FINAL DESIGN REPORT
REMEDIAL DESIGN
WIDE BEACH DEVELOPMENT SITE
WIDE BEACH, NEW YORK
TOWN OF BRANT
ERIE COUNTY, NEW YORK

FEBRUARY 1989

APPENDIX B
PERCHED WATER
TREATABILITY STUDY RESULTS

EPA WORK ASSIGNMENT NUMBER: 86-2L46
EPA CONTRACT NUMBER: 68-01-7250
EBASCO SERVICES INCORPORATED

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NOTICE

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WIDE BEACH SITE

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ERIE COUNTY, NEW YORK

AUGUST, 1988

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EXECUTIVE SUMMARY

As part of the Remedial Design Work Assignment for the Wide Beach site Ebasco has performed a treatability study of the perched water. The cleanup criterion is to remove PCB's in the perched water to below 1 ug/l. Ebasco developed an experimental plan which called for a phased approach with pretreatment of perched water as Phase I.

Samples of the perched water were collected from the sewer wells. Due to higher suspended solids concentration than expected, two rounds of sampling were performed. Pretreatment tests were performed on several samples with varying suspended solids concentrations. Multiple samples were pretreated varying the pH, coagulant dosage and floculant dosage to obtain the optimum dosage for removing suspended solids. PCBs were successfully removed from perched water from as high as 16 ug/l to below 1 ug/l together with the suspended solids on all tests. It is concluded that pretreatment to remove suspended solids alone is effective to remediate PCBs in perched water, due to the fact that PCBs tend to be adsorbed to the soil particles rather than be dissolved in water.

1.0 INTRODUCTION

The Wide Beach Superfund site is a 55 acre residential community located in Erie County in western New York State on Lake Erie approximately 30 miles south of Buffalo, New York. The site soils are contaminated with polychlorinated biphenyls (PCBs) due to the spreading of approximately 30,000 to 40,000 gallons of waste oil on the dirt roads for dust control between 1968 and 1978.

Part of the selected remedial action for the Wide Beach site in EPA's Record of Decision (ROD) signed in September 1985 requires that the water perched in the sanitary sewer trench be "extracted utilizing the shallow wells installed in the trench, and subsequently be treated utilizing granular activated carbon (GAC)". The 1984 Remedial Investigation/Feasibility Study (RI/FS) conducted by EA Engineering indicated that the perched water in the sewer trench was contaminated by PCBs. As part of the Remedial Design Work Assignment for the Wide Beach site and development of design for the perched water treatment system, Ebasco performed a treatability study of the perched water.

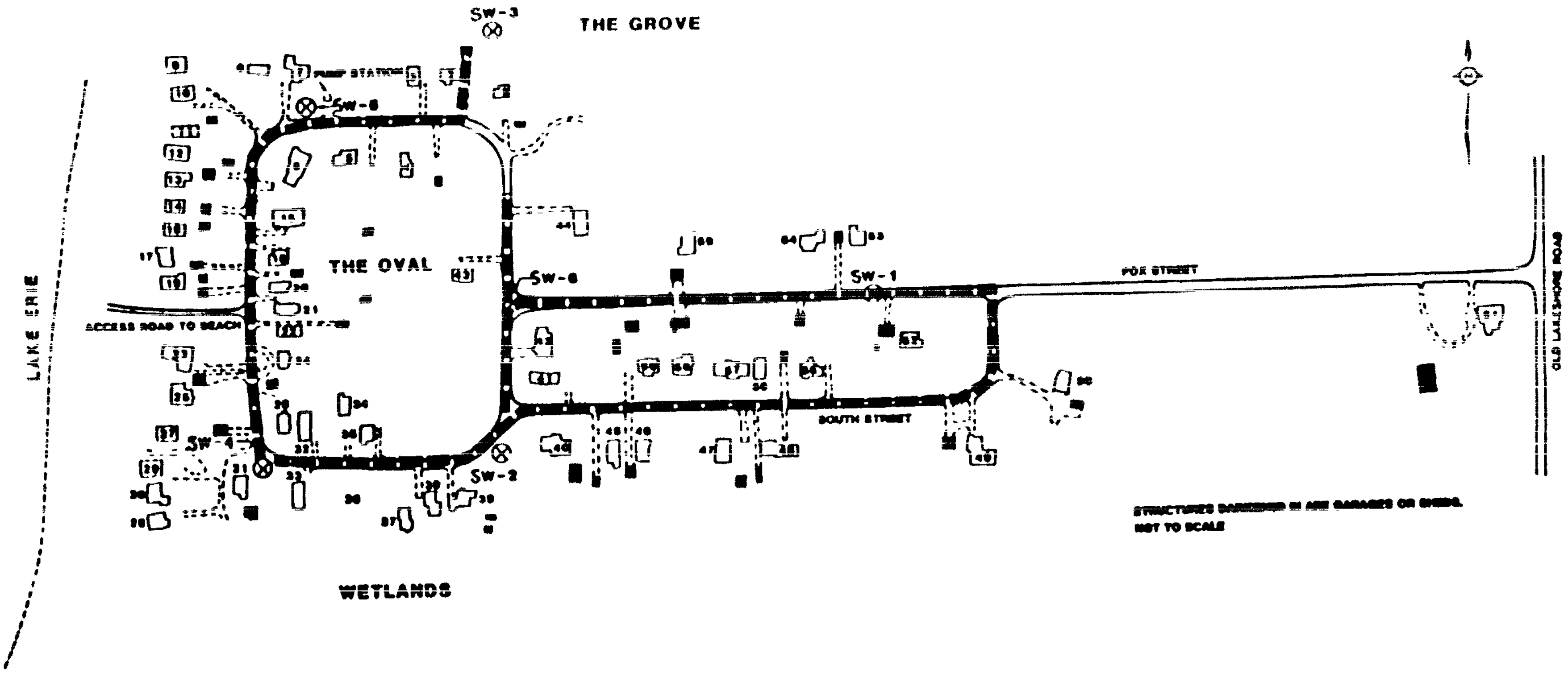
This report presents the results of sampling of the perched water in the sewer trench conducted in December 1986 and January 1987 and the results of the treatability study conducted by Ebasco personnel during January to February 1987.

