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PLAN FOR DISCONTINUING

SANITARY SEWER DISCHARGES AT THE

REILLY TAR & CHEMICAL CORP. N.P.L. SITE

ST. LOUIS PARK, MINNESOTA

MARCH, 1990

Submitted By:

REILLY INDUSTRIES, INC.

Prepared By:

REMEDIATION TECHNOLOGIES, INC.

PLAN FOR DISCONTINUING SANITARY SEWER DISCHARGES

AT THE REILLY TAR & CHEMICAL CORP. N.P.L. SITE

ST. LOUIS PARK, MINNESOTA

Submitted To:

Regional Administrator
U.S. Environmental Protection Agency, Region V
and
Director
Minnesota Pollution Control Agency

Submitted By:

Reilly Industries, Inc.
and
Remediation Technologies, Inc.

MARCH, 1990

TABLE OF CONTENTS

NO.	DESCRIPTION	PAGE
1.0	INTRODUCTION	1
2.0	PROPOSED DISCHARGE PLAN	2
3.0	IMPLEMENTATION SCHEDULE	4
4.0	CESSATION CRITERIA	6

ATTACHMENT A: AGENCIES COMMENTS TO PLAN SUBMITTED IN NOVEMBER, 1989.

ATTACHMENT B: TREATABILITY STUDY REPORT FOR TREATMENT OF PUMPED GROUNDWATERS AT ST. LOUIS PARK, MINNESOTA

ATTACHMENT C: ENGINEERING EVALUATION REPORT FOR TREATMENT OF PUMPED GROUNDWATERS AT ST. LOUIS PARK, MINNESOTA

ATTACHMENT D: COPY OF THE NPDES PERMIT APPLICATION TO BE SUBMITTED TO THE MINNESOTA POLLUTION CONTROL AGENCY FOR TREATMENT OF PUMPED GROUNDWATERS FROM A ST. LOUIS PARK, MINNESOTA SITE

LIST OF TABLES

NO.	DESCRIPTION	PAGE
1	Comparison of Anticipated NDPES Discharge Limits and Current Source Control Well Discharge Concentrations	3
2	Tentative Implementation Schedule for Discontinuing Sanitary Sewer Discharges	5

1.0 INTRODUCTION

This Plan for Discontinuing Sanitary Sewer Discharges (Plan) is submitted to the U.S. Environmental Protection Agency (U.S. EPA) and the Minnesota Pollution Control Agency (MPCA) pursuant to Section 2.9 of the Remedial Action Plan (RAP) embodied in the Consent Decree in the case of the United States of America, et al. vs. Reilly Tar & Chemical Corporation, et al. (U.S. District Court, Minnesota, Civil No. 4-80-469). This Plan is a revision to the one submitted to the U.S. EPA and the MPCA in November, 1989 as it incorporates the comments received from these two agencies. Respective copies of the comment letters from both the U.S. EPA and the MPCA are given as Attachment A; a summary of responses to agencies comments is also provided.

Section 2.9 of the RAP addresses the planning and approval process required if Reilly Industries wishes "to change the discharge to the storm sewer or a surface water body of any source control or gradient control well that is required to be discharged to the sanitary sewer by the provisions of the RAP" (RAP pg. 9). In particular, this Plan describes the proposed construction and operation of a treatment plant that will allow the discharges from source control wells W23, W420, and W421 to be routed to a storm sewer that discharges to Minnehaha Creek. Well W23 is the Prairie du Chien-Jordan source control well installed by Reilly pursuant to RAP Section 7.1, and Wells W420 and W421 are the Drift and Platteville, respectively, source control wells installed by Reilly pursuant to RAP Section 9.1. All three source control wells currently are discharged to the sanitary sewer. Switching their discharges to the storm sewer is required by Paragraph 2(c) of the City/Reilly Agreement (which is incorporated in the Consent Decree) by September, 1990. Moreover, the sanitary sewer discharge permit for these wells expires at the same time.

2.0 PROPOSED DISCHARGE PLAN

Section 2.6 of the RAP specifies the discharge limits to be incorporated in the draft of any NPDES discharge permit that is needed as a result of a remedial action required by the RAP. These discharge limits are exceeded by the current discharges from each of the source control wells at issue (See Table 1). Reilly is proposing, therefore, to construct a single central treatment facility for treating the discharges from all three wells so that the treated effluent will meet the NPDES limits. The proposed treatment consists of oxidation/precipitation pretreatment for iron and manganese removal followed by activated carbon adsorption for removal of PAHs and phenolics.

The efficacy of the proposed treatment-scheme has been demonstrated by extensive laboratory and pilot-scale treatability testing conducted for Reilly by Remediation Technologies, Inc. (ReTeC). ReTeC's treatability study report is presented as Attachment B of this Plan. ReTeC's engineering evaluation report, which presents a conceptual design of the treatment plant and describes its operation, is presented as Attachment C of this Plan. Both of these reports constitute an integral portion of this Plan, and should be consulted for technical details. Specifically, Attachment C (Section 5.0) presents a proposed plan for operational and permit monitoring of the treatment system.

TABLE 1

COMPARISON OF ANTICIPATED NPDES DISCHARGE LIMITS AND CURRENT SOURCE CONTROL WELL DISCHARGE CONCENTRATIONS

	NPDES LIMITS[a]		CURRENT DISCHARGES[b]	
PARAMETER	DAILY MAX.	30-DAY AVG.[c]	W23	W420\W421[d]
(μg/l)				
Total Potentially Carcinogenic PAH	NA [e]	0.31 (0.07)[f]	0.57	0.03
Total Other PAH	34	17	365	849
Phenanthrene	2	1	23	9
Phenolics (4-AAP)	NA	10	10	30

Notes:

[a] Per RAP Section 2.6.

[b] Upper 95 percent confidence interval limit values per Table 3-2 in Attachment C.

[c] A yearly quarterly average may be imposed instead of a 30-day average.

[d] For flow-proportioned combined discharge.

[e] Not Applicable.

[f] Per December 19, 1989 comment letter from the MPCA as given in Attachment A.

3.0 IMPLEMENTATION SCHEDULE

The schedule for implementing treatment for Wells W23, W420, and W421 depends primarily on the time required to obtain the necessary NPDES permit. The objective is to have the treatment plant constructed and operating in September, 1990. This objective should be achievable if the NPDES permitting proceeds expeditiously, so that a permit can be issued six months after the application is made.

Table 2 presents a tentative schedule based on a six-month NPDES permitting period. Under this schedule, the treatment plant should be in place and operational by the end of September, 1990. The schedule is tentative because of uncertainties in Agencies review time and permitting times. As cited by the MPCA (see Attachment A), this schedule could be greatly extended due to requests for a public hearing, and if such a public hearing is granted. The fixed schedule items are submission of this Plan and submission of an NPDES permit application by December 1, 1989. The NPDES permit application has been made by the City of St. Louis Park. A copy of the permit application to be submitted is included as Attachment D of this Plan. The other fixed schedule item is submission of detailed design drawings and specifications for review and comment by the U.S. EPA, MPCA, and the City of St. Louis Park. This submission will be made by April 20, 1990. This schedule also assumes that all necessary local permits will be obtained as required.

Once the NPDES permit is granted and Agencies approval of the detailed design is obtained (i.e., June 1, 1990), Reilly will let bids for construction of the treatment plant, select a contractor and begin construction. The bidding process should take about one month. Construction is expected to take about three months, provided that the work is started sufficiently in advance of winter.

TABLE 2

TENTATIVE IMPLEMENTATION SCHEDULE FOR DISCONTINUING SANITARY SEWER DISCHARGES

ACTIVITY	APPROX. DATE
Submit Plan to U.S. EPA and MPCA	No. 21, 1989 *
Submit NPDES Permit Application to MPCA	Dec. 1, 1989 *
U.S. EPA/MPCA Comments on Plan	Feb. 22, 1990 *
Submit Revised Plan to U.S. EPA and MPCA	March 23, 1990 *
U.S. EPA/MPCA Approval of Plan	April 16, 1990
Submit Detailed Design for U.S. EPA, MPCA and City Review	April 20, 1990
U.S. EPA/MPCA/City Comments on Detailed Design	April 30, 1990
Final Detailed Design Drawings and Specifications	May 25, 1990
U.S. EPA/MPCA/City Approval of Detailed Design	June 1, 1990
Issuance of NPDES Permit (allowing 6 months)	June 1, 1990
Complete Bidding Process for Construction	July 1, 1990
Complete Construction of Treatment Plant	Sept. 30, 1990

Note:

* Activity Complete

4.0 CESSATION CRITERIA

Section 2.9 of the RAP requires that this Plan propose criteria by which it can be determined that treatment of the source control well discharges is no longer required. One obvious criterion is that treatment of a given well's discharge should not be required if the untreated discharge meets the criterion already established in the RAP for cessation of pumping (see RAP Sections 7.1.4 and 9.1.4). It is possible that a given well's discharge could meet the NPDES permit limits without treatment even though the cessation criterion for pumping has not been met (e.g., Well W23's untreated discharge could contain less than 17 μg/l but more than 10 μg/l total Other PAH).

On this basis, the proposed criteria for cessation of treatment for one or more of the source control Wells W23, W420, and W421 are as follows:

1. Treatment can be ceased for a given well if the untreated well discharge meets the criteria for cessation of pumping established by the applicable section of the RAP (§7.1.4 or §9.1.4).

2. Treatment of all three wells can be ceased if statistical evaluation of six months of monitoring data shows that the combined discharge of all three wells will meet the NPDES limits without treatment. This statistical evaluation will be based on the upper 95 percent confidence interval of six samples of the combined influent flow over a six-month period. This also applies to the case of ceasing only the activated carbon treatment but continuing the iron/manganese removal pretreatment (e.g., if the PAH and phenolics limits can be met without treatment but iron and manganese levels are too high).

Any request for cessation of treatment will be submitted to the U.S. EPA and MPCA for review and approval (or disapproval) in accordance with Part G of the Consent Decree.

ATTACHMENT A

ATTACHMENT A

AGENCIES' COMMENTS TO PLAN SUBMITTED IN NOVEMBER, 1989

ATTACHMENT A-1

DECEMBER 19, 1989 LETTER BY MR. DAVID R. NELSON OF THE MPCA TO MR. JOHN C. CRAUN OF REILLY; SUMMARY OF REILLY'S COMMENTS TO LETTER ALSO INCLUDED.

ATTACHMENT A-2

FEBRUARY 22, 1990 LETTER BY MR. DARRYL OWENS OF THE U. S. EPA AND MS. JULIE SHORTRIDGE OF THE MPCA TO MR. JIM BRATINA OF REILLY; SUMMARY OF REILLY'S COMMENTS TO LETTER ALSO INCLUDED.

ATTACHMENT A-1

DECEMBER 19, 1989 LETTER BY MR. DAVID R. NELSON OF THE MPCA TO MR. JOHN C. CRAUN OF REILLY; SUMMARY OF REILLY'S COMMENTS TO LETTER ALSO INCLUDED.

Minnesota Pollution Control Agency
520 Lafayette Road, Saint Paul, Minnesota 55155
Telephone (612) 296-6300

Celebrate MINNESOTA 1990

December 19, 1989

Mr. John C. Craun, P.E.
Senior Engineer
Corporate Environmental Affairs
Reilly Industries, Inc.
1500 South Tibbs Avenue
P.O. Box 41076
Indianapolis, Indiana 46241

Dear Mr. Craun:

We have reviewed the plan which was submitted November 21, 1989, for discontinuing the sanitary sewer discharges at the Reilly Tar and Chemical Corporation N.P.L. site in St. Louis Park, Minnesota. We have the following comments on this plan.

As discussed during the November 29, 1989 meeting, we will not allow the blending of treated water with untreated water as a means of achieving the final effluent limits. This was proposed as the second option for ceasing treatment of a given well on page 3 of the report. A 90 percent confidence interval is proposed in the report for determining whether effluent limits are being met. This would not provide adequate assurance of environmental protection. We typically use a 95 percent confidence interval for evaluation of effluent data. The first and the third cessation criteria are acceptable.

Regarding the anticipated NPDES limits on page 5 of the report, the limit for total carcinogenic PAH will likely be 0.07 ug/L, not 0.31 ug/L. This change is the result of a change in the amount of fish consumption that is assumed in calculating the effluent limit. I am anticipating the there will be an iron limit of 1 mg/l.

There will need to be more discussion on what an appropriate monitoring frequency is for this discharge. My initial thoughts are that it will be most appropriate to have internal monitoring between the carbon columns as part of the monitoring program to more accurately determine when breakthrough occurs. This monitoring could be less frequent for the initial life of the column and more frequent as it approaches the anticipated breakthrough. The need for internal monitoring will decrease after the first two or three times that carbon columns have been switched.

The final effluent monitoring will be more constant over the life of the permit. With potentially carcinogenic chemicals, chronic exposure is typically considered in setting any limitation. I am currently planning to require one HPLC test per month, with a quarterly average limitation instead of a 30-day

average. We also want to avoid gross exceedances of this limit, therefore a daily maximum will also be imposed that is somewhat higher than the quarterly average.

As discussed, the schedule on page 6 of the report could be delayed due to requests for a public hearing. If a public hearing is granted, the delays could be extensive.

You may also want to contact the Department of Natural Resources to insure that they do not have any permit requirements for the discharge of additional water to Minnehaha Creek.

On page 41 of the Appendix there is a comment that the naphthalene concentrations in the influent tank varies somewhat. This is an understatement in that the concentrations in Table 5-5 on page 39 vary by an order of magnitude. There is a similar level of variability in the concentrations listed for the sand filtration effluent on page 40. Do you have any explanation for this variation? Considering the magnitude of the variation it may be more appropriate to use a more conservative design parameter than the average concentration for estimating the carbon exhaustion rates.

I disagree with the conclusions that are reached on page 45 with respect to the carbon breakthrough. I believe that breakthrough occurred at week 17. Based on the use of the Freundlich equation with the parameters specified in the EPA Treatability Manual, EPA-600/2-82-001a, page I.10.15-2, the carbon consumption can be estimated to be 0.189#/1000 gallons to achieve a final effluent concentration of 0.017 mg/L total PAH. This appears to agree with my interpretation of the data from the pilot study, since this carbon consumption rate would correspond to breakthrough at week 19. The variability in the naphthalene concentration could easily account for the sooner than expected breakthrough if the actual influent concentrations were slightly higher than the measured average.

The discussion that the first column is still removing up to 90 percent of the influent naphthalene at week 30 does not mean that breakthrough has not occurred since the point of breakthrough is not the same as the point of carbon exhaustion. Please note the attached diagram which differentiates between the two events.

I do not necessarily disagree that the first column should be left on line for some period of time after breakthrough occurs to more fully use the carbon. However, it should be noted that the second column will begin to adsorb pollutants immediately after breakthrough, and will thus be used up faster than would be assumed if this were not taken into consideration. An appropriate operation and maintenance plan will be essential to the effectiveness of this treatment system. This plan should consider the implications of influent PAH concentrations that may be higher than the average recorded for the pilot study. It should also explain what will be done with the spent carbon.

My general comment on the plan is that it is not conservative enough in its estimation of the carbon exhaustion rates and that this may cause operability problems later. You may wish to consider designing the system with a third carbon column or alternatively designing the building such that an additional column can be added later. This would also provide additional assurance of adequate treatment.

If you have questions or comments regarding any of the issues raised in this letter, please feel free to contact me at (612) 296-7355.

Sincerely,

David R. Nelson, P.E.
Regulatory Compliance Section
Division of Water Quality

DRN:ls

Enclosure

cc: Jim Grube, P.E., Director of Public Works, St. Louis Park
John R. Smith, Ph.D., RETEC, Pittsburg
William M. Gregg, ENSR Consulting and Engineering, St. Louis Park

SUMMARY OF RESPONSES TO AGENCIES' COMMENTS

Plan For Discontinuing the Sanitary Sewer Discharges at the Reilly Tar and Chemical Corporation N.P.L. Site in St. Louis Park, Minnesota

I

Responses to December 19, 1989 letter by Mr. David R. Nelson of the Minnesota Pollution Control Agency

(NOTE: Responses are given in the same order as presented in the letter.)

Page 1 - ¶ 2

The second option for ceasing treatment has been eliminated and a 95 percent confidence interval will be used for determining whether effluent limits are being met.

Page 1 - ¶ 3

The report has been changed to reflect the lower total potentially carcinogenic PAH NPDES limit of 0.07 μg/L along with the previous limit of 0.31 μg/L.

Page 1 - ¶ 4 and 5

Section 5.0 of the *Engineering Evaluation Report* (Attachment C) specifically addresses the issues raised and the changes recommended.

Page 2 - ¶ 1

This comment is now mentioned as part of the discussion related to the schedule.

Page 2 - ¶ 2

Even though there is some variation associated with naphthalene, the carbon column influent average value of 5411 μg/L does represent the mean loading applied, and thus should be representative. Using a higher value would only serve to make the carbon adsorptive capacity for naphthalene be higher than the cited value of 0.047 lb. naphthalene/lb. carbon.

Page 2 - ¶ 3

This comment is noted.

Page 2 ¶ 4

Following the procedure outlined by Metcalf and Eddy along with U.S. EPA [2] isotherm data, an influent naphthalene concentration of 541 μg/L applied at a flowrate of 140 gpm corresponds to a carbon consumption rate of 0.044 # carbon/1000 gallons. This is approximately half of the value of 0.096 # carbon/1000 gallons based on treatability study results and much less than the value of 0.189 # carbon/1000 gallons cited in the MPCA's letter. Thus, the carbon usage rate cited in the Plan and naphthalene is valid.

Page 2 - ¶ 5

This issue has been clarified in the report. Specific reference should be given to Figure 6-3 in the *Treatability Study Report* (Attachment B).

Page 2 - ¶ 6

Section 5.0 of the *Engineering Evaluation Report* (Attachment C) specifically addresses these comments and details an operation and maintenance plan. Additionally, this section also states that spent carbon will be removed and regenerated by a contracted carbon supplier.

Page 3 - ¶ 1

Based on the responses given under Page 2 - ¶ 4, it is felt that a third in-series carbon column is not required.

REFERENCES

[1] Metcalf & Eddy, Inc. Wastewater Engineering: Treatment/Disposal/Reuse, 2nd Edition, McGraw-Hill Book Company, New York, 1979.

[2] U.S. EPA, Office of Research and Development, "Treatment Manual - Volume 1, Treatability Data," U.S. EPA Document No. EPA-600/2-82-001a, U.S. Government Printing Office, Washington, D.C., September, 1981.

ATTACHMENT A-2

FEBRUARY 22, 1990 LETTER BY MR. DARRYL OWENS OF THE U. S. EPA AND MS. JULIE SHORTRIDGE OF THE MPCA TO MR. JIM BRATINA OF REILLY; SUMMARY OF REILLY'S COMMENTS TO LETTER ALSO INCLUDED.

Minnesota Pollution Control Agency
520 Lafayette Road, Saint Paul, Minnesota 55155
Telephone (612) 296-6300

Celebrate MINNESOTA 1990

February 22, 1990

Mr. Jim Brettina
Reilly Industries
1510 Market Square Center
151 North Delaware Street
Indianapolis, IN 46204

Dear Mr. Brettina:

Staff at the U.S. Environmental Protection Agency and Minnesota Pollution Control Agency (Agencies) have reviewed Reilly's plan for treating and discharging to surface water effluent from Wells W23, W420 and W421, thereby discontinuing the present effluent discharges to the sanitary sewer system. The Agencies have the following comments on the plan.

1) Water from Well W23 was not used in the pilot study because of the difficulty in transporting water to the pilot unit. It was also concluded that since all three wells contained the same PAH's, the fact that Well W23 would not be tested was not significant. However, as noted in Table 4-3, an HPLC analysis of Well W23 indicated .57 ug/l of potentially carcinogenic PAH while the other wells had no readings. Since Well W23 was not tested, can it be concluded that potentially carcinogenic PAH's would also be removed to the NPDES discharge limit?

2) During the pilot study several parameters were measured in order to provide adequate treatment. These parameters have been modified in the full scale system. It was unclear in the Report as to why the parameters were modified. Please explain the following modifications:

   a) Table 3-3 Appendix B
   The dosage for $KMnO_4$ in the pilot study was measured to be 9.2 mg/1. The calculated value for the full scale system is to be 2.4 mg/1. Is the 2.4 mg/1 for the full scale system realistic in light of the fact that 9.2 mg/1 was required for adequate treatment in the pilot study?

   b) Table 3-3 Appendix B
   The mesh size for the activated carbon system in the pilot study was 12x40 while the mesh size of the carbon system in the full scale system will be 8x30. Please explain what impact of this modification will be.

   c) The superficial flow rate in the pilot study was measured at 2.9 gpm/ft^2. The design for the full scale system is to be 4.95 gpm/ft^2. Will the modification impact the treatment of the activated carbon filter system and also impact the time frame at which the contaminants will break through the carbon system?

d) Appendix B Page 33
Please clarify why the activated carbon units 1 and 2 are shown to be 10,000 lbs/unit while previous comments in the Report indicate they will be 5,000 pounds per unit.

e) Appendix C Page 4
The Dynasand system has a flow through rate of 39 gpm with an 8 gpm reject stream. The reject stream measured in this pilot study is 20% of the processed water. Why then on page 33, table 4-1 is an estimate of 7% reject water used for the design?

3) The following questions and comments regard the operational mode of the proposed system.

a) Please explain the operation mode of switching the flow to the lead carbon cell every 6 months and changing the carbon in the lead carbon cell every 10 months.

b) Appendix B Fig. 4-1
The piping system shown only allows parallel operation. Please indicate the modifications which will be done to allow series operation.

c) Appendix B Fig. 4-1
Some mechanism should be used to allow flow to be diverted to the backwash system instead of discharging directly to the storm sewer.

d) In order to continue the pump out system during a complete failure of the carbon treatment system, pipe may be added to allow a bypass of the carbon system and disposal into the sanitary sewer system.

e) Appendix B Page 32
Please clarify whether the activated carbon columns will be operated in series as stated on this page or in the parallel as shown in Fig. 4-1.

f) Appendix B Page 33
The in-line static mixer should be rated for 145 gpm to allow the backwash water of 5 gpm to be bled back into the system.

g) Will the system be operated on a constant flow basis to increase the life of the carbon filtration system?

The Agencies look forward to receiving a more detailed design for our review which will include clarification of the above issues.

Sincerely,

Darryl Owens

Darryl Owens
Remedial Project Manager
U.S. Environmental Protection Agency

Julie Shortridge

Julie Shortridge
Project Manager
Minnesota Pollution Control Agency

cc: John Smith, Retec
Jim Grube, City of St. Louis Park

DO/kn

Responses to February 5, 1990 letter by Ms. Julie Shortridge of the MPCA to Mr. Jim Bratina of Reilly Industries, Inc.

(NOTE: Responses appear in the same order as presented in the letter.)

No. 1

A sand filtration/activated carbon pilot system was set up to treat a flow proportioned side stream from wells W420 and W421 at the St. Louis Park site. Groundwater from well W23 was not included in the pilot program because it would have been too difficult to transport water from the location of W23 to the location of W420/W421 where the pilot-scale unit was set up. This is not a significant issue since all three wells contain the same PAHs plus the fact that the respective chemical concentrations of W23 are generally an order of magnitude lower than W420 and W421. Thus, the worst case groundwater was tested during the pilot work. This contention is also valid in light of the fact that well W23 groundwater analysis performed as part of the initial characterization work (See Table 4-3) did show detectable concentrations (by HPLC) of some individual Potentially Carcinogenic PAHs in the fraction of the part per billion (ppb) level while sample analysis from wells W420 and W421 did not show any detectable concentrations. It is felt that this very low level of Potentially Carcinogenic PAHs will be sufficiently removed by activated carbon treatment when W23 groundwater is treated jointly with groundwater from wells W420 and W421. Even though groundwater from well W23 was not used in the pilot-scale treatability work, it should be noted that the Potentially Carcinogenic PAHs, which are relatively insoluble compared to the other PAH compounds, are greatly adsorbed onto carbon to a much greater degree than the Other PAH compounds measured in wells W420 and W421. This fact is supported by published isotherm data and theory [2]. Such references cite that of the St. Louis Park PAH list, carbon usage will be determined based upon naphthalene adsorption. Naphthalene is the PAH compound present in the highest concentration in all three wells and is also the PAH compound which is expected to first be detected in the carbon column effluent with all of the other PAHs not being detectable. The Potentially Carcinogenic PAHs will be the very last to be detected in the effluent if allowed. However, this is not expected to occur based upon the fact that a particular carbon column will be replaced once it is exhausted for either naphthalene or phenolics, which ever occurs first. Exhaustion is defined as where the effluent concentration equals the influent concentration. Additionally, once W23 groundwater is added to flows from W420 and W421, the total Potentially Carcinogenic PAH concentration in the combined flow will be near 0.024 μg/L as cited in Table 4-7 of the *Treatability Study Report* (Attachment B). This is below the anticipated permit requirement range of 0.07 to 0.31 μg/L average. Thus, the fact that W23 groundwater was not used in the pilot work should not be an issue.

No. 2a

This was an error in the report. The dosage of $KMnO_4$ used in the pilot study was 3.1 mg/L which corresponds to a $KMnO_4$:Fe dose of 1.16 mg:1 mg and a $KMnO_4$:Mn dose of 2.16 mg:1 mg. These ratios are very close to the 1:1 and 2:1 ratios respectively used for Fe and Mn in the full-scale design.

No. 26

Even though the available adsorptive surface area for these two mesh sizes are basically the same, the full-scale system will use 12 x 40 mesh size as was used in the pilot work.

No. 2c

The difference in superficial flowrates between that used in the pilot-scale work was that proposed for the full-scale design should not impact the carbon usage projected for the full-scale system. This is because of the fact that the first in-series pilot-scale carbon column on which carbon usage estimates are based operated at an empty bed contact time (EBCT) of 7.5 minutes. This is the dame EBCT designed for each of the two column in the full-scale system. Stated another way, the first in-series pilot-scale column has a carbon bed depth of three feet and the full-scale first in-series column will have a carbon bed depth of five feet. Thus, the difference in hydraulic loadings is off-set by the difference in bed depths in terms of affecting carbon usage.

No. 2d

This was an error, the full-scale carbon process will be comprised of two (2) 5,000 lb. carbon units operated in-series.

No. 2e

At an influent flowrate of approximately 39 gpm, the backwash flowrate is approximately 8 gpm, or approximately 21 percent of the applied flow. For a full-scale process treating 140 gpm, the backwash flow would be approximately 10 gpm, or 7 percent of the applied flow. The reason for these two different backwash flowrates being approximately the same with different applied flowrates is because the backwashing mechanism in any DynaSand filter is basically the same, regardless of unit size, and will require approximately the same backwash rate.

No. 3a

This is a misunderstanding. Switching the flow pattern will be done concurrently with changing of a carbon column so that the most recently replaced carbon is in the second in-series column. This will insure that the final column has adequate adsorptive capacity for polishing purposes.

No. 3b

Figure 4-1 of the *Engineering Evaluation Report* (Attachment C) has been changed to show series operation along with the capability of switching flow direction. It should be noted that Figure 4-1 is not intended to serve as a process & instrumentation diagram (P&ID) but rather as a conceptual schematic. Some of the comments infer that the reviewers may view Figure 4-1 as a P&ID drawing. Such detail will be given in the process design report.

No. 3c

Figure 4-1 of the *Engineering Evaluation Report* (Attachment C) has been changed to show this.

No. 3d

This recommended change has been implemented with emergency by-passing of either the chemical oxidation/sand filtration process or the carbon adsorption process into the sanitary sewer available.

No. 3e

The carbon adsorption process will be operated in series.

No. 3f

The in-line static mixer will be rated for 145 gpm.

No. 3g

Baring upset conditions or backwashing of the carbon process, it is anticipated that the treatment system will be operated continuously.

REFERENCES

[1] Metcalf & Eddy, Inc. Wastewater Engineering: Treatment/Disposal/Reuse, 2nd. Edition, McGraw-Hill Book Company, New York, New York, 1979.

[2] U.S. EPA, Office of Research and Development, "Treatability Manual - Volume 1, Treatability Data", U.S. EPA Document No. EPA-600/2-82-001a, U.S. Government Printing Office, Washington, D.C., September, 1981.

TREATABILITY STUDY REPORT FOR

TREATMENT OF PUMPED GROUNDWATERS

AT ST. LOUIS PARK, MINNESOTA

Prepared For:

REILLY INDUSTRIES, INC.
1500 South Tibbs Avenue
Indianapolis, IN 46421

Prepared By:

REMEDIATION TECHNOLOGIES, INC.
3040 William Pitt Way
Pittsburgh, PA 15238

(ReTeC Project No. E90-352-300)

MARCH, 1990

TABLE OF CONTENTS

NO.	DESCRIPTION	PAGE
EXECUTIVE SUMMARY		v
1.0	INTRODUCTION	1
2.0	BACKGROUND	3
3.0	STUDY OVERVIEW	8
3.1	Treatability Studies	8
3.2	Project Personnel	10
3.3	Analytical Testing	10
3.4	QA/QC Procedures	12
4.0	LABORATORY TESTING	13
4.1	Initial Characterization	13
	Procedures	13
	Results and Discussion	13
4.2	Pretreatment Evaluation	18
	Procedures	18
	Results and Discussion	21
4.3	Accelerated Column Testing	21
	Procedures	21
	Results and Discussion	23
5.0	ONSITE PILOT-SCALE STUDY	27
5.1	Pilot-Scale Unit Description	27
5.2	Operation and Monitoring	32
	Daily Monitoring and Maintenance	32
	Pretreatment	36
	Carbon Column Breakthrough Monitoring	36
	NPDES Permit Sampling	36
	Sand Filter Backwash Monitoring	37

TABLE OF CONTENTS

CONTINUED

NO.	DESCRIPTION	PAGE
5.3	Results and Discussion	37
	Daily Monitoring	37
	Pretreatment	38
	Carbon Column Breakthrough Monitoring	42
	NPDES Permit Sampling	50
	Sand Filter Backwash Monitoring	55
6.0	DISCUSSION	58
6.1	Comparison of PAH Analysis by Different Methods	58
6.2	Engineering Design Issues	60
	Chemical Oxidation/Sand Filtration Pretreatment	60
	Activated Carbon Treatment	62
6.3	Permitting Considerations	71
7.0	SUMMARY AND CONCLUSIONS	74
	REFERENCES	76

APPENDIX A - Analytical Parameter List, Methods and Detection Limits

APPENDIX B - Raw Analytical Data

APPENDIX C - ReTeC's Standard Operating Procedures

APPENDIX D - Calgon's Act Evaluation Report

APPENDIX E - Priority Pollutant Results

LIST OF TABLES

NO.	DESCRIPTION	PAGE
2-1	Average Background Water Quality Data of Well Discharge	4
2-2	Average Flow for Well Discharges	6
3-1	Treatability Testing Chronological Overview	9
3-2	Analytical Parameter Categories	11
4-1	Characterization Results for SLP-PAH List	14
4-2	Initial Characterization Results of Conventional/Metal/Nutrient Analyses	15
4-3	Initial Characterization Results for PAH Comparison by HPLC and GC/MS	17
4-4	Filtration Media Characterization Summary	20
4-5	Comparison of Sand Filtration Runs for Different Media	22
4-6	Two Well Composite Sample Results	24
4-7	Three Well ACT Composite Sample Results	25
5-1	Summary of Groundwater Volume Treated at Respective Sampling Dates	33
5-2	Pilot-Scale Testing Analytical Sampling Schedule	34
5-3	Pilot-Scale Testing Operational Monitoring Sheet	35
5-4	Summary of Daily Monitoring Parameters	39
5-5	Influent Tank (INFTNK) Sampling Results	40
5-6	Sand Filtration Column Effluent (SFCEFF) Sampling Results	41
5-7	Activated Carbon Column 1 Effluent (AC1EFF) Sampling Results	46
5-8	Activated Carbon Column 2 Effluent (AC2EFF) Sampling Results	47
5-9	Activated Carbon Column 3 Effluent (AC3EFF) Sampling Results	48
5-10	NPDES Permit Sampling Results for Conventional/ Nutrients/Metals/PAHs by HPLC	51
5-11	NPDES Permit Sampling Results for SLP-PAH	52
5-12	NPDES Permit Sampling Results for Priority Pollutants	53
5-13	Dissolved Oxygen (D.O.) Sampling Results Across the Carbon Column Pilot-Scale System	56
5-14	Sand Filter Backwash Water Sampling Results	57
6-1	Comparison of HPLC and GC/MS Methods for PAH Monitoring Purposes	59
6-2	Pilot-Scale Operation Generated Design Parameters	61
6-3	Statistical Compilation of Iron and Manganese Groundwater Concentrations	63
6-4	Statistical Compilation of Column 1 Influent (SFCEFF) Sampling Results	70

LIST OF FIGURES

NO.	DESCRIPTION	PAGE
5-1	Pilot-Scale Sand Filtration/Activated Carbon Treatment System Schematic	29
5-2	Grain Size Distribution Graph of Sand Media in Pilot-Scale Filtration Column	31
5-3	Iron Concentrations of Sand Filter Influent and Effluent	43
5-4	Manganese Concentrations of Sand Filter Influent and Effluent	44
5-5	Total PAH Concentrations of the Sand Filter Influent and Effluent	45
6-1	Comparison of Influent and Effluent Naphthalene Concentrations for Carbon Column 1	64
6-2	Comparison of Influent and Effluent Phenolic Concentrations for Carbon Column 1	65
6-3	Schematic Representation of the Movement of the Carbon Adsorption Zone and the Resulting Breakthrough Curve	67

EXECUTIVE SUMMARY

Remediation Technologies, Inc. (ReTeC) has been contracted by Reilly Industries, Inc. (Reilly) to evaluate activated carbon column treatment of pumped groundwaters from a former wood treating and coal tar refining site located in St. Louis Park, Minnesota, which is a superfund site. A Remedial Action Plan (RAP) embodied within a Consent Decree (CD) among Reilly, the City of St. Louis Park (City), the Minnesota Pollution Control Agency (MPCA) and the U.S. Environmental Protection Agency (U.S. EPA) provides requirements for remedial action of site groundwaters.

As part of an agreement between Reilly and the City, which is a part of the Consent Decree, Reilly must, by September, 1990, provide sufficient treatment of three separate source and gradient control well discharges to permit their routing to storm sewers which ultimately discharge into Minnehaha Creek. These three wells are designated as W23, W420, and W421. Presently, these well discharges are being routed into the Minneapolis/St. Paul Metropolitan sanitary sewer system without any treatment. For storm sewer discharge, specific water quality limits to comply with National Pollution Discharge Elimination System (NPDES) permitting requirements are proposed in the Consent Decree. Site chemicals-of-interest given focused attention in these requirements are phenolics (4-AAP) and thirty specified polynuclear aromatic hydrocarbons (PAHs) previously identified with the site groundwaters.

Activated carbon treatment is the method of choice for the well discharges. Even though activated carbon is a proven and generally accepted technology for treatment of site groundwaters, treatability testing was performed to provide information to evaluate certain outstanding technical and economic issues. Technical issues related to: (i) determining the need for iron and manganese removal via a pretreatment process, (ii) the extent to which site chemicals-of-interest are removed by the treatment system, (iii) identifying any potential operational issues associated with extended treatment, and (iv) identifying any additional control processes (e.g., pH control and backwash tanks) which may be needed. Economic issues relate to engineering design optimization of the treatment system in terms of associated capital and O&M costs. Such information relates

to: (i) generating representative carbon exhaustion rates, (ii) quantifying required empty bed contact times (EBCT), (iii) quantifying dosages of treatment chemicals if required, and (iv) establishing proper hydraulic loading rates.

To answer these questions, laboratory and on-site pilot-site testing was performed. The laboratory work was performed from December, 1988, through February, 1989, and focused on further groundwater characterization and pretreatment testing for iron and manganese reduction. Based on this preliminary work, it was determined that iron and manganese removal was needed and represented a very important design step prior to activated carbon column treatment. This is because it is highly likely that reduced iron and manganese species will be chemically oxidized in the activated carbon treatment system and precipitate out of solution, thus, fouling and plugging the carbon column. The reduced iron could also be microbially oxidized resulting in bacterial build-up within the column as well as iron precipitation. In addition to preventing plugging of the carbon columns, the total iron and manganese groundwater concentrations may require reductions to anticipated NPDES levels below 1 mg/L.

Based on the laboratory testing results performed, an onsite pilot-scale treatment system was designed, constructed and operated. The unit was operated from March 28, 1989, through October 17, 1989, and consists of the following sequential process components:

- Chemical oxidation with potassium permanganate,
- Anthracite/sand filtration via a downflow packed bed column, and
- Activated carbon column treatment via three downflow packed bed columns arranged in-series.

The potassium permanganate ($KMnO_4$) chemical oxidation/sand filtration pretreatment step proved to be very effective in reducing total iron and total manganese groundwater concentrations from above 1 mg/L to below 0.2 mg/L and 0.3 mg/L, respectively. Following this pretreatment step, activated carbon column treatment work quite well in terms of organics removal both technically and economically. In terms of NPDES permitting considerations, pilot-scale test results indicate that the final effluent

from a full-scale treatment system, comprised of sand filtration pretreatment and activated carbon treatment, should generally contain non-detectable PAHs at a reporting limit of 0.01 ug/L, less than 0.5 mg/L iron and manganese, non-detectable nutrients, a pH between 6 to 9, and near non-detectable conventional parameter (e.g., TOC, BOD_5) concentrations. Regarding economic issues, preliminary data puts carbon usage for the pilot unit somewhere between 0.096 and 0.133 lb. of carbon/1,000 gallons treated. The 0.096 usage rate corresponds to week 30 of operation and the 0.133 usage rate corresponds to week 22 of operation.

The results of the treatability work will serve as the primary engineering design of the full-scale treatment system. Specifics of the treatability work performed are documented in the following treatability report with the full-scale conceptual engineering design presented in an associated report.

This report incorporates comments received from the U.S. EPA and the MPLA to a draft report issued in November, 1989.

1.0 INTRODUCTION

Reilly Industries, Inc. (Reilly) contracted with Remediation Technologies Inc. (ReTeC) of Pittsburgh, PA to perform an engineering evaluation of alternative treatment systems for pumped groundwaters at a former wood treating and coal tar refining site located in St. Louis Park, Minnesota, which is a superfund site. A Remedial Action Plan (RAP) embodied within a Consent Decree (CD) among Reilly, the City of St. Louis Park (City), the Minnesota Pollution Control Agency (MPCA) and the U.S. Environmental Protection Agency (U.S. EPA) provides specific requirements for remedial action of site groundwaters.

The treatability work performed involved both laboratory bench-scale testing and on-site pilot-scale testing of sand filtration pretreatment followed by activated carbon column treatment. The sand filtration pretreatment step also involved chemical oxidation and subsequent precipitation of reduced iron and manganese prior to sand filtration. Such pretreatment was needed due to the fact that it is highly likely that reduced iron and manganese species will have been chemically oxidized and precipitated out of solution, thus, plugging the carbon column. The reduced iron could have also been microbially oxidized resulting in bacterial build-up within the column as well as resulting in iron precipitation. In addition to preventing plugging of the carbon column, the total iron and manganese groundwater concentrations may require reduction to anticipated NPDES levels below 1 mg/L. This work was performed to provide information to evaluate both the technical and economic issues associated with sand filtration/activated carbon treatment of pumped groundwaters for removal of coal tar related chemicals-of-interest (e.g., polynuclear aromatic hydrocarbons). Technical issues relate to determining the extent to which the various chemicals-of-interest are removed by the treatment system, along with evaluating potential operational issues associated with extended treatment such as column short circuiting, plugging and backwashing needs. Economic issues relate to generating engineering design information needed to optimize the treatment system in terms of cost considerations. Such information includes determining: (i) representative carbon exhaustion rates for the various chemicals-of-interest, (ii) proper hydraulic loading rates, and (iii) if any need exists for any ancillary equipment (e.g., pH control).

On the basis of the information presented in this report, it is concluded that a system comprised of sand filtration, in conjunction with potassium permanganate chemical oxidation, followed by activated carbon column treatment represents both a technically feasible and economically efficient solution for treatment of pumped groundwaters at the Reilly Industries, Inc. St. Louis Park site.

Specific areas related to the treatability work are addressed in the following respective sections. Section 2.0 provides background information associated with the project. Section 3.0 provides an overview of the treatability work performed. Section 4.0 details the procedures and results associated with the laboratory treatability work performed, and Section 5.0 does the same with regard to the onsite pilot-scale testing. Section 6.0 discusses the treatability testing results in terms of permitting and engineering design issues, and Section 7.0 presents the summary and conclusions. Results of the raw analytical data are given in the Appendices with respective statistical summaries of the data given in the text.

This document serves as a complimentary report to a conceptual design engineering report [1] and the State of Minnesota National Pollutant Discharge Elimination System (NPDES) permit application [2] prepared as part of the overall project related to implementing a system for treatment of source control well discharges at the St. Louis Park site.

2.0 BACKGROUND

The St. Louis Park, Minnesota site is a former wood treating and coal tar refining plant site previously owned and operated by Reilly Industries, Inc. (Reilly). Reilly is complying with various remedial action requirements for the site, which is a Superfund site. Under the terms of the RAP, Reilly installed five source and gradient control wells in 1987. These wells are now being operated by the City with discharges routed to sanitary sewers.

Under a separate agreement that is part of a Consent Decree (CD), Reilly has agreed with the City to provide sufficient treatment of the source and gradient control well discharges to permit their routing to storm sewers by September, 1990. Presently, five source and gradient control wells (W23, W105, W420, W421, W422) are being pumped into the Minneapolis/St. Paul Metropolitan sanitary sewer system without any treatment. Reilly anticipates discharge of well W422 effluent will be treated in conjunction with an adjacent St. Peter aquifer groundwater treatment system which will be installed by the City. Because of the relatively good and improving water quality of well W105, it is anticipated that pumping will be discontinued. As such, the focus of this study is on the remaining three wells (W23, W420, W421). Well W23 is located on Louisiana Avenue in a pumphouse located at the edge of an open park. Wells W420 and W421 are located in a single pumphouse situated in a light industrial area, approximately 1200 feet south of well W23, at the intersection of Louisiana Avenue and West Lake Street. The RAP specifies that W23 must pump 50 gpm for the Prairie du Chein/Jordon aquifer, and wells W420 and W421 must each pump 25 gpm from the Drift and the Platterville aquifers, respectively. Subsequent aquifer testing has shown that W420 must pump 40 gpm [3].

Under the terms of the RAP and the CD, discharge from these three wells (W23, W420, and W421) will be routed to storm sewers which ultimately discharge into Minnehaha Creek. As such, specific water quality limits must be met to comply with National Pollution Discharge Elimination System (NPDES) permitting requirements. On this basis, Reilly is assuming that the NPDES discharge concentration limits suggested in the RAP will be the treatment levels which must be met. Table 2-1 lists these anticipated

TABLE 2-1

AVERAGE BACKGROUND WATER QUALITY DATA OF WELL DISCHARGES

PARAMETER	TARGET NPDES DISCHARGE CONCENTRATIONS		PRAIRIE DU CHEIN/JORDAN W23 SCW DISCHARGE				DRIFT W420 SCW DISCHARGE				PLATTEVILLE W421 SCW DISCHARGE			
POTENTIALLY CARCINOGENIC (P.C.) PAH (ug/L)	DAILY MAX.	30 DAY AVG.[a]	#	AVG.	L95%	U95%	#	AVG.	L95%	U95%	#	AVG.	L95%	U95%
Quinoline			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Benzo(a)anthracene			1	0.235	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Chrysene			1	0.283	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Benzofluoranthenes			1	0.024	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Benzo(a)pyrene			1	0.028	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Indeno(1,2,3-cd)pyrene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Dibenzo(a,h)anthracene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Benzo(ghi)perylene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
TOTAL DETECTABLE P.C. PAH	NA	0.31 (0.07)[b]	1	0.570	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
OTHER PAH (ug/L)														
2,3-Benzofuran			4	6.5	0.0	13.6	7	41.8	19.8	63.8	4	2.6	0.3	4.8
2,3-Dyhydroindene			9	22.5	10.9	34.2	8	127.3	89.4	165.1	8	128.0	100.0	156.0
Indene			9	18.3	0.1	36.5	8	203.6	113.2	294.0	8	86.0	64.0	108.0
Naphthalene			10	66.1	23.2	109.0	9	1661.8	1034.6	2288.9	9	500.4	410.2	590.7
Benzo(b)thiophene			9	11.7	3.1	20.3	7	112.3	67.8	156.8	7	63.6	50.1	77.1
Indole			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
2-Methylnaphthalene			9	14.6	0.0	29.6	7	87.4	37.6	137.3	3	1.9	0.0	3.9
1-Methylnaphthalene			9	20.4	5.9	35.0	7	84.9	50.9	118.8	7	27.3	19.6	35.0
Biphenyl			9	6.2	2.4	9.9	6	18.6	11.7	25.5	3	3.3	1.3	5.4
Acenaphthylene			10	5.1	2.2	7.9	1	61.7	NA*	NA*	1	44.2	NA*	NA*
Acenaphthene			10	20.7	13.1	28.3	8	73.8	51.6	95.9	7	18.1	12.7	23.4
Dibenzofuran			9	10.5	4.3	16.6	7	27.0	18.4	35.6	3	2.9	0.3	5.5
Fluorene			10	14.4	9.6	19.1	8	21.7	14.0	29.4	5	3.7	2.2	5.2
Dibenzothiophene			6	1.4	1.1	1.7	2	1.8	0.0	5.4	1	100.0	NA*	NA*
Phenanthrene	2.0	1.0	10	16.8	10.5	23.0	6	9.8	4.8	14.8	3	1.3	1.1	1.6
Anthracene			10	2.2	1.5	2.9	0	ND	ND	ND	0	ND	ND	ND
Acridine			0	ND	ND	ND	0	ND	ND	ND	2	1.1	0.6	1.5
Carbazole			8	2.9	1.6	4.3	7	47.4	37.5	57.4	7	16.9	12.1	21.6
Fluoranthene			10	5.4	4.1	6.7	0	ND	ND	ND	0	ND	ND	ND
Pyrene			10	4.4	3.5	5.3	0	ND	ND	ND	0	ND	ND	ND
Benzo(e)pyrene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Perylene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
TOTAL DETECTABLE OTHER PAH	34.0	17.0	10	234.6	103.9	365.3	9	2378.3	1480.6	3276.1	9	811.1	661.3	960.8
OTHER PARAMETERS (mg/l)														
Oil & Grease			1	5	NA*	NA*	1	10	NA*	NA*	1	7	NA*	NA*
Phenolics (4-AAP)	NA	0.010	1	0.010	NA*	NA*	8	0.230	0.089	0.370	7	0.037	0.024	0.049
TSS			1	2	NA*	NA*	1	9	NA*	NA*	1	1	NA*	NA*

NOTES: Taken from Table 2-3 in the Engineering Evaluation Report [1].

