0.01 mg NO_3-N. Prepare each analysis.

Standard nitrate solution: Dilute 1.0 ml of stock nitrite solution to 100 ml. 1.0 ml = 0.01 mg NO_2-N. Solution is unstable; prepare as required.

Procedure

1. Turn on colorimeter, let warm up for 30 mins.
2. Set up manifold as shown in Figure 1.
3. Turn on pump and pump D.I. through all lines.
4. When all lines are filled with D.I. and flow is steady, place all reagent lines in reagent bottles.
5. When reagents have filled tubes, put on the reduction column taking care not to introduce any air bubbles in the column.
6. Standard prep; make stds, - 0.01, 0.05, 0.1, 0.2 ug/ml NO_3N 6 g diluting appropriate amounts of the standard nitrate solution to 100 mls with D.I. water.

7. Make a 0.2 ug/ml NO_2-N standard by diluting 2 ml of Nitrite standard solution to 100 mls.

8. After the chemistry has stabilized adjust the baseline with the B knob on the colorimeteric.

9. When the baseline is steady, maximize the sensitivity by running the high NO_3-N standard and adjust the response to 90% scale using the standard cal dial on the colorimeter.

10. Readjust baseline with B knob if needed.

11. Run the 0.2 ug/ml NO_3-N and NO_2-N standards, the peak-height for these two standards should be the same. If the NO_2-N standard is the larger of the two, it indicates that the reduction column isn't reducing completely and needs to be replaced.

12. Run a standard curve (two cups) in increasing order, verify with LCS.

13. Load sample tray with samples (two cups each), every 5 samples place 1 cup of CCV.

14. Run samples.

Nitrate and Nitrite in Soil Samples

When analyzing a soil sample for nitrate and nitrite, prepare as directed below. Then analyze as for an aqueous sample.

1. Weigh out between 1 and 2 grams of wet sample, place in a specimen container.

2. Add 50 ml of DI H_2O and mix either by shaking, sonication, or both.

3. Let sample leach for at least 30 minutes.

4. Filter an aliquot through a 0.45u membrane filter before analysis by technicon as an aqueous sample.

5. Determine percent solids for sample and report results as ug/g NO32-N, dry weight.

Calculations: Measure peak heights for standards and samples and average the two peaks. Prepare a regression curve by plotting standard concentration against average peak height. Compute concentrations of samples by comparing average sample peak height with standards.

Reference: Method 353.2 of Methods of Chemical Analysis of Water and Wastes, March 1983, Environmental Monitoring and Support Laboratory. Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

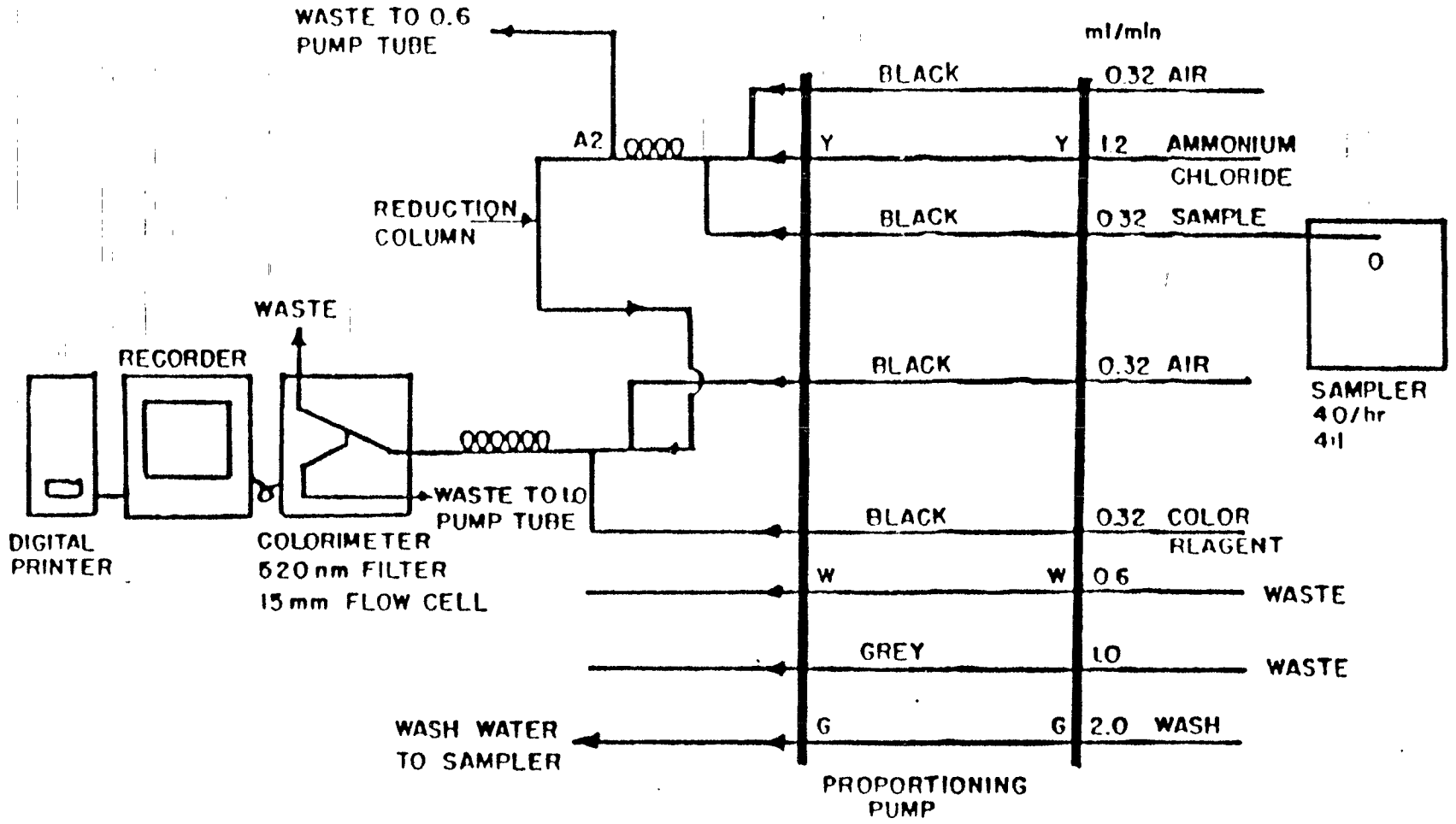

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FIGURE 3 NITRATE-NITRITE MANIFOLD AA II

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TOTAL ORGANIC CARBON

Scope and Application

This method is used to determine the concentration of organic carbon in ground water, surface and saline waters, and domestic and industrial wastes. If the furnace is used this method can be used to determine the concentration of organic carbon in soils and solid waste.

Summary of Method

1) Low temperature system converts organic carbon in a sample to carbon dioxide (CO_2) by wet chemical oxidation. The CO_2 formed is then measured directly by infrared detector.

2) High temperature system converts organic carbon in a sample to carbon dioxide (CO_2) by catalytic combustion. the CO_2 formed is then measured directly by infrared detector.

Apparatus

Dohrman DC-80 Total Organic Carbon Analyzer:

1. EM-2 Microprocessor Electronic Module
2. UV-Persulfate Reaction Module
3. IR-I NDIR Detector Module
4. DC-80 Printer Module
5. PRG-1 Furnace Module
6. Sludge/Sediment Sampler Module

Reagents

1. Reagent Water: Distilled or Deionized water of good quality, "organic free."

2. Potassium Persulfate Solution, 2%: Prepare by dissolving 20 grams of reagent grade Potassium Persulfate ($K_2S_2O_8$) in 1 liter of reagent water. Add 1 milliliter of concentrated phosphoric acid and mix well. Store in a cool dark location. Shelf life is approximately 1 month.

3. Potassium Persulfate-Mercuric Salt Solution: This solution is used with High Salt (Chloride) containing samples. Prepare by dissolving 8.2 grams of reagent grade Mercuric Chloride ($HgCl$) and 9.6 grams of reagent grade Mercuric Nitrate, monohydrate ($Hg(NO_3)_2.H_2O$) in 400 milliliters of reagent water. Add 20 grams of reagent grade Potassium Persulfate ($K_2S_2O_8$) and 5 milliliters of concentrated nitric acid. Mix well and make to 1 liter with reagent water.

4. Organic Carbon Standards: Prepare a 2000 PPM C standard by weighing 425 milligrams of reagent grade Potassium Hydrogen Phthalate ($C_8H_5O_4K$), KHP, dried to a constant weight and transferring quantitatively with reagent water to a 100 milliliter flask, dissolve, add 0.1 milliliter of concentrated phosphoric acid and make to volume with reagent water. Store this solution in dark glass under refrigeration and replace monthly.

a. Prepare a 400 PPM C standard by introducing 20.0 milliliters of the 2000 PPM C standard into a 100 milliliter volumetric flask and make to volume with reagent water. Larger volumes may be prepared by 5 to 1 dilution ratio of the 2000 PPM C standard. This solution should be stored in dark glass under refrigeration and prepared fresh weekly.

b. Prepare a 10 PPM C standard by introducing 1.0 milliliters of the 2000 PPM standard into 2 separate 200 milliliter volumetric flasks and make to exactly the same volume. Calibrate the analyzer to 10.00 PPM using one solution while reserving the duplicate. Verify repeatable calibration by replicate injections.
After repeated washings with reagent water - analyse replicate injections of the reagent water.
Determine the system blank by injection of freshly withdrawn reactor solution. Calculate a volume of water to be added to the reserved 200 milliliter standard as follows:

$$\text{VOLUME (Ml)} = 20X + 2X^2$$

Where: X = the average for the reagent water sample after subtraction of the system blank determined above.
Add this volume to the reserved standard using a MOHR measuring pipet and mix well.
Recalibrate the system using this 10 PPM C standard.

5. Acid for Sample Pretreatment: When available, use phosphoric or sulfuric acid to adjust sample to pH=2. Other acids may also be suitable, but NEVER PRESERVE SAMPLES WITH HYDROCHLORIC ACID.

Procedure:

Low Temperature System -

1. Instrument start-up

1. Turn on electronics module
2. Increase O_2 pressure to 40 psi.
3. Put pressure fingers and pump tubes into pumping position
4. Turn on Reactor Module, Power, Pump, Lamp.
5. Let warm up for 30 mins.
6. After warm up, set detector to 0.0100.

2. Instrument Calibration

1. Select range in which you want to standardize (Table 1)

2. Press calibration button for more than one second to remove previous calibration.

3. Inject appropriate volume of standard (Table 1) and press start button.

4. When run is finished, step 3 two more times.

5. After 3 injections of the standard are run, press the calibration button quickly (less than 1 second). The instrument is now calibrated.

3. Sample Preparation

Place an aliquot of sample into a clean glass scintillation vial and add dropwise concentrated sulfuric acid to the sample to reach a pH of $\leq$ 2. Sparge the acidified sample with oxygen for 5 to 10 mins. to remove any inorganic carbon.

4. Sample Analysis

1. Inject sample at the same volume at which you calibrated the instrument.

2. Analyze sample 2 to 3 times and take an average value of the injections.

TABLE 1

Volume, microliters	Operating Range, ppm	Standard Concentration ppm
40	100-4000	2000
200	10-800	400
1000	0.1-160	10

High Temperature System -

A. Instrument Start Up

1. Turn on electronics module.

2. Increase O_2 pressure to 40 psi.

3. Turn on furnace.

4. Turn on Reactor Module, Power, Pump, don't turn on lamp.

5. Pump may be turned off when reactor vessel is filled with persulfate solution.

6. Let electronics warm up for 30 mins., and let furnace get up to temp. ($800^{o}C$).

7. After warm up, set detector to 0.0100.

8. Clean platinum boat, place clean quartz wool in boat and bake it in the furnace until all inorganic carbon is gone. Place boat at the cooling zone.

B. Instrument Calibration

1. Set calibration range to 40 microliters.

2. Press calibration button for more than one second to remove previous calibration.

3. Place 40 microliters of 2,000 ppm TOC standard in the platinum boat.

4. Press the start button, then slowly slide the boat into the furnace, stopping the boat about a quarter of the way in the furnace (allows the aqueous portion of the sample or std. to evaporate) for about 15-30 seconds and then push the boat all the way in the furnace.

5. Repeat step 4 two more times.

6. After the standard has been run 3 times, press the calibration button quickly (less than one second). The instrument is now calibrated.

C. Sample Preparation

1. Weigh a representative portion of sample into a clean scintillation vial.

2. Add an appropriate volume of D.I. water, and a clean teflon coated stir bar.

3. Add concentrated sulfuric acid dropwise until a pH of ≤ 2 has been reached.

4. Purge sample by bubbling O_2 in slurry for at least 10 minutes to remove inorganic carbon.

D. Sample Analysis

1. While the acidified sparged slurry is stirring, take a 40ul aliquot and place it in the cooled platinum boat.

2. Press the start button and move the platinum boat as was done in step 4 of Instrument Calibration.

3. Analyze the sample at least 3 times and take an average of the 3 results.

Calculations

Low Temperature System -
Average of the direct results from the instrument.

High Temperature -

$$TOC_{ug/g} = A \times B / (C \times \% \text{ solids of sample})$$

A = Average of results from instrument ($_{ug}/_{ml}$).
B = mls of DI water added to sample.
C = Weight (grams) of the sample.

References:

1) Method 415.1, 415.2, Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

2) Method 9060, SW846

3) Dohrman. DC-80 Total Organic Carbon Systems Manual, Edition 10, August 1985.

SULFATE (Colorimetric, Automated, Methylthymol Blue, AAII)
(EPA Method 375.2)

Scope and Application

This automated method is applicable to drinking and surface waters, domestic and industrial wastes.

Samples in the range of 3 to 300 mg SO_4/l can be analyzed. The sensitivity of the method can be increased by a minor modification to analyze samples in the range of 0.5 to 30 mg SO_4/l. Approximately 30 samples per hour can be analyzed

Summary of Method

The sample is first passed through a sodium form cation-exchange column to remove multivalent metal ions. The sample containing sulfate is then reacted with an alcohol solution of barium chloride and methylthymol blue (MTB) at a pH of 2.5-3.0 to form barium sulfate. The combined solution is raised to a pH of 12.5-13.0 so that excess barium reacts with MTB. The uncomplexed MTB color is gray; if it is all chelated with barium, the color is blue. Initially, the barium and MTB are equimolar and equivalent to 300 mg SO_4/l; thus the amount of uncomplexed MTB is equal to the sulfate present.

Apparatus

Technicon Auto Analyzer consisting of:
- Sampler
- Manifold - high or low level (Figure I)
- Proportioning pump
- Colorimeter equipped with 15 mm flow cell and 460 nm interference filters
- Recorder
- Digital Printer for AAII (optional)

Reagents

Barium chloride: Dissolve 1.526 g of barium chloride dihydrate in 500 ml of distilled water and dilute to 1 liter.

Methylthymol blue: Dissolve 0.1182 g of methylthymol blue in 25 ml of barium chloride solution. Add 4 ml of 1.0 N hydrochloric acid which changes the color to bright orange. Add 71 ml of water and dilute to 500 ml with ethanol. The pH of this solution is 2.6. This reagent should be prepared the day before and stored in a brown plastic bottle in the refrigerator.

Buffer, pH 10.5 $\pm$ 0.5: Dissolve 6.75 g of ammonium chloride in 500 ml of distilled water. Add 57 ml of concentrated ammonium hydroxide and dilute to one liter with distilled water.

Sodium hydroxide solution, (50%): Dissolve 500 g NaOH in 600 ml of distilled water, cool, and dilute to 1 liter.

Sodium hydroxide, 0.18 N: Dilute 14.4 ml of sodium hydroxide solution to 1 liter.

Ion exchange resin: Bio-Rex 70, 20-50 mesh, sodium form, Bio-Rad

Laboratories, Richmond, California. Free from fines by stirring with several portions of deionized water and decant the supernate before settling is complete.

Dilution water: Add 0.75 ml of sulfate stock solution and 3 drops of Brij-35 to 2 liters of distilled water.

Sulfate stock solution, 1 ml = 1 mg SO_4: Dissolve 1.479 g of dried (105°C) Na_2SO_4 in distilled water and dilute to 1 liter.

Dilute sulfate solution, 1 ml = 0.1 mg SO_4: Dilute 100 ml of sulfate stock solution to 1 liter.

High level working standards, 10-300 mg/l: Prepare high level working standards by diluting the following volumes of stock standard to 100 ml.

ml stock	mg/l SO_4
1	10
5	50
10	100
15	150
25	250
30	300

Low level working standards, 1-30 mg/l: Prepare low level working standards by diluting the following volumes of dilute sulfate solution to 100 ml.

ml stock	mg/l SO_4
1	1.0
5	5.0
10	10.0
15	15.0
25	25.0
30	30.0

Procedure

Set up the manifold for high (0-300 mg SO_4/l) or low (0-30 mg SO_4/l) level samples as described in Figure I.

The ion exchange column is prepared by pulling a slurry of the resin into a piece of glass tubing 7.5 inches long, 2.0 mm ID and 3.6 mm OD. This is conveniently done by using a pipet and a loose fitting glass wool plug in the tubing. Care should be taken to avoid allowing air bubbles to enter the column. If air bubbles become trapped, the column should be prepard over again. The column can exchange the equivalent of 35 mg of calcium. For the high level manifold this corresponds to about 900 samples with 200 mg/l Ca. The column should be prepared as often as necessary to assure that no more than 50% of its capacity is used up.

Allow the colorimeter, recorder, and printer to warm up for 30 minutes. Pump all reagents until a stable baseline is achieved.

Analyze all working standards in duplicate at the beginning of a run to develop a standard curve. The A and B control standards are analyzed every hour to assure that the system remains properly calibrated. Since the chemistry is non-linear the 180 mg/l standard is set at 50% on the recorder using the standard calibration control on the

colorimeter.

At the end of each day, the system should be washed with the buffered EDTA solution. This is done by placing the methylthymol blue line and the sodium hydroxide line in water for a few minutes and then in the buffered EDTA solution for 10 minutes. Wash the system with water for 15 minutes before shutting down.

Calculation

Prepare a standard curve by plotting peak heights of processed standards against known concentrations. Compute concentration of samples by comparing sample peak heights with the standard curve.

Reference: Method 375.2, Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinatti, OH 45268.

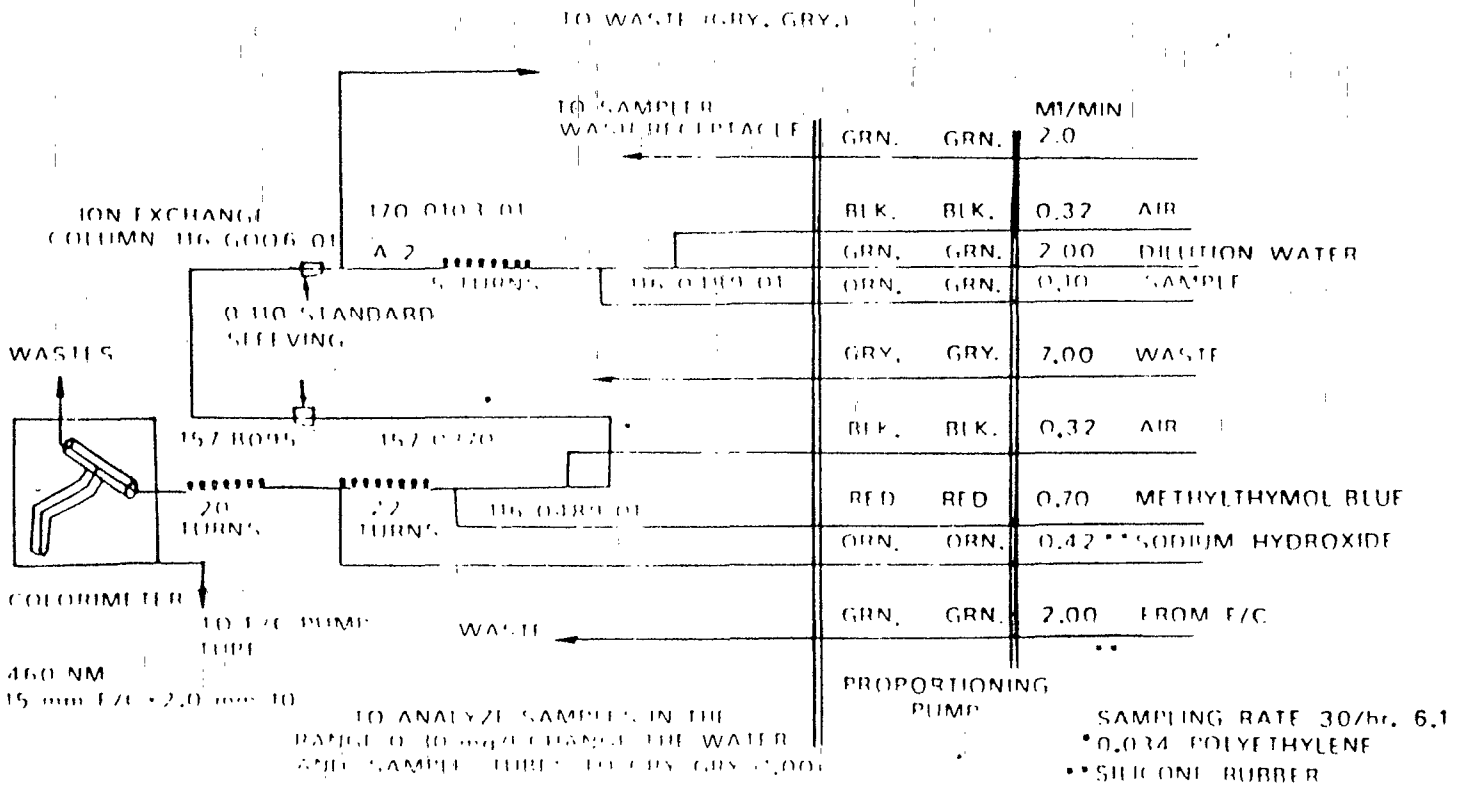

FIGURE 1 SULFATE MANIFOLD AA11

Sulfate
Turbidimetric

Scope and Application

This method is applicable to drinking and surface waters, domestic and industrial wastes.
The method is suitable for all concentration ranges of sulfate; however, in order to obtain reliable readings, use a sample aliquot containing not more than 40 mg SO_4/l.
The minimum detectable limit is approximately 1 mg/l sulfate.

Summary of Method

Sulfate ion is converted to a barium sulfate suspension under controlled conditions. The resulting turbidity is determined by a nephelometer, filter photometer or spectrophotometer and compared to a curve prepared from standard sulfate solutions.

Interferences

Suspended matter and color interfere. Correct by running blanks from which the barium chloride has been omitted.
Silica in concentrations over 500 mg/l will interfere.

Apparatus

1. Magnetic stirrer, variable speed so that it can be held constant just below splashing. Use identical shape and size magnetic stirring bars.

2. Spectrophotometer for use at 420 nm with light path of 4 to 5 cm.

3. Stopwatch, if the magnetic stirrer is not equipped with an accurate timer.

4. Measuring spoon, capacity 0.2 to 0.3 ml.

Reagents

1. Conditioning reagent: Place 30 ml conc. HCl, 300 ml distilled water, 100 ml 95% ethanol or isopropanol and 75 g NaCl in solution in a container. Add 50 ml glycerol and mix.

2. Barium chloride, $BaCl_2$, crystals, 20 to 30 mesh.

3. Sodium carbonate solution (approximately 0.05N): Dry 3 to 5 g primary standard Na_2CO_3 at 250°C for 4 hours and cool in a desiccator. Weigh 2.5 $\pm$ 0.2 g (to the nearest mg), transfer to a 1 liter volumetric flask and fill to the mark with distilled

water.

4. Standard Sulfate Solution (1.0 ml = 100 ug SO_4): Dissolve 147.9 mg anhydrous Na_2SO_4 in DI water in a 1 liter volumetric flask and dilute to the mark with DI water.

Procedure

Formation of barium sulfate turbidity:

1. Place 100 ml sample, or a suitable portion diluted to 100 ml, into a 250 Erlenmeyer flask.
2. Add exactly 5.0 ml conditioning reagent.
3. Mix in the stirring apparatus.
4. While the solution is being stirred, add a measuring spoonful of $BaCl_2$ crystals and begin timing immediately.
5. Stir exactly 1.0 minute at constant speed.

Measurement of barium sulfate turbidity:

1. Immediately after the stirring period has ended, pour solution into absorbance cell.
2. Measure turbidity at 30 second intervals for 4 minutes.
3. Record the maximum reading obtained in the 4 minute period.

Preparation of calibration curve:

1. Prepare calibration curve using standard sulfate solution.
2 Space standards at 5 mg/l increments in the 0-40 mg/l sulfate range.
3. Above 50 mg/l the accuracy decreases and the suspensions lose stability.
4. Check reliability of calibration curve by running a standard with every 3 to 4 samples.

Correction for sample color and turbidity:

1. Run a sample blank using the procedure without the addition of barium chloride.

Calculations

Read mg SO_4 from calibration curve

$$\text{mg } SO_4/l = \frac{\text{mg } SO_4 \times 1{,}000}{\text{ml sample}}$$

Reference

Method 375.4. Methods for Chemical Analysis of Water and Wastes, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

METHOD 9036

SULFATE (COLORIMETRIC, AUTOMATED, METHYLTHYMOL BLUE, AA II)

Summary of Method

The sample is first passed through a sodium-form cation-exchange column to remove multivalent metal ions. The sample containing sulfate is then reacted with an alcohol solution of barium chloride and methylthymol blue (MTB) at a pH of 2.5-3.0 to form barium sulfate. The combined solution is raised to a pH of 12.5-13.0 so that excess barium reacts with MTB. The uncomplexed MTB color is gray; if it is all chelated with barium, the color is blue. Initially, the barium and MTB are equimolar and equivalent to 30 mg SO_4^{-2}/liter; thus the amount of uncomplexed MTB is equal to the sulfate present.

Interferences

1. The ion-exchange column eliminates interferences from multivalent cations. A mid-scale sulfate standard containing Ca^{++} should be analyzed periodically to ensure that the column is functioning properly.

2. Samples with pH below 2 should be neutralized because high acid concentrations elute cations from the ion-exchange resin.

3. Turbid samples should be filtered or centrifuged.

Apparatus and Materials

1. Automated continuous-flow analytical instrument:
   1. Sampler
   2. Manifold: High- or low-level (Figure 1)
   3. Proportioning pump
   4. Heating bath: Operable at the temperature specified
   5. Colorimeter: Equipped with 15 mm flowcell and 460 nm interference filters.
   6. Filters: Of specified transmittance
   7. Recorder

Reagents

1. ASTM Type II water (ASTM D1193): Water should be monitored for impurities

2. Barium chloride: Dissolve 1.526 g of barium chloride dihydrate in 500 ml of Type II water and dilute to 1 liter.

3. Methylthymol blue: Dissolve 0.1182 g of methylk thymol blue in 25 ml of barium chloride solution. Add 4 ml of 1.0 N hydrochloric acid,

which changes the color to bright orange. Add 71 ml of water and dilute to 500 ml with ethanol. The pH of this solution is 2.6. This reagent should be prepared the day before and stored in a brown plastic bottle in the freezer.

4. Buffer, pH 10.5 ± 0.5: Dissolve 6.75 g of ammonium chloride in 500 ml of Type II water. Add 57 ml of concentrated ammonium hydroxide and dilute to 1 liter with Type II water.

5. Buffered EDTA: Dissolve 40 g of tetrasodium EDTA in pH 10.5 buffer and dilute to 1 liter with buffer.

6. Sodium hydroxide solution (50%): Dissolve 500 g NaOH in 600 ml of Type II water, cool, and dilute to 1 liter.

7. Sodium hydroxide, 0.18 N: Dilute 14.4 ml of sodium hydroxide solution to 1 liter.

8. Ion-exchange resin: Bio-Rex 70, 20-5- mesh, sodium form, Bio-Rad Laboratories, Richmond, California. Free from fines by stirring with several portions of Type II water and decant the supernate before settling is complete.

9. Dilution water: Add 0.75 ml of sulfate stock solution and 3 drops of Brij-35 to 2 liters of Type II water.

10. Sulfate stock solution, 1 ml = 1 mg $SO_4^=$: Dissolve 1.479 g of dried Na_2SO_4 (105°C) in Type II water and dilute to 1 liter.

11. Dilute sulfate solution, 1 ml = 0.1 mg $SO_4^=$: Dilute 100 ml of sulfate stock solution to 1 liter.

12. Working Standards, 0.5 - 30 mg/l: Prepare low-level working standards by diluting the following volumes of dilute sulfate solution to 100 ml.:

Stock Solution (ml)	Concentration (mg/l)
0.5	0.5
1	1.0
5	5.0
10	10.0
15	15.0
25	25.0
30	30.0

Procedure

1. Set up manifold as described in Figure 1.

2. The ion-exchange column is prepared by pulling a slurry of the resin into a piece of glass tubing 7.5-in. long, 2.0-mm I.D., and 3.6-mm O.D. This is conveniently done by using a pipet and a loose fitting glass wool plug in the tubing. Care should be taken to avoid allowing air bubbles to enter the column. If air bubbles become trapped, the

column should be prepared again. The column can exchange the equivalent of 35 mg of calcium. For the high-level manifold, this corresponds to about 900 samples with 200 mg/L Ca. The column should be prepared as often as necessary to ensure that no more than 50% of its capacity is used.

3. Allow the colorimeter, recorder, and printer to warm up for 30 min. Pump all reagents until a stable baseline is achieved.

4. Analyze all working standards in duplicate at the beginning of a run to develop a standard curve. The A and B control standards must be analyzed every hour to ensure that the system remains properly calibrated. Because the chemistry is nonlinear, the 180-mg/l standard is set at 50% on the recorder using the standard calibration control on the colorimeter.

5. At the end of each day, the system should be washed with the buffered EDTA solution. This is done by placing the methylthymol blue line and the sodium hydroxide line in water for a few minutes and then in the buffered EDTA solution for 10 min. Wash the system with water for 15 min. before shutting down.

6. Prepare a standard curve by plotting peak heights of five processed standards against known concentrations. Compute concentration of samples by comparing sample peak heights with the standard curve. Note that this is not a linear curve but a third order curve.