2.0 NATURE AND EXTENT OF PROBLEM

The major problem at the site is PCB contaminated soil which is to be remediated by excavation and chemically treated using the KPEG process. The site groundwater used by residents of the site for drinking water from individual wells, detected trace levels of PCBs in several wells. For protection, a particulate filter was installed in each home. The perched water in the sewer trench was to be treated using activated carbon as noted previously.

Figure 2-1 is a site plan depicting the location of the houses and sewer trench wells. The sanitary sewer trench follows the roadway and leaves the site via a pump station near SW-5 north of the site. The six sewer trench wells were constructed in the previous 1984 RI/FS studies. Table 2-1 shows the total PCB concentration in each well from the 1984 sampling program. Only PCB Aroclor 1254 was detected at concentrations ranging from 1.4 to 5.7 ug/l

Aroclor 1254 is a Monsanto product name. Like all Aroclors, it is a mixture of various PCB congeners (the term congeners refers to the compounds in which the parent molecule remains the same (biphenyl) but different numbers of chlorine atoms are attached). The "12" part of the "1254" signifies that the mixture contains



SOURCE: EA ENGINEERING
REMEDIAL INVESTIGATION REPORT
AUGUST 1985

FIGURE 2–1

LOCATION OF SEWER TRENCH WELLS

TABLE 2-1

AROCLOR 1254 CONCENTRATION
IN SEWER TRENCH WELLS (1984)

Well	PCB Aroclor 1254 (ug/l)
SW-1	2.5
SW-2	4.3
SW-3	1.4
SW-4	2.6
SW-5	5.7
SW-6	1.5

only biphenyls as opposed to the "10" designation which indicates terphenyls. The "54" of the "1254" indicates that the mixture is 54% (by weight) chlorine.

Figure 2-2 shows the hydraulic profile of the perched water and the sanitary sewer trench and the location of the sewer monitoring wells along the trench. A section of the sewer trench between monitoring wells SW-4 and SW-5 was installed in the bedrock which consists of a fractured shale. The bedrock is saturated with groundwater, and it is believed that the excavation into bedrock has caused an artesian upflow which forms a perched water condition in the trench resulting in water levels higher than the normal water table outside the sewer trench. The perched water accumulates and is confined in the trench between SW-4 and SW-5 and between SW-1 and SW-5. The sewer trench is surrounded by low permeable clay soil with hydraulic conductivity in the range of 3.4 x 10^{-4} to 8 x 10^{-6} cm/sec (Appendix A, Hydrology of Sewer Trench). The movement of the perched water is very slow since the hydraulic gradient is less than 0.002 from SW-5 towards SW-4. Off-site migration of PCBs via the sewer trench is judged to be minimal since the perched water is essentially stagnated in an equilibrium condition and any flow in the trench is directed to the low point at SW-4. Any withdrawal of perched water would be recharged by an upward flow from the bedrock under the sewer trench between SW-4 and SW-5. The estimated volume of water in the sewer trench including the perched water is approximately 80,000 gallons.

The following summarizes the site conditions:

1. The perched water condition in the sewer trench is caused by a section of sanitary sewer trench that cuts into the bedrock aquifer at the site.

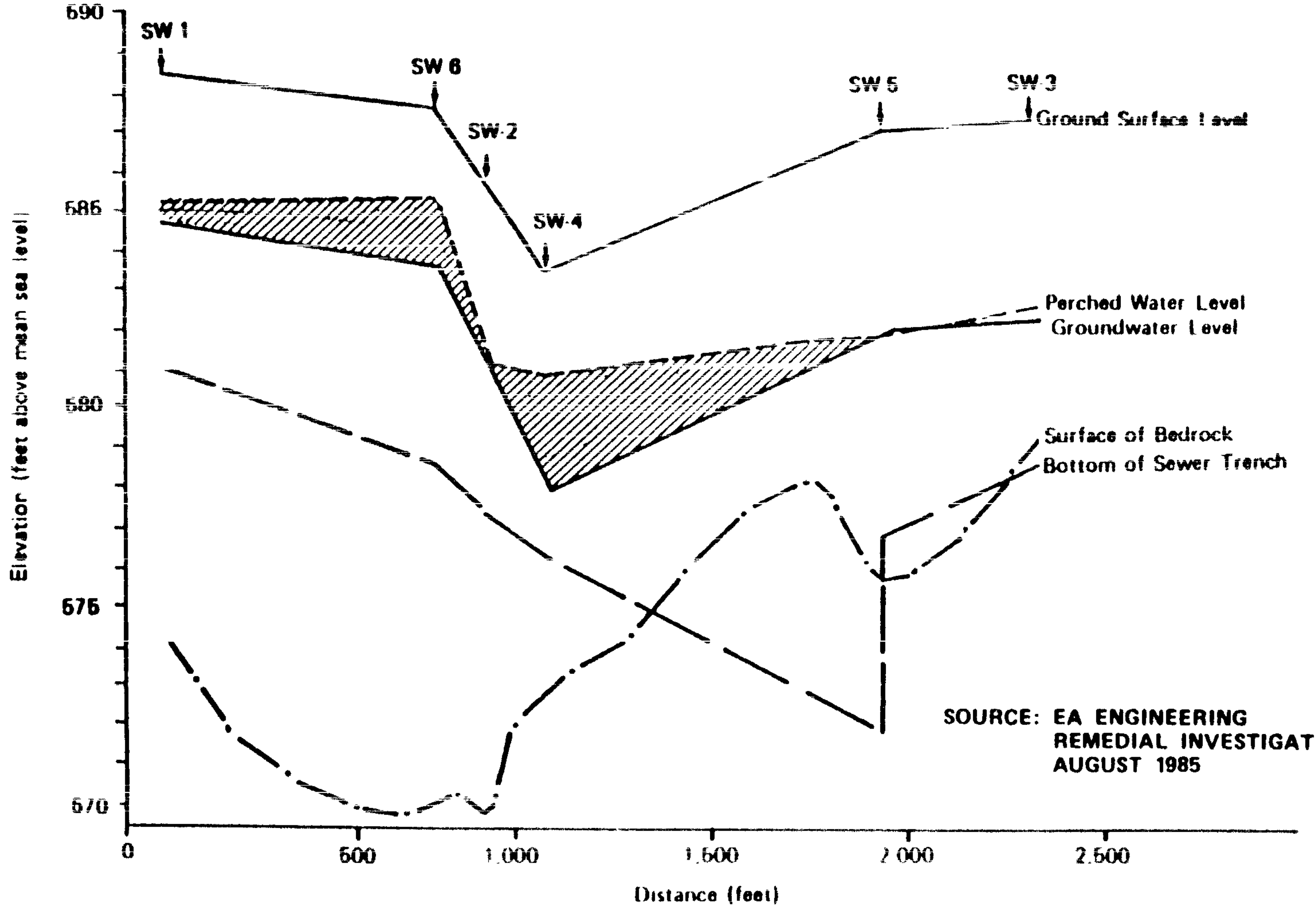
2. There is negligible off-site migration of PCB via the sewer trench due to the following:

   - Hydraulic gradient is in direction of SW-4 and not off-site to the north near the sewage pumping station

   - Perched water is stagnated in an equilibrium condition

3.0 OBJECTIVES

EPA's ROD signed in September 1985 required that the water perched in the sanitary sewer trench be treated to remove PCBs.



SOURCE: EA ENGINEERING
REMEDIAL INVESTIGATION REPORT
AUGUST 1985

FIGURE 2-2 Topographic profile along the sewer trench

The cleanup criterion, for the treatment system is to reduce PCB concentrations to less than 1 ug/l based on the New York State Department of Health recommended concentration limit for PCB in groundwater.

Therefore the objectives of the perched water treatability study are as follows:

1. To determine the feasibility of removing the PCB from the water to less than 1 ug/l. The recommended technology was carbon adsorption.
2. To develop any pretreatment required for other contaminants that may be present such as suspended solids, iron, oil and grease and heavy metals.
3. To obtain treatment process design information.
4. To provide treatment information for developing cost estimates for the treatment system, both capital and operation and maintenance costs.

4.1 DESCRIPTION OF TREATABILITY TESTS

This section discusses the treatability testing program and the tests conducted on samples of the perched water.

4. EXPERIMENTAL PLAN

Ebasco developed an experimental plan for a bench-scale treatability study to determine the feasibility of reducing PCB concentrations in the trench water to below the 1 ug/l limit and defining the appropriate design criteria for the full-scale treatment system. The experimental plan was submitted as part of the Draft Remedial Design Work Plan to EPA in September 1986.

The plan consisted of three phases. In Phase I, pretreatment tests would be performed using pH adjustment, alum coagulation and polymer flocculation to remove suspended solids, free and emulsified oil and iron from samples of trench water. Phase II would investigate the adsorptive capacity of commercially available granular activated carbons (GAC) and the equilibrium concentrations of PCB in effluent by running batch adsorption isotherms. The design and execution of dynamic GAC column tests to provide carbon usage data constituted Phase III. All the above tests would be conducted using composite samples from sewer well water. Composite samples were used to simulate an actual full-scale operation which would combine water from all the wells for treatment in one process train. During the execution of the Phase I program, Ebasco modified the experimental plan due to initial sampling results and the Phase I pretreatment results

After the well water samples were collected, Ebasco noticed that SW-4 well water contained relatively high concentrations of suspended solids and oil when compared to the other well water samples. As a result, it was recommended to EPA that two separate water samples be tested to determine treatment requirements and conceptual cost estimates. The two samples included well water from SW-4, the most contaminated or "worst case" condition, and a composite of SW-3 and SW-5. A revised experimental plan was submitted to EPA in January, 1987.

Upon analysis of the two samples, it was found they contained unusually high concentrations of PCBs when compared to historic data. Ebasco decided that resampling of the well water was required. A composite of the three wells that were resampled became the third water sample tested in the treatability study.

The pretreatment of the three water samples has produced exceptionally good results. All PCBs were removed to below 1 ug/l. In order to confirm these results, spiked samples were prepared and were tested following the same pretreatment procedures. Similar results were obtained in the spiked samples.

The results of these pretreatment tests were discussed with EPA. It was concluded that further treatability tests were not required. The treatability tests were terminated at Phase I.

4.2 PERCHED WATER SAMPLING

Samples were collected from the sewer trench wells in December, 1986. Only four wells (SW-3, SW-4, SW-5 and SW-6) could be sampled to obtain perched water. SW-1 and SW-2 had been removed. Samples from SW-6 were excluded from treatability tests due to the very slow recovery after purging, which makes future pumping of well water for treatment impracticable. Well water samples were visually inspected in the field. SW-4 sample had high turbidity and some noticeable oil. SW-3 and SW-5 samples contained lower turbidity and suspended solids and no visible oil. Ebasco was concerned that higher concentrations of suspended solids would contain higher concentrations of PCBs (see discussion in Chapter 6) and therefore selected two samples, instead of the one composite sample as originally planned for treatability testing. Both samples were sent to Ebasco's laboratory in Columbia, MD for treatability tests. The two samples were the SW-4 well water and a composite of the SW-3 and SW-5 well waters.