NA* - Not Applicable since parameter was detected in only one sample.

NA - Not Applicable.

ND - Not Detectable.

[a] - Yearly quarterly monitoring may be used in place of the 30 - day average.

[b] - Per MPCA comments to draft Treatability Report in December 19, 1989 letter.

- Number of detectable concentrations used to compute respective statistics.

AVG - Average of reported values.

L95% - Lower 95% Confidence Interval Limit.

U95% - Upper 95% Confidence Interval Limit.

NPDES discharge requirements along with average concentrations of the respective parameters for the discharge from wells W23, W420, and W421. The parameters cited are those previously identified in the RAP to be representative of the site. The average values given are computed from past well monitoring data performed since 1987; the actual data used to compute the averages are given in the associated engineering report [1]. Only detectable concentrations were used in computing the average values. The average values computed are cited along with their respective 95 percent confidence intervals (these intervals identify a range for which there is a 95 percent probability that the true means will fall within assuming a normal distribution of the data). The data in Table 2-1 indicate that all three well discharges exceed some or all of the target permit conditions cited. The target NPDES discharge concentrations cited are recommended by the RAP. It is noteworthy that the limit of 0.31 μg/L for Total Potentially Carcinogenic PAH may be further reduced to 0.07 μg\L based on MPCA comments received for the November, 1989 treatability report. Specific permit conditions will have to be negotiated with MPCA through a permit application process. A more detailed discussion of NPDES discharge issues are provided in Section 6.3 and the permit application [2].

Table 2-2 presents the average flowrates and the respective upper and lower 95% confidence interval limits for the three wells in question. These values are based on average monthly values recorded since pumping began in 1987. The specific monthly values used are provided in the engineering report [1]. As cited, relatively little variation exists in terms of flowrates for the three respective wells.

To help comply with the provisions of the RAP, Reilly contracted Remediation Technologies, Inc. (ReTeC) to perform an engineering evaluation of treatment options for the three source and gradient control well discharges. Given the previously discussed treatment objectives and historic groundwater quality data, ReTeC performed an engineering screening evaluation with biological fluidized bed, ozone/UV, hydrogen peroxide/UV and activated carbon treatment considered as potential options based on technical feasibility. This evaluation focused on: (i) combined treatment of W420/W421 and single treatment of W23, and (ii) combined treatment of all three wells. In terms of economic considerations (i.e., capital and O&M costs), activated carbon treatment of all three wells combined offered the best alternative. On this basis, plus the fact that

TABLE 2-2

AVERAGE FLOW FOR WELL DISCHARGES

WELL	AVERAGE MONTHLY FLOWRATE (GPM)	LOWER 95% CONFIDENCE LIMIT (GPM)	UPPER 95% CONFIDENCE LIMIT (GPM)
W23	56	51	60
W420	40	37	43
W421	31	28	34

NOTE: SEE ENGINEERING REPORT [1] FOR ACTUAL DATA.

activated carbon treatment is a proven and generally accepted technology, ReTeC proceeded with laboratory and onsite pilot-scale testing to generate site-specific engineering design data for full-scale implementation of activated carbon treatment and to generate the data necessary to address NPDES permitting issues.

The remaining sections of this report present the procedures and results of the treatability work performed.

3.0 STUDY OVERVIEW

This section presents an overview of the treatability work performed, the project personnel involved, the related analytical testing done, and the Quality Assurance/Quality Control (QA/QC) procedures followed.

3.1 TREATABILITY STUDIES

The treatability work performed involved both laboratory and onsite pilot-scale testing. Table 3-1 provides a chronological summary of the specific work carried out. As indicated, work was begun in November, 1988, with an initial site visit for groundwater characterization purposes.

Preparatory work was carried out prior to implementing the onsite column work. This preparatory work involved laboratory testing to examine various pretreatment schemes for removal of reduced iron and manganese. If not removed, iron and manganese precipitation could cause fouling and plugging of the carbon columns. Once a pretreatment scheme was decided upon, sufficient volume was pretreated and sent to Calgon Carbon Corporation for micro-scale accelerated column testing (ACT) evaluation.

Following laboratory testing, an onsite pilot-scale sand filtration/activated carbon unit was set-up and operated to demonstrate the technical feasibility and economic viability of such a system for treatment of the St. Louis Park site pumped groundwaters. Data generated from this onsite work will also be used for engineering design optimization and NPDES permitting issues. The onsite pilot-scale carbon column was started on March 28, 1989 and operated through October 17, 1989. It was originally estimated that the unit would achieve exhaustion in June, 1989. However, due to lower than anticipated carbon column exhaustion, operation was continued until October 17, 1989. Operation of the pilot-scale unit through October provides additional data supporting sand filtration/activated carbon column treatment of the pumped site groundwaters.

TABLE 3-1

TREATABILITY TESTING CHRONOLOGICAL OVERVIEW

ACTIVITY	DATE OR TIME PERIOD	PURPOSE
1. Initial Site Visit	November, 1988	To become familiar with the site and to collect grab samples for well characterization and laboratory testing.
2. Laboratory Pretreatment Evaluation Testing	December, 1988 thru January, 1989	To evaluate pretreatment of the site groundwaters for reduced iron and manganese removal in conjunction with collection and analyses of additional site groundwater samples.
3. Calgon ACT Evaluation Testing	December 5, 1988 thru May 12, 1989 (Report Provided)	To evaluate activated carbon treatment of a pretreated groundwater sample using Calgon's ACT procedure.
4. Pilot-Scale Activated Carbon Column Unit Construction	February, 1989 thru March, 1989	To design, procure equipment and construct the pilot-scale carbon unit to be operated onsite.
5. Pilot-Scale Carbon Column Operation	March 28, 1989 thru October, 1989	To set-up, operate and monitor the pilot-scale carbon unit.
6. Draft Report	September, 1989 thru November, 1989	To compile data and report procedures and results of the pilot-scale unit operation.
7. Final Report	March, 1990	To incorporate MPCA and U.S. EPA comments.

3.2 PROJECT PERSONNEL

Primary treatability and engineering efforts for the laboratory and pilot scale work performed for this project were performed by ReTeC's Pittsburgh Office personnel. Dr. John R. Smith was Project Manager. The primary project scientists associated with the treatability testing were Mr. Paul Chavez and Mr. Robin Weightman.

With the exception of Calgon's ACT work, all laboratory treatability testing was performed by ReTeC personnel. ReTeC was also responsible for design, construction and set-up of the pilot-scale unit. After an initial training period, St. Louis Park personnel operated and monitored the unit with supervision provided by ReTeC personnel.

All associated analyses was performed by contract laboratories as cited in the next sub-section.

3.3 ANALYTICAL TESTING

Table 3-2 lists the analytical parameter categories monitored during both the laboratory and onsite pilot-scale studies. This specific parameter category list was used so that the proper information would be obtained related to both evaluation of the treatment system for engineering design purposes and NPDES permitting considerations. The specific analytical parameters associated with the different categories are given in Appendix A along with the methods used and the respective method detection limits.

Also cited in Table 3-2 are the respective analytical laboratories which performed the analyses. Keystone Environmental Resources, Inc. (KER) located in Monroeville, Pennsylvania, performed all analyses related to conventional parameter metals, nutrients, polynuclear aromatic hydrocarbons (PAHs) by HPLC and priority pollutants. Rocky Mountain Analytical Laboratory (RMAL), located in Arvada, Colorado, tested for the PAHs presently being analyzed in the well discharges by the City of St. Louis Park (SLP) on a quarterly basis; this specific PAH list will be identified in this report as the SLP-PAH List.

TABLE 3-2

ANALYTICAL PARAMETER CATEGORIES

CATEGORY	ANALYTICAL LABORATORY
Conventional	KER
Metals	KER
Nutrients	KER
SLP-PAH List (GC/MS)	RMAL
PAH by HPLC	KER
Priority Pollutants	KER

NOTE: KER - Keystone Environmental Resources, Inc. Laboratory
RMAL - Rocky Mountain Analytical Laboratory

See Appendix A for list of specific analytical parameters, analytical methods used and method detection limits.

All analytical results associated with the treatability work performed as generated by the contract laboratories are provided as Appendix B.

3.4 QA/QC PROCEDURES

Quality Assurance/Quality Control (QA/QC) procedures were followed with regard to: (i) sample collection, shipment and storage; and (ii) sample analyses.

For the sample collection, shipment and storage, ReTeC's Standard Operating Procedure (SOP No. 507) was followed. This involved overnight shipment for all treatability samples and analytical samples along with following proper chain-of-custody procedures. A copy of the SOP is provided as Appendix C.

Analytical QA/QC procedures entailed analyzing for various chemical parameters in distilled water blanks during selected sampling events. The distilled water was transferred into similar sample containers used for the treatability samples. This procedure checked for contamination of the sample containers supplied by the respective analytical laboratories as well as for any cross-contamination associated with the analytical testing equipment. In addition, both KER and RMAL use in-house QA/QC procedures cited by the U.S. EPA. This involves routinely running blanks, spikes and duplicates along with regular laboratory samples submitted for analyses.

4.0 LABORATORY TESTING

Laboratory testing of the three groundwater well discharges (W23, W420, W421) was first performed to provide input into the design of the onsite pilot-scale treatability study. The work carried out focused on: (i) initial characterization of the groundwater well discharges, (ii) pretreatment evaluation, and (iii) ACT evaluation by Calgon. Detailed procedures and results of these three activities are presented in this section.

4.1 INITIAL CHARACTERIZATION

Procedures

Grab samples were collected from discharges at wells W23, W420, and W421 on November 30, 1988, and again on December 28, 1988. The November 30 samples were submitted to RMAL for analysis of the SLP-PAH list, and to KER for conventional, nutrients, and metals analyses. These analyses were done so as to provide data for parameters other than the SLP-PAH list. On December 28, split samples were collected in conjunction with the quarterly monitoring performed by the City of St. Louis Park for the SLP-PAH list. The additional split samples collected were sent to KER for PAH analysis by HPLC. This was done so that a comparison could be made in terms of the SLP-PAHs by GC/MS and PAHs by HPLC.

Results and Discussion

Results of the November 30 sampling are given in Table 4-1 for the RMAL results and Table 4-2 for the KER results. For the SLP-PAH list, Table 4-1 gives that the reporting limit (i.e., method detection limits) for W23 is 1 ug/L, and 100 ug/L for W420 and W421. These quantifiable detection limits are much higher than requested limit of 0.01 ug/L requested of RMAL due to interferences encountered during the analysis. This low a detection limit was needed to properly evaluate the well PAH concentrations in terms of the target NPDES permit levels previously cited in Table 2-1. Due to these

TABLE 4-1

CHARACTERIZATION RESULTS FOR SLP-PAH LIST

PARAMETER	WELL DISCHARGE		
	W23	W420	W421
Reporting Limit (ug/L)	1.0	100	100
POTENTIALLY CARCINOGENIC (P.C.) PAH (ug/L):			
Quinoline	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND
Chrysene	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND
Total Detectable P.C. PAH	0	0	0
OTHER PAH (ug/L):			
2,3 Benzofuran	ND	ND	ND
2,3-dihydroindene	8.6	130	170
Indene	2.3	120	140
Naphthalene HA 410	16.0	500	600
Benzo(b)thiophene	3.8	ND	ND
Indole	ND	ND	ND
2-Methylnaphthalene	2.4	ND	ND
1-Methylnaphthalene	6.0	ND	ND
Biphenyl	2.1	ND	ND
Acenaphthylene	1.7	ND	ND
Acenaphthene	9.3	ND	ND
Dibenzofuran	4.7	ND	ND
Fluorene	7.5	ND	ND
Dibenzothiophene	ND	ND	ND
Phenanthrene	8.3	ND	ND
Anthracene	1.1	ND	ND
Acridine	ND	ND	ND
Carbazole	1.5	ND	ND
Fluoranthene	2.9	ND	ND
Pyrene	2.5	ND	ND
Benzo(e)pyrene	ND	ND	ND
Perylene	ND	ND	ND
Total Detectable Other PAH	80.7	750	910

Note: Analyses by RMAL

ND = Not Detectable in terms of reporting limits cited.

TABLE 4-2

INITIAL CHARACTERIZATION RESULTS OF CONVENTIONAL/ METAL/NUTRIENT ANALYSES

PARAMETER	WELL DISCHARGE		
	W23	W420	W421
CONVENTIONAL (mg/L)			
Phenolics (4-AAP)	0.006	0.033	0.039
pH (units)	7.4	7.1	7.2
Total Dissolved Solids	342	644	556
Total Suspended Solids	8.77	10.0	6.00
Fixed Suspented Solids	8.77	7.00	3.00
Volatile Suspended Solids	<1.00	3.00	3.00
Chemical Oxygen Demand	50.0	<10.0	16.0
Total Organic Carbon	3.65	6.53	6.86
Oil and Grease	<6.00	<5.00	<5.00
METALS (mg/L)			
Iron-Total	1.310	2.320	1.310
Iron-Ferrous	0.129	0.148	2.820
Manganese-Total	0.082	0.466	0.287
NUTRIENTS (mg/L)			
Ortho-Phosphate as P	<0.100	<0.100	<0.100
Ammonia as N	<1.00	<1.00	<1.00
Nitrate as N	<0.020	<0.020	<0.020
Nitrite as N	<0.020	<0.020	<0.020

Note: Analyses by KER.
< - Represents less than detectable concentrations.

relatively high reporting values, PAHs were only detected for the noncarcinogenic category with no interpretation able to be made for the potentially carcinogenic PAH category. Nevertheless, the results do substantiate that all three well discharges will require treatment based on exceedence of the target NPDES permit concentrations for noncarcinogenic PAHs. The Total Other PAH concentrations cited for respective wells W23 and W420 are much lower than the average values previously cited in Table 2-1; Total Detectable Other PAH concentration for W421 are similar to previous results.

The data given in Table 4-2 show that wells W420 and W421 are above the target NPDES permit level for phenolics. Otherwise, these well discharges do not appear to be heavily contaminated with conventional pollutant parameters. As expected, no nutrients were detected. Metal results show that iron is present in the groundwaters at concentrations that may cause fouling problems with activated carbon column treatment (i.e., >1 mg/L Fe). For this reason, laboratory work was carried out evaluating iron removal from the three well discharges in question.

Table 4-3 gives the results of the December 28 sampling event. As cited, results are provided for the respective split samples analyzed by both GC/MS and HPLC methods. The GC/MS method was done as part of the City's quarterly monitoring and the HPLC method was done as part of ReTeC's treatability testing. While certain discrepancies are noted, in general there is good agreement between the two analytical methods for respective parameters. This is especially the case for naphthalene, which is the PAH present at the highest concentration in all three well samples. The reason why the GC/MS results for Total Detectable Other PAH are consistently higher than the HPLC results is because 30 PAHs were analyzed by GC/MS with only 9 being analyzed by HPLC. The general agreement between the two methods for individual PAH compounds is significant because it supports the use of PAH analysis by HPLC as a less expensive alternative for following carbon breakthrough of the more soluble and less adsorbable PAHs (e.g., naphthalene) as needed for engineering design and operational monitoring purposes. This is what was done for the onsite pilot-scale treatability testing program performed. Further discussion of this issue is given in Section 6.1.

TABLE 4-3

INITIAL CHARACTERIZATION RESULTS FOR PAH COMPARISON BY HPLC AND GC/MS

PARAMETER	WELL W23		WELL W420		WELL W421	
	HPLC	GC/MS	HPLC	GC/MS	HPLC	GC/MS
POTENTIALLY CARCINOGENIC (P.C.) PAH (ug/L):						
Quinoline	NA	<10.0	NA	<10.0	NA	<10.0
Benzo(a)anthracene	0.235	<10.0	<0.020	<10.0	<0.020	<10.0
Chrysene	0.283	<10.0	<0.150	<10.0	<0.150	<10.0
Benzo(b)fluoranthene	0.024	<10.0	<0.020	<10.0	<0.020	<10.0
Benzo(k)fluoranthene	<0 020	<10.0	<0.020	<10.0	<0.020	<10.0
Benzo(a)pyrene	0.028	<10.0	<0.020	<10.0	<0.020	<10.0
Indeno(1,2,3-cd)pyrene	<0.050	<10.0	<0.050	<10.0	<0.050	<10.0
Dibenzo(a,h)anthracene	<0.030	<10.0	<0.030	<10.0	<0.030	<10.0
Benzo(g,h,i)perylene	<0.050	<10.0	<0.050	<10.0	<0.050	<10.0
Total Detectable P.C. PAH	0.57	0	0	0	0	0
OTHER PAH (ug/L):						
2,3 Benzofuran	NA	<10.0	NA	9 6	NA	1.8
2,3-Dibenzohydroindene	NA	12.0	NA	130.0	NA	180.0
Indene	NA	2.8	NA	74 0	NA	75.0
Naphthalene	28.8	34.0	626	730.0	424	670.0
Dibenzo(b)thiophene	NA	4.4	NA	71.0	NA	80.0
Indole	NA	<10.0	NA	<10.0	NA	<10.0
2-Methylnaphthalene	NA	3.4	NA	13.0	NA	1.3
1-Methylnaphthalene	NA	7.7	NA	37.0	NA	36.0
Biphenyl	NA	2.9	NA	6.4	NA	4.1
Acenaphthylene	15.2	2.4	61.7	<10.0	44.2	<10.0
Acenaphthene	21.4	12.0	34.1	33.0	12.6	25.0
Dibenzofuran	NA	12.0	NA	6.8	NA	3.7
Fluorene	9.28	9.8	6.82	6.8	2.90	4.2
Dibenzothiophene	NA	1.2	NA	<10.0	NA	<10.0
Phenanthrene	9.92	12.0	3.41	3.5	1.22	1.4
Anthracene	1.83	1.6	<0.500	<10.0	<0.500	<10.0
Acridine	NA	<10.0	NA	<10.0	NA	1.1
Carbazole	2.61	2.2	INT	27.0	INT	23.0
Fluoranthene	2.48	5.2	<0.200	<10.0	<0.200	<10.0
Pyrene	2.00	4.4	<0.200	<10.0	<0.200	<10.0
Benzo(e)pyrene	NA	<10.0	NA	<10.0	NA	<10.0
Perylene	NA	<10.0	NA	<10.0	NA	<10.0
Total Detectable Other PAH	93.5	130	732.0	1148	484.9	1107

Note: GC/MS Analyses by RMAL.
HPLC Analyses by KER.
NA - Indicates not analyzed.
INT - Indicates interference.
< - Represents less than detectable concentrations.
Fourth Quarter (28-DEC-88) monitoring split samples of wells W23, W420, and W421.

4.2 PRETREATMENT EVALUATION

Procedures

Laboratory pretreatment evaluation work focused on the removal of iron and manganese from groundwater composite samples via chemical oxidation and sand filtration. Testing was performed on flow proportioned composite samples of wells W23/W420/W421 and W420/W421. Visual inspection and initial characterization results of the groundwater indicated that soluble iron and manganese were present in the well water at levels which could foul or plug an activated carbon system. Laboratory testing was performed to evaluate and optimize iron and manganese removal via chemical oxidation and filtration.

Various chemical oxidants were first evaluated. These included hydrogen peroxide (H_2O_2), potassium permangate ($KMnO_4$), and compressed air. These oxidants were tested in terms of their capability to oxidize reduced and soluble iron and manganese to a state where they would precipitate out of solution. This evaluation included optimizing chemical dosage, pH, and reaction time to achieve maximum precipitation based on visual observation of precipitate formed. Once precipitated, the iron and/or manganese can be removed via sand filtration. Visual observations suggested that potassium permanganate would provide the maximum oxidation at the lowest dosage with no pH adjustment needed.

To evaluate the effectiveness of $KMnO_4$ oxidation followed by sand filtration, bench-scale filtration testing was performed on a flow proportioned composite sample from wells W420/W421. These two well composite samples were used to simulate the combined groundwater which would be treated in the onsite pilot-scale carbon column unit. The flow proportioned sample was dosed with potassium permanganate at a level of 1 mg $KMnO_4$ per mg iron and 2 mg $KMnO_4$ per mg manganese to cause oxidation and precipitation of the soluble iron and manganese. The potassium permanganate was allowed to react for five minutes before filtering. The sample was then pumped to a 2-inch diameter column of filtration media and allowed to flow by gravity at a rate of

approximately 600 ml/min (this corresponds to a hydraulic loading of approximately 6.9 gpm/sq. ft of filter surface area).

Various combinations of different filtration media were evaluated. The different filtration media tested included general purpose sand, anthracite, and "FerroSand". The general purpose sand was sized and washed, and is considered chemically inert. The anthracite filtration media was washed and sized anthracitic coal. "FerroSand" is processed glauconitic greensand; it is also chemically active for the oxidation of soluble iron and manganese in conjunction with $KMnO_4$. The uniformity coefficients and the effective sizes of the three different media types tested are given in Table 4-4. These three media types tested are all within acceptable ranges recommended by Metcalf & Eddy [4] for gravity downflow sand filters.

Four separate sand filtration runs were performed using the following four combinations of filter media:

1. Twelve (12) inches of general purpose sand.
2. Dual media consisting of 12 inches of anthracite on top of 12 inches of general purpose sand.
3. Twelve (12) inches of "FerroSand".
4. Dual media consisting of 12 inches of anthracite on top of 12 inches of "FerroSand".

An unfiltered well composite sample along with filtered samples for each filtration run were analyzed for iron, manganese and total dissolved solids (TDS) by KER. The same samples were also tested for pH and conductivity by ReTeC personnel at the time of testing.

TABLE 4-4

FILTRATION MEDIA CHARACTERIZATION SUMMARY

GENERAL PURPOSE SAND

Uniformity Coefficient (d_{60}/d_{10})	=	1.53
Effective Size (d_{10})	=	0.47 mm

(Data obtained from sieve analysis performed by ReTeC)

ANTHRACITE

Uniformity Coefficient (d_{60}/d_{10})	=	1.70
Effective Size (d_{10})	=	0.9 mm

(Data supplied by Carbonite Corporation)

FerroSand

Uniformity Coefficient (d_{60}/d_{10})	=	1.50
Effective Size (d_{10})	=	0.30-0.35 mm

(Data supplied by H&T, Inc. [6] in Clayton, New Jersey)

NOTE: d_{60} = Particle diameter of filtration media of which 60 percent of the material is finer, on a dry weight basis.

d_{10} = Particle diameter of filtration media of which 10 percent of the material is finer, on a dry weight basis.

Results and Discussion

Results of the filtration runs performed are summarized in Table 4-5. As cited, all four filtration media combinations achieved significant reductions of iron (Fe) and manganese (Mn). The dual media combinations with the anthracite appeared to work best, with the single media material of sand and "FerroSand" both achieving similar, but somewhat less effective results. Based on these results, it was decided that a combination of general purpose sand and anthracite coal would be used as the filtration media in the pilot-scale testing with $KMnO_4$ as the chemical oxidant. Even though anthracite may not be needed in a full-scale unit, it does provide a greater extent of filtration by providing a wider range of filtration media size gradation.

4.3 ACCELERATED COLUMN TESTING

Procedures

It was originally intended that Accelerated Column Testing (ACT) would be performed by Calgon Corporation, Inc. on 2- and 3-well flow proportioned composite samples of wells W420/W421 and W23/W420/W421, respectively. However, due to technical questions associated with the validity of the ACT work and time constraints, Calgon only performed testing on the 3-well composite sample. Nevertheless, both composite samples were pretreated via chemical oxidation and sand filtration prior to being submitted to Calgon for subsequent ACT work.

Both the 2- and 3-well composite samples were pretreated with $KMnO_4$ used as the chemical oxidant, and general purpose sand used as the filtration media. The respective amounts of each well sample used to make-up the composite samples were computed based upon the respective average flowrates previously cited in Table 2-2. Each composite sample was analyzed before pretreatment for phenolics (4-AAP), total organic carbon (TOC), total dissolved solids (TDS), total Fe, total Mn and PAH by HPLC; all analyses were performed by KER. After pretreatment, the filtered samples

TABLE 4-5

COMPARISON OF SAND FILTRATION RUNS FOR DIFFERENT MEDIA

FILTRATION MEDIA	ANALYTICAL RESULTS				
	Fe (mg/L)	Mn (mg/L)	TDS (mg/L)	pH (units)	Conductivity (u-mhos/cm)
Initial Unfiltered Composite Sample	1.630	0.379	25.3	7.4	950
Sand	0.124	0.161	15.3	7.5	1050
Sand/Anthracite	<0.100	0.081	17.7	7.4	1000
FerroSand	0.165	0.184	19.3	7.5	1000
FerroSand/Anthracite	<0.100	0.043	18.7	7.2	1000

Note: < - Represents less than detectable concentrations.

were analyzed for phenolics (4-AAP), TOC, TDS, totalFe and total Mn by KER, and for the SLP-PAH list by RMAL. The pretreated 3-well composite sample was carried through the ACT evaluation with the effluent sample analyzed for phenolics (4-AAP), total Fe and total Mn by KER, and the SLP-PAH list by RMAL. This ACT run simulated 80 gpm of groundwater being treated through a 20,000 lb. in series double bed carbon unit with a contact time of 5-6 minutes. The ACT treated effluent sample was collected at a time corresponding to a carbon use rate of 1.04 lb. of carbon per 1,000 gallons of water treated.

Results and Discussion

Analytical results of the 2-well composite sample testing are summarized in Table 4-6 with results of the 3-well composite sample work summarized in Table 4-7.

For the 2-well composite sample work, the data in Table 4-6 indicate that the pretreatment step was very effective in reducing phenolics, iron and manganese. In terms of PAHs, the results show that of the four compounds detected in the untreated sample, three showed a significant reduction across the sand filter with naphthalene not showing any. Otherwise, comparison of the treated and untreated PAH results shows consistent results between the HPLC and GC/MS methods. The 2-well composite data also indicate that the total Potentially Carcinogenic PAH target NPDES requirement of 0.31 μg/L is not exceeded in the pretreated effluent with only three compounds being detected above 0.01 ug/L. However, the alternately proposed limit of 0.07 μg/L is close to being exceeded. The slight increase for benzo(a)anthracene between the "initial untreated" and "pretreated" samples is not very significant and may be due to analytical variability. The target NPDES requirements for the "Total Detectable Other PAH" compounds are exceeded due to the 2,3-dihydroindene, naphthalene, benzo(b)thiophene and carbazole concentrations present in the well discharges at relatively high levels.

For the 3-well composite sample work, the data in Table 4-7 indicate that the pretreatment step was again very effective in reducing groundwater concentrations of phenolics (4-AAP) and total-Fe; total-Mn was not reduced to any significant extent. PAH reductions through the pretreatment step were similar to the 2-well composite sample with

TABLE 4-6

TWO WELL AT COMPOSITE SAMPLE RESULTS

PARAMETER	INITIAL UNTREATED	PRETREATED
CONVENTIONAL (mg/L):		
Phenolics (4-AAP)	0.042	0.007
Total Dissolved Solids	712	861
Total Organic Carbon	4.87	4.14
METALS (mg/L):		
Iron-Total	1.890	<0.100
Manganese-Total	0.430	0.048
PAH (ug/L)	by HPCL	by GC/MS
POTENTIALLY CARCINOGENIC (P.C.):		
Quinoline	NA	<0.010
Benzo(a)anthracene	<0.020	0.026
Chrysene	<0.150	0.028
Benzo(b)fluoranthene	<0.020	0.014
Benzo(k)fluoranthene	<0.020	<0.010
Benzo(a)pyrene	<0.020	<0.010
Indeno(1,2,3-c,d)pyrene	<0.050	<0.010
Dibenz(a,h)anthracene	<0.030	<0.010
Benzo(g,h,i)perylene	<0.050	<0.010
Total Detectable P C. PAH	0.000	0.068
OTHER PAH (ug/L):		
2,3-Benzofuran	NA	<0.010
2,3-Dihydroindene	NA	37.00
Indene	NA	<0.010
Naphthalene	142	140.0
Benzo(b)thiophene	NA	28.00
Indole	NA	0.023
2-Methylnaphthalene	NA	<0.010
1-Methylnaphthalene	NA	<0.010
Biphenyl	NA	<0.010
Acenaphthylene	23.1	0.027
Acenaphthene	5.28	<0.010
Dibenzofuran	NA	<0.010
Fluorene	1.24	<0.010
Dibenzothiophene	NA	0.058
Phenanthrene	<0.500	0.250
Anthracene	<0.500	<0.010
Acridine	NA	<0.010
Carbazole	INT	13.00
Fluoranthene	<0.200	0.082
Pyrene	<0.200	0.055
Benzo(e)pyrene	NA	<0.010
Perylene	NA	<0.010
Total Detectable Other PAH	171.6	218.5

Note: Conventional, Metals, and HPLC analyses by KER.
GC/MS analyses by RMAL.
NA - Indicates not analyzed.
INT - Indicates interference.
< - Represents less than detectable concentrations.

TABLE 4-7

THREE WELL ACT COMPOSITE SAMPLE RESULTS

PARAMETER	INITIAL UNTREATED	PRETREATED ACT INFLUENT	ACT TREATED EFFLUENT
CONVENTIONAL (mg/L):			
Phenolics (4-AAP)	0.030	<0.005	<0.005
Total Dissolved Solids	569	643	NA
Total Organic Carbon	2.86	3.03	NA
METALS (mg/L):			
Iron-Total	1.640	0.165	<0.100
Manganese-Total	0.287	0.218	NA
PAH (ug/L)	by HPLC	by GC/MS	by GC/MS
POTENTIALLY CARCINOGENIC (P.C.):			
Quinoline	NA	<0.010	<0.010
Benzo(a)anthracene	0.024	<0.010	<0.010
Chrysene	<0.150	0.012	<0.010
Benzo(b)fluoranthene	<0.020	<0.010	<0.010
Benzo(k)fluoranthene	<0.020	<0.010	<0.010
Benzo(a)pyrene	<0.020	<0.010	<0.010
Indeno(1,2,3-c,d)pyrene	<0.050	<0.010	<0.010
Dibenz(a,h)anthracene	<0.030	<0.010	<0.010
Benzo(g,h,i)perylene	<0.050	<0.010	<0.010
Total Detectable P.C. PAH	0.024	0.012	0.000
OTHER PAH (ug/L):			
2,3 Benzofuran	NA	0.190	<0.010
2,3-dihydroindene	NA	12.00	<0.010
Indene	NA	0.011	<0.010
Naphthalene	80.6	56.00	0.079
Benzo(b)thiophene	NA	12.00	<0.010
Indole	NA	<0.010	<0.010
2-Methylnaphthalene	NA	0.380	0.013
1-Methylnaphthalene	NA	2.000	0.010
Biphenyl	NA	0.260	<0.010
Acenaphthylene	22.0	<0.010	<0.010
Acenaphthene	5.28	1.600	<0.010
Dibenzofuran	NA	0.330	<0.010
Fluorene	2.02	0.380	<0.010
Dibenzothiophene	NA	0.044	<0.010
Phenathrene	1.05	0.230	<0.010
Anthracene	<0.500	<0.010	<0.010
Acridine	NA	<0.010	<0.010
Carbazole	INT	9.600	<0.010
Fluoranthene	0.287	0.099	<0.010
Pyrene	<0.200	0.058	<0.010
Benzo(e)pyrene	NA	<0.010	<0.010
Perylene	NA	<0.010	<0.010
Total Detectable Other PAH	111.2	95.18	0.102

Note: Conventional, Metals, and HPLC analyses by KER.
GC/MS analyses by RMAL.
NA - Indicates not analyzed.
INT - Indicates interference.
< - Represents less than detectable concentrations.

some of the higher molecular weight PAHs being reduced more than others. Naphthalene was not reduced to any major extent; there was also a rather good comparison between the HPLC and GC/MS results for naphthalene. This good comparison for both the 2- and 3-well composite samples further supports that naphthalene analysis by HPLC could be used for operational monitoring purposes of a sand filtration/activated carbon column treatment system.

Results of the ACT work performed on the 3-well composite sample, as summarized in Table 4-7, demonstrate the effectiveness of sand filtration/activated carbon for treatment of St. Louis Park site groundwaters. Corresponding to a carbon use rate of 1.04 lb. of carbon per 1,000 gallons of groundwater treated, the data presented show that naphthalene and methylnaphthalenes were detected in the treated effluent but at concentrations far below the target NPDES requirement for "other PAH". It should be pointed out however, that the results of the ACT work are questionable because Calgon pressure filtered the sample submitted to them prior to the ACT run. As cited in Appendix D (Calgon's ACT Report), this filtration step may have resulted in removal of naphthalene onto the filter material, with no naphthalene being detected at 1 ug/L in the feed to the ACT column. Thus, it is not known what the naphthalene concentration applied to the ACT column was, as well as the concentration of other PAH compounds. Appendix C contains Calgon's ACT evaluation report.

5.0 ONSITE PILOT-SCALE STUDY

This section addresses the onsite pilot-scale treatability work which was carried out at the St. Louis Park site. The treatment system evaluated included potassium permanganate ($KMnO_4$) chemical oxidation with sand filtration, followed by activated carbon column treatment. The remainder of this section gives: (i) a detailed description of the pilot-scale unit, (ii) to operation and monitoring procedures, and (iii) results and discussion.

5.1 PILOT-SCALE UNIT DESCRIPTION

A sand filtration/activated carbon pilot system was set up to treat a flow proportioned side stream from wells W420 and W421 at the St. Louis Park site. Groundwater from well W23 was not included in the pilot program because it would have been too difficult to transport water from the location of W23 to the location of W420/W421 where the pilot-scale unit was set-up. It is felt that this is not a significant issue since all three wells contain the same PAHs, plus the fact that the respective chemical concentrations of W23 are generally an order of magnitude lower than W420 and W421. Thus, a worst case groundwater was tested during the pilot work.

This contention is also valid in light of the fact that well groundwater analysis performed as part of the initial characterization work (See Table 4-3) did show detectable concentrations (by HPLC) of some individual Potentially Carcinogenic PAHs in the fraction of the part per billion (ppb) level while sample analyses from wells W420 and W421 did not show any detectable concentrations. It is felt that this very low level of Potentially Carcinogenic PAHs will be sufficiently removed by activated carbon treatment when well W23 groundwater is treated jointly with groundwater from wells W420 and W421. Even though groundwater from well W23 was not used in the pilot-scale treatability work, it should be noted that the Potentially Carcinogenic PAHs, which are relatively insoluble compared to Other PAHs compounds, are greatly adsorbed onto carbon to a much greater degree than the Other PAH compounds measured in wells W420 and W421. This contention is supported by the fact that an existing carbon

treatment system treating pumped site groundwater from wells W10 and W15 is removing Potentially Carcinogenic PAHs to drinking water levers. Additionally, published isotherm data and theory [5] cite that of the St. Louis Park PAH list, carbon usage will be determined based upon naphthalene adsorption. Naphthalene is the PAH compound present in the highest concentration in all three wells and is also the PAH compound which is expected to first be detected in the carbon column effluent with all of the other PAHs not being detectable. The Potentially Carcinogenic PAHs would be the very last to be detected in the effluent if allowed. However, this is not expected to occur based upon the fact that a particular carbon column will be replaced once it is exhausted for either naphthalene or phenolics, which ever occurs first. Exhaustion is defined as that condition where the effluent concentration of a particular chemical equals the influent concentration. Additionally, once W23 groundwater is added to flows from W420 and W421, the Total Potentially Carcinogenic PAH concentration in the combined flow will be near 0.024 μg/L as cited in Table 4-7. This is below the anticipated permit requirement range of 0.07 to 0.31 μg/L average. Thus, the fact that W23 groundwater was not used in the pilot work should not be an issue.

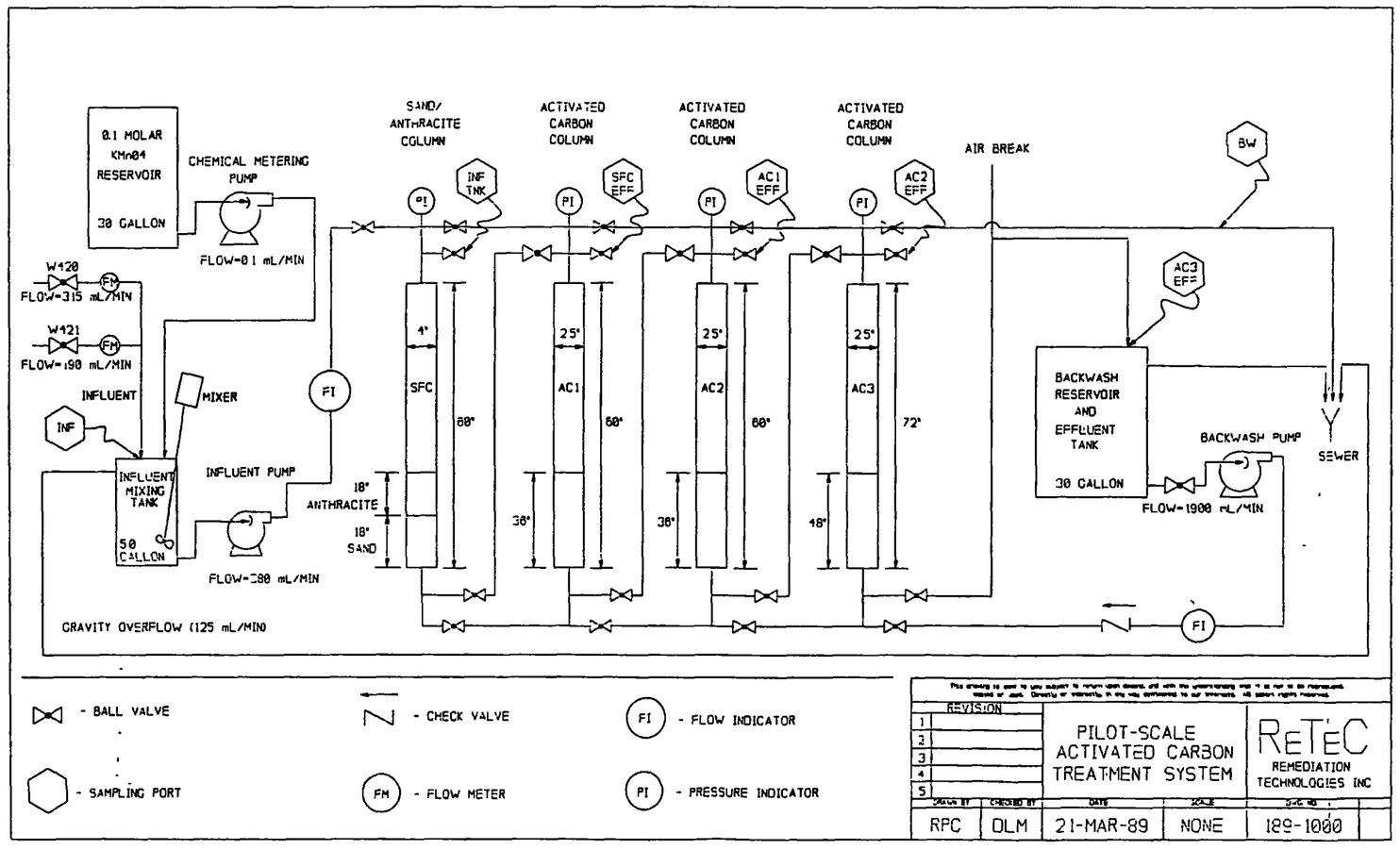
The pilot system included chemical oxidation and sand filtration for removal of soluble iron and manganese. This was followed by a series of three activated carbon columns for treatment of organic contaminants. Figure 5-1 shows a schematic of the pilot-scale system operated.

The influent was a flow proportioned side stream from wells W420 and W421. The flowrate from W420 was approximately 315 ml/minute and the flowrate from W421 was approximately 190 ml/minute. The combined flowrate of 505 ml/minute from the two wells exceeded the influent flowrate of 380 ml/minute to the pilot unit from influent mix tank. The excess flow was allowed to overflow to the sanitary sewer thus eliminating the need for low level pump controls and ensuring a constant flow to the sand filter.

Continuous oxidation of the soluble iron was achieved in a 5-gallon influent mixing tank (INFTNK) by the addition of 0.1 molar $KMnO_4$ solution fed at approximately 0.1 ml/minute. This resulted in $KMnO_4$ being added at a influent dosage of 3.1 mg/L. Based on results of the laboratory pretreatment evaluation work discussed in Section 4.0, it was

FIGURE 5-1

PILOT-SCALE SAND FILTRATION/ACTIVATED CARBON TREATMENT SYSTEM SCHEMATIC



anticipated that this dosage would approximately correspond to a $KMnO_4$: soluble Fe ratio of approximately 1:1 and a $KMnO_4$: soluble Mn ratio of approximately 2:1.

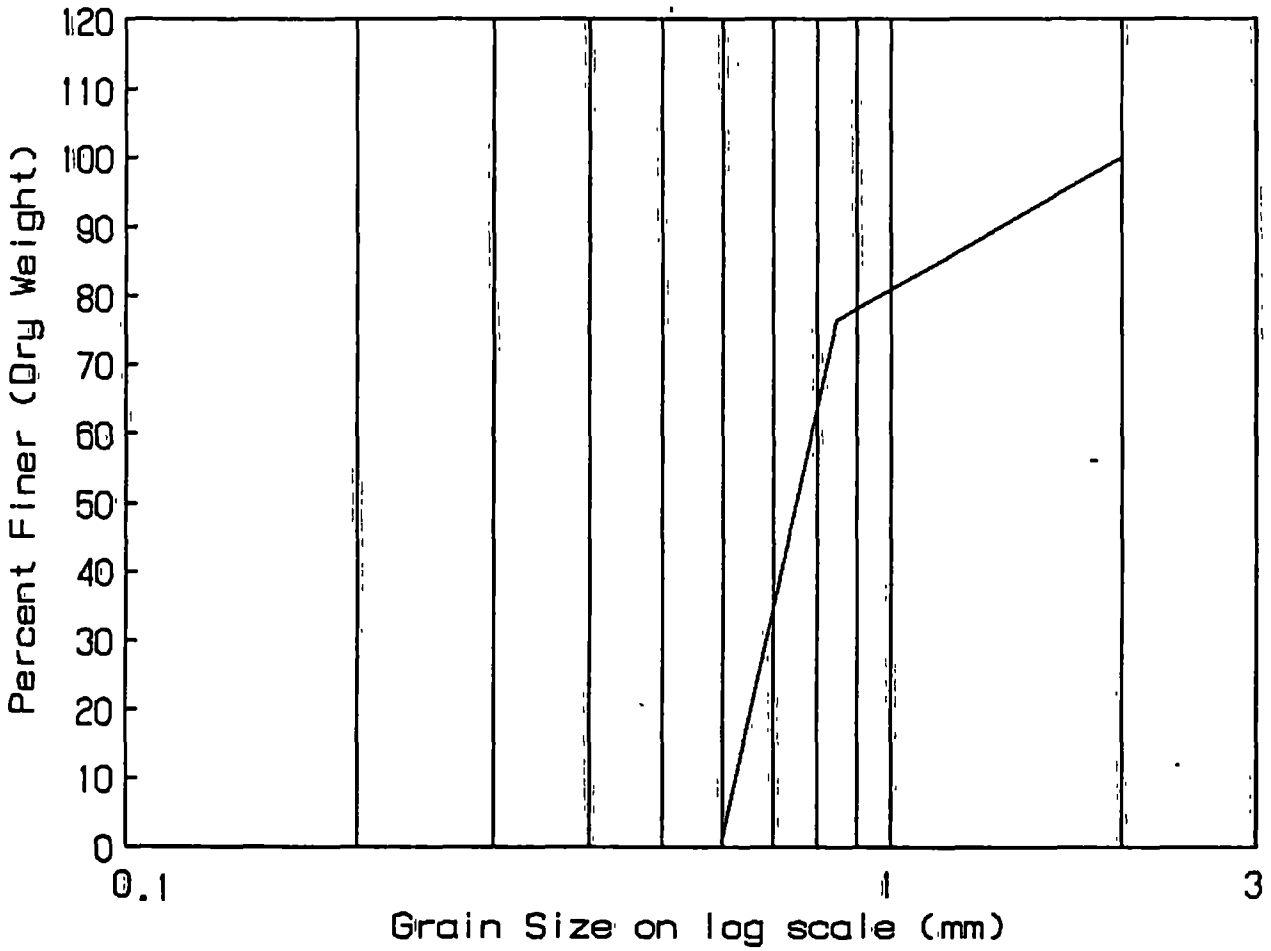
Water from the influent tank was then pumped to a fixed bed dual media sand filtration column (SFC). The sand column was four inches in diameter and contained an 18-inch bed of anthracitic coal with an effective size of 0.85 to 0.95 mm and a maximum uniformity coefficient of 1.70; and an 18-inch bed of sand with an effective size of 0.48 mm and an uniformity coefficient of 1.46. Grain-size distribution of the sand used is graphed in Figure 5-2. The hydraulic loading to the sand column was 1.15 gpm/ft^2. The sand column was backwashed at a hydraulic loading of 12.0 gpm/ft^2. The backwash containing the precipitated filtered solids of iron and manganese and was discharged to the sanitary sewer.