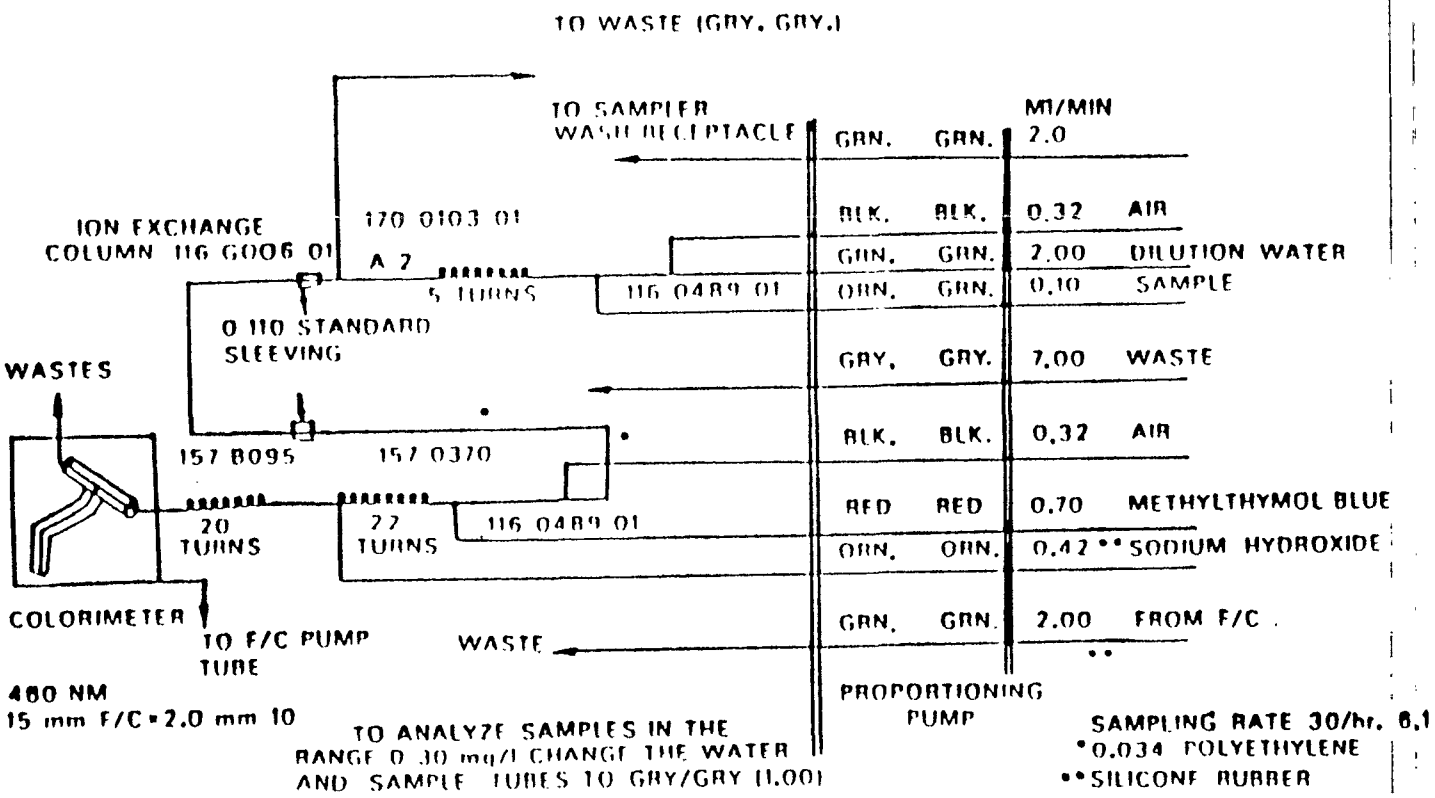

FIGURE 1 SULFATE MANIFOLD AA11

Revision 0
Date September 1986

Total Dissolved Solids

Scope of Application

This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes.

The practical range of the determination is 10 mg/l to 20,000 mg/l.

Summary of Method

A well-mixed sample is filtered through a standard glass fiber filter. The filtrate is evaporated and dried to constant weight at 180°C.

Interferences

Highly mineralized waters containing significant concentrations of calcium, magnesium, chloride, and/or sulfate may be hydroscopic and will require prolonged drying, desiccation and rapid weighing.

Samples containing high concentrations of bicarbonate will require careful and possibly prolonged drying at 180°C to insure that all the bicarbonate is converted to carbonate.

Too much residue in the evaporating dish will crust over and entrap water that will not be driven off during drying. Total residue should be limited to about 200 mg.

Apparatus

Glass fiber filter disc, 4.7 cm without organic binder, Reeve Angel type 934-AH, Gelman type A/E, or equivalent.

Filter holder, membrane filter funnel or Gooch crucible adapter.

Suction flask, 500 ml

Gooch crucibles, 25 ml (if 2.1 cm filter is used).

Evaporating dishes, porcelain, 100 ml volume. (Vycor or platinum dishes may be substituted).

Steam bath

Drying oven, 180°C ± 2°C.

Desiccator

Analytical balance, capable of weighing to 0.1 mg

Procedure

Preparation of glass fiber filter disc: Place the disc on the membrane filter apparatus or insert into bottom of a suitable Gooch crucible. While vacuum is applied, wash the disc with three successive 20 ml volumes of distilled water. Remove all traces of water by continuing to apply vacuum after water has passed through. Discard washings.

Preparation of evaporating dishes: If Volatile Residue is also to be measured heat the clean dish to 550 $\pm$ 50°C for one hour in a muffle furnace. If only Filterable Residue is to be measured heat the clean dish to 180 $\pm$ 2°C for one hour. Cool in desiccator an store until needed. Weigh immediately before use.

Assemble the filtering apparatus and begin suction. Shake the sample vigorously and rapid transfer 100 ml to the funnel by means of a 100 ml graduated cylinder. If total filterable residue is low, a larger volume may be filtered.

Filter the sample through the glass fiber filter, rinse with three 10 ml portions of distilled water and continue to apply vacuum for about 3 minutes after filtration is complete to remove as much water as possible.

Transfer 100 ml (or a larger volume) of the filtrate to a weighed evaporating dish and evaporate to dryness on a steam bath.

Dry the evaporated sample for at least one hour at 180 $\pm$ 2°C. Cool in a desiccator and weigh. Repeat the drying cycle until a constant weight is obtained or until weight loss is less than 0.5 mg.

Calculations

Calculate Total Dissolved Solids as follows:

$$\text{TDS, mg/l} = \frac{(A - B) \times 1{,}000}{C}$$

where:

A = weight of filter (or filter and crucible) + residue in mg
B = weight of filter (or filter and crucible) in mg
C = ml of sample filtered

Reference

Method 160.1 of Method of Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

Total Suspended Solids

Scope of Application

This method is applicable to drinking, surface, and saline waters, domestic and industrial wastes.

The practical range of the determination is 4 mg/l to 20,000 mg/l.

Summary of Method

A well-mixed sample is filtered through a glass fiber filter, and the residue retained on the filter is dried to constant weight at 103-105°C.

The filtrate from the method may be used for Residue, Filterable.

Interferences

Filtration apparatus, filter material, pre-washing, post-washing, and drying temperature are specified because these variable have been shown to affect the results.

Sample high in Filterable Residue (dissolved solids), such as saline water, brines and some wastes, may be subject to a positive interference. Care must be taken in selecting the filtering apparatus so that washing of the filter and any dissolved solids in the filter (7.5) minimizes this potential interference.

Apparatus

Glass fiber filter discs, without organic binder, such as Millipore AP-40, Reeves Angel 934-AH, Gelman type A/E, or equivalent.

Filter support: filtering apparatus with reservoir and a coarse (40-60 microns) fritted disc as a filter support.

Suction flask
Drying Oven, 103-105°C
Desiccator
Analytical balance, capable of weighing to 0.1 mg

Procedure

Preparation of glass filter disc: Place the glass filter on the membrane filter apparatus or insert into bottom of a suitable Gooch crucible with wrinkled surface up. While vacuum is applied, wash the disc with three successive 20 ml volumes of distilled water. Remove all traces of water by continuing to apply vacuum after water has passed through. Remove filter from membrane filter apparatus or both crucible and filter if Gooch crucible is

used, and dry in an oven at 103-105°C for one hour. Remove to desiccator and store until needed. Repeat the drying cycle until a constant weight is obtained (weight loss is less than 0.5 mg). Weigh immediately before use. After weighing, handle the filter or crucible/filter with forceps or tongs only.

Assemble the filtering apparatus and begin suction. Wet the filter with a small volume of distilled water to seat it against the fritted support.

Shake the sample vigorously and quantitatively transfer the predetermined sample volume selected in 7.2 to the filter using a graduated cylinder. Remove all traces of water by continuing to apply vacuum after sample has passed through.

With suction on, wash the graduated cylinder, filter, non-filterable residue and filter funnel wall with three portions of distilled water allowing complete drainage between washing. Remove all traces of water by continuing to apply vacuum after water has passed through.

Carefully remove the filter from the filter support. Alternatively, remove crucible and filter from crucible adapter. Dry at least one hour at 103-105°C. Cool in a desiccator and weigh. Repeat the drying cycle until a constant weight is obtained (weight loss is less than 0.5 mg).

Calculations

Calculate Total Suspended Solids as follows:

$$\text{TSS, mg/l} = \frac{(A - B) \times 1{,}000}{C}$$

where:

A = weight of filter (or filter and crucible) + residue in mg
B = weight of filter (or filter and crucible) in mg
C = ml of sample filtered

Reference

Method 160.2 of Method of Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

Attachment 3

A Sample Report

for the

Hellertown, PA RI/FS Project

Prepared By:

Cambridge Analytical Associates, Inc.
1106 Commonwealth Avenue
Boston, Massachusetts 02215

January 13, 1989

R E P O R T T O

Client
address
city, state zip code

Attn: Client Representative

Work ID: Demonstration Work Order
P.O. No.: 88888
Work Order: 88-01-021

Cambridge Analytical Associates
Environmental Division
1106 Commonwealth Avenue
Boston MA 02215

304741

Received: 01/06/88

REPORT

01/06/88 15:04:46

Work Order # 88-01-021

REPORT TO
Client
address
city, state zip code

ATTEN Mr. Client Contact

CLIENT CLIENT SAMPLES 7
COMPANY Client
FACILITY

WORK ID Demonstration Work Order
TAKEN by client
TRANS by Fed. Ex. 000000000
TYPE
P.O. # 88888
INVOICE under separate cover

PREPARED BY
Cambridge Analytical Assoc.
Environmental Division
1106 Commonwealth Avenue
Boston, MA 02215

ATTEN
PHONE 617-232-2207

CERTIFIED BY

CONTACT HAUSKNECHT

This report is approved for release by the following staff:
Laboratory Director: Lab Director Signature
Inorganic Laboratory: Inorganic Lab Manager
Organic Laboratory: Organic Lab Manager

SAMPLE IDENTIFICATION

01	Demo. Sample 1
02	Demo. Sample 2
03	Demo. Sample 3
04	Demo. Sample 4
05	Demo. Sample 5
06	Demo. Sample 6
07	Demo. Sample 7

TEST CODES and NAMES used on this report

ABN_A	ABN(GC/MS)-aqueous-EPA 625
AG_I_A	Silver (Ag)-ICP
AS_GFA	Arsenic (As)-furnace AAS
BE_I_A	Beryllium (Be)-ICP
CD_GFA	Cadmium (Cd)-furnace AAS
CNT_A	Total cyanide-EPA 335.3
COD	Chemical oxygen demand
CR6_A	Hexavalent Cr-218.5
CR_I_A	Chromium (Cr)-ICP
CU_I_A	Copper (Cu)-ICP
DIG_AQ	Acid digestion-aqueous-EPA
EXABNA	A/B/N ext-aqueous-EPA 625
EXCR6A	Ext-hex Cr-EPA 218.5
HG_CVA	Mercury (Hg)-cold vapor
NI_I_A	Nickel (Ni)-ICP
NO3_A	Nitrate-EPA 300.0
PB_GFA	Lead (Pb)-furnace AAS
PHEN_A	Phenols-EPA 420.2
SB_GFA	Antimony (Sb)-furnace
SE_GFA	Selenium (Se)-furnace
TDS	Dissolved solids-EPA 160.1
TKN_A	Total Kjeldahl N-EPA 351.3
TL_GFA	Thallium (Tl)-furnace
TOC_A	Organic carbon-EPA 415.1
TS	Total solids-EPA 160.3
TSS	Suspended solids-EPA 160.2
V624_A	VOC-aqueous-EPA 624
ZN_I_A	Zinc (Zn)-ICP

REPORT
Results By Test

SAMPLE Sample Id	Test:AG_I_A mg/l	Test:AS_GFA mg/l	Test:BE_I_A mg/l	Test:CD_GFA mg/l	Test:CNT_A mg/l
01 Demo. Sample 1	**	**	**	**	
04 Demo. Sample 4					**

SAMPLE Sample Id	Test:COD mg/l	Test:CR6_A mg/l	Test:CR_I_A mg/l	Test:CU_I_A mg/l	Test:DIG_AQ date complete
01 Demo. Sample 1			**	**	01/06/88
02 Demo. Sample 2		**			
03 Demo. Sample 3	**				

SAMPLE Sample Id	Test:EXABNA extraction date	Test:EXCR6A date complete	Test:HG_CVA mg/l	Test:NI_I_A mg/l	Test:NO3_A mg/l as N
01 Demo. Sample 1			**	**	
02 Demo. Sample 2		01/06/88			
03 Demo. Sample 3					**
05 Demo. Sample 5	01/06/88				

SAMPLE Sample Id	Test:PB_GFA mg/l	Test:PHEN_A mg/l	Test:SB_GFA mg/l	Test:SE_GFA mg/l	Test:TDS mg/l
01 Demo. Sample 1	**		**	**	
03 Demo. Sample 3		**			

REPORT
Results By Test

SAMPLE Sample Id	Test:PB_GFA mg/l	Test:PHEN_A mg/l	Test:SB_GFA mg/l	Test:SE_GFA mg/l	Test:TDS mg/l
07 Demo. Sample 7					**

SAMPLE Sample Id	Test:TKN_A mg/l as N	Test:TL_GFA mg/l	Test:TOC_A mg/l	Test:TS mg/l	Test:TSS mg/l
01 Demo. Sample 1		**			
03 Demo. Sample 3	**		**		
07 Demo. Sample 7				**	**

SAMPLE Sample Id	Test:ZN_I_A mg/l
01 Demo. Sample 1	**

SAMPLE ID Demo. Sample 1 SAMPLE # 01 FRACTIONS: A
Date & Time Collected 01/04/87 Category AQUEOUS

AG_I_A ** mg/l	AS_GFA ** mg/l	BE_I_A ** mg/l	CD_GFA ** mg/l	CR_I_A ** mg/l	CU_I_A ** mg/l
DIG_AQ 01/06/88 date complete	HG_CVA ** mg/l	NI_I_A ** mg/l	PB_GFA ** mg/l	SB_GFA ** mg/l	SE_GFA ** mg/l
TL_GFA ** mg/l	ZN_I_A ** mg/l				

SAMPLE ID Demo. Sample 2 SAMPLE # 02 FRACTIONS: A
Date & Time Collected 01/04/87 Category AQUEOUS

CR6_A ** mg/l	EXCR6A 01/06/88 date complete

SAMPLE ID Demo. Sample 3 SAMPLE # 03 FRACTIONS: A
Date & Time Collected not specified Category AQUEOUS

COD ** mg/l	NO3_A ** mg/l as N	PHEN_A ** mg/l	TKN_A ** mg/l as N	TOC_A ** mg/l

SAMPLE ID Demo. Sample 4 SAMPLE # 04 FRACTIONS: A
Date & Time Collected not specified Category AQUEOUS

CNT_A ** mg/l

SAMPLE ID Demo. Sample 5 SAMPLE # 05 FRACTIONS: A
Date & Time Collected 01/04/88 Category AQUEOUS

EXABNA 01/06/88 extraction date

Received: 01/06/88 Results by Sample

SAMPLE ID Demo. Sample 5 FRACTION 05A TEST CODE ABN_A NAME ABN(GC/MS)-aqueous-EPA 625
Date & Time Collected 01/04/88 Category AQUEOUS

Analysis Completed: 01/06/88

BASE/NEUTRALS

COMPOUND	ug/L(a)	COMPOUND	ug/L(a)
bis(2-Chloroethyl)Ether	**	Di-n-butylphthalate	**
1,3-Dichlorobenzene	**	Fluoranthene	**
1,4-Dichlorobenzene	**	Pyrene	**
1,2-Dichlorobenzene	**	Butylbenzylphthalate	**
bis(2-Chloroisopropyl)Ether	**	3,3'-Dichlorobenzidine	**
N-Nitroso-di-n-propylamine	**	Benzo(a)Anthracene	**
Hexachloroethane	**	bis(2-Ethylhexyl)phthalate	**
Nitrobenzene	**	Chrysene	**
Isophorone	**	Di-n-octylphthalate	**
bis(2-Chloroethoxy)Methane	**	Benzo(b)Fluoranthene	**
1,2,4-Trichlorobenzene	**	Benzo(k)Fluoranthene	**
Naphthalene	**	Benzo(a)Pyrene	**
Hexachlorobutadiene	**	Indeno(1,2,3-cd)Pyrene	**
Hexachlorocyclopentadiene	**	Dibenzo(a,h)Anthracene	**
2-Chloronaphthalene	**	Benzo(g,h,i)Perylene	**
Dimethylphthalate	**		
Acenaphthylene	**	The following are non-priority pollutant Hazardous Substance List compounds.	
Acenaphthene	**		
2,4-Dinitrotoluene	**		
2,6-Dinitrotoluene	**	Aniline	**
Diethylphthalate	**	Benzyl Alcohol	**
4-Chlorophenyl-phenylether	**	4-Chloroaniline	**
Fluorene	**	2-Methylnaphthalene	**
N-Nitrosodiphenylamine	**	2-Nitroaniline	**
4-Bromophenyl-phenylether	**	3-Nitroaniline	**
Hexachlorobenzene	**	Dibenzofuran	**
Phenanthrene	**	4-Nitroaniline	**
Anthracene	**		
		DETECTION LIMIT	**

(a) - Concentrations less than the detection limit are left blank. Concentrations between 1 and 10 times the detection limit are listed as trace levels 'TR'.

REPORT
Results by Sample

SAMPLE ID Demo. Sample 5

FRACTION 05A TEST CODE ABN_A NAME ABN(GC/MS)-aqueous-EPA 625
Date & Time Collected 01/04/88 Category AQUEOUS

ACID COMPOUNDS

	ug/L(a)
Phenol	**
2-Chlorophenol	**
2-Nitrophenol	**
2,4-Dimethylphenol	**
2,4-Dichlorophenol	**
4-Chloro-3-methylphenol	**
2,4,6-Trichlorophenol	**
2,4-Dinitrophenol	**
4-Nitrophenol	**
4,6-Dinitro-2-methylphenol	**
Pentachlorophenol	**

The following are non-priority pollutant Hazardous Substance List compounds.

2-Methylphenol	**
4-Methylphenol	**
Benzoic Acid	**
2,4,5-Trichlorophenol	**
DETECTION LIMIT	**

(a) - Concentrations less than the detection limit are left blank. Concentrations between 1 and 10 times the detection limit are listed as trace levels 'TR'.

Received: 01/06/88 Results by Sample

SAMPLE ID Demo. Sample 6 FRACTION 06A TEST CODE V624_A NAME VOC-aqueous-EPA 624
Date & Time Collected 01/04/88 Category AQUEOUS

Analysis
Completed: *

COMPOUND	ug/L(ppb) (a)	COMPOUND	ug/L(ppb) (a)
Chloromethane	**	2-Chloroethylvinyl Ether	**
Bromomethane	**	Bromoform	**
Vinyl Chloride	**	1,1,2,2-Tetrachloroethane	**
Chloroethane	**	Tetrachloroethylene	**
Methylene Chloride	**	Toluene	**
1,1-Dichloroethylene	**	Chlorobenzene	**
1,1-Dichloroethane	**	Ethylbenzene	**
trans-1,2-Dichloroethylene	**	total Xylenes	**
Chloroform	**		
1,2-Dichloroethane	**	The following are non-priority pollutant Hazardous Substance List compounds.	
1,1,1-Trichloroethane	**		
Carbon Tetrachloride	**		
Bromodichloromethane	**	Carbon Disulfide	**
1,2-Dichloropropane	**	2-Butanone (MEK)	**
trans-1,3-Dichloropropene	**	Vinyl Acetate	**
Trichloroethylene	**	2-Hexanone (MPK)	**
Chlorodibromomethane	**	4-Methyl-2-pentanone (MIBK)	**
1,1,2-Trichloroethane	**	Styrene	**
Benzene	**		
cis-1,3-Dichloropropene	**	DETECTION LIMIT	**

(a) - Concentrations less than the detection limit are left blank
Concentrations between 1 and 10 times the detection limit are listed as trace levels 'TR'.

REPORT
Results by Sample

Work Order # 88-01-021

SAMPLE ID Demo. Sample 7 SAMPLE # 07 FRACTIONS: A
Date & Time Collected 01/04/88 Category AQUEOUS

TDS	TS	TSS
** mg/l	** mg/l	** mg/l

TEST CODE ABN_A NAME ABN(GC/MS)-aqueous-EPA 625

Method Reference: U.S. EPA, 1984. Methods for Organic Analysis of Municipal and Industrial Wastewater. Appendix A. 40CFR Part 136. Federal Register, Vol. 49, No. 209. Method 625, test method for base/neutral and acid organic compounds.

Method Description: The analytes in an aqueous sample are isolated and concentrated by solvent extraction. The extract is injected into into a gas chromatograph (GC) where the analytes are separated and detected with a mass spectrometric (MS) detector.

Quality Control Procedures: The GC/MS is tuned every twelve hours with decafluorotriphenylphosphine (DFTPP). Instrument response is calibrated every twelve hours using EPA traceable standard reference solutions. Analytes are quantified using the internal standard method. Surrogate standard compounds are added to every sample to monitor method performance. Additional quality control includes the analysis of replicates, duplicate matrix spikes, and blanks.

TEST CODE AG_I_A NAME Silver (Ag)-ICP

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 200.7-Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Silver is determined by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

TEST CODE AS_GFA NAME Arsenic (As)-furnace AAS

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 206.2-arsenic (atomic absorption, graphite furnace).

TEST CODE AS_GFA NAME Arsenic (As)-furnace AAS

Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846 (Second edition). EPA/Office of Solid Waste and Emergency Response, Washington, DC. Method 7060.

Method Description: Arsenic is determined by graphite furnace atomic absorption spectrophotometry on a Perkin-Elmer Model 5000 atomic absorption spectrophotometer using stabilized-temperature platforms, matrix modification, and Zeeman-effect background correction.

Quality Control Procedures: The instrument is calibrated using a blank and at least three working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are performed with each batch of samples. Duplicates and matrix spikes are performed at a frequency of 10 %.

TEST CODE BE_I_A NAME Beryllium (Be)-ICP

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 200.7-Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Beryllium is determined by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

TEST CODE CD_GFA NAME Cadmium (Cd)-furnace AAS

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 213.2-cadmium (atomic absorption, graphite furnace).

TEST CODE CD_GFA NAME Cadmium (Cd)-furnace AAS

Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846 (Second edition). EPA/Office of Solid Waste and Emergency Response, Washington, DC. Method 7131.

Method Description: Cadmium is determined by graphite furnace atomic absorption spectrophotometry on a Perkin-Elmer Model 5000 atomic absorption spectrophotometer using stabilized-temperature platforms, matrix modification, and Zeeman-effect background correction, or a Perkin-Elmer Model 2380 atomic absorption spectrophotometer using stabilized temperature platforms, matrix modification, and deuterium arc background correction.

Quality Control Procedures: The instrument is calibrated using a blank and at least three working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are performed with each batch of samples. Duplicates and matrix spikes are performed at a frequency of 10 %.

TEST CODE CNT_A NAME Total cyanide-EPA 335.3

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 335.2-Cyanide, total (spectrophotometric). Method 335.3-cyanide, total (colorimetric, automated UV).

Method Description: Cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of a reflux-distillation operation and absorbed in a scrubber containing sodium hydroxide solution. Cyanide ion in the absorbing solution is determined colorimetrically. Cyanide is converted to cyanogen chloride by reaction with chloramine-T at a pH less than 8 without hydrolyzing to cyanate. After the reaction is complete, color is formed by addition of pyridine-barbituric acid reagent. Absorbance is read at 578 nm. Colorimetric determinations are made using a Technicon AutoAnalyzer II.

QC Procedures: The spectrophotometer is calibrated using a blank and four working standards. Accuracy of the working standards is verified by analysis of an independent check standard. A procedural blank is run with each batch of samples, and duplicates and matrix spikes are run at a frequency of 10 %.

TEST CODE COD NAME Chemical oxygen demand

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. EPA/EMSL, Cincinnati, Ohio. Method 410.1- chemical oxygen demand, titrimetric).

Method Description: Organic and oxidizable inorganic substances in the sample are oxidized by potassium dichromate in 50% sulfuric acid solution at reflux temperature. Silver sulfate is used as a catalyst and mercuric sulfate is added to remove chloride interference. The excess dichromate is titrated with standard ferrous ammonium sulfate, using orthophenanthroline ferrous complex as an indicator.

Quality Control Procedures: Blanks and duplicates are run at a frequency of 1 per 20 samples. EPA reference standards are analyzed with each analytical run.

TEST CODE CR6_A NAME Hexavalent Cr-218.5

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 218.5-Chromium,Dissolved Hexavalent (Atomic Absorption,Furnace Technique) Method 200.7-Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Hexavalent chromium is coprecipitated as lead chromate with lead sulfate in acetic acid solution. The precipitate is dissolved in nitric acid and analyzed by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks and standards are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

TEST CODE CR_I_A NAME Chromium (Cr)-ICP

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 200.7-Inductively Coupled Plasma-Atomic Emission

TEST CODE CR_I_A NAME Chromium (Cr)-ICP

Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Chromium is determined by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

TEST CODE CU_I_A NAME Copper (Cu)-ICP

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 200.7-Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Copper is determined by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

TEST CODE DIG_AQ NAME Acid digestion-aqueous-EPA

Method Description: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Section 4.1.3.
Additional references: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846. EPA/Office of Solid Waste, Washington, DC.

Method Description: A 100-ml aliquot of sample is transferred to an acid-washed

TEST CODE DIG_AQ NAME Acid digestion-aqueous-EPA

beaker. Following addition of 3 ml of concentrated Instra-analyzed nitric acid, the sample is placed on a hot plate and evaporated to near-dryness without boiling. After cooling, another 3-ml portion of acid is added, followed by 2 ml of 30 % hydrogen peroxide, and the sample is reluxed until digestion is complete (generally indicated by a yellow color). Additional acid is added until no change in sample composition is observed. The sample is again taken to near-dryness. For furnace AAS determinations, the sample is diluted to 100 ml with distilled, deionized water so that the final acid concentration is 0.5 %. For flame AAS and ICP determinations, and for furnace determinations of Sb and Sn, the final dilution is performed with 1:1 HCl (5 ml/100 ml of solution). Insoluble material is removed by filtering or settling.

TEST CODE HG_CVA NAME Mercury (Hg)-cold vapor

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 245.1-Mercury (Manual Cold Vapor Technique).
Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste. SW-846-Second edition. (Update No. 1-April 1984). EPA/Office of Solid Waste, Washington, DC. Method 7470-Mercury (Manual Cold-Vapor Technique).

Method Description: Mercury is determined in drinking, surface and saline waters,as well as domestic and industrial wastes by digestion of sample in sulfuric and nitric acids, followed by oxidation with potassium permanganate and potassium persulfate. Mercury in the digested sample is then measured by cold vapor atomic absorption spectrophotometry on a SpectroProducts Hg-3 analyzer.

Quality Control Procedures: Instrumental calibration is performed by analyzing a blank and four or more working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Matrix spikes and duplicates are analyzed at a frequency of 10 %.

TEST CODE NI_I_A NAME Nickel (Ni)-ICP

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 200.7-Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Nickel is determined by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

TEST CODE PB_GFA NAME Lead (Pb)-furnace AAS

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 239.2-lead (atomic absorption, graphite furnace).

Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846 (Second edition). EPA/Office of Solid Waste and Emergency Response, Washington, DC. Method 7421.

Method Description: Lead is determined by graphite furnace atomic absorption spectrophotometry on a Perkin-Elmer Model 5000 atomic absorption spectrophotometer using stabilized-temperature platforms, matrix modification, and Zeeman-effect background correction, or a Perkin-Elmer Model 2380 atomic absorption spectrophotometer using stabilized temperature platforms, matrix modification, and deuterium arc background correction.

Quality Control Procedures: The instrument is calibrated using a blank and at least three working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are performed with each batch of samples. Duplicates and matrix spikes are performed at a frequency of 10 %.

TEST CODE PHEN_A NAME Phenols-EPA 420.2

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 420.2-phenol, total recoverable, automated 4-AAP with distillation).

Method Description: A 500-ml sample is distilled to remove phenolic material and then reacted with 4-aminoantipyrine in the presence of potassium ferricyanide at pH 10 to form a red-colored complex. Absorbance is measured at 505 or 520 nm. The colorimetry is performed utilizing a Technicon AutoAnalyzer II.

QC Procedures: The Technicon AutoAnalyzer II is calibrated using a blank and four working standards. Accuracy of the working standards is verified by analysis of an independent check standard. A procedural blank is run with each batch of samples, and duplicates and matrix spikes are run at a frequency of 10 %.

TEST CODE SB_GFA NAME Antimony (Sb)-furnace

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 204.2-antimony (atomic absorption, graphite furnace).

Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846 (Second edition). EPA/Office of Solid Waste and Emergency Response, Washington, DC. Method 7041.

Method Description: Antimony is determined by graphite furnace atomic absorption spectrophotometry on a Perkin-Elmer Model 5000 atomic absorption spectrophotometer using stabilized-temperature platforms, matrix modification, and Zeeman-effect background correction.

Quality Control Procedures: The instrument is calibrated using a blank and at least three working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are performed with each batch of samples. Duplicates and matrix spikes are performed at a frequency of 10 %.

TEST CODE SE_GFA NAME Selenium (Se)-furnace

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 270.2-selenium (atomic absorption, graphite furnace).

Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846 (Second edition). EPA/Office of Solid Waste and Emergency Response, Washington, DC. Method 7740.