Table 4-1 presents the results of chemical analysis of the two perched water samples analyzed. It should be noted that Well SW-4 had a high concentration of suspended solids at 3856 mg/l and PCB of 68 ug/l while the composite of the other two wells had a TSS of 228 ug/l and PCB of 4.3 ug/l. Historic data for PCB concentrations were below 10 ug/l as shown previously in Table 2-1

TABLE 4-1

ANALYSES OF TRENCH WATER

	Well SW-4 Sampled 12/86	Composite of Wells SW-3 & 5 Sampled 12/86 (Comp -1)	Composite of Wells SW-3,4&5 Sampled 1/87 (Comp -2)
Total PCB (mg/l)	68	4.3	<1.0
TOC (mg/l)	59	39	-
TSS (mg/l)	3856	228	159
COD (mg/l)	506	41	-
Alkalinity (mg/l)	272	204	-
Iron (mg/l)	60.2	11.9	0.26
Oil and Grease (mg/l)	-	-	<3.0
BOD (mg/l)	7	7	-
TDS (mg/l)	460	-	520

PCB = Polychlorinated biphenyl (Aroclor 1254)
TOC = Total organic carbon
TSS = Total suspended solids
COD = Chemical oxygen demand
BOD-5 = Biochemical oxygen demand (5-day)
TDS = Total dissolved solids

Due to the unexpected high levels of suspended solids and PCBs in the sewer trench wells, a second round of samples were collected in January 1987 to determine if the initial samples were representative. The well water samples were composited. The results of the second-round samples showed lower concentrations of suspended solids and PCBs of less than 1 ug/L. It was suspected that the SW-4 sample collected in December 1986 was contaminated by surface water runoff as a result of EPA's cleanup of accumulated water in a drainage ditch. These cleanup activities occurred a week or so prior to the sampling. Table 4-2 provides a brief description of well water samples.

4.3 TEST PROGRAM

Samples from each container were examined for color, relative turbidity, visible oil and visible solids. Samples drawn for testing were examined for these characteristics before and after treatment.

Because of the variations in contaminant concentration between samples collected in December 1986 and samples collected in January 1987, three combinations of water samples were tested during the pretreatment phase (Phase I) of the treatability study. The samples tested were:

SW-4 - the high solids sample from SW-4 of 12/86
Comp-1 - the composite sample from SW-3 and SW-5 of 12/86
Comp-2 - a composite sample from SW-3, SW-4 and SW-5 of 1/87.

The first set of pretreatment tests showed that removing suspended solids from the sample effectively removed PCBs. Two spiked samples were therefore prepared and tested to demonstrate that this relationship held true at higher PCB/TSS ratios.

Spike 1 - SW-4 was spiked with Aroclor 1254 and TOC.

Spike 2 - Comp-2 was spiked with Wide Beach site soil.

Preparation of Composite Samples

Composite samples of untreated water were prepared by emptying one five-gallon container of each collected sample into a drum and stirring the mixture vigorously for several minutes. The composite was transferred back into the original containers for storage, using a 1/4-inch diameter clear plastic siphon hose. During transfer the composite was stirred vigorously to prevent the solids from settling.

TABLE 4-2

DESCRIPTION OF WELL WATER SAMPLES

SEWER WELL	DATE	VOLUME	DESCRIPTION
SW-4	12/17/86	three 5-gal containers two 1-liter amber bottles	o have red & black solids deposited in bottom of container. o undisturbed water has a grey tint. o slightly turbid.
SW-3	12/17/86	one 5-gal container two 1-liter amber bottles	o water has orange tint. o grey stain on container wall. o red and black solids on bottom of container o slightly turbid.
SW-5	12/17/86	one 5-gal container two 1-liter amber bottles	o black solids on bottom of container. o grey stain on container walls. o no orange tint
SW-6	12/17/86	one 5-gal container	o slight amount of black solids on bottom of container. o No orange tint o Small amount of grey stain.

TABLE 4-2 (Cont'd)

DESCRIPTION OF WELL WATER SAMPLES

SEWER WELL	DATE	VOLUME	DESCRIPTION
SW-3	1/14/87	four 5-gal carboys	o orange tint/ evidence of iron oxide deposits on inside of bottle. o slightly turbid. o no visible oil.
SW-4	1/14/87	four 5-gal carboys two 1-liter amber bottles	o orange tint/ evidence of iron oxide precipitate on inside of container. o slight turbidity o no visible oil
SW-5	1/14/87	three 5-gal carboys two 1-liter amber bottles	o clear/white color o black solids deposited on bottom of container, do not resuspend readily. o no visible oil.

Preparation of Spiked Samples

Spike-1 sample was prepared by adding 0.5 ml of 1000 ug/ul Aroclor 1254 in an acetone-hexane-octane mixture to 10.0 liter of SW-4; 80 ml of 25,000 ug/l potassium acid phthalate (KHP) was also added. The mixture was stirred for 24 hours in a covered polypropylene drum. The resulting sample would contain 50 ug/l of PCBs and 50 mg/l of TOC.

Spike-2 sample was prepared by adding 12.4 grams of contaminated soil from the Wide Beach site to 8.0 l of Comp-2 and stirring the mixture at high speed for over 18 hours to create a mixture estimated to have 1,000 mg/l suspended solids (TSS) and 100 mg/l Aroclor 1254.

Jar Tests

Alum coagulation and polymer flocculation were performed on the samples. Tests were conducted using a conventional 6-paddle stirrer with variable speed control and tachometer. Samples were tested in 1,000 ml Griffin beakers.

Settling tests were performed in a 1,000 ml graduated cylinder. pH measurements were made using a Fisher Scientific model 805MP pH/mV meter and a standard glass body electrode (Ag/AgCl reference). The meter and electrode were calibrated to pH 7.00 using standard buffer.

pH Adjustment: The pH of the samples were adjusted using 1.00 N NaOH solution and 1.00 N H_2SO_4 solution. The base and acid solutions were purchased ready-made from Fisher Scientific.

Alum Coagulation: Alum solution was prepared by dissolving 5.0 grams of ACS reagent grade aluminum sulfate ($Al_2(SO_4)_3 - 18H_2O$) in organic-free water and diluting to 500 ml. One (1) ml of this solution in a 1,000 ml sample produces a concentration of 0.5 mg/l alum.

Flocculant: Anionic polymer was used as the flocculant. A sample of polymer (Olin 5026) was obtained from Olin Water Services, Overland, KS. Following the manufacturer's instructions, 1.0 gram of the polymer emulsion was diluted in 99 ml of water to make a 1% emulsion. This emulsion was then diluted to 0.1% before use so that 1.0 ml of the final emulsion would produce a 1 mg/l polymer concentration in a 1,000 ml sample.