From the sand column, the pretreated groundwater passed through a series of three activated carbon columns. Each of the carbon columns was 2.5 inches in diameter and had a hydraulic loading of 2.9 gpm/ft^2. The carbon used was virgin U.S. Standard 12 x 40 mesh carbon with an apparent bulk density of 27.5 lbs/ft^3; the carbon was obtained from Tigg Corporation of Pittsburgh, Pennsylvania. The first (AC1) and second (AC2) activated carbon columns each had 36-inch bed depths and contained approximately 2.8 lbs. of carbon. The third (AC3) activated carbon column had a 48-inch bed depth and contained approximately 3.8 lbs. of carbon. The empty bed contact time for columns AC1 and AC2 was approximately 7.5 minutes. The empty bed contact time for column AC3 was approximately 10 minutes. Jointly, the carbon pilot unit simulated carbon column treatment with a total empty bed contact time of approximately 25 minutes.

From the carbon columns, the treated water was collected in a 30-gallon tank which also served as a reservoir for backwashing the sand filtration column and the carbon columns as needed. For backwashing purposes, the columns measured between 60 to 72 inches in height. Each column was also equipped with a pressure gauge to indicate headlosses across each column and which also served to indicate any signs of plugging or flow restriction.

FIGURE 5-2

GRAIN SIZE DISTRIBUTION GRAPH OF SAND MEDIA IN PILOT-SCALE FILTRATION COLUMN



5.2 OPERATION AND MONITORING

The pilot unit was started up on March 28, 1989, and operated through October 17, 1989. The first analytical sampling was performed on March 29, 1989, after the system had time to come to equilibrium. As cited in Table 5-1, the October 17 date corresponds to approximately 29,088 total gallons of groundwater treated over a 202 day period; and computed carbon loadings of approximately 0.10 lb/1,000 gallons for Column 1, 0.19 lb/1,000 gallons for Columns 1 and 2 combined, and 0.32 lb./1,000 gallons for all three columns combined.

Operation and monitoring of the onsite pilot-scale treatability work was performed as related to:

- Daily Monitoring and Maintenance,
- Pretreatment,
- Carbon Column Breakthrough Monitoring,
- NPDES Permit Sampling, and
- Sand Filter Backwash Water Monitoring.

The analytical sampling schedule carried out during the study is summarized in Table 5-2. The analytical sampling weeks identified correspond to the same weeks and dates cited in Table 5-1. As given in Table 5-2, an extensive sampling program was carried out to evaluate pretreatment, carbon column breakthrough, NPDES permit issues and water quality of the sand filter backwash.

Daily Monitoring and Maintenance

Daily monitoring and maintenance of the pilot unit was conducted by personnel from the City of St. Louis Park Water Department. Daily monitoring included pH and conductivity analyses, and recording flowrates and column pressures. Maintenance included adjustment of flowrates and column backwashing as needed. All data including operational notes were recorded in a standard sheet provided by ReTeC. A copy of the standard sheet is provided as Table 5-3.

TABLE 5-1

SUMMARY OF GROUNDWATER VOLUME TREATED AT RESPECTIVE SAMPLING DATES

ANALYTICAL SAMPLING DATE	ANALYTICAL SAMPLING WEEK	CUMMULATIVE DAYS OF OPERATION	CUMMULATIVE GALLONS OF WATER TREATED	COMPUTED CARBON LOADINGS (POUNDS OF CARBON/1000 GALLONS TREATED)		
				COLUMN 1	COLUMN 1, & 2	COLUMN 1,2, & 3
March 28, 1989	Start-up	---	---	---	---	---
March 29,1989	1	1	144	19.44	38.89	65.28
April 3, 1989	2	6	864	3.24	6.48	10.88
April 10, 1989	3	13	1872	1.50	2.99	5.02
April 17, 1989	4	20	2880	0.97	1.94	3.26
April 24, 1989	5	27	3888	0.72	1.44	2.42
May 1, 1989	6	34	4896	0.57	1.14	1.92
May 8, 1989	7	41	5904	0.47	0.95	1.59
May 15, 1989	8	48	6912	0.41	0.81	1.36
May 22, 1989	9	55	7920	0.35	0.71	1.19
June 5, 1989	11	69	9936	0.28	0.56	0.95
June 19, 1989	13	83	11952	0.23	0.47	0.79
July 3, 1989	15	97	13968	0.20	0.40	0.67
July 17, 1989	17	111	15984	0.18	0.35	0.59
July 31, 1989	19	125	18000	0.16	0.31	0.52
August 14, 1989	21	139	20016	0.14	0.28	0.47
October 2, 1989	28	188	27072	0.10	0.21	0.35
October 17, 1989	30	202	29088	0.10	0.19	0.32

TABLE 5-2

PILOT-SCALE TESTING ANALYTICAL SAMPLING SCHEDULE

PARAMETERS	INF	INFTNK	SPCEFF	AC1EFF	AC2EFF	AC3EFF	BW1	QA/QC BLANK
CONVENTIONAL:								
Phenolics (4-AAP)	1,7,13	1-9	1-9,13,17, 21,28,30	2-9,11,13, 15,17,19, 21,28,30	1,3,5,7,9, 11,13,15,17 19,21,28,30	1,3,5,7,9, 11,13,17, 21,28,30		1,7,13
pH (units)	1,7,13	1-9	1-9			1,7,13		1,7,13
Total Dissolved Solids	1,7,13					1,7,13		1,7,13
Total Suspended Solids	1,7,13	1-9	1-9			1,7,13	1-9	1,7,13
Biochemical Oxygen Demand	1,7,13					1,7,13	5,7,9	1,7,13
Chemical Oxygen Demand	1,7,13					1,7,13		1,7,13
Total Organic Carbon	1,7,13	1-9	1-9			1,7,13	1-9	1,7,13
Oil and Grease	1,7,13					1,7,13		1,7,13
Hardness (as CaCO3)	1,7,13					1,7,13		1,7,13
NUTRIENTS:								
Orthophosphate as P	1,7,13					1,7,13		1,7,13
Ammonia Nitrogen as N	1,7,13					1,7,13		1,7,13
Nitrite as N	1,7,13					1,7,13		1,7,13
Nitrate as N	1,7,13					1,7,13		1,7,13
METALS:								
Iron-Total	1,7,13	1-9	1-9	1-9		1,7,13		1,7,13
Iron-Ferrous	1,7,13	1-9	1-9	1-9		1,7,13		1,7,13
Iron-Filtered	1,7,13	1-9	1-9	1-9		1,7,13		1,7,13
Manganese-Total	1,7,13	1-9	1-9	1-9		1,7,13		1,7,13
PAH by HPLC:	1,13	1-9	1-9,13,17, 21,28,30	1-9,11,13, 15,17,19, 21,28,30	1,3,5,7,9, 11,13,15,17 19,21,28,30	1,3,5,7,9, 11,13,17, 21,28,30	5,7,9	
PAH by GC/MS:	1,7,13					1,7,13		1,7,13
PRIORITY POLLUTANT SCAN:	1,13					1,13		
OTHER PARAMETERS:								
Temperature	D					D		
pH	D					D		
Conductivity	D					D		
D.O.	30					30		

Note: Respective numbers correspond to Analytical Sampling Week given in Table 5-1.
Refer to Appendix A for specific analytical methods.
D - Daily monitoring.
See Figure 5-1 for identification of respective streams.

TABLE 5-3

PILOT-SCALE OPERATIONAL MONITORING SHEET

Daily Worksheet

Carbon Pilot Unit
Reilly Industries
Saint Louis Park, MN

In case of Emergency, Please call:

1. Paul Chavez at W 412/ 826-3340
   H 412/ 733-5018
2. John Smith at W 412/ 765-0366
   H 412/ 242-5998

Parameters:

	INF TNK	EFF TNK
Temperature	_____°C	_____°C
pH	_____	_____
Conductivity	_____u-mhos/cm°	_____u-mhos/cm°
Dissolved Oxygen	_____mg/L	_____mg/L

Flow Rates:

$KMnO_4$	_____ml/min
W420	_____ gal/hr
W421	_____ gal/hr
Total Column Influent	_____ gal/hr

Backwash:

Column	SFC	AC1	AC2	AC3
Initial Flow	_____gal/hr			
Pressure	_____psig	_____psig	_____psig	_____psig
Backwash Rate	_____gal/min	_____gal/min	_____gal/min	_____gal/min
Backwash Time	_____min	_____min	_____min	_____min
Final Flow	_____gal/hr			
Final Pressure	_____psig	_____psig	_____psig	_____psig

Notes and observations: _____

Record additional notes on the back of this page.

Time: _____
Date: _____/_____/_____ Sampler: _____

Backwash SFC column daily, back pressure not to exceed 20 psig.
Columns AC1, AC2, AC3 to be backwashed if pressure exceeds 20 psig.

Pretreatment

To evaluate the effectiveness of chemical ($KMnO_4$) oxidation/sand filtration pretreatment, a sampling program was initiated to track some selected conventional parameters, metals and PAHs across the sand filter on a weekly basis during the first nine weeks of operation. This time period was considered sufficient with no further monitoring of parameters across the sand filter performed after the initial nine weeks all samples collected were grab.

Carbon Column Breakthrough Monitoring

Phenolics and PAHs were tracked across the three carbon columns during operation of the pilot unit. For carbon column 1 (AC1), grab samples were collected of the influent and effluent on a weekly basis during the first nine weeks of the study. Breakthrough in Column 1 (AC1) for either naphthalene or phenolics (4-AAP) was estimated, based on published isotherm data [5], to be achieved within the first 48 days of the study. However, breakthrough was not achieved as anticipated, and biweekly sampling of AC1 was implemented for phenolics and PAHs through Week 21, with two more similar samplings performed during Week 28 and Week 30. A periodic sampling program for phenolics and PAHs was carried out for Columns 2 and 3 (AC2 and AC3) with the specific schedule given in Table 5-2.

NPDES Permit Sampling

The influent (INF) and final carbon column effluent (AC3EFF) were monitored for conventional parameters, metals, nutrients, and PAHs by both HPLC and GC/MS at the beginning of the study (Week 1), at Week 7, and at Week 13. In addition, a Priority Pollutant Scan was performed on the influent and effluent water at the beginning of the study and at Week 13. The purpose of these analyses was to gather data to be used with regard to NPDES permit issues. All samples collected were grab.

Sand Filter Backwash Monitoring

During the first nine weeks of operation, grab samples were collected weekly of the sand filter backwash water and analyzed for total suspended solids (TSS) and total organic carbon (TOC). During Weeks 5, 7, and 9, grab samples were also collected for BOD and PAH analyses. Backwash Water collected during weeks 5 through 9 was saved for analysis of the filtered solid for the PAH-SLP list by GC/MS. Solid material was allowed to settle, and the clear supernatant was decanted. The settled material was filtered using a 1.5 um filter. The filter cake was submitted to RMAL for SLP-PAH analysis when sufficient filtered material was collected.

5.3 RESULTS AND DISCUSSION

Results of the onsite treatability pilot work are presented and discussed with regard to the same five categories cited in the preceding sub-section.

Daily Monitoring

In terms of operation of the pilot-scale treatment unit, daily recorded pressures for the sand filter generally ranged between 0 to 15 psig. Initially, the sand filter was backwashed every third day but this resulted in AC1 achieving a pressure of 10 psig. At this time, AC1 was backwashed and daily backwashing of the sand filter was implemented. This resulted in recorded pressures for the carbon columns ranging between 0 to 2 psig. This low pressure range supports that the chemical oxidation/sand filtration pretreatment step was effective in removing precipitated solids from the groundwater stream being treated, thus reducing the potential for plugging or fouling of the carbon columns. Daily backwashing for the sand filtration column represented approximately 21 percent of the daily flowrate to the treatment system which was maintained at approximately 144 gpd; thus the sand filter backwash flowrate was approximately 30 gpd.

Results of the daily monitoring are summarized in Table 5-4 for temperature, pH, and conductivity. As given, there was not much variation of these parameters over the course of the study for both the influent and effluent as evidenced by the narrow range between the upper and lower 95 percent confidence interval limits (U95%, L95%) of the averages cited. There was also not much variation between the influent (INF) and the final treated effluent (AC3EFF) averages given for the respective parameters monitored. In addition, replicate Dissolved Oxygen (DO) measurements, using a standard YSI oxygen meter, were taken of the influent and the AC3 effluent during Week 30.

Completed copies of the Daily Pilot-Scale Unit Operational Monitoring Sheets (Table 5-3) are available upon request.

Pretreatment

Analytical data results of the sampling performed on the chemical oxidation/sand filtration pretreatment process are given in Tables 5-5 and 5-6 for the influent (INFTNK) and effluent (SFCEFF), respectively, across the sand filtration column. Comparisons between the INFTNK and the SFCEFF should be made for the first nine weeks of monitoring, results of the SFCEFF, during Weeks 13, 17, 21, 18 and 30, apply to carbon column breakthrough monitoring.

The influent tank results (Table 5-5) show that the groundwater quality remained fairly constant in terms of pH, TSS, total iron and total manganese during the nine week sampling period. It is noteworthy that the manganese concentrations cited represent increases above that present in the pumped groundwater due to the addition of $KMnO_4$ to the influent tank. Results of manganese and iron concentrations prior to $KMnO_4$ addition are given in the sub-section entitled, "NPDES Permit Sampling". The data in Table 5-5 show that the total iron detected was soluble and in a oxidized state based on the fact that reduced ferrous iron (Fe^{2+}) was not detected and that filtered iron concentrations were approximately the same as the total iron concentrations; exceptions are noted for Weeks 1, 6 and 7. This observation supports that while the iron was

TABLE 5-4

SUMMARY OF DAILY MONITORING PARAMETERS

	TEMPERATURE (C)		pH (units)		CONDUCTIVITY (umohs/cm)	
	INFLUENT	EFFLUENT	INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
AVG	11.7	15.5	7.02	6.95	926	1033
MAX	14.0	20.0	7.30	7.80	1025	1250
MIN	10.0	11.0	6.20	6.60	800	900
STD	0.8	2.1	0.11	0.13	47	89
U95%	11.9	15.9	7.05	6.98	935	1051
L95%	11.6	15.1	7.00	6.93	917	1016

Note: Data repersent 106 sampling during weeks 1-13 of operation.
AVG - Average sample value.
MAX - Maximum sample value.
MIN - Minimum sample value.
STD - Sample standard deviation.
U95% - Upper bound 95% confidence limit.
L95% - Lower bound 95% confidence limit.

TABLE 5-5

INFLUENT TANK (INFTNK) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		< 0.005	0.026	0.022	0.007	*	0.009	< 0.005	< 0.005	0.024
pH (units)		7.4	7.3	7.3	7.7	7.2	7.4	7.5	7.5	7.3
Total Suspended Solids		14.0	8.00	12.0	15.0	14.0	19.0	29.0	15.0	17.0
Total Organic Carbon		6.86	17.3	101	6.14	5.68	33.0	6.59	7.35	7.48
METALS (mg/L):										
Iron-Total		1.730	1.610	1.700	1.840	1.800	1.790	2.010	1.880	1.710
Iron-Ferrous		0.166	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Iron-Filtered		< 0.100	1.750	1.890	1.820	1.800	< 0.100	< 0.100	1.920	1.700
Manganese Total [a]		3.480	2.280	3.390	4.660	6.080	5.460	7.310	5.050	3.610
PAH by HPLC (ug/L):										
Carbazole	3	2.38	<2.00	<2.00	34.8	<2.00	<2.00	<2.00	23.7	<2.00
Naphthalene	2	866	885	4.22	8.18	631	494	598	691	57.2
Acenaphthylene	3	40.6	39.9	4.93	<20.0	3.70	INT	INT	<20.0	INT
Acenaphthene	3	35.9	41.3	24.9	31.9	19.0	7.39	5.68	<20.0	10.0
Fluorene	3	12.5	12.2	10.8	12.6	6.79	5.84	4.45	10.6	9.97
Phenanthrene	3	8.17	7.47	6.48	8.37	5.3	3.31	3.22	7.09	6.48
Anthracene	3	2.65	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		968.2	985.9	51.3	95.9	665.8	510.5	611.4	732.4	83.7

Note: Analyses by KER.
INT - Indicates interference.
< - Represents less than detectable concentrations.
* - Indicates sample was damaged in shipment.
[a] - Represents increase due to KMnO4 addition.

TABLE 5-6

SAND FILTRATION COLUMN EFFLUENT (SFCEFF) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		0.038	0.025	0.028	0.019	< 0.005	0.009	0.044	< 0.005	0.009
pH (units)		7.2	7.5	7.4	7.5	7.6	7.8	7.5	7.5	7.4
Total Suspended Solids		8.00	4.00	1.00	< 1.00	< 1.00	5.00	3.00	1.00	3.00
Total Organic Carbon		7.35	4.41	101	11.7	5.59	7.98	6.99	7.16	8.52
METALS (mg/L):										
Iron-Total		< 0.100	6.540	< 0.100	< 0.100	< 0.100	< 0.100	0.150	< 0.100	< 0.100
Iron-Ferrous		< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Iron-Filtered		< 0.100	2.180	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Manganese		0.022	7.060	0.165	0.041	0.031	0.256	0.249	0.160	0.095
PAH by HPLC (ug/L):										
Carbazole	3	2.49	<2.00	<2.00	<2.00	INT	INT	INT	10.7	INT
Naphthalene	2	743	950	311	110	564	672	10.2	792	876
Acenaphthylene	3	34.0	44.9	17.3	<2.00	6.07	INT	INT	<20.0	INT
Acenaphthene	3	31.0	50.2	30.0	<2.00	19.9	14.4	<2.00	<20.0	14.7
Fluorene	3	9.83	13.8	11.6	9.63	6.74	11.4	13.1	9.25	11.3
Phenanthrene	3	5.66	9.16	5.43	1.81	4.76	6.73	4.72	7.02	8.26
Anthracene	3	<0.500	0.503	<0.500	<0.500	<0.500	<0.500	2.21	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	0.218	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	0.262	0.204	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		825.98	1068.5	383.33	121.44	591.47	704.53	30.71	767.17	910.26

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK13	WK17	WK21	WK28	WK30
CONVENTIONAL (mg/L):						
Phenol (4-AAP)		0.016	< 0.005	0.012	0.017	< 0.500
PAH by HPLC (ug/L):						
Carbazole	3	9.12	8.97	<2.00	471	65.0
Naphthalene	2	583	47.5	<2.00	980	460
Acenaphthylene	3	55.6	137	<2.00	<20.0	<20.0
Acenaphthene	3	44.7	<20.0	31.0	<20.0	88.0
Fluorene	3	12.7	13.7	11.3	22.4	22.2
Phenanthrene	3	8.73	11	6.96	13.4	9.50
Anthracene	3	<0.500	<0.500	<0.500	1.20	1.27
Fluoranthene	4	0.355	<0.200	<0.200	<0.200	0.560
Pyrene	4	<0.200	<0.200	<0.200	0.654	1.71
Benzo(a)anthracene	4	0.033	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		714.23	210.17	50.06	1488.8	648.24

Note: Analyses by KER
INT - Indicates interference.
< - Represents less than detectable concentrations.

oxidized in the influent tank via $KMnO_4$ chemical oxidation, precipitate formation (i.e., $Fe(OH)_3$) was not pronounced enough to where the iron was removed through a 0.45 μm filter.

Some of the PAHs detected in the influent tank (e.g., naphthalene) did vary somewhat during the nine week sampling period. Only the 2- and 3-ring PAHs were detected with none of the potentially carcinogenic 4-, 5- and 6-ring PAHs detected at the reporting limits cited.

The sand filtration column effluent results (Table 5-6) support that the pretreatment step worked quite well in terms of removing iron and manganese from the groundwater prior to carbon treatment, an exception is to be noted for Week 2. Week 2 sample results show iron and manganese values above the influent tank values as a result of overloading of the sand filter. The INFTNK and SFCEFF results for total iron and manganese are graphically presented in Figures 5-3 and 5-4, respectively. Referring to Figure 5-4, the relatively high influent Mn values is due to the fact that Mn was added to the groundwater as part of the $KMnO_4$ chemical oxidant.

Conversely and as anticipated, phenolics (4-AAP), TOC and PAHs were not appreciably removed across the sand column. Total detectable PAH results across the sand column are graphically illustrated in Figure 5-5. Exceptions in terms of PAHs across the sand filter are to be noted for Weeks 3, 7 and 9, possibly due to sampling and analytical variability. However, it can be inferred from the data that partial phenolics oxidation may have occurred due to $KMnO_4$ oxidation. The data in Table 5-5 shows phenolics levels ranging between < 0.005 mg/L to 0.026 mg/L. With the influent tank receiving $KMnO_4$ addition, there is a possibility that partial phenolics oxidation may have occurred as previously cited in Section 4.3 (i.e., Tables 4-6 and 4-7).

Carbon Column Breakthrough Monitoring

Phenolics and PAH monitoring results of the three carbon column effluents are given in Tables 5-7 through 5-9. These results very substantially support that activated

FIGURE 5-3

IRON CONCENTRATIONS OF SAND FILTER INFLUENT AND EFFLUENT

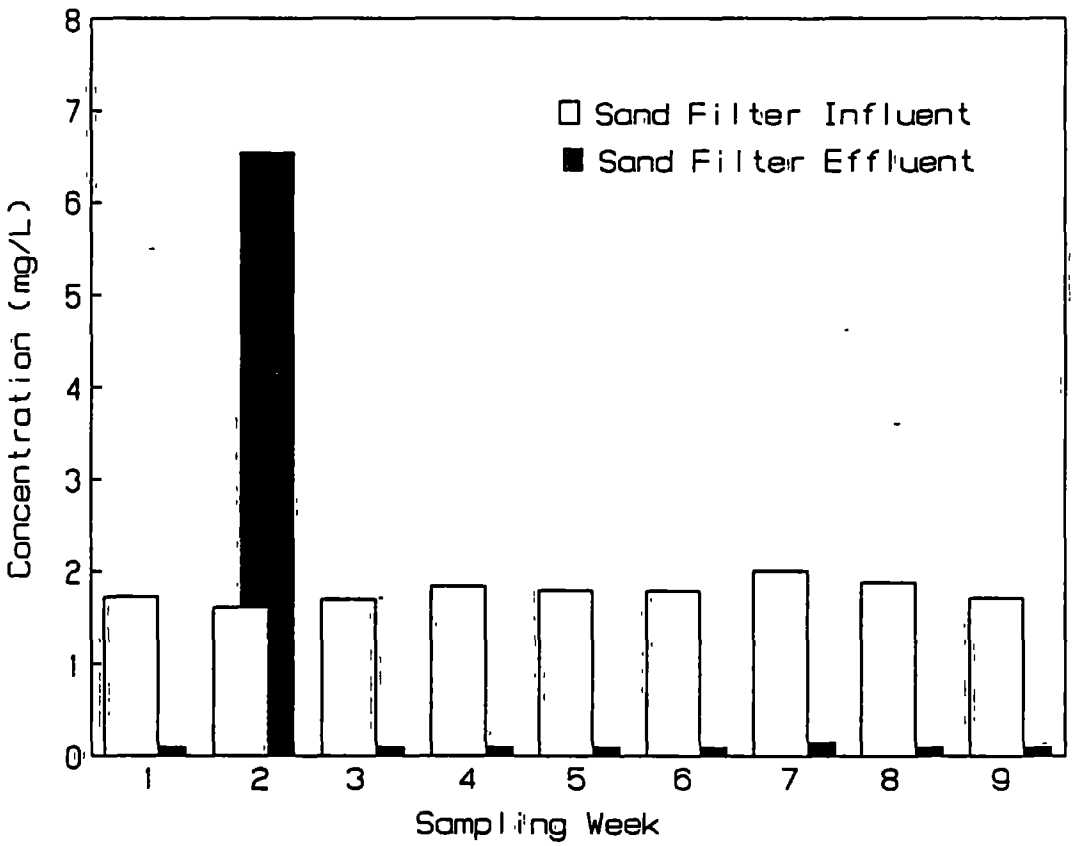


FIGURE 5-4

MANGANESE CONCENTRATIONS OF SAND FILTER INFLUENT AND EFFLUENT

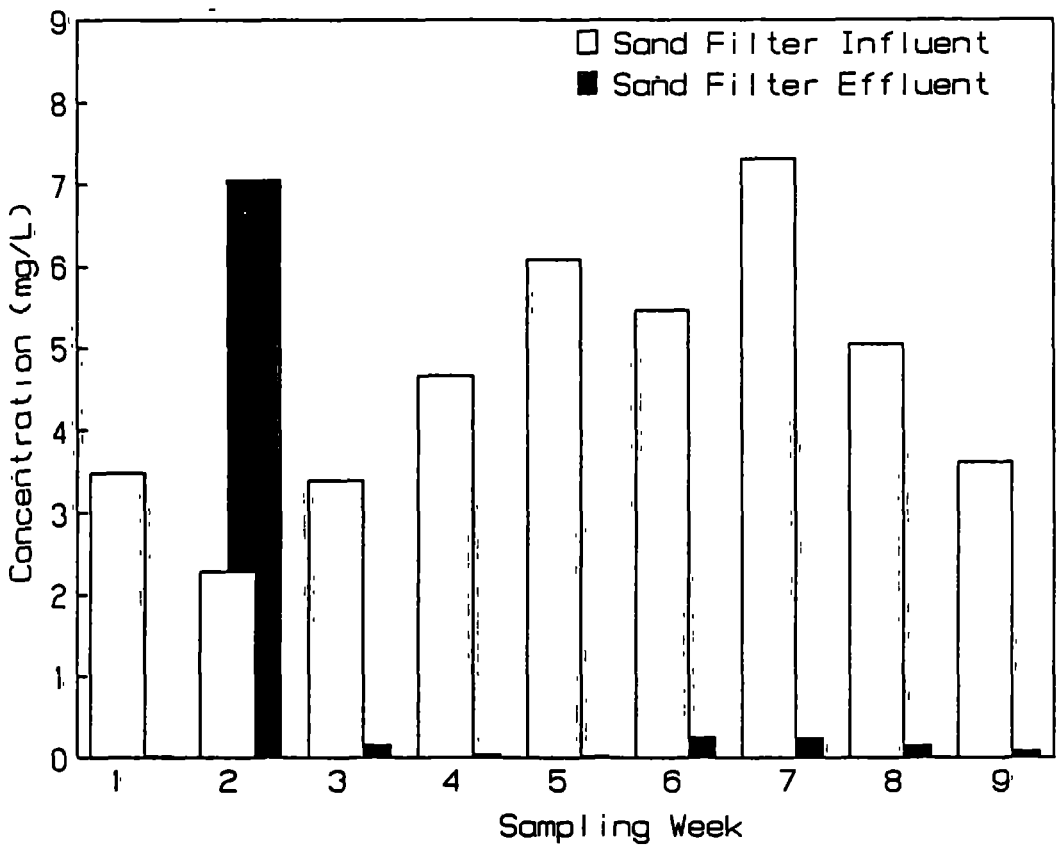


FIGURE 5-5

TOTAL PAH CONCENTRATIONS OF THE SAND FILTER INFLUENT AND EFFLUENT

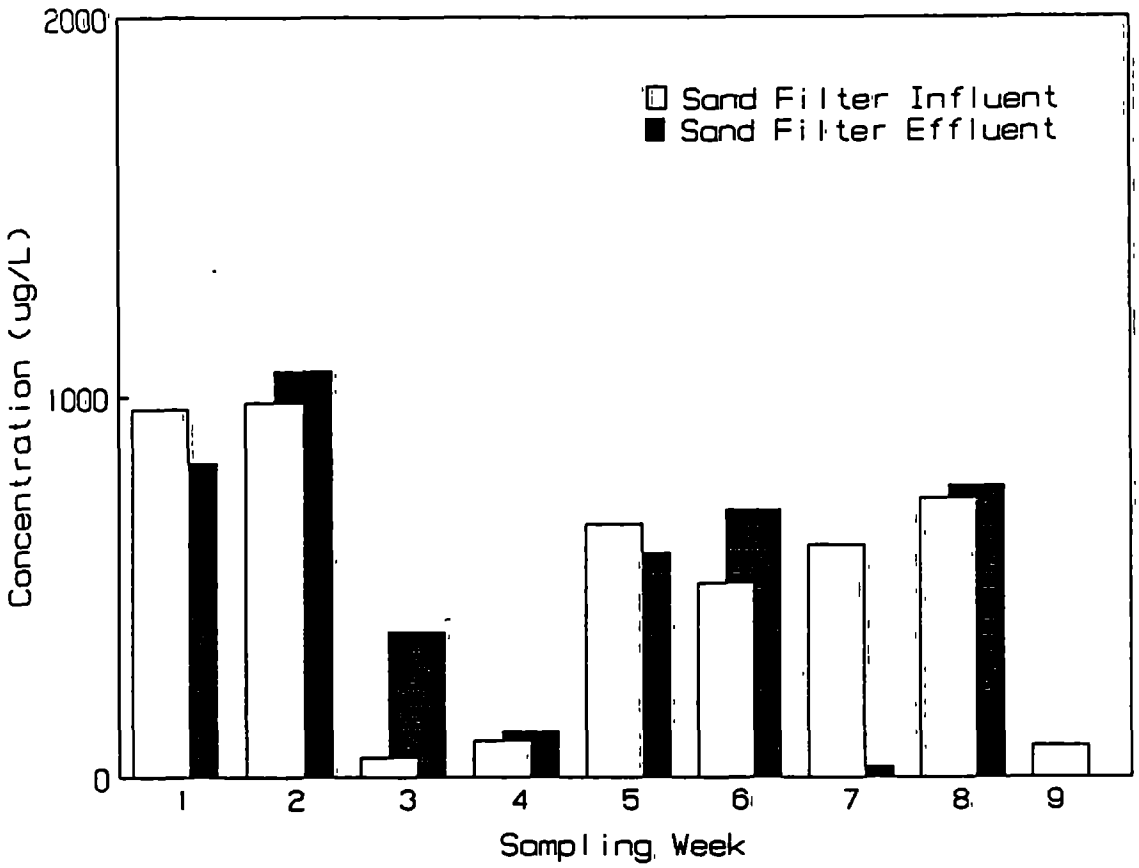


TABLE 5-7

ACTIVATED CARBON COLUMN 1 EFFLUENT (AC1EFF) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
PAH by HPLC (ug/L):										
Carbazole	3	<2.00	<2.00		<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Naphthalene	2	<2.00	<2.00		<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthylene	3	<2.00	<2.00		<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthene	3	<2.00	<2.00		<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Fluorene	3	<0.200	0.655		<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Phenanthrene	3	<0.500	0.830		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Anthracene	3	<0.500	<0.500		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200		<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200		<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150		<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020		<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030		<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK11	WK13	WK15	WK17	WK19	WK21	WK28	WK30
CONVENTIONAL (mg/L):									
Phenolics (4-AAP)		< 0.005	0.016	0.007	0.008	0.005	< 0.005	0.013	< 0.500
PAH by HPLC (ug/L):									
Carbazole	3	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	2.08	<2.00
Naphthalene	2	<2.00	<2.00	<2.00	9.37	21.4	<2.00	25.30	39.60
Acenaphthylene	3	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	14.00	14.30
Acenaphthene	3	<2.00	<2.00	<2.00	<2.00	2.77	<2.00	6.11	<2.00
Fluorene	3	<0.200	<0.200	<0.200	<0.200	0.370	<0.200	0.750	1.100
Phenanthrene	3	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Anthracene	3	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.500	<0.500	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.500	<0.500	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.500	<0.500	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.500	<0.500	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.500	<0.500	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.500	<0.500	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.500	<0.500	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.500	<0.500	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.500	<0.500	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.500	<0.500	<0.050	<0.050	<0.050
Total Detectable PAH		0.0	0.0	0.0	9.4	24.5	0.0	48.2	55.0

Note: Analysis by KER.
NA - Indicates not analyzed.
< - Represents less than detectable concentrations.
* - Indicates sample was damaged in shipment.

TABLE 5-8

ACTIVATED CARBON COLUMN 2 EFFLUENT (AC2EFF) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK3	WK5	WK7	WK9
CONVENTIONAL (mg/L):						
Phenolics (4-AAP)		NA	< 0.005	< 0.005	< 0.005	< 0.005
PAH by HPLC (ug/L):						
Carbazole	3	<2.00	<2.00	<2.00	<2.00	<2.00
Naphthalene	2	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthylene	3	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthene	3	<2.00	<2.00	<2.00	<2.00	<2.00
Fluorene	3	<0.200	<0.200	<0.200	<0.200	<0.200
Phenanthrene	3	<0.500	<0.500	<0.500	<0.500	<0.500
Anthracene	3	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		0.00	0.00	0.00	0.00	0.00

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK11	WK13	WK15	WK17	WK19	WK21	WK28	WK30
CONVENTIONAL (mg/L):									
Phenolics (4-AAP)		< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.500
PAH by HPLC (ug/):									
Carbazole	3	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Naphthalene	2	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthylene	3	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthene	3	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Fluorene	3	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Phenanthrene	3	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Anthracene	3	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Analyses by KER
NA - Indicates not analyzed.
< - Represents less than detectable concentrations.

TABLE 5-9

ACTIVATED CARBON COLUMN 3 EFFLUENT (AC3EFF) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK3	WK5	WK7	WK9
CONVENTIONAL (mg/L):						
Phenolics (4-AAP)		NA	< 0.005	< 0.005	< 0.005	< 0.005
PAH by HPLC (ug/L):						
Carbazole	3	<2.00	<2.00	<2.00	<2.00	<2.00
Naphthalene	2	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthylene	3	<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthene	3	<2.00	<2.00	<2.00	<2.00	<2.00
Fluorene	3	<0.200	<0.200	<0.200	<0.200	<0.200
Phenanthrene	3	<0.500	<0.500	<0.500	<0.500	<0.500
Anthracene	3	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		0.00	0.00	0.00	0.00	0.00

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK11	WK13	WK17	WK21	WK28	WK30
CONVENTIONAL (mg/L):							
Phenolics (4-AAP)		NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.500
PAH by HPLC (ug/L):		NA					
Carbazole	3		<2.00	<2.00	<2.00	<2.00	<2.00
Naphthalene	2		<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthylene	3		<2.00	<2.00	<2.00	<2.00	<2.00
Acenaphthene	3		<2.00	<2.00	<2.00	<2.00	<2.00
Fluorene	3		<0.200	<0.200	<0.200	<0.200	<0.200
Phenanthrene	3		<0.500	<0.500	<0.500	<0.500	<0.500
Anthracene	3		<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4		<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4		<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4		<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4		<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5		<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5		<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5		<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5		<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6		<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6		<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH			0.00	0.00	0.00	0.00	0.00

Note: Analyses by KER.
NA - Indicates not analyzed.
< - Represents less than detectable concentrations.

carbon treatment is very effective for treatment of pumped groundwaters at the St. LouisPark site. Analytical results of the pretreated groundwater applied to Carbon Column 1 (SFCEFF) were previously cited in Table 5-6.

Except for just detectable concentrations of fluorene and phenanthrene at Week 2, Column 1 effluent results in Table 5-7 cite no detectable concentrations of PAHs until naphthalene was measured at Week 17. Subsequently, naphthalene was detected in AC1 effluent at Weeks 19, 28 and 30 along with acenaphthylene, acenaphthene and fluorene being detected somewhat randomly (i.e., sometimes they were detected and sometimes they were not). Also, no PAHs were detected at Week 21. This observed trend of increasing PAH for effluent concentration is generally consistent with the pattern of carbon adsorption normally obtained for a fixed-bed carbon column adsorber continuously fed a water stream as cited by Weber [8]. This is particularly so for the case of naphthalene with it beginning to be detected in carbon column 1 effluent with the concentrations increasing at a gradual rate. Further discussions of this are provided in Section 6.2 under "Activated Carbon Treatment".

For the case of phenolics (4-AAP), Table 5-7 data shows that detection occurred above the target NPDES level of 0.01 mg/L at Weeks 13 and 28, with just above detectable concentrations measured at Weeks 15, 17 and 19, and none detected at Week 21. At Week 30, interferences with the analytical method resulted in an uncharacteristically high method detection limit of 0.5 mg/L rather than the normal 0.005 mg/L. Thus, no conclusions can be made for Week 30 results. Based on these data, it appears that the same trend observed for naphthalene equally applies to phenolics (4-AAP). However, the increasing concentration trend for phenolics is not as pronounced as that measured for naphthalene with phenolics being measured at values just slightly above the method detection limit of 0.005 mg/L at Weeks 15, 17, 19 and 28. Such small differences could be attributed to analytical interferences alone.

As to be specifically discussed in Section 6.2, these carbon column effluent values represent a very low carbon use rate. Also, the fact that phenolics and naphthalene were the first compounds detected in Carbon Column 1 effluent is consistent with published carbon isotherm data [5] which empirically predicts that phenolics and naphthalene are

the least adsorbable relative to the other organic chemicals monitored for during the study.

Further supporting the efficiency of activated carbon treatment is the fact that at no time during the 30 weeks of operation were PAHs detected in effluents from columns 2 or 3 (See Tables 5-8 and 5-9). This is also the case for phenolics with the exception of Week 30 results where the detection limit was 0.5 mg/L, as opposed to the normal 0.005 mg/L level. This datum point, as well as that for AC1EFF at Weeks 13, 15, 17 and 19, is suspect because it is just above the method detection limit of 0.005 mg/L. Additionally, phenolics was measured at 0.007 mg/L in AC2EFF at Week 13 with all other weeks being less than detection. Thus, these data indicate that there may be some inherent variability with the phenolics analytical method at such low concentrations.

NPDES Permit Sampling

Tables 5-10, 5-11 and 5-12 summarize results of the NPDES permit sampling performed. The results presented correspond to samples of the influent (INF) comprised of a flow proportioned stream of wells W420 and W421 prior to $KMnO_4$ addition, and the effluent of Carbon Column 3 (AC3EFF). These two streams are identified on Figure 5-1. Grab samples of these two flows were taken at Weeks 1, 7 and 13 during operation and analyzed for conventional, metals, nutrients, PAHs by HPLC, SLP-PAH list, and priority pollutant parameters (Weeks 1 and 13 only) as previously given in Table 5-12.

Table 5-10 presents results for conventional parameters, metals, nutrients and PAHs by HPLC. As cited, the majority of conventional and nutrient parameters analyzed generally showed less than detectable concentrations in the final treated effluent with relatively very low or non-detectable concentrations present in the influent (e.g., nutrients). The pilot-scale treatment was also very effective for reductions of metals and PAHs by HPLC. Due to a communication mix-up, a PAH influent sample was not collected during Week 7. The distilled water blank sample results generally showed non-detectable concentrations of the respective parameters monitored, thus supporting the results obtained in terms of a QA/QC check.

TABLE 5-10

NPDES PERMIT SAMPLING RESULTS FOR CONVNETIONAL/ NUTRIENTS/METALS/PAHs BY HPLC

PARAMETERS	NO. OF PAH RINGS	WEEK 1 INFLUENT	WEEK 1 EFFLUENT	WEEK 1 BLANK	WEEK 7 INFLUENT	WEEK 7 EFFLUENT	WEEK 7 BLANK	Week 13 INFLUENT	Week 13 EFFLUENT	Week 13 BLANK
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		0.074	< 0.005	< 0.005	0.06	< 0.005	< 0.005	0.124	0.012	< 0.005
pH (units)		7.9	7.8	7.6	7.5	7.5	6.6	7.6	7.6	5.8
Total Dissolved Solids		673	560	< 1.00	711	693	< 1.00	715	730	4.00
Total Suspended Solids		10.0	16.0	1.00	14.0	2.0	< 1.00	1.00	< 1.00	< 1.00
Biochemical Oxygen Demand		5.43	< 1.00	< 1.00	4.42	< 1.00	< 1.00	7.20	< 1.00	< 1.00
Chemical Oxygen Demand		16.0	< 10.0	< 10.0	32.0	10.0	< 10.0	20.0	28.0	< 10.0
Total Organic Carbon		7.15	< 1.00	< 1.00	7.06	2.53	< 1.00	2.46	5.26	< 1.00
Oil and Grease		< 6.00	< 6.00	< 6.00	< 5.00	9.11	< 5.00	< 5.00	< 6.00	< 6.00
Hardness (as CaCO3)		453	443	< 1.00	471	475	2.20	501	454	< 1.00
NUTRIENTS (mg/L):										
Orthophosphate as P		< 0.010	0.030	0.014	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia Nitrogen as N		< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	1.05	< 1.00	< 1.00
Nitrite as N		< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Nitrate as N		< 0.020	< 0.020	0.033	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
METALS (mg/L):										
Iron-Total		1.840	< 0.100	< 0.100	2.120	< 0.100	< 0.100	1.980	< 0.100	< 0.100
Iron-Ferrous		0.411	< 0.100	< 0.100	< 0.100	< 0.100	0.110	0.118	< 0.100	< 0.100
Iron-Filtered		< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	0.100	< 0.100	< 0.100
Manganese-Total		0.374	0.034	< 0.015	0.361	0.244	< 0.015	0.374	0.691	< 0.015
PAH by HPLC (ug/L):				NA	NA		NA			NA
Carbazole	3	2.30	<2.00			<2.00		11.1	<2.00	
Naphthalene	2	765	<2.00			<2.00		747	<2.00	
Acenaphthylene	3	84.0	<2.00			<2.00		106	<2.00	
Acenaphthene	3	48.9	<2.00			<2.00		60.2	<2.00	
Fluorene	3	13.3	<0.200			<0.200		14.4	<0.200	
Phenanthrene	3	7.21	<0.500			<0.500		7.03	<0.500	
Anthracene	3	<0.500	<0.500			<0.500		0.691	<0.500	
Fluoranthene	4	<0.200	<0.200			<0.200		<0.200	<0.200	
Pyrene	4	<0.200	<0.200			<0.200		<0.200	<0.200	
Benzo(a)anthracene	4	<0.020	<0.020			<0.020		<0.020	<0.020	
Chrysene	4	<0.150	<0.150			<0.150		<0.150	<0.150	
Benzo(b)fluoranthene	5	<0.020	<0.020			<0.020		<0.020	<0.020	
Benzo(k)fluoranthene	5	<0.020	<0.020			<0.020		<0.020	<0.020	
Benzo(a)pyrene	5	<0.020	<0.020			<0.020		<0.020	<0.020	
Dibenzo(a,h)anthracene	5	<0.030	<0.030			<0.030		<0.030	<0.030	
Benzo(g,h,i)perylene	6	<0.050	<0.050			<0.050		<0.050	<0.050	
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050			<0.050		<0.050	<0.050	
Total Detectable PAH		920.7	0.0			0.0		946.4	0.0	

Note: Analyses by KER.
NA - Indicates not analyzed.
< - Represents less than detectable concentrations.

TABLE 5-11

NPDES PERMIT SAMPLING RESULTS FOR SLP-PAH

PARAMETERS	NO. OF PAH RINGS	WEEK 1			WEEK 7			Week 13		
		INFLUENT	EFFLUENT	BLANK	INFLUENT	EFFLUENT	BLANK	INFLUENT	EFFLUENT	BLANK
Reporting Limit		100	0.01	0.01	10	0.01	0.01	10	0.01	0.01
PAH (ug/L)										
POTENTIALLY CARCINOGENIC (P.C.):										
Quinoline	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	6	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Detectable P.C. PAH		0	0	0	0	0	0	0	0	0
OTHER PAH										
2,3 - Benzofuran	2	ND	ND	ND	18	ND	ND	17	ND	ND
2,3-Dihydroindene	2	140	0.025	ND	140	ND	ND	130	ND	ND
Indene	2	120	ND	ND	150	ND	ND	150	ND	ND
Naphthalene	2	1200	0.041	ND	430	ND	0.021	510	ND	0.032
Benzo(b)thiophene	2	ND	ND	ND	37	ND	ND	86	ND	ND
Indole	2	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	2	ND	ND	ND	45	ND	ND	40	ND	0.013
1-Methylnaphthalene	2	ND	ND	ND	73	ND	ND	65	ND	ND
Biphenyl	2	ND	ND	ND	10	ND	ND	10	ND	ND
Acenaphthylene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	3	ND	ND	ND	52	ND	ND	51	ND	ND
Dibenzofuran	3	ND	ND	ND	14	ND	ND	15	ND	ND
Fluorene	3	ND	ND	ND	17	ND	ND	16	ND	ND
Dibenzothiophene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acridine	3	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	3	ND	ND	ND	26	ND	ND	34	ND	ND
Fluoranthene	4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene	4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perylene	5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Detectable Other PAH		1460	0.066	0.000	1032	0.000	0.020	1121	0.000	0.045

Note: Analyses by RMAL.

ND - Not detectable in terms of reporting limits stated.

TABLE 5-12

NPDES PERMIT SAMPLING RESULTS FOR PRIORITY POLLUTANTS

PARAMETERS	WEEK 1				WEEK 13			
	INFLUENT		EFFLUENT		INFLUENT		EFFLUENT	
VOLATILES (ug/L):								
Vinyl Chloride		31	<	10		13	<	10
Methylene chloride		17		15	<	5	<	5
trans-1,2-Dichloroethene		40	<	5		25	<	5
Trichloroethene		110	<	5		83	<	5
Benzene		97	<	5		100	<	5
Tetrachloroethene		57	<	5		25	<	5
Toluene		11	<	5		12	<	5
Ethyl benzene		79	<	5		92	<	5
SEMI-VOLATILES (ug/L):								
Naphthalene		470	<	20		1900	<	20
Dimethyl phthalate		35	<	20	<	20	<	20
Fluorene		12	<	20		21	<	20
Bis(2-ethylhexyl) phthalate	<	10	<	20	<	20		120
2,4-Dimethylphenol	<	10	<	20		30	<	20
METALS (mg/L):								
Iron		1.840	<	0.100		1.980	<	0.100
Manganese		0.374		0.034		0.374		0.691
Zinc		0.085	<	0.020		0.083		0.031
MISCELLANEOUS (mg/L):								
Phenolics (4-AAP)		0.074	<	0.005		0.124		0.012

Note: Analyses by KER
Only priority pollutants detected are cited.
See Appendix E for the complete priority pollutant results.
< - Represents less than detectable concentrations.