Method Description: Selenium is determined by graphite furnace atomic absorption spectrophotometry on a Perkin-Elmer Model 5000 atomic absorption spectrophotometer using stabilized-temperature platforms, matrix modification, and Zeeman-effect background correction.

QC Procedures: The instrument is calibrated using a blank and at least three working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are performed with each batch of

TEST CODE SE_GFA NAME Selenium (Se)-furnace

samples. Duplicates and matrix spikes are performed at a frequency of 10 %.

TEST CODE TKN_A NAME Total Kjeldahl N-EPA 351.3

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 351.3 -Nitrogen, Kjeldahl, Total (Colorimetric; Titrimetric; Potentiometric).

Method Description: Total nitrogen is determined by converting the nitrogen components of biological compounds to ammonia by strong acid digestion. A 50-ml aliquot of sample is transfered to a pre-distilled flask. Following addition of 10-ml sulfuric acid-mercuric sulfate-potassium sulfate solution, the sample is placed into a Buchi Model 425 Digestor. The mixture is evaporated for 30 min after SO3 fumes appear and the solution turns clear or pale yellow. After cooling, 30-ml of deionized water is added to the residue. This digestate is made basic by addition of 10-ml of sodium hydroxide-thiosulfate solution and distilled in a Buchi Model 315 Steam Distillation Unit. The distillate is analyzed for ammonia colorimetrically or by titration.

Quality Control Procedures: A calibration curve is established using a blank and at least 3 standards. Calibration is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Matrix spikes and duplicates are analyzed at a frequency of 10%.

TEST CODE TL_GFA NAME Thallium (Tl)-furnace

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 279.2-thallium (atomic absorption, graphite furnace).

Additional References: EPA. 1982. Test Methods for Evaluating Solid Waste-Physical/Chemical Methods. SW-846 (Second edition). EPA/Office of Solid Waste and Emergency Response, Washington, DC. Method 7840.

Method Description: Arsenic is determined by graphite furnace atomic absorption spectrophotometry on a Perkin-Elmer Model 5000 atomic absorption spectrophotometer using stabilized-temperature platforms, matrix modification, and Zeeman-effect background correction.

TEST CODE TL_GFA NAME Thallium (Tl)-furnace

Quality Control Procedures: The instrument is calibrated using a blank and at least three working standards. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are performed with each batch of samples. Duplicates and matrix spikes are performed at a frequency of 10 %.

TEST CODE TOC_A NAME Organic carbon-EPA 415.1

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 415.1-Total Organic Carbon (Combustion or Oxidation).

Method Description: Total organic carbon is determined by converting organic carbon to carbon dioxide by wet chemical oxidation and measured by an infrared detector.

Quality Control Procedures: The instrument is calibrated by single point with the appropriate injection volume and standard concentration in the range of interest. Three operating concentration ranges are available, i.e. 0.1-160 ppm, 10-800 ppm, and 100-4000 ppm. Accuracy of the working standards is verified by analysis of an independent EPA reference standard, and calibration is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates are analyzed at a frequency of 10 %.

TEST CODE V624_A NAME VOC-aqueous-EPA 624

Method Reference: U.S. EPA, 1984. Methods for Organic Analysis of Municipal and Industrial Wastewater. Appendix A. 40CFR Part 136. Federal Register, Vol. 49, No. 209. Method 624, test method for volatile organic compounds.

Method Description: The analytes in an aqueous sample are isolated and concentrated by purging the sample with inert gas and trapping them on an absorbant. The absorbant is thermally desorbed into a gas chromatograph (GC) where the analytes are separated and detected with a mass spectrometric (MS) detector.

Quality Control Procedures: The GC/MS is tuned daily with bromofluorobenzene (BFB). Instrument response is calibrated daily using EPA traceable standard reference solutions. Analytes are quantified using the internal standard method. Surrogate standard compounds are added to every sample to monitor method performance. Additional quality control includes the analysis of matrix spikes, duplicate matrix spikes, and blanks.

TEST CODE ZN_I_A NAME Zinc (Zn)-ICP

Method Reference: EPA. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600-4/79-020 (Revised March 1983). EPA/EMSL, Cincinnati, Ohio. Method 200.7-Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes.

Method Description: Zinc is determined by inductively coupled argon plasma emission spectroscopy on a Jarrell-Ash Model 2000 sequential plasma spectrometer.

Quality Control Procedures: The instrument is calibrated using a blank and a 10 ppm standard. Accuracy of the working standards is verified by analysis of an independent EPA or NBS reference standard, and calibraton is checked every 10 samples during the run. Procedural blanks are prepared with each batch of samples. Duplicates and matrix spikes are analyzed at a frequency of 10 %.

Attachment 4

Analytical Results - Diskette Deliverables

for the

Hellertown, PA RI/FS Project

Prepared By:

Cambridge Analytical Associates, Inc.
1106 Commonwealth Avenue
Boston, Massachusetts 02215

January 13, 1989

Cambridge Analytical Associates,1106 Commonwealth Avenue,Boston, MA 02215
tel (617)232-2207

SPECIFICATIONS FOR ANALYTICAL LABORATORY DATA PROVIDED ON DISKETTE

****
NOTE:CHANGES FROM PREVIOUS VERSION (DATED 1/15/88)
The third field (analyte reference code) has been changed from a length of 10 characters to 11 characters.
****

SPECIFICATIONS:

The data will be provided on 360kB 5-1/4" diskettes.

Files will follow the naming convention of Mnnnnnnn.CAA, where nnnnnnn is the unique seven digit workorder number assigned by CAA to a set of samples received for analytical testing.

There is one file per CAA workorder.

The files are flat ASCII files, with fixed length records, with one row per analyte. A description of the fields within each record follows:

#	length	Field contents	format of data
1	26	client sample ID	specified by client
2	17	date and time sample collected	dd/mm/yy hh:mm:ss
3	11	analyte reference code (ie. CAS #)	Cnnnnnnnnn for organics
4	30	analyte name	follows EPA naming convention
5	1	Flag to refer to hardcopy	blank or *
6	1	flag for analytical result	blank, <,>, or T
7	1	reserved flag field	unassigned
8	15	Analytical result	number
9	15	Units	standard units
10	6	CAA method reference	A-Z,0-9,_ only
11	12	CAA sample ID	yymmnnnxxyyqc

All fields, except analytical result, are left justified. Analytical result is right justified.

A detailed description of the contents of each field follows:

Client Sample ID- This is the ID assigned by the client to completely identify a sample (except for date and time of collection). A maximum of 26 characters are allowed. The exact format of what information is entered must be documented with the samples when they are received at CAA. Normally, information is transcribed from the chain of custody documentation that accompanies the samples. If upper and lower case, spacing, or order of data entry is critical, is must be clearly specified at time of sample receipt (or before by prior arrangement).

Date and Time Collected- This is in the format of dd/mm/yy hh:mm:ss. A date may be entered without a time. This information must be documented

304766

at time of sample receipt. If this information is needed, please specify it with the paperwork accompanying the samples or by prior arrangement to ensure this information is entered.

NOTE: The above data must be specified correctly at time of sample receipt. If information needs to be entered or changed after the sample are received, a nominal fee may have to be charged in order to recode the data.

Analyte Reference Code- This is a standard analyte identification code. For organic compounds this will be the CAS number in the format of Cnn_nnn_nnn, where 'C' is the first character and nn_nnn_nnn is the CAS number with dashes relaced by underscores. NOTE: CAS numbers do not all have the same total number of characters or number of digits between hyphens. Metals will follow the same convention, using the CAS number of the neutral state metal. For analytes with no CAS numbers, a mnemonic code will be used (ie. BOD for biological oxygen demand, TSS for total suspended solids, etc). A list of mnemonic codes used will be supplied to the client upon request.

Full Analyte Name- This is the name of the analyte or parameter whose result is being reported (ie. 'Methylene Chloride', 'Total Organic Carbon', etc). Naming conventions used by EPA will be followed (ie. 'Methylene Chloride' will be used, not 'Dichloromethane').

Flag to refer to Hardcopy-If a '*' is present, then a comment about the analytical result is present in the hardcopy report regarding this parameter.

Flag Field for Result- This one character field is reserved for flagging the following analytical result. Flags that are used are:

< indicates the analyte was not detected. The reported analytical result is then the detection limit.

> indicates the analyte was present at a concentration greater than the following reported analytical value.

T this flag was used historically to indicate the analytical result is considered a trace concentration. This flag is no longer used in reporting analytical data.

Analytical Result- This is measured concentration of the parameter determined by the analysis. The value reported is exactly the same as the value in the hardcopy report, including number of significant figures. The number of figures (if any) reported past the decimal point is NOT fixed.

Units- This is the analytical units used to report the analytical result. Standard units used for organic analyses are in ppb, with 'ug/L' reported for aqueous analyses, and 'ug/Kg (dry wt)' for soil analyses. Standard units for inorganic parameters are ppm, with 'mg/L' reported for aqueous samples, and 'ug/g (dry wt)' for soil analyses.

Cambridge Analytical Associates, 1106 Commonwealth Avenue, Boston, MA 02215
tel (617)232-2207

SPECIFICATIONS FOR ANALYTICAL LABORATORY DATA PROVIDED ON DISKETTE

CAA Method Reference- This is a mnemonic code for the test method used to produce the reported analytical result. The hardcopy report contains a cross reference between the mnemonic codes used and method references that completely describe the EPA test method used to perform the analyses. For example if Methylene Chloride was reported with a CAA method reference of VCLP_A, the hardcopy report would indicate that the analysis was performed using current USEPA Contract Laboratory Program protocols. If the method reference was V624_A, the report would indicate the analysis was performed using EPA method 624 described in the Federal Register, Vol. 49, No. 209.

CAA Sample ID- This is a unique sample ID assigned by CAA to each sample at time of receipt. All samples received from a client at one time are grouped together using a common workorder number, which makes up the first seven digits of the CAA sample ID. Each sample is also assigned a unique two digit sample number. Furthermore, each aliqout (ie. separate bottles for volatiles and acid/base/neutrals analyses) of each sample is assigned a unique one letter fraction code. The last two characters are reserved for future use. Very large projects (more than 42 total fractions) and samples received in batches over several days will have multiple work order numbers assigned. The analytical data for all samples within one work order are reported in one file named Myymmnnn.CAA, where yymmnnn is the CAA work order number.

Appendix B

Qualifications of ESC personnel

Richard E. Freudenberger

Mr. Freudenberger, Senior Vice President of Environmental Strategies Corporation, directs the technical staff in a wide range of projects. He has been most heavily involved in the design of groundwater clean-up and Superfund remedial investigation programs, assessments for mergers and acquisitions, environmental audits, and environmental assessments for major corporate clients. His past government service qualifies him to represent clients effectively in negotiations with regulatory agencies.

Specifically, Mr. Freudenberger has worked with a major ESC client in the wood preserving industry in designing and planning extensive clean-ups of creosote and penta-chlorophenol contamination under CERCLA, RCRA, and ECRA regulations. In two other Superfund projects under ESC direction, Mr. Freudenberger is directing the preparation of RI/FS documents to address characterization and remediation of groundwater contamination by chlorinated organics.

He has designed detailed health and safety and soil sampling plans for dioxin (2,3,7,8-TCDD) and performed the field sampling programs. He directed the remedial activities in the field for the clean-up and secure storage of the dioxin contaminated soils.

He has designed sampling and remedial action programs for groundwater and soil contamination at a number of industrial sites. He has performed over 150 industrial site surveys and risk assessments for a wide variety of industrial clients.

Mr. Freudenberger was formerly Vice President of Risk Science International. Before that, he was with Gannett Fleming Corddry and Carpenter, Inc., as a consulting engineer, where he oversaw a wastewater facility construction management contract for the City of Baltimore during 1979-81.

Previously, Mr. Freudenberger was Director of Public Works for Howard County, Maryland, with management responsibility for solid waste collection and disposal, environmental engineering, wastewater treatment, road maintenance, engineering, and capital projects in the county. Before that, he was project engineer for a $50 million expansion to the county's wastewater treatment plant and successfully directed the permitting and siting process for a new 600-acre sanitary landfill. He spent three years as superintendent of operations and maintenance for a 10-mgd secondary wastewater treatment plant.

Mr. Freudenberger is a registered professional engineer in Maryland, a certified wastewater treatment plant operator in Maryland, and a Diplomate of the American Academy of Environmental Engineers. He received a B.S. in civil engineering and an M.S. in environmental engineering at the University of Maryland.

Catherine H. Price

Catherine H. Price is a Senior Engineer with Environmental Strategies Corporation. Before joining ESC, she was an Environmental Consultant with Jacobs Engineering Group, Inc. in Plano, Texas, where she was the Assistant Regional Manager on a Technical Enforcement Support contract with the U.S. Environmental Protection Agency. She provided enforcement support to EPA under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). She performed RCRA compliance inspections of treatment, storage, and disposal facilities as well as generator and transporter facilities. She performed technical reviews of RCRA facility plans and CERCLA responsible party plans and evaluated of records to determine compliance with record keeping and reporting requirements and records of compliance with regulations. Ms. Price also performed health and environmental assessments, including CERCLA endangerment assessments, and prepared community relations plans. She conducted responsible party searches, including record searches, title searches, and interviews of knowledgeable persons. She provided emergency response on the Technical Assistance Team contract to EPA Emergency Response Branch, which involved responding to hazardous chemical and oil spills, performing site investigations, designing remedial site activities, and sampling and performing environmental monitoring. Ms. Price prepared a QA/QC manual. She was involved in training on hazardous waste site control and site entry, site sampling plan development, health and safety plans, and First Responders Course.

Other positions held include Operations Manager at The Pillsbury Company and Warehouse Department Manager at Procter and Gamble. The positions involved management of personnel and operations, scheduling of production and raw materials, inventory control, and shipping and receiving finished products.

Ms. Price has a B.S. in Chemical Engineering from the Georgia Institute of Technology, Atlanta, Georgia and a B.S. in Chemistry from Albany State College in Albany, Georgia.

David Y. Badio, Jr.

Mr. Badio is a Staff Environmental Chemist with Environmental Strategies Corporation. Before joining ESC, he was an Associate at ICF Technology. While with ICF, as the Senior Organic Chemist on the ESAT Headquarters Team, he was responsible for providing technical and scientific support on organic issues to the CLP's National Program Office at EPA Headquarters. He assisted in the development, improvement and revision of methods for organic analysis. He helped develop and perform technical reviews of organic methods for volatile, semivolatiles, and pesticides/PCBs in drinking, well, and groundwater. He was involved in the development of a system for monitoring organic and inorganic regional reviews including preparation of Data Evaluation Summaries outlining regional and laboratory trends. Mr. Badio participated in a workgroup that developed the organic methods and QA/QC requirements for quick turnaround analyses using gas chromatography. He attended a one-week training course on CLP validation of organic and inorganic data sponsored by Region III; he also attended the OSWER QA training course.

Before joining ICF, Mr. Badio was the QA/QC Coordinator at Environmental Systems of Maryland (ESM), a laboratory specializing in the analysis of hazardous waste samples using RCRA, CLP, and other EPA-approved methods and QA/QC protocols. At ESM, Mr. Badio was responsible for the design, implementation, and enforcement of the laboratory's QA/QC program. During those two years, ESM qualified as a CLP laboratory. He also gained a working knowledge of GC, GC/MS, AA. IC. HPLC, and ICP instrumentation. Mr. Badio reviewed organic and inorganic analytical and QA/QC data to determine compliance with EPA, ESM, and other protocols. He prepared QA summaries for all client reports.

Mr. Badio was a Quality Assurance Chemist at Viar & Company for two years. He conducted quantitative and qualitative reviews of analytical data produced using CLP methods, and QA/QC protocols, and GC, GC/MS, AA, and ICP instrumentation. He assisted in the evaluation and modification of criteria for the CLP's Contract Compliance Screening (CCS).

Mr. Badio has a B.S. in Chemistry from the University of Liberia, and an M.S. in Analytical Chemistry from American University, Washington, D.C.

David M. Boylan

Mr. Boylan is a Staff Hydrogeologist at Environmental Strategies Corporation where he performs field work and data analysis. While at ESC, he has performed numerous remedial investigations of abandoned industrial waste impoundments, leaking underground storage tanks, and active wood treatment and industrial chemical manufacturing facilities. In addition, Mr. Boylan has initiated field investigations for property acquisitions by coordinating and supervising well installation work, and he has provided technical guidance for groundwater recovery systems. Additional field work has included sampling work and soil for laboratory analysis. As a third party contact, Mr. Boylan has reviewed groundwater quality and quantity data to support groundwater and soil contaminant liability claims.

Before joining ESC, he was a hydrogeologist with the Handex Corporation, where his responsibilities in the field included supervising drilling operations, logging drill holes, collecting and analyzing groundwater data. His duties also included reviewing and analyzing groundwater data, laboratory analysis reports, and planning underground petroleum contaminant cleanup programs.

His other endeavors include positions as a geologist with the New York State Electric Company, an independent consulting petroleum geologist, a Water Treatment Specialist, and an Assistant Operator for the City of Waco, Texas, Water Treatment Department.

Mr. Boylan has a B.S. in Geology from Edinboro University of Pennsylvania and M.S. in Hydrogeology from Baylor University. He is a member of the National Water Well Association.

Appendix D - Phase I RI report revised per EPA comments

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VOLUME I
PHASE I REMEDIAL INVESTIGATION REPORT
HELLERTOWN MANUFACTURING COMPANY FACILITY
IN
HELLERTOWN, PENNSYLVANIA

PREPARED

BY

ENVIRONMENTAL STRATEGIES CORPORATION

APRIL 22, 1988

REVISED
JANUARY 19, 1989
REVISED
MAY 23, 1989
REVISED
AUGUST 28, 1989

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Executive Summary

Through its former subsidiary, the Hellertown Manufacturing Company (HMC), the Champion Spark Plug Company owned an inactive manufacturing complex in Hellertown, Pennsylvania, which was closed in October 1982. Champion sold the site in late 1988. The site is located about 1.5 miles southeast of Bethlehem, Pennsylvania. It was originally developed as a spark plug manufacturing facility in 1918 and has been dedicated to the manufacture of spark plugs since that time. Hellertown purchased the facility in 1951.

Reportedly, the site originally consisted of only a manufacturing building. Several wastewater handling lagoons were constructed sometime after 1947. HMC expanded the existing manufacturing building to its current 124,000-square foot size and installed a fifth wastewater lagoon. These lagoons received a variety of materials throughout the history of the plant including high temperature bluing wastewater, low temperature blackening wastewater, electroplating wastewater, and other metal treating residuals. Investigations into the groundwater quality in 1984 revealed degraded groundwater.

The lagoons were closed in 1975 under the direct supervision of the Reading office of the Pennsylvania Department of Environmental Resources (PADER). Telephone communications with the PADER and investigative work performed by the PADER for Potential Hazardous Waste Site designation of the plant caused Champion to assess the

potential for the site to cause environmental impairment. Monitoring wells were installed and sampled in December 1984 and January 1985.

Subsequently, due to the detection of 1,2-dichloroethane and trichloroethylene in samples from the wells, the PADER (in a meeting on May 2, 1985) made demands on Champion to prepare a work plan that would address further study of the site. After several iterations, a work plan acceptable to the PADER was prepared.

An ongoing investigation is being performed voluntarily by HMC at the request of the PADER to determine the horizontal and vertical extent of contaminated soils and groundwater at the site. In spite of Champion's continuing and extensive investigations at the site and its responsiveness to the PADER, the HMC facility was proposed to be added to the Superfund NPL on January 22, 1987. A summary of the investigative work performed thus far follows.

Four existing monitoring wells were sampled and analyses were performed on or about June 24, 1986, and November 10, 1986. Five additional wells were installed in January and February 1987 and the four existing wells and three of the five newly installed wells were sampled on or about February 24, 1987. The nine onsite wells were resampled on August 11, 1987. Two offsite private wells, the Kniha well and the Reichard well, were sampled on August 12, 1987. Only the Reichard well is used for potable drinking water. The original plan called for sampling of two other offsite wells, the Sheesly Concrete Company well and a Lehigh University well. Neither of these wells could be located and may no longer exist or be accessible to sampling.

A total of 87 soil samples were collected from 19 borings in the filled-in surface impoundments onsite during the June 1986 sampling episode. These soil samples were collected above and below an inferred sludge layer in an attempt to identify potential contamination sources. In addition, surface water upstream and downstream from the site on the closest significant surface water feature (Saucon Creek) was sampled during June 1986 and analyzed. Two additional soil samples were collected from two borings in the filled-in surface impoundments and one soil sample was collected from a former truck washing area during the February 1987 sampling episode.

Investigations thus far confirm the presence of small amounts of chlorinated organics in groundwater downgradient from the main plant building on the site. Since this area is in proximity to the western property line, there is some potential that contaminants are migrating offsite. The results of the soil boring study to date do not confirm the presence of a contamination source that could produce the observed groundwater quality effects. The most concentrated constituents, polycyclic aromatic hydrocarbons (PAHs), were detected in the soils in one group of the surface impoundment borings. These constituents do not appear to present a threat to environmental receptors since they are generally insoluble and since the buried contaminants are precluded from becoming airborne.

1.0 Introduction

This document is intended to be a Phase I Remedial Investigation (RI) document. It is not intended to be a complete RI report. ESC is presenting the results of previous investigations in a Remedial Investigation format that follows the U.S. EPA guidance document, "Guidance on Remedial Investigations Under CERCLA," June 1985. This was done to identify any significant information gaps and to facilitate review of the site by EPA Region III and the PADER. A Data Gaps Report accompanies this document. The proposed and ongoing investigations will be used to augment this document and satisfy all information deficiencies. This document will serve as the template and guide for continuing investigation of the Hellertown site.

1.1 Site Background Information

Through its former subsidiary, the Hellertown Manufacturing Company (HMC), the Champion Spark Plug Company owned an inactive manufacturing complex in Hellertown, Pennsylvania. Champion closed the facility in October 1982 and sold the site in late 1988. The HMC facility is located north of Hellertown and approximately 1.5 miles southeast of Bethlehem, Pennsylvania (Figure 1). The coordinates of the facility are 40 degrees, 35 minutes, 43.5 seconds north latitude and 75 degrees, 20 minutes and 34 seconds west longitude. Currently, there is a 124,000-square foot manufacturing building, which is situated on the southeast portion of an 8.75-acre site.

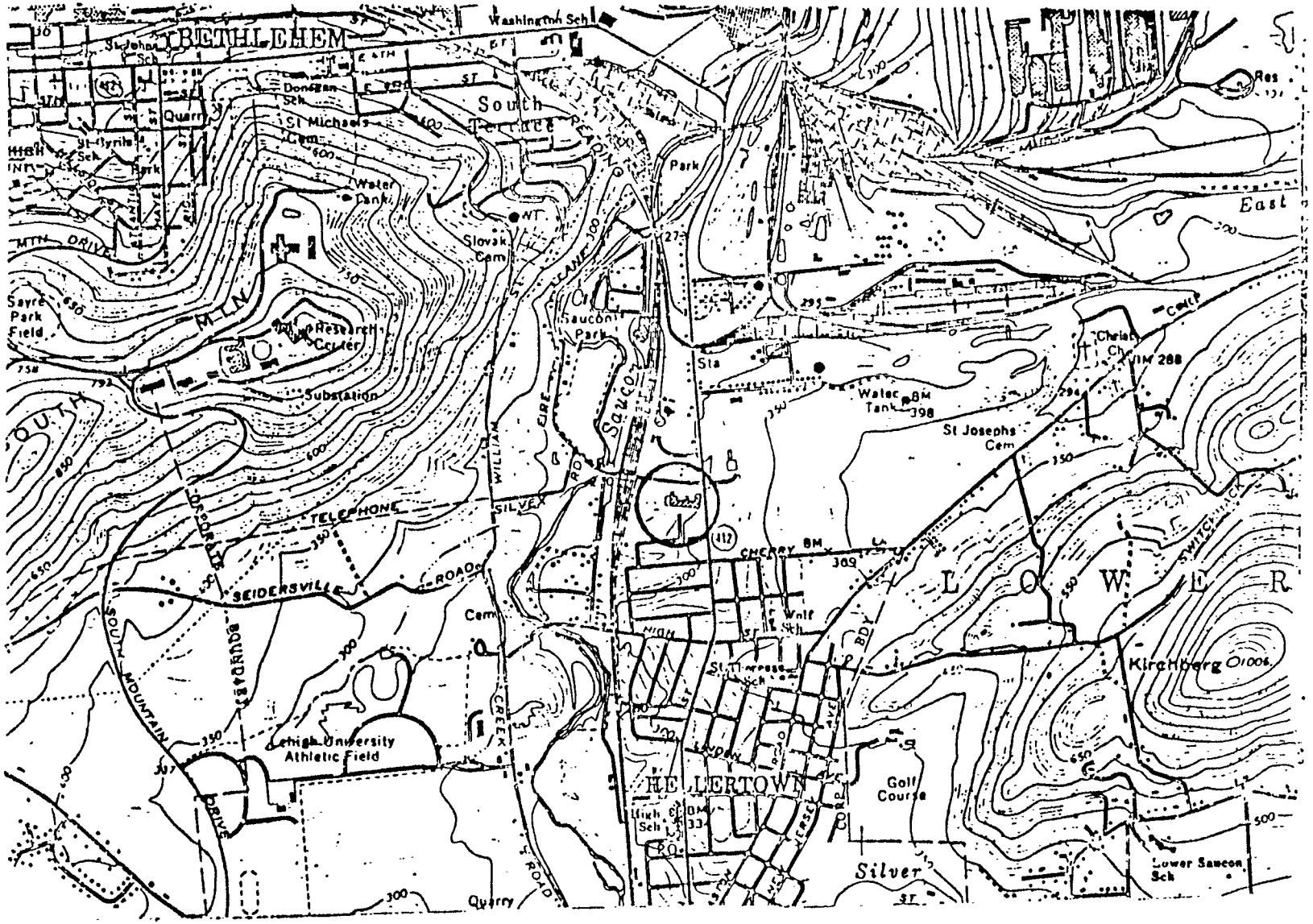

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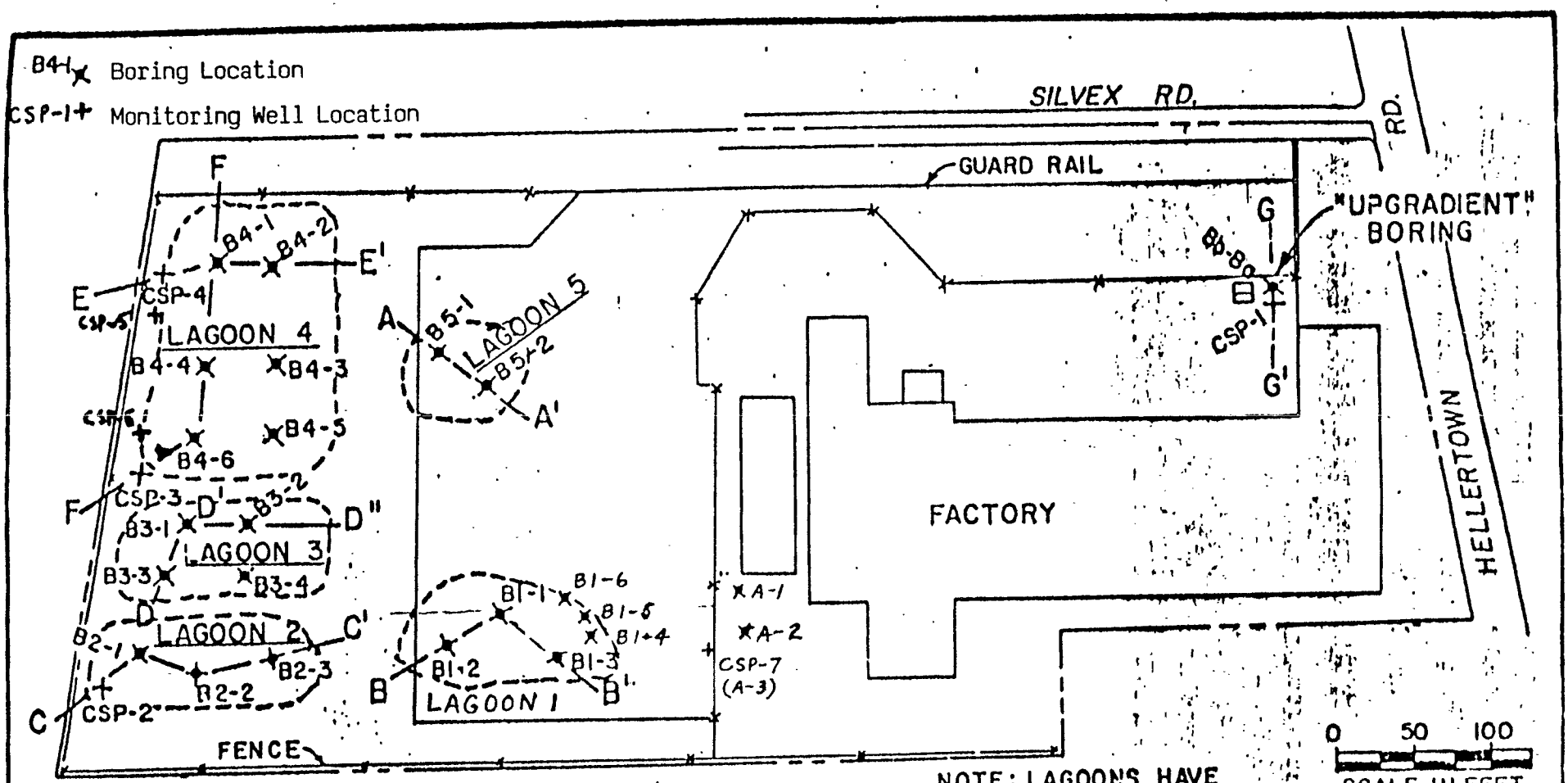
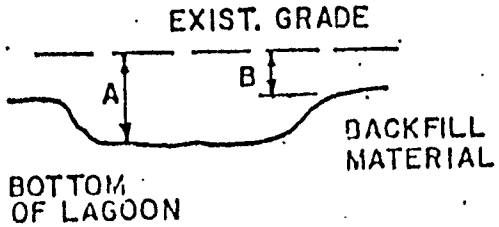
Figure 1 - Location of the Hellertown Manufacturing Company

The site was developed as a spark plug manufacturing facility in approximately 1918 by the Bethlehem Spark Plug Company. The Edison-Splitdorf Company acquired the site in the 1930s and sold the facility to the Hellertown Manufacturing Company in the spring of 1951. Environmental Strategies Corporation (ESC) is continuing to investigate the current status of these previous entities. The site boundaries have generally remained unchanged since it was originally developed with the exception of a small portion in the northwest corner of the site near lagoon 4. This portion was sold to the state of Pennsylvania for modifications resulting from construction of I-78. HMC expanded the original 60,000-square foot manufacturing building in 1976. Other significant site features include five underground tanks, a wastewater treatment system and associated sludge drying beds, and five closed wastewater handling lagoons (Figure 2).