Six 1,000 ml samples of trench water were drawn from the sample containers, taking care to keep the solids in the container suspended during the transfer operation. Each sample was transferred to a 1,000 ml Griffin beaker. The paddle stirrer was inserted into the beaker about 1/4 inch, so that the paddle was off-center, clearing the beaker wall. Jars were assigned numbers 1 through 6.

All tests were run using samples and reagents that were near room temperature (about 23 to 25°C).

The steps of the jar tests were as follows:

(1) Sample pH was adjusted to approximately the values shown below:

Jar	1	2	3	4	5	6
pH	4	5	6	-	8.5	9.5

The pH of the sample in jar 4 was not adjusted for any test. SW-4 had a pH of 7.0, Comp-1 had a pH of 7.3 and Comp-2 had a pH of 7.5.

(2 With the stirrer turned off, 1 ml of alum stock was added to each jar. The samples were then stirred at 100 to 120 rpm for 2 minutes, followed by a slow mixing period (15 to 20 rpm) for approximately 20 minutes. During the slow mixing period of floc formation the floc size was observed and noted.

This step was repeated until one of the following conditions was encountered: (1) floc was formed, or (2) the addition of more alum caused no additional improvement in floc formation.

(3) The stirrer was then stopped and the paddles withdrawn. The coagulated particles were allowed to settle for 20 minutes. The settleability of the particles and the appearance of the supernatant were recorded.

(4) Flocculant was added to each jar to a concentration of 1 mg/l. After a fast mix period of 2 minutes, the sample was stirred slowly for 15 to 20 minutes. The formation and size of the flocs were observed and any significant improvement noted. Settling of the flocs was also observed.

Another 1 mg/l of flocculant was then added to each jar and the test repeated.

(5) The pH of the supernatant was then measured.

Centrifugation Tests

SW-4 sample and the two spiked samples were centrifuged to remove the suspended solids. The decanted supernatants were analyzed for dissolved PCBs. The centrifuge (International Equipment Company, Needham, MA: Model CS) was run at 3200 rpm for 20 minutes. The radius of the rotor plus the length of the bottle was 6.0 inches. Each centrifuge bottle held about 240 mL of sample up to 20 bottles of the sample had to be run to collect enough samples for analysis.

4.4 LABORATORY ANALYSES

During the first series of jar tests (SW-4, Comp 1 and Comp 2), untreated and treated trench water samples were analyzed for PCB, total organic carbon (TOC), chemical oxygen demand (COD), biochemical oxygen demand (BOD5), total suspended solids (TSS), oil and grease; and iron. The centrifuged sample (SW-4 12/86) was analyzed for PCB and TOC only.

During the second round of tests (SW-4, Spike-1 and Spike-2), untreated treated and centrifuged samples were analyzed for PCB, TOC, TSS and iron. The supernatant from a treated sample of SW-4 (12/86) was also analyzed for cadmium, chromium, copper, zinc mercury and total phosphate. Metals and phosphate analyses were performed on unfiltered samples to provide a better estimate of the concentrations that might be found in the treatment system effluent. All analyses were performed using EPA referenced methods as shown in Table 4-3 along with detection limits for the various parameters.

5.0 TREATABILITY TEST RESULTS

5.1 RESULTS OF FIRST ROUND TESTS

The first round of pretreatment tests was performed on January 21 and 22, 1987. Jar tests were performed on SW-4, Comp-1 and Comp-2. A portion of SW-4 was also centrifuged to remove suspended solids to check PCB concentrations after separating the suspended solids in the sample.

Examination of Untreated Samples

SW-4

The untreated sample had a dark brown color and a high solids content. When well-mixed the sample was opaque. Some of the suspended solids settled out quickly, but after an hour the supernatant was still quite turbid. There was no visible oil or floating matter present Acidifying the sample to below pH of 2 with sulfuric acid did not free any oil from emulsion but did cause the supernatant to clarify significantly within an hour.

TABLE 4-3

METHODS OF ANALYSIS

Parameter	Method Reference	Detection Limit
PCB-1254	EPA 608	1 ug/1
TOC	SM 505B	1 mg/1
COD	SM 508B	5 mg/1
TSS	SM 209C	1 mg/1
Oil and Grease	SM 503A	3 mg/1
BOD-	SM 507	1 mg/1
Iron	EPA 236.1	0.03 mg/1
TDS	EPA 160.1	1 mg/1

Note SM refers to "Standard Methods for the Examination of Water and Wastewater" APHA-AWWA-WPCF, 16th Edition.

EPA 608 from "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Appendix A to 40 CFR 136.

EPA 236.1 from "Methods for Chemical Analysis of Water and Wastes", EPA, 1979, revised 1983.

Comp-1

The untreated sample was similar in appearance to SW-4, except that it had a light brown color. After settling for an hour the supernatant was quite turbid, but not as turbid as SW-4. The supernatant had a slight orange color. There was no oil or floating matter present. Acidifying the sample did not free any oil, and only partially clarified the supernatant.

Comp-2

This untreated sample had only a very small amount of settleable solids and was very slightly turbid. There was no visible oil or floating material, but the supernatant had a slight orange color. Acidification did not free any oil, but did improve the clarity of the supernatant.

Results of Jar Tests

Portions of all three samples were tested to determine the pH, alum and flocculant dosages required to remove solids, and produce a large, rapidly forming and settling floc, and a clear supernatant.

SW-4

Portions of the sample were tested at pH from 3.9 to 9.4, alum concentrations of 10, 20 and 30 mg/l and flocculant concentrations of 0, 1 and 2 mg/l. Large, rapidly settling floc and clear supernatant were produced using 20 mg/l alum and 2 mg/l flocculant at initial pH of 5.9, 7.0 and 8.3. The results produced under these conditions were clearly superior to those achieved at other pHs, with smaller coagulant or flocculant dosages Additional coagulant did not improve treatment performance.