Referring to the data given in Table 5-10, several issues are noteworthy. One is that phenolics were detected in AC3EFF at Weeks 13 in the sample collected for priority pollutant analysis while another AC3EFF sample collected at approximately the same timeshowed no phenolics detected (Table 5-9). This fact further supports the previous statement that phenolics analysis near the method detection limit of 0.005 mg/L may be subject to some inherent variability. A second issue is the suspicion that some phenolics reduction may be occurring via $KMnO_4$ chemical oxidation. Comparing phenolics data in Table 5-5 with those in Table 5-10 for Weeks 1 and 7 show that no concentrations were detected in the influent tank receiving $KMnO_4$, with respective concentrations of 0.074 mg/L and 0.06 mg/L detected in the combined influent to the influent tank. While such a fact can be inferred, sufficient samples were not collected for definite conclusions to be made. The last issue to note is that the manganese concentrations cited in Table 5-10 are those representative of the site groundwater and not those given in Table 5-5 which include Mn added to the influent tank as $KMnO_4$. For this reason, both the total iron and manganese values given in Table 5-10 will be used to estimate the $KMnO_4$ dosage added in terms of oxidizing requirements.

Table 5-11 presents results of the PAH-SLP list performed by RMAL. As cited, while parameters were detected in the influent above target NPDES permit requirements, none were detected in the treated effluent at a detectable concentration of 0.01 ug/L (10 ng/L). No parameters were detected in the respective blank samples except for Week 13 where naphthalene and 2-methylnaphthalene were detected just above the method detection limit.

In terms of priority pollutant parameters, no unexpected parameters were detected in the influent and effluent samples collected. Table 5-12 cites that while some volatiles and semi-volatile parameters were detected in the influent, only methylene chloride and Bis(2-ethylhexyl)phthalate were detected in the effluent. Methylene chloride was detected in the influent and effluent during Week 1 only. Methylene chloride is often associated with residual from the analytical extraction. Bis(2-ethylhexyl)phthalate was detected in the effluent, but not the influent during Week 13. Bis(2-ethylhexyl)phthalate is associated with plastic tubing and was probably detected due to such a contact during analytical testing. Only those priority pollutants which were detected in the respective samples collected are given in Table 5-12. The complete priority pollutant test results are given in Appendix

E. In terms of metals and phenolics, the results are the same as that cited in Table 5-10 with the exception of zinc which was detected in the influent sample, but at very low concentrations.

Results of dissolved oxygen monitoring are given in Table 5-13. As cited, the D.O. was very consistent over the sampling period with a level greater than 2.0 mg/L measured in both the influent and effluent across the carbon column process.

Sand Filter Backwash Water Monitoring

Sampling and analysis of the backwash water from the pilot unit sand filtration column were performed to determine the extent, if any, of PAHs being present. The results of this monitoring are given in Table 5-14. As cited, weekly sampling results for total suspended solids (TSS) varied between approximately 300 to 2,270 mg/L with total organic carbon (TOC) varying between approximately 4 to 100 mg/L. The relatively high TSS values cited are due to iron and manganese precipitation as hydroxides resulting from the chemical oxidation step.

Samples were also collected during Weeks 5, 7, and 9 and analyzed for BOD_5 and PAHs by HPLC. As given, BOD_5 was only detected in the Week 9 sample and only some PAHs were detected; these being naphthalene, acenaphthalene, fluorene, and phenanthrene. For these three samples, the PAHs detected were below the target NPDES permit requirements with the exception of naphthalene at Week 9. No explanation is clear as to why naphthalene was relatively high in the Week 9 sample. Also, no PAHs were detected in a filtered solids sample of the backwash water at a detection limit of 0.330 mg/Kg for each respective PAH compound.

On the basis of the sampling results presented, there is no reason why discharge of the sand filtration backwash water cannot be routed to the Minneapolis/St. Paul Metropolitan POTW. For a full-scale groundwater treatment system, the backwash daily flow should be between 10 to 15 percent of the applied groundwater treated.

TABLE 5-13

DISSOLVED OXYGEN (D.O.) SAMPLING RESULTS ACROSS THE CARBON COLUMN PILOT-SCALE SYSTEM

DISSOLVED OXYGEN (mg/L)	
INFLUENT	AC3 EFFLUENT
2.5	2.5
2.5	2.5
2.5	2.6
2.6	2.6
2.4	2.5

NOTE: Results of replicate sampling taken on October 17, 1989.

TABLE 5-14

SAND FILTER BACKWASH WATER SAMPLING RESULTS

PARAMETERS	ANALYTICAL WEEK								
	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CONVENTIONAL (mg/L):									
Total Suspended Solids	1050	362	2270	394	970	1140	292	522	992
Total Organic Carbon	6.86	17.3	101	6.14	49.9	NA	3.77	7.35	78.4
Biological Oxygen Demand	NA	NA	NA	NA	< 1	NA	< 1	NA	9.15
PAH by HPLC (ug/L):	NA	NA	NA	NA		NA		NA	
Carbazole					<2.00		<2.00		<2.00
Naphthalene					7.71		4.31		162
Acenaphthylene					<2.00		<2.00		INT
Acenaphthene					3.55		2.45		10.9
Fluorene					2.15		3.35		9.23
Phenanthrene					1.87		0.799		6.99
Anthracene					<0.500		<0.500		<0.500
Fluoranthene					<0.200		<0.200		<0.200
Pyrene					<0.200		<0.200		<0.200
Benzo(a)anthracene					<0.020		<0.020		<0.020
Chrysene					<0.150		<0.150		<0.150
Benzo(b)fluoranthene					<0.020		<0.020		<0.020
Benzo(k)fluoranthene					<0.020		<0.020		<0.020
Benzo(a)pyrene					<0.020		<0.020		<0.020
Dibenzo(a,h)anthracene					<0.030		<0.030		<0.030
Benzo(g,h,i)perylene					<0.050		<0.050		<0.050
Indeno(1,2,3-c,d)pyrene					<0.050		<0.050		<0.050
Total Detectable PAH					15.28		10.91		189.12

Note: Analyses by KER.
NA - Indicates not analyzed.
INT - Indicates interference.
< - Represents less than dectable concentrations.

6.0 DISCUSSION

While the information presented in Section 5.0 supports the technical feasibility of a sand filtration/activated carbon column system for treatment of specified pumped groundwaters from the St. Louis Park site, this section specifically addresses the results in terms of:

- Comparison of PAH analysis by HPLC, GC/MS and the GC/MS-SIM methods,
- Engineering design issues, and
- Permitting considerations.

These items are specifically addressed in the respective sub-sections.

6.1 COMPARISON OF PAH ANALYSIS BY DIFFERENT METHODS

During the course of the treatability work performed, PAHs were analyzed by KER using both HPLC and GC/MS methods, and by RMAL using the GC/MS-SIM method. Comparison of these three methods is important for the purpose of determining whether or not the three methods provide similar results in terms of individual PAHs as well as total PAHs. Table 6-1 provides such a comparison between the samples taken for NPDES permit sampling purposes.

While some differences are noted for some quantifable PAHs, there does appear to be some consistency among the three methods in terms of general trends. For the Potentially Carcinogenic PAHs, non-detectable levels are cited in the respective samples by all three different analytical methods with widely varying reporting limits. Also, the HPLC method achieved better detection limits in the influent samples than the two GC/MS methods.

TABLE 6-1

COMPARISON OF HPLC AND GC/MS METHODS FOR PAH MONITORING PURPOSES

		WEEK 1						WEEK 13					
		INFLUENT			COLUMN 1 EFFLUENT			INFLUENT			COLUMN 1 EFFLUENT		
PARAMETERS	No. of PAH Rings	EMAL GC/MS-SIM	EEE GC/MS	EEE HPLC	EMAL GC/MS-SIM	EEE GC/MS	EEE HPLC	EMAL GC/MS-SIM	EEE GC/MS	EEE HPLC	EMAL GC/MS-SIM	EEE GC/MS	EEE HPLC
PAH (mg/L)													
POTENTIALLY CARCINOGENIC (P.C.)													
Quinoline	2	<200	NA	NA	<0.01	NA	NA	<20	NA	NA	<0.010	NA	NA
Benzo(a)anthracene	4	<200	<20	<0.020	<0.01	<10	<0.020	<20	<20	<0.020	<0.010	<20	<0.020
Chrysene	4	<200	<10	<0.170	<0.01	<10	<0.170	<10	<20	<0.170	<0.010	<20	<0.170
Benzo(b)fluoranthene	5	<100	<10	<0.020	<0.01	<10	<0.020	<10	<20	<0.020	<0.010	<20	<0.020
Benzo(k)fluoranthene	5	<100	<10	<0.020	<0.01	<10	<0.020	<10	<20	<0.020	<0.010	<20	<0.020
Benzo(a)pyrene	5	<100	<10	<0.020	<0.01	<10	<0.020	<10	<20	<0.020	<0.010	<20	<0.020
Indeno(1,2,3-c,d)pyrene	6	<100	<10	<0.020	<0.01	<10	<0.020	<10	<20	<0.020	<0.010	<20	<0.020
Dibenzo(a,h)anthracene	5	<100	<10	<0.020	<0.01	<10	<0.020	<10	<20	<0.020	<0.010	<20	<0.020
Benzo(g,h,i)perylene	6	<100	<10	<0.020	<0.01	<10	<0.020	<10	<20	<0.020	<0.010	<20	<0.020
Total Detectable P.C. PAH		0	0	0.000	0.00	0	0.000	0	0	0.000	0.000	0	0.000
OTHER PAH (mg/L)													
1,3 - Benzodiene	2	<100	NA	NA	<0.01	NA	NA	17	NA	NA	<0.010	NA	NA
2,3-Dihydrobenzene	2	140	NA	NA	0.015	NA	NA	130	NA	NA	<0.010	NA	NA
Indene	2	120	NA	NA	<0.01	NA	NA	120	NA	NA	<0.010	NA	NA
Naphthalene	2	1200	430	765	0.041	<20	<3.00	310	1900	707	<0.010	<20	<3.00
Benzothiophene	2	<100	NA	NA	<0.01	NA	NA	55	NA	NA	<0.010	NA	NA
Indole	2	<100	NA	NA	<0.01	NA	NA	<10	NA	NA	<0.010	NA	NA
2-Methylnaphthalene	2	<100	NA	NA	<0.01	NA	NA	40	NA	NA	<0.010	NA	NA
1-Methylnaphthalene	2	<100	NA	NA	<0.01	NA	NA	65	NA	NA	<0.010	NA	NA
Biphenyl	2	<100	NA	NA	<0.01	NA	NA	10	NA	NA	<0.010	NA	NA
Acenaphthylene	2	<100	<10	84.0	<0.01	<20	<3.00	<10	<20	105	<0.010	<20	<3.00
Acenaphthene	3	<100	15	68.9	<0.01	<20	<3.00	31	<20	83.3	<0.010	<20	<3.00
Dibenzofuran	3	<100	NA	NA	<0.01	NA	NA	15	NA	NA	<0.010	NA	NA
Fluorene	3	<100	13	13.5	<0.01	<20	<0.320	16	21	14.4	<0.010	<20	<0.320
Dibenzothiophene	3	<100	NA	NA	<0.01	NA	NA	<10	NA	NA	<0.010	NA	NA
Phenanthrene	3	<100	<10	7.21	<0.01	<20	<0.320	<10	<20	7.05	<0.010	<20	<0.320
Anthracene	3	<100	<10	<0.320	<0.01	<20	<0.320	<10	<20	0.0091	<0.010	<20	<0.320
Acridine	3	<100	NA	NA	<0.01	NA	NA	<10	NA	NA	<0.010	NA	NA
Carbazole	3	<100	NA	5.3	<0.01	NA	<3.00	36	NA	11.1	<0.010	NA	<3.00
Fluoranthene	4	<100	<10	<0.320	<0.01	<20	<0.320	<10	<20	<0.320	<0.010	<20	<0.320
Pyrene	4	<100	NA	<0.320	<0.01	NA	<0.320	<10	NA	<0.320	<0.010	NA	<0.320
Benzo(a)pyrene	5	<100	NA	<0.320	<0.01	NA	<0.320	<10	NA	<0.320	<0.010	NA	<0.320
Perylene	5	<100	NA	NA	<0.01	NA	NA	<10	NA	NA	<0.010	NA	NA
Total Detectable Other PAH		1460	517	951	0.056	0	0.00	1121	1921	946	0.000	0	0.00

Note: Respective results taken from NYDEC process sampling data given on Sheets 3-5.

NA = Indicates not analyzed.

< = Represents less than detectable measurement.

For the Other PAH parameters, naphthalene was always detected in the two influent samples at respective concentrations which represented the majority of the detectable PAH compounds. In terms of the naphthalene concentrations measured, some differences are noted for the three methods.

The results presented, along with those previously given in Table 4-3, do support that PAH analysis by HPLC can be used for operational monitoring of the treatment system rather than the more costly GC/MS methods. The basis of this conclusion statement is the fact that naphthalene comprises the majority of the total PAHs detected and that naphthalene is a very quantifable parameter by HPLC analysis. This argument is further supported by the fact that naphthalene will also be one of the first compounds to break through (i.e., be detected) in the carbon column effluent. Phenolics is another parameter which should break through early. Further discussions of this are given in the next sub-section.

6.2 ENGINEERING DESIGN ISSUES

One of the primary reasons for operating the pilot-scale treatment unit was to generate engineering design data related to chemical oxidation/sand filtration pretreatment, and activated carbon column treatment of a full-scale system. Design data for these two processes are given in Table 6-2.

Chemical Oxidation/Sand Filtration Pretreatment

For pretreatment of pumped site groundwaters, the $KMnO_4$ dose ratios cited in Table 6-2 for Fe and Mn removal are based upon operation of the pilot unit. These values were computed based on the fact that approximately 3.1 mg of $KMnO_4$ was added per liter of influent groundwater. This value is close to the requirement of 2.7 mg/L

TABLE 6-2

PILOT-SCALE OPERATION DESIGN PARAMETERS

I. <u>Chemical Oxidation/Sand Filtration Pretreatment</u>

• $KMnO_4$ Dosage Ratio:	1.16 mg $KMnO_4$: mg Fe 2.16 mg $KMnO_4$: mg Mn
• Sand Filter Hydraulic Loading	1.15 gpm/ft^2 (downflow)
• Filter Media	
• Anthracite	
Effective Size	0.9 mm
Uniformity Coefficient	1.70
• Pool Sand	
Effective Size	0.48
Uniformity Coefficient	1.46
• Intermittent Daily Backwash	21% of Applied Daily Flowrate

II. <u>Activated Carbon Column Treatment</u>

• Mesh Size	12 x 40
• Hydraulic Loading	2.9 gpm/ft^2
• Empty Bed Contact Times	AC1 = 7.5 minutes AC2 = 7.5 minutes AC3 = 10 minutes Total = 25 minutes
• Carbon Usage	
• Phenolics (Week 22 through 28)	0.133 - 0.103 lb. carbon/1000 gal. treated 0.0014 - 0.0018 lb. phenolics/lb. carbon
• Naphthalene (Week 30)	0.096 lb. carbon/1000 gal. treated 0.047 lb. naphthalene/lb. carbon

computed based on the referenced [6] dose values of 1:1 (mg $KMnO_4$: mg Fe) for iron and 2:1 (mg $KMnO_4$: mg Mn) for manganese using the average influent values for iron and manganese measured in the groundwater influent (INF) samples as cited in Table 6-3. Thus, the computed dose ratios actually added are 1.16:1 for Fe and 2.16:1 for Mn. The hydraulic loading to the sand filter was 1.15 gpm/ft^2 which is near the low range for most downflow fixed bed type sand filters [4]. A single excursion for iron and manganese concentrations in the sand filter effluent during Week 2 of operation is attributed to solids overloading of the sand filter. Daily backwashing of the sand filtration unit rectified this condition. The daily backwashing represented approximately 21 percent of the daily applied flowrate to the sand filter which was applied for 30 minutes per day at a flowrate of 11.5 gpm/ft^2 as needed to fluidize the sand bed. Normally, the backwash rate for a full-scale sand filter represents between 5 to 15 percent of the applied flowrate on a daily basis [4].

Activated Carbon Treatment

The three in-series activated carbon columns operated during the pilot testing simulated a single column with sampling ports representing 7.5, 15, and 25 minutes of empty bed contact times (EBCT) with the same hydraulic loading of 2.9 gpm/ft^2 applied to each column. Data generated for NPDES permitting considerations were generated under the 25 minute EBCT condition while data generated to estimate carbon chemical loadings and exhaustion rates were generated under an EBCT of 7.5 minutes for Carbon Column 1 (AC1). Figure 6-1 plots the influent and treated effluent concentrations of naphthalene for Carbon Column 1 (AC1). Figure 6-2 does the same for phenolics.

Carbon adsorption in a fixed bed column represents an unsteady-state condition in that activated carbon continues to remove increasing amounts of impurities from solution over the entire period of useful operation. As cited by Weber [8], Figure 6-3 is a plot of a typical carbon breakthrough curve for a particular solute with an influent concentration C_o. As given, the solute or impurity is adsorbed most rapidly and effectively by the upper few layers of fresh carbon during the initial stages of operation. These upper layers are of course in contact with the solution at its highest concentration levels, C_o. The small amounts of solute which escape adsorption in the first few layers of adsorbent are then

TABLE 6-3

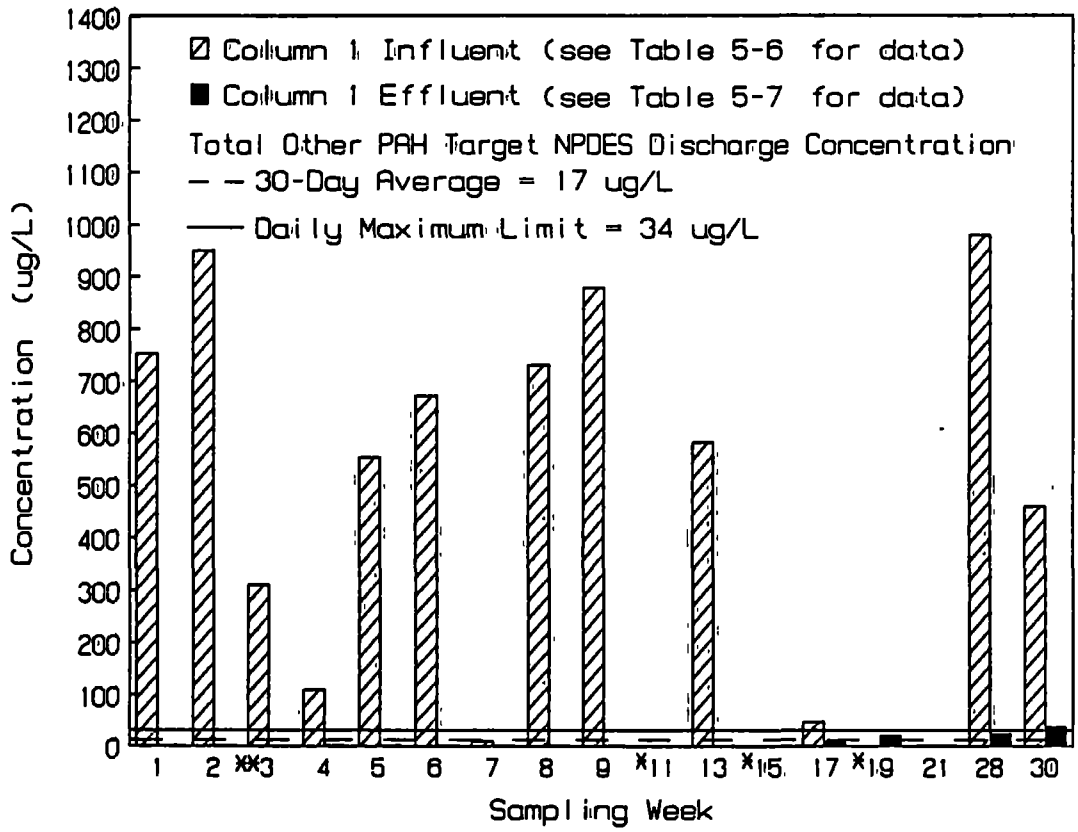
STATISTICAL COMPILATION OF IRON AND MANGANESE GROUNDWATER CONCENTRATIONS

PARAMETER	#	AVG	MAX	MIN	STD	L95%	U95%
METALS (mg/L)							
Iron	3	1.980	2.120	1.840	0.140	0.000	2.328
Mangnese	3	0.370	0.370	3.610	0.008	0.000	0.388

NOTE: # - Number of samples used to compute respective statistics.
AVG - Average of reported values.
MAX - Maximun of reported vlaues.
MIN - Minimun of reported vlaues.
STD - Sample standard deviation.
L95% - Lower bound 95% confidence interval limit.
U95% - Upper bound 95% confidence interval limit.
Analysis by KER.
Table 6-3 developed from respective data given in Table 5-10

FIGURE 6-1

COMPARISON OF INFLUENT AND EFFLUENT NAPHTHALENE CONCENTRATIONS FOR CARBON COLUMN 1



NOTE:

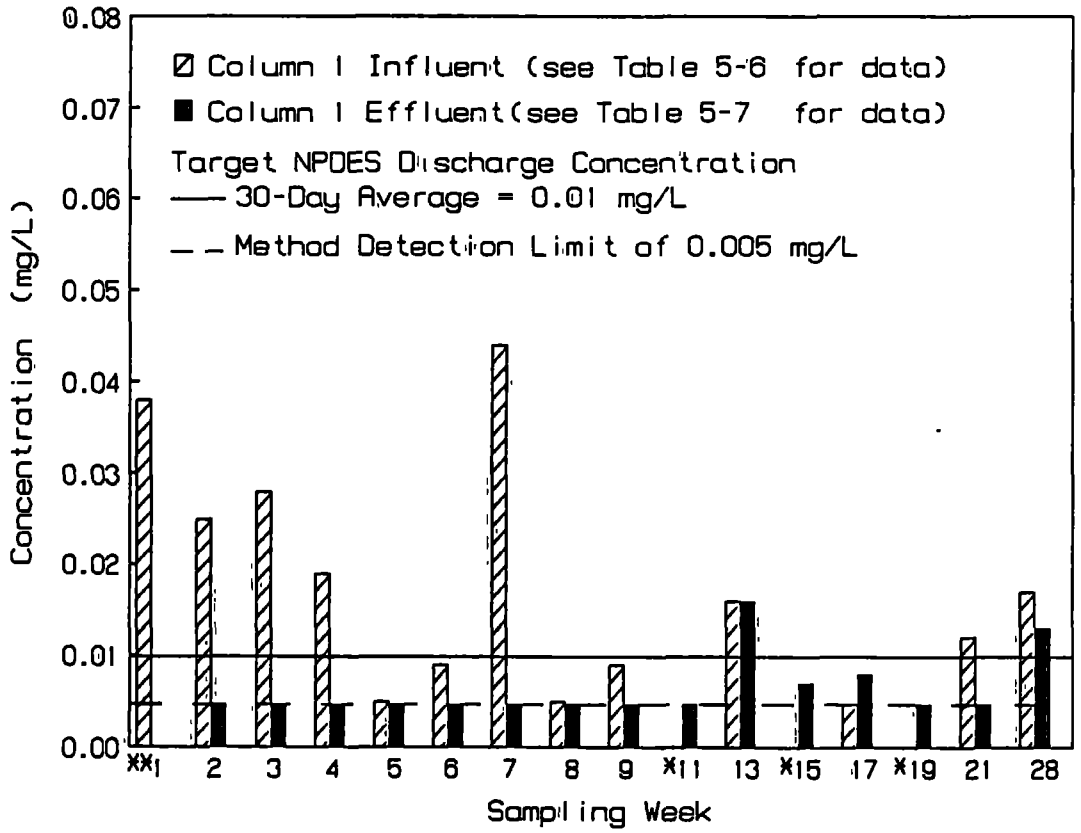
* - Only Effluent Sample Taken

** - Only Influent Sample Taken

No naphthalene detected in effluent through Week 15 and at Week 21 in both influent and effluent at method detection limit of 2 μg/L.

FIGURE 6-2

COMPARION OF INFLUENT AND EFFLUENT PHENOLIC CONCENTRATIONS FOR CARBON COLUMN 1



NOTE:

* - Only Effluent Sample Taken

** - Only Influent Sample Taken

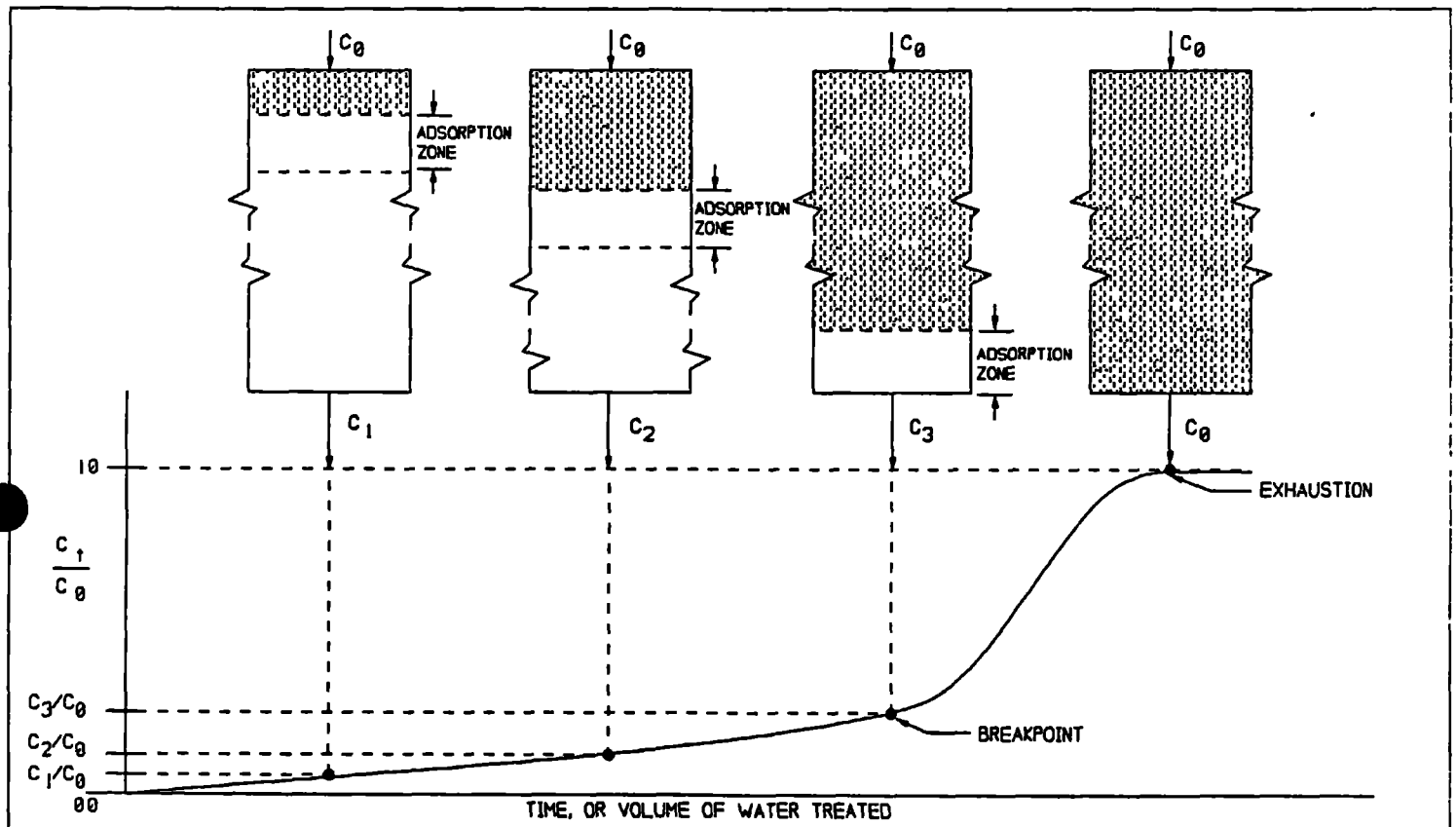
Week 30 results not shown due to analytical interferences giving an abnormally high method detection limit of 0.5 mg/L.

removed from solution in the lower strata of the bed, and especially no solute escapes from the adsorber initially (C = 0). The primary adsorption zone is concentrated near the top or influent end of the column. As the polluted feedwater continues to flow into the column, the top layers of carbon become practically saturated with solute and less effective for further adsorption. Thus the primary adsorption zone moves downward through the column to regions of fresher adsorbent. The wavelike movement of this zone, accompanied by a movement of the C_o concentration front, occurs at a rate which is generally much slower than the linear velocity of the water or wastewater. As the *primary adsorption zone* moves downward, more and more solute tends to escape in the effluent, as indicated in the sequence of schematic drawings in Figure 6-3. The plot of C_t/C_o versus time (for a constant flow rate or volume of water treated) depicts the increase in the ratio of effluent to influent concentrations as the zone moves through the column. The *breakpoint* on this curve represents that point in operation where, for all practical purposes, the column is in equilibrium with the influent water, and beyond which little additional mass removal of solute will occur. Beyond the *breakpoint*, the solute concentration in the effluent increase rapidly to a value equal to that of the influent, C_o. At this point, the bed is *exhausted*. Generally, the adsorption capacity of carbon is established at the *breakpoint*.

The method chosen for operation of a fixed-bed adsorber is dependent to a large extent on the shape of the curve given by plotting C_t/C_o versus time or volume. As noted previously, this curve is referred to as a *breakthrough* curve. For most adsorption operations in water and wastewater treatment, *breakthrough* curves exhibit a characteristic S shape, but with varying degrees of steepness and position of breakpoint. Factors which affect the actual shape of the curve include all of the parameters discussed earlier (solute concentration, pH, rate-limiting mechanism for adsorption and nature of the equilibrium conditions, particle size, etc.) and, in addition, the depth of the column of carbon and the velocity of flow. As a general rule, the time to breakpoint is decreased by: (i) increased particle size of the carbon; (ii) increased concentration of solute in the influent; (iii) increased pH of the water; (iv) increased flow rate; and (v) decreased bed depth. If the total bed depth is smaller than the length of the primary adsorption zone required for

FIGURE 6-3

SCHEMATIC REPRESENTATION OF THE MOVEMENT OF THE CARBON ADSORPTION ZONE AND THE RESULTING BREAKTHROUGH CURVE



NOTE: C_0 - INFLUENT CONCENTRATION

C_t - EFFLUENT CONCENTRATION AT SPECIFIED TIME OF OPERATION OR TOTAL VOLUME TREATED

- CONCEPT TAKEN FROM WEBER [8]

effective removal of solute from solution, then the concentration of solute in the effluent will rise sharply from the time the effluent is first discharged from the adsorber. For each type of adsorption operation there exists a critical minimum carbon depth.

With two columns operated in-series, it is possible to run the first column to the point of exhaustion with the second column ensuring continued adsorption within the adsorption zone. As long as the adsorption zone does not breakthrough in the second column effluent, this process will ensure maximum carbon utilization.

Based on the naphthalene data in Figure 6-1, it is supported that the *breakpoint* for naphthalene did not occur during the 30 weeks of operation. During the time period between Week 17 (when naphthalene was first detected) and Week 30, the average influent naphthalene concentration was an order of magnitude higher than the effluent. Rather than drastically increase with time after a certain time period, the effluent naphthalene concentration increased very gradually. This was most likely due to the fact that the front end of the *adsorption zone* was beginning to near the effluent end of the carbon column as previously illustrated in Figure 6-3. At Week 30, greater than 90 percent of the applied naphthalene was still being adsorbed. Thus, while the *breakpoint* was most likely being approached, it had not yet been reached. However, as a conservative design estimate, Week 30 data will be used to estimate carbon usage based on naphthalene. It is also noteworthy that the anticipated 30-day average NPDES target concentration of 17 ug/L for Total Other PAH was exceeded on three occasions, but that the daily maximum value of 34 ug/L was slightly exceeded only at Week 30.

Citing the phenolics data plotted in Figure 6-2, it can be argued that phenolics breakthrough occurred somewhere between Week 22 and Week 28 as a conservative estimate. As previously cited in Section 5.3 (Carbon Column Breakthrough Monitoring), determining an exact carbon exhaustion rate based on phenolics is difficult due to: (i) the influent phenolics concentrations being relatively low (i.e., only 6 to 8 times greater than the method detection limit of 0.005 mg/L), and (ii) the observed variability associated with phenolics analysis near these low concentrations. For item (i), the low phenolics (4-AAP) level measured in the influent to Carbon Column 1 may be due to some of the phenolics present in the pumped groundwater being partially oxidized by the $KMnO_4$ added for Fe

and Mn oxidation. For item (ii), it is not known if the phenolics concentrations detected at Weeks 15 and 17 is due to analytical interferences or not. At Week 22, it is supported that phenolics removal is still occurring and at Week 28, exhaustion is being reached.

Referring to Table 6-2, Week 30 of the pilot-scale operation corresponds to a carbon usage of 0.096 lb. carbon/1,000 gallons treated based on naphthalene. Correspondingly for phenolics, Weeks 22 through 28 relate to a carbon exhaustion range of 0.133 to 0.103 lb. carbon/1,000 gallons treated. These values correspond to the same respective values given in Table 5-1 for Carbon Column 1 at the same weeks specified.

These carbon exhaustion rates can alternatively be expressed in terms of mass of chemical adsorbed per mass of the average influent concentrations of naphthalene and phenolics present in the groundwater applied to AC1 for a specified time period. For naphthalene, an average applied naphthalene concentration of 541 ug/L for a 30-week time period represents an exhaustion rate of 0.047 lb. naphthalene adsorbed per lb. of carbon per the following equation:

$$\frac{0.047 \text{ lb. Naphthalene}}{\text{lb. Carbon}} = \frac{541 \text{ ug Naphthalene}}{\text{L of Groundwater}} \times (8.345 \times 10^{-9}) + \frac{0.096 \text{ lb. Carbon}}{1000 \text{ gallons treated}} \qquad (6\text{-}1)$$

with: 8.345×10^{-9} being a conversion factor for ug/L to lb./gallon

A very similar computation was performed for phenolics but with Week 22 and Week 28 data used to give a range of 0.0014 to 0.0018 lb. phenolics per lb. of carbon as cited in Table 6-2.

In computing the carbon exhaustion rates for naphthalene and phenolics, the average influent concentration used was computed using all respective values measured in the sand filtration column effluent (SFCEFF) applied to Carbon Column 1 (AC1) during the pilot-scale testing. This data extended over 30 weeks of operation and included 11 individual data points as previously cited in Table 5-6. Table 6-4 summarizes the statistical data for naphthalene, phenolics and other PAHs monitored. As with all

TABLE 6-4

STATISTICAL COMPILATION OF COLUMN 1 INFLEUNT (SFCEFF) SAMPLING RESULTS

PARAMETERS	#	AVG	MAX	MIN	STD	L95%	U95%
CONVENTIONAL (mg/L):							
Phenolics (4-AAP)	9	0.022	0.044	0.009	0.012	0.013	0.030
PAH by HPLC (ug/L):							
Carbazole	6	95.5	471	2.49	185	0	306
Naphthalene	13	541	980	10.2	334	339	743
Acenaphthylene	6	49.1	137	6.07	47	0	98
Acenaphthene	9	36.9	88.0	14.4	22.9	19.4	54.6
Fluorene	14	12.8	22.4	6.74	4.5	10.3	15.3
Phenanthrene	14	7.36	13.4	1.81	2.9	5.7	9.0
Anthracene	3	1.29	2.21	0.503	0.7	0.2	2.4
Fluoranthene	3	0.378	0.560	0.218	0.172	0	0.805
Pyrene	4	0.758	1.710	0.204	0.700	0	1.871
Benzo(a)anthracene	1	0.033	0.033	0.033			
Chrysene		ND					
Benzo(b)fluoranthene		ND					
Benzo(k)fluoranthene		ND					
Benzo(a)pyrene		ND					
Dibenzo(a,h)anthracene		ND					
Benzo(g,h,i)perylene		ND					
Indeno(1,2,3-c,d)pyrene		ND					
Total Detectable PAH		609	1489	31	417	368	849

Note: Sand Filter Column Effluent statistical data through week 30.
- Number of samples used to compute respective statistics.
AVG - Average of reported values.
MAX - Maximum reported value.
MIN - Minimum reported value.
STD - Sample standard deviation.
U95% - Upper bound 95% confidence limit.
L95% - Lower bound 95% confidence limit.
ND - Not Detected.
Table developed from respective data given in Table 5-6
Table 6-4 corresponds to Table B-4 in the Engineering Evaluation Report [1].

statistical results presented in this report the 95 percent confidence interval limits given were computed for the mean based on a Student-t distribution analysis with n-1 degrees of freedom assuming a normal distribution and unknown variances. Detailed discussions of this statistical compilation are provided elsewhere [7].

The fact that phenolics and naphthalene were the first and only two site chemicals-of-interest detected in carbon column 1 effluent is consistent with published isotherm data which predicts that breakthrough of naphthalene and phenolics will occur prior to any other organic compounds present in the pumped groundwaters. Using published isotherm data and the respective pilot-scale influent average concentrations given in Table 6-4, the carbon exhaustion rate for phenolics is given at 0.0026 lb. phenolics adsorbed per lb. carbon and 0.102 lb. naphthalene adsorbed per lb. carbon for naphthalene. These empirically computed carbon adsorption rates are just slightly higher than those determined from the pilot-scale testing results. One reason for these differences is that the isotherm data used are based on single solute adsorption with the slightly lower pilot-scale carbon adsorption rates due to competition for available adsorption sites from other solutes present in the groundwater. Also, carbon isotherm estimates assume complete carbon exhaustion while the pilot-scale results are based more on breakpoint data, this is especially the case for naphthalene.

6.3 PERMITTING CONSIDERATIONS

As previously discussed in Section 2.0, in accordance with the agreement between Reilly and the City of St. Louis Park, Reilly must provide treatment of source and gradient control well discharge to allow routing to storm sewers by September, 1990. Routing of treated source and gradient control well discharges into storm sewers will require an NPDES permit. The RAP provides recommended NPDES permit limits which are assumed will hold on the permit. The anticipated NPDES permit limits from the RAP are those previously cited in Table 2-1. Additionally, backwash water from the sand filter will require a POTW discharge permit.

For NPDES permitting considerations, a single carbon column with a 25 minute empty bed contact time is assumed. This corresponds to treated effluent from Carbon Column 3 (AC3EFF) of the pilot unit. As such, the anticipated NPDES permit limits were never exceeded based on the results presented in Section 5.3 under "NPDES Permit Sampling".

Focusing on specific issues, iron and manganese are of interest with regard to the permitting and treatment system operation. Permit concentrations for iron and manganese are expected to be near 1 mg/L each, based on previous discussions with the Minnesota Pollution Control Agency. Sand filtration column effluent data indicate that iron and manganese concentration of less than 1 mg/L are easily achievable using $KMnO_4$ chemical oxidation followed by sand filtration. A single excursion exceeding the anticipated NPDES concentration limit for iron and manganese is attributable to overloading of the pilot sand filter during Week 2 of operation. Daily backwashing of the sand filtration column rectified this overloading condition. In terms of other parameters which may be permitted, analysis for respective conventional parameters (e.g., TSS, BOD_5), nutrients, metals, and priority pollutants during the pilot unit operation gave non-detectable concentrations for most and just above detectable concentrations for the rest of the chemicals-of-interest monitored. In addition, it is expected that the D.O. in the treatment system effluent will be greater than 2.0 mg/L. Lastly, a special note should be made for the case of the target NPDES phenolics (4-AAP) concentration of 0.01 mg/L. This value is just above the normal method detection limit of 0.005 mg/L. Thus, any slight interference with the analytical test method may indicate permit excess, when in fact it has not occurred. This is exactly what happened at Week 13. One effluent sample (Table 5-10) had a phenolics concentration of 0.013 mg/L while a second effluent sample collected at the same time (Table 5-9) had a concentration of < 0.005 mg/L. Thus, any NPDES permit should account for this potential issue of phenolics analysis.

At this time, it is proposed to route backwash water from the sand filtration process into the POTW. Based on analysis of this stream, as well as the filtered solids for PAHs, there appears to be no major reason as to why this option cannot be pursued. Analytical results which demonstrated near detectable BOD_5 and TOC concentrations also support this claim. The associated Engineering Report [1] cites procedures and results of additional pilot-scale sand filtration work which evaluated a continuous backwashing type sand filter.

A draft of an NPDES permit application for a full-scale treatment system, based on this pilot work performed, is provided elsewhere [2].

7.0 SUMMARY AND CONCLUSIONS

Laboratory and onsite pilot-scale treatability work was performed to evaluate combined treatment of three source control well (W23/W420/W421) discharges at a St. Louis Park, Minnesota site. Results of the testing performed can be summarized as follows:

1. A system comprised of chemical oxidation/sand filtration pretreatment followed by activated carbon column treatment offers a technically viable and cost efficient treatment system.

2. In terms of pretreatment, potassium permanganate ($KMnO_4$) was found to be the best chemical oxidant for precipitation of iron and manganese at dosages of 1 mg $KMnO_4$ per mg total iron and 2 mg $KMnO_4$ per mg manganese. Downflow media filtration served to remove the precipitated iron and manganese species with sand, "FerroSand", anthracite/sand and anthracite/"FerroSand" all capable of serving as adequate media types at a hydraulic loading of approximately 1 gpm/ft^2.

3. In terms of water quality, $KMnO_4$ oxidation/sand filtration pretreatment served to consistently reduce phenolics, total iron and total manganese groundwater concentrations to levels less than 0.2 mg/L and 0.3 mg/L, respectively. Total suspended solids concentrations in the sand filter effluent were near the detectable limit of 1 mg/L. No appreciable reductions were measured for TOC and PAHs via sand filtration.

4. The pilot-scale pretreatment process was observed to work best with daily backwashing of the sand filter. Analyses of the backwash flow showed it to contain just detectable TOC, BOD_5 and PAH concentrations and appreciable TSS levels. No PAHs were measured on filtered backwash solids. These analyses serve to support that POTW discharge of the backwash stream from the sand filter in a full-scale treatment system offers a viable option. On a

daily basis, the backwash flowrate should represent approximately 5 to 15 percent of the groundwater flow applied to the treatment system.

5. After pretreatment for iron and manganese removal, activated carbon column treatment is well suited for organics removal. At an empty bed contact time (EBCT) of 7.5 minutes and a hydraulic loading of 2.9 gpm/ft^2, carbon exhaustion is estimated within a range of 0.133 to 0.096 lb. carbon/1000 gallons treated. These two values respectively correspond to carbon exhaustion loadings of 0.0014 lb. phenolics/lb. carbon and a 0.047 lb. naphthalene/lb. carbon. Phenolics and naphthalene were used to calculate exhaustion loadings because they were detected in the treated effluent from the first in series carbon column at levels exceeding their respective NPDES anticipated 30-day target levels. This is not surprising since naphthalene is the PAH compound present in the groundwater at the highest concentration, and both phenolics and naphthalene are predicted to breakthrough first based on isotherm data analysis.

6. In terms of NPDES permitting considerations, activated carbon column treatment with an EBCT of 25 minutes represents a technically viable treatment alternative. Pilot-scale test results support that effluent from the treatment system should contain non-detectable PAHs at a reporting limit of 0.01 μg/L, less than 0.5 mg/L metals (iron, manganese), no detectable nutrients, near detectable conventional parameters (e.g., TOC, BOD_5), a pH between 6 to 9, and a dissolved oxygen concentration greater than 2.0 mg/L. Also, any permit should account for potential analytical interferences with phenolics (4-AAP) analysis which could give the anticipated target level of 0.01 mg/L being exceeded when in fact it is not. Possibly, make the level 0.05 mg/L.

7. For operational monitoring purposes, it was substantiated through the analytical treatability work performed that PAH analysis by HPLC can be used in place of comparable, but more costly, GC/MS analysis.

REFERENCES

[1] Remediation Technologies, Inc. (Pittsburgh, PA), "Engineering Evaluation Report for Treatment of Pumped Groundwaters at St. Louis Park, Minnesota", Report prepared for Reilly Industries, Inc., October, 1989.

[2] Remediation Technologies, Inc. (Pittsburgh, PA), NPDES Permit Application for Submittal to the Minnesota Pollution Control Agency for Treatment of Pumped Groundwaters from a St. Louis Park, Minnesota Site, Prepared for Reilly Industries, Inc., October, 1989.

[3] City of St. Louis Park, "Annual Monitoring Report for 1988 - Reilly Tar & Chemical Corporation, NPL Site - St. Louis Park, Minnesota", March 15, 1988, pg. 2.

[4] Metcalf & Eddy, Inc. Wastewater Engineering: Treatment/Disposal/Reuse, 2nd. Edition, McGraw-Hill Book Company, New York, New York, 1979.

[5] U.S. EPA, Office of Research and Development, "Treatability Manual - Volume 1, Treatability Data", U.S. EPA Document No. EPA-600/2-82-001a, U.S. Government Printing Office, Washington, D.C., September, 1981.

[6] Hungerford & Terry, Inc., (Clayton, NJ) "FerroSand CR & IR", Brochure RV3M-87, 1987.

[7] Miller, I. and Freund, J.E., Probability and Statistics for Engineers, Pretice-Hall, Inc., Englewood Cliffs, New Jersey, 1965.

[8] Weber, J., Walter, J., Phyicochemical Process for Water Quality Control, John Wiley & Sons, New York, New York, 1972.