Throughout its history, the facility has been dedicated to the manufacture of spark plugs. Modifications to the manufacturing process have occurred, particularly during the most recent tenure of the plant. When the facility was closed in 1982, the plant was a modern factory with continuous in-line assembly operations. Manufacturing activities were divided into shell manufacturing and spark plug assembly. The process was initiated by the extrusion of a crude spark plug shell from coils of solid wire. This activity was subsequently curtailed at HMC in favor of a centralized manufacturing effort at a sister plant. Subsequent manufacturing steps are summarized in Table 1.



LAGOON NO.	DIM. A	DIM. B
1	30'-0"	12'-0"
2	20'-0"	12'-0"
3	17'-0"	12'-0"
4	17'-0"	12'-0"
5	17'-0"	12'-0"



NOTE: LAGOONS HAVE BEEN BACKFILLED & GRADED TO APPROX. 12' ABOVE OLD LAGOON SURFACE LEVELS. SEE SKETCH FOR VARYING DEPTHS. DIMENSIONS ARE APPROXIMATE.

ESC
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FIGURE. 2
PLANT LAYOUT
HELLERTOWN MANUFACTURING FACILITY
HELLERTOWN, PENNSYLVANIA

TABLE 1

shell manufacturing

1. COLD FORMING PRESSES
These machines cold form or extrude the one-piece spark plug shells from coils of solid wire.

2. GAUGE ROOM
Here incoming parts and tooling are inspected for accuracy. Also, new gauges are set up for use in production while other gauges are changed and calibrated.

3. AUTOMATIC CHUCKING MACHINES
Secondary operations are performed on the extruded shell blanks. On leaving these machines, the shells are complete except for threads and side electrodes.

4. DAVENPORT AUTOMATICS
These machines fabricate the terminals by which ignition cables are attached to spark plugs.

5. CHIP DISPOSAL
Machining scraps from cutting operations are centrifuged and the cutting oil is reclaimed. The chips are then squeezed into briquets and shipped to steel mills.

6. AUTOMATIC SCREW MACHINES
Bars of steel are fed into the automatic screw machines which completely form, drill and ream shells. Shells are complete, except for threads and ground electrodes.

7. SHELL INSPECTION
Detailed inspections of shells from each machine are constantly made. Similar inspection facilities are in all departments.

8. SIDE ELECTRODE WELDING AND ROLL THREADING
The ground electrode, special nickel alloy wire, is fed from rolls into the electric welder, straightened, welded to the shell, cut to the proper length and given a partial bend. The threads are then rolled on the shells.

9. PLATING
Completed shells are given a permanent and lasting silvery finish by an electrolytic process. This provides a protective coating and adds to the appearance of the plug.

10. CENTER ELECTRODE FABRICATION
To resist deterioration from heat and corrosion, the lower half of the center electrode is a specially developed nickel alloy. A head is formed which later becomes part of the seal.

spark plug assembly

11. WELDING OF CENTER ELECTRODE
The lower half nickel alloy center electrode is electrically welded to the basic steel upper half of the electrode.

12. AUTOMATIC ROTARY CORE TAMPING AND STUD CEMENTING MACHINE
The special nickel alloy wires are sealed into the insulators by Silimenl tamper under extreme pressure. The terminal or stud is then cemented into the insulator.

13. CORE PUSH-OUT TEST
Random sampling to test pressure tolerances of seal for center electrode.

14. PLUG TAMPING
Insulator assemblies are sealed in the shell with Silimenl under 3,000 to 6,000 pounds of pressure. After reaming to correct depth and angle, the shell flange is crimped to complete the gas-tight seal.

15. FIXED GASKET MACHINE
The gasket is crimped over the thread body to prevent its falling off.

16. AUTOMATIC GASKET, TRIM AND GAP MACHINES
The completely assembled spark plug is placed in a rotating table. The center electrode is trimmed to the correct specifications and the ground electrode is given the final bend to form the proper gap. Outside gaskets are automatically attached.

17. FINAL INSPECTION
In addition to the step-by-step inspections and tests, Champion plugs are given a final visual inspection to ensure that they have been assembled in accordance with rigorous specifications.

18. AUTOMATIC PACKAGING
The cartons are formed and the plugs are placed in the open cartons on the conveyor. They are wrapped in plastic film, placed first in a container and then in a shipping box and sent to the shipping room.

There are two other plant activities that are relevant to this investigation. Company officials report that methylene chloride and trichloroethylene were used in the past in vapor degreasers. In addition, perchlorethylene and trichloroethylene were used in a dielectric testing procedure. Reportedly, less than 300 gallons/year of these materials were purchased. Due to the high vapor pressure of these materials, very little waste liquid was generated. Reportedly, waste residuals from these activities were sent offsite for disposal; however, some material may have been spilled or disposed of onsite.

When the HMC acquired the site in 1952, there were four lagoons (nos. 1 through 4). Former employees of the plant indicate that the four lagoons were originally constructed in the mid 1930s. However, aerial photographs indicate that the impoundments did not exist in 1947 (Figures 3, 4, 5, and 6). It is known that lagoon no. 5 was constructed around 1966. The lagoons were used to handle wastewater residuals from metal treatment processes. A physical characterization of each of the lagoons is summarized in Table 2. The source of this information is a lagoon inventory conducted by HMC in approximately 1970 at the behest of the Pennsylvania Department of Health. The lagoons provided a total storage capacity of approximately 500,000 cubic feet and ranged in capacity from 186,000 cubic feet (lagoon no. 1) to 21,600 cubic feet (lagoon no. 5).

Metal finishing before 1952 probably consisted of parts washing and high temperature bluing. Bluing salts consisted of sodium

Figure 3 - Aerial photograph of site in 1947

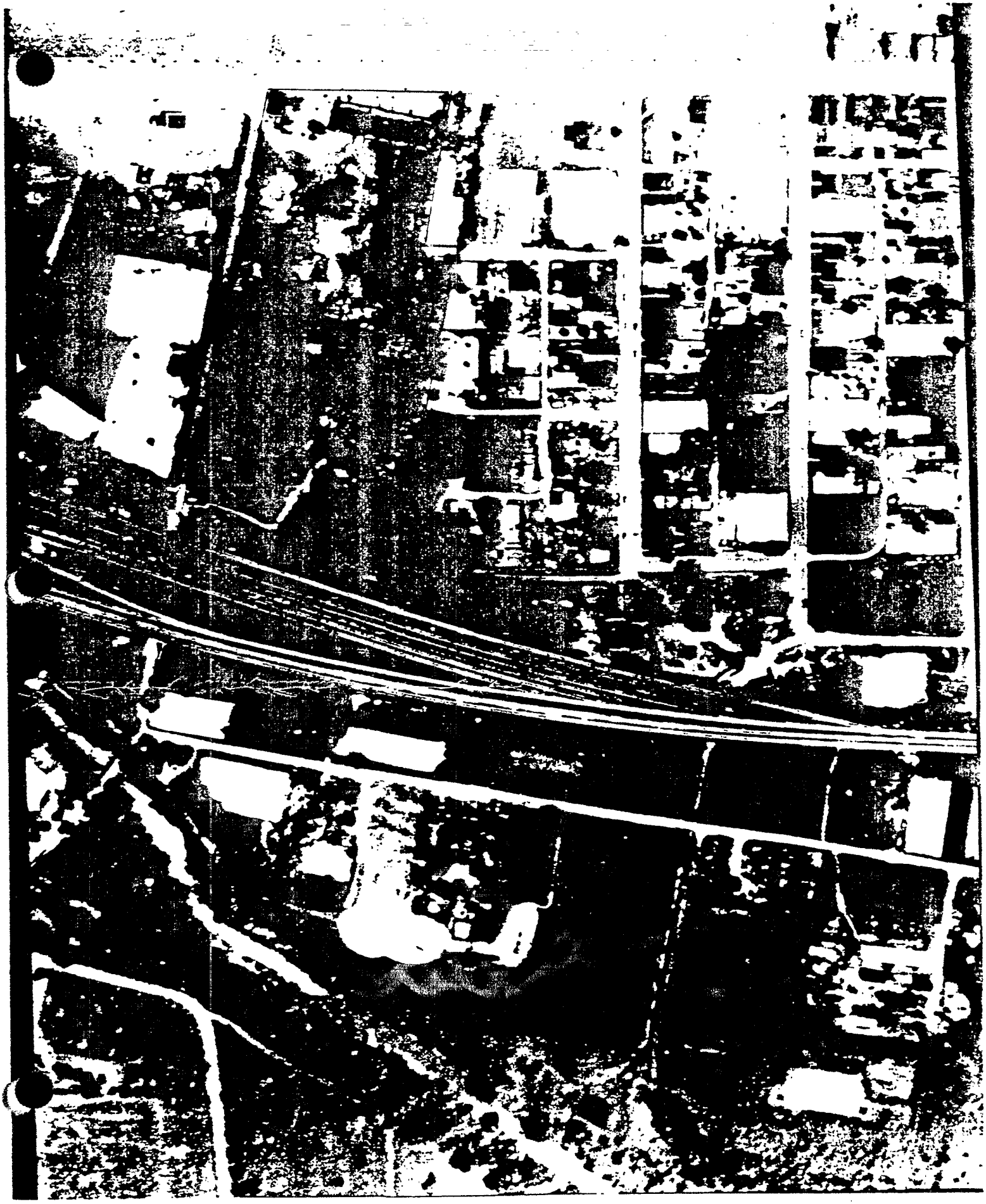

Figure 4 - Aerial photograph of site in 1958

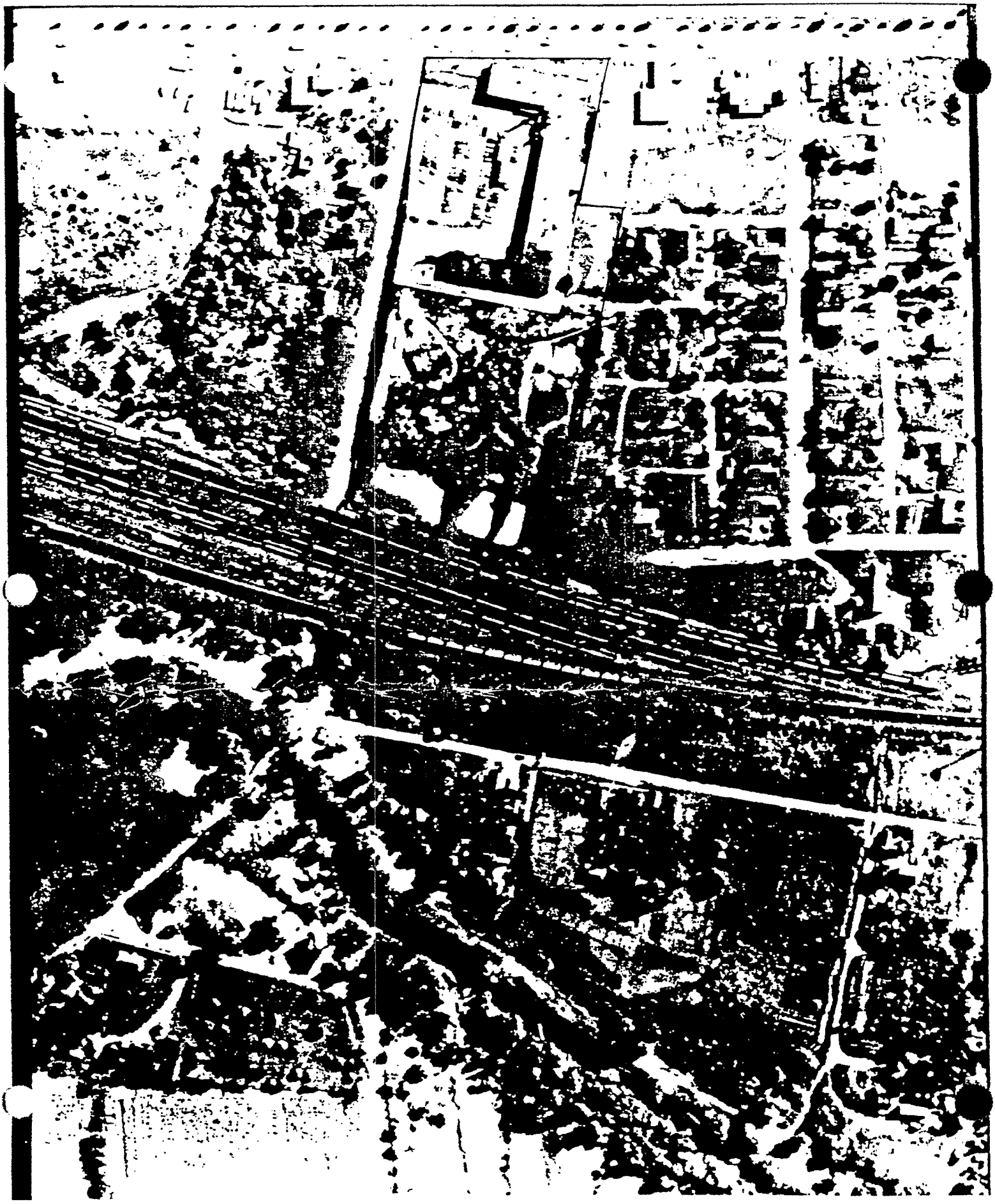

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Figure 5 - Aerial photograph of site in 1971

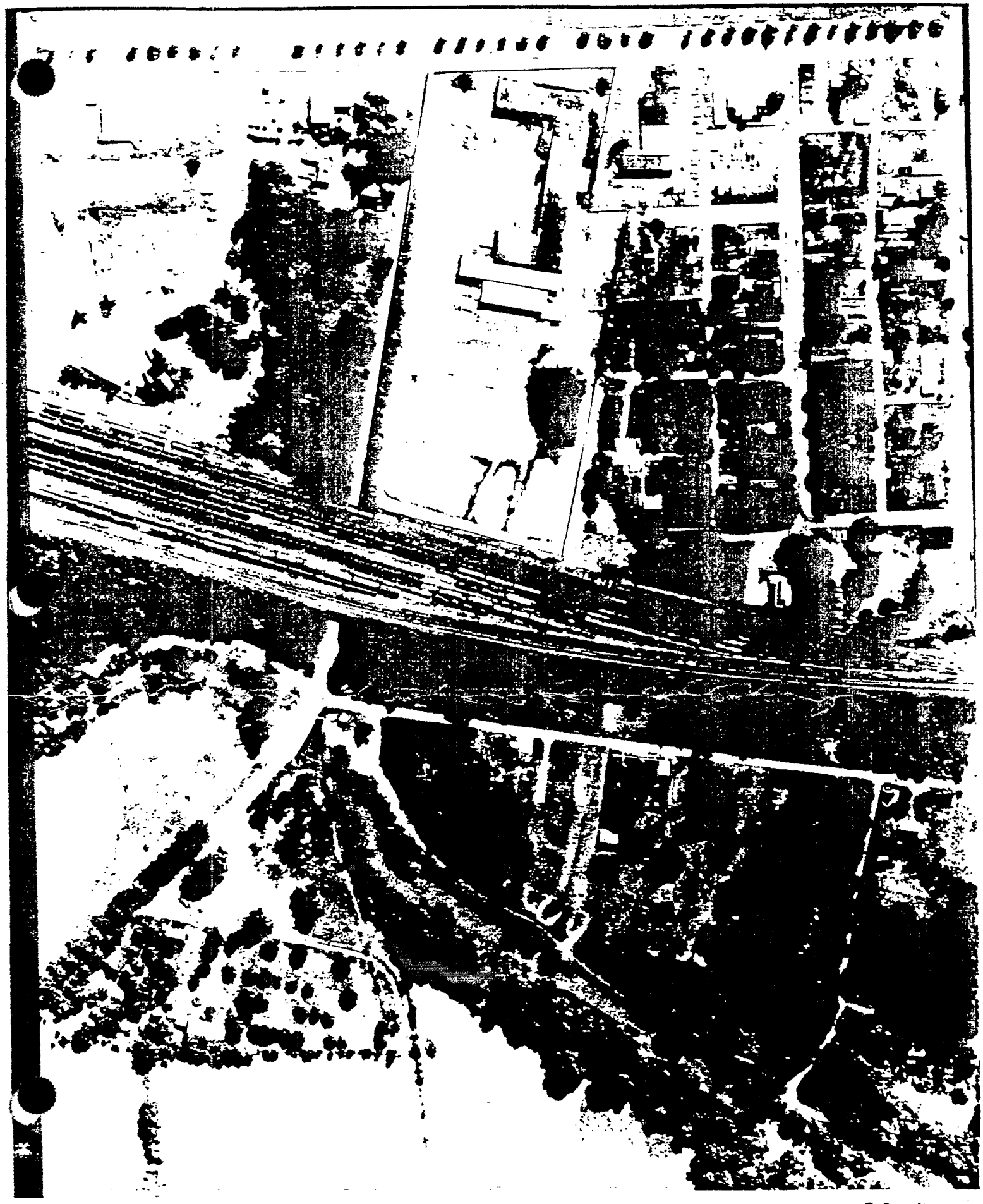

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Figure 6 - Aerial photograph of site in 1981

304791

Table 2

Hellertown Manufacturing Company
Lagoon Inventory[a]

	No. 1	No. 2	No. 3	No. 4	No. 5
Elevations (ft):					
Top of Bank Average	285.0	275.0	272.0	268.0	275.0
Water Level	271.0	258.0	256.0	255.0	255.0
Bottom Level	257.0	246.0	246.0	250.0	250.0
Dimensions:					
Area surface (sq ft)	13,300	10,650	7,200	18,000	5,400
Width (ft)					
West End	55'	71'	60'	120'	45'
East End	91'	71'	60'	120'	45'
Length (ft)	150'	150'	120'	150'	120'
Depth (Average; ft)	14'	12'	10'	5'	4'
Capacities:	186,000 ft^3	127,000 ft^3	72,000 ft^3	90,600 ft^3	21,600 ft^3
Gallons	1,396,000	948,000	540,000	675,000	162,000
Cu ft clear water	26,000	21,300	14,400	36,000	10,800
Influent:					
20 gpm, 16 hrs, 5 days	30,000 gal	From No. 1	From No. 2	From No. 3	From No. 4
Discharge:					
Type	Subsurface	Subsurface	Subsurface	Subsurface	Subsurface
To	No. 2	No. 3	No. 4	No. 5	None

a/ Source - 1970 Report by Gilbert Associates for HMC - see answer 12, CERCLA 104(e) response.

and potassium nitrates and nitrites. The wastes discharged to the lagoons would have consisted of oily and corrosive wastes. Residuals flowed from the plant to lagoons no. 1, 2, 3, and 4 in series. A low temperature blackening process replaced the high temperature bluing process and was employed by HMC from 1953 to 1959.

Cyanide-based zinc electroplating operations were initiated in 1959. Lagoon no. 5 was constructed in approximately 1966 and received discharges from lagoon no. 4.

As a result of a breach in lagoon no. 4, state regulatory authorities required the installation of a wastewater treatment system. During 1965, an integrated wastewater treatment system was installed to treat cyanide and hexavalent chromium. The system consisted of an alkaline chlorination step to oxidize cyanide and a closed loop Lancy package treatment system for the reduction and subsequent precipitation of hexavalent chromium. Before 1967, floating oils were typically present on the surface of each lagoon. In 1967, an underflow system was installed to retain all floating oils in lagoon no. 1. The oil was collected by a pump truck and employed locally as a dust suppressant.

Pursuant to state requests, an upgraded wastewater treatment system was installed in 1971-1972. The system was completed in 1972 and included oil removal, cyanide destruction, chromium reduction and precipitation, and sludge dewatering. Treatment was performed in concrete basins or steel tanks. The sludge drying bed was concrete lined and had an underdrain system above the concrete which

was plumbed back to the wastewater treatment system. Treated wastewater was discharged to the municipal sanitary sewer system and treated in the Bethlehem Municipal Waste Treatment System. The treated sludges were dewatered in sludge drying beds and hauled offsite to a local disposal site, the Chrin Landfill. When RCRA was implemented, the wastes were sent offsite under manifests as hazardous wastes to a site operated by Waste Conversion. Manifests for these wastes are included in Volume I (Response 8) of the September 29, 1986, response to the U.S. EPA Region III CERCLA 104(e) information request.

Former plant officials report that until the construction of the initial wastewater treatment plant, lagoon no. 1 was dredged out at least annually. Lagoon no. 2 was dredged at least once. Dredged residuals were placed on the berms surrounding the two lagoons. The amount of sludge thus placed is unknown. ESC is continuing to research this question. It is known that flows to the lagoon system have been variously reported as ranging from 10 gpm to 62 gpm. Documentation suggests that the plant operated an average of 12 hours per day. Assuming an average flow of 15 gpm and an average 12-hour work day, the upgraded wastewater treatment system produced approximately 27 cubic feet of sludge daily. Solids generated by the initial wastewater treatment system have been estimated to be approximately 50 cubic yards monthly.

When construction of the upgraded wastewater treatment plant was completed, closure of the five lagoons was coordinated with the PADER. Gilbert Associates of Reading, Pennsylvania, performed some

waste characterization on the impoundment solids and supernatant. This effort was performed to support the proposal to close the abandoned lagoons by allowing the supernatant to seep through the lagoon bottoms and then subsequently backfilling the lagoons with clean fill. Surface impoundment residuals as well as neighboring water supply wells were sampled.

The results of lagoon supernatant samples are summarized in Table 3. A total constituent analysis of the sludge from four of the lagoons is reported in Table 4. No analytical results are available for lagoon no. 5. Water quality in the then known water supply wells is summarized in Table 5. It should be noted that well A was <u>not</u> used as a potable water supply for the Kniha residence. The well at the Sheesley Concrete Company was used to supply process water only.

After a review of the Gilbert Associates documentation (which has been summarized here in Tables 3 through 5), the state approved the closure of the lagoons. The lagoons were subsequently filled in to surface grade.

The following materials were known to have been disposed of in the lagoons as part of the fill:

- sillment powder
- spark plug insulators
- reject spark plug and core assemblies
- reject spark plugs
- crushed stone and fine crushed stone

Table 3

Lagoon Supernatant Samples[a]

Constituent			Lagoon No. 1	Lagoon No. 2	Lagoon No. 3	Lagoon No. 4
Chloride	mg/l	Cl	136			
Chromium, hexavalent	mg/l	Cr^{+6}	0.02			
Chromium, total	mg/l	Cr	0.83	0.086	0.046	0.021
Copper	mg/l	Cu	0.097			
Cyanide, amenable to chlorine	mg/l	CN	0.60			
Cyanide, total	mg/l	CN	0.60	0.61	0.15	0.14
Lead	mg/l	Pb	0.14	<0.04	<0.04	0.04
Nickel	mg/l	Ni	0.07			
Nitrate	mg/l	NO_3	QNS[b]			
pH			9.6	9.3	9.1	9.4
Phenols	ug/l	C_6H_5OH	QNS			
Solids, Dissolved (180° C)	mg/l		904	920	1,060	1,090
Solvent extractables	mg/l		972			
Sulfate	mg/l	SO_4	292			
Zinc	mg/l	Zn	15.9	3.4	2.7	0.8

a/ Source - Gilbert Associates Report, 1975 (Answer 12, CERCLA 104(e) response)

b/ QNS - Quantity of sample not sufficient for analysis

Table 4

Total Constituent Analyses of Lagoon Sludges[a]

Constituent [b]			Lagoon No. 1	Lagoon No. 2	Lagoon No. 3	Lagoon No. 4
Chloride	mg/l	Cl	154			
Chromium, hexavalent	mg/l	Cr^{+6}	<0.01			
Chromium, total	mg/l	Cr	115.0	7.7	63.1	15.4
Copper	mg/l	Cu	13.7			
Cyanide, amenable to chlorine	mg/l	CN	1.28			
Cyanide, total	mg/l	CN	1.28	22.60	73.20	3.80
Lead	mg/l	Pb	5.1	1.3	6.0	1.8
Nickel	mg/l	Ni	7.1			
Nitrate	mg/l	NO_3	3.8			
pH			9.9	9.2	9.0	9.3
Phenols	ug/l	C_6H_5OH	191			
Solids, Dissolved (180° C)	mg/l		1,120	1,166	1,170	1,280
Solvent extractables	mg/l		7,776			
Sulfate	mg/l	SO_4	289			
Zinc	mg/l	Zn	1,594	426	3,142	676

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a/ Source - Gilbert Associates Report, 1975 (Answer 12, CERCLA 104(e) response)

b/ Special sample preparation required for metal analyses

Table 5

Quality of Water From Neighboring Water Supply Wells[a]

Constituent		Well A - Kniha	Sheesley Concrete Company
Chloride	mg/l Cl	8.0	
Chromium, hexavalent	mg/l Cr^{+6}	<0.01	
Chromium, total	mg/l Cr	<0.01	
Copper	mg/l Cu	0.014	
Cyanide, amenable to chlorine	mg/l CN	<0.02	
Cyanide, total	mg/l CN	<0.02	
Lead	mg/l Pb	0.04	<0.04
Nickel	mg/l Ni	0.01	
Nitrate	mg/l NO_3	33.0	
pH		7.3	7.3
Phenols	ug/l C_6H_5OH	1.8	
Solids, Dissolved (180° C)	mg/l	278	418
Solvent extractables	mg/l	9.6	
Sulfate	mg/l SO_4	37.2	
Zinc	mg/l Zn	0.32	

a/ Source - Gilbert Associates Report, 1975 (Answer 12, CERCLA 104(e) response)

- sand and highly diluted cement wash
- broken cinder and concrete blocks
- broken bricks
- plaster
- fill from the expansion of the Bethlehem POTW.
- asphalt surface and stone ballast from a street expansion project

Subsequent investigations have been performed by O. H. Materials and ESC. ESC is continuing to investigate the site. The efforts of O.H. Materials and the results of the ESC investigation will be discussed in subsequent sections of this document.

Elevations at the facility ranged from 250 to 300 feet msl before the lagoons were filled in. Filling operations raised the elevation of land areas in the vicinity of the lagoons approximately 23 feet. Lagoons no. 2, 3, and 4 were filled in and seeded. Lagoons no. 1 and 5 were filled in and paved over with asphalt. Soil types and site geology are addressed in subsequent sections.

Figures 3 through 6 are aerial photographs of the site for the years 1947, 1958, 1971, and 1981. These photographs chronicle changes to the site over the periods of record. Note the absence of lagoons in Figure 3 (1947). An obvious surface water feature can be discerned west of the manufacturing building in what was, at the time, the future location of the lagoons. The four lagoons are present in Figures 4 and 5 (years 1958 and 1971). In addition, the building expansion previously discussed can be seen. Figure 6 shows

a more current view of the site (1981), which shows that the lagoons have been covered with asphalt or a vegetated surface.

There are five underground tanks onsite. At least two of the tanks are known to contain fuel oil. This will be verified at the time of the tank testing. There are two 10,000-gallon tanks, two 20,000-gallon tanks, and one 1,000-gallon tank. The two 20,000-gallon tanks and a 10,000-gallon tank are used to store no. 2 fuel oil. A 10,000-gallon tank was used to store a machining oil (12 CM Mobil oil). A 1,000-gallon tank was used to store stoddard cleaner. The 20,000-gallon tanks are about 10 years old. The other tanks are older but of unknown age and were previously located north of the manufacturing building. These tanks were relocated south of the manufacturing building and placed on a concrete subbase with a sacrificial anode system.

The HMC had an additional underground tank system for the control and storage of catastrophic spills from the electroplating area. The emergency storage system was located just north and outside of the main plant building. The system consisted of several 1,000-gallon concrete septic tanks that were plumbed to valved drains in the electroplating area. If a massive spill were to occur, the valve on the drain could be directed to the concrete underground tanks. HMC officials report that the system was never used. The past and existing locations of the underground tank farm(s) onsite are indicated in Figure 7. In addition, company officials reported that an area filled with gravel was used to clean equipment and received spillage associated with deliveries of

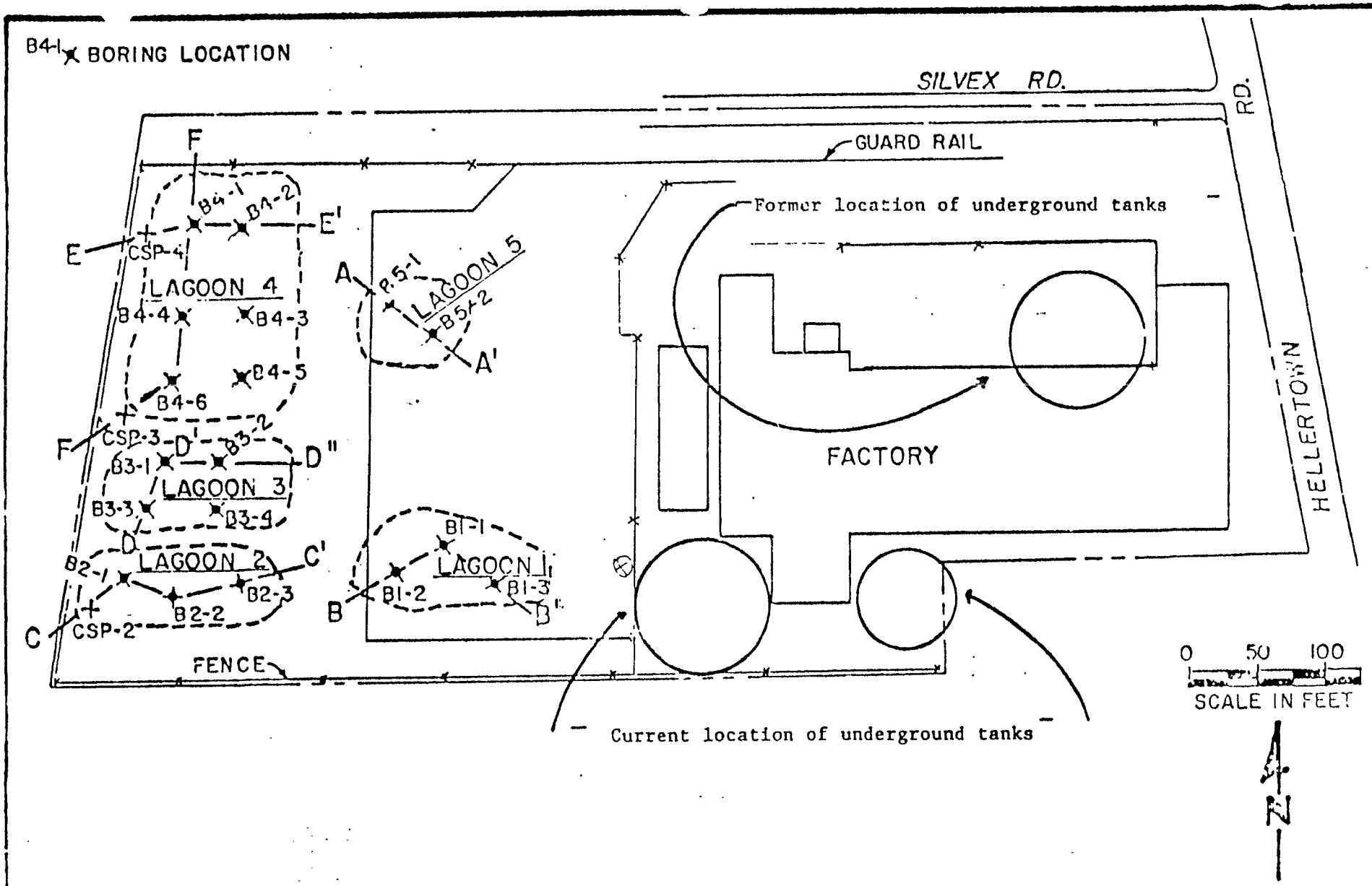

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Figure 7 - Location of underground tank farms

products to underground tanks. This area is reportedly between former lagoon No. 1 and the factory.