Samples for analyses were treated by pH adjustment and alum coagulation, followed by flocculation:

Initial pH	Alum Concentration	Flocculant Concentration	Supernatant pH
7.0	20 mg/l	2 mg/l	7.0
8.5	20 mg/l	2 mg/l	7.3

An untreated sample was also collected for analysis. Table 5-1 presents the results of the chemical analysis showing PCB concentration being reduced from 16 to less than 1.0 ug/l by centrifuging the sample and by alum coagulation. The PCB in the aliquot sample used for the jar tests which measured 16 ug/l was less than the 68 ug/l initially measured in SW-4 since the

TABLE 5-1

RESULTS OF LABORATORY ANALYSES OF FIRST-ROUND SAMPLES

Sample (Sample Code)	Treatment	PCB (µg/l)	TOC (mg/l)	COD (mg/l)	BOD5 (mg/l)	TDS (mg/l)	TSS (mg/l)	Oil & Grease (mg/l)	Iron (mg/l)
SW-4 (WBCS-04)	No treatment	16	5.5	130	4	460	1,090	<3.0	0.49
SW-4 (WBCS-05)	No pH adjustment (pH 7.0), 20 mg/l alum; 2 mg/l flocculant	<1.0	3.3	12	<1	-	5	<3.0	0.12
SW-4 (WBCS-10)	Duplicate of WBCS-05, same treatment	<1.0	3.8	13	3	-	4	<3.0	0.13
SW-4 (WBCS-06)	pH adjustment to 8.5; 20 mg/l alum; 2 mg/l flocculant	<1.0	3.6	7	1	-	21	<3.0	0.14
SW-4 (WBCS-11)	Centrifuged to remove solids	<1.0	3.8	-		-	-	-	-
Comp-1 (WBCS-07)	No treatment	16	5.2	86	2	530	2,160	<3.0	0.16
Comp-1 (WBCS-08)	No pH adjustment (pH 7.2); 20 mg/l alum; 2 mg/l flocculant	<1.0	2.9	<5	<1		14	<3.0	0.16
Comp-1 (WBCS-09)	pH adjustment to 8.6; 20 mg/l alum; 2 mg/l flocculant	<1.0	2.9	6	<1	-	30	<3.0	0.22
Comp-2 (WBCS-01)	No treatment	<1.0	4.0	11	2	520	159	<3.0	0.26
Comp-2 (WBCS-02)	No pH adjustment (pH 7.5); 25 mg/l alum; 1 mg/l flocculant	<1.0	5.0	14	<1	-	11	<3.0	0.06
Comp-2 (WBCS-03)	pH adjustment to 9.4; 15 mg/l alum;	<1.0	2.7	<5	<1	-	4	<3.0	<0.03

smaller size sample had a lower suspended solids concentation. The lower suspended solids concentration resulted from difficulty in maintaining a well mixed sample when withdrawing an aliquot from the original 5 gallon container.

Comp-1

Portions of the sample were tested at pH from 3.9 to 9.4, alum concentration of 10, 20 and 30 mg/l and flocculant concentrations of 0, 1 and 2 mg/l.

A good rapidly settling floc and clear supernatant were produced using 20 mg/l alum and 2 mg/l flocculant at initial pH of 6.2, 7.3 and 8.4.

Samples for analysis were treated by pH adjustment and alum coagulation followed by flocculation:

Initia pH	Alum Concentration	Flocculant Concentration	Supernatant pH
7.3	20 mg/l	2 mg/l	7.2
8.4	20 mg/l	2 mg/l	7.5

An untreated sample was also collected for analysis. These results also shown in Table 5-1 show good suspended solids removal

Comp-2

Portions of the sample were tested at pH from 4.4 to 9.5, alum concentrations of 5 thorugh 25 mg/l, and flocculant concentrations of 0 and 1 mg/l. Large, quickly settling floc and clear supernatant was produced at pH 7.4 using 25 mg/l alum followed by 1 mg/l of flocculant. A good, quickly settling floc was achieved at pH 9.5 with 15 mg/l alum and no flocculant. No other cases produced better results.

Samples for analysis were prepared under the following conditions:

Initial pH	Alum Concentration	Flocculant Concentration	Supernatant pH
7.5	25 mg/l	1 mg/l	7.4
9.5	15 mg/l	None	8.6

An untreated sample was also collected for analysis. The analyses shown in Table 5-1 shows good suspended solids removal. However, PCB was already less than 1 ug/l before treatment due to the low concentration of suspended solids of 159 mg/l.

Test Results

The result of the above tests demonstrated that treatment with alum and flocculant is effective in reducing total suspended solids (TSS), chemical oxygen demand (COD), total organic carbon (TOC) and PCB concentrations in the samples.

5.2 RESULTS OF SECOND ROUND TESTS

The second round of pretreatment tests were performed on February 3 and 4, 1987.

Examination of Untreated Samples

SW-4

This sample was similar in appearance to SW-4 described in Section 5.1, but was drawn from a separate container.

Spike-1

This sample was drawn from the same container of SW-4 as above and was indistinguishable in appearance.

Spike-2

After 18.5 hours of stirring, the solids were as finely dispersed as the solids in SW-4 and Comp-1. However, they were darker in color and settled more rapidly. No oil was visible. Floating particles (believed to be plant matter) were removed before collecting samples for treatment or analysis. Only a very small amount of floating particles were present.

Results of Jar Tests

SW-4

Portions of this sample were treated with 20 mg/l alum and 2 mg/l of flocculant to confirm the optimum pretreatment conditions. No pH adjustment was needed. The coagulated flocs formed were smaller than those formed during earlier tests. The final flocs were good and settled quickly, but were not as large as those formed during earlier tests. An untreated portion of the sample was also analyzed for comparison.

Spike-1

As this sample was prepared from the same batch of trench water as the SW-4 sample, the same treatment procedure was used. The quality and formation of the floc was similar to that for the unspiked SW-4 sample. In addition, a centrifuged portion and an untreated portion of the sample were also analyzed for comparison.

Spike-2

The sample was treated using 20 mg/l alum and 2 mg/l flocculant. No pH adjustment was needed. Floc formation was slow and the floc was much smaller than that formed by the other samples. The floc settled slowly, leaving a very small amount of floating matter which was removed before analysis. The supernatant, however, was clear and free of visible solids.

Test Results

Laboratory analyses of the samples from the second round of pretreatment tests are presented in Table 5-2. The tests demonstrated that removal of the suspended solids (TSS) also removed the PCB from the water.