APPENDIX A

ANALYTICAL PARAMETER LIST

- **TABLE A-1: CONVENTIONAL/METALS/NUTRIENTS ANALYSES**
- **TABLE A-2: SLP-PAH LIST**
- **TABLE A-3: PAH ANALYSES BY HPLC**
- **TABLES A-4a THROUGH A-4e: PRIORITY POLLUTANT LIST FROM CLEAN WATER ACT**

  4a: Priority Pollutant List from the Clean Water ACT Volatiles by GC/MS

  4b: Priority Pollutant List from the Clean Water ACT Semi-Volatiles by GC/MS

  4c: Priority Pollutant List from the Clean Water ACT Pesticides/PCB's by GC/MS

  4d: Priority Pollutant List from the Clean Water ACT Metals

  4e: Priority Pollutant List from the Clean Water ACT Miscellaneous

TABLE A-1

CONVENTIONAL/METALS/NUTRIENT ANALYSES

PARAMETER	METHOD	METHOD DETECTION LIMIT (mg/L)
CONVENTIONAL:		
pH	EPA 150.1	--
BOD-5	EPA 405.1	1
COD	EPA 410.4	10
Hardness	EPA 130.2	1
Oil and Grease	EPA 413.1	5
TDS	EPA 160.1	1
TOC	EPA 415.1	1
Phenolics	4-AAP	0.005
TSS	EPA 160.2	1
METALS:		
Iron-Total	EPA 200.7	0.1
Iron-Ferrous	SM 3158	0.1
Iron Filtered	EPA 200.7	
Manganese	EPA 200.7	0.015
NUTRIENTS:		
Ortho-Phosphate	EPA 365.2	5
Ammonia	EPA 350.1	1
Nitrate	EPA 353.2	0.02
Nitrite	EPA 353.2	0.02

NOTE: Analyses by KER.

TABLE A-2

SLP-PAH LIST
(GC/MS SELECTIVE ION METHOD - SIM)

PARAMETER	LIQUID METHOD DETECTION LIMIT (ug/L)	SOLIDS METHOD DETECTION LIMIT (ug/L)
POTENTIAL CARCINOGENS		
Quinoline	0.01	330
Benzo(a)anthracene	0.01	330
Chrysene	0.01	330
Benzo(b)fluoranthene	0.01	330
Benzo(k)fluoranthene	0.01	330
Benzo(a)pyrene	0.01	330
Indeno(1,2,3-c,d)pyrene	0.01	330
Dibenz(a,h)anthracene	0.01	330
Benzo(g,h,i)pyrene	0.01	330
OTHER PAHS		
2,3-Benzofuran	0.01	330
2,3-DHI	0.01	330
Indene	0.01	330
Naphthalene	0.01	330
Benzo(b)thiophene	0.01	330
Indole	0.01	330
2-Methylnaphthalene	0.01	330
1-Methylnaphthalene	0.01	330
Biphenyl	0.01	330
Acenaphthylene	0.01	330
Acenaphthene	0.01	330
Dibenzofuran	0.01	330
Fluorene	0.01	330
Dibenzothiophene	0.01	330
Phenanthrene	0.01	330
Anthracene	0.01	330
Acridine	0.01	330
Carbazole	0.01	330
Fluoranthene	0.01	330
Pyrene	0.01	330
Benzo(e)pyrene	0.01	330
Perylene	0.01	330
7,12-Dimethylbenzanthracene	0.01	330
Dibenz(a,c)anthracene	0.01	330
3-Methylcholanthrene	0.01	330

NOTE: Analyses by RMAL

TABLE A-3

PAH ANALYSES BY HPLC

PARAMETER	METHOD	METHOD DETECTION LIMIT (ug/L)
Acenaphthene	EPA 624	2
Acenaphthylene		2
Anthracene		0.5
Benzo(a)anthracene		0.02
Benzo(b)fluoranthene		0.02
Benzo(K)fluoranthene		0.02
Benzo(g,h,i)perylene		0.05
Benzo(a)pyrene		0.02
Carbazole		2
Chrysene		0.15
Dibenzo(a,h)anthracene		0.03
Fluoranthene		0.2
Fluorene		0.2
Indeno(1,2,3-cd)pyrene		0.05
Naphthalene		2
Phenanthrene		0.5
Pyrene		0.2

NOTE: Analyses by KER.

TABLE A-4a

PRIORITY POLLUTANT LIST FROM THE CLEAN WATER ACT VOLATILES BY GC/MS

PARAMETER	METHOD	METHOD DETECTION LIMIT (ug/L)
Acrolein	EPA 624	5
Acrylonitrile		5
Benzene		5
Bromoform		5
Bromodichloromethane		5
Bromomethane		10
Carbon tetrachloride		5
Chlorobenzene		5
Chloroethane		10
Chlorodibromomethane		5
2-Chloroethyl Vinyl Ether		10
Chloroform		5
1,1-Dichloroethane		5
1,2-Dichloroethane		5
1,1-Dichloroethylene		5
1,2-Dichloropropane		5
c-1,3-dichloropropylene		5
t-1,3-dichloropropylene		5
Trans-1,2-Dichloroethylene		5
1,2-Diphenylhydrazine		5
Ethylbenzene		5
Methylene chloride		5
1,1,2,2-Tetrachloroethane		5
Tetrachloroethylene		5
Toluene		5
1,1,1-Trichloroethane		5
1,1,2-Trichloroethane		5
Trichloroethylene		5
Vinyl Chloride		10

Note: Analyses by KER.

TABLE A-4b

PRIORITY POLLUTANT LIST FROM THE CLEAN WATER ACT SEMI-VOLATILES BY GC/MS

PARAMETER	METHOD	METHOD DETECTION LIMIT (ug/L)
4-Bromophenyl phenyl ether	EPA 625	10
Butyl benzyl phthalate		10
4-Chloro-3-methylphenol		10
2-Chloronaphthalene		10
2-Chlorophenol		10
4-Chlorophenyl phenyl ether		10
Chrysene		10
Di-n-Butylphthalate		10
Di-n-Octylphthalate		10
Dibenzo(a,h)anthracene		10
1,2-Dichlorobenzene		10
1,3-Dichlorobenzene		10
1,4-Dichlorobenzene		10
Benzidine		80
Benzo(a)anthracene		10
Benzo(a)pyrene		10
Acenaphthene		10
Acenaphthylene		10
Benzo (b) fluoranthene		10
Benzo (g,h,i) perylene		10
Benzo (k) fluoranthene		10
Bis (2-chloroethoxy) methane		10
Bis (2-chloroethyl) ether		10
Bis (2-ethylhexyl) phthalate		10
3,3-Dichlorobenzidine		20
Diethyl phthalate		10
Dimethyl phthalate		10
2,4-Dimethylphenol		10
4,6-Dinitro-2-methylphenol		50
2,4-Dinitrophenol		50
2,4-Dinitrotoluene		10
2,6-Dinitrotoluene		10
Fluoranthene		10
Fluorene		10
Hexachlorobenzene		10
Hexachlorobutadiene		10
Hexachlorocyclopentadiene		10
Hexachloroethane		10
Indeno (1,2,3,-cd) pyrene		10
Isophorone		10

Note: Analyses by KER.

TABLE A-4b cont.

PRIORITY POLLUTANT LIST FROM THE CLEAN WATER ACT SEMI-VOLATILES BY GC/MS

PARAMETER	METHOD	METHOD DETECTION LIMIT (ug/L)
N-Nitrosodipropylamine		10
N-Nitrosodimethylamine		10
N-Nitrosodiphenylamine		10
Naphthalene		10
Nitrobenezne		10
2-Nitrophenol		10
4-Nitrophenol		50
Pentachlorophenol		50
Phenanthrene		10
Phenol		10
Pyrene		10
2,4,6-Trichlorophenol		10
1,2,4-Trichlorobenzene		10

Note: Analyses by KER.

TABLE A-4c

PRIORITY POLLUTANT LIST FROM THE CLEAN WATER ACT PESTICIDES/PCB's BY GC/MS

PARAMETERS	METHOD	METHOD DETECTION LIMIT (ug/L)
Aldrin	EPA 608	0.05
Dieldrin		0.1
Chlordane		0.5
4,4'-DDT		0.1
4,4'-DDD		0.1
Endosulfan I		0.05
Endosulfan II		0.1
Endosulfan Sulfate		0.1
Endrin		0.1
Endrin aldehyde		0.1
Heptachlor		0.05
Heptachlor epoxide		0.05
BHC (alpha)		0.05
BHC (beta)		0.05
BHC (gamma)		0.05
BHC (delta)		0.05
Toxaphene		1
PCB 1242		0.5
PCB 1254		1
PCB 1221		0.5
PCB 1232		0.5
PCB 1248		0.5
PCB 1260		1
PCB 1016		0.5

Note: Analyses by KER

TABLE A-4d

PRIORITY POLLUTANT LIST FROM THE CLEAN WATER ACT METALS

PARAMETERS	METHOD	METHOD DETECTION LIMIT (mg/L)
Antimony	EPA 204.2	60
Arsenic	EPA 206.2	10
Beryllium	EPA 200.7	5
Cadmium	EPA 200.7	5
Chromium	EPA 200.7	10
Copper	EPA 200.7	25
Lead	EPA 239.2	5
Mercury	EPA 245.1	0.2
Nickel	EPA 200.7	40
Selenium	EPA 270.2	5
Silver	EPA 200.7	10
Thallium	EPA 279.2	10
Zinc	EPA 200.7	20

Note: Analyses by KER.

TABLE A-4e

PRIORITY POLLUTANT LIST FROM THE CLEAN WATER ACT MISCELLANEOUS

PARAMETERS	METHOD	METHOD DETECTION LIMIT (mg/L)
Phenolics	4-AAP	0.005
Cyanide	EPA 335.3	0.01

Note: Analyses by KER

APPENDIX B

ANALYTICAL DATA

LABORATORY DATA

ATTACHMENT 1:	INITIAL CHARACTERIZATION
ATTACHMENT 2:	PRETREATMENT/SAND FILTRATION
ATTACHMENT 3:	ACT EVALUATION/COMPOSITE SAMPLES

PILOT STUDY DATA

ATTACHMENT 4:	BREAKTHROUGH MONITORING
ATTACHMENT 5:	NPDES PERMIT MONITORING
ATTACHMENT 6:	BACKWASH SOLIDS ANALYSIS
ATTACHMENT 7:	PRIORITY POLLUTANT SCAN

APPENDIX B

ATTACHMENT 1

INITIAL CHARACTERIZATION

Polynuclear Aromatic Hydrocarbons, SIM

PAH SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: W 23
Lab ID: 002872-0001-SA Enseco ID: 1022615
Matrix: AQUEOUS Sampled: 30 NOV 88 Received: 01 DEC 88
Authorized: 01 DEC 88 Prepared: 02 DEC 88 Analyzed: 15 DEC 88

Parameter	Result	Wet wt. Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	1000
2,3-Dihydroindene	8600	ng/L	1000
Indene	2300	ng/L	1000
Naphthalene	16000	ng/L	1000
Benzo(b)thiophene	3800	ng/L	1000
Quinoline	ND	ng/L	1000
1H-Indole	ND	ng/L	1000
2-Methylnaphthalene	2400	ng/L	1000
1-Methylnaphthalene	6000	ng/L	1000
Biphenyl	2100	ng/L	1000
Acenaphthylene	1700	ng/L	1000
Acenaphthene	9300	ng/L	1000
Dibenzofuran	4700	ng/L	1000
Fluorene	7500	ng/L	1000
Dibenzothiophene	ND	ng/L	1000
Phenanthrene	8300	ng/L	1000
Anthracene	1100	ng/L	1000
Acridine	ND	ng/L	1000
Carbazole	1500	ng/L	1000
Fluoranthene	2900	ng/L	1000
Pyrene	2500	ng/L	1000
Benzo(a)anthracene	ND	ng/L	1000
Chrysene	ND	ng/L	1000
Benzo(b)fluoranthene	ND	ng/L	1000
Benzo(k)fluoranthene	ND	ng/L	1000
7,12-Dimethylbenz-anthracene	ND	ng/L	1000
Benzo(e)pyrene	ND	ng/L	1000
Benzo(a)pyrene	ND	ng/L	1000
Perylene	ND	ng/L	1000
3-Methylcholanthrene	ND	ng/L	1000
Dibenz(a,h)anthracene	ND	ng/L	1000
Dibenz(a,c)anthracene	ND	ng/L	1000
Benzo(g,h,i)perylene	ND	ng/L	1000
Indeno(1,2,3-c,d)pyrene	ND	ng/L	1000
Naphthalene-d8	ND	%	--
Fluorene-d10	ND	%	--
Chrysene-d12	ND	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Jay Garamone Approved By: Jeff Lowry

The cover letter is an integral part of this report.
Rev 230787

Ensec

Polynuclear Aromatic Hydrocarbons, SIM

PAH SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: W 420
Lab ID: 002872-0002-SA Enseco ID: 1022616
Matrix: AQUEOUS Sampled: 30 NOV 88 Received: 01 DEC 88
Authorized: 01 DEC 88 Prepared: 02 DEC 88 Analyzed: 19 DEC 88

Parameter	Result	Wet wt. Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	100000
2,3-Dihydroindene	130000	ng/L	100000
Indene	120000	ng/L	100000
Naphthalene	500000	ng/L	100000
Benzo(b)thiophene	ND	ng/L	100000
Quinoline	ND	ng/L	100000
1H-Indole	ND	ng/L	100000
2-Methylnaphthalene	ND	ng/L	100000
1-Methylnaphthalene	ND	ng/L	100000
Biphenyl	ND	ng/L	100000
Acenaphthylene	ND	ng/L	100000
Acenaphthene	ND	ng/L	100000
Dibenzofuran	ND	ng/L	100000
Fluorene	ND	ng/L	100000
Dibenzothiophene	ND	ng/L	100000
Phenanthrene	ND	ng/L	100000
Anthracene	ND	ng/L	100000
Acridine	ND	ng/L	100000
Carbazole	ND	ng/L	100000
Fluoranthene	ND	ng/L	100000
Pyrene	ND	ng/L	100000
Benzo(a)anthracene	ND	ng/L	100000
Chrysene	ND	ng/L	100000
Benzo(b)fluoranthene	ND	ng/L	100000
Benzo(k)fluoranthene	ND	ng/L	100000
7,12-Dimethylbenz-anthracene	ND	ng/L	100000
Benzo(e)pyrene	ND	ng/L	100000
Benzo(a)pyrene	ND	ng/L	100000
Perylene	ND	ng/L	100000
3-Methylcholanthrene	ND	ng/L	100000
Dibenz(a,h)anthracene	ND	ng/L	100000
Dibenz(a,c)anthracene	ND	ng/L	100000
Benzo(g,h,i)perylene	ND	ng/L	100000
Indeno(1,2,3-c,d)pyrene	ND	ng/L	100000
Naphthalene-d8	ND	%	--
Fluorene-d10	ND	%	--
Chrysene-d12	ND	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Jay Garamone Approved By: Jeff Lowry

The cover letter is an integral part of this report.
Rev 230787

Ensec

Polynuclear Aromatic Hydrocarbons, SIM

PAH SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: W 421
Lab ID: 002872-0003-SA Enseco ID: 1022617
Matrix: AQUEOUS Sampled: 30 NOV 88 Received: 01 DEC 88
Authorized: 01 DEC 88 Prepared: 02 DEC 88 Analyzed: 19 DEC 88

Parameter	Result	Wet wt. Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	100000
2,3-Dihydroindene	170000	ng/L	100000
Indene	140000	ng/L	100000
Naphthalene	600000	ng/L	100000
Benzo(b)thiophene	ND	ng/L	100000
Quinoline	ND	ng/L	100000
1H-Indole	ND	ng/L	100000
2-Methylnaphthalene	ND	ng/L	100000
1-Methylnaphthalene	ND	ng/L	100000
Biphenyl	ND	ng/L	100000
Acenaphthylene	ND	ng/L	100000
Acenaphthene	ND	ng/L	100000
Dibenzofuran	ND	ng/L	100000
Fluorene	ND	ng/L	100000
Dibenzothiophene	ND	ng/L	100000
Phenanthrene	ND	ng/L	100000
Anthracene	ND	ng/L	100000
Acridine	ND	ng/L	100000
Carbazole	ND	ng/L	100000
Fluoranthene	ND	ng/L	100000
Pyrene	ND	ng/L	100000
Benzo(a)anthracene	ND	ng/L	100000
Chrysene	ND	ng/L	100000
Benzo(b)fluoranthene	ND	ng/L	100000
Benzo(k)fluoranthene	ND	ng/L	100000
7,12-Dimethylbenz-anthracene	ND	ng/L	100000
Benzo(e)pyrene	ND	ng/L	100000
Benzo(a)pyrene	ND	ng/L	100000
Perylene	ND	ng/L	100000
3-Methylcholanthrene	ND	ng/L	100000
Dibenz(a,h)anthracene	ND	ng/L	100000
Dibenz(a,c)anthracene	ND	ng/L	100000
Benzo(g,h,i)perylene	ND	ng/L	100000
Indeno(1,2,3-c,d)pyrene	ND	ng/L	100000
Naphthalene-d8	ND	%	--
Fluorene-d10	ND	%	--
Chrysene-d12	ND	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Jay Garamone Approved By: Jeff Lowry

The cover letter is an integral part of this report.
Rev 230787

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 1: SUMMARY OF ANALYTICAL DATA PRODUCED ON 12/20/88 AT 10:30 PAGE

SAMPLE #	RSLT. LNE		SOURCE
FERROUS IRON			
88120050	Ferrous Iron, mg/L..	: 0.129	W23
88120049	Ferrous Iron, mg/L..	: 0.148	W421
88120048	Ferrous Iron, mg/L..	: 2.82	W420
NITRATE			
88120048	Nitrate as N, mg/L..	: <0.020	W420
88120049	Nitrate as N, mg/L..	: <0.020	W421
88120050	Nitrate as N, mg/L..	: <0.020	W23
NITRITE			
88120048	Nitrite as N, mg/L..	: <0.020	W420
88120049	Nitrite as N, mg/L..	: <0.020	W421
88120050	Nitrite as N, mg/L..	: <0.020	W23
ORTHOPHOSPHATE AS P			
88120048	Phosphate(O)asP, mg/L	: <0.100	W420
88120049	Phosphate(O)asP, mg/L	: <0.100	W421
88120050	Phosphate(O)asP, mg/L	: <0.100	W23
TOTAL ORGANIC CARBON			
88120048	TOC, mg/L.....	: 6.86	W420
88120049	TOC, mg/L.....	: 6.53	W421
88120050	TOC, mg/L.....	: 3.65	W23
TOTAL DISSOLVED SOLIDS			
88120048	Total DS@180C, mg/L.	: 644	W420
88120049	Total DS@180C, mg/L.	: 556	W421
88120050	Total DS@180C, mg/L.	: 342	W23
SUSPENDED SOLIDS (TOTAL, FIXED & VOLATILE)			
88120048	Total SS @103C, mg/L.	: 10.0	W420
88120048	Fixed SS @550C, mg/L.	: 7.00	W420
88120048	Volatile SS, mg/L...	: 3.00	W420
88120049	Total SS @103C, mg/L.	: 6.00	W421
88120049	Fixed SS @550C, mg/L.	: 3.00	W421
88120049	Volatile SS, mg/L...	: 3.00	W421
88120050	Total SS @103C, mg/L.	: 8.77	W23
88120050	Fixed SS @550C, mg/L.	: 8.77	W23
88120050	Volatile SS, mg/L...	: <1.00	W23
pH			
88120048	pH, units.....	: 7.1	W420
88120049	pH, units.....	: 7.2	W421
88120050	pH, units.....	: 7.4	W23
CHEMICAL OXYGEN DEMAND (TOTAL)			
88120048	COD (Total), mg/L...	: 16.0	W420
88120049	COD (Total), mg/L...	: <10.0	W421
88120050	COD (Total), mg/L...	: 50.0	W23
AMMONIA			
88120048	NH3 as N, mg/L.....	: <1.00	W420
88120049	NH3 as N, mg/L.....	: <1.00	W421
88120050	NH3 as N, mg/L.....	: <1.00	W23

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 1: SUMMARY OF ANALYTICAL DATA PRODUCED ON 12/20/88 AT 10:31 PAGE

SAMPLE #	RSLT. LNE		SOURCE
OIL & GREASE, TOTAL RECOVERABLE, GRAVIMETRIC			
88120048	Oil & Grease, mg/L..	: <5.00	W420
88120049	Oil & Grease, mg/L..	: <5.00	W421
88120050	Oil & Grease, mg/L..	: <6.00	W23
TOTAL RECOVERABLE PHENOLICS (AS PHENOL)			
88120048	Phenol, mg/L.....	: 0.033	W420
88120049	Phenol, mg/L.....	: 0.039	W421
88120050	Phenol, mg/L.....	: 0.006	W23

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 2: SUMMARY OF METALS DATA PRODUCED ON 12/20/88 AT 10:31 PAGE

SAMPLE #	RSLT.LNE		SOURCE
IRON (TOTAL)			
88120048	Iron-Total, ug/L....	: 2320	W420
88120049	Iron-Total, ug/L....	: 1310	W421
88120050	Iron-Total, ug/L....	: 1310	W23
MANGANESE (TOTAL)			
88120048	Manganese, ug/L.....	: 466	W420
88120049	Manganese, ug/L.....	: 287	W421
88120050	Manganese, ug/L.....	: 82.8	W23

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 1: SUMMARY OF ANALYTICAL DATA PRODUCED ON 01/25/89 AT 16:07 PAGE

SAMPLE #	RSLT. LNE		SOURCE
TOTAL RECOVERABLE PHENOLICS (AS PHENOL)			
88120975	Phenol, mg/L.....	: <0.005	RTSLP-W23
88120976	Phenol, mg/L.....	: 0.041	RTSLP-W420
88120977	Phenol, mg/L.....	: 0.033	RTSLP-W421

KEYSTONE ENVIRONMENTAL RESOURCES, INC

TABLE 2: SUMMARY OF LC610 DATA

Sample: 88120975

Source: RTSLP-W23
Description: WATER SAMPLES

Date Collected: 12/28/88
Date Received: 12/29/88

Date Extracted: 12/30/88
Date Analyzed: 01/14/89

Clean up Method

silica gel clean-up ___yes ___no
florisil clean-up ___yes ___no
alumina clean-up ___yes ___no
sulfur clean-up ___yes ___no

Polynuclear Aromatic Hydrocarbons

Acenaphthene.....	:	21.4
Acenaphthylene.....	:	15.2
Anthracene.....	:	1.83
Benzo(a)anthracene....	:	0.235
Benzo(a)pyrene.....	:	0.028
Benzo(b)fluoranthene..	:	0.024
Benzo(g,h,i)perylene..	:	<0.050
Benzo(k)fluoranthene..	:	<0.020
Chrysene.....	:	0.283
Dibenz(ah)anthracene..	:	<0.030
Fluoranthene.....	:	2.48
Fluorene.....	:	9.28
Indeno(123-cd)pyrene..	:	<0.050
Phenanthrene.....	:	9.92
Pyrene.....	:	2.00

Other Polynuclear Aromatic Compounds tested:

Carbazole.....	:	2.61
Naphthalene.....	:	28.8

The above results are reported in ug/L .

All LC610 identifications are from retention data only.

TABLE 2: SUMMARY OF LC610 DATA

Sample: 88120976

Source: RTSLP-W420
Description: WATER SAMPLES

Date Collected: 12/28/88
Date Received: 12/29/88

Date Extracted: 12/30/88
Date Analyzed: 01/14/89

Clean up Method

silica gel clean-up ___yes ___no
florisil clean-up ___yes ___no
alumina clean-up ___yes ___no
sulfur clean-up ___yes ___no

Polynuclear Aromatic Hydrocarbons

Acenaphthene.....	:	34.1
Acenaphthylene.....	:	61.7
Anthracene.....	:	<0.500
Benzo(a)anthracene....	:	<0.020
Benzo(a)pyrene.....	:	<0.020
Benzo(b)fluoranthene..	:	<0.020
Benzo(g,h,i)perylene..	:	<0.050
Benzo(k)fluoranthene..	:	<0.020
Chrysene.....	:	<0.150
Dibenz(ah)anthracene..	:	<0.030
Fluoranthene.....	:	<0.200
Fluorene.....	:	6.83
Indeno(123-cd)pyrene..	:	<0.050
Phenanthrene.....	:	3.41
Pyrene.....	:	<0.200

Other Polynuclear Aromatic Compounds tested:

Carbazole.....	:	INTERFEREN
Naphthalene.....	:	626

The above results are reported in ug/L .

All LC610 identifications are from retention data only.

TABLE 2: SUMMARY OF LC610 DATA

Sample: 88120977

Source: RTSLP-W421
Description: WATER SAMPLES

Date Collected: 12/28/88
Date Received: 12/29/88

Date Extracted: 12/30/88
Date Analyzed: 01/15/89

Clean up Method

silica gel clean-up ___yes ___no
florisil clean-up ___yes ___no
alumina clean-up ___yes ___no
sulfur clean-up ___yes ___no

Polynuclear Aromatic Hydrocarbons

Acenaphthene.....	:	12.6
Acenaphthylene.....	:	44.2
Anthracene.....	:	<0.500
Benzo(a)anthracene....	:	<0.020
Benzo(a)pyrene.....	:	<0.020
Benzo(b)fluoranthene..	:	<0.020
Benzo(g,h,i)perylene..	:	<0.050
Benzo(k)fluoranthene..	:	<0.020
Chrysene.....	:	<0.150
Dibenz(ah)anthracene..	:	<0.030
Fluoranthene.....	:	<0.200
Fluorene.....	:	2.90
Indeno(123-cd)pyrene..	:	<0.050
Phenanthrene.....	:	1.22
Pyrene.....	:	<0.200

Other Polynuclear Aromatic Compounds tested:

Carbazole.....	:	INTERFEREN
Naphthalene.....	:	424

The above results are reported in ug/L .

All LC610 identifications are from retention data only.

APPENDIX B

ATTACHMENT 2

PRETREATMENT/SAND FILTRATION

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE OF CONTENTS PRODUCED ON 12/28/88 AT 09:26 PAGE

SAMPLE #	SOURCE	DESCRIPT	DATE-COL	DATE-REC	ORD #
88120094	W420 INF	RTSLP PRETREATMENT E	12/02/88	12/02/88	M8812019
88120095	W420 EFF	RTSLP PRETREATMENT E	12/02/88	12/02/88	M8812019
88120096	W421 INF	RTSLP PRETREATMENT E	12/02/88	12/02/88	M8812019
88120097	W421 EFF	RTSLP PRETREATMENT E	12/02/88	12/02/88	M8812019
88120098	W23 INF	RTSLP PRETREATMENT E	12/02/88	12/02/88	M8812019
88120099	W23 EFF	RTSLP PRETREATMENT E	12/02/88	12/02/88	M8812019

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 1: SUMMARY OF ANALYTICAL DATA PRODUCED ON 12/28/88 AT 09:26 PAGE

SAMPLE #	RSLT. LNE			SOURCE
FERROUS IRON				
88120094	Ferrous Iron,	mg/L..	: <0.100	W420 INF
88120095	Ferrous Iron,	mg/L..	: <0.100	W420 EFF
88120096	Ferrous Iron,	mg/L..	: <0.100	W421 INF
88120097	Ferrous Iron,	mg/L..	: <0.100	W421 EFF
88120098	Ferrous Iron,	mg/L..	: <0.100	W23 INF
88120099	Ferrous Iron,	mg/L..	: <0.100	W23 EFF
TOTAL DISSOLVED SOLIDS				
88120094	Total DS@180C,	mg/L.	: 613	W420 INF
88120095	Total DS@180C,	mg/L.	: 632	W420 EFF
88120096	Total DS@180C,	mg/L.	: 645	W421 INF
88120097	Total DS@180C,	mg/L.	: 658	W421 EFF
88120098	Total DS@180C,	mg/L.	: 328	W23 INF
88120099	Total DS@180C,	mg/L.	: 325	W23 EFF

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 2: SUMMARY OF METALS DATA PRODUCED ON 12/28/88 AT 09:27 PAGE

SAMPLE #	RSLT. LNE		SOURCE
IRON (TOTAL)			
88120094	Iron-Total, ug/L....	: 2780	W420 INF
88120095	Iron-Total, ug/L....	: 232	W420 EFF
88120096	Iron-Total, ug/L....	: 1390	W421 INF
88120097	Iron-Total, ug/L....	: 115	W421 EFF
88120098	Iron-Total, ug/L....	: 1060	W23 INF
88120099	Iron-Total, ug/L....	: 251	W23 EFF
MANGANESE (TOTAL)			
88120094	Manganese, ug/L.....	: 640	W420 INF
88120095	Manganese, ug/L.....	: 19.5	W420 EFF
88120096	Manganese, ug/L.....	: 273	W421 INF
88120097	Manganese, ug/L.....	: <15.0	W421 EFF
88120098	Manganese, ug/L.....	: 48.8	W23 INF
88120099	Manganese, ug/L.....	: <15.0	W23 EFF

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 1: SUMMARY OF ANALYTICAL DATA PRODUCED ON 02/02/89 AT 09:59 PAGE

SAMPLE #	RSLT. LNE			SOURCE
TOTAL DISSOLVED SOLIDS				
89010833	Total DS@180C, mg/L.	:	639	INT
89010834	Total DS@180C, mg/L.	:	636	PSF
89010835	Total DS@180C, mg/L.	:	142	PSAF
89010836	Total DS@180C, mg/L.	:	648	PGSF
89010837	Total DS@180C, mg/L.	:	613	PGSAF
89010838	Total DS@180C, mg/L.	:	619	PALSF
IRON (TOTAL)				
89010833	Iron-Total, ug/L....	:	1630	INT
89010834	Iron-Total, ug/L....	:	124	PSF
89010835	Iron-Total, ug/L....	:	<100	PSAF
89010836	Iron-Total, ug/L....	:	165	PGSF
89010837	Iron-Total, ug/L....	:	<100	PGSAF
89010838	Iron-Total, ug/L....	:	668	PALSF
MANGANESE (TOTAL)				
89010833	Manganese, ug/L.....	:	379	INT
89010834	Manganese, ug/L.....	:	161	PSF
89010835	Manganese, ug/L.....	:	81.4	PSAF
89010836	Manganese, ug/L.....	:	184	PGSF
89010837	Manganese, ug/L.....	:	43.2	PGSAF
89010838	Manganese, ug/L.....	:	595	PALSF

APPENDIX B

ATTACHMENT 3

ACT EVALUATION/COMPOSITE SAMPLES

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

PAH SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: Filt. 2 well comp
Lab ID: 003284-0001-SA Enseco ID: 1025815
Matrix: AQUEOUS Sampled: 09 JAN 89 Received: 11 JAN 89
Authorized: 11 JAN 89 Prepared: 11 JAN 89 Analyzed: 17 JAN 89

Parameter	Result	Wet wt. Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	37000	ng/L	10
Indene	ND	ng/L	10
Naphthalene	140000	ng/L	10
Benzo(b)thiophene	28000	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	23	ng/L	10
2-Methylnaphthalene	ND	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	27	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	58	ng/L	10
Phenanthrene	250	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	13000	ng/L	10
Fluoranthene	82	ng/L	10
Pyrene	55	ng/L	10
Benzo(a)anthracene	26	ng/L	10
Chrysene	28	ng/L	10
Benzo(b)fluoranthene	14	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	63.7	%	--
Fluorene-d10	198	%	--
Chrysene-d12	38.2	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Phillip Tallarico Approved By: Jeff Lowry

The cover letter is an integral part of this report.
Rev 230787

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

TABLE 1: SUMMARY OF ANALYTICAL DATA PRODUCED ON 02/02/89 AT 13:07 PAGE

SAMPLE #	RSLT.LNE		SOURCE
TOTAL RECOVERABLE PHENOLICS (AS PHENOL)			
89010320	Phenol, mg/L.....	: 0.042	INIT 2 WELL COM
89010321	Phenol, mg/L.....	: 0.030	INIT 3 WELL COM
89010322	Phenol, mg/L.....	: 0.007	FILT 2 WELL COM
89010323	Phenol, mg/L.....	: <0.005	FILT 3 WELL COM
TOTAL ORGANIC CARBON			
89010320	TOC, mg/L.....	: 4.87	INIT 2 WELL COM
89010321	TOC, mg/L.....	: 2.86	INIT 3 WELL COM
89010322	TOC, mg/L.....	: 4.14	FILT 2 WELL COM
89010323	TOC, mg/L.....	: 3.03	FILT 3 WELL COM
TOTAL DISSOLVED SOLIDS			
89010320	Total DS@180C, mg/L.	: 712	INIT 2 WELL COM
89010321	Total DS@180C, mg/L.	: 569	INIT 3 WELL COM
89010322	Total DS@180C, mg/L.	: 861	FILT 2 WELL COM
89010323	Total DS@180C, mg/L.	: 643	FILT 3 WELL COM
IRON (TOTAL)			
89010320	Iron-Total, ug/L....	: 1890	INIT 2 WELL COM
89010321	Iron-Total, ug/L....	: 1640	INIT 3 WELL COM
89010322	Iron-Total, ug/L....	: <100	FILT 2 WELL COM
89010323	Iron-Total, ug/L....	: 165	FILT 3 WELL COM
MANGANESE (TOTAL)			
89010320	Manganese, ug/L.....	: 430	INIT 2 WELL COM
89010321	Manganese, ug/L.....	: 287	INIT 3 WELL COM
89010322	Manganese, ug/L.....	: 47.5	FILT 2 WELL COM
89010323	Manganese, ug/L.....	: 218	FILT 3 WELL COM

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

PAH SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: Filt. 3 well comp
Lab ID: 003284-0002-SA Enseco ID: 1025816
Matrix: AQUEOUS Sampled: 10 JAN 89 Received: 11 JAN 89
Authorized: 11 JAN 89 Prepared: 11 JAN 89 Analyzed: 17 JAN 89

Parameter	Result	Wet wt. Units	Reporting Limit
2,3-Benzofuran	190	ng/L	10
2,3-Dihydroindene	12000	ng/L	10
Indene	11	ng/L	10
Naphthalene	56000	ng/L	10
Benzo(b)thiophene	12000	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	380	ng/L	10
1-Methylnaphthalene	2000	ng/L	10
Biphenyl	260	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	1600	ng/L	10
Dibenzofuran	330	ng/L	10
Fluorene	380	ng/L	10
Dibenzothiophene	44	ng/L	10
Phenanthrene	230	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	9600	ng/L	10
Fluoranthene	99	ng/L	10
Pyrene	58	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	12	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	40.8	%	--
Fluorene-d10	402	%	--
Chrysene-d12	36.8	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Phillip Tallarico Approved By: Jeff Lowry

The cover letter is an integral part of this report.
Rev 230787

TABLE 2: SUMMARY OF LC610 DATA

Sample: 89010321

Source: INIT 3 WELL COM
Description: WATER SAMPLES

Date Collected: 01/10/89
Date Received: 01/11/89

Date Extracted: 01/11/89
Date Analyzed: 01/31/89

Clean up Method

silica gel clean-up ___yes ___no
florisil clean-up ___yes ___no
alumina clean-up ___yes ___no
sulfur clean-up ___yes ___no

Polynuclear Aromatic Hydrocarbons

Acenaphthene..... :	5.28
Acenaphthylene..... :	22.0
Anthracene..... :	<0.500
Benzo(a)anthracene.... :	0.024
Benzo(a)pyrene..... :	<0.020
Benzo(b)fluoranthene.. :	<0.020
Benzo(g,h,i)perylene.. :	<0.050
Benzo(k)fluoranthene.. :	<0.020
Chrysene..... :	<0.150
Dibenz(ah)anthracene.. :	<0.030
Fluoranthene..... :	0.287
Fluorene..... :	2.02
Indeno(123-cd)pyrene.. :	<0.050
Phenanthrene..... :	1.05
Pyrene..... :	<0.200

Other Polynuclear Aromatic Compounds tested:

Carbazole..... :	INTERFERENCE
Naphthalene..... :	137

The above results are reported in ug/L .

All LC610 identifications are from retention data only.

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

PAH SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: ATC 3 WELL EFF
Lab ID: 003625-0001-SA Enseco ID: 1028223
Matrix: AQUEOUS Sampled: 14 FEB 89 Received: 15 FEB 89
Authorized: 15 FEB 89 Prepared: 20 FEB 89 Analyzed: 24 FEB 89

Parameter	Result	Wet wt. Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	ND	ng/L	10
Indene	ND	ng/L	10
Naphthalene	79	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	13	ng/L	10
1-Methylnaphthalene	10	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	112	%	--
Fluorene-d10	103	%	--
Chrysene-d12	58.0	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Phillip Tallarico Approved By: Jeff Lowry

Summary of Analytical Results

Date received: 3-OCT-1989 Customer: ReTec Job name: M89-10.13

		Samples			
Keystone ID		13-003	13-004	13-005	13-006
Date Sampled		2-OCT-1989	2-OCT-1989	2-OCT-1989	2-OCT-1989
Customer ID		WK28 AC1-EFF	WK28 AC2-EFF	WK28 AC3-EFF	WK28 SFC-EFF
Parameters	Units				
Phenol	mg/L	0.013	0.006	0.005	0.017
LC610					
Carbazole	ug/L	2.08	<2.00	<2.00	471
Naphthalene	ug/L	25.3	<2.00	<2.00	980
Acenaphthylene	ug/L	14.0	<2.00	<2.00	<20.0
Acenaphthene	ug/L	6.11	<2.00	<2.00	<20.0
Fluorene	ug/L	0.750	<0.200	<0.200	22.4
Phenanthrene	ug/L	<0.500	<0.500	<0.500	13.4
Anthracene	ug/L	<0.500	<0.500	<0.500	1.20
Fluoranthene	ug/L	<0.200	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	<0.200	0.854
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050
LC610-SURROGATES					
2-Fluorobiphenyl	% Recovery	88.6	75.7	82.1	Matrix Int.
Benzo(e)pyrene	% Recovery	79.3	76.4	81.4	89.4

APPENDIX B

ATTACHMENT 4

BREAKTHROUGH MONITORING

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M87-03.136

		Samples					
Keystone ID		136-001	136-002	136-003	136-004	136-005	136-006
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I	BNK-I	WK1-INFTNK	WK1-SFCEFF	WK1-AC1EFF
Parameters	Units						
Biochemical Oxygen Demand	mg/L	5.43	<1.00	<1.00	N/A	N/A	N/A
COD	mg/L	16.0	<10.0	<10.0	N/A	N/A	N/A
Ferrous Iron	mg/L	0.411	<0.100	<0.100	0.166	<0.100	N/A
Hardness	mg/L	453	443	<1.00	N/A	N/A	N/A
Ammonia Nitrogen as N	mg/L	<1.00	<1.00	<1.00	N/A	N/A	N/A
Nitrite as N	mg/L	<0.020	<0.020	<0.020	N/A	N/A	N/A
Nitrate as N	mg/L	<0.020	<0.020	0.033	N/A	N/A	N/A
Oil and Grease	mg/L	<6.00	<6.00	<6.00	N/A	N/A	N/A
pH	units	7.9	7.8	6.5	7.4	7.2	N/A
Phenol	mg/L	0.074	<0.005	<0.005	<0.005	0.0380	N/A
Orthophosphate	mg/L	<0.010	0.030	0.014	N/A	N/A	N/A
Total Dissolved Solids	mg/L	673	560	<1.00	N/A	N/A	N/A
Total Organic Carbon	mg/L	7.15	<1.00	<1.00	6.86	7.35	N/A
Total Suspended Solids	mg/L	10.0	16.0	1.00	14.0	8.00	N/A
Silver	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Arsenic	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Beryllium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Cadmium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Chromium	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Copper	ug/L	<25.0	<25.0	N/A	N/A	N/A	N/A
Iron	ug/L	1840	<100	<100	1730	<100	N/A
Dissolved Iron	ug/L	<100	<100	<100	<100	<100	N/A
Manganese	ug/L	374	33.9	<15.0	3480	21.5	N/A
Nickel	ug/L	<40.0	<40.0	N/A	N/A	N/A	N/A
Lead	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Antimony	ug/L	<60.0	<60.0	N/A	N/A	N/A	N/A
Selenium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Thallium	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Zinc	ug/L	85.4	<20.0	N/A	N/A	N/A	N/A

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples		
Keystone ID		136-007	136-008	136-009
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		WK1-AC2EFF	WK1-AC3EFF	WK1-BW1
Parameters	Units			
Total Suspended Solids	mg/L	N/A	N/A	1050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples	
Keystone ID	136-001	136-002
Date Sampled	29-MAR-1989	29-MAR-1989
Customer ID	INF-I	AC3 EFF-I

Parameters	Units		
GC608			
a-BHC	ug/L	<0.500	<0.050
g-BHC	ug/L	<0.500	<0.050
b-BHC	ug/L	<0.050	<0.050
Heptachlor	ug/L	<0.050	<0.050
d-BHC	ug/L	<0.050	<0.050
Aldrin	ug/L	<0.050	<0.050
Heptachlor epoxide	ug/L	<0.050	<0.050
Endosulfan I	ug/L	<0.050	<0.050
4,4'-DDE	ug/L	<0.100	<0.100
Dieldrin	ug/L	<0.100	<0.100
Endrin	ug/L	<0.100	<0.100
4,4'-DDD	ug/L	<0.100	<0.100
Endosulfan II	ug/L	<0.100	<0.100
4,4'-DDT	ug/L	<0.100	<0.100
Endrin aldehyde	ug/L	<0.100	<0.100
Endosulfan sulfate	ug/L	<0.100	<0.100
Methoxychlor	ug/L	<0.500	<0.500
Chlordane	ug/L	<0.500	<0.500
Toxaphene	ug/L	<1.00	<1.00
PCB-1016	ug/L	<0.500	<0.500
PCB-1221	ug/L	<0.500	<0.500
PCB-1232	ug/L	<0.500	<0.500
PCB-1242	ug/L	<0.500	<0.500
PCB-1248	ug/L	<0.500	<0.500
PCB-1254	ug/L	<1.00	<1.00
PCB-1260	ug/L	<1.00	<1.00

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples					
Keystone ID		136-001	136-002	136-003	136-004	136-005	136-006
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I	BNK-I	WK1-INFTNK	WK1-SFCEFF	WK1-AC1EFF
Parameters	Units						
LC610							
Carbazole	ug/L	2.30	<2.00	N/A	2.38	2.49	<2.00
Naphthalene	ug/L	765	<2.00	N/A	866	743	<2.00
Acenaphthylene	ug/L	84.0	<2.00	N/A	40.6	34.0	<2.00
Acenaphthene	ug/L	48.9	<2.00	N/A	35.9	31.0	<2.00
Fluorene	ug/L	13.3	<0.200	N/A	12.5	9.83	<0.200
Phenanthrene	ug/L	7.21	<0.500	N/A	8.17	5.66	<0.500
Anthracene	ug/L	<0.500	<0.500	N/A	2.65	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	N/A	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	N/A	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples	
Keystone ID		136-007	136-008
Date Sampled		29-MAR-1989	29-MAR-1989
Customer ID		WK1-AC2EFF	WK1-AC3EFF
Parameters	**Units**		
LC610			
Carbazole	ug/L	<2.00	<2.00
Naphthalene	ug/L	<2.00	<2.00
Acenaphthylene	ug/L	<2.00	<2.00
Acenaphthene	ug/L	<2.00	<2.00
Fluorene	ug/L	<0.200	<0.200
Phenanthrene	ug/L	<0.500	<0.500
Anthracene	ug/L	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples	
Keystone ID		136-001	136-002
Date Sampled		29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I
Parameters	Units		
MS624			
Chloromethane	ug/L	<10.0	<10.0
Bromomethane	ug/L	<10.0	<10.0
Vinyl chloride	ug/L	31.0	<10.0
Chloroethane	ug/L	<10.0	<10.0
Methylene chloride	ug/L	17.0	15.0
Trichlorofluoromethane	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<5.00	<5.00
1,1-Dichloroethane	ug/L	<5.00	<5.00
trans-1,2-Dichloroethene	ug/L	40.0	<5.00
Chloroform	ug/L	<5.00	<5.00
1,2-Dichloroethane	ug/L	<5.00	<5.00
1,1,1-Trichloroethane	ug/L	<5.00	<5.00
Carbon tetrachloride	ug/L	<5.00	<5.00
Bromodichloromethane	ug/L	<5.00	<5.00
1,2-Dichloropropane	ug/L	<5.00	<5.00
cis-1,3-Dichloropropene	ug/L	<5.00	<5.00
Trichloroethene	ug/L	110	<5.00
Benzene	ug/L	97.0	<5.00
Dibromochloroethane	ug/L	<5.00	<5.00
1,1,2-Trichlorothane	ug/L	<5.00	<5.00
trans-1,3-Dichloropropene	ug/L	<5.00	<5.00
2-Chloroethylvinyl ether	ug/L	<10.0	<10.0
Bromoform	ug/L	<5.00	<5.00
1,1,2,2-Tetrachloroethane	ug/L	<5.00	<5.00
Tetrachloroethene	ug/L	57.0	<5.00
Toluene	ug/L	11.0	<5.00
Chlorobenzene	ug/L	<5.00	<5.00
Ethyl benzene	ug/L	79.0	<5.00

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples
Keystone ID	136-002
Date Sampled	29-MAR-1989
Customer ID	AC3 EFF-I

Parameters	Units	
MS625		
1,3-Dichlorobenzene	ug/L	<20.0
1,4-Dichlorobenzene	ug/L	<20.0
Hexachloroethane	ug/L	<20.0
Bis(2-chloroethyl) ether	ug/L	<20.0
1,2-Dichlorobenzene	ug/L	<20.0
Bis(2-chloroisopropyl) ether	ug/L	<20.0
N-Nitrosodi-n-propylamine	ug/L	<20.0
Nitrobenzene	ug/L	<20.0
Hexachlorobutadiene	ug/L	<20.0
1,2,4-Trichlorobenzene	ug/L	<20.0
Isophorone	ug/L	<20.0
Naphthalene	ug/L	<20.0
Bis(2-chloroethoxy) methane	ug/L	<20.0
Hexachlorocyclopentadiene	ug/L	<20.0
2-Chloronaphthalene	ug/L	<20.0
Acenaphthylene	ug/L	<20.0
Acenaphthene	ug/L	<20.0
Dimethyl phthalate	ug/L	<20.0
2,6-Dinitrotoluene	ug/L	<20.0
Fluorene	ug/L	<20.0
4-Chlorophenyl phenyl ether	ug/L	<20.0
2,4-Dinitrotoluene	ug/L	<20.0
Diethylphthalate	ug/L	<20.0
N-Nitrosodiphenylamine	ug/L	<20.0
Hexachlorobenzene	ug/L	<20.0
4-Bromophenyl phenyl ether	ug/L	<20.0
Phenanthrene	ug/L	<20.0
Anthracene	ug/L	<20.0
Fluoranthene	ug/L	<20.0
Pyrene	ug/L	<20.0