The first indication of possible onsite contamination was presented in April 1985 as a result of an investigation conducted by OHM.

In January 1987, the site was proposed by EPA to be added to the Superfund National Priorities List. On February 22, 1988, Champion Spark Plug Company and the United States Environmental Protection Agency (EPA), Region III, mutually agreed in an Administrative Order by Consent to work together in the environmental investigation and cleanup of the site. The Consent Order formally outlines the necessary requirements for a Remedial Investigation/Feasibility Study (RI/FS) of the property. The RI/FS work will lead to the selection and implementation of a cleanup alternative that will ensure that the site poses no environmental problems for the community.

1.2 Nature and Extent of Problem

The O.H. Materials Company (OHM) investigation conducted in December 1984 and January 1985 included the installation and sampling of four monitoring wells: one upgradient and three downgradient wells east and west of the HMC plant, respectively. The more significant results of the OHM report are:

- Barium concentrations ranged from 11.0 to 13.0 mg/l in all wells. OHM reports the "RCRA standard" is 10.0 mg/l.

- Two organic compounds (1,2-dichloroethane and trichloroethylene) were found to exist at concentrations above 50 ug/l.
- OHM determined that nitrate levels found were slightly above drinking water standards in all wells including the background well. Nitrate concentrations ranged from 20 to 42 mg/l.

OHM concluded that although analytical results indicate several constituents were above water quality standards, only marginal contamination was "evident."

Investigations were taken over by Risk Science International of Washington, D.C., and later by Environmental Strategies Corporation (ESC) of Vienna, Virginia, and have included reviewing pertinent documents, interviewing former HMC plant personnel, conducting a local well survey, assessing surface water quality, installing and sampling groundwater monitoring wells, sampling surface and subsurface soils, and other sampling investigations.

Based on ESC's information review, it is not anticipated that there are any special waste considerations (e.g., explosive, radioactive, or acutely hazardous wastes).

The portions of the site which were the most likely repository of wastes are currently buried beneath approximately 23 feet of fill. The lagoons were filled in with a variety of materials in approximately 1975. The cover material on lagoons no. 2, 3, and 4 was subsequently graded and seeded. The cover material on lagoons no. 1 and 5 was paved over with asphalt.

The nature and potential of contaminant releases from the site are still being investigated by ESC. Some preliminary conclusions have been made. There reportedly was a release from lagoon no. 4 in the past due to a breached berm. This breach was repaired and plant officials were unaware of any negative consequences from the incident.

It is considered very unlikely that contaminants are being released to the air due to the depth of the cover material. ESC has performed a surface water quality assessment to evaluate the water quality of site runoff. These results, discussed more fully in Section 3.0, Hazardous Substance Investigation, do not suggest that the contamination is affecting surface water quality. The continuing investigation by ESC is further assessing the effect of site runoff on surface water quality.

ESC collected surface water samples from Saucon Creek on June 23, 1986, Analyses of these samples indicated that no organic priority pollutants were detected. A relatively high concentration of total dissolved solids was found in downgradient samples compared to the upgradient sample. These levels may be a result of the construction activities associated with the interstate highway passing over Saucon Creek in this vicinity.

The only known contaminant release is associated with the flow of groundwater. OHM determined that groundwater is flowing from east to west across the site. ESC confirmed this in recent investigations.

One of the most significant results of the ongoing ESC investigative effort is the detection of several volatile organic priority pollutants in downgradient wells at concentrations in excess of established regulatory standards. Methylene chloride, trichloroethylene, tetrachloroethylene, vinyl chloride, and 1,2-trans-dichloroethylene were detected in the onsite downgradient wells. These constituents were not detected in the upgradient wells. In addition, nitrate was detected in upgradient and downgradient wells at concentrations in excess of established regulatory standards. The standards of greatest concern are the recommended maximum contaminant levels as established in the Federal Register of November 13, 1985.

The definition and extent of the problem caused by the degraded groundwater quality is complicated by the geology of the site. The soil in the area is underlain by a creviced and cavernous limestone formation known as the Leithsville Formation which may extend to a depth of 1,000 feet. Reportedly, most of the water-yielding openings are in the upper few hundred feet of the formation.

There is evidence that shallow bedrock in the vicinity of the site contains numerous fractures or solution openings capable of transmitting relatively large volumes of water. The presence of such voids is indicated on the log for monitoring well CSP-1. A high loss of drilling fluid was reported at 25 feet and at 50 feet, presumably in limey shale bedrock. Drilling fluid was not used during drilling of the boreholes for the other three monitoring

wells, so data on fluid losses could not be obtained. Only one of the other three borings (CSP-4) reached bedrock.

In 1984 and 1985, borings were made on the north side of Silvex Road to describe shallow subsurface conditions before the construction of highway I-78. Four borings were made due north of the HMC plant. All four of the borings encountered limestone within 12 feet of the land surface and all were terminated within 30 feet of land surface. Two of the borings reported that water was lost in the limestone during drilling. The water levels in the borings suggest a groundwater flow direction toward the west and Saucon Creek.

Numerous other borings of similar depth installed in conjunction with the highway construction also reported loss of drilling fluid and the presence of highly fractured limestone. More details regarding subsurface hydrogeologic conditions and additional discussion addressing the nature and extent of the water quality problem at the site are provided in the Hydrogeologic Investigation section.

As previously indicated, the quantity of wastes disposed of onsite is currently unknown. ESC is actively involved in establishing this information based on a review of documents and interviews with former plant personnel.

ESC has conducted a local well survey to assess the importance of groundwater as an environmental pathway. Preliminary results of the initial survey indicate that, other than domestic wells along William Street, there are no active water-supply wells within a 0.5-

mile radius of the site. According to Mr. Carl Newswanger of the Bethlehem Water Department, there are at least eight residences on William Street between the Slovak Cemetery and Silvex Road which are supplied with water from residential wells. William Street is located approximately 2,500 feet west of the HMC. About 1.5 to 2.0 miles north of the plant, there is an extensive wellfield that draws an estimated 10,000 gpm for the Bethlehem Steel plant. It is reported that these wells are 4,000 feet deep. They probably obtain water from a thick section of rocks extending to 4,000 feet. In addition, there is a water-supply well located in Hellertown about 1.5 miles south of the site, which is used to augment the municipal water supply. Two abandoned wells, owned by a resident (Kniha) and the Sheesley Concrete Company, are near the site. Several additional wells in the vicinity of the City of Hellertown have been located. A state water well inventory was used to identify wells installed after 1966. Some wells installed before 1966 have also been identified from USGS records. The well schedules for several wells, including their locations, are provided in Appendix A.

The impacts of site conditions and contaminant migration in the subsurface are currently unknown. ESC has proposed additional actions in this document to aid in establishing information on this important point. The only known action that has been taken to date to mitigate problems associated with the site was to cover the most likely contamination sources (the lagoons) with soils and a relatively impermeable layer of asphalt.

1.3 History of Response Actions

The initial response action at the HMC site was the installation of an upgraded wastewater treatment system in 1971-72. This was done by HMC in accordance with state requests. With the completion of the construction of the upgraded wastewater treatment system, closure proceedings for the lagoons were initiated. Correspondence between HMC and the PADER suggest that the closure of the lagoons was coordinated with the PADER. A letter dated November 22, 1971, from HMC to the PADER, indicated the discontinuation of lagoon outfall and detailed plans for lagoon abandonment. HMC proposed to abandon four of the five lagoons. In a letter dated January 21, 1975, from HMC to the PADER, HMC indicated its intention to abandon all five lagoons and to treat all its industrial waste and discharge to the municipal sewer system. This letter also described the requirements surrounding lagoon abandonment procedures as understood by HMC and a schedule for backfilling the lagoons.

In response to the PADER's dissatisfaction with HMC's response regarding impoundment violations, documentation indicates that HMC representatives attended a conference at the PADER on February 25, 1975, to resolve these issues. As a result of this conference, HMC collected groundwater samples from area wells to clarify any possible groundwater contamination from the HMC lagoon seepage. HMC engaged the services of Gilbert Associates of Reading, Pennsylvania, to characterize the surface impoundment solids and supernatant and

the quality of neighboring water supply wells. Based on a review of these sampling results, the closure plan for the lagoons was approved by the PADER. In a September 22, 1975, letter from the PADER to HMC, it was indicated that the PADER agreed with HMC's continued backfilling and elimination of the waste impoundments without removal of their present contents. There were questions regarding the backfilling of lagoons nos. 4 and 5, which were answered in a letter from HMC to the PADER, dated October 14, 1975.

HMC continued to work with the PADER on the closure of the lagoons, maintaining communication on all site activities and adhering to the requests of the PADER, including conducting quarterly analyses of groundwater for specific constituents. The PADER acknowledged receipt of groundwater sample analyses and indicated that, based on their review of sample data, further sampling could be discontinued in a letter to HMC dated June 7, 1976. The PADER also thanked HMC for their cooperation and positive approach. In a letter from the PADER to HMC dated October 6, 1976, the PADER acknowledged receiving a letter from HMC regarding the completion of backfilling the lagoons. The PADER also thanked HMC for their cooperation and prompt action.

In December 1984 and January 1985, OHM installed and sampled four groundwater monitoring wells because of Champion's interest in assessing the potential for the site to cause environmental impairment. Champion's actions were prompted by indications from the PADER that the HMC facility was being considered for designation

as a potential hazardous waste site. The results of this sampling provided the first indication of possible onsite contamination.

The PADER conducted a Preliminary Assessment (PA) at the HMC facility in late 1984 and prepared a report at the request of EPA in January 1985.

In May 1985, after the PADER review of the PA and the groundwater data in the OHM report and at the PADER's suggestion, Champion prepared and submitted a work plan to address further study of the site. Because of the PADER's displeasure with the initial work plan, Champion retained the services of Risk Science International and later Environmental Strategies Corporation (ESC) of Vienna, Virginia, to revise the work plan and address the PADER concerns. The work plan was revised by ESC, and a subsequent meeting was held with the PADER and ESC in June 1986, which led to further work plan amendments to address PADER concerns.

The work plan was implemented by ESC beginning in June 1986. Components of the work plan included one year of quarterly sampling of the groundwater monitoring wells; sampling the surface water in Saucon Creek; installing and sampling of additional groundwater monitoring wells; installing and sampling soil borings upgradient of and within the closed lagoon areas; and hydrostatic testing of underground storage tanks. ESC began with the quarterly sampling of the existing groundwater monitoring wells. Additionally, samples were collected from Saucon Creek, and 87 soil samples were collected from 19 borings on the HMC site.

The groundwater sampling data indicated the presence of volatile chlorinated organic compounds in two downgradient wells and nitrates in upgradient and downgradient wells at levels exceeding EPA regulatory standards. No contamination was detected in the Saucon Creek samples. Soil boring analyses indicated a high level of cyanide in one soil sample. Fluoride was detected in some of the soil samples from the site. The RCRA EP toxicity test standards were not exceeded in any of the soil samples from the impoundment.

In November 1986, ESC conducted the second quarter sampling of the wells. Laboratory analyses confirmed the presence of volatile organics in groundwater from downgradient wells, as well as low concentrations of 1,2-dichloroethane, 1,1-dichloroethylene, benzene, and trichloroethylene.

Five additional monitoring wells were installed onsite in January and February 1987. Four of the new wells and the four existing wells were sampled in February 1987. Additional soil borings in the lagoon area were also made downgradient of the underground storage tanks and lagoon no. 1. Six borings were made and 34 samples were collected. Base neutral extractables, specifically, polycyclic aromatic hydrocarbons (PAHs) were detected in the impoundment samples. Based on the analytical results of the third sampling session, volatile organic compounds were determined to be the primary constituents of concern.

In August 1987, all nine onsite wells and two offsite private wells were sampled. The analytical results reflected the presence

of volatile organics and small amounts of chlorinated organics in groundwater from wells downgradient of the HMC plant building.

1.4 Investigation Summary

The original ESC work plan for the site was designed to further define the lateral and vertical extent of possible subsurface contamination and addressed specific concerns raised at several meetings with the PADER. The plan detailed a year-long program of groundwater and stream monitoring on a quarterly schedule, underground tank testing, and the installation and sampling of soil borings "upgradient" of and within the closed lagoon areas.

The results of the initial ESC investigative efforts were detailed in a report entitled "Remedial Investigation of the Former Hellertown Manufacturing Company Facility in Hellertown, Pennsylvania," dated November 7, 1986, and submitted to the PADER. The results of that investigation have also been included in this document.

Based on the results of the initial site work, ESC will propose additional investigation efforts and additional site work to supplement previously collected site data.

CLP Protocol - ESC will use CLP Protocol for all key environmental samples related to the site to ensure that analytical data can be validated.

Well Inventory - A water well inventory within a two-mile radius from the HMC facility was conducted. Area wells were

identified using a state water well inventory, USGS records, and information supplied by the Bethlehem Water Department.

Hydrogeologic Investigation - Surface and subsurface soil samples were collected both onsite and offsite. In 1984 and 1985, borings were made on the north side of Silvex Road to describe shallow subsurface conditions before the construction of highway I-78. Four borings were made north of the HMC plant and numerous others were installed at various other locations.

In June 1986, 87 soil samples were collected from 19 borings in the filled-in surface impoundments. Soil samples were collected from the berms around lagoons no. 1 and 2 and from areas where solvents may have been previously handled or disposed of. A total of 34 samples were collected from six borings during the week of February 23, 1987.

Five new groundwater monitoring wells were installed and sampled, and the quarterly sampling of the four existing wells occurred. Details of the well construction and installation are discussed in Section 4.3. The original four wells were sampled in June 1986, November 1986, and February 1987. Four of the new wells were also sampled in February 1987. All nine wells and two offsite private wells were sampled in August 1987.

Investigations thus far confirm the presence of small amounts of chlorinated organics in groundwater downgradient from the main plant building on the site. Since this area is in proximity to the western property line, there is some potential that contaminants are migrating offsite. The results of the soil boring study to date do

not confirm the presence of a contamination source that could produce the observed groundwater quality effects. The most concentrated constituents, polycyclic aromatic hydrocarbons (PAHs), were detected in the soils in one group of the surface impoundment borings. These constituents do not appear to present a threat to environmental receptors since they are generally insoluble and since the buried contaminants are precluded from becoming airborne.

Although small concentrations of semivolatile organics have been detected in groundwater samples collected in the most recent sampling reported herein, the constituents detected most frequently in the four sampling sessions of recent record are volatile organics. The volatile organics detected in the monitoring wells include vinyl chloride, trichloroethylene, trans-1,2-dichloroethylene, benzene, 1,1-dichloroethylene, and 1,1,1-trichloroethane. These constituents have been detected at concentrations as high as 1.4 ppm (TCE in well CSP-5b) and 1.25 ppm (trans-1,2-dichloroethylene in well CSP-3).

In evaluating the significance of the groundwater data collected thus far, it seems appropriate to compare groundwater monitoring results with the EPA Maximum Contaminant Levels for drinking water. The reasons for making this comparison are that: 1) groundwater appears to be the environmental medium most affected at the site; and 2) groundwater is used in the area as a drinking water source. The MCLs for several of the organics listed above, including vinyl chloride, trichloroethylene, benzene, and trans-1,2-dichloroethylene were exceeded in several of the wells in each

sampling session. For example, the MCLs for vinyl chloride, trans-1,2-dichloroethylene, and trichloroethylene have been consistently exceeded in well CSP-3 for each of the last three sampling sessions.

Water-level elevations in the monitoring wells and in Saucon Creek were recorded by a previous investigator in January 1985 and by ESC in June and November 1986 and February 1987. ESC also performed pumping tests and calculated approximate values of transmissivity of the formations in February 1987. The values of transmissivity and the hydraulic gradient suggest groundwater flow velocities on the order of feet per day. A generalized map of the water table indicates that the hydraulic gradient across the site is to the west toward Saucon Creek. There is also a small northward component of groundwater flow.

The water-level elevations in one well cluster show a slight downward gradient from an upper screened interval (CSP-5A) to a middle screened interval (CSP-5B) and a relatively large upward gradient from the lowest screened interval (CSP-5C) to the middle interval. Pumping of well CSP-5C produced an immediate drawdown in CSP-5B. The apparent hydraulic connection between the two water-transmitting zones and the upward component of flow from the deeper one at this location, which is only about 500 feet from Saucon Creek, suggest that the entire groundwater system (bedrock and unconsolidated formations) is discharging in the vicinity of the creek.

The extremely low levels of organic compounds found in the Reichard well are well below any drinking water standards

established by EPA and do not pose a health threat of any kind. There is also a possibility that since the levels are so low, a detection level error was made in the laboratory analysis. ESC believes resampling of this well is necessary to determine if the August sampling results are valid.

It remains to be determined if contaminants have migrated downward into relatively deep zones in the bedrock at the site and if these pollutants have then moved westward to a surficial discharge zone along Saucon Creek or into water-bearing strata on the west side of Saucon Creek. This is particularly significant given the location of private water supply wells about 2,500 feet west of the site (beyond Saucon Creek).

1.5 Overview of Report

This report is a Phase I RI report which summarizes the existing information on previous site activities to date. The report is organized into an Executive Summary and nine chapters, plus appendices. Not all chapters contain complete information since ESC is currently in the process of gathering additional data.

Chapter 1 (Introduction) contains information relating to the history of site operations, wastestreams, and waste handling procedures. It also contains information on the suspected nature and extent of contamination, a history of previous response actions and activities at the site, and a summary of information generated

by investigations at the site. Chapter 2 (Site Features Investigation) contains information relating to the site demography, land use, natural resources, and climatology. This chapter contains partial information on site demography. Other information will be gathered and included in the completed RI report. Chapter 3 (Hazardous Substance Investigation) contains partial information on the types of wastes, locations, and components of wastes at the site. Waste amounts and other information pertaining to the waste will be provided in the completed RI report after further study. Chapter 4 (Hydrogeologic Investigation) contains existing information on the soil types, depth, contents, and characteristics. Additionally, information is included on geologic features as well as groundwater investigation data.

Data are presented relating the contaminants and levels of contamination currently identified in soils and groundwater. Chapter 5 (Surface Water Investigation) presents partial information concerning surface water sampling and analyses, surface water flow and possible contaminant migration. Information on sediments and other areas is not available at this time but will be included in the completed RI report. Chapter 6 (Air Investigation) contains existing information on any suspected air contamination. Chapter 7 (Biota Investigation) contains existing information relating to contamination of area flora and fauna. This section will be addressed in more detail in the completed RI report. Chapter 8 (Bench and Pilot Tests) presents information on potential alternatives for remedial actions. No information currently exists

on bench and pilot tests on site wastes. Chapter 9 (Public Health and Environmental Concerns) contains the currently existing information on public health and environmental concerns. More complete information will be obtained in the RI phase and will be presented in the completed RI report.

Appendix A contains the preliminary results of the well survey. Appendix B contains soil boring information, specifically soil boring locations for the borings made in June 1986; the depths of soil samples; and logs of borings from June 1986. Appendix C contains information on the locations and depths of soil borings made in February 1987. Appendix D contains diagrams showing cross-sections of the lagoons. Appendix E contains the boring logs for monitoring wells CSP-1, 2, 3 and 4. Appendix F contains information on the installation of well clusters CSP-5 and CSP-6. Appendix G contains water level recovery measurements and semilog plots of water level recovery. Appendix H contains laboratory deliverables for sampling dates November 1986 to August 1987. Appendix I contains information on the offsite well sampling program.

2.0 Site Features Investigation

2.1 Investigation of Demographic Features

ESC had a demographic ring study performed using 1986 census data. The point chosen for the center of the ring study was the intersection of Silvex Road and Main Street, an intersection adjacent to the plant. The estimated 1986 population at a radius of 0.5 mile from that intersection is 803. The 1986 estimated populations for radii of 1, 2, 3, and 4 miles are 4,132; 15,182; 45,781; and 79,171.

The plant, offices, and parking lot occupy about 4.6 acres of the site. The open, undeveloped filled-in area is about 1.9 acres. The balance of the site (1.5 acres) contains outdoor storage. The site slopes to the west with a 2.3% grade. The average yearly rainfall near Hellertown is about 43 inches. The evapotranspiration value for this area is approximately 0.50. Climatology, land use, and natural resources are being further researched for inclusion in later documents. Preliminary investigations into natural resources indicate that there are extensive abandoned zinc mines in the area. Mining activities were conducted as deep as 2,600 feet.

3.0 Hazardous Substance Investigation

3.1 Historical Review of Waste Types

The waste types potentially present onsite are the result of past production and waste handling practices. The lagoons received plant effluent from approximately 1950 until January 1975. The chemical and physical nature of the effluent likely varied significantly over that period.

One can conceptualize the waste balance inputs into the lagoon system as metal forming wastes, parts washing wastes, and metal finishing wastes. The metal forming operations involved cold forming presses, cutting operations, chucking, etc. (Table 1). Lubricants essential for these operations had to be removed before metal finishing operations were possible and probably ended up in the lagoon system. Several PADER inspection reports (circa 1975) make mention of the presence of an oil layer on the surface of lagoon supernatant.

It is known that metal finishing before 1952 consisted of parts washing and high temperature bluing. Bluing salts consisted of sodium and potassium nitrates and nitrites. The process involved generating a controlled oxide layer on the surface of a part. In the initial step, the spark plug shell was cleaned in an alkaline cleaning solution and then dipped in a dilute acid bath. The parts were then immersed in a molten bath (temperature 700 to 800^0 F) consisting of sodium nitrate and sodium nitrite. Some HMC

representatives indicated that potassium based nitrates and nitrites may also have been used in the process. Reportedly, the parts would take on a bluish tint (hence the name) in the molten bath. After the molten bath step, the parts were rinsed with water and a rust preventative was applied.

The wastes discharged to the lagoons probably consisted of oily alkaline wastes, acid wastes, and sodium nitrate/nitrite contaminated rinsewater from the bluing process. Residuals flowed from the plant to lagoons no. 1, 2, 3, and 4, in series. Reportedly, the lagoons were not designed with a discharge to surface waters. Since it is considered unlikely that the plant effluent was treated before discharge, the lagoons essentially functioned as crude settling and infiltration basins.

The high temperature bluing process was replaced with a low temperature blackening process from 1953 to 1959. This process was conducted at much lower temperatures (about 290^{0} F). The low temperature blackening process was conducted in an aqueous solution consisting of sodium nitrate, sodium nitrite, and caustic soda. The bath also contained proprietary materials to prevent iron precipitation. As in the high temperature bluing process, parts were washed in alkaline cleaning baths and dilute acid baths before immersion in the nitrite/nitrate/caustic bath. The parts were then rinsed in a water bath and a black wax was applied as a rust preventative. HMC progressed from the black wax to a soluble resin and then an acrylic resin for the rust preventative.

Wastes from the low temperature blackening process probably consisted of oily alkaline wastes and acid wastes from parts washing and highly alkaline wastes from the blackening operation. Wastes from the blackening process were routed to the lagoon system.

The low temperature blackening process was eventually replaced with cyanide-based zinc electroplating in 1959. This process change significantly affected the waste matrix discharged to the lagoons. Residuals from the electroplating operation probably consisted of acid wastes, zinc, hexavalent chromium, trivalent chromium, and cyanide-containing wastes from metal pretreatment and treatment.

In about 1965, HMC voluntarily installed a wastewater treatment system which probably had a notable effect on the physical amd chemical character of the plant effluent. The system was designed to treat cyanide and hexavalent chromium. The treated effluent from the system was discharged to the lagoons. At some point after the installation of the wastewater treatment system (approximately 1966), lagoon no. 5 was constructed to receive discharges from lagoon no. 4.

The wastewater treatment system was eventually upgraded in 1971-1972. From that time until about 1975, the various plant effluent sources were gradually routed from the lagoons to the treatment unit. All treatment occurred in steel tanks and concrete lined sumps. Treated wastewater was discharged to the municipal sanitary sewer system and treated sludges were dewatered in a concrete lined drying bed and hauled offsite to a local disposal site, the Chrin Landfill.

All discharges to the lagoons ceased in about 1975, prompting HMC to close the lagoons by filling and covering the units with clean fill. The earliest analytical results for the lagoon contents are from a 1975 Gilbert Associates Report prepared to address PADER concerns regarding the propriety of filling in the lagoons without removing supernatant and sludge (Answer 12, CERCLA 104(e) response). The sampling and analytical methodology have not been made available to ESC. In addition, it is not possible to validate the analytical results because there are no known laboratory deliverables for such "historic" data. Nevertheless, a summary of the analytical results for lagoon supernatant samples and lagoon sludges is reported in Tables 3 and 4.

One reasonable conclusion that can be drawn from the information summarized in Table 3 is that the supernatant in the lagoons at the time of closure does not appear to be overly burdened with cyanide or chromium. Supernatant concentrations of total cyanide (range 0.14-0.61 mg/l) and total chromium (range 0.021-0.83 mg/l) were highest in lagoons no. 2 and 1, respectively. Zinc concentrations however, seem influenced by an anthropogenic source (range 0.8 to 15.9 mg/l). Except for zinc, trace element concentrations for the lagoon sludges seem to be well within the common range expected in soils (Table 6). The concentration of zinc in the sludge from each of the lagoons is outside the common range of zinc in soils (10-300 mg/kg). In addition, total cyanide concentrations in the sludge seem to be elevated. In general, contaminant levels do not seem to correlate with the hydraulic

Table 6

Trace Chemical Element Content of Natural Soils (ppm)[a]

Element	Common Range	Average	Element	Common Range	Average
Aluminum	10,000-300,000	71,000	Lithium	5-200	20
Antimony	2-10	-	Magnesium	600-6,000	5,000
Arsenic	1-50	5	Manganese	20-3,000	600
Barium	100-3,000	430	Mercury	0.01-0.3	0.03
Beryllium	0.1-40	6	Molybdenum	0.2-5	2
Boron	2-100	10	Nickel	5-500	40
Bromine	1-10	5	Radium	8×10^{-5}	
Cadmium	0.01-0.7	0.06	Rubidium	50-500	100
Cesium	0.3-25	6	Selenium	0.1-2	0.3
Chlorine	20-900	100	Silver	0.01-5	0.05
Chromium	1-1,000	100	Strontium	50-1,000	200
Cobalt	1-40	8	Tin	2-200	10
Copper	2-100	30	Tungsten		1
Fluorine	10-4,000	200	Uranium	0.9-9	1
Gallium	0.4-300	30	Vanadium	20-500	100
Gold		1	Yttrium	25-250	50
Iodine	0.1-40	5	Zinc	10-300	50
Lanthanum	1-5,000	30	Zirconium	60-2,000	300
Lead	2-200	10			

a/ Source: USEPA Office of Solid Waste and Emergency Response, HAZARDOUS WASTE LAND TREATMENT, SW-874 (April, 1983) Page 273, Table 6.46.

profile as one would expect. For example, total cyanide and zinc are highest in lagoon no. 3 rather than lagoon no. 1, the first lagoon to receive wastes from the plant.

In view of the uncertainties pertaining to the sampling and analytical methodologies and given that the samples were collected after the cessation of discharges, it is unlikely the results are representative of lagoon contents throughout the history of the HMC. One can make crude inferences regarding the chemical/physical nature of the untreated effluent discharge to the lagoon system in the interim between initiation of the cyanide-based zinc plating and installation of the first wastewater treatment system. Correspondence between the HMC and the City of Bethlehem Department of Public Works (March 3, 1978, Answer 4, 104(e) response) appears to address discharges from the plating line before treatment. These data must be interpreted with care because of the lack of information about sampling and analytical methodologies and the absence of laboratory deliverables. In the referenced correspondence, flow from the plating line has been quantified at 22,753 gpd and the characteristics of the wastewater are described as follows:

Parameter	Concentration (mg/l)
Cyanide	0.092
Chromium	3.05
Copper	0.24
Zinc	92.5
Nickel	0.13
Iron	33.5
pH	11.5

One could infer that the untreated discharges from the plating line to the lagoon system were similar. It should be recognized, however, that plating line discharges to the lagoon would have been comingled with other plant wastewater flows and that the chemical and physical character of influent flows into the lagoon systems probably varied with plant output.