The treated portion of SW-4 was also analyzed (in duplicate) for cadmium chromium, copper, mercury, zinc and total phosphorus as shown in Table 5-3. None of these metals were detected. Phosphorus was present at 20 ug/l or less.

6.0 DISCUSSION OF RESULTS

6. PHYSICAL/CHEMICAL PROPERTIES OF PCB

The most important physical/chemical properties of PCBs from a treatability point of view, are solubility and partition coefficient. The solubility of PCBs in water is low and decreases with increasing chlorine content. The perched water contains mainly Aroclor 1254.

The solubility of Aroclor 1254 has been reported in water at 20°C at approximately 56 ug/l (Reference 1). However, the concentration of PCB in water is significantly reduced whenever water comes in contact with a solid surface or particulate matter because PCB is strongly adsorbed at the liquid-solid interface. Studies show that the concentrations of Aroclor 1254 decreased more than 80 percent by the addition of increasing amounts of soil from 0 to 15,000 mg/l (Reference 1).

TABLE 5-2

RESULTS OF LABORATORY ANALYSES OF SECOND-ROUND SAMPLES

Sample (Sample Code)	Treatment	PCB (ug/l)	TOC (mg/l)	TDS (mg/l)	TSS (mg/l)	Iron (mg/l)
SW-4 (WBCS-12)	No treatment	29	6.8		2,360	22
SW-4 (WBCS-13)	No pH adjustment (pH 7.5): 20 mg/l alum, 2 mg/l flocculant (replicate of WBCS-05)	<1.0	3.2	-	3	0.07
Spike-1 (WBCS-15)	No treatment	27	60.2	-	720	9.4
Spike-1 (WBCS-16)	Centrifuged to remove solids	<1.0	59.7	-	<1	0.16
Spike-1 (WBCS-21)	Duplicate (WBCS-16); same treatment	<1.0	59.3	-	-	-
Spike-1 (WBCS-17)	No pH adjustment (pH 7.4); 20 mg/l alum;2 mg/l flocculant	<1.0	58.6	-	6	0.10
Spike-2 (WBCS 18)	No treatment	47	4.2	480	466	2.5
Spike-2 (WBCS 19)	Centrifuged to remove Solids	<1.0	4.0	-	<1	0.07
Spike-2 (WBCS 20)	No pH adjustment (pH 6.8); 20 mg/l alum; 2 mg/l flocculant	<1.0	3.6	-	15	0.06

TABLE 5-3

METALS AND PHOSPHATE ANALYSES ON TREATED SAMPLES

Sample (Sample Code)	Treatment	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Hg (ug/l)	Zn (ug/l)	Total P (ug/l)
SW-4 (WBCS-13)	No pH adjustment (pH 7.5) 20 mg/l alum; 2 mg/l flocculant (replicate of WBCS-05)	0.005	0.01	0.01	0.0002	0.01	0.01
SW-4 (WBCS-14)	Duplicate (split) of WBCS-13	0.005	0.01	0.01	0.0002	0.01	0.02

The PCB concentration of the perched water will depend on the adsorption and leaching of Aroclor 1254 from soil to water and the dispersal of suspended solids through water. Laboratory tests indicate that Aroclor 1254 is adsorbed most efficiently on soils with a high organic content and small particle size (e.g., clays) (Reference 2) PCBs are strongly adsorbed to sediment and their fate and transport in water depends on the movement of the sediment (Reference 2).

The partitioning of PCB between the dissolved and particulate phase is governed by physical/chemical properties of the sorbent and sorbate. For the sorbent, organic adsorption increases with decreasing particle size and increasing organic content. Thus, the partition coefficient K_p for a specific sediment-water system is obtained by modifying the organic carbon - water partition coefficient by the fractional organic content of the sediment (sorbent) to yield:(Reference 3)

K_p = K_{ow} (octanol-water partition coefficient) x OC (% of organic content)

Studies of PCB sediments in the Great Lakes (Reference 4) has developed the following statistical equation showing the PCBs distribution in sediments which may be used here for comparison purposes.

$$C_d = \frac{C_p}{K_p \cdot SS}$$

K_p = partition coefficient (distribution coefficient) (l/mg)
C_p = particulate PCB concentration (ug/l)
C_d = dissolved PCB concentration (ug/l)
SS = suspended solids concentration (mg/l)

The calculation of C_d for the treatability testing samples are as follows:

Sample	K_{ow} l/mg	OC ----	K_p l/mg	C_p ug/l	SS mg/l	C_d ug/l
SW-4	0.53	0.0238	0.013	16	1090	1.1
Comp-1	0.53	0.0238	0.013	16	2160	0.6

Based on the above calculations, only 0.6 to 1.1 ug/l Aroclor 1254 would be expected to be dissolved in the perched water. These calculated dissolved PCB concentrations generally agree with the pretreatment test results that PCB concentrations less than 1 ug/l are achievable if the suspended solids concentrations are reduced to low levels.

6.1 PHASE I PRETREATMENT TESTS

The results of the pretreatment tests showed that for all three water samples tested, PCB concentrations vary with suspended solids concentrations.

The results of the Phase I tests confirm that most of the PCBs are adsorbed to the solids and are removed to below the target level of 1 ug/l when the solids are removed. Table 6-1 summarizes the test results. The treated water contains PCB below 1 ug/l level, TSS below 15 mg/l, oil and grease below 3.0 mg/l and iron below 0.3 mg/l.

As a result of these pretreatment tests it was concluded:

- that the Phase II and Phase III carbon adsorption tests were not needed.
- that the perched water requires only suspended solids removal to remove PCB to acceptable levels.

7.0 CONCLUSIONS

1. Treatment of the perched water by chemical coagulation, flocculation and sedimentation achieved PCB concentration reduction from 16 ug/l to less than 1 ug/l.

2. The physical/chemical properties of PCB Aroclor 1254 including low solubility and high organic carbon-water partition coefficient support the treatability study results.