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples
Keystone ID	136-002
Date Sampled	29-MAR-1989
Customer ID	AC3 EFF-I

Parameters	Units	
MS625 (continued)		
Benzidine	ug/L	<200
Butyl benzyl phthalate	ug/L	<20.0
Bis(2-ethylexyl) pnthalate	ug/L	<20.0
Chrysene	ug/L	<20.0
Benzo(a)anthracene	ug/L	<20.0
3,3'-Dichlorobenzidine	ug/L	<40.0
Di-n-octyl phthalate	ug/L	<20.0
Benzo(b)fluoranthene	ug/L	<20.0
Benzo(k)fluoranthene	ug/L	<20.0
Benzo(a)pyrene	ug/L	<20.0
Indeno(1,2,3-c,d)pyrene	ug/L	<20.0
Dibenzo(a,h)anthracene	ug/L	<20.0
Benzo(ghi)perylene	ug/L	<20.0
N-Nitrosodimethylamine	ug/L	<20.0
2-Chlorophenol	ug/L	<20.0
2,4-Dichlorophenol	ug/L	<20.0
2,4-Dimethylphenol	ug/L	<20.0
4,6-Dinitro-2-methylphenol	ug/L	<100
2,4-Dinitrophenol	ug/L	<100
2-Nitrophenol	ug/L	<20.0
4-Nitrophenol	ug/L	<100
4-Chloro-3-methylphenol	ug/L	<20.0
Pentachlorophenol	ug/L	<100
Phenol	ug/L	<20.0
2,4,6-Trichlorophenol	ug/L	<20.0
Di-n-butyl phthalate	ug/L	<20.0
1,2-Diphenylhydrazine	ug/L	<20.0

Summary of Analytical Results

Date received: 4-APR-1989 Customer: ReTec Job name: M89-04.6

		Samples			
Keystone ID		6-001	6-002	6-003	6-004
Date Sampled		3-APR-1989	3-APR-1989	3-APR-1989	3-APR-1989
Customer ID		WK#2 INFTNK	WK#2 SFCEFF	WK#2 ACIEFF	WK#2 BW 1
Parameters	Units				
Ferrous Iron	mg/L	<0.100	<0.100	N/A	N/A
pH		7.3	7.5	N/A	N/A
Phenol	mg/L	0.026	0.025	<0.005	N/A
Total Organic Carbon	mg/L	17.3	4.41	N/A	N/A
Total Suspended Solids	mg/L	8.00	4.00	N/A	362
Iron	ug/L	1610	6540	N/A	N/A
Dissolved Iron	ug/L	1750	2180	N/A	N/A
Manganese	ug/L	2280	7060	N/A	N/A

Summary of Analytical Results

Date received: 4-APR-1989 Customer: ReTec Job name: M89-04.6

		Samples		
Keystone ID		6-001	6-002	6-003
Date Sampled		3-APR-1989	3-APR-1989	3-APR-1989
Customer ID		WK#2 INFTNK	WK#2 SFCEFF	WK#2 ACTEFF
Parameters	Units			
LC610				
Carbazole	ug/L	<2.00	<2.00	<2.00
Naphthalene	ug/L	885	950	<2.00
Acenaphthylene	ug/L	39.9	44.9	<2.00
Acenaphthene	ug/L	41.3	50.2	<2.00
Fluorene	ug/L	12.2	13.8	0.655
Phenanthrene	ug/L	7.47	9.16	0.830
Anthracene	ug/L	<0.500	0.503	<0.500
Fluoranthene	ug/L	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 11-APR-1989 Customer: ReTec Job name: M89-04.42

		Samples					
Keystone ID		42-001	42-002	42-003	42-004	42-005	42-006
Date Sampled		10-APR-1989	10-APR-1989	10-APR-1989	10-APR-1989	10-APR-1989	10-APR-1989
Customer ID		WK#3 INFINK	WK#3 SFCEFF	WK#3 AC1EFF	WK#3 AC2EFF	WK#3 AC3EFF	WK#3 BW1
Parameters	Units						
Ferrous Iron	mg/L	<0.100	<0.100	N/A	N/A	N/A	N/A
pH	units	7.3	7.4	N/A	N/A	N/A	N/A
Phenol	mg/L	0.022	0.028	<0.005	<0.005	<0.005	N/A
Total Organic Carbon	mg/L	101	101	N/A	N/A	N/A	N/A
Total Suspended Solids	mg/L	12.0	1.00	N/A	N/A	N/A	2270
Iron	ug/L	1700	<100	N/A	N/A	N/A	N/A
Dissolved Iron	ug/L	1890	<100	N/A	N/A	N/A	N/A
Manganese	ug/L	3390	165	N/A	N/A	N/A	N/A
LC610							
Carbazole	ug/L	<2.00	<2.00	N/A	<2.00	<2.00	N/A
Naphthalene	ug/L	4.22	311	N/A	<2.00	<2.00	N/A
Acenaphthylene	ug/L	4.93	17.3	N/A	<2.00	<2.00	N/A
Acenaphthene	ug/L	24.9	38.0	N/A	<2.00	<2.00	N/A
Fluorene	ug/L	10.8	11.6	N/A	<0.200	<0.200	N/A
Phenanthrene	ug/L	6.48	5.43	N/A	<0.500	<0.500	N/A
Anthracene	ug/L	<0.500	<0.500	N/A	<0.500	<0.500	N/A
Fluoranthene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	N/A
Pyrene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	N/A
Benzo(a)anthracene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	N/A
Chrysene	ug/L	<0.150	<0.150	N/A	<0.150	<0.150	N/A
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	N/A
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	N/A
Benzo(a)pyrene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	N/A
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	N/A	<0.030	<0.030	N/A
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	N/A
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	N/A

Summary of Analytical Results

Date received: 18-APR-1989 Customer: ReTec Job name: M89-04.85

		Samples			
Keystone ID		85-001	85-002	85-003	85-004
Date Sampled		17-APR-1989	17-APR-1989	17-APR-1989	17-APR-1989
Customer ID		WK#4 INFTNK	WK#4 SFCEFF	WK#4 ACIEFF	WK#4 BW1
Parameters	Units				
Ferrous Iron	mg/L	<0.100	<0.100	NR	NR
pH	units	7.7	7.5	NR	NR
Phenol	mg/L	0.007	0.019	<0.005	NR
Total Organic Carbon	mg/L	6.14	11.7	NR	NR
Total Suspended Solids	mg/L	15.0	<1.00	NR	394
Iron	ug/L	1840	<100	NR	NR
Dissolved Iron	ug/L	1820	<100	NR	NR
Manganese	ug/L	4660	41.4	NR	NR
LC610					
Carbazole	ug/L	34.8	<2.00	<2.00	NR
Naphthalene	ug/L	8.18	110	<2.00	NR
Acenaphthylene	ug/L	<20.0	<2.00	<2.00	NR
Acenaphthene	ug/L	31.9	<2.00	<2.00	NR
Fluorene	ug/L	12.6	9.63	<0.200	NR
Phenanthrene	ug/L	8.37	1.81	<0.500	NR
Anthracene	ug/L	<0.500	<0.500	<0.500	NR
Fluoranthene	ug/L	<0.200	<0.200	<0.200	NR
Pyrene	ug/L	<0.200	<0.200	<0.200	NR
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	NR
Chrysene	ug/L	<0.150	<0.150	<0.150	NR
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	NR
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	NR
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	NR
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	NR
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	NR
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	NR

Summary of Analytical Results

Date received: 18-APR-1989 Customer: ReTec Job name: M89-04.85

	Samples
Keystone ID	85-005
Date Sampled	17-APR-1989
Customer ID	FEED TO INFTNK

Parameters	Units	
MS625		
1,3-Dichlorobenzene	ug/L	<10.0
1,4-Dichlorobenzene	ug/L	<10.0
Hexachloroethane	ug/L	<10.0
Bis(2-chloroethyl) ether	ug/L	<10.0
1,2-Dichlorobenzene	ug/L	<10.0
Bis(2-chloroisopropyl) ether	ug/L	<10.0
N-Nitrosodi-n-propylamine	ug/L	<10.0
Nitrobenzene	ug/L	<10.0
Hexachlorobutadiene	ug/L	<10.0
1,2,4-Trichlorobenzene	ug/L	<10.0
Isophorone	ug/L	<10.0
Naphthalene	ug/L	470
Bis(2-chloroethoxy) methane	ug/L	<10.0
Hexachlorocyclopentadiene	ug/L	<10.0
2-Chloronaphthalene	ug/L	<10.0
Acenaphthylene	ug/L	<10.0
Acenaphthene	ug/L	35.0
Dimethyl phthalate	ug/L	<10.0
2,6-Dinitrotoluene	ug/L	<10.0
Fluorene	ug/L	12.0
4-Chlorophenyl phenyl ether	ug/L	<10.0
2,4-Dinitrotoluene	ug/L	<10.0
Diethylphthalate	ug/L	<10.0
N-Nitrosodiphenylamine	ug/L	<10.0
Hexachlorobenzene	ug/L	<10.0
4-Bromophenyl phenyl ether	ug/L	<10.0
Phenanthrene	ug/L	<10.0
Anthracene	ug/L	<10.0
Fluoranthene	ug/L	<10.0
Pyrene	ug/L	<10.0

Summary of Analytical Results

Date received: 18-APR-1989 Customer: ReTec Job name: M89-04.85

	Samples
Keystone ID	85-005
Date Sampled	17-APR-1989
Customer ID	FEED TO INFTNK

Parameters	Units	
MS625 (continued)		
Benzidine	ug/L	<100
Butyl benzyl phthalate	ug/L	<10.0
Bis(2-ethylexyl) phthalate	ug/L	37.0
Chrysene	ug/L	<10.0
Benzo(a)anthracene	ug/L	<10.0
3,3'-Dichlorobenzidine	ug/L	<20.0
Di-n-octyl phthalate	ug/L	<10.0
Benzo(b)fluoranthene	ug/L	<10.0
Benzo(k)fluoranthene	ug/L	<10.0
Benzo(a)pyrene	ug/L	<10.0
Indeno(1,2,3-c,d)pyrene	ug/L	<10.0
Dibenzo(a,h)anthracene	ug/L	<10.0
Benzo(ghi)perylene	ug/L	<10.0
N-Nitrosodimethylamine	ug/L	<10.0
2-Chlorophenol	ug/L	<10.0
2,4-Dichlorophenol	ug/L	<10.0
2,4-Dimethylphenol	ug/L	<10.0
4,6-Dinitro-2-methylphenol	ug/L	<50.0
2,4-Dinitrophenol	ug/L	<50.0
2-Nitrophenol	ug/L	<10.0
4-Nitrophenol	ug/L	<50.0
4-Chloro-3-methylphenol	ug/L	<10.0
Pentachlorophenol	ug/L	<50.0
Phenol	ug/L	<10.0
2,4,6-Trichlorophenol	ug/L	<10.0
Di-n-butyl phthalate	ug/L	<10.0

Summary of Analytical Results

Date received: 25-APR-1989 Customer: ReTec Job name: M89-04.119

		Samples					
Keystone ID		119-001	119-002	119-003	119-004	119-005	119-006
Date Sampled		24-APR-1989	24-APR-1989	24-APR-1989	24-APR-1989	24-APR-1989	24-APR-1989
Customer ID		WK5 INF TNK	WK5 AC1 EFF	WK5 AC2 EFF	WK5 AC3 EFF	WK5 BW1	WK5 SFC EFF
Parameters	Units						
Biochemical Oxygen Demand	mg/L	NR	NR	NR	NR	<1.00	NR
Ferrous Iron	mg/L	<0.100	NR	NR	NR	NR	<0.100
pH	units	7.2	NR	NR	NR	NR	7.6
Phenol	mg/L	NR	<0.005	<0.005	<0.005	NR	<0.005
Total Organic Carbon	mg/L	5.68	NR	NR	NR	49.9	5.59
Total Suspended Solids	mg/L	14.0	NR	NR	NR	970	<1.00
Iron	ug/L	1800	NR	NR	NR	NR	<100
Dissolved Iron	ug/L	1800	NR	NR	NR	NR	<100
Manganese	ug/L	6080	NR	NR	NR	NR	30.6
LC610							
Carbazole	ug/L	<2.00	<2.00	<2.00	<2.00	<2.00	Interference
Naphthalene	ug/L	631	<2.00	<2.00	<2.00	7.71	554
Acenaphthylene	ug/L	3.70	<2.00	<2.00	<2.00	<2.00	6.07
Acenaphthene	ug/L	19.0	<2.00	<2.00	<2.00	3.55	19.9
Fluorene	ug/L	6.79	<0.200	<0.200	<0.200	2.15	6.74
Phenanthrene	ug/L	5.30	<0.500	<0.500	<0.500	1.87	4.76
Anthracene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	ug/L	0.262	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 2-MAY-1989 Customer: ReTec Job name: M89-05.19

		Samples			
Keystone ID		19-001	19-002	19-003	19-004
Date Sampled		1-MAY-1989	1-MAY-1989	1-MAY-1989	1-MAY-1989
Customer ID		WK6 INFTNK	WK6 SFCEFF	WK6 ACIEFF	WK6 BWI
Parameters	Units				
Ferrous Iron	mg/L	<0.100	<0.100	NR	NR
pH	units	7.4	7.8	NR	NR
Phenol	mg/L	0.009	0.009	<0.005	NR
Total Organic Carbon	mg/L	33.0	7.98	NR	NR
Total Suspended Solids	mg/L	19.0	5.00	NR	1140
Iron	ug/L	1790	<100	NR	NR
Dissolved Iron	ug/L	<100	<100	NR	NR
Manganese	ug/L	5460	256	NR	NR
LC610					
Carbazole	ug/L	<2.00	Interference	<2.00	NR
Naphthalene	ug/L	494	672	<2.00	NR
Acenaphthylene	ug/L	Interference	Interference	<2.00	NR
Acenaphthene	ug/L	7.39	14.4	<2.00	NR
Fluorene	ug/L	5.84	11.4	<0.200	NR
Phenanthrene	ug/L	3.31	6.73	<0.500	NR
Anthracene	ug/L	<0.500	<0.500	<0.500	NR
Fluoranthene	ug/L	<0.200	<0.200	<0.200	NR
Pyrene	ug/L	<0.200	<0.200	<0.200	NR
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	NR
Chrysene	ug/L	<0.150	<0.150	<0.150	NR
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	NR
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	NR
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	NR
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	NR
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	NR
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	NR

Summary of Analytical Results

Date received: 9-MAY-1989 Customer: ReTec Job name: M89-05.70

		Samples					
Keystone ID		70-001	70-002	70-003	70-004	70-005	70-006
Date Sampled		8-MAY-1989	8-MAY-1989	8-MAY-1989	8-MAY-1989	8-MAY-1989	8-MAY-1989
Customer ID		WK7 INFTNK	WK7 SFCEFF	WK7 AC1EFF	WK7 AC2EFF	WK7 AC3EFF	WK7 BW1
Parameters	Units						
Ferrous Iron	mg/L	<0.100	<0.100	NR	NR	NR	NR
pH	units	7.5	7.5	NR	NR	NR	NR
Phenol	mg/L	<0.005	0.044	<0.005	<0.005	<0.005	NR
Total Organic Carbon	mg/L	6.59	6.99	NR	NR	NR	3.77
Total Suspended Solids	mg/L	29.0	3.00	NR	NR	NR	292
Biochemical Oxygen Demand	mg/L	NR	NR	NR	NR	NR	<1.00
Iron	ug/L	2010	150	NR	NR	NR	NR
Dissolved Iron	ug/L	<100	<100	NR	NR	NR	NR
Manganese	ug/L	7310	246	NR	NR	NR	NR
LC610							
Carbazole	ug/L	<2.00	Interference	<2.00	<2.00	<2.00	<2.00
Naphthalene	ug/L	598	10.2	<2.00	<2.00	<2.00	4.31
Acenaphthylene	ug/L	Interference	Interference	<2.00	<2.00	<2.00	<2.00
Acenaphthene	ug/L	5.68	<2.00	<2.00	<2.00	<2.00	2.45
Fluorene	ug/L	4.45	13.1	<0.200	<0.200	<0.200	3.35
Phenanthrene	ug/L	3.22	4.72	<0.500	<0.500	<0.500	0.799
Anthracene	ug/L	<0.500	2.21	<0.500	<0.500	<0.500	<0.500
Fluoranthene	ug/L	<0.200	0.218	<0.200	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	0.262	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 16-MAY-1989 Customer: ReTec Job name: M89-05.98

		Samples			
Keystone ID		98-001	98-002	98-003	98-004
Date Sampled		15-MAY-1989	15-MAY-1989	15-MAY-1989	15-MAY-1989
Customer ID		WK8 INFTNK	WK8 SFCEFF	WK8 ACIEFF	WK8 BW1
Parameters	Units				
Ferrous Iron	mg/L	<0.100	<0.100	NR	NR
pH	units	7.5	7.5	NR	NR
Phenol	mg/L	<0.005	<0.005	<0.005	NR
Total Organic Carbon	mg/L	7.35	7.16	NR	NR
Total Suspended Solids	mg/L	15.0	1.00	NR	522
Iron	ug/L	1880	<100	NR	NR
Dissolved Iron	ug/L	1920	<100	NR	NR
Manganese	ug/L	5050	160	NR	NR
LC610					
Carbazole	ug/L	23.7	18.7	<2.00	NR
Naphthalene	ug/L	691	732	<2.00	NR
Acenaphthylene	ug/L	<20.0	<20.0	<2.00	NR
Acenaphthene	ug/L	<20.0	<20.0	<2.00	NR
Fluorene	ug/L	10.6	9.25	<0.200	NR
Phenanthrene	ug/L	7.09	7.02	<0.500	NR
Anthracene	ug/L	<0.500	<0.500	<0.500	NR
Fluoranthene	ug/L	<0.200	<0.200	<0.200	NR
Pyrene	ug/L	<0.200	0.204	<0.200	NR
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	NR
Chrysene	ug/L	<0.150	<0.150	<0.150	NR
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	NR
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	NR
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	NR
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	NR
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	NR
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	NR

Summary of Analytical Results

Date received: 23-MAY-1989 Customer: ReTec Job name: M89-05.130

		Samples					
Keystone ID		130-001	130-002	130-003	130-004	130-005	130-006
Date Sampled		22-MAY-1989	22-MAY-1989	22-MAY-1989	22-MAY-1989	22-MAY-1989	22-MAY-1989
Customer ID		WK9-AC1 EFF.	WK9-AC2 EFF.	WK9-AC3 EFF.	WK9-INFTNK	WK9-SFCEFF	WK9-BW1
Parameters	Units						
Biochemical Oxygen Demand	mg/L	NR	NR	NR	NR	NR	9.15
Ferrous Iron	mg/L	NR	NR	NR	<0.100	<0.100	NR
pH	units	NR	NR	NR	7.3	7.4	NR
Phenol	mg/L	0.005	<0.005	<0.005	0.024	0.009	NR
Total Organic Carbon	mg/L	NR	NR	NR	7.48	8.52	78.4
Total Suspended Solids	mg/L	NR	NR	NR	17.0	3.00	952
Iron	ug/L	NR	NR	NR	1710	<100	NR
Dissolved Iron	ug/L	NR	NR	NR	1700	<100	NR
Manganese	ug/L	NR	NR	NR	3610	94.6	NR
LC610							
Carbazole	ug/L	<2.00	<2.00	<2.00	<2.00	Interference	<2.00
Naphthalene	ug/L	<2.00	<2.00	<2.00	57.2	876	462
Acenaphthylene	ug/L	<2.00	<2.00	<2.00	Interference	Interference	Interference
Acenaphthene	ug/L	<2.00	<2.00	<2.00	10.0	14.7	10.9
Fluorene	ug/L	<0.200	<0.200	<0.200	9.97	11.3	9.23
Phenanthrene	ug/L	<0.500	<0.500	<0.500	6.48	8.25	6.99
Anthracene	ug/L	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 6-JUN-1989 Customer: ReTec Job name: M89-06.25

		Samples	
Keystone ID		25-001	25-002
Date Sampled		5-JUN-1989	5-JUN-1989
Customer ID		WK11 AC1 EFF	WK11 AC2 EFF
Parameters	Units		
Phenol	mg/L	<0.005	<0.005
LC610			
Carbazole	ug/L	<2.00	<2.00
Naphthalene	ug/L	<2.00	<2.00
Acenaphthylene	ug/L	<2.00	<2.00
Acenaphthene	ug/L	<2.00	<2.00
Fluorene	ug/L	<0.200	<0.200
Phenanthrene	ug/L	<0.500	<0.500
Anthracene	ug/L	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.99

		Samples			
Keystone ID		99-001	99-002	99-003	99-004
Date Sampled		19-JUN-1989	19-JUN-1989	19-JUN-1989	19-JUN-1989
Customer ID		WK13 AC1 EFF	WK13 AC2 EFF	WK13 AC3 EFF	WK13 SCF EFF
Parameters	Units				
Phenol	mg/L	0.016	0.007	<0.005	0.016
LC610					
Carbazole	ug/L	<2.00	<2.00	<2.00	9.12
Naphthalene	ug/L	<2.00	<2.00	<2.00	583
Acenaphthylene	ug/L	<2.00	<2.00	<2.00	55.6
Acenaphthene	ug/L	<2.00	<2.00	<2.00	44.7
Fluorene	ug/L	<0.200	<0.200	<0.200	12.7
Phenanthrene	ug/L	<0.500	<0.500	<0.500	8.73
Anthracene	ug/L	<0.500	<0.500	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	<0.200	0.355
Pyrene	ug/L	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	0.033
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 6-JUL-1989 Customer: ReTec Job name: M89-07.16

		Samples	
Keystone ID		16-001	16-002
Date Sampled		5-JUL-1989	5-JUL-1989
Customer ID		WK15 AC1 EFF	WK15 AC2 EFF
Parameters	Units		
Phenol	mg/L	0.007	<0.005
LC610			
Carbazole	ug/L	<2.00	<2.00
Naphthalene	ug/L	<2.00	<2.00
Acenaphthylene	ug/L	<2.00	<2.00
Acenaphthene	ug/L	<2.00	<2.00
Fluorene	ug/L	<0.200	<0.200
Phenanthrene	ug/L	<0.500	<0.500
Anthracene	ug/L	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 18-JUL-1989 Customer: ReTec Job name: MB9-07.72

		Samples			
Keystone ID		72-001	72-002	72-003	72-004
Date Sampled		17-JUL-1989	17-JUL-1989	17-JUL-1989	17-JUL-1989
Customer ID		WK17-AC1 EFF	WK17-AC2 EFF	WK17-AC3 EFF	WK17-SFC EFF
Parameters	Units				
Phenol	mg/L	0.008	0.006	<0.005	<0.005
LC610					
Carbazole	ug/L	<2.00	<2.00	<2.00	8.97
Naphthalene	ug/L	9.37	<2.00	<2.00	47.5
Acenaphthylene	ug/L	<2.00	<2.00	<2.00	137
Acenaphthene	ug/L	<2.00	<2.00	<2.00	<20.0
Fluorene	ug/L	<0.200	<0.200	<0.200	13.7
Phenanthrene	ug/L	<0.500	<0.500	<0.500	11.0
Anthracene	ug/L	<0.500	<0.500	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 1-AUG-1989 Customer: ReTec Job name: M89-08.1

		Samples	
Keystone ID		1-001	1-002
Date Sampled		31-JUL-1989	31-JUL-1989
Customer ID		WK19-AC1-EFF.	WK19-AC2-EFF.
Parameters	Units		
Phenol	mg/L	0.005	<0.005
UC610			
Carbazole	ug/L	<2.00	<2.00
Naphthalene	ug/L	21.4	<2.00
Acenapnthylene	ug/L	<2.00	<2.00
Acenaphthene	ug/L	2.77	<2.00
Fluorene	ug/L	0.370	<0.200
Phenanthrene	ug/L	<0.500	<0.500
Anthracene	ug/L	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 15-AUG-1989 Customer: ReTec Job name: MB9-08.91

		Samples			
Keystone ID		91-001	91-002	91-003	91-004
Date Sampled		14-AUG-1989	14-AUG-1989	14-AUG-1989	14-AUG-1989
Customer ID		WK21-ACI-EFF	WK21-AC2-EFF	WK21-AC3-EFF	WK21-SFC-EFF
Parameters	Units				
Phenol	mg/L	<0.005	<0.005	<0.005	0.012
LC610					
Carbazole	ug/L	<2.00	<2.00	<2.00	<2.00
Naphthalene	ug/L	<2.00	<2.00	<2.00	<2.00
Acenaphthylene	ug/L	<2.00	<2.00	<2.00	<2.00
Acenaphthene	ug/L	<2.00	<2.00	<2.00	31.8
Fluorene	ug/L	<0.200	<0.200	<0.200	11.3
Phenanthrene	ug/L	<0.500	<0.500	<0.500	6.96
Anthracene	ug/L	<0.500	<0.500	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 19-OCT-1989 Customer: ReTec Job name: M89-10.109

		Samples			
Keystone ID		109-003	109-004	109-005	109-006
Date Sampled		17-OCT-1989	17-OCT-1989	17-OCT-1989	17-OCT-1989
Customer ID		WK30 SFCEFF	WK30 AC1EFF	WK30 AC2EFF	WK30 AC3EFF
Parameters	Units				
Phenol	mg/L	<0.500	<0.500	<0.500	<0.500
LC610					
Carbazole	ug/L	65.0	<2.00	<2.00	<2.00
Naphthalene	ug/L	460	39.6	<2.00	<2.00
Acenaphthylene	ug/L	<20.0	14.3	<2.00	<2.00
Acenaphthene	ug/L	88.0	<2.00	<2.00	<2.00
Fluorene	ug/L	22.2	1.10	<0.200	<0.200
Phenanthrene	ug/L	9.50	<0.500	<0.500	<0.500
Anthracene	ug/L	1.27	<0.500	<0.500	<0.500
Fluoranthene	ug/L	0.560	<0.200	<0.200	<0.200
Pyrene	ug/L	1.71	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	<0.050	<0.050
LC610-SURROGATES					
2-Fluorobiphenyl	% Recovery	Matrix Int.	105	79.2	83.9
Benzo(e)pyrene	% Recovery	77.2	75.2	79.4	71.7

APPENDIX B

ATTACHMENT 5

NPDES PERMIT MONITORING

Ensec

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP INF I
Lab ID: 004110-0001-SA Enseco ID: 1031575
Matrix: AQUEOUS Sampled: 29 MAR 89 Received: 30 MAR 89
Authorized: 30 MAR 89 Prepared: 31 MAR 89 Analyzed: 13 APR 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ug/L	100
2,3-Dihydroindene	140	ug/L	100
Indene	120	ug/L	100
Naphthalene	1200	ug/L	100
Benzo(b)thiophene	ND	ug/L	100
Quinoline	ND	ug/L	100
1H-Indole	ND	ug/L	100
2-Methylnaphthalene	ND	ug/L	100
1-Methylnaphthalene	ND	ug/L	100
Biphenyl	ND	ug/L	100
Acenaphthylene	ND	ug/L	100
Acenaphthene	ND	ug/L	100
Dibenzofuran	ND	ug/L	100
Fluorene	ND	ug/L	100
Dibenzothiophene	ND	ug/L	100
Phenanthrene	ND	ug/L	100
Anthracene	ND	ug/L	100
Acridine	ND	ug/L	100
Carbazole	ND	ug/L	100
Fluoranthene	ND	ug/L	100
Pyrene	ND	ug/L	100
Benzo(a)anthracene	ND	ug/L	100
Chrysene	ND	ug/L	100
Benzo(b)fluoranthene	ND	ug/L	100
Benzo(k)fluoranthene	ND	ug/L	100
7,12-Dimethylbenz-anthracene	ND	ug/L	100
Benzo(e)pyrene	ND	ug/L	100
Benzo(a)pyrene	ND	ug/L	100
Perylene	ND	ug/L	100
3-Methylcholanthrene	ND	ug/L	100
Dibenz(a,h)anthracene	ND	ug/L	100
Dibenz(a,c)anthracene	ND	ug/L	100
Benzo(g,h,i)perylene	ND	ug/L	100
Indeno(1,2,3-c,d)pyrene	ND	ug/L	100
Naphthalene-d8	ND	%	--
Fluorene-d10	ND	%	--
Chrysene-d12	ND	%	--

ND=Not Detected
NA=Not Applicable

Reported By: Michael Gallik Approved By: Jeff Lowry

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP AC3-EFF-I
Lab ID: 004106-0002-SA Enseco ID: 1031577
Matrix: AQUEOUS Sampled: 29 MAR 89 Received: 30 MAR 89
Authorized: 30 MAR 89 Prepared: 31 MAR 89 Analyzed: 03 APR 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	25	ng/L	10
Indene	ND	ng/L	10
Naphthalene	41	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	ND	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	100	%	%
Fluorene-d10	114	%	%
Chrysene-d12	82.5	%	%

ND=Not Detected
NA=Not Applicable

Reported By: Michael Blades Approved By: Jeff Lowry

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP BNK I
Lab ID: 004106-0001-SA Enseco ID: 1031576
Matrix: AQUEOUS Sampled: 29 MAR 89 Received: 30 MAR 89
Authorized: 30 MAR 89 Prepared: 31 MAR 89 Analyzed: 03 APR 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	ND	ng/L	10
Indene	ND	ng/L	10
Naphthalene	ND	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	ND	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	30.6	%	%
Fluorene-d10	36.4	%	%
Chrysene-d12	28.4	%	%

ND=Not Detected
NA=Not Applicable

Reported By: Michael Blades Approved By: Jeff Lowry

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples					
Keystone ID		136-001	136-002	136-003	136-004	136-005	136-006
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I	BNK-I	WK1-INFTNK	WK1-SFCEFF	WK1-AC1EFF
Parameters	Units						
Biochemical Oxygen Demand	mg/L	5.43	<1.00	<1.00	N/A	N/A	N/A
COD	mg/L	16.0	<10.0	<10.0	N/A	N/A	N/A
Ferrous Iron	mg/L	0.411	<0.100	<0.100	0.166	<0.100	N/A
Hardness	mg/L	453	443	<1.00	N/A	N/A	N/A
Ammonia Nitrogen as N	mg/L	<1.00	<1.00	<1.00	N/A	N/A	N/A
Nitrite as N	mg/L	<0.020	<0.020	<0.020	N/A	N/A	N/A
Nitrate as N	mg/L	<0.020	<0.020	0.033	N/A	N/A	N/A
Oil and Grease	mg/L	<6.00	<6.00	<6.00	N/A	N/A	N/A
pH	units	7.9	7.8	7.6	7.4	7.2	N/A
Phenol	mg/L	0.074	<0.005	<0.005	<0.005	0.0380	N/A
Orthophosphate	mg/L	<0.010	0.030	0.014	N/A	N/A	N/A
Total Dissolved Solids	mg/L	673	560	<1.00	N/A	N/A	N/A
Total Organic Carbon	mg/L	7.15	<1.00	<1.00	6.86	7.35	N/A
Total Suspended Solids	mg/L	10.0	16.0	1.00	14.0	8.00	N/A
Silver	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Arsenic	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Beryllium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Cadmium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Chromium	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Copper	ug/L	<25.0	<25.0	N/A	N/A	N/A	N/A
Iron	ug/L	1840	<100	<100	1730	<100	N/A
Dissolved Iron	ug/L	<100	<100	<100	<100	<100	N/A
Manganese	ug/L	374	33.9	<15.0	3480	21.5	N/A
Nickel	ug/L	<40.0	<40.0	N/A	N/A	N/A	N/A
Lead	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Antimony	ug/L	<60.0	<60.0	N/A	N/A	N/A	N/A
Selenium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Thallium	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Zinc	ug/L	85.4	<20.0	N/A	N/A	N/A	N/A

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples		
Keystone ID		136-007	136-008	136-009
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		WK1-AC2EFF	WK1-AC3EFF	WK1-BW1
Parameters	Units			
Total Suspended Solids	mg/L	N/A	N/A	1050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples	
Keystone ID	136-001	136-002
Date Sampled	29-MAR-1989	29-MAR-1989
Customer ID	INF-I	AC3 EFF-I

Parameters	Units		
GC608			
a-BHC	ug/L	<0.500	<0.050
g-BHC	ug/L	<0.500	<0.050
b-BHC	ug/L	<0.050	<0.050
Heptachlor	ug/L	<0.050	<0.050
d-BHC	ug/L	<0.050	<0.050
Aldrin	ug/L	<0.050	<0.050
Heptachlor epoxide	ug/L	<0.050	<0.050
Endosulfan I	ug/L	<0.050	<0.050
4,4'-DDE	ug/L	<0.100	<0.100
Dieldrin	ug/L	<0.100	<0.100
Endrin	ug/L	<0.100	<0.100
4,4'-DDD	ug/L	<0.100	<0.100
Endosulfan II	ug/L	<0.100	<0.100
4,4'-DDT	ug/L	<0.100	<0.100
Endrin aldehyde	ug/L	<0.100	<0.100
Endosulfan sulfate	ug/L	<0.100	<0.100
Methoxychlor	ug/L	<0.500	<0.500
Chlordane	ug/L	<0.500	<0.500
Toxaphene	ug/L	<1.00	<1.00
PCB-1016	ug/L	<0.500	<0.500
PCB-1221	ug/L	<0.500	<0.500
PCB-1232	ug/L	<0.500	<0.500
PCB-1242	ug/L	<0.500	<0.500
PCB-1248	ug/L	<0.500	<0.500
PCB-1254	ug/L	<1.00	<1.00
PCB-1260	ug/L	<1.00	<1.00

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples					
Keystone ID		136-001	136-002	136-003	136-004	136-005	136-006
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I	BNK-I	WK1-INFTNK	WK1-SFCEFF	WK1-AC1EFF
Parameters	Units						
LC610							
Carbazole	ug/L	2.30	<2.00	N/A	2.38	2.49	<2.00
Naphthalene	ug/L	765	<2.00	N/A	866	743	<2.00
Acenaphthylene	ug/L	84.0	<2.00	N/A	40.6	34.0	<2.00
Acenaphthene	ug/L	48.9	<2.00	N/A	35.9	31.0	<2.00
Fluorene	ug/L	13.3	<0.200	N/A	12.5	9.83	<0.200
Phenanthrene	ug/L	7.21	<0.500	N/A	8.17	5.66	<0.500
Anthracene	ug/L	<0.500	<0.500	N/A	2.65	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	N/A	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	N/A	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples	
Keystone ID	136-007	136-008
Date Sampled	29-MAR-1989	29-MAR-1989
Customer ID	WK1-AC2EFF	WK1-AC3EFF

Parameters	Units		
LC610			
Carbazole	ug/L	<2.00	<2.00
Naphthalene	ug/L	<2.00	<2.00
Acenaphthylene	ug/L	<2.00	<2.00
Acenaphthene	ug/L	<2.00	<2.00
Fluorene	ug/L	<0.200	<0.200
Phenanthrene	ug/L	<0.500	<0.500
Anthracene	ug/L	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples	
Keystone ID	136-001	136-002
Date Sampled	29-MAR-1989	29-MAR-1989
Customer ID	INF-I	AC3 EFF-I
Parameters	**Units**	
MS624		
Chloromethane	ug/L	<10.0 <10.0
Bromomethane	ug/L	<10.0 <10.0
Vinyl chloride	ug/L	31.0 <10.0
Chloroethane	ug/L	<10.0 <10.0
Methylene chloride	ug/L	17.0 15.0
Trichlorofluoromethane	ug/L	<10.0 <10.0
1,1-Dichloroethene	ug/L	<5.00 <5.00
1,1-Dichloroethane	ug/L	<5.00 <5.00
trans-1,2-Dichloroethene	ug/L	40.0 <5.00
Chloroform	ug/L	<5.00 <5.00
1,2-Dichloroethane	ug/L	<5.00 <5.00
1,1,1-Trichloroethane	ug/L	<5.00 <5.00
Carbon tetrachloride	ug/L	<5.00 <5.00
Bromodichloromethane	ug/L	<5.00 <5.00
1,2-Dichloropropane	ug/L	<5.00 <5.00
cis-1,3-Dichloropropene	ug/L	<5.00 <5.00
Trichloroethene	ug/L	110 <5.00
Benzene	ug/L	97.0 <5.00
Dibromochloroethane	ug/L	<5.00 <5.00
1,1,2-Trichlorothane	ug/L	<5.00 <5.00
trans-1,3-Dichloropropene	ug/L	<5.00 <5.00
2-Chloroethylvinyl ether	ug/L	<10.0 <10.0
Bromoform	ug/L	<5.00 <5.00
1,1,2,2-Tetrachloroethane	ug/L	<5.00 <5.00
Tetrachloroethene	ug/L	57.0 <5.00
Toluene	ug/L	11.0 <5.00
Chlorobenzene	ug/L	<5.00 <5.00
Ethyl benzene	ug/L	79.0 <5.00

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples
Keystone ID	136-002
Date Sampled	29-MAR-1989
Customer ID	AC3 EFF-I

Parameters	Units	
MS625		
1,3-Dichlorobenzene	ug/L	<20.0
1,4-Dichlorobenzene	ug/L	<20.0
Hexachloroethane	ug/L	<20.0
Bis(2-chloroethyl) ether	ug/L	<20.0
1,2-Dichlorobenzene	ug/L	<20.0
Bis(2-chloroisopropyl) ether	ug/L	<20.0
N-Nitrosodi-n-propylamine	ug/L	<20.0
Nitrobenzene	ug/L	<20.0
Hexachlorobutadiene	ug/L	<20.0
1,2,4-Trichlorobenzene	ug/L	<20.0
Isophorone	ug/L	<20.0
Naphthalene	ug/L	<20.0
Bis(2-chloroethoxy) methane	ug/L	<20.0
Hexachlorocyclopentadiene	ug/L	<20.0
2-Chloronaphthalene	ug/L	<20.0
Acenaphthylene	ug/L	<20.0
Acenaphthene	ug/L	<20.0
Dimethyl phthalate	ug/L	<20.0
2,6-Dinitrotoluene	ug/L	<20.0
Fluorene	ug/L	<20.0
4-Chlorophenyl phenyl ether	ug/L	<20.0
2,4-Dinitrotoluene	ug/L	<20.0
Diethylphthalate	ug/L	<20.0
N-Nitrosodiphenylamine	ug/L	<20.0
Hexachlorobenzene	ug/L	<20.0
4-Bromophenyl phenyl ether	ug/L	<20.0
Phenanthrene	ug/L	<20.0
Anthracene	ug/L	<20.0
Fluoranthene	ug/L	<20.0
Pyrene	ug/L	<20.0

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples
Keystone ID		136-002
Date Sampled		29-MAR-1989
Customer ID		AC3 EFF-I
Parameters	**Units**	
MS625 (continued)		
Benzidine	ug/L	<200
Butyl benzyl phthalate	ug/L	<20.0
Bis(2-ethylexyl) phthalate	ug/L	<20.0
Chrysene	ug/L	<20.0
Benzo(a)anthracene	ug/L	<20.0
3,3'-Dichlorobenzidine	ug/L	<40.0
Di-n-octyl phthalate	ug/L	<20.0
Benzo(b)fluoranthene	ug/L	<20.0
Benzo(k)fluoranthene	ug/L	<20.0
Benzo(a)pyrene	ug/L	<20.0
Indeno(1,2,3-c,d)pyrene	ug/L	<20.0
Dibenzo(a,h)anthracene	ug/L	<20.0
Benzo(ghi)perylene	ug/L	<20.0
N-Nitrosodimethylamine	ug/L	<20.0
2-Chlorophenol	ug/L	<20.0
2,4-Dichlorophenol	ug/L	<20.0
2,4-Dimethylphenol	ug/L	<20.0
4,6-Dinitro-2-methylphenol	ug/L	<100
2,4-Dinitrophenol	ug/L	<100
2-Nitrophenol	ug/L	<20.0
4-Nitrophenol	ug/L	<100
4-Chloro-3-methylphenol	ug/L	<20.0
Pentachlorophenol	ug/L	<100
Phenol	ug/L	<20.0
2,4,6-Trichlorophenol	ug/L	<20.0
Di-n-butyl phthalate	ug/L	<20.0
1,2-Diphenylhydrazine	ug/L	<20.0

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-INF-E
Lab ID: 005399-0001-SA Enseco ID: 1042154
Matrix: AQUEOUS Sampled: 19 JUN 89 Received: 20 JUN 89
Authorized: 20 JUN 89 Prepared: 25 JUN 89 Analyzed: 14 JUL 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	17	ug/L	10
2,3-Dihydroindene	130	ug/L	10
Indene	150	ug/L	10
Naphthalene	510	ug/L	10
Benzo(b)thiophene	86	ug/L	10
Quinoline	ND	ug/L	10
1H-Indole	ND	ug/L	10
2-Methylnaphthalene	40	ug/L	10
1-Methylnaphthalene	62	ug/L	10
Biphenyl	10	ug/L	10
Acenaphthylene	ND	ug/L	10
Acenaphthene	51	ug/L	10
Dibenzofuran	15	ug/L	10
Fluorene	16	ug/L	10
Dibenzothiophene	ND	ug/L	10
Phenanthrene	ND	ug/L	10
Anthracene	ND	ug/L	10
Acridine	ND	ug/L	10
Carbazole	34	ug/L	10
Fluoranthene	ND	ug/L	10
Pyrene	ND	ug/L	10
Benzo(a)anthracene	ND	ug/L	10
Chrysene	ND	ug/L	10
Benzo(b)fluoranthene	ND	ug/L	10
Benzo(k)fluoranthene	ND	ug/L	10
7,12-Dimethylbenz-anthracene	ND	ug/L	10
Benzo(e)pyrene	ND	ug/L	10
Benzo(a)pyrene	ND	ug/L	10
Perylene	ND	ug/L	10
3-Methylcholanthrene	ND	ug/L	10
Dibenz(a,h)anthracene	ND	ug/L	10
Dibenz(a,c)anthracene	ND	ug/L	10
Benzo(g,h,i)perylene	ND	ug/L	10
Indeno(1,2,3-c,d)pyrene	ND	ug/L	10
Naphthalene-d8	77.5	%	--
Fluorene-d10	83.5	%	--
Chrysene-d12	66.0	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Marshall Tibury Approved By: Jeff Lowry

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-EFF-E
Lab ID: 005396-0001-SA Enseco ID: 1042152
Matrix: AQUEOUS Sampled: 19 JUN 89 Received: 20 JUN 89
Authorized: 20 JUN 89 Prepared: 21 JUN 89 Analyzed: 17 JUL 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	ND	ng/L	10
Indene	ND	ng/L	10
Naphthalene	ND	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	ND	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	39.4	%	--
Fluorene-d10	48.7	%	--
Chrysene-d12	39.2	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Phillip Tallarico Approved By: Jeff Lowry

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-BNK-E
Lab ID: 005396-0002-SA Enseco ID: 1042153
Matrix: AQUEOUS Sampled: 19 JUN 89 Received: 20 JUN 89
Authorized: 20 JUN 89 Prepared: 21 JUN 89 Analyzed: 12 JUL 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	ND	ng/L	10
Indene	ND	ng/L	10
Naphthalene	32	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	13	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	45.1	%	--
Fluorene-d10	65.3	%	--
Chrysene-d12	45.6	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Bob Martin Approved By: Jeff Lowry

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples		
Keystone ID		100-001	100-002	100-003
Date Sampled		19-JUN-1989	19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E	RTSLP BNK-E
Parameters	Units			
Biochemical Oxygen Demand	mg/L	7.20	<1.00	<1.00
COD	mg/L	20.0	28.0	<10.0
Ferrous Iron	mg/L	0.118	<0.100	<0.100
Hardness	mg/L	501	454	<1.00
Ammonia Nitrogen as N	mg/L	1.05	<1.00	<1.00
Nitrite as N	mg/L	<0.020	<0.020	<0.020
Nitrate as N	mg/L	<0.020	<0.020	<0.020
Oil and Grease	mg/L	<5.00	<6.00	<6.00
Orthophosphate as Phorphorous	mg/L	<0.010	<0.010	<0.010
pH	units	7.6	7.6	5.8
Phenol	mg/L	0.124	0.012	<0.005
Total Dissolved Solids	mg/L	715	730	4.00
Total Organic Carbon	mg/L	2.46	5.26	<1.00
Total Suspended Solids	mg/L	1.00	<1.00	<1.00
Silver	ug/L	<10.0	<10.0	NR
Arsenic	ug/L	<10.0	<10.0	NR
Beryllium	ug/L	<5.00	<5.00	NR
Cadmium	ug/L	<5.00	<5.00	NR
Chromium	ug/L	<10.0	<10.0	NR
Copper	ug/L	<25.0	<25.0	NR
Iron	ug/L	1980	<100	<100
Dissolved Iron	ug/L	100	<100	<100
Manganese	ug/L	374	691	<15.0
Nickel	ug/L	<40.0	<40.0	NR
Lead	ug/L	<5.00	<5.00	NR
Antimony	ug/L	<60.0	<60.0	NR
Selenium	ug/L	<5.00	<5.00	NR
Thallium	ug/L	<10.0	<10.0	NR
Zinc	ug/L	83.0	31.1	NR

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
GC608			
a-BHC	ug/L	<0.050	<0.050
g-BHC	ug/L	<0.050	<0.050
b-BHC	ug/L	<0.050	<0.050
Heptachlor	ug/L	<0.050	<0.050
d-BHC	ug/L	<0.050	<0.050
Aldrin	ug/L	<0.050	<0.050
Heptachlor epoxide	ug/L	<0.050	<0.050
Endosulfan I	ug/L	<0.050	<0.050
4,4'-DDE	ug/L	<0.100	<0.100
Dieldrin	ug/L	<0.100	<0.100
Endrin	ug/L	<1.00	<0.100
4,4'-DDD	ug/L	<1.00	<0.100
Endosulfan II	ug/L	<1.00	<0.100
4,4'-DDT	ug/L	<1.00	<0.100
Endrin aldehyde	ug/L	<0.100	<0.100
Endosulfan sulfate	ug/L	<0.100	<0.100
Methoxychlor	ug/L	<0.500	<0.500
Chlordane	ug/L	<0.500	<0.500
Toxaphene	ug/L	<1.00	<1.00
PCB-1016	ug/L	<0.500	<0.500
PCB-1221	ug/L	<0.500	<0.500
PCB-1232	ug/L	<0.500	<0.500
PCB-1242	ug/L	<0.500	<0.500
PCB-1248	ug/L	<0.500	<0.500
PCB-1254	ug/L	<1.00	<1.00
PCB-1260	ug/L	<1.00	<1.00