3.1.1 Investigations to Determine Waste Types

The history of potential wastewater discharges to the lagoon systems at the HMC has been reconstructed as completely as possible in the previous section. There is a relative lack of detailed information regarding the hazardous substances handled and discharged throughout the history of the site. In an effort to establish the lateral and vertical extent of possible subsurface contamination, HMC retained several environmental consultants (including ESC) in the past. The results of these investigations shed some light on the types of waste present at the site.

In November 1984, O.H. Materials Company (OHM) was requested to provide a proposal to define subsurface environmental conditions at the unoccupied HMC plant in Hellertown, Pennsylvania. A field drilling and sampling program was initiated on December 17, 1984, and completed on January 5, 1985. Four wells were installed: an upgradient well (CSP1) and 3 downgradient wells (CSP2, CSP3, and CSP4).

OHM's findings from this investigation are contained in a report entitled "Final Report: Geohydrologic Characterization, Hellertown Manufacturing Facility, Hellertown, Pennsylvania" (see Answer 10, CERCLA 104(e) response). The findings indicated the need for additional investigations, and Environmental Strategies Corporation (ESC) was requested to perform this additional work.

The work plan for the additional work was designed to further define the lateral and vertical extent of possible subsurface contamination, to characterize any sludge or waste layers in the abandoned lagoons, and to address specific concerns raised by the PADER. The plan detailed a year-long program of groundwater and stream monitoring on a quarterly schedule, underground tank testing, and the installation and sampling of soil borings "upgradient" of and within the closed lagoon areas. As a result of the PADER review, the work plan was approved with the following modifications as documented in correspondence of July 14, 1986, from Mr. Bruce Beitler, Operations Supervisor, of the PADER to Mr. Michael J. Murphy, Chairman and Chief Executive Officer of ESC.

1. The specific soil boring locations as established at the June 25 meeting were deemed acceptable. The location of the upgradient soil boring was moved as recommended to an area near the parking lot which was accessible to the drilling rig.
2. Soil samples were collected utilizing continuous split-spoon sampling from the land surface above the lagoons to

refusal. The drilling rig was decontaminated by steam cleaning between borings.

3. Borings were backfilled with a cement and bentonite grout to an interval above the base of the lagoons and above an identifiable "sludge" layer.

4. The list of parameters to be analyzed in soil samples (presented on page 6 of the work plan) was expanded to include cadmium, manganese, iron, phenols, and nitrates.

5. Step 5 of the sampler decontamination procedure on Page 8 of the proposal was amended to read "acetone rinse."

6. The investigation and evaluation of a surface-water discharge area in the northwest corner of the property was included in the project.

7. Groundwater sampling did not include downgradient private wells located near Saucon Creek. Such an activity would require coordination with and the cooperation of the PADER. This would facilitate the effort and provide an appropriate interface with the private parties involved. It was recommended that the PADER sample the private wells of concern and split the resulting samples with ESC for subsequent analysis.

8. Surface water samples (3) from Saucon Creek, groundwater samples (4) from onsite monitoring wells, and soil samples (87) from borings drilled onsite were collected by ESC from June 23 to July 1, 1986.

A description of the field work and a presentation and discussion of results related to characterizing the lagoon contents and any underlying contaminated soil follow. A description of the field work related to surface and groundwater sampling is included in the section on Hydrogeologic Investigation.

3.1.2 Description of Field Work to Characterize Hazardous Substances in the Abandoned Lagoons

Soil Sampling June 24, 1986

A total of 87 soil samples were collected from 19 borings on the HMC site from June 24 to 27, 1986 (Figure 2). Appendix B describes the exact location and depth of each sample.

The borings were drilled using eight-inch hollow-stem augers. Samples were collected with a 2-inch diameter split-spoon sampler driven by a 140-pound hammer ahead of the auger. Eighteen-inch samples were taken at five-foot intervals to a depth at which a horizon was encountered which appeared to be contaminated. At this critical depth, 3 continuous 24-inch samples were taken to ensure the collection of representative material. Once below the apparently contaminated zone, sampling was resumed at five-foot intervals to refusal or bedrock.

The nature of the fill material, which contains an abundance of cobbles and boulders, resulted in the snapping off of three auger heads and in refusal above bedrock in some borings. When refusal was encountered above the critical "sludge zone," additional borings

were attempted in the general location of the original boring. At four boring locations, B1-3, B2-3, B3-4, and B4-4, it was not possible to reach the "sludge" horizon. In each case, it was decided that the critical interval was sufficiently sampled from other borings in the particular lagoon.

A portable Century Organic Vapor Analyzer (OVA, model 108), calibrated to methane was used to scan split-spoon samples to determine relative levels of volatile organics within each boring. Values were recorded and listed on the boring logs contained in Appendix B.

Forty samples were placed in teflon sealed 1-liter jars and 40-milliliter vials provided by the primary laboratory (Environmental Testing and Certification Laboratory - ETC). Thirty-one of these samples were selected for analysis. Seven of the 31 samples were split and placed in pint jars and 40-millimeter vials provided by the referee laboratory (Environmental Science Corporation) for duplicate analysis. The nine remaining samples were sent to ETC and archived. Forty-seven other samples are being stored at the HMC site.

Samples were kept in iced coolers and sent to the ETC and Environmental Science Corporation labs at the end of each day of sampling.

Soil Sampling - February 23, 1987

Soil samples were collected from two areas of the site during the week of February 23, 1987, in order to continue investigations

into the waste types at the site. The borings for soil sample collection were made under the supervision of an ESC hydrogeologist. Borings B1-4, B1-5, and B1-6 were made in the area of filled lagoon no. 1. Borings A-1, A-2, and A-3 were made downgradient from the underground storage tanks in an area where parts washing and some dumping of industrial wastes had been reported. The general locations of the borings and the exact depths of the samples are shown in Appendix C.

A total of 34 samples were collected and screened for VOCs using an HNU photoionizer. The protocol for soil sample collection has been previously described. Based on HNU readings, visual appearance, and obvious odors, three of the samples were selected for laboratory analysis for volatile organic compounds (Table 7).

The purpose of the work in the lagoon no. 1 area was to collect samples from the bank of the former lagoon. Before closure, the lagoon was reported to have been dredged periodically with the spoil deposited on the bank. After closure, the lagoon was filled and graded and the area of the lagoon is now covered by an asphalt surface parking lot. As discussed below, no thick accumulations of lagoon bottom sediment were encountered.

The location of the former bank of the lagoon no. 1 was inferred from old aerial photographs. Borings B1-1, B1-5, and B1-6 were drilled in a line across the inferred bank near the former inlet to the lagoon. Due to the presence of rubble fill, it was necessary to move several of the borings. The final locations are shown in Appendix C.

Table 7

Soil Samples Analyzed for VOCs

Boring No.	Sample No.	Depth Interval (ft)
A-2	S-3	4-6
A-3	S-5	8-10
B1-6	S-4	13-16

Weathered rock was encountered in each of the B1 borings at less than 20 feet (Appendix C). The material above rock is largely fill composed primarily of native silt and clay materials with abundant rock fragments. HNU readings were less than 5 ppm for each sample.

Layers with gray or black discoloration and some odor were present in borings B1-5 and B1-6. This material presumably represents bottom sediment or sludge from lagoon no. 1. The sludge layer in B1-6 was only one inch thick and did not provide sufficient volume for analysis. In boring B1-6, a black sludge layer approximately 6 inches thick was present in sample S-4 which was taken through the depth interval from 13 to 16 feet. The HNU reading was less than 1 ppm; however, because of its appearance this sample was sent to CompuChem Laboratory for analysis for VOC.

The three "A" series borings are located downgradient from the underground storage tank area. The highest HNU reading was 15 ppm in boring A-2 in a zone of gray discoloration from 1 to 6 feet below land surface. A sample of this material was sent to both the primary and the referee laboratories for analysis.

In boring A-3 (the boring for well CSP-7), no obvious industrial waste was encountered although the presence of occasional spark plugs to about 10 feet indicated the presence of fill. Sample S-5 from 8 to 10 feet below grade was sent to CompuChem for VOC analysis. This sample had an HNU reading of 5 ppm, the highest in the boring.

Boring A-1 was terminated in weathered rock at 15 feet. There was no visual evidence of industrial waste in this boring. The highest HNU reading was 4 ppm.

Cleaning of Sampling Equipment and Backfilling of Boreholes

Augers and sampler stems were steam cleaned between each boring. Split-spoon samplers were decontaminated between each sample using the following procedure:

1. Soap and tap water wash
2. Tap water rinse
3. Deionized water rinse
4. Ten percent acidic solution rinse
5. Deionized water rinse
6. Reagent grade acetone rinse
7. Total air dry
8. Deionized water rinse

The borings were backfilled with a grout mixture consisting of a 95-pound bag of Portland cement and 5 pounds of bentonite per 10 gallons of water. The grout was pumped down the hole with the base of the augers set at the base of the "sludge" horizon. Each boring was grouted to a level above this interval to ensure that the borings would not create a conduit through which contaminants could enter the groundwater. All cuttings from the drilling activity were disposed of on the site in the lagoon field.

Descriptions of Lagoons

The locations of the soil borings made in June 1986 in the five lagoons at the HMC site are shown on Figure 2. The 18 soil borings in the lagoon area penetrated the base of all lagoons. Generally, in each lagoon, soil samples from the horizon showing the most discoloration and the highest OVA readings and from the horizon directly beneath were sent to the laboratories for analysis.

The characteristics of the soils and subsurface stratigraphy are discussed in the section entitled, "Hydrogeologic Investigation."

Presentation and Discussion of Analytical Results

The analytical results for the lagoon borings, groundwater, collected on June 24, 1986, are presented in Tables 8 through 13. The analytical results for the samples collected in February 1987 are presented in Table 14. Only those compounds that appeared in detectable concentrations are reported in the tables. Each table is grouped to report metals, conventional pollutants (conventionals), the results of EP toxicity tests (if applicable), and organic priority pollutants. Duplicate samples analyzed by Environmental Science Corporation of Hartford, Connecticut, are reported immediately adjacent to the relevant ETC sample.

The "duplicate" samples are actually field replicate samples (splits). One sample was analyzed by the referee laboratory (Environmental Science Corporation, ESO), while the other sample was analyzed by the Primary laboratory, Environmental Testing and Certification (ETC). The precision expected for field replicate

Table 8

Background Borings for Sample Period June 1986

Compound	B6-Bg-15	B6-Bg-20
Metals (ug/kg)		
Barium	13,000	12,000
Cadmium	610U	610U
Chromium	13,000	11,000
Copper	18,000	16,000
Iron	20,700,000	18,300,000
Manganese	326,000	266,000
Nickel	16,000	16,000
Sodium	22,000	26,000
Zinc	50,000	39,000
Conventionals (mg/kg)		
Fluoride	2U	2U
Nitrate as N	420	440
Sulfate as SO4	150U	150U
Phenolics, total	0.1U	0.1U
Cyanide, total	1.7	0.5U
EP Tox (mg/l)		
Arsenic	insufficient	1.0U
Barium	sample	5.0U
Cadmium	0.2U	
Chromium	1.0U	
Lead	1.0U	
Mercury	0.003U	
Selenium	0.3U	
Silver	0.2U	
Organic Priority Pollutants (ug/kg)		
Methylene chloride	27.0[a,b]	30.4[1,2]

a/ Amended corrections January 2, 1987
b/ Indicates analyte also found in lab blank.

Table 9

Impoundment I For Sample Period June 1986

Compound	B1-1-15	B1-1-25	Referee Split[a] B-1-25	B1-2-13	B-1-3-15
Metals (ug/kg)					
Barium	58,500	18,000	20,100	64,900	84,200
Cadmium	610U	610U	140[b]	610U	610U
Chromium	40,000	6,900	166,000	14,000	17,000
Copper	67,000	10,000	31,300	24,000	21,000
Iron	36,000,000	13,800,000	22,519,000	20,200,000	21,000,000
Manganese	625,000	192,000	265,000	1,170,000	575,000
Nickel	22,000	5,100	22,500	14,000	14,000
Sodium	91,000	160,000	364,000	90,000	78,000
Zinc	1,080,000	87,100	279,000	137,000	277,000
Conventionals (mg/kg)					
Fluoride	6	<2	4	10	9
Nitrate as N	81	79	46	99	91
Sulfate as S04	330	970	20	190	330
Phenolics, total	0.8	0.1U	2.0U	0.1U	0.1U
Cyanide, Total	0.5U	1.1	2.0U	0.7	0.5U
EP Tox (mg/l)					
Arsenic	1.0U	1.0U	0.05U	1.0U	1.0U
Barium	5.0U	5.0U	0.19U	5.0U	5.0U
Cadmium	0.2U	0.2U	0.01U	0.2U	0.2U
Chromium	1.0U	1.0U	0.01U	1.0U	1.0U
Lead	1.0U	1.0U	0.03U	1.0U	1.0U
Mercury	0.003U	0.003U	0.002U	0.003U	0.003U
Selenium	0.3U	0.3U	0.04U	0.3U	0.3U
Silver	0.2U	0.2U	0.04U	0.2U	0.2U

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Table 9

Impoundment I (continued)

Compound	B1-1-15	B1-1-25	Referee Split[a] B-1-25	B1-2-13	B-1-3-15
Organic Priority Pollutants (ug/kg)					
Methylene chloride	121.0[B,c]	12.2[c]	ND[a]	2.8U	27.4[B,c]
Trichloroethylene	1.9U	59.3	ND	1.9U	1.9U
Fluoranthene	168	73U	ND	53.6	1,530
Isophorone	143	73U	ND	68J	68U
Phenanthrene	338	325	ND	244	170U
Pyrene	232	63U	ND	375	1,280
Anthracene	63U	63U	ND	102	59U
Benzo(a) anthracene	260U	260U	ND	303	451
Benzo (a) pyrene	82U	83U	ND	315	77U
Benzo (k) fluoranthene	120U	120U	ND	890	1,210
Chrysene	82U	83U	ND	330	527
Indo (1,2,3,-cd) pyrene	150U	160U	ND	150U	486
Naphthalene	53U	53U	ND	51U	108
Benzene	4.4U	4.4U	9.0	4.4U	4.4U
Ethylbenzene	7.2U	7.2U	6.8	7.2U	7.2U
Di-n-butyl Phthalate	330U	330U	ND	132J	310U

a/ Referee lab data indicate minimum detectable level (MDL) of 1 ug/kg for all organic pollutants.

b/ Exceeds the upper limit of common range of trace element content of natural soil (US EPA 1983).

c/ Amended corrections January 2, 1987. B - Indicates analyte also found in lab blank.

Table 10

Impoundment II For Sample Period June 1986

Compound	2-1-21	Referee Split 2-1-21	2-1-30	2-2-20	2-2-25.5	2-3-20	Referee Split 2-3-20
Metals (ug/kg)							
Barium	76,100	23,500	13,000	67,000	10,000	52,500	16,600[a]
Cadmium	610U	430	610U	610U	610U	610U	270[a]
Chromium	1,010,000	421,000[a]	20,000	140,000	17,000	17,000	12,200
Copper	20,000	184,000[a]	16,000	24,000	4,800	16,000	3,500
Iron	33,800,000	12,422,000	14,800,000	24,100,000	18,000,000	17,800,000	11,515,000
Manganese	817,000	454,000	209,000	686,000	454,000	876,000	527,000
Nickel	26,000	425,000	13,000	16,000	9,100	10,000	22,000
Sodium	230,000[a]	168,000[a]	530,000	150,000[a]	920,000	89,000	80,000[a]
Zinc	11,400,000[a]	3,928,000[a]	96,200	1,470,000[a]	91,300	212,000	484,000[a]
Conventionals (mg/kg)							
Fluoride	8	17.0	3	5	5	5	5.8
Nitrate as N	650	118	51	87	40	59	15
Sulfate as SO_4	160	1,118	150U	200	150U	210	10U
Phenolics, total	0.4	2U	0.1U	0.9	0.1	0.1U	2U
Cyanide, Total	2.3	2U	0.5U	42	0.5U	2.5	2U
EP Tox (mg/l)							
Arsenic	insufficient	0.05U	1.0U	1.0U	1.0U	insufficient	0.05U
Barium	sample	0.23	5.0U	5.0U	5.0U	sample	0.20
Cadmium		0.01	0.2U	0.2U	0.2U		0.01U
Chromium		0.01	1.0U	1.0U	1.0U		0.01U
Lead		0.04	1.0U	1.0U	1.0U		0.03
Mercury		0.002U	0.003U	0.003U	0.003U		0.002U
Selenium		0.001U	0.3U	0.3U	0.3U		0.01
Silver		0.05	0.2U	0.2U	0.2U	0.04	

Table 10

Impoundment II (continued)

Compound	2-1-21	Referee Split 2-1-21	2-1-30	2-2-20	2-2-25.5	2-3-20	Referee Split 2-3-20
Organic Priority Pollutants (ug/kg)							
Methylene chloride	13.8	696	18.3	18.9	18.7	41.0	32
Benzene	4.4U	337	4.4U	4.4U	4.4U	4.4U	ND[b]
Chlorobenzene	6U	370	6U	6U	6U	6U	ND
Ethyl benzene	10U	1,588	10U	10U	10U	10U	109
1,1,2,2-Tetra-chlorethane	6.9U	380[c]	6.9U	6.9U	6.9U	6.9U	ND
Tetrachloroethylene	4.1U	380[c]	4.1U	2.2J	4.1U	4.1U	ND
Toluene	6U	2,059	6U	2.6J	6U	6U	181
Trichloroethylene	1.9U	3,477	1.9U	1.9U	1.9U	1.9U	75
Benzoanthracene	2,600U	ND[b]	260U	2,600U	230U	2,130	ND
Phenanthene	25,400	ND	180U	3,960	65U	728	ND
Fluoranthene	730U	ND	73U	2,100	56U	4,170	ND
Fluorene	630U	ND	63U	858	ND	101	ND
Isophorone	730U	ND	73U	720U	287	71U	ND
Acenaphthene	630U	ND	63U	630U	56U	121	ND
Anthracene	630U	ND	63U	630U	56U	527	ND
Benzo (a) pyrene	830U	ND	83U	820U	74U	1,370	ND
Benzo (ghi) pyrene	1,400U	ND	140U	1,300U	120U	934	ND
Benzo (k) fluoranthene	1,200U	ND	120U	1,200U	100U	5,850	ND
Chrysene	830U	ND	83U	820U	74U	2,400	ND
Pyrene	630U	ND	63U	630U	56U	3,230	ND
Indeno (1,2,3-cd) pyrene	1,600U	ND	160U	1,500U	140U	842	ND
Naphthalene	530U	ND	53U	530U	47U	124	ND

a/ Exceeds the upper limit of the common range of trace element content of natural soils (US EPA 1983).
b/ Referee lab data indicate MDLs of 1 ug/kg for all organic pollutants.
c/ These compounds co-elute, the result reported may be either one or a combination of the two compounds.

Table 11

Impoundment III For Sample Period June 1986

Compound	3-1-19	3-1-25	3-2-15	3-2-23	3-3-15	3-3-25	3-4-10	3-4-15
Metals (ug/kg)								
Barium	46,800	65,800	62,700	insuf-	46,800	114,000	97,900	38,900
Cadmium	610U	610U	<610	ficient	610U	610U	610U	610U
Chromium	19,000	15,000	24,000	sample	241,000	13,000	16,000	11,000
Copper	130,000[a]	28,000	225,000		37,000	43,000	18,000	12,000
Iron	26,800,000	42,000,000	30,300,000[a]		27,500,000	68,700,000	24,600,000	12,200,000
Manganese	368,000	1,250,000	651,000		474,000	1,990,000	975,000	661,000
Nickel	130,000	27,000	130,000		27,000	40,000	14,000	
Sodium	290,000	670,000	220,000		220,000	330,000	65,000	130,000
Zinc	370,000[a]	80,300	317,000[a]		1,830,000[a]	221,000	189,000	94,100
Conventionals (mg/kg)								
Fluoride	8	4	4	12	5	5	4	4.0
Nitrate as N	520	600	16	57	45	1,500	330	55
Sulfate as SO_4	260	280	150U	260	560	210	270	410
Phenolics, total	0.1U	0.1U	0.1U	sample depleted	0.3	0.1U	0.1U	sample depleted
Cyanide, total	1.4	0.5U	0.5U	5U	1.5	0.5U	0.5U	0.5
EP Tox (mg/l)								
Arsenic	1.0U	1.0U	1.0U	insuf-	1.0U	1.0U	1.0U	insuf-
Barium	5.0U	5.0U	5.0U	icient	5.0U	5.0U	5.0U	icient
Cadmium	0.2U	0.2U	0.2U	sample	0.2U	0.2U	0.2U	sample
Chromium	1.0U	1.0U	1.0U		1.0U	1.0U	1.0U	
Lead	1.0U	1.0U	1.0U		1.0U	1.0U	1.0U	
Mercury	0.003U	0.003U	0.003U		0.003U	0.003U	0.003U	
Selenium	0.3U	0.3U	0.3U		0.3U	0.3U	0.3U	
Silver	0.2U	0.2U	0.2U		0.2U	0.2U	0.2U	

Table 11

Impoundment III (continued)

Compound	3-1-19	3-1-25	3-2-15	3-2-23	3-3-15	3-3-25	3-4-10	3-4-15
Organic Priority Pollutants (ug/kg)								
Methylene chloride	3.40[B,b]	6.20[b]	9.602	2.8U	6.60[B,b]	5.00[B,b]	63.9	2.8U
Anthracene	56U	63U	59U	63U	61U	63	342.0	315
Benzo (a) anthracene	230U	260U	240U	260U	250U	260U	2,280	735
Benzo (a) pyrene	73U	83U	78U	83U	80U	83U	2,190	603
Benzo (ghi) pyrene	120U	140U	130U	140U	130U	140U	1,570	220U
Benzo (k) fluoranthene	100U	120U	110U	120U	110U	120U	5,740	2,180
Chrysene	73U	83U	78U	83U	80U	83U	1,300	904
Fluoranthene	64U	73U	68U	73U	70U	73U	3,500	1,260
Indeno(1,2,3-cd) pyrene	140U	160U	150U	160U	150U	160U	712	365
Naphthalene	47U	53U	50U	53U	51U	53U	229	169
Phenanthrene	160U	180U	170U	180U	99J	180U	526	537
Pyrene	56U	63U	59U	63U	61U	63U	2,870	971
1,2-Trans-dichloroethylene	7.79	1.6U	1.6U	1.6U	1.6U	1.6U	1.6U	1.6U
Di-n-octyl phthalate	290U	330U	310U	233J	320U	721	83J	590U
Benzene	4.4U	3.9J	4.4U	4.4U	4.4U	4.4U	4.4U	4.4U

a/ Exceeds the upper limit of the common range of trace element content of natural soils (US EPA 1983).

b/ Amended corrections January 2, 1987. B - Analyte also found in lab blank.

Table 12

Impoundment IV for Sample Period June 1986

Compound	4-1-17	Referee Split 4-1-17	4-1-25	4-2-20	4-2-30	4-3-17	4-3-25	4-5-17
Metals (ug/kg)								
Barium	240,000	6,600[a]	14,000	30,000	10,000	60,000	11,000	238,000
Cadmium	610U	80[a]	610U	610U	610U	610U	610U	610U
Chromium	32,000	3,170	15,000	352,000	8,400	21,000	86,000	35,000
Copper	15,000	550	23,000	38,000	15,000	34,000	18,000	8,800
Iron	11,000,000	4,850,000	31,500,000	27,900,000	16,900,000	16,900,000	35,900,000	12,600,000
Manganese	1,280,000	827,000	165,000	335,000	398,000	429,000	119,000	2,130,000
Nickel	16,000	1,330	21,000	30,000	13,000	17,000	17,000	6,600
Sodium	670,000[a]	146,000	670,000	340,000[a]	1,200,000[a]	210,000	920,000[a]	790,000
Zinc	566,000[a]	88,300	95,200	1,030,000[a]	672,000[a]	198,000	1,200,000[a]	90,900
Conventionals (mg/kg)								
Fluoride	4	9.6	9.0	6.0	2.0U	3.0	2.0U	6.0
Nitrate as N	5U	124.0	100.0	41.0	50.0	32.0	31.0	10.0
Sulfate as SO_4	3,300	104.0	160.0	340.0	180.0	150.0U	250.0	610.0
Phenolics, total	0.4	2.0U	0.1U	0.1U	0.1U	0.2	0.1	0.8
Cyanide, Total	4.3	2.0U	3.4	0.5U	1.9	1.1	0.5U	1.7
EP Tox (mg/l)								
Arsenic	1.0U	0.5U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Barium	5.0U	0.09	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Cadmium	0.02U	0.01	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chromium	1.0U	0.01	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Lead	1.0U	0.05	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Mercury	0.003U	0.002U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Selenium	0.3U	0.01	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Silver	0.2U	0.19	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

Table 12

Impoundment IV (continued)

Compound	4-1-17	Referee Split 4-1-17	4-1-25	4-2-20	4-2-30	4-3-17	4-3-25	4-5-17
Organic Priority Pollutants (ug/kg)								
1,2-Trans-dichloroethylene	2.16	ND[b]	1.6U	1.6U	1.6U	1.6U	1.6U	1.6U
Benzene	4.4U	5.0	4.4U	4.4U	4.4U	4.4U	4.4U	4.1J
Chlorobenzene	6U	30	6U	6U	6U	6U	6U	6U
Ethyl benzene	7.2U	48	7.2U	7.2U	7.2U	7.2U	7.2U	16.3
Methylene chloride	2.8U	53	32.0	40.3	14.0	20.2	117.0	2.8U
Toluene	6U	547.0	6U	6U	6U	6U	6U	4.2J
Trichloroethylene	1.9U	143	1.9U	1.9U	1.9U	1.9U	1.9U	1.9U
Fluoranthene	3,500	ND	72U	525.0	73U	281	73U	2,800U
Bis (2-ethyl hexyl) phthalate	2,130	ND	330U	320U	330U	330U	330U	13,000U
Anthracene	1,220	ND	62U	61U	63	63	63U	2,400U
Phenanthrene	720U	ND	180U	283.0	180U	123J	180U	38,300
Pyrene	250U	ND	62U	493.0	63U	285.0	63U	32,300
Isophorone	290U	ND	62U	71U	73U	73.7	73U	2,800U
Acenaphthene	250U	ND	62U	61U	63U	63	63U	3,720.0
Fluorene	250U	ND	62U	61U	63U	63	63U	7,660.0
Naphthalene	210	ND	52U	52U	53U	53	53	3,470.0

Table 12

Impoundment IV (continued)

Compound	4-6-17
Metals (ug/kg)	
Barium	186,000
Cadmium	280
Chromium	30,000
Copper	13,000
Iron	14,800,000
Manganese	1,610,000
Nickel	9,300
Sodium	520,000
Zinc	633,000[a]
Conventionals (mg/kg)	
Fluoride	4
Nitrate as N	40
Sulfate as SO_4	840
Phenolics, total	0.2
Cyanide, Total	0.5U
EP Tox (mg/l)	
Arsenic	1.0U
Barium	5.0U
Cadmium	0.2U
Chromium	1.0U
Lead	1.0U
Mercury	0.003U
Selenium	0.3U
Silver	0.2U

Table 12

Impoundment IV (continued)

Compound	4-6-17
Organic Priority Pollutants (ug/kg)	
1,2-Trans-dichloroethylene	1.6U
Benzene	4.4U
Chlorobenzene	6U
Ethyl benzene	7.2U
Methylene chloride	23.4[c]
Toluene	6U
Trichloroethylene	1.9U
Fluoranthene	1,500U
Bis (2-ethyl hexyl) phthalate	6,600U
Anthracene	1,300U
Phenanthrene	3,600U
Pyrene	1,300U
Isophorone	1,500U
Acenaphthene	1,300U
Fluorene	1,300U
Naphthalene	1,100U

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a/ Exceeds the upper limit of common range of the trace element content of natural soils (US EPA 1983).

b/ Referee lab data indicate MDL of 1 ug/kg for all organic pollutants.

c/ Amended corrections January 2, 1987

Table 13

Impoundment V for Sample Period June 1986

Compound	5-1-16	5-2-25	5-2-16	Referee Split 5-2-16	5-2-20
Metals (ug/kg)					
Barium	148,000	31,900	49,100	14,500[a]	9,000
Cadmium	<610	610U	610U	170[a]	610U
Chromium	38,000	211,000	55,000	144,000	6,300
Copper	71,000	22,000	41,000	61,600	20,000
Iron	37,700,000	23,500,000	29,100,000	49,821,000	14,300,000
Manganese	1,020,000	481,000	635,000	563,000	224,000
Nickel	58,000	20,000	22,000	28,300	9,200
Sodium	270,000[a]	330,000[a]	86,000	190,000[a]	59,000
Zinc	354,000[a]	330,000[a]	132,000	53,731,000[a]	27,000
Conventionals (mg/kg)					
Fluoride	6	2U	10	190	10
Nitrate as N	88	78	99	94	30
Sulfate as S04	640	230	150U	252	150U
Phenolics, total	0.5	0.4	0.3	2U	0.1U
Cyanide, Total	2.2	2.9	1.4	2U	0.5U
EP Tox (mg/l)					
Arsenic	1.0U	1.0U	1.0U	0.05U	Insufficient
Barium	5.0U	5.0U	5.0U	0.11	Sample
Cadmium	0.2U	0.2U	0.2U	0.01U	
Chromium	1.0U	1.0U	1.0U	0.01U	
Lead	1.0U	1.0U	1.0U	0.03	
Mercury	0.003U	0.003U	0.003U	0.022U	
Selenium	0.3U	0.3U	0.3U	0.01U	
Silver	0.2U	0.2U	0.2U	0.01U	

Table 13

Impoundment V (continued)

Compound	5-1-16	5-1-25	5-2-16	Referee Split 5-2-16	5-2-20
Organic Priority Pollutants (ug/kg)					
1,2 Trans-dichloroethylene	1.6U	1.6U	11.4	ND[b]	1.6U
Trichloroethylene	1.9U	1.9U	1.9U	160	1.9U
Ethyl benzene	10.6	7.2U	7.2U	ND	7.2U
Methylene chloride	134[c]	74.0[c]	48.83	198	16.62
Toluene	19.2	63U	6U	91	6U
Acenaphthene	19,500	63U	63U	ND	63U
Anthracene	43,800	63U	63U	ND	63U
Benzo (a) anthracene	36,000	660	260U	ND	260U
Benzo (a) pyrene	37,400	803	83U	ND	83U
Benzo (k) fluoranthene	67,000	1,670	120U	ND	120U
Chrysene	36,700	687	83U	ND	83U
Fluoranthene	246,000	2,490	73U	ND	73U
Fluorene	20,700	63U	63U	ND	63U
Naphthalene	12,200	53U	53U	ND	53U
Phenanthene	142,000	578	180U	ND	180U
Pyrene	190,000	2,000	63U	ND	63U

a/ Exceeds the upper limit of common range of trace element content of natural soils (US EPA 1983).

b/ Referee lab data indicate MDL of 1 ug/kg for all organic pollutants.

c/ Amended corrections January 2, 1987

Table 14

Soil Boring Analysis (ug/kg) For Sample Period February 1987

Compound	Sample Designation: Referee Duplicate		A-2-4		B-1-16-13		CSP7-5	
HSL Organics								
Methylene chloride	470	JB	120	B	12	B	22	B
Acetone	600	J	170	B	120	B	110	B
trans-1,2-Dichloroethylene	3,000		1,100		2.0	J	20	
2-Butanone	1,800		62	U	26		12	U
Trichloroethylene	13,000		720		1.4	J	2.9	J
m-Xylene	310							
o-p-Xylene	310	}	31	U	6.2	U	5.8	U
Tetrachloroethylene	260		15	J	6.2	U	5.8	U
Naphthalene	NA		NA		120	J	NA	
2-Methylnaphthalene	NA		NA		51	J	NA	
Acenapthylene	NA		NA		94	J	NA	
Acenapthene	NA		NA		18	J	NA	
Dibenzofuran	NA		NA		170	J	NA	
Phenanthrene	NA		NA		2,100		NA	
Anthracene	NA		NA		500		NA	
Fluoranthene	NA		NA		2,300		NA	
Pyrene	NA		NA		2,300		NA	
Benzo(a)anthracene	NA		NA		1,400		NA	
Chrysene	NA		NA		1,300		NA	
Benzo(k) or B fluoranthene	NA		NA		1,500		NA	
Benzo(a)pyrene	NA		NA		790		NA	
Indeno(1,2,3-cd)pyrene	NA		NA		390	J	NA	
Dibenz(a,h)anthracene	NA		NA		200	J	NA	
Benzo(g,h,i)perylene	NA		NA		150	J	NA	

Table 14 (continued)

Soil Boring Analysis (ug/kg) For Sample Period February 1987

U	Indicates element was analyzed for but not detected. Detection limit cited is the highest detection limit for the constituent at the reported sample locations. Detection limit at a specific sample location could be lower.
NA	Indicates constituent was not analyzed.
J	Indicates an estimated value.
B	Indicates analyte found in blank as well as sample.
	Referee trip blank contained 6 ug/l methylene chloride.

samples analyzed by the same laboratory cannot be expected of these samples due to the variability inherent in laboratory performance. A preliminary review of data submitted (by both laboratories) for each split sample has been performed. Items evaluated during the review include:

- Analytical Methods
- QA/QC Protocols
- Supporting raw data submitted.