3. If treatment of perched water was to be implemented, the treatment process most applicable for PCB removal would be chemical coagulation with alum and polymer at approximate dosages of 20 mg/l and 2 mg/l, respectively, flocculation and sedimentation. Carbon adsorption would not be required except possibly as a polishing step for other organic chemicals, if present.

TABLE 6-1

PRETREATMENT TREATABILITY TEST RESULTS

Sample	Treatment	PCB (ug/l)	TSS (mg/l)	Oil & Grease (mg/l)	Iron (mg/l)	TDS (mg/l)
SW-4	1. Before Treatment	16	1090	<3.0	0.49	460
	2. Centrifuge	<1.0		-		
	3. Add 20 mg/l Alum, 2 mg/l Polymer, No pH Adjustment	<1.0	5	<3.0	0.12	
Comp-1	1. Before Treatment	16	2160	<3.0	0.16	530
	2. Add 20 mg/l Alum, 2 mg/l Polymer, No pH Adjustment	<1.0	14	<3.0	0.16	
Comp-2	1. Before Treatment	<1.0	159	<3.0	0.26	520
	2. Add 25 mg/l Alum, 1 mg/l Polymer, No pH Adjustment	<1.0	11	<3.0	0.06	
Spike-1	1. Before Treatment	27	720	-	9.4	-
	2. Centrifuge	<1.0	1.0	-	0.16	
	3. Add 20 mg/l Alum, 2 mg/l Polymer, No pH Adjustment	<1.0	6	-	0.10	
Spike-2	1. Before Treatment	47	466	-	2.5	480
	2. Centrifuge	<1.0	<1.0	-	0.07	
	3. Add 20 mg/l Alum, 2 mg/l Polymer, No pH Adjustment	1.0	15	-	0.06	

8.0 REFERENCES

1. "Aqueous Solubility, Adsorption, and Vapor Behavior of Polychlorinated Biphenyl Aroclor 1254" Rizwanual Hague, etc., Environmental Science & Technology, Volume 8, Number 2, February 1974.

2. "Criteria Document for PCBs" Mass Audubon Society prepared for EPA, U.S. Department of Commerce, PB-255-397, July 1976.

3. "PCB Dynamics in Lake Superior Water" S.J. Eisenreich, etc., Physical Behavior of PCBs in the Great Lakes, Ann Arbor Science, 1980.

4. "Dynamic Mass Balance of PCB and Suspended Solids in Saginaw Bay - A Case Study," W.L. Richardson, etc. Physical Behavior of PCBs in the Great Lakes, Ann Arbor Science, 1980

9.0 APPENDIX A

Hydrogeology of Sewer Trench

Recharge to the sewer trench occurs via the bedrock in two areas. The first area is located between wells SW-5 and SW-4. The second area is located in the vicinity of well SW-3. The sewer trench lies directly in fractured shale. Groundwater in the fractured shale is essentially confined with an upward gradient into the pea gravel of the sewer trench.

Once the sewer trench is filled with water, flow into the trench ceases to be in an upward direction and the system is at equilibrium. At this point, flow assumes a horizontal direction and would conform to the site specific flow direction.

As shown in Figure 2-1, surface recharge to the sewer trench occurs along South Street where the sewer trench is located directly under the drainage ditch. This is most likely the primary cause of the perched water in the sewer trench east of well SW-4. Based on hydraulic gradients in this area, groundwater flow direction in this area would flow towards well SW-4.

Hydraulic conductivities within the sewer trench range from 5.7 (10^{-4}) to 4.7 (10^{-3}) cm/sec based on slug tests performed on wells SW-3 and SW-4 respectively. Slug tests were also performed on bedrock wells MW-6 and OW-3 with hydraulic conductivity ranging from 8.1 (10^{-6}) cm/sec to 3.4 10^{-4}) cm/sec respectively.

A maximum gradient in the trench of 0.002 was calculated from water level data in wells SW-5 and SW-4. Assuming a porosity of 0.30 within the pea gravel and hydraulic conductivity measurements within the trench, a groundwater velocity of between 30 to 300 ft/year could be calculated. Slug tests performed in the bedrock aquifer indicate flow velocities on the order of approximately 1 foot/year although flow through fractures in the bedrock would conceivably yield much greater flow velocities in the order of feet per day. It is difficult to determine groundwater flow velocities transverse to where the trench is cut into the bedrock, although the fact that the trench was filled with water during construction, indicates high flow rates in this area.

The hydraulic conductivities were determined by the Bouwer-Rice Method where

$$K = \frac{r_c^2 \, (\ln r_e/r_w) \quad (\ln y_o/y_1)}{2 \quad L_e \quad t}$$

and where:
r_c is radius of the well casing
r_e is effective radius of the well
r_w is radius to the sand pack or trench
y_o is displacement at time, $t = 0$
y_t is point of displacement
L_e is length of well screen
t is time of displacement

$$\ln re/rw = \frac{1}{\frac{1.1}{\ln L_w/r_w} + \frac{C}{L_e/r_w}}$$

and where:
L_w is length of static water column
C is a dimensional parameter relating to L_e/r_w

The data is shown in Table A-2, Slug Test Variables.

(Bouwer, H., and R. C. Rice, 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resour. Res. 12: 423-428)

TABLE A-1

SLUG TEST RESULTS

Well No.	Hydraulic Conductivity - K
MW-6	3.4 (10^{-4}) cm/sec
OW-2	8.1 (10^{-6}) cm/sec
SW-3	5.7 (10^{-4}) cm/sec
SW-4	4.7 (10^{-3}) cm/sec

TABLE A-2

SLUG TEST DATA

WELL NO.	L_w ft	r_w ft	C	L_e ft	ln $^{re}/_{rw}$	Y_o ft	Y_t ft	t sec	K cm/sec
MW-6	20	0.3	2.5	15	3.20	0.45	0.01	300	3.4 (10^{-4})
OW-3	21.25	0.3	2.5	15	3.24	4.94	4.9	60	8.1 (10^{-6})
SW-3	2.58	0.09	2.5	2.5	2.50	0.07	0.01	420	5.7 (10^{-4})
SW-4	6.38	0.10	1.95	2.5	2.92	0.14	0.02	60	4.7 (10^{-3})