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
LC610			
Carbazole	ug/L	11.1	<2.00
Naphthalene	ug/L	747	<2.00
Acenaphthylene	ug/L	106	<2.00
Acenaphthene	ug/L	60.2	<2.00
Fluorene	ug/L	14.4	<0.200
Phenanthrene	ug/L	7.03	<0.500
Anthracene	ug/L	0.691	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
MS624			
Chloromethane	ug/L	<10.0	<10.0
Bromomethane	ug/L	<10.0	<10.0
Vinyl chloride	ug/L	13.0	<10.0
Chloroethane	ug/L	<10.0	<10.0
Methylene chloride	ug/L	<5.00	<5.00
Trichlorofluoromethane	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<5.00	<5.00
1,1-Dichloroethane	ug/L	<5.00	<5.00
trans-1,2-Dichloroethene	ug/L	25.0	<5.00
Chloroform	ug/L	<5.00	<5.00
1,2-Dichloroethane	ug/L	<5.00	<5.00
1,1,1-Trichloroethane	ug/L	<5.00	<5.00
Carbon tetrachloride	ug/L	<5.00	<5.00
Bromodichloromethane	ug/L	<5.00	<5.00
1,2-Dichloropropane	ug/L	<5.00	<5.00
cis-1,3-Dichloropropene	ug/L	<5.00	<5.00
Trichloroethene	ug/L	83.0	<5.00
Benzene	ug/L	100	<5.00
Dibromochloromethane	ug/L	<5.00	<5.00
1,1,2-Trichloroethane	ug/L	<5.00	<5.00
trans-1,3-Dichloropropene	ug/L	<5.00	<5.00
2-Chloroethylvinyl ether	ug/L	<10.0	<10.0
Bromoform	ug/L	<5.00	<5.00
1,1,2,2-Tetrachloroethane	ug/L	<5.00	<5.00
Tetrachloroethene	ug/L	25.0	<5.00
Toluene	ug/L	12.0	<5.00
Chlorobenzene	ug/L	<5.00	<5.00
Ethyl benzene	ug/L	92.0	<5.00

Summary of Analytical Results

Data received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	**Units**		
MS625 (continued)			
Indeno(1,2,3-c,d)pyrene	ug/L	<20.0	<20.0
Dibenzo(a,h)anthracene	ug/L	<20.0	<20.0
Benzo(ghi)perylene	ug/L	<20.0	<20.0
N-Nitrosodimethylamine	ug/L	<20.0	<20.0
2-Chlorophenol	ug/L	<20.0	<20.0
2,4-Dichlorophenol	ug/L	<20.0	<20.0
2,4-Dimethylphenol	ug/L	30.0	<20.0
4,6-Dinitro-2-methylphenol	ug/L	<100	<100
2,4-Dinitrophenol	ug/L	<100	<100
2-Nitrophenol	ug/L	<20.0	<20.0
4-Nitrophenol	ug/L	<100	<100
4-Chloro-3-methylphenol	ug/L	<20.0	<20.0
Pentachlorophenol	ug/L	<100	<100
Phenol	ug/L	<20.0	<20.0
2,4,6-Trichlorophenol	ug/L	<20.0	<20.0
Di-n-butyl phthalate	ug/L	<20.0	<20.0
1,2-Diphenylhydrazine	ug/L	<20.0	<20.0

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
MS&S			
1,3-Dichlorobenzene	ug/L	<20.0	<20.0
1,4-Dichlorobenzene	ug/L	<20.0	<20.0
Hexachloroethane	ug/L	<20.0	<20.0
Bis(2-chloroethyl) ether	ug/L	<20.0	<20.0
1,2-Dichlorobenzene	ug/L	<20.0	<20.0
Bis(2-chloroisopropyl) ether	ug/L	<20.0	<20.0
N-Nitrosodi-n-propylamine	ug/L	<20.0	<20.0
Nitrobenzene	ug/L	<20.0	<20.0
Hexachlorobutadiene	ug/L	<20.0	<20.0
1,2,4-Trichlorobenzene	ug/L	<20.0	<20.0
Isophorone	ug/L	<20.0	<20.0
Naphthalene	ug/L	1900	<20.0
Bis(2-chloroethoxy) methane	ug/L	<20.0	<20.0
Hexachlorocyclopentadiene	ug/L	<20.0	<20.0
2-Chloronaphthalene	ug/L	<20.0	<20.0
Acenaphthylene	ug/L	<20.0	<20.0
Acenaphthene	ug/L	<20.0	<20.0
Dimethyl phthalate	ug/L	<20.0	<20.0
2,6-Dinitrotoluene	ug/L	<20.0	<20.0
Fluorene	ug/L	21.0	<20.0
4-Chlorophenyl phenyl ether	ug/L	<20.0	<20.0
2,4-Dinitrotoluene	ug/L	<20.0	<20.0
Diethylphthalate	ug/L	<20.0	<20.0
N-Nitrosodiphenylamine	ug/L	<20.0	<20.0
Hexachlorobenzene	ug/L	<20.0	<20.0
4-Bromophenyl phenyl ether	ug/L	<20.0	<20.0
Phenanthrene	ug/L	<20.0	<20.0
Anthracene	ug/L	<20.0	<20.0
Fluoranthene	ug/L	<20.0	<20.0
Pyrene	ug/L	<20.0	<20.0
Benzidine	ug/L	<200	<200
Butyl benzyl phthalate	ug/L	<20.0	<20.0
Bis(2-ethylhexyl) phthalate	ug/L	<20.0	120
Chrysene	ug/L	<20.0	<20.0
Benzo(a)anthracene	ug/L	<20.0	<20.0
3,3'-Dichlorobenzidine	ug/L	<40.0	<40.0
Di-n-octyl phthalate	ug/L	<20.0	<20.0
Benzo(b)fluoranthene	ug/L	<20.0	<20.0
Benzo(k)fluoranthene	ug/L	<20.0	<20.0
Benzo(a)pyrene	ug/L	<20.0	<20.0

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-INF-M
Lab ID: 004820-0001-SA Enseco ID: 1037364
Matrix: AQUEOUS Sampled: 08 MAY 89 Received: 09 MAY 89
Authorized: 09 MAY 89 Prepared: 12 MAY 89 Analyzed: 01 JUN 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	18	ug/L	10
2,3-Dihydroindene	140	ug/L	10
Indene	150	ug/L	10
Naphthalene	450	ug/L	10
Benzo(b)thiophene	73	ug/L	10
Quinoline	ND	ug/L	10
1H-Indole	ND	ug/L	10
2-Methylnaphthalene	45	ug/L	10
1-Methylnaphthalene	73	ug/L	10
Biphenyl	10	ug/L	10
Acenaphthylene	ND	ug/L	10
Acenaphthene	52	ug/L	10
Dibenzofuran	14	ug/L	10
Fluorene	17	ug/L	10
Dibenzothiophene	ND	ug/L	10
Phenanthrene	ND	ug/L	10
Anthracene	ND	ug/L	10
Acridine	ND	ug/L	10
Carbazole	26	ug/L	10
Fluoranthene	ND	ug/L	10
Pyrene	ND	ug/L	10
Benzo(a)anthracene	ND	ug/L	10
Chrysene	ND	ug/L	10
Benzo(b)fluoranthene	ND	ug/L	10
Benzo(k)fluoranthene	ND	ug/L	10
7,12-Dimethylbenz-anthracene	ND	ug/L	10
Benzo(e)pyrene	ND	ug/L	10
Benzo(a)pyrene	ND	ug/L	10
Perylene	ND	ug/L	10
3-Methylcholanthrene	ND	ug/L	10
Dibenz(a,h)anthracene	ND	ug/L	10
Dibenz(a,c)anthracene	ND	ug/L	10
Benzo(g,h,i)perylene	ND	ug/L	10
Indeno(1,2,3-c,d)pyrene	ND	ug/L	10
Naphthalene-d8	56.0	%	--
Fluorene-d10	90.0	%	--
Chrysene-d12	86.0	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Angie Poturalski Approved By: Jeff Lowry

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-EFF-M
Lab ID: 004819-0001-SA Enseco ID: 1037366
Matrix: AQUEOUS Sampled: 08 MAY 89 Received: 09 MAY 89
Authorized: 09 MAY 89 Prepared: 12 MAY 89 Analyzed: 02 JUN 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	ND	ng/L	10
Indene	ND	ng/L	10
Naphthalene	ND	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	ND	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	53.5	%	--
Fluorene-d10	62.2	%	--
Chrysene-d12	51.2	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Deneen Miller Approved By: Jeff Lowry

Enseco

Polynuclear Aromatic Hydrocarbons, SIM

Method 8270/SIM

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-BNK-M
Lab ID: 004819-0002-SA Enseco ID: 1037367
Matrix: AQUEOUS Sampled: 08 MAY 89 Received: 09 MAY 89
Authorized: 09 MAY 89 Prepared: 12 MAY 89 Analyzed: 02 JUN 89

Parameter	Result	Units	Reporting Limit
2,3-Benzofuran	ND	ng/L	10
2,3-Dihydroindene	ND	ng/L	10
Indene	ND	ng/L	10
Naphthalene	20	ng/L	10
Benzo(b)thiophene	ND	ng/L	10
Quinoline	ND	ng/L	10
1H-Indole	ND	ng/L	10
2-Methylnaphthalene	ND	ng/L	10
1-Methylnaphthalene	ND	ng/L	10
Biphenyl	ND	ng/L	10
Acenaphthylene	ND	ng/L	10
Acenaphthene	ND	ng/L	10
Dibenzofuran	ND	ng/L	10
Fluorene	ND	ng/L	10
Dibenzothiophene	ND	ng/L	10
Phenanthrene	ND	ng/L	10
Anthracene	ND	ng/L	10
Acridine	ND	ng/L	10
Carbazole	ND	ng/L	10
Fluoranthene	ND	ng/L	10
Pyrene	ND	ng/L	10
Benzo(a)anthracene	ND	ng/L	10
Chrysene	ND	ng/L	10
Benzo(b)fluoranthene	ND	ng/L	10
Benzo(k)fluoranthene	ND	ng/L	10
7,12-Dimethylbenz-anthracene	ND	ng/L	10
Benzo(e)pyrene	ND	ng/L	10
Benzo(a)pyrene	ND	ng/L	10
Perylene	ND	ng/L	10
3-Methylcholanthrene	ND	ng/L	10
Dibenz(a,h)anthracene	ND	ng/L	10
Dibenz(a,c)anthracene	ND	ng/L	10
Benzo(g,h,i)perylene	ND	ng/L	10
Indeno(1,2,3-c,d)pyrene	ND	ng/L	10
Naphthalene-d8	74.3	%	--
Fluorene-d10	74.4	%	--
Chrysene-d12	73.9	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Deneen Miller Approved By: Jeff Lowry

Summary of Analytical Results

Date received: 9-MAY-1989 Customer: ReTec Job name: M89-05.07

		Samples		
Keystone ID		89-001	89-002	89-003
Date Sampled		8-MAY-1989	8-MAY-1989	8-MAY-1989
Customer ID		SMK-M	ACSEFF	INF-M
Parameters	Units			
Biochemical Oxygen Demand	mg/L	<1.00	<1.00	4.42
COD	mg/L	<10.0	10.0	32.0
Ferrous Iron	mg/L	0.110	<0.100	<0.100
Hardness	mg/L	2.20	475	471
Ammonia Nitrogen as N	mg/L	<1.00	<1.00	<1.00
Nitrite as N	mg/L	<0.020	<0.020	<0.020
Nitrate as N	mg/L	<0.020	<0.020	<0.020
Oil and Grease	mg/L	<5.00	9.11	<5.00
Orthophosphate as Phosphorus	mg/L	<0.010	<0.010	<0.010
pH	units	6.6	7.3	7.3
Phenol	mg/L	<0.005	<0.005	0.060
Total Dissolved Solids	mg/L	<1.00	693	711
Total Organic Carbon	mg/L	<1.00	2.53	7.06
Total Suspended Solids	mg/L	<1.00	2.00	14.0
Iron	ug/L	<100	<100	2120
Dissolved Iron	ug/L	<100	<100	<100
Manganese	ug/L	<15.0	244	361

APPENDIX B

ATTACHMENT 6

BACKWASH SOLIDS ANALYSIS

Enseco

Polynuclear Aromatic Hydrocarbons, GC/MS

Method 8270

Client Name: REMEDIATION TECHNOLOGIES, INC.
Client ID: RTSLP-BW1-SOL
Lab ID: 005464-0001-SA Enseco ID: 1042764
Matrix: SOIL Sampled: 21 JUN 89 Received: 23 JUN 89
Authorized: 23 JUN 89 Prepared: 05 JUL 89 Analyzed: 14 JUL 89

Parameter	Result	Units	Reporting Limit
Naphthalene	ND	ug/kg	330
Acenaphthylene	ND	ug/kg	330
Acenaphthene	ND	ug/kg	330
Fluorene	ND	ug/kg	330
Phenanthrene	ND	ug/kg	330
Anthracene	ND	ug/kg	330
Fluoranthene	ND	ug/kg	330
Pyrene	ND	ug/kg	330
Benzo(a)anthracene	ND	ug/kg	330
Chrysene	ND	ug/kg	330
Benzo(b)fluoranthene	ND	ug/kg	330
Benzo(k)fluoranthene	ND	ug/kg	330
Benzo(a)pyrene	ND	ug/kg	330
Dibenz(a,h)anthracene	ND	ug/kg	330
Benzo(g,h,i)perylene	ND	ug/kg	330
Indeno(1,2,3-c,d)pyrene	ND	ug/kg	330
2,3-Benzofuran	ND	ug/kg	330
2,3-Dihydroindene	ND	ug/kg	330
Indene	ND	ug/kg	330
Benzo(b)thiophene	ND	ug/kg	330
Quinoline	ND	ug/kg	330
1H-Indole	ND	ug/kg	330
2-Methylnaphthalene	ND	ug/kg	330
1-Methylnaphthalene	ND	ug/kg	330
Biphenyl	ND	ug/kg	330
Dibenzofuran	ND	ug/kg	330
Dibenzothiophene	ND	ug/kg	330
Acridine	ND	ug/kg	330
Carbazole	ND	ug/kg	330
7,12-Dimethylbenz-anthracene	ND	ug/kg	330
Benzo(e)pyrene	ND	ug/kg	330
Perylene	ND	ug/kg	330
3-Methylcholanthrene	ND	ug/kg	330
Dibenz(a,c)anthracene	ND	ug/kg	330
Nitrobenzene-d5	69.4	%	--
2-Fluorobiphenyl	66.8	%	--
Terphenyl-d14	72.6	%	--

N.D. = Not Detected
N.A. = Not Applicable

Reported By: Marshall Tibury Approved By: Jeff Lowry

APPENDIX B

ATTACHMENT 7

PRIORITY POLLUTANT SCAN

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: MBF-03.136

		Samples					
Keystone ID		136-001	136-002	136-003	136-004	136-005	136-006
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		INF-I	ACB EFF-I	BNK-I	WK1-INFTNK	WK1-SFCEFF	WK1-ACIEFF
Parameters	Units						
Biochemical Oxygen Demand	mg/L	5.43	<1.00	<1.00	N/A	N/A	N/A
COD	mg/L	16.0	<10.0	<10.0	N/A	N/A	N/A
Ferrous Iron	mg/L	0.411	<0.100	<0.100	0.166	<0.100	N/A
Hardness	mg/L	453	443	<1.00	N/A	N/A	N/A
Ammonia Nitrogen as N	mg/L	<1.00	<1.00	<1.00	N/A	N/A	N/A
Nitrite as N	mg/L	<0.020	<0.020	<0.020	N/A	N/A	N/A
Nitrate as N	mg/L	<0.020	<0.020	0.033	N/A	N/A	N/A
Oil and Grease	mg/L	<6.00	<6.00	<6.00	N/A	N/A	N/A
pH	units	7.9	7.8	6.5	7.4	7.2	N/A
Phenol	mg/L	0.074	<0.005	<0.005	<0.005	0.0360	N/A
Orthophosphate	mg/L	<0.010	0.030	0.014	N/A	N/A	N/A
Total Dissolved Solids	mg/L	673	560	<1.00	N/A	N/A	N/A
Total Organic Carbon	mg/L	7.15	<1.00	<1.00	6.86	7.35	N/A
Total Suspended Solids	mg/L	10.0	16.0	1.00	14.0	8.00	N/A
Silver	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Arsenic	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Beryllium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Cadmium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Chromium	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Copper	ug/L	<25.0	<25.0	N/A	N/A	N/A	N/A
Iron	ug/L	1840	<100	<100	1730	<100	N/A
Dissolved Iron	ug/L	<100	<100	<100	<100	<100	N/A
Manganese	ug/L	374	33.9	<15.0	3480	21.5	N/A
Nickel	ug/L	<40.0	<40.0	N/A	N/A	N/A	N/A
Lead	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Antimony	ug/L	<60.0	<60.0	N/A	N/A	N/A	N/A
Selenium	ug/L	<5.00	<5.00	N/A	N/A	N/A	N/A
Thallium	ug/L	<10.0	<10.0	N/A	N/A	N/A	N/A
Zinc	ug/L	65.4	<20.0	N/A	N/A	N/A	N/A

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples		
Keystone ID		136-007	136-008	136-009
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		WK1-4C2EFF	WK1-4C3EFF	WK1-BW1
Parameters	Units			
Total Suspended Solids	mg/L	N/A	N/A	1050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: MB9-03:136

	Samples	
Keystone ID	136-001	136-002
Date Sampled	29-MAR-1989	29-MAR-1989
Customer ID	INF-I	AC3 EFF-I

Parameters	Units		
GC608			
a-BHC	ug/L	<0.500	<0.050
g-BHC	ug/L	<0.500	<0.050
b-BHC	ug/L	<0.050	<0.050
Heptachlor	ug/L	<0.050	<0.050
d-BHC	ug/L	<0.050	<0.050
Aldrin	ug/L	<0.050	<0.050
Heptachlor epoxide	ug/L	<0.050	<0.050
Endosulfan I	ug/L	<0.050	<0.050
4,4'-DDE	ug/L	<0.100	<0.100
Dieldrin	ug/L	<0.100	<0.100
Endrin	ug/L	<0.100	<0.100
4,4'-DDD	ug/L	<0.100	<0.100
Endosulfan II	ug/L	<0.100	<0.100
4,4'-DDT	ug/L	<0.100	<0.100
Endrin aldehyde	ug/L	<0.100	<0.100
Endosulfan sulfate	ug/L	<0.100	<0.100
Methoxychlor	ug/L	<0.500	<0.500
Chlordane	ug/L	<0.500	<0.500
Toxaphene	ug/L	<1.00	<1.00
PCB-1016	ug/L	<0.500	<0.500
PCB-1221	ug/L	<0.500	<0.500
PCB-1232	ug/L	<0.500	<0.500
PCB-1242	ug/L	<0.500	<0.500
PCB-1248	ug/L	<0.500	<0.500
PCB-1254	ug/L	<1.00	<1.00
PCB-1260	ug/L	<1.00	<1.00

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples					
Keystone ID		136-001	136-002	136-003	136-004	136-005	136-006
Date Sampled		29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I	BNK-I	WK1-INFTNK	WK1-SFCEFF	WK1-AC1EFF
Parameters	Units						
LC610							
Carbazole	ug/L	2.30	<2.00	N/A	2.38	2.49	<2.00
Naphthalene	ug/L	765	<2.00	N/A	866	743	<2.00
Acenaphthylene	ug/L	84.0	<2.00	N/A	40.6	34.0	<2.00
Acenaphthene	ug/L	48.9	<2.00	N/A	35.9	31.0	<2.00
Fluorene	ug/L	13.3	<0.200	N/A	12.5	9.83	<0.200
Phenanthrene	ug/L	7.21	<0.500	N/A	8.17	5.66	<0.500
Anthracene	ug/L	<0.500	<0.500	N/A	2.65	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200	N/A	<0.200	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150	N/A	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020	N/A	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030	N/A	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050	N/A	<0.050	<0.050	<0.050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples	
Keystone ID		136-007	136-008
Date Sampled		29-MAR-1989	29-MAR-1989
Customer ID		WK1-AC2EFF	WK1-AC3EFF
Parameters	Units		
LC610			
Carbazole	ug/L	<2.00	<2.00
Naphthalene	ug/L	<2.00	<2.00
Acenaphthylene	ug/L	<2.00	<2.00
Acenaphthene	ug/L	<2.00	<2.00
Fluorene	ug/L	<0.200	<0.200
Phenanthrene	ug/L	<0.500	<0.500
Anthracene	ug/L	<0.500	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples	
Keystone ID		136-001	136-002
Date Sampled		29-MAR-1989	29-MAR-1989
Customer ID		INF-I	AC3 EFF-I
Parameters	Units		
MS624			
Chloromethane	ug/L	<10.0	<10.0
Bromomethane	ug/L	<10.0	<10.0
Vinyl chloride	ug/L	31.0	<10.0
Chloroethane	ug/L	<10.0	<10.0
Methylene chloride	ug/L	17.0	15.0
Trichlorofluoromethane	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<5.00	<5.00
1,1-Dichloroethane	ug/L	<5.00	<5.00
trans-1,2-Dichloroethene	ug/L	40.0	<5.00
Chloroform	ug/L	<5.00	<5.00
1,2-Dichloroethane	ug/L	<5.00	<5.00
1,1,1-Trichloroethane	ug/L	<5.00	<5.00
Carbon tetrachloride	ug/L	<5.00	<5.00
Bromodichloromethane	ug/L	<5.00	<5.00
1,2-Dichloropropane	ug/L	<5.00	<5.00
cis-1,3-Dichloropropene	ug/L	<5.00	<5.00
Trichloroethene	ug/L	110	<5.00
Benzene	ug/L	97.0	<5.00
Dibromochloroethane	ug/L	<5.00	<5.00
1,1,2-Trichlorothane	ug/L	<5.00	<5.00
trans-1,3-Dichloropropene	ug/L	<5.00	<5.00
2-Chloroethylvinyl ether	ug/L	<10.0	<10.0
Bromoform	ug/L	<5.00	<5.00
1,1,2,2-Tetrachloroethane	ug/L	<5.00	<5.00
Tetrachloroethene	ug/L	57.0	<5.00
Toluene	ug/L	11.0	<5.00
Chlorobenzene	ug/L	<5.00	<5.00
Ethyl benzene	ug/L	79.0	<5.00

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

	Samples
Keystone ID	136-002
Date Sampled	29-MAR-1989
Customer ID	AC3 EFF-I

Parameters	Units	
MS625		
1,3-Dichlorobenzene	ug/L	<20.0
1,4-Dichlorobenzene	ug/L	<20.0
Hexachloroethane	ug/L	<20.0
Bis(2-chloroethyl) ether	ug/L	<20.0
1,2-Dichlorobenzene	ug/L	<20.0
Bis(2-chloroisopropyl) ether	ug/L	<20.0
N-Nitrosodi-n-propylamine	ug/L	<20.0
Nitrobenzene	ug/L	<20.0
Hexachlorobutadiene	ug/L	<20.0
1,2,4-Trichlorobenzene	ug/L	<20.0
Isophorone	ug/L	<20.0
Naphthalene	ug/L	<20.0
Bis(2-chloroethoxy) methane	ug/L	<20.0
Hexachlorocyclopentadiene	ug/L	<20.0
2-Chloronaphthalene	ug/L	<20.0
Acenaphthylene	ug/L	<20.0
Acenaphtnene	ug/L	<20.0
Dimethyl phthalate	ug/L	<20.0
2,6-Dinitrotoluene	ug/L	<20.0
Fluorene	ug/L	<20.0
4-Chlorophenyl phenyl ether	ug/L	<20.0
2,4-Dinitrotoluene	ug/L	<20.0
Diethylphthalate	ug/L	<20.0
N-Nitrosodiphenylamine	ug/L	<20.0
Hexachlorobenzene	ug/L	<20.0
4-Bromophenyl phenyl ether	ug/L	<20.0
Phenanthrene	ug/L	<20.0
Anthracene	ug/L	<20.0
Fluoranthene	ug/L	<20.0
Pyrene	ug/L	<20.0

Summary of Analytical Results

Date received: 18-APR-1989 Customer: ReTec Job name: M89-04.85

		Samples
Keystone ID		85-005
Date Sampled		17-APR-1989
Customer ID		FEED TO INFTNK
Parameters	**Units**	
MS625 (continued)		
Benzidine	ug/L	<100
Butyl benzyl phthalate	ug/L	<10.0
Bis(2-ethylexyl) phthalate	ug/L	37.0
Chrysene	ug/L	<10.0
Benzo(a)anthracene	ug/L	<10.0
3,3'-Dichlorobenzidine	ug/L	<20.0
Di-n-octyl phthalate	ug/L	<10.0
Benzo(b)fluoranthene	ug/L	<10.0
Benzo(k)fluoranthene	ug/L	<10.0
Benzo(a)pyrene	ug/L	<10.0
Indeno(1,2,3-c,d)pyrene	ug/L	<10.0
Dibenzo(a,h)anthracene	ug/L	<10.0
Benzo(ghi)perylene	ug/L	<10.0
N-Nitrosodimethylamine	ug/L	<10.0
2-Chlorophenol	ug/L	<10.0
2,4-Dichlorophenol	ug/L	<10.0
2,4-Dimethylphenol	ug/L	<10.0
4,6-Dinitro-2-methylphenol	ug/L	<50.0
2,4-Dinitrophenol	ug/L	<50.0
2-Nitrophenol	ug/L	<10.0
4-Nitrophenol	ug/L	<50.0
4-Chloro-3-methylphenol	ug/L	<10.0
Pentachlorophenol	ug/L	<50.0
Phenol	ug/L	<10.0
2,4,6-Trichlorophenol	ug/L	<10.0
Di-n-butyl phthalate	ug/L	<10.0

Summary of Analytical Results

Date received: 18-APR-1989 Customer: ReTec Job name: M89-04.85

		Samples
Keystone ID		85-005
Date Sampled		17-APR-1989
Customer ID		FEED TO INFTNK
Parameters	**Units**	
MS625		
1,3-Dichlorobenzene	ug/L	<10.0
1,4-Dichlorobenzene	ug/L	<10.0
Hexachloroethane	ug/L	<10.0
Bis(2-chloroethyl) ether	ug/L	<10.0
1,2-Dichlorobenzene	ug/L	<10.0
Bis(2-chloroisopropyl) ether	ug/L	<10.0
N-Nitrosodi-n-propylamine	ug/L	<10.0
Nitrobenzene	ug/L	<10.0
Hexachlorobutadiene	ug/L	<10.0
1,2,4-Trichlorobenzene	ug/L	<10.0
Isophorone	ug/L	<10.0
Naphthalene	ug/L	470
Bis(2-chloroethoxy) methane	ug/L	<10.0
Hexachlorocyclopentadiene	ug/L	<10.0
2-Chloronaphthalene	ug/L	<10.0
Acenaphthylene	ug/L	<10.0
Acenaphthene	ug/L	35.0
Dimethyl phthalate	ug/L	<10.0
2,6-Dinitrotoluene	ug/L	<10.0
Fluorene	ug/L	12.0
4-Chlorophenyl phenyl ether	ug/L	<10.0
2,4-Dinitrotoluene	ug/L	<10.0
Diethylphthalate	ug/L	<10.0
N-Nitrosodiphenylamine	ug/L	<10.0
Hexachlorobenzene	ug/L	<10.0
4-Bromophenyl phenyl ether	ug/L	<10.0
Phenanthrene	ug/L	<10.0
Anthracene	ug/L	<10.0
Fluoranthene	ug/L	<10.0
Pyrene	ug/L	<10.0

Summary of Analytical Results

Date received: 30-MAR-1989 Customer: ReTec Job name: M89-03.136

		Samples
Keystone ID		136-002
Date Sampled		29-MAR-1989
Customer ID		AC3 EFF-I
Parameters	**Units**	
MS625 (continued)		
Benzidine	ug/L	<200
Butyl benzyl phthalate	ug/L	<20.0
Bis(2-ethylexyl) pnthalate	ug/L	<20.0
Chrysene	ug/L	<20.0
Benzo(a)anthracene	ug/L	<20.0
3,3'-Dichlorobenzidine	ug/L	<40.0
Di-n-octyl phthalate	ug/L	<20.0
Benzo(b)fluoranthene	ug/L	<20.0
Benzo(k)fluoranthene	ug/L	<20.0
Benzo(a)pyrene	ug/L	<20.0
Indeno(1,2,3-c,d)pyrene	ug/L	<20.0
Dibenzo(a,h)anthracene	ug/L	<20.0
Benzo(ghi)perylene	ug/L	<20.0
N-Nitrosodimethylamine	ug/L	<20.0
2-Chlorophenol	ug/L	<20.0
2,4-Dichlorophenol	ug/L	<20.0
2,4-Dimethylphenol	ug/L	<20.0
4,6-Dinitro-2-methylphenol	ug/L	<100
2,4-Dinitrophenol	ug/L	<100
2-Nitrophenol	ug/L	<20.0
4-Nitrophenol	ug/L	<100
4-Chloro-3-methylphenol	ug/L	<20.0
Pentachlorophenol	ug/L	<100
Phenol	ug/L	<20.0
2,4,6-Trichlorophenol	ug/L	<20.0
Di-n-butyl phthalate	ug/L	<20.0
1,2-Diphenylhydrazine	ug/L	<20.0

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples		
Keystone ID		100-001	100-002	100-003
Date Sampled		19-JUN-1989	19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E	RTSLP BNK-E
Parameters	Units			
Biochemical Oxygen Demand	mg/L	7.20	<1.00	<1.00
COD	mg/L	20.0	28.0	<10.0
Ferrous Iron	mg/L	0.118	<0.100	<0.100
Hardness	mg/L	501	454	<1.00
Ammonia Nitrogen as N	mg/L	1.05	<1.00	<1.00
Nitrite as N	mg/L	<0.020	<0.020	<0.020
Nitrate as N	mg/L	<0.020	<0.020	<0.020
Oil and Grease	mg/L	<5.00	<6.00	<6.00
Orthophosphate as Phorphorous	mg/L	<0.010	<0.010	<0.010
pH	units	7.6	7.6	5.8
Phenol	mg/L	0.124	0.012	<0.005
Total Dissolved Solids	mg/L	715	730	4.00
Total Organic Carbon	mg/L	2.46	5.26	<1.00
Total Suspended Solids	mg/L	1.00	<1.00	<1.00
Silver	ug/L	<10.0	<10.0	NR
Arsenic	ug/L	<10.0	<10.0	NR
Beryllium	ug/L	<5.00	<5.00	NR
Cadmium	ug/L	<5.00	<5.00	NR
Chromium	ug/L	<10.0	<10.0	NR
Copper	ug/L	<25.0	<25.0	NR
Iron	ug/L	1980	<100	<100
Dissolved Iron	ug/L	100	<100	<100
Manganese	ug/L	374	691	<15.0
Nickel	ug/L	<40.0	<40.0	NR
Lead	ug/L	<5.00	<5.00	NR
Antimony	ug/L	<60.0	<60.0	NR
Selenium	ug/L	<5.00	<5.00	NR
Thallium	ug/L	<10.0	<10.0	NR
Zinc	ug/L	83.0	31.1	NR

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
GC608			
a-BHC	ug/L	<0.050	<0.050
g-BHC	ug/L	<0.050	<0.050
b-BHC	ug/L	<0.050	<0.050
Heptachlor	ug/L	<0.050	<0.050
d-BHC	ug/L	<0.050	<0.050
Aldrin	ug/L	<0.050	<0.050
Heptachlor epoxide	ug/L	<0.050	<0.050
Endosulfan I	ug/L	<0.050	<0.050
4,4'-DDE	ug/L	<0.100	<0.100
Dieldrin	ug/L	<0.100	<0.100
Endrin	ug/L	<1.00	<0.100
4,4'-DDD	ug/L	<1.00	<0.100
Endosulfan II	ug/L	<1.00	<0.100
4,4'-DDT	ug/L	<1.00	<0.100
Endrin aldehyde	ug/L	<0.100	<0.100
Endosulfan sulfate	ug/L	<0.100	<0.100
Methoxychlor	ug/L	<0.500	<0.500
Chlordane	ug/L	<0.500	<0.500
Toxaphene	ug/L	<1.00	<1.00
PCB-1016	ug/L	<0.500	<0.500
PCB-1221	ug/L	<0.500	<0.500
PCB-1232	ug/L	<0.500	<0.500
PCB-1242	ug/L	<0.500	<0.500
PCB-1248	ug/L	<0.500	<0.500
PCB-1254	ug/L	<1.00	<1.00
PCB-1260	ug/L	<1.00	<1.00

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
LC610			
Carbazole	ug/L	11.1	<2.00
Naphthalene	ug/L	747	<2.00
Acenaphthylene	ug/L	106	<2.00
Acenaphthene	ug/L	60.2	<2.00
Fluorene	ug/L	14.4	<0.200
Phenanthrene	ug/L	7.03	<0.500
Anthracene	ug/L	0.691	<0.500
Fluoranthene	ug/L	<0.200	<0.200
Pyrene	ug/L	<0.200	<0.200
Benzo(a)anthracene	ug/L	<0.020	<0.020
Chrysene	ug/L	<0.150	<0.150
Benzo(b)fluoranthene	ug/L	<0.020	<0.020
Benzo(k)fluoranthene	ug/L	<0.020	<0.020
Benzo(a)pyrene	ug/L	<0.020	<0.020
Dibenzo(a,h)anthracene	ug/L	<0.030	<0.030
Benzo(g,h,i)perylene	ug/L	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	ug/L	<0.050	<0.050

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
MS624			
Chloromethane	ug/L	<10.0	<10.0
Bromomethane	ug/L	<10.0	<10.0
Vinyl chloride	ug/L	13.0	<10.0
Chloroethane	ug/L	<10.0	<10.0
Methylene chloride	ug/L	<5.00	<5.00
Trichlorofluoromethane	ug/L	<10.0	<10.0
1,1-Dichloroethene	ug/L	<5.00	<5.00
1,1-Dichloroethane	ug/L	<5.00	<5.00
trans-1,2-Dichloroethene	ug/L	25.0	<5.00
Chloroform	ug/L	<5.00	<5.00
1,2-Dichloroethane	ug/L	<5.00	<5.00
1,1,1-Trichloroethane	ug/L	<5.00	<5.00
Carbon tetrachloride	ug/L	<5.00	<5.00
Bromodichloromethane	ug/L	<5.00	<5.00
1,2-Dichloropropane	ug/L	<5.00	<5.00
cis-1,3-Dichloropropene	ug/L	<5.00	<5.00
Trichloroethene	ug/L	83.0	<5.00
Benzene	ug/L	100	<5.00
Dibromochloromethane	ug/L	<5.00	<5.00
1,1,2-Trichloroethane	ug/L	<5.00	<5.00
trans-1,3-Dichloropropene	ug/L	<5.00	<5.00
2-Chloroethylvinyl ether	ug/L	<10.0	<10.0
Bromoform	ug/L	<5.00	<5.00
1,1,2,2-Tetrachloroethane	ug/L	<5.00	<5.00
Tetrachloroethene	ug/L	25.0	<5.00
Toluene	ug/L	12.0	<5.00
Chlorobenzene	ug/L	<5.00	<5.00
Ethyl benzene	ug/L	92.0	<5.00

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: MB9-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
MS625 (continued)			
Indeno(1,2,3-c,d)pyrene	ug/L	<20.0	<20.0
Dibenzo(a,h)anthracene	ug/L	<20.0	<20.0
Benzo(ghi)perylene	ug/L	<20.0	<20.0
N-Nitrosodimethylamine	ug/L	<20.0	<20.0
2-Chlorophenol	ug/L	<20.0	<20.0
2,4-Dichlorophenol	ug/L	<20.0	<20.0
2,4-Dimethylphenol	ug/L	30.0	<20.0
4,6-Dinitro-2-methylphenol	ug/L	<100	<100
2,4-Dinitrophenol	ug/L	<100	<100
2-Nitrophenol	ug/L	<20.0	<20.0
4-Nitrophenol	ug/L	<100	<100
4-Chloro-3-methylphenol	ug/L	<20.0	<20.0
Pentachlorophenol	ug/L	<100	<100
Phenol	ug/L	<20.0	<20.0
2,4,6-Trichlorophenol	ug/L	<20.0	<20.0
Di-n-butyl phthalate	ug/L	<20.0	<20.0
1,2-Diphenylhydrazine	ug/L	<20.0	<20.0

Summary of Analytical Results

Date received: 20-JUN-1989 Customer: ReTec Job name: M89-06.100

		Samples	
Keystone ID		100-001	100-002
Date Sampled		19-JUN-1989	19-JUN-1989
Customer ID		RTSLP INF-E	RTSLP EFF-E
Parameters	Units		
MS625			
1,3-Dichlorobenzene	ug/L	<20.0	<20.0
1,4-Dichlorobenzene	ug/L	<20.0	<20.0
Hexachloroethane	ug/L	<20.0	<20.0
Bis(2-chloroethyl) ether	ug/L	<20.0	<20.0
1,2-Dichlorobenzene	ug/L	<20.0	<20.0
Bis(2-chloroisopropyl) ether	ug/L	<20.0	<20.0
N-Nitrosodi-n-propylamine	ug/L	<20.0	<20.0
Nitrobenzene	ug/L	<20.0	<20.0
Hexachlorobutadiene	ug/L	<20.0	<20.0
1,2,4-Trichlorobenzene	ug/L	<20.0	<20.0
Isophorone	ug/L	<20.0	<20.0
Naphthalene	ug/L	1900	<20.0
Bis(2-chloroethoxy) methane	ug/L	<20.0	<20.0
Hexachlorocyclopentadiene	ug/L	<20.0	<20.0
2-Chloronaphthalene	ug/L	<20.0	<20.0
Acenaphthylene	ug/L	<20.0	<20.0
Acenaphthene	ug/L	<20.0	<20.0
Dimethyl phthalate	ug/L	<20.0	<20.0
2,6-Dinitrotoluene	ug/L	<20.0	<20.0
Fluorene	ug/L	21.0	<20.0
4-Chlorophenyl phenyl ether	ug/L	<20.0	<20.0
2,4-Dinitrotoluene	ug/L	<20.0	<20.0
Diethylphthalate	ug/L	<20.0	<20.0
N-Nitrosodiphenylamine	ug/L	<20.0	<20.0
Hexachlorobenzene	ug/L	<20.0	<20.0
4-Bromophenyl phenyl ether	ug/L	<20.0	<20.0
Phenanthrene	ug/L	<20.0	<20.0
Anthracene	ug/L	<20.0	<20.0
Fluoranthene	ug/L	<20.0	<20.0
Pyrene	ug/L	<20.0	<20.0
Benzidine	ug/L	<200	<200
Butyl benzyl phthalate	ug/L	<20.0	<20.0
Bis(2-ethylhexyl) phthalate	ug/L	<20.0	120
Chrysene	ug/L	<20.0	<20.0
Benzo(a)anthracene	ug/L	<20.0	<20.0
3,3'-Dichlorobenzidine	ug/L	<40.0	<40.0
Di-n-octyl phthalate	ug/L	<20.0	<20.0
Benzo(b)fluoranthene	ug/L	<20.0	<20.0
Benzo(k)fluoranthene	ug/L	<20.0	<20.0
Benzo(a)pyrene	ug/L	<20.0	<20.0

APPENDIX C

ReTeC'S STANDARD OPERATING PROCEDURES

- **SOP 507: SAMPLE HANDLING FOR SHIPMENT OF ANALYTICAL AND TREATABILITY SAMPLES**

STANDARD OPERATING PROCEDURES

Sample Handling for Shipment of Analytical and Treatability Samples

1.0 PURPOSE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes sample labeling, packaging and chain-of-custody procedures for shipping samples from a site location at the time of collection through receipt of the samples at a designated laboratory. Laboratory receipt of soil, sludge or water samples refers to receipt at either an analytical laboratory or a treatability laboratory for subsequent testing. This SOP also identifies the procedures for transport of unused treatability samples back to the particular site location from which they were taken. Samples sent to an analytical laboratory are generally handled by the respective laboratory and thus there is not need for return of unused analytical samples back to the site. The SOP also relates to samples sent to an analytical laboratory associated with pilot-scale or bench-scale treatability testing.

The objective of this SOP is to document proper procedures for sample shipping and handling as: (1) to ensure sample integrity, (2) to ensure sample quality conforming to proper holding times and using proper sample preservatives, and (3) to identify chain-of-custody protocol to document the sample history from collection through transport to the lab.

This SOP does not pertain to shipment of listed hazardous waste samples but rather to soil, sludge or water samples contaminated with respective chemicals for treatability testing, and to respective analytical samples for characterization testing.

Section 2 cites the different personnel responsibilities and Section 3 lists the supporting materials related to this SOP. Section 4 details the methods and procedures and Section 5 cites quality assurance/quality control. Section 6 relates to Health and Safety, and Section 7 relates to documentation.

2.0 RESPONSIBILITIES

It is the responsibility of the field team leader to ensure that samples are properly labeled and packaged for transport. The field team leader is also responsible for the field sample notebook and chain-of-custody protocol for sample documentation during handling and transport. It's the responsibility of the lab coordinator to finalize the chain-of-custody procedures outlined in this SOP.

The field team leader is also responsible to see that all related Health and Safety field procedures are properly followed. He is also responsible to check with the project engineer or manager to ensure that the samples shipped are not listed as hazardous wastes. If they are, then ReTeC's SOP No. 520 related to sample shipping and handling of hazardous wastes should be followed.

3.0 SUPPORTING MATERIALS

The following general equipment is needed:

1. Common coolers for shipment of analytical samples.
2. Styrofoam or other packing material.
3. Analytical sample bottles with preservatives.
4. Packing tape.
5. DOT approved 5-gallon plastic containers with air tight lids.

4.0 METHODS AND PROCEDURES

Specific methods and procedures related to labeling, packaging, chain-of-custody and laboratory log-in are given in the respective sub-sections.

4.1 Labeling

Samples are identified using standard RETEC sample labels as in Attachment 1. Each label contains information on:

1. Sample identification.
2. Sampling location.
3. Date of collection.
4. Time of day.
5. Identity of sampler.
6. Tests requested (for analytical).
7. Preservatives.

Labels are attached immediately after samples are collected.

Specific to treatability samples, informational labels may be needed to describe the contents of a shipping carton, list any procedures to follow in the event of leakage or an accidental spill, and list person or persons to contact in the event of any leakage or a spill.

4.2 Packaging

Small samples for chemical or physical analysis purposes are packaged in containers suitable for transport (coolers, boxes or transport cartons). Styrofoam or other packing material is used as an insulator/filler to prevent excess movement and breakage of sample bottles. Ice or cold packs are added to keep the shipment cool during transport. All shipping containers are wrapped with a packing tape and secured with a standard RETEC custody seal (see Attachment 1).

Custody seals are used as a quality assurance procedure to prevent tampering during transport. The seals contain information on:

1. The date samples were packaged.
2. The signature of sampler/packer.
3. Seal identification number.

Large samples for treatability testing are packaged in Department of Transportation (D.O.T.) approved 55-gallon drums or 5-gallon buckets. All containers have lockable, airtight seals which prevent accidental spillage during handling and transport. A sample label and custody seal are placed on each container prior to transport.

Samples for analytical water testing are usually collected in designated pre-preserved glass bottles with the specific preservative added dependent upon the particular analytical test requested. Soil and sludge samples generally do not receive such preservative treatment.

A field log notebook is to be kept by the site coordinator and should contain the following information:

1. Sample number.
2. Sampling Location.
3. Sample type.
4. Date and time of sampling.
5. Name of sampler.
6. Visual description of sample.

4.3 Shipping

To comply with designated holding times for analytical testing, samples should be transported from the site to the respective laboratory within a 24-hour period. This can be accomplished by carrying the samples yourself or using an overnight delivery service. Designated holding times vary depending upon the specific analyses to be run and can be obtained from the laboratory performing the analytical testing. Attachment 2 is to accompany all respective samples sent to an analytical laboratory.

For treatability samples, there is no designated holding time. However, samples should be no longer than 4 to 5 days in transit. Soil and sludge samples are not as critical as water samples.

4.4 Chain-of-Custody

All sample containers will be accompanied by RETEC's standard chain-of-custody form as shown in Attachment 3. Procedures used for proper chain-of-custody manifesting of samples include:

1. The sampler will complete the chain-of-custody form which includes:

    a. Sampling location.
    b. Name of sampler.
    c. Sample date and time.
    d. Sample identification number.
    e. Sample descriptions.
    f. Number of containers.
    g. Analysis (if applicable).

2. Upon relinquishing samples to the transporter, the sender will request the courier's signature and the date and time of processing for transport.

3. A copy of each chain-of-custody form will be retained with the field sample book while the original will be sent with the samples.

4. Upon receipt of the samples at the laboratory, the chain-of-custody form will be signed by a person-in-charge along with the date and time sample was received.

5. The original will be retained at the lab with a copy sent to the project manager and/or project engineer.

6. The authority of the chain-of-custody manifest will be relinquished to the quality assurance protocol of the receiving laboratory.

4.5 Log-In

All samples entering the laboratory will be recorded in a log-in book. Information recorded includes:

- assignment of identification number
- sampling personnel
- receiving personnel
- date received
- date sampled
- sample type

- project number
- sample location
- date returned or disposed

Treatability samples are to be placed into a cooler approx. 5°C for preservation until their use. At the conclusion of the project, the remaining sample will be logged out and returned to the client. The date and destination of the samples will be noted in the log-in book.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

With regard to analytical samples, QA/QC is addressed by being aware of the following procedures:

1. Complying with the designated holding times.
2. Using trip blanks to accompany the respective samples.
3. Packaging the samples properly to guard against breakage.
4. Inspection of samples upon receipt to check that they were not tampered with.