When these split samples were collected in 1986 the site had not been designated as an NPL site. Therefore, the laboratories were not required to follow EPA-CLP protocols or methods. Both laboratories used EPA-approved methods to analyze the split samples including EPA methods 624 and 625 for volatile and semivolatile priority pollutants, respectively. ETC used a subcontractor for some of the wet chemistry parameters, sulfate, phenols, fluoride, cyanide, and nitrate. An example of the ETC report for one sample, including all supporting raw data for the organics, a brief description of the methodologies used, QA/QC results for the organics, and the sample results, is attached (Appendix J). ETC did not submit supporting raw or QC data for the analyses performed by its subcontractor. Sample results from ESO were presented in summary tables with results for lab blanks. No other supporting raw or QA/QC results were submitted by ESO.

Based on a preliminary review of the data submitted, the ETC results for the organic priority pollutants are more useful because they can be validated. In fact, several values in Tables 9 through

13 have been revised using the supporting raw data submitted by ETC. For example, some results previously reported as "ND," not detected, are reported in the revised tables with "J" qualifiers. Neither laboratory submitted supporting raw data for the inorganic parameters. While the results for these parameters are probably equally useful, they cannot be validated using the data submitted.

It is noteworthy that the subsequent samples (February 1987) were analyzed and reported using CLP protocols.

The Data Management Technical Report for each sample, which includes results, quality assurance data, method performance data, and QA protocols, appeared in Appendix G of a November 7, 1986, report entitled "Remedial Investigation of the Former Hellertown Manufacturing Company Facility in Hellertown, Pennsylvania." Due to the prevalence of rocks, spark plugs, and various nonsoil artifacts (spark plugs and other materials) in the impoundments, there were insufficient sample quantities to perform some of the analytical tests. This has been noted on the tables as "insufficient sample" or "sample depleted."

The elevated levels of chlorinated organic constituents in downgradient wells and the uncertainties pertaining to the flow of groundwater from the site suggest that remediation of the source of contamination may be appropriate. This may or may not prove to be the ultimate action needed. Nevertheless, the extent of or potential for waste migration must be defined before a conclusion on remediation is made. The most obviously contaminated horizon from each of the soil borings was sampled in an effort to identify

and delineate the extent of materials that could be readily excavated if deemed necessary. Background soil borings were collected to provide a baseline for comparison with contaminated impoundment borings.

The results for the background borings are reported in Table 8. As noted, there was insufficient sample volume to perform EP toxicity analysis for sample B6-Bg-15; however, it is not expected that an undisturbed soil sample in the upgradient boring would have the EP toxicity characteristic. Soil from a slightly lower soil horizon (sample B6-Bg-20) did not exceed the RCRA EP toxicity limit for the inorganic constituents evaluated. The only organic priority pollutant detected in the background borings is methylene chloride. The source of this constituent in an otherwise undisturbed soil sample is unknown. This constituent was only detected at minimal concentrations, however, and the fact that it is ubiquitous in laboratory blank samples strongly suggests the result may have been caused by laboratory error. The results of the metal analyses for all of the background borings indicate that the metal content of the samples is well within the range expected of soils (Table 6).

The RCRA EP toxicity standard was not exceeded in any of the impoundment soil samples tested (Tables 9 through 13). Phenol concentrations were either nondetectable, or if detectable, not indicative of a consequential contamination source. Nitrate concentrations in the impoundment borings are similar in magnitude to the nitrate concentrations detected in the background borings.

Sulfate, which was not detectable in the background borings, was detected at concentrations ranging from the detection limit of 150 mg/kg to 3,300 mg/kg (sample 4-1-17). Analysis of a duplicate of the same sample, however, resulted in a value of 104 mg/kg of sulfate. A laboratory discrepancy for sulfate results is also indicated in sample 2-2-21 with an ETC value of 160 mg/kg and an Environmental Science Corporation value of 1,118 mg/kg. Samples 5-1-16, 4-5-17, and 3-3-15 had sulfate concentrations two to three times higher than the detection limit (640, 610, and 560 mg/kg). These concentrations are above those found in the background soil samples. These discrepancies were investigated as part the ESC QA/QC review. At this time, the discrepancies are believed to be due to the fact that the labs used different analytical methodologies and that the duplicates were heterogeneous.

The most marked analytical results for the conventional pollutants are the fluoride and cyanide concentrations in several samples. Fluoride concentrations ranged from nondetectable to 190 mg/kg (duplicate sample 5-2-16); however, the ETC analytical value for the same sample was 10 mg/kg. Without the 190 mg/kg result, the upper range of the fluoride level was 17 mg/kg. The mean fluoride content of the surface impoundment samples is 6.5 mg/kg; however, fluoride was undetectable in the background boring. As will be discussed in the hydrogeologic section, the fluoride content in the impoundments, as indicated by these samples, could be the source of the elevated fluoride levels in the downgradient groundwater monitoring wells CSP-3 and CSP-4.

The cyanide concentrations of most of the samples are similar to those detected in the background samples. One sample (2-2-20) contained 42 mg/kg cyanide, which is far in excess of the cyanide content detected in the background borings and in other impoundment boring samples. The elevated cyanide level may be related to past electroplating operations which were conducted at the plant.

The total metal content of the impoundment borings was determined in an effort to locate an impoundment horizon that had been obviously affected by an anthropogenic source. The total metal content for each of the impoundment borings is summarized in Tables 9 through 13. Metals which exceeded the upper limit of the common range of trace elements in soils have been noted. The expected manganese, cadmium, and copper concentrations were exceeded in one, four, and two samples, respectively. The expected zinc content was exceeded in 14 samples. Samples with elevated cadmium, copper, and zinc concentrations may be indicative of the presence of electroplating residues.

It was postulated that the elevated concentration of chlorinated organic compounds in the groundwater (i.e., 12.5 ppm trans-1,2-dichloroethylene) might be explained by the presence of a source of chlorinated organics in or near the impoundments. In addition, it was further expected in theory that due to attenuation mechanisms, such as adsorption to soil components, biodegradation, and dilution, a chlorinated organic "source" sufficient to cause the degraded water quality in the downgradient wells would be discovered. As depicted in the boring logs (Appendix B), elevated

OVA levels in association with the "sludge layer" might suggest the presence of a significant source of volatile organics. The organic priority pollutant concentrations for the impoundment borings (Tables 9 through 13), however, do not support these expectations. The highest concentrations of trichloroethylene and tetrachloroethylene, both of which were detected in the downgradient wells, were 3,477 and 380 ug/kg in the soil samples. Vinyl chloride was not detected in any of the soil samples. Trans-1,2-dichloroethylene and methylene chloride were detected at maximum concentrations of 11.4 and 696 ug/kg in sample 2-2-21 (duplicate). In view of the concentrations of these halogenated constituents of concern and the attenuation mechanisms discussed above, the link between the observed groundwater contamination and an identifiable contamination source in the former surface impoundment is tenuous at best.

Analytical results for the February 1987 samples collected from the vicinity of the former surface impoundment also do not contain unusually elevated concentrations of volatile organics. The referee duplicate of A-2-4, however, does contain elevated concentrations of some of the constituents of concern detected in the downgradient wells, including trans-1,2-dichloroethylene and trichloroethylene. The area in the vicinity of boring A-2-4 was used as an equipment washing area. This could be at least one of the contamination sources.

One explanation for the elevated OVA levels is associated with the detection characteristics of the instrument. Methane would be

detected and reported by the OVA meter. There is some potential for methane to have been produced in subsurface zones containing significant organic matter and this methane could have led to erroneous detection of volatile compounds.

The most prevalent class of organic priority pollutants detected in the impoundment borings is the base neutral extractables, more specifically, polycyclic aromatic hydrocarbons (PAHs). These constituents were detected in each of the former surface impoundments. Samples from boring 5-1-16 contained the most elevated concentrations of these constituents. The most likely source of these materials is the waste oil residues from shell forming and alkaline cleaning.

There is no specific action level for PAHs, but there is concern regarding their potential effect on human health and the environment because many of the PAHs are known or suspected carcinogens. PAHs are essentially insoluble and thus unlikely to migrate offsite via ground or surface water. The only significant pathway of environmental exposure to PAHs is via the air route. It is highly unlikely that the PAHs present in the subsurface sludge zone will become airborne and place environmental receptors at risk.

3.2 Waste Component Characteristics and Behavior

The following waste component characteristic profiles have been included to aid in decision making regarding investigations and corrective action, if any. These constituents are included because

they were handled at the site or they have been detected during investigations at the site.

Methylene Chloride

Methylene chloride, also known as dichloromethane, is a highly volatile, colorless liquid. As such, most reported exposures to the compound are via inhalation. Methylene chloride can be an irritant of the skin, eyes, and mucous membranes. In addition to inhalation, it can be absorbed by ingestion or through the skin. In the body, methylene chloride is metabolized to carbon monoxide. This compound binds with the hemoglobin in the red blood cells, forming carboxyhemoglobin, a form of the compound that is considerably less efficient at transporting oxygen. The major effect from exposures to high concentrations of methylene chloride via inhalation is narcosis. Headaches, numbness and tingling in the limbs can also result. The LD_{50} for oral exposure of rats is 2,524 mg/kg. Rats and mice exposed by inhalation showed LC_{50}s of 88,000 mg/m^3 for 30 minutes, and 14,400 ppm for 7 hours. NIOSH has established a TWA for the compound of 75 ppm.

There is little evidence of severe damage from chronic exposure to methylene chloride. Damage to the liver and central nervous system has been reported from such exposures. The data regarding carcinogenicity are equivocal at present. IARC has classified the compound as an indefinite carcinogen. There is no evidence reported that the compound is carcinogenic in humans, and many laboratory studies have produced negative results. Methylene chloride has been

found to be mutagenic in tests with bacterial systems. Inhalation exposures of pregnant rats and mice have resulted in developmental abnormalities of the muscles, skeleton, and urogenital system, as well as effects on the behavior of the offspring.

Its high volatility means that methylene chloride will not persist in many environmental situations. It is somewhat soluble in water, but dissolves at a limited rate. The compound will readily evaporate from water bodies. In the air, methylene chloride photodecomposes.

Trichloroethylene

Trichloroethylene (TCE) is a widely used industrial solvent. It can be a severe irritant of the skin and eyes; skin contact can result in blistering. Also, TCE is absorbed readily through the skin. Ingestion and inhalation are also potential routes of exposure to TCE. It is distributed in the body to fatty tissues.

In acute exposures, the compound is a depressant of the central nervous system. It can cause visual disturbances, confusion, fatigue, nausea, and vomiting. Heart arrythmias and necrosis of the liver and kidneys also can result from acute exposures, as can respiratory failure and cardiac arrest when TCE is ingested. TCE is not highly toxic in acute exposures, however. The LD_{50} for oral administration to rats was 4,920 mg/kg, while for mice it was 2,402 mg/kg. The ACGIH has proposed a TLV for TCE of 50 ppm (270 mg/m^3), while the OSHA TWA has been set at 100 ppm.

Chronic exposures to TCE can also result in kidney and liver damage. The compound has been found to be carcinogenic in some laboratory animals when administered by ingestion or inhalation. TCE can cross the placenta. Inhalation exposures have resulted in developmental abnormalities in rats. TCE has not been shown to be mutagenic, however. The EPA has proposed a Recommended Maximum Contaminant Level in drinking water of zero ppm TCE.

TCE will not be persistent in many environmental situations. It is fairly volatile, the evaporative half-life is about 20 minutes, and it readily photooxidizes. Also, it can undergo significant biodegradation. Nevertheless, it remains a significant contaminant of deeper soils and groundwater. While it has been found to be toxic to aquatic life in bioassays, its poor water solubility will frequently preclude such concentrations being reached in natural aquatic systems.

Tetrachloroethylene

Tetrachloroethylene (perchloroethylene) is a colorless, nonflammable liquid. It is moderately volatile, and not very soluble in water (150 mg/l). Tetrachloroethylene resists hydrolysis and can be very stable in the environment. It can be biodegraded if the microorganisms are given time to adapt.

Tetrachloroethylene is primarily absorbed by inhalation. Absorption is slow by ingestion and across the skin. Tetrachloroethylene is not highly metabolized. The half-life in the body is about 65 hours for tetrachloroethylene and 144 hours

for its metabolites. In high concentrations, tetrachloroethylene can act as an irritant of the eyes, nose, and throat. Prolonged dermal exposure can result in dermatitis. Tetrachloroethylene can act as a central nervous system depressant, but at high concentrations. Acute exposures can result in vertigo, fatigue, nausea, and impaired coordination. Sustained atmospheric concentrations of 200 ppm can lead to narcosis and death. However, tetrachloroethylene has a low potential for producing organ damage in acute exposures. The LD_{50}s for oral administration were reported to be 8,850 mg/kg in rats and 8,100 mg/kg in mice. An LC_{50} for rats was reported as being 5,040 ppm for 8 hours. The NIOSH TWA has been set at 50 ppm (335 mg/m^3). Few problems from industrial exposures have been reported.

Chronic exposure to tetrachloroethylene can result in liver and kidney damage. Tetrachloroethylene was found to cause liver tumors in mice but none in rats in NCI bioassays. When administered to pregnant rats and mice, fetal weight was found to decrease, the number of resorptions increased, but no teratogenic effects were found. Mutagenicity studies with bacteria have given negative results.

The EPA has set a suggested no adverse response level (SNARL) for tetrachloroethylene of 20 ug/l for long term exposures. They have set a recommended maximum contaminant level (RMCL) in drinking water of zero. The EPA water quality criterion for tetrachloroethylene is 5,280 ug/l to protect freshwater aquatic life in acute exposures, and 840 ug/l in chronic exposures.

Trans-1,2,-Dichloroethylene

Trans-1,2-dichloroethylene is a colorless liquid. It is not widely used as an industrial solvent because of its flammability. Trans-1,2-dichloroethylene has a flash point of 36-39 F. It is fairly volatile, with a vapor pressure of 324 mm Hg. Trans-1,2-dichloroethylene is also moderately soluble in water (6,300 mg/l). Relatively little information was found in the sources searched on the toxicity of trans-1,2-dichloroethylene. Inhalation exposures can cause narcosis at high doses, with a disturbance of equilibrium and prostration. The LD_{50} for oral administration to the rat was found to be 770 mg/kg. The TWA has been set at 200 ppm.

The liver appears to be the target organ in chronic exposure to trans-1,2-dichloroethylene. Such exposures can lead to fatty degeneration and kidney damage. Testing for mutagenicity in bacterial systems has given negative results.

The EPA has proposed a recommended maximum contaminant level (RMCL) for trans-1,2-dichloroethylene of 70 ug/l. The water quality criterion to protect freshwater aquatic life in acute exposures has been set at 11,600 ug/l.

Cyanides

Cyanide compounds are highly toxic substances found in a variety of forms: bound to sodium, potassium, or metal complexes or as hydrogen cyanide gas. The toxicity of cyanides ultimately is due to undissociated hydrocyanic acid (HCN). Inorganic cyanides

are rapidly absorbed through the skin, by ingestion, and by inhalation. Cyanide is distributed by the blood to all organs and tissues, and in mammals it is rapidly converted to hydrogen cyanide. Cyanide is not stored in the tissues. Eventually it is converted to less toxic thiocyanate, and is eliminated in the urine.

Cyanide poisoning causes acute hypoxia, an inability of the tissues to use oxygen. Cyanide inhibits the enzyme cytochrome C oxidase in mitochondria, disrupting cellular respiration and electron transport. Cyanide forms stable complexes with a number of other biologically active metal-containing ions, particularly those containing iron and copper. Cyanide poisoning is rapidly fatal. Exposure to 270 ppm by humans results in instant death, while 135 ppm is fatal in 30 minutes. The mean lethal dose for ingestion by humans varies from 50 to 200 mg, about 1-3 mg/kg. Nonfatal doses of the compound can cause weakness, headache, nausea, and vomiting; however, recovery is rapid and complete.

The LC_{50}s for inhalation exposures are 484 ppm for 5 minutes in rats, 323 ppm for 5 minutes in mice, 616 mg/m^3 for 1 minute for dogs, and 1,226 mg/m^3 for 1 minute for cats. The LD_{50} for oral exposures is 3,700 ug/kg in mice. OSHA has established an 8-hour TWA of 5 mg/m^3, but NIOSH suggests a limit of 10 minutes of exposure to this level.

Cyanide does not accumulate in the body, and no effects have been found from repeated sublethal doses. There is no evidence to indicate cyanide is carcinogenic or mutagenic. It apparently can cross the placenta and cause fetotoxicity, but is not teratogenic.

Cyanides are unlikely to be persistent in many environmental situations. Cyanide is very soluble in water, where it stays in equilibrium among cyanide ion, hydrogen cyanide, and forms bound to organic or inorganic compounds. Hydrogen cyanide is very volatile, so the cyanide will gradually disappear from aquatic systems. In aquatic systems, a free cyanide concentration of 50-200 ug/l is fatal to most species. A concentration of 1.0 mg/l can have an inhibitory effect on activated sludge treatment systems.

Even in soils, contact with moisture will liberate hydrogen cyanide gas. Because of its water solubility, cyanide is mobile in soils.

Chromium

Chromium exists in compounds mostly in the trivalent or hexavalent states. Trivalent chromium compounds are more common and less toxic than the hexavalent forms. It is mainly the hexavalent compounds that are irritants and corrosives. Acute exposures to dusts or mists of chromium compounds can result in coughing, headache, dyspnea, loss of weight, and pain on respiration. Industrial exposures to hexavalent chromic acid mists have resulted in ulcers of the skin and nasal septa. Hexavalent chromium compounds can cause severe contact dermatitis. Absorption through the skin can result in kidney damage. Although chromates are poorly absorbed after ingestion, hexavalent compounds can cause gastrointestinal hemorrhaging. Large oral doses can also cause kidney damage. The LD_{50}s for oral administration of hexavalent

compounds to laboratory animals have been found to range from around 300-500 mg/kg. The OSHA TWA is 0.5 mg/m^3 for soluble chromium compounds, and 1.0 mg/m^3 for insoluble ones.

Some hexavalent chromium compounds are carcinogenic at the site of exposure. Lung cancers have been found to result from inhalation exposures in the workplace. While hexavalent compounds have been found to be mutagenic in bacterial and other test systems, the trivalent compounds have not shown mutagenic activity. Some hexavalent compounds also appear to be teratogenic and embryotoxic. The EPA primary drinking water standard for chromium is 0.05 mg/l.

Trivalent chromium compounds tend to be insoluble in water except at a very low pH. Hexavalent compounds are moderately soluble. In the environment, hexavalent chromium, being a strong oxidizer, readily reacts with reducing agents to form trivalent compounds, which are far more stable. Trivalent chromium compounds readily precipitate except in highly acid solutions. Both types of compounds only adsorb weakly to sediments. The EPA standard for chromium to protect freshwater aquatic life varies with the hardness of the water body, but generally ranges from 2.2-9.9 mg/l. For hexavalent chromium, the standard is 21 ug/l.

Zinc and Zinc Compounds

Zinc is a silvery white metal. Zinc ion is poorly absorbed by ingestion. Large doses can damage the mucous membranes of the gastrointestinal system. Inorganic zinc compounds are nontoxic by ingestion, but can act as irritants. Soluble zinc salts have a

metallic taste and can cause vomiting. Chronic exposures can cause digestive disorders. Zinc is the most abundant trace metal in the body. It occurs widely in metalloenzymes and in metal-protein complexes.

Inhalation of zinc oxide fumes by foundry workers has been reported to cause a metal fume fever and gastrointestinal effects. Zinc oxide dust is relatively innocuous, but can present an explosion hazard. The TLV for zinc oxide fume is 5 mg/m^3 and for zinc oxide dust is 10 mg/m^3 as a nuisance dust.

High concentrations of zinc chloride fumes can cause fatal lung damage due to its causticity. Zinc chloride has been shown to be mutagenic in some bacterial systems. The LD_{50}s for oral exposures to rats and mice are 350 mg/kg and to guinea pigs is 200 mg/kg.

The EPA secondary standard for zinc in drinking water is 5 mg/l.

In aquatic systems, zinc can occur in both suspended and dissolved forms. However, relatively minor changes in water chemistry can alter the forms in which zinc occurs. The predominant fate of zinc in aquatic systems is sorption to sediments or to suspended solids. Available data suggest that zinc can produce acute or chronic toxicity in fresh water aquatic species at relatively low concentrations. The EPA Ambient Water Quality Criteria (AWQC) for zinc states that unless a locally important species is very sensitive, freshwater organisms and their uses should not be affected unacceptably if the four-day average concentration of zinc (in ug/l) does not exceed the numerical value

given by $e^{(0.8473\ [\ln\ (\text{hardness})]\ +\ 0.7614)}$ more than once every three years on the average and if the one-hour average concentration (in ug/l) does not exceed the numerical value given by $e^{(0.8473\ [\ln\ (\text{hardness})]\ +\ 0.8604)}$ more than once every three years on the average. For example, at hardnesses of 50, 100, and 200 mg/l as $CaCO_3$, the four-day average concentrations of zinc are 59,110 and 190 ug/l, respectively, and the one-hour average concentrations are 65, 120, and 210 ug/l.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a large class of compounds that are made up of a number of fused rings in linear, staggered or three dimensional configurations. Although this class of compounds contains hundreds of members, the EPA has listed 16 as "priority pollutants." These 16 are fairly representative of the group as a whole in terms of their toxicological and environmental properties. Of the 16, benzo(a)pyrene (BaP) is the most widely studied, and is often used, not always appropriately, as a surrogate for the whole group.

PAHs form from the incomplete combustion of organic material, and thus are extremely widespread compounds. Apparently, the most abundant current sources of PAHs in the environment are from the combustion of carbonaceous fuels, such as gasoline, diesel fuel, coal, and wood. PAHs appear to be ubiquitous, having even been detected in the soils of Swiss alpine valleys.

PAHs are not water soluble, and are not very volatile (volatility decreases with the size of the compound). As a result, in the air they are mostly found adsorbed to small particles, while in aquatic systems they show a tendency to partition to particulate organic matter. Some PAHs can be broken down by exposure to UV light and by soil microorganisms, but for the most part, they appear to be very persistent in the environment.

As indicated in the table below, humans are regularly exposed to PAHs.

Estimate of Human Exposure to PAH (ng/day)

Source	BaP	Carcinogenic PAH	Total PAH
Water	1.1	4.2	27
Food	160-1600	720-7200	1600-16000
Air	11.5	30-46	164-251
Total	166-1600	up to 10000	1600-16000

In this table, the carcinogenic PAHs are BaP, Benzo(j)flouranthene and indenopyrene. In addition to the above, smoking contributes an average of 400 ng of BaP for each cigarette.

PAHs are readily absorbed orally, dermally and by inhalation. Most human exposure occurs through food consumption and by inhalation. They are rapidly distributed to all organs, although there tend to be some localized concentrations in fatty tissues. The compounds are readily metabolized by the microsomal mixed-

function oxidase system, which occurs in most cells and in general is responsible for the metabolism of foreign compounds. Those PAHs that show toxic effects do so because of the nature of the metabolites produced. After a number of steps, carcinogenic PAHs are metabolized to diol-epoxide compounds. The diol-epoxides covalently bind with DNA molecules to form adducts. It is the formation of the adducts that is responsible for the carcinogenic and mutagenic responses.

There does not appear to be a threshold below which adduct formation does not occur. However, adduct formation can be affected by a number of external factors. The concentration of adducts can be affected by the presence of other compounds. The adduct-forming behavior of BaP, for example will vary depending on whether it is administered as a pure compound or in PAH mixtures. Because of the number of steps involved, there are considerable differences in adduct formation among tissue types and among individuals. Also, different tissues are affected differently by adduct formation. As a result, to a certain extent, the effective biological dose of PAHs may be taken to be the concentration of adducts. This will not always linearly relate to the actual exposure concentrations.

The production of adducts with DNA by certain PAHs can influence DNA replication and transcription. This will in turn affect the expression of the genes. Also, this implies that even in exposures to low concentrations, continuous exposure could result in persistent adduct formation. The rate of adduct accumulation will depend on the rates of DNA repair in cells and cell turnover,

both of which will vary considerably among tissues and among individuals. Adduct formation can lead directly to tumor formation.

Various PAHs have been shown to produce cancers in laboratory animals through all routes of administration. Some PAHs are among the most potent carcinogens known. Cancers can be induced both at and distant to the site of administration. While about 99% of the PAH intake in humans is in the diet, the gastrointestional system must somehow be resistant to PAH toxicity or biochemically adaptable. There is little evidence implicating oral intake of PAHs with pathology in humans, despite the high concentrations involved.

Inhalation exposures of PAHs in humans do appear to lead to tumor formation. PAHs are thought to be responsible, in part, for the carcinogenic effects of cigarette smoking. There is considerable epidemiological evidence implicating exposure to PAHs in coke oven workers and other occupational settings with increased lung cancer rates.

As indicated, PAH exposures are usually to mixtures of the compounds, and the effects of these mixtures can vary considerably, depending on their composition. Therefore, it is extremely difficult to establish exposure limits to PAHs as a class, or individual PAHs. In part for this reason, the EPA declined to establish any standards for PAHs in air. The ACGIH has established an 8-hour TWA of 0.2 mg/m^3 for the benzene soluble fraction of coal tar pitch volatiles. This limit was established due to the toxicity of the PAHs that are only a small component of this fraction. The actual limit for PAHs would be considerably smaller. The NAS risk

assessments for several PAH exposures concluded that exposure to 40-50 ng/m^3 in the air for a workday gave the same increase in risk as smoking 1.5-2 cigarettes a day for a lifetime. The highest occupational exposure reported was for certain workers in a coal and pitch coking plant, who were exposed to 700 ug/day of PAH.

PAHs do not appear to have other toxic effects at the low levels needed to produce carcinogenicity and mutagenicity. BaP suppresses the ability of beta lymphocytes to develop into antibody producing cells, but large doses are required to produce this effect. Some PAHs can traverse the placenta, but the data implicating them in teratogenic effects are equivocal. No toxic effects have been reported from acute exposures to PAHs.

Because of the ubiquity of PAHs in the environment, it is difficult to make a satisfactory assessment of their ecological effects. Apparently, organisms having well developed mixed function oxidase systems are able to metabolize PAHs, thereby preventing their accumulation. High bioconcentration factors are only found in freshwater and marine invertebrates lacking those systems. Many of the organisms not readily able to metabolize PAHs are filter feeders, and thus would tend to accumulate the particulate matter on which the PAHs are absorbed. Removal of these organisms to contamination-free environments rapidly reduces their concentrations of PAHs. Only the organisms directly feeding on these invertebrates would potentially be affected by the PAHs; they would not accumulate up the food chain. The EPA Water Quality Criteria Document for PAHs

states that the limited data available does not permit a statement concerning the acute or chronic freshwater toxicity of PAHs.

Waste Oil

The composition of waste oil varies widely depending on its source and former use. There are three general categories of industrial oils. Mineral oils include most motor oils and many industrial oils. These are usually complex hydrocarbon mixtures. Emulsified oils are used for industrial applications such as cutting and cooling. They consist of emulsifiers, biocides, and water mixtures. Synthetic oils usually contain few hydrocarbons, being mostly aromatics and paraffins. Examples include silicone polymers and fluorocarbons. Less than 5% of industrial oils are synthetics.

Because of the variability of the composition of waste oils, their toxicity will vary widely. Table 15 lists some of the potentially hazardous constituents found in waste oil. Notable is the fact that PCBs are common in waste oil, but usually at low levels (<5 ppm). The flammability of waste oil also varies, usually ranging from about 100-400° F, although specialized oils can have a higher flash point.

Table 15

SUMMARY OF ANALYTICAL RESULTS FOR POTENTIALLY HAZARDOUS CONSTITUENTS FOUND IN WASTE OIL*

	Total analyzed samples	Samples with detected contaminant		Samples quantifying contamination†	Concentration range (ppm)		Average concentration‡ (ppm)
		Number	Percent		Low	High	
Metals							
Barium	159	130	79	130	0	3,906	187
Cadmium	189	87	46	87	0	36	2.9
Chromium	273	221	81	221	0.1	537	18
Lead	339	325	96	325	0	21,700	1,527
Arsenic	17	17	100	17	0.4	45	12
Zinc	232	227	98	227	0.7	5,000	561
Chlorinated solvents							
Dichlorodifluoromethane	78	53	68	53	0	2,000	361
Trichlorotrifluoroethane	44	25	57	7	0	550,000	2415
1,1,1-Trichloroethane	146	124	85	101	0	110,000	2535
Trichloroethylene	143	108	76	91	0	300,000	5915
Tetrachloroethylene	100	89	89	89	1	3,900	408
Total chlorine	62	62	100	62	40	459,000	3,719§
Other organics							
Benzene	56	39	70	15	0	280	115
Toluene	69	57	83	18	0	5,100	843
Xylene	53	42	79	11	0	139,000	2195
Benzo(a)anthracene	17	14	82	14	5	660	88
Benzo(a)pyrene	19	11	58	11	3.2	405	59
Naphthalene	15	15	100	15	110	790	389
PCB's	264	86	33	86	0.4	3,150	54§

* The summary data presented in this table may not be representative of the true nature of the waste oil samples. Tables 4 to 18 and Figures 4 to 8 provide a better understanding of the concentration of these contaminants in each waste oil sample.

† This is the number of samples used to calculate average concentration. Some tests that detected the presence of the contaminant did not quantify its concentration.

‡ Values reported as "0" were used to calculate average, but values reported as "less than" any given concentration were omitted.

§ Calculation of the average concentration shown was based on the omission of one or two highly contaminated samples that would distort the average.

4.0 Hydrogeologic Investigation

The pattern of movement of pollutants from the filled waste lagoons can be inferred and the rate of subsurface travel estimated from the hydrogeologic characteristics of the unconsolidated sedimentary formations in which the lagoons were excavated and the underlying consolidated formations (bedrock).

4.1 Regional Hydrogeologic Setting

4.1.1 Soils and Unconsolidated Formations

The unconsolidated sedimentary formations (including the surficial soils) comprise a mantle of varying thickness on the bedrock. This mantle appears to be as much as 50 feet thick at the Hellertown facility and has had a long, complex geologic history. A summary of this history is useful to interpret the hydrologic conditions which govern the subsurface movement of pollutants.

The geologic development of the unconsolidated materials starts with the decomposition and weathering of the bedrock. The underlying limestone and shale bedrock was exposed to subaerial weathering for a long period of time during which chemical and mechanical weathering processes formed a mantle of clay, silt, and rock fragment of all sizes. Alluvial processes redeposited these materials as strata of clay, silt, sand, gravel, and boulders. Saucon Valley reportedly was occupied later by glacial ice which picked up these materials and transported and redeposited them with

other materials carried in the ice as a complex mixture of glaciofluvial and glaciolacustrine deposits and till.

A generalized contour map of the buried bedrock surface at the Hellertown facility (Figure 8), based on the logs of the monitoring wells and test borings for the nearby Interstate Highway, suggests the occurrence of a west sloping tributary to Saucon Valley. However, this depiction of the bedrock surface must be regarded as a crude generalization. The position of the top of bedrock on the well logs and highway test borings was interpreted as the first description of relatively fresh or unweathered rock. Although the project boring logs in or near the lagoons could not be used for control points, it is apparent from some of them that the surface of the bedrock in places is composed of relatively soft, weathered rock that is undisturbed and probably grades with depth to fresh rock. Thus, in places, the actual position of the buried surface may be on the order of 10 feet higher than shown.

The filling and burial of the bedrock valley by the unconsolidated sedimentary formations appear to have obliterated any surficial evidence of its presence.

The unconsolidated formations are composed of a heterogeneous mixture of deposits, including clay, silt, sand, gravel, and boulders. As a consequence, the hydraulic properties of the formations are highly variable.

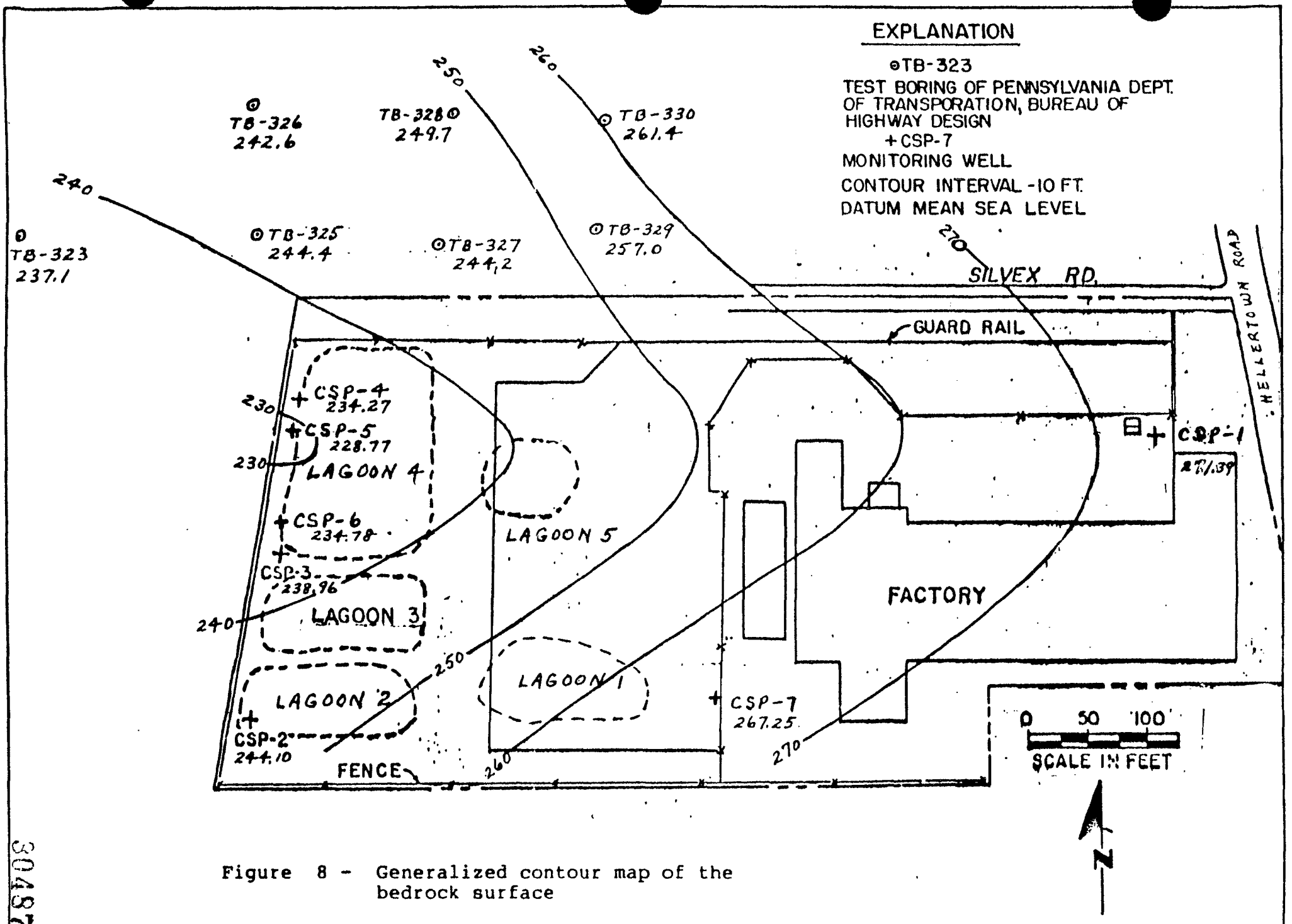


Figure 8 - Generalized contour map of the bedrock surface

4.1.2 Bedrock Formations

The consolidated rocks consist mainly of light gray limestone and orange-brown shale of the Leithsville Formation, which are fractured and contain solution-enlarged cavities. The rock matrix (unfractured rock) has a relatively small permeability, but on a regional scale the body of rock, which has been reported to extend to about 1,000 feet, comprises an extensive aquifer. Evidence of the regional extent of this aquifer is available from the history of dewatering of zinc mines in the carbonate rocks to the southwest of Northampton County. This pumping, which reportedly started in January 1953, created a deep depression in the piezometric surface which extended to the vicinity of Hellertown. Pumping reportedly ceased, however, in October 1983 and the cone of depression was essentially obliterated or filled by May 1986. The history of mine dewatering and recovery of water levels in the carbonate rocks indicates that they are hydraulically connected regionally and to great depths and are highly transmissive on a regional scale. Further evidence of the transmissive nature of the limestone aquifer is the fact that large capacity wells can be developed. Several industrial wells located about 1.5 miles north of the HMC facility yield up to 15,000 gpm from the carbonate rocks. In addition, the borough operates a well at the confluence of Silver Creek and Saucon Creek, about 1.5 miles south of the site.

4.2 Subsurface Hydrogeologic Conditions

The lithologic properties and stratigraphy of the unconsolidated formations were characterized from soil borings. The locations of the borings are shown on Figure 2. The soil borings in the lagoon areas penetrated the base of all lagoons. In each lagoon, except for borings B1-4, B1-5, and B1-6, samples from the stratigraphic horizon showing the most discoloration and the highest OVA (Organic Vapor Analyzer) readings and samples from the horizon directly beneath were sent to the laboratories for analysis. Samples from borings B1-4, B1-5, and B1-6 were selected for laboratory analysis for VOCs based on HNU readings, visual appearance, and odor.

Field identification of the stratigraphic horizons is based on color and texture of the material and on the OVA values recorded. Seven cross sections through the lagoons show the subsurface stratigraphy (Appendix D).

Borings B1-4, B1-5, and B1-6, in the area of lagoon no. 1, were drilled in a line along the inferred position of the bank of the former lagoon to sample material that reportedly was dredged from the lagoon and deposited on the bank. Borings A-1, A-2, and A-3 were located downgradient from an underground storage tank area and where some dumping of industrial waste materials was reported.

4.2.1 Summary

Under the lagoon area of the Hellertown site, there appear to be four unconsolidated stratigraphic units. Weathered bedrock is designated as unit five on the cross sections.

Unit 1. Fill composed of reddish-brown to brown sandy silt; contains abundant gravel-to-boulder size rock fragments. This horizon is found on the surface or just below the asphalt in all lagoons except lagoon no. 5. The poorly sorted nature of the fill makes it very difficult to penetrate with the hollow-stem auger. The OVA values were generally very low.

Unit 2. Fill composed of greenish-gray sandy silt contains gravel but fewer boulder-size rock fragments than the overlying reddish-brown fill. This horizon is interpreted to be discolored reddish-brown fill which may contain some sludge or leachate. Spark plug parts are often seen in this horizon. The greenish-gray fill is present in all lagoons except lagoon no. 4. The soil horizon has OVA values ranging from 20 ppm (lagoon no. 3) to 2,000 ppm (lagoon no. 5).

Unit 3. "Sludge zone" made of sediments with a variety of grain sizes and colors ranging from light gray to black, fine sand and silt, to black, sticky gravel and cobble layers. Characteristically, this horizon is the darkest material present in any of the borings. The "sludge zone" is found just below or at the estimated position of the bottoms of the lagoons indicated in Figure 2 and is interpreted to be composed of the material present in the lagoons before backfilling. The highest OVA values were recorded at this

horizon except in lagoon no 5. This zone is present in lagoons no. 2, 4, and 5 and may be present in the southern half of lagoon no. 1.

Unit 4. "Native soil" (natural unconsolidated strata) composed of reddish-brown clayey silt and silt layers, with a minor amount of sand and gravel. This soil can be discolored gray and mottled gray and reddish brown, which may be the result of leachate filtering down from the "sludge zone." This interval is found between the "sludge zone" and the bedrock. The OVA values are generally lower than those in the overlying "sludge zone." The "native soil" horizon is present in lagoons no. 2, 3, 4, and 5.

4.2.2 Conditions at Specific Locations

Lagoon No. 1

Three borings (B1-1, B1-2, and B1-3) were made on June 30, 1986, in lagoon no. 1. Cross section B-B' (Appendix D) shows the interpretation of stratigraphic relationships. Four of the samples collected were sent to the ETC laboratory for analysis. Lagoon no. 1 has asphalt blacktop at the surface and 7 to 10 feet of fill composed of reddish-brown silt with gravel (stratigraphic unit 1) below it. A 5- to 10-foot layer of greenish-gray sandy silt with gravel (stratigraphic unit 2) underlies stratigraphic unit 1 in all borings except B-1, where the equivalent fill is brown and contains spark plug parts. Weathered limestone bedrock (stratigraphic

unit 5) lies directly below the brown silt fill in boring B1-1 at a depth of 20 feet. Alternating layers of limestone and orange-brown silty clay (weathered shale) are present to a depth of 37 feet.

The bottom of lagoon no. 1 was encountered in boring B1-1 along the lagoon's northern edge. Borings B1-2 and B1-3 did not penetrate the bottom which is estimated to be at a depth of 30 feet. A "sludge zone" was not encountered in the first three borings drilled in lagoon no. 1.

Stratigraphic unit 2, at a depth of 13 to 17 feet in boring B1-2, has OVA values of 400 to 600 ppm, while the highest values found in borings B1-1 and B1-3 are less than 30 ppm. The high values in the fill in boring B1-2 suggest that a "sludge zone" may be present at a depth of 30 feet below the ground surface at B1-1-2 and along the southern half of the lagoon.

Borings B1-4, B1-5, and B1-6 were made on February 25, 1987, to collect samples from the bank of lagoon no. 1 (boring logs are shown in Appendix B). Before it was closed, the lagoon was reported to have been dredged periodically and the soil deposited on the bank. After closure, the lagoon was filled and graded and the area of the lagoon is now covered by an asphalt surfaced parking lot. As indicated below, no thick accumulations of lagoon bottom materials were encountered.

The location of the former bank of lagoon no. 1 was inferred from aerial photographs. Borings B1-1, B1-5, and B1-6 were drilled in a line across the inferred bank near the former inlet to the lagoon. Due to the presence of rubble in the fill, it was necessary

to relocate some of the borings from their original locations. The final locations are shown on Figure 2 and in Appendix C.

Weathered rock (stratigraphic unit 5) was encountered in each of the B1 borings at less than 20 feet. For comparison with borings B1-1, B1-2, and B1-3, shown on cross section B-B', (Appendix D) stratigraphic unit numbers are indicated on the boring logs. The material above rock is largely fill composed primarily of native silt and clay materials with abundant rock. HNU readings were less than 5 ppm for each sample.

Layers with gray or black discoloration and yielding some odors were present in borings B1-5 and B1-6. This material presumably represents bottom sediment or sludge in lagoon no. 1. The sludge layer in B1-5, tentatively included in stratigraphic unit 1, was only 1.0 inch thick and did not provide sufficient volume for analysis. In boring B1-6, a black sludge layer approximately 6 inches thick (interpreted as part of stratigraphic unit 3) was present in sample S-4, which represents the depth interval 13 to 16 feet. The HNU reading was less than 1 ppm; however, because of its appearance, this sample was sent to CompuChem Laboratory for analysis for VOC.

Lagoon No. 2

Three borings were made in lagoon no. 2. Cross section C-C' (Appendix D) shows the stratigraphic relationships. Five samples were sent to the ETC laboratory for analysis.

The top layer in each boring is fill composed of reddish-brown silt with gravel and boulders (stratigraphic unit 1). This layer

ranges in thickness from 7 feet (B2-2) to 17 feet (B2-1). Below stratigraphic unit 1 is a medium-gray silty sand with gravel (stratigraphic unit 2) which ranges from 3 to 12 feet in thickness. Monitoring well CSP-2 penetrated 4 feet of dark gray sandy silt which may be equivalent to stratigraphic unit 2 in lagoon no 2. A 5-foot thick "sludge zone" composed of dark gray to black silt with light olive-green laminations was found in borings B2-1 and B2-2 (stratigraphic unit 3). "Native soil" (stratigraphic unit 4) was not recognized in any of the borings in lagoon no. 2 but is described in CSP-2 on the southwest edge of the lagoon. Weathered limestone bedrock was penetrated in borings B2-1 and B2-2 at a depth of about 25 feet, while in monitoring well CSP-2, bedrock was recorded at 35 feet. The bottom of the lagoon was estimated to be at 20 feet in Figure 2. Cross section C-C' (Appendix D) indicates that the "sludge zone" is from 20 to 25 feet, which suggests that stratigraphic unit 3 is composed of material left in the lagoon or that it is "native soil" containing residual leachate.

An OVA value of 5,000 ppm, the highest reading for the entire project, was recorded in the "sludge zone" in boring B2-1. A value of 1,000 ppm was recorded in the same interval in boring B2-2. Below the "sludge zone" the OVA values dropped to 90 ppm and 10 ppm at depths of 35 and 40 feet in the bedrock.

Lagoon No. 3

Four borings were made in lagoon no. 3. Cross section D-D' (Appendix D) shows the distribution of the stratigraphic units. Eight samples were sent to the ETC laboratory for analysis.

Three of the four stratigraphic units defined have been recognized in lagoon no. 3. The shallowest is fill composed of the characteristic reddish-brown silt with gravel and boulders (stratigraphic unit 1). Beginning at a depth of 10 feet in all of the borings, there is a layer of fill composed of greenish-gray sandy silt with gravel, averaging 7 feet in thickness (stratigraphic unit 2). Below stratigraphic unit 2 is gray silt with a minor amount of gravel which is commonly mottled reddish-brown and is interpreted as "native soil" with some residual leachate (stratigraphic unit 4). A reddish-brown clayey silt, from 3 to 15 feet thick, lies below the brown and gray mottled silt and is also considered uncontaminated "native soil" (stratigraphic unit 4). Weathered light-brown to light-gray limestone and shaley limestone are found at the bottoms of the borings (stratigraphic unit 5). The base of the lagoon is estimated to be at a depth of 17 feet. This corresponds to the contact between stratigraphic unit 2 and the mottled portion of stratigraphic unit 4. The "sludge zone" was not recognized in lagoon no. 3.

OVA values of 100 to 150 ppm were recorded in stratigraphic unit 2 and at the top of unit 4 in lagoon no. 3. In the uncontaminated "native soil" of unit 4, OVA values were 40 to 60 ppm. In the limestone bedrock, OVA values were 2 to 10 ppm. The relatively low OVA values in lagoon no. 3 may reflect the absence of the "sludge zone."

Lagoon No. 4

Six borings were attempted in lagoon no. 4. Five were successful with boring B4-4 being abandoned at a depth of 9 feet. Two cross sections, E-E' and F-F' (Appendix D), show the stratigraphic relationships. Eight samples were sent to the ETC laboratory for analysis.

A layer of fill composed of reddish-brown and brown silt with gravel and boulders was the first unit penetrated by all borings in lagoon no. 4 (stratigraphic unit 1). At a depth of about 17 feet, a 5- to 7-foot thick dark gray "sludge zone" layer was encountered. This soil unit (stratigraphic unit 3) is characterized by light to dark gray silty sand with gravel-size limestone fragments. Boring B4-1 penetrated a reddish-brown clayey silt layer (stratigraphic unit 4) directly below the "sludge zone." Under the "sludge zone" in boring B4-2, there was a dark-gray silt, which is interpreted to be "native soil" containing residual leachate. Weathered limestone bedrock was penetrated in borings B4-1, B4-2, and B4-3. The western edge of the lagoon can be inferred to be between well CSP-3 and boring B4-6, and between well CSP-4 and boring B4-1. The bottom of lagoon no. 4 corresponds with the contact between stratigraphic units 1 and 3 at a depth of 17 to 20 feet.

The "sludge zone" in borings B4-3 and B4-6 had OVA values of 275 and 300 ppm, respectively, which are the highest values observed in lagoon no. 4. The "native soil" in B4-1 had a very low OVA value of 2 ppm. The limestone bedrock in B4-3 had an OVA value of 30 ppm. It must be noted, however, that the readings in B4-1 and B4-2 may

not be valid due to the low level of hydrogen in the OVA instrument at the time of sampling.

Lagoon No. 5

Two borings were made in lagoon no. 5. Cross section A-A' (Appendix D) shows the stratigraphic relationships. Four samples were sent to the ETC laboratory for analysis.

Lagoon no. 5 is unique in that the borings did not penetrate the reddish-brown silt fill of stratigraphic unit 1. Immediately below the asphalt surface, the borings encountered fill composed of greenish-gray sandy silt with gravel (stratigraphic unit 2). A very dark gray to black silt with gravel, the "sludge zone" (stratigraphic unit 3), was penetrated in boring B5-1 at 16 to 21 feet. Below stratigraphic unit 3, the gray silt and sand grades into orange-brown silt and sand of stratigraphic unit 4. This partially contaminated "native soil" is similar to that seen in lagoon no. 3. Weathered limestone bedrock was penetrated at 29 feet (stratigraphic unit 5). The same greenish-gray silt fill (stratigraphic unit 2) is present in boring B5-2, but no "sludge zone" was observed. The gray silt fill passed directly into alternating layers of red-brown and dark-gray silt of stratigraphic unit 4. Weathered limestone bedrock was reached at 20.5 feet. The estimated position of the bottom of lagoon no. 5 is 16 feet, which corresponds to the top of the "sludge zone" in boring B5-1.

The OVA readings in boring B5-1 were highest in stratigraphic unit 2 with values of 1,500 to 2,000 ppm. The underlying "sludge zone" had values of only 700 ppm. This concentration distribution

is the reverse of that observed in the other lagoons. The OVA values decreased to 130 ppm in the contaminated "native soil" and to 25 ppm in the weathered limestone bedrock.

Vicinity of Underground Storage Tank Area

Borings A-1, A-2, and A-3 (Figure 2) were installed down-gradient (west) of the underground storage tank area and where some dumping of industrial waste materials was reported. The highest HNU reading was 15 ppm in boring A-2 in a zone discolored gray from 1 to 6 feet below land surface (stratigraphic unit 1). A sample of this material was sent to both the primary and referee laboratories for analysis of VOC.

In boring A-3 (the boring for well CSP-7), no obvious industrial waste was encountered although the presence of occasional spark plugs to a depth of about 10 feet indicated the presence of fill. Sample S-5, from 8 to 10 feet below grade, was sent to CompuChem for VOC analysis. This sample had an HNU reading of 5 ppm, the highest in the boring.

Boring A-1 was terminated in weathered sandstone at 15 feet. There was no visual evidence of industrial waste in this boring. The highest HNU reading was 4 ppm.

Upgradient from Lagoon Areas

One boring (B6-Bg) was made to establish a background level of contamination near the northeast corner of the Hellertown facility. The boring is located 12 feet north of well CSP-1, the upgradient monitoring well (Figure 2). Cross section G-G' (Appendix D) shows

the stratigraphic relationships at this location. Two samples were sent to the laboratory for analysis.

Boring B6-Bg penetrated two feet of crushed gravel fill below the asphalt at the surface. Below the gravel fill, there were 15 feet of reddish-brown and orange-brown, clayey silt with light brown layers of weathered limestone (stratigraphic unit 4) above limestone bedrock (stratigraphic unit 5), which was at a depth of 18.5 feet. OVA values of 0 to 2 ppm were recorded from the samples in B6-Bg.

4.3 Groundwater Investigation

4.3.1 Installation of Monitoring Wells

Wells CSP-1, CSP-2, CSP-3, and CSP-4 were installed in December 1984 by drilling below the bottoms of borings made with a hollow-stem auger. The logs and construction features of the wells are shown in Appendix E.

During the week of February 9, 1987, four relatively deep 2-inch diameter, PVC-cased wells were installed on the downgradient (west) side of the filled lagoons (Figure 2). These wells were installed adjacent to existing shallow wells CSP-3 and CSP-4 in order to determine if the observed VOC concentrations also occur at depth. The wells were installed by the R.H. Odenheimer Company under the supervision of an ESC hydrogeologist.

Three of the deep wells, CSP-5A, CSP-5B, and CSP-5C, are clustered in the same borehole 27 feet south of well CSP-4, with

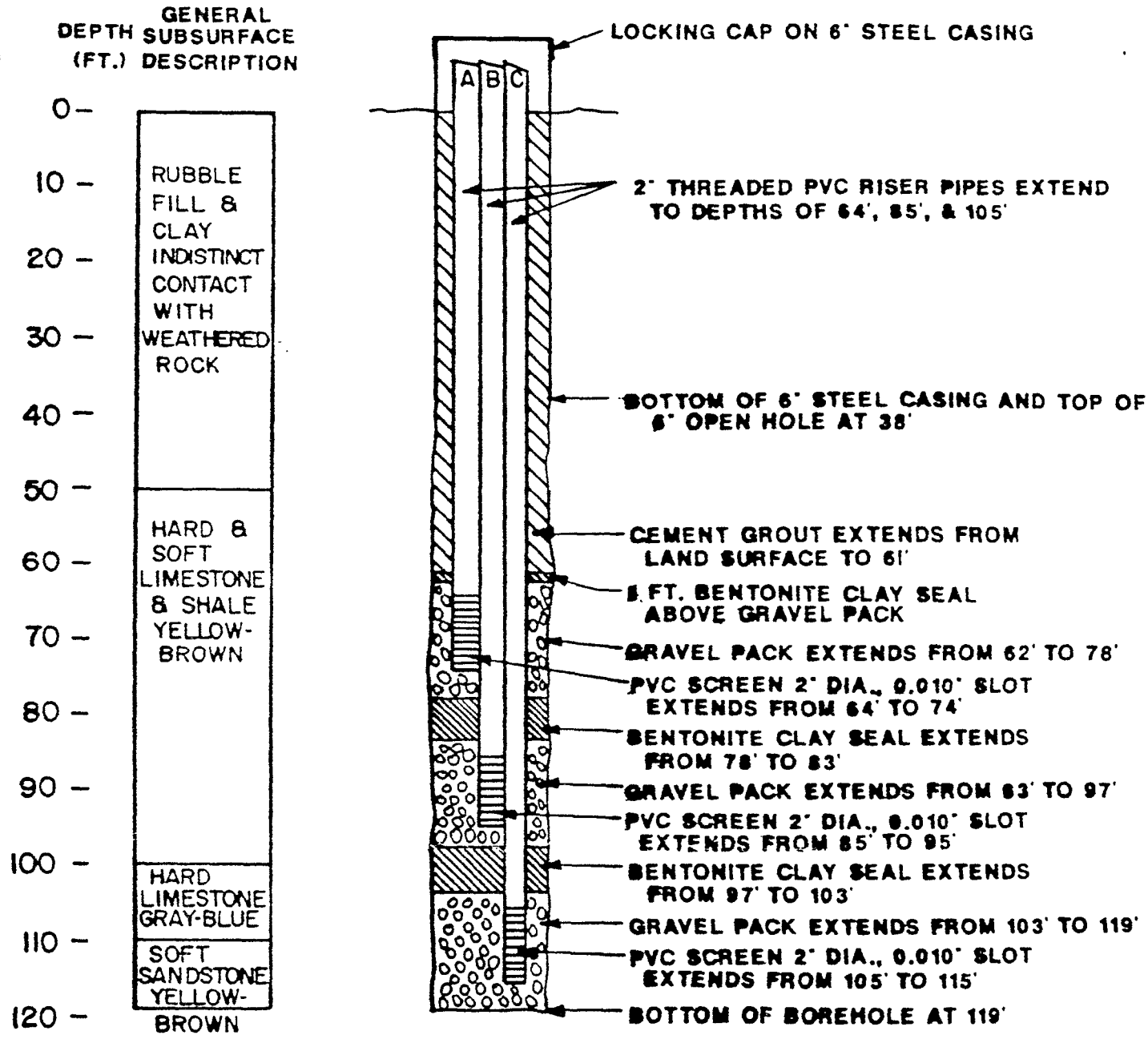
screen settings of 64-74, 85-95, and 105-115 feet below land surface (Figure 9). As indicated in Figure 9, bentonite clay seals from 78-83 feet and from 97-103 feet were placed between the three screened sections of wells CSP-5a, CSP-5b, and CSP-5c. The bentonite seal above the screened section of the deepest well (CSP-5c) appears to have effectively isolated this well from the two more shallow wells. The effectiveness of the seal between CSP-5a and CSP-5b cannot be judged with the same degree of certainty. The borehole for a second cluster was made 25 feet north of well CSP-3; however, due to borehole collapse, only one screen was set in this well (CSP-6), from 70 to 80 feet below land surface (Figure 10).

Specific details on the methods used to install the deep wells are given in Appendix F. Installation data on the existing wells and the new wells are summarized in Table 16.

A general description of the subsurface materials encountered during drilling is given on Figures 9 and 10. The descriptions are general since they are based on an examination of cuttings rather than cores or split-spoon samples. Hard and soft layers were evident from the rate of drilling, and the occurrence of permeable water-bearing zones was inferred from the volume of water discharged during drilling.

The rock encountered in wells CSP-5A, CSP-5B, CSP-5C, and CSP-6 consisted of alternating very soft and hard layers to the total depth of the well. The collapse of the borehole in CSP-6 between 83 and 100 feet was evidence of the incompetent nature of the rock at this location. The only significant water-bearing zone encountered in CSP-6 was at 73 feet.

Figure 9



CSP-5A, 5B, & 5C COMPLETED ON 2-12-87
WATER LEVELS BELOW GROUND SURFACE IN CSP-5A, 5B, & 5C ON 2-14-87 = 35.84, 35.99 & 35.06, RESPECTIVELY

ENVIRONMENTAL STRATEGIES CORPORATION 8521 LEESBURG PIKE SUITE 650 VIENNA, VIRGINIA 22180	**MONITORING WELLS** **CSP-5A, 5B & 5C** HELLERTOWN MANUFACTURING CO. HELLERTOWN, PENNSYLVANIA