QA/QC for treatability samples can be addressed by the following:

1. Using durable sample containers which are air-tight to prevent any leakage or volatile loss.

2. With special reference to water samples, respective samples can be taken for indicator analytical parameters (e.g., pH) just prior to shipment and sampled for these same parameters upon receipt at the laboratory as a check that the quality did not significantly change in transit. It is more difficult to perform such a check with regard to soil and sludge samples due to their heterogeneous nature.

6.0 HEALTH AND SAFETY

During packaging of samples, the field coordinator should check to ensure that all field personnel are taking proper measures by wearing, at a minimum, gloves and safety glasses; and if warranted, more protection such as a dust mask or a vapor face mask. Care should be taken to ensure the integrity of the samples during shipment, particularly against leakage or breakage.

A meeting should be held between the project manager and/or the project engineer and the field personnel to discuss all related health and safety issues associated with sample handling and shipment.

Upon receipt of the samples at the designated laboratory, the respective sample containers should be opened under a fume hood with personnel wearing proper protective clothing. There is a possibility that gases could have built up in concentration during shipment.

7.0 DOCUMENTATION

Proper documentation for this SOP includes:

1. Filling out all previously described field books and shipping labels.
2. Attaching any informational sheets to samples.
3. A properly executed chain-of-custody form.

All related documentation will be retained in the laboratory project file during testing and in the office central file once the overall project is completed.

ATTACHMENT 1

REIEC
REMEDIATION TECHNOLOGIES INC

22419 72nd Avenue S.
Kent, Washington 98032
(206) 872-0247

SAMPLE I.D. _____

LOCATION _____

DATE _____ TIME _____

SAMPLED BY _____

TEST(S) _____

_____

PRESERVATIVE _____

FILTER YES NO

CUSTODY SEAL

DATE _____

SIGNATURE _____

SEAL NO. _____

REIEC
REMEDIATION TECHNOLOGIES INC

22419 72nd Avenue S.
Kent, Washington 98032
(206) 872-0247

ATTACHMENT 2

RETEC

PITTSBURGH TREATABILITY LABORATORY

ANALYTICAL REQUEST SHEET

PROJECT CONTACT: _____

ADDRESS: Remediation Technologies, Inc.
3040 William Pitt Way
Pittsburgh, PA 15238

RETEC PHONE NO.: (412) 826-3340

ANALYTICAL LAB: _____

DATE SUBMITTED: _____

DATE RESULTS DUE: _____

PURCHASE ORDER NO.: _____

PROJECT NO.: _____

SAMPLE ID	NO. OF SAMPLE CONTAIN.	MATRIX	PARAMETERS	METHOD REQUIRED	MINIMUM DETECTION LIMIT

SPECIAL INSTRUCTIONS: _____

№

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME
SAMPLERS: (Signature)	

SAMPLE NO.	DATE	TIME	SAMPLE LOCATION	NO. OF CON-TAINERS							REMARKS

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	**Date / Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date / Time**	**Received by: (Signature)**
Relinquished by: (Signature)	**Date / Time**	**Received for Laboratory by: (Signature)**	**Date / Time**		

REMARKS:

REIEC
REMEDIATION TECHNOLOGIES INC

REMEDIATION TECHNOLOGIES
22419 72nd Avenue South
Kent, Washington 98032
(206) 872-0247

ATTACHMENT 3

APPENDIX D

ST. LOUIS PARK TREATABILITY STUDY

CALGON'S ACT EVALUATION REPORT

- THREE WELL COMPOSITE SAMPLE - W23/W420/W421

APPENDIX D

ST. LOUIS PARK TREATABILITY STUDY

CALGON'S ACT EVALUATION REPORT

- **THREE WELL COMPOSITE SAMPLE - W23/W420/W421**

CALGON CARBON CORPORATION

Technical Service Report No. 1288-26

Accelerated Column Test for Removal of Napthalene from Groundwater

Prepared for:

RETEC
Pittsburgh, PA

Author: T. P. Hartig
T. P. Hartig 6630

Date: May 3, 1989

INTRODUCTION

RETEC is involved in a groundwater remediation project in Minnesota. A sample of the contaminated water was shipped to CCC for a phenol and napthalene removal ACT.

SUMMARY AND CONCLUSIONS

An ACT simulating a dual Model 7.5 with 20,000 lbs of F-300 at 80 gpm was run for napthalene removal.

- The napthalene concentration in the filtered feed water was <1 ppb.
- The ACT simulated 39.354 MM gallons treated and 343.3 days on-line without napthalene breakthrough.

DISCUSSION

The remediation site is a former tar and chemical works in Minnesota. Removal of polynuclear aromatic compounds and phenol from the groundwater is the object of this phase of the project.

CCC received three 5-gallon plastic buckets of the groundwater for the study. An iron/solids removal pretreatment process had reportedly been applied to this water. However, the samples contained a large amount of suspended solids, which resembled iron floc. A pressure filtration step was employed to remove this floc and to preserve the semi-volatile napthalene contaminant.

GC analysis of a decant of the unfiltered sample showed approximately 80 ppb of napthalene and no detectable phenol. After the pressure filtration step, which used a 1 micron filter cartridge, the napthalene level was <1 ppb. This reduction was due to the affinity of the solids that are trapped on the filter cartridge for the napthalene. Previous studies of P. A. Reiser have demonstrated this phenomena. She performed solvent extraction on the filter media and the retained solids. Large quantities of napthalene were recovered.

The ACT was designed to simulate two Model 7.5 vessels in series, with a total of 20,000 lbs of F-300 carbon. The simulated operating conditions were 80 gpm flow rate, 1.8 gpm/ft^2 surface loading rate, and 56 minutes contact time.

A large effluent composite sample was collected for shipment to RETEC's contract laboratory for PNA, GC/MS, phenol, and metals analyses. The volume requirement necessitated a large simulation "window". The sample represents 168 simulated days, 19.233 MM simulated gallons, and 1.04 #/1000 gallons use rate.

The study was run until depletion of feed. At that point, 343.3 simulated days, 39.354 MM simulated gallons, and 0.5#/1000 gallon use rate, the column effluent still showed no detectable napthalene. The carbon loading at termination was 0.0164 mg napthalene/g carbon.

The column effluent samples were collected in septum top vials to prevent volatilization of the napthalene during the ACT run. Napthalene analysis was performed by EPA method 503.1, purge and trap with F.I.D.

/njt

APPENDIX E

PRIORITY POLLUTANT RESULTS

- TABLE E-1 - VOLATILES
- TABLE E-2 - SEMI-VOLATILES
- TABLE E-3 - PESTICIDES
- TABLE E-4 - METALS
- TABLE E-5 - MISCELLANEOUS

TABLE E-1

VOLATILES

PARAMETER	WEEK 1 INFLUENT	WEEK 1 EFFLUENT	WEEK 13 INFLUENT	WEEK 13 EFFLUENT
VOLATILES (ug/L)				
Chloromethane	< 10	< 10	< 10	< 10
Bromomethane	< 10	< 10	< 10	< 10
Vinyl Chloride	31	< 10	13	< 10
Chloroethane	< 10	< 10	< 10	< 10
Methylene chloride	17	15	< 5	< 5
Trichlorofluoromethane	< 10	< 10	< 10	< 10
1,1-Dichloroethene	< 5	< 5	< 5	< 5
1,1-Dichloroethane	< 5	< 5	< 5	< 5
trans-1,2-Dichloroethene	40	< 5	25	< 5
Chloroform	< 5	< 5	< 5	< 5
1,2-Dichloroethane	< 5	< 5	< 5	< 5
1,1,1-Trichloroethane	< 5	< 5	< 5	< 5
Carbon Tetrachloride	< 5	< 5	< 5	< 5
Bromodichloromethane	< 5	< 5	< 5	< 5
1,2-Dichloropropane	< 5	< 5	< 5	< 5
cis-1,3-Dichloropropene	< 5	< 5	< 5	< 5
Trichloroethene	110	< 5	83	< 5
Benzene	97	< 5	100	< 5
Dibromochloromethane	< 5	< 5	< 5	< 5
1,1,2-Trichloroethane	< 5	< 5	< 5	< 5
trans-1,3-Dichloropropene	< 5	< 5	< 5	< 5
2-Chloroethylvinyl ether	< 10	< 10	< 10	< 10
Bromoform	< 5	< 5	< 5	< 5
1,1,2,2-Tetrachloroethane	< 5	< 5	< 5	< 5
Tetrachloroethene	57	< 5	25	< 5
Toluene	11	< 5	12	< 5
Chlorobenzene	< 5	< 5	< 5	< 5
Ethyl benzene	79	< 5	92	< 5

TABLE E-2

SEMI-VOLATILES

PARAMETER	WEEK 1 INFLUENT	WEEK 1 EFFLUENT	WEEK 13 INFLUENT	WEEK 13 EFFLUENT
SEMI-VOLATILES (ug/L)				
1,3-Dichlorobenzene	< 10	< 20	< 20	< 20
1,4-Dichlorobenzene	< 10	< 20	< 20	< 20
Hexachloroethane	< 10	< 20	< 20	< 20
Bis(2-chloroethyl) ether	< 10	< 20	< 20	< 20
1,2-Dichlorobenzene	< 10	< 20	< 20	< 20
Bis(2-chloroisopropyl) ether	< 10	< 20	< 20	< 20
N-Nitrosodi-n-propylamine	< 10	< 20	< 20	< 20
Nitrobenzene	< 10	< 20	< 20	< 20
Hexachlorobutadiene	< 10	< 20	< 20	< 20
1,2,4-Trichlorobenzene	< 10	< 20	< 20	< 20
Isophorone	< 10	< 20	< 20	< 20
Naphthalene	470	< 20	1900	< 20
Bis(2-chloroethoxy) methane	< 10	< 20	< 20	< 20
Hexachlorocyclopentadiene	< 10	< 20	< 20	< 20
2-Chloronaphthalene	< 10	< 20	< 20	< 20
Acenaphthylene	< 10	< 20	< 20	< 20
Acenaphthene	< 10	< 20	< 20	< 20
Dimethyl phthalate	35	< 20	< 20	< 20
2,6-Dinitrotoluene	< 10	< 20	< 20	< 20
Fluorene	12	< 20	21	< 20
4-Chlorophenyl phenyl ether	< 10	< 20	< 20	< 20
2,4-Dinitrotoluene	< 10	< 20	< 20	< 20
Diethylphthalate	< 10	< 20	< 20	< 20
N-Nitrosodiphenylamine	< 10	< 20	< 20	< 20
Hexachlorobenzene	< 10	< 20	< 20	< 20
4-Bromophenyl phenyl ether	< 10	< 20	< 20	< 20
Phenanthrene	< 10	< 20	< 20	< 20
Anthracene	< 10	< 20	< 20	< 20
Fluoranthene	< 10	< 20	< 20	< 20
Pyrene	< 10	< 20	< 20	< 20
Benzidine	< 10	< 200	< 200	< 200
Butyl benzyl phthalate	< 10	< 20	< 20	< 20
Bis(2-ethylhexyl) phthalate	< 10	< 20	< 20	120
Chrysene	< 10	< 20	< 20	< 20
Benzo(a)anthracene	< 10	< 20	< 20	< 20

TABLE E-2 cont.

SEMI-VOLATILES

PARAMETER	WEEK 1 INFLUENT	WEEK 1 EFFLUENT	WEEK 13 INFLUENT	WEEK 13 EFFLUENT
SEMI-VOLATILES (ug/L)				
3,3'-Dichlorobenzidine	< 10	< 40	< 40	< 40
Di-n-octyl phthalate	< 10	< 20	< 20	< 20
Benzo(b)fluoranthene	< 10	< 20	< 20	< 20
Benzo(k)fluoranthene	< 10	< 20	< 20	< 20
Benzo(a)pyrene	< 10	< 20	< 20	< 20
Indeno(1,2,3-c,d)pyrene	< 10	< 20	< 20	< 20
Dibenzo(a,h)anthracene	< 10	< 20	< 20	< 20
Benzo(ghi)perylene	< 10	< 20	< 20	< 20
N-Nitrosodimethylamine	< 10	< 20	< 20	< 20
2-Chlorophenol	< 10	< 20	< 20	< 20
2,4-Dichlorophenol	< 10	< 20	< 20	< 20
2,4-Dimethylphenol	< 10	< 20	30	< 20
4,6-Dinitro-2-methylphenol	< 10	< 100	< 100	< 100
2,4-Dinitrophenol	< 10	< 100	< 100	< 100
2-Nitrophenol	< 10	< 20	< 20	< 20
4-Nitrophenol	< 10	< 100	< 100	< 100
4-Chloro-3-methylphenol	< 10	< 20	< 20	< 20
Pentachlorophenol	< 10	< 100	< 100	< 100
Phenol	< 10	< 20	< 20	< 20
2,4,6-Trichlorophenol	< 10	< 20	< 20	< 20
Di-n-butyl phthalate	< 10	< 20	< 20	< 20
1,2-Diphenylhydrazine	< 10	< 20	< 20	< 20

TABLE E-3

PESTICIDES

PARAMETER	WEEK 1 INFLUENT	WEEK 1 EFFLUENT	WEEK 13 INFLUENT	WEEK 13 EFFLUENT
PESTICIDES (ug/L)				
a-BHC	< 0.5	< 0.05	< 0.05	< 0.05
g-BHC	< 0.5	< 0.05	< 0.05	< 0.05
b-BHC	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor	< 0.05	< 0.05	< 0.05	< 0.05
d-BHC	< 0.05	< 0.05	< 0.05	< 0.05
Aldrin	< 0.05	< 0.05	< 0.05	< 0.05
Heptachlor epoxide	< 0.05	< 0.05	< 0.05	< 0.05
Endosulfan I	< 0.05	< 0.05	< 0.05	< 0.05
4,4'-DDE	< 0.1	< 0.1	< 0.1	< 0.1
Dieldrin	< 0.1	< 0.1	< 0.1	< 0.1
Endrin	< 0.1	< 0.1	< 1	< 0.1
4,4'-DDD	< 0.1	< 0.1	< 1	< 0.1
Endosulfan II	< 0.1	< 0.1	< 1	< 0.1
4,4'-DDT	< 0.1	< 0.1	< 1	< 0.1
Endrin aldehyde	< 0.1	< 0.1	< 0.1	< 0.1
Endosulfan sulfate	< 0.1	< 0.1	< 0.1	< 0.1
Methoxychlor	< 0.5	< 0.5	< 0.5	< 0.5
Chlordane	< 0.5	< 0.5	< 0.5	< 0.5
Toxaphene	< 1	< 1	< 1	< 1
PCB-1016	< 0.5	< 0.5	< 0.5	< 0.5
PCB-1221	< 0.5	< 0.5	< 0.5	< 0.5
PCB-1232	< 0.5	< 0.5	< 0.5	< 0.5
PCB-1242	< 0.5	< 0.5	< 0.5	< 0.5
PCB-1248	< 0.5	< 0.5	< 0.5	< 0.5
PCB-1254	< 1	< 1	< 1	< 1
PCB-1260	< 1	< 1	< 1	< 1

TABLE E-4

METALS

PARAMETER	WEEK 1		WEEK 13	
	INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
METALS (mg/L):				
Silver	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic	< 0.010	< 0.010	< 0.010	< 0.010
Beryllium	< 0.005	< 0.005	< 0.005	< 0.005
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005
Chromium	< 0.010	< 0.010	< 0.010	< 0.010
Copper	< 0.025	< 0.025	< 0.025	< 0.025
Iron	1.840	< 0.100	1.080	< 0.100
Dissolved Iron	< 0.100	< 0.100	0.010	< 0.100
Manganese	0.374	0.034	0.374	0.691
Nickel	< 0.040	< 0.040	< 0.040	< 0.040
Lead	< 0.010	< 0.010	< 0.010	< 0.010
Antimony	< 0.060	< 0.060	< 0.060	< 0.060
Selenium	< 0.005	< 0.005	< 0.005	< 0.005
Thallium	< 0.010	< 0.010	< 0.010	< 0.010
Zinc	0.085	< 0.020	0.083	0.031

TABLE E-5

MISCELLANEOUS

PARAMETER	WEEK 1		WEEK 13	
	INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
MISCELLANEOUS (mg/L):				
Phenolics (4-AAP)	0.074	< 0.005	0.124	0.012

ATTACHMENT C

ENGINEERING EVALUATION REPORT FOR TREATMENT OF PUMPED GROUNDWATERS AT ST. LOUIS PARK, MINNESOTA

ENGINEERING EVALUATION REPORT

FOR TREATMENT OF PUMPED GROUNDWATERS

AT ST. LOUIS PARK, MINNESOTA

Prepared For:

REILLY INDUSTRIES, INC.
1500 South Tibbs Avenue
Indianapolis, IN 46421

Prepared By:

REMEDIATION TECHNOLOGIES, INC.
3040 William Pitt Way
Pittsburgh, PA 15238

ReTeC Project No. E90-352-300

MARCH, 1990

TABLE OF CONTENTS

NO.	DESCRIPTION	PAGE
	EXECUTIVE SUMMARY	v
1.0	INTRODUCTION	1
2.0	BACKGROUND	3
	2.1 Site Conditions	3
	2.2 Preliminary Engineering Evaluation	14
	2.3 Treatability Testing	14
	2.4 Schedule of Compliance Event	16
3.0	ENGINEERING DESIGN BASIS	19
	3.1 Flowrates	19
	3.2 Chemicals-of-Interest Concentrations	22
	3.3 Chemical Oxidation/Sand Filtration Pretreatment	22
	3.4 Activated Carbon Column Treatment	25
4.0	TREATMENT SYSTEM DESCRIPTION	31
	4.1 General Description	31
	4.2 Major Equipment Items	34
	4.3 Building Requirements	36
5.0	OPERATIONAL AND PERMIT MONITORING CONSIDERATIONS	38
	5.1 Operational Monitoring	38
	DynaSand Filter Process	40
	Activated Carbon Treatment Process	41
	5.2 Permit Monitoring	41
	DynaSand Filter Process	42
	Activated Carbon Treatment Process	45
REFERENCES		48
APPENDIX A	- Flow and Water Quality Data for Wells W23/W420/W421 Based on Quarterly Monitoring	

TABLE OF CONTENTS
(Continued)

APPENDIX B	-	Applicable St. Louis Park Treatability Study Summary Tables
APPENDIX C	-	DynaSand Filter Pilot-Scale Test Report
APPENDIX D	-	Manufacturers' Information on Selected Equipment Items

LIST OF TABLES

NO.	DESCRIPTION	PAGE
2-1	Summary of Source and Gradient Control Well Characteristics	4
2-2	Anticipated NPDES Discharge Requirements	5
2-3	Chemicals-of-Interest With Respective Values for W23, W420 and W421	7
2-4	Schedule of Compliance Events	17
3-1	Design Flowrates	20
3-2	Summary of Engineering Design Chemicals-of-Interest Concentrations	23
3-3	Engineering Design Basis for Chemical Oxidation/Sand Filtration	24
3-4	Engineering Design Basis for Activated Carbon Column Treatment	26
4-1	Summary of Major Equipment and Utility Requirements	35
5-1	Proposed Operational Monitoring Frequency Summary	39
5-2	Proposed Discharge Monitoring Frequency Summary	43
5-3	Measured Sand Filter Backwash Water Quality	44
5-4	Measured Carbon Column Process Effluent Quality	46

LIST OF FIGURES

NO.	DESCRIPTION	PAGE
2-1	Well Locations - W23, W420 & W421	8
2-2	Total Potentially Carcinogenic PAHs -vs- Cumulative Pumpage	9
2-3	Total Other PAHs -vs- Cumulative Pumpage	10
2-4	Naphthalene -vs- Cumulative Pumpage	11
2-5	Phenolics -vs- Cumulative Pumpage	12
3-1	Graphical Presentation of Well Discharge Flowrates	21
4-1	Full-Scale Treatment System Conceptual Schematic	32
4-2	Suggested Plant Layout	37

EXECUTIVE SUMMARY

Reilly Industries, Inc (Reilly) contracted with Remediation Technologies, Inc. (ReTeC) of Pittsburgh, PA to perform an engineering evaluation of alternative treatment systems for pumped groundwaters at its former wood treating and coal tar refining site located in St. Louis Park, Minnesota, which is a Superfund site. A Remedial Action Plan (RAP) embodied within a Consent Decree among Reilly, the City of St. Louis Park (City), the Minnesota Pollution Control Agency (MPCA) and the U.S. Environmental Protection Agency (U.S. EPA) provides specific requirements for remedial action of site groundwaters.

To comply with the provisions of the RAP in terms of achieving groundwater treatment objectives, ReTeC, using historic groundwater quality data, performed an engineering screening evaluation with biological fluidized bed, ozone/UV, hydrogen peroxide/UV and activated carbon treatment considered as potential options based on technical feasibility. This evaluation focused on: (i) combined treatment of wells W420/W421 with single treatment of well W23, and (ii) combined treatment of all three wells. In terms of both technical and economic considerations (i.e., capital and O&M costs), activated carbon treatment of all three wells combined offered the best alternative.

On this basis, plus the fact that activated carbon treatment is a proven and accepted technology, ReTeC performed treatability testing to provide site specific information related to the technical and economic issues associated with the treatment of the pumped groundwaters via activated carbon treatment. Technical issues related to: (i) the extent to which chemicals-of-interest are removed by the treatment system, (ii) potential operational issues associated with extended treatment, and (iii) the need, if any, for additional controls (i.e., pH control, iron removal, filtration). Economic issues related to engineering design optimization of the treatment system in terms of associated capital and O&M costs. Such information included: (i) representative carbon exhaustion rates, (ii) quantifying required Empty Bed Contact Times, (iii) determining the need for additional controls, and (iv) establishing proper hydraulic loading rates.

This engineering report has been prepared in conjunction with a Treatability Study Report. Based upon the information developed during treatability testing, it was substantiated that a treatment system comprised of pretreatment (i.e, potassium permanganate chemical oxidation and sand filtration to remove associated iron and manganese) followed by activated carbon column treatment represents both a technically feasible and economically efficient solution for the St. Louis Park site groundwaters.

The following report provides the detailed conceptual design which evaluates the information developed and establishes the following design conclusions:

- The treatment system requires a 1200 foot connecting pipe to be installed between the locations of wells W23 and W420/W421.

- A single treatment system will be located at the W420/W421 location.

- The primary components of the treatment system include:

  - A chemical feed system to add potassium permanganate ($KMnO_4$) to the pumped groundwater flow.

  - An in-line static mixer to achieve mixing of the potassium permanganate and the pumped groundwater,

  - A DynaSand model DSF38 continuous backwashing type sand filter, and

  - Two (2) five-thousand pound (5,000 lb) activated carbon columns in-series.

The purpose of the potassium permanganate addition is to chemically oxide reduced iron and manganese species present in the groundwater. This will result in precipitation of the iron and manganese as hydroxides with removal from the groundwaters achieved via sand filtration. The coal-tar related organics (e.g., phenolics and polynuclear aromatic

hydrocarbons) will be removed via activated carbon column treatment. Effluent from the treatment system is expected to meet or exceed all targeted National Pollution Discharge Elimination System (NPDES) criteria. This treated effluent discharge will be routed from the site to Minnehaha Creek via a storm sewer. Sand filter backwash water will be discharged to the Minneapolis/St. Paul Metropolitan sanitary sewer system. The total design flowrate for this treatment system is 140 gpm.

Application for an NPDES permit is being made to the State of Minnesota Pollution Control Agency with both this Engineering Evaluation Report and a related Treatability Study Report being supplied as background and supporting documentation.

Plans are to begin discharging the treated groundwater into Minnehaha Creek in September, 1990. Thus, process design, procurement and construction must begin in the first quarter of 1990, once regulatory approval is granted by the State of Minnesota regarding the conceptual approach.

This report incorporates comments received from the U.S. EPA and the MPCA to a draft report issued in November, 1989.

1.0 INTRODUCTION

Reilly Industries, Inc. (Reilly) has contracted with Remediation Technologies, Inc. (ReTeC) to perform an Engineering Evaluation of Treatment Options for Source Control Well Discharges at a site located in St. Louis Park, Minnesota.

Based upon results of laboratory treatability work and on-site pilot-scale work performed at the St. Louis Park site, it is concluded that a full-scale groundwater treatment system should include pretreatment via chemical oxidation/sand filtration followed by activated carbon column treatment. Furthermore, it is recommended that potassium permanganate ($KMnO_4$) be used as the chemical oxidant. The purpose of the potassium permanganate/sand filtration pretreatment step is to reduce the iron and manganese levels to within anticipated National Pollution Discharge Elimination System (NPDES) limitations (i.e., <1.0 mg/l) and to circumvent plugging of the activated carbon columns needed for subsequent removal of organics (e.g., phenolics and polynuclear aromatic hydrocarbons).

The following Engineering Evaluation Report is based upon treatability and the engineering design work performed to date. This report is issued in conjunction with ReTeC's associated Treatability Study Report [1] and an NPDES Permit Application [2].

Specific areas related to the engineering evaluation of the treatability work performed and design of a full-scale system are addressed in the following sections. Section 2.0 provides background information associated with the project and the site. Section 3.0 provides the engineering design parameters used as a basis for design of the full-scale system. Section 4.0 gives an overview of the process train associated with the full-scale treatment system, including utility and building requirements. Section 5.0 addresses anticipated effluent quality and other associated permitting issues, including recommendations for operational and permit monitoring. Analytical data, statistical summaries, the DynaSand Filter Pilot-Scale test report and specific equipment manufacturers' information are given in the respective Appendices.

This report incorporates comments received from the U.S. EPA and the MPCA on a draft report issued in November, 1989.

2.0 BACKGROUND

This section provides background information related to:

- Site Conditions,
- Preliminary Engineering Evaluation,
- Treatability Testing, and
- Schedule of Compliance Events.

2.1 SITE CONDITIONS

In accordance with various remedial action requirements for its former wood treating and coal tar refining plant site located in St. Louis Park, Minnesota, Reilly installed a series of five different source and gradient control wells in 1987. Relevant characteristics of the wells, designated as W23, W105, W420, W421 and W422, are summarized in Table 2-1.

Installation of the wells was specified under the terms of a Remedial Action Plan (RAP) embodied in a Consent Decree between Reilly, the City of St. Louis Park (City), the Minnesota Pollution Control Agency (MPCA) and the United States Environmental Protection Agency (U.S. EPA). These wells, operated by the City, currently discharge to sanitary sewers. As part of a separate arrangement between Reilly and the City that is part of the Consent Decree, Reilly must, by September 1990, provide treatment to permit discharge to storm sewers. These waters will ultimately discharge into Minnehaha Creek, and as such, will require an NPDES discharge permit. The RAP requires that the MPCA draft the necessary NPDES permit using the anticipated NPDES limits given in Table 2-2. At this time, it appears that W105 will not require treatment since its' discharge meets both the cessation criteria established by the RAP and the anticipated

TABLE 2-1

SUMMARY OF SOURCE AND GRADIENT CONTROL WELL CHARACTERISTICS

CHARACTERISTICS	W23	W105	W420 [c]	W421 [c]	W422
AQUIFER PUMPED [a]	Prairie du Chein/ Jordan	Ironton/ Gainesville	Drift	Platteville	Drift
RAP REQUIRED PUMPING RATE (gpm)	50	25	40	25	50
DESIGN PUMPING RATE (gpm)	60	NA	50	30	NA
START UP DATE	11/5/87	11/5/87	1/11/88	1/11/88	1/11/88
TOTAL PAH CONC. (ug/l) [b]	190	2.4	3,800	840	56
PHENOLICS (4AAP) (ug/l) [b]	10	< 10	330	< 50	10

NOTES:

[a] - The Drift is the surficial aquifer and is connected hydraulically to the underlying Platteville. The Ironton/Gainesville and Prairie du Chein/Jordan are deep, confined bedrock aquifers.

[b] -Averages bBased on available sample results through October 1988.

[c] - These wells are located next to each other and share a common discharge line to the sewer.

< - Designates below limit of detection.

NA - Not Applicable.

TABLE 2-2

ANTICIPATED NPDES DISCHARGE REQUIREMENTS

PARAMETER	DAILY MAXIMUM CONCENTRATION	30-DAY AVERAGE CONCENTRATION[b]
Total Potentially Carcinogenic PAHs (μg/L)[a]	NA	0.31 (0.07)[c]
Total Other PAHs (μg/L)[a]	34	17
Phenanthrene (μg/L)	2	1
Phenolics (4-AAP) (μg/L)	NA	10

NOTES:

NA - Not Applicable
[a] - See Table 2-3 for list of respective individual PAHs.
[b] - Yearly quarterly monitoring may be used in place of the 30-day average.
[c] - Per MPCA comments to draft Engineering Report on December 19, 1989 letter.

NPDES limits given in Table 2-2 [3]. Reilly does not intend to pursue treatment of W422 at the present time as this will be addressed by the City in conjunction with the City's operation and discharge of the adjacent St. Peter aquifer source control well W410. Therefore, the engineering evaluation is limited to wells W23, W420 & W421. As illustrated in Figure 2-1, well W23 is located on Louisiana Avenue in a pump house along the edge of an open park. Wells W420 & W421 are located in a pump house located in a light industrial area, approximately 1200 feet south of well W23, at the intersection of Louisiana Avenue and West Lake Street.

These three source wells have been pumping for approximately 2 years and their chemicals-of-interest concentrations have varied over this time period. Table 2-3 gives the targeted NPDES permit limits along with the average concentrations of the respective parameters for wells W23, W420, and W421. The specific PAH compounds listed are presently being monitored by the City in the three well discharges on a quarterly basis. This list of specific PAHs is referred to as the St. Louis Park - Polynuclear Aromatic Hydrocarbons (SLP-PAH) list; which is specified in the RAP. The values given in Table 2-3 are computed from monitoring data from 1987 through June, 1989, as given in Appendix A. The average values indicate the mean values for all detectable quantities measured. The Lower 95% Confidence Interval Limit (L95%) and the Upper 95% Confidence Interval Limit (U95%) identify a range within which there exists a 95% probability that the true mean will fall assuming a normal distribution of the data. Specific discussions of this statistical methodology are provided elsewhere [4].

Figures 2-2 through 2-5 provide graphical presentations of the quarterly well monitoring data for selected chemicals-of-interest as a function of cumulative pumpage. These figures respectively depict detectable concentrations for Total Potentially Carcinogenic PAHs, Total Other PAHs, naphthalene and phenolics. These parameters, with the exception of naphthalene, were selected based on their application to NPDES permitting issues. Naphthalene was graphically presented because it generally represents the largest percentage of the total PAH concentrations measured in the well discharges, and also because it is the parameter which will be one of the more important chemicals in determining carbon exhaustion for the full-scale treatment system, with phenolics being another possibility.

TABLE 2-3

CHEMICALS-OF-INTEREST WITH RESPECTIVE VALUES FOR W23, W420 AND W421

PARAMETER	TARGET NPDES DISCHARGE CONCENTRATIONS		PRAIRIE DU CHEIN/JORDAN W23 SCW DISCHARGE				DRIFT W420 SCW DISCHARGE				PLATTEVILLE W421 SCW DISCHARGE			
POTENTIALLY CARCINOGENIC (P.C.) PAH (ug/L)	DAILY MAX.	30 DAY AVG.[a]	#	AVG.	L95%	U95%	#	AVG.	L95%	U95%	#	AVG.	L95%	U95%
Quinoline			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Benzo(a)anthracene			1	0.235	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Chrysene			1	0.283	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Benzofluoranthenes			1	0.024	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Benzo(a)pyrene			1	0.028	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
Indeno(1,2,3-cd)pyrene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Dibenzo(a,h)anthracene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Benzo(ghi)perylene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Total Detectable P.C. PAH	NA	0.31 (0.07)[b]	1	0.570	NA*	NA*	0	ND	ND	ND	0	ND	ND	ND
OTHER PAH (ug/L)														
2,3-Benzofuran			4	6.5	0.0	13.6	7	41.8	19.8	63.8	4	2.6	0.3	4.8
2,3-Dyhydroindene			9	22.5	10.9	34.2	8	127.3	89.4	165.1	8	128.0	100.0	156.0
Indene			9	18.3	0.1	36.5	8	203.6	113.2	294.0	8	86.0	64.0	108.0
Naphthalene			10	66.1	23.2	109.0	9	1661.8	1034.6	2288.9	9	500.4	410.2	590.7
Benzo(b)thiophene			9	11.7	3.1	20.3	7	112.3	67.8	156.8	7	63.6	50.1	77.1
Indole			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
2-Methylnaphthalene			9	14.6	0.0	29.6	7	87.4	37.6	137.3	3	1.9	0.0	3.9
1-Methylnaphthalene			9	20.4	5.9	35.0	7	84.9	50.9	118.8	7	27.3	19.6	35.0
Biphenyl			9	6.2	2.4	9.9	6	18.6	11.7	25.5	3	3.3	1.3	5.4
Acenaphthylene			10	5.1	2.2	7.9	1	61.7	NA*	NA*	1	44.2	NA*	NA*
Acenaphthene			10	20.7	13.1	28.3	8	73.8	51.6	95.9	7	18.1	12.7	23.4
Dibenzofuran			9	10.5	4.3	16.6	7	27.0	18.4	35.6	3	2.9	0.3	5.5
Fluorene			10	14.4	9.6	19.1	8	21.7	14.0	29.4	5	3.7	2.2	5.2
Dibenzothiophene			6	1.4	1.1	1.7	2	1.8	0.0	5.4	1	100.0	NA*	NA*
Phenanthrene	2.0	1.0	10	16.8	10.5	23.0	6	9.8	4.8	14.8	3	1.3	1.1	1.6
Anthracene			10	2.2	1.5	2.9	0	ND	ND	ND	0	ND	ND	ND
Acridine			0	ND	ND	ND	0	ND	ND	ND	2	1.1	0.6	1.5
Carbazole			8	2.9	1.6	4.3	7	47.4	37.5	57.4	7	16.9	12.1	21.6
Fluoranthene			10	5.4	4.1	6.7	0	ND	ND	ND	0	ND	ND	ND
Pyrene			10	4.4	3.5	5.3	0	ND	ND	ND	0	ND	ND	ND
Benzo(e)pyrene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Perylene			0	ND	ND	ND	0	ND	ND	ND	0	ND	ND	ND
Total Detectable Other PAH	34.0	17.0	10	234.6	103.9	365.3	9	2378.3	1480.6	3276.1	9	811.1	661.3	960.8
OTHER PARAMETERS (mg/l)														
Oil & Grease			1	5	NA*	NA*	1	10	NA*	NA*	1	7	NA*	NA*
Phenolics (4-AAP)	NA	0.010	1	0.010	NA*	NA*	8	0.230	0.089	0.370	7	0.037	0.024	0.049
TSS			1	2	NA*	NA*	1	9	NA*	NA*	1	1	NA*	NA*

NOTES: Actual data given in Appendix A

NA* - Not Applicable since parameter was detected in only one sample.

NA - Not Applicable.

ND - Not Detectable.

[a] - Yearly quarterly monitoring may be used in place of the 30 - day average.

[b] - Per MPCA comments to draft Engineering Report in December 19, 1989 letter.

\# - Number of detectable concentrations used to compute respective statistics.

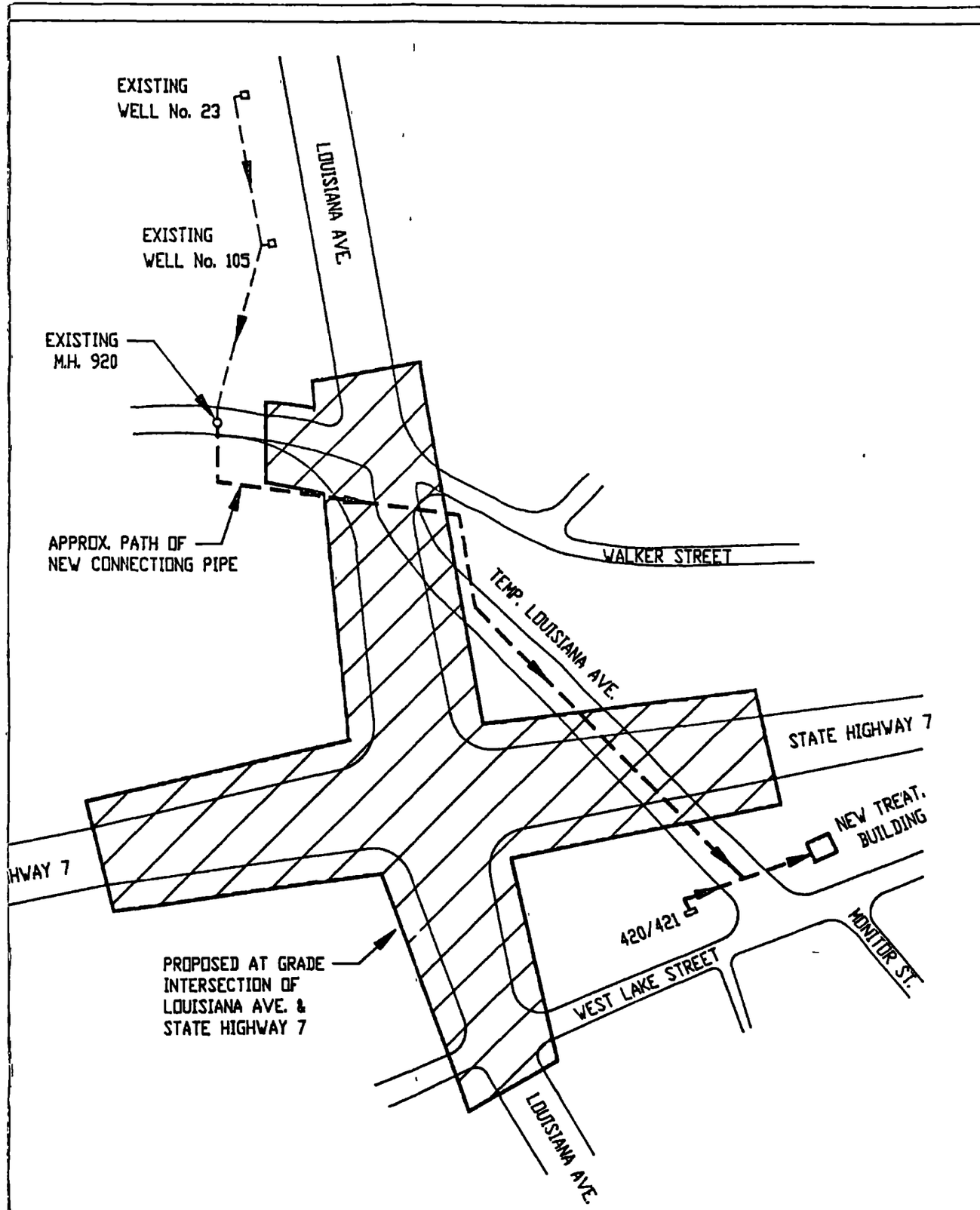
AVG - Average of reported values.

L95% - Lower 95% Confidence Interval Limit.

U95% - Upper 95% Confidence Interval Limit.

FIGURE 2-1

WELL LOCATIONS
W23, W420 AND W421



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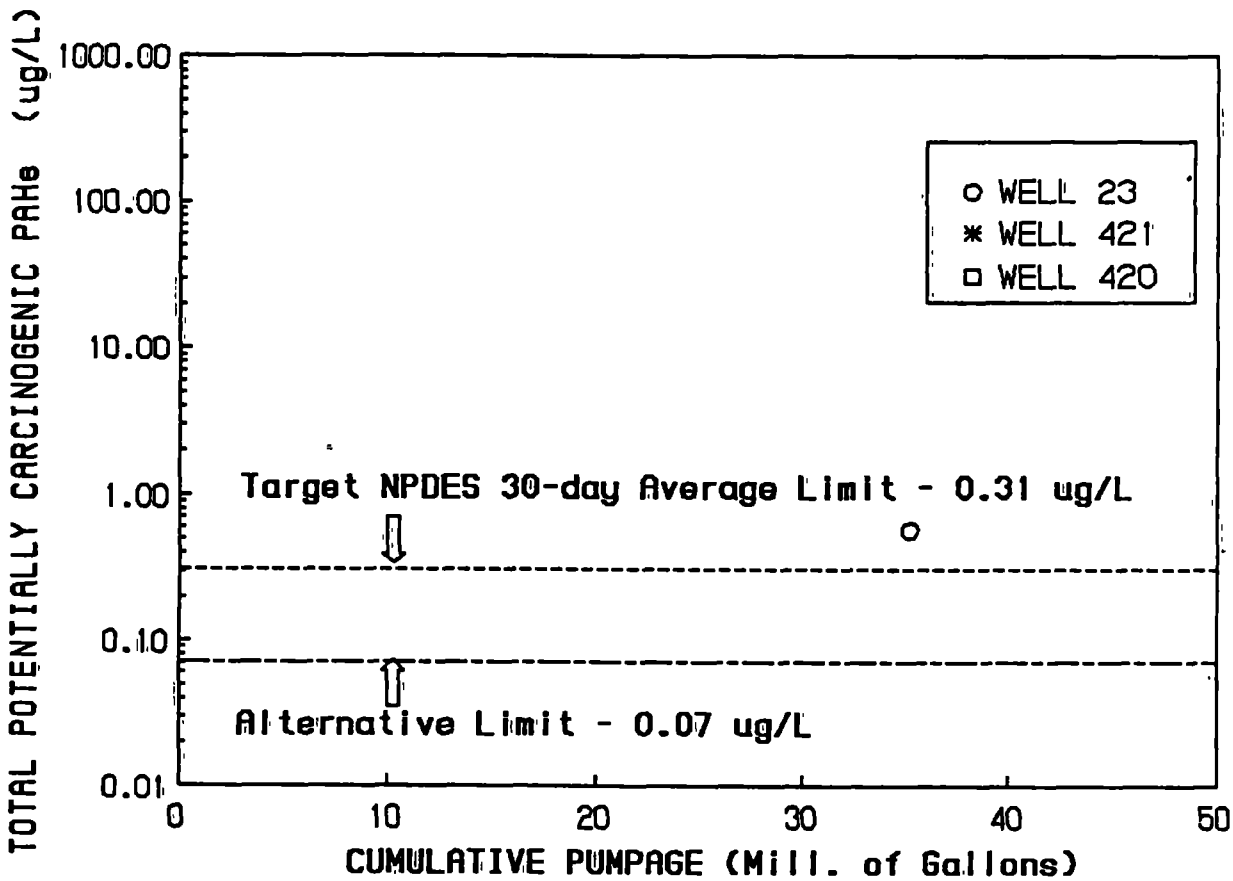
REVISION					
1	WELL LOCATIONS			ReTeC REMEDIATION TECHNOLOGIES INC.	
2	W23, W105, W420 & W421				
3	St. Louis Park, MN				
4					
5					
DRAWN BY	CHECKED BY	DATE	SCALE	DWG. NO.	
L.M.	D.L.M.	11-20-89	1"=200'	189-1004	C

emTech Consultants, Inc.
L.MENEICE 11-16-89

FIGURE 2-2

TOTAL POTENTIALLY CARCINOGENIC PAHs
-VS-
CUMULATIVE PUMPAGE



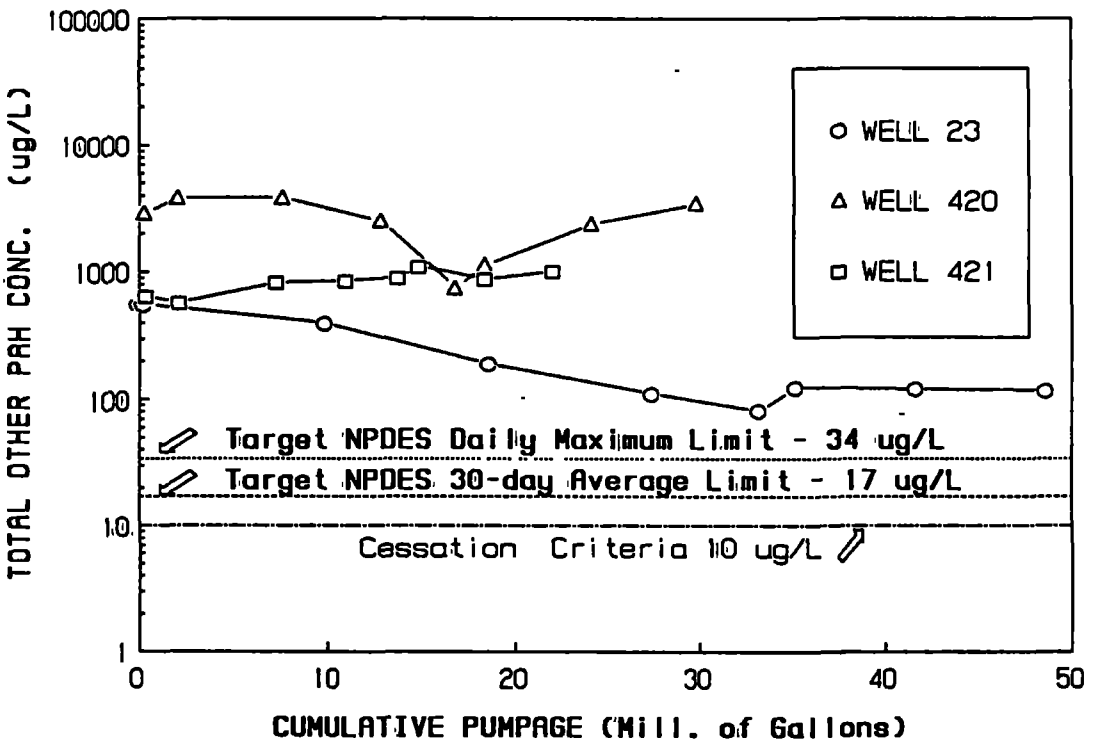
NOTE:

Daily maximum limit is not applicable.

Only one sampling unit where respective concentrations were detected below 1.0 mg/L.

FIGURE 2-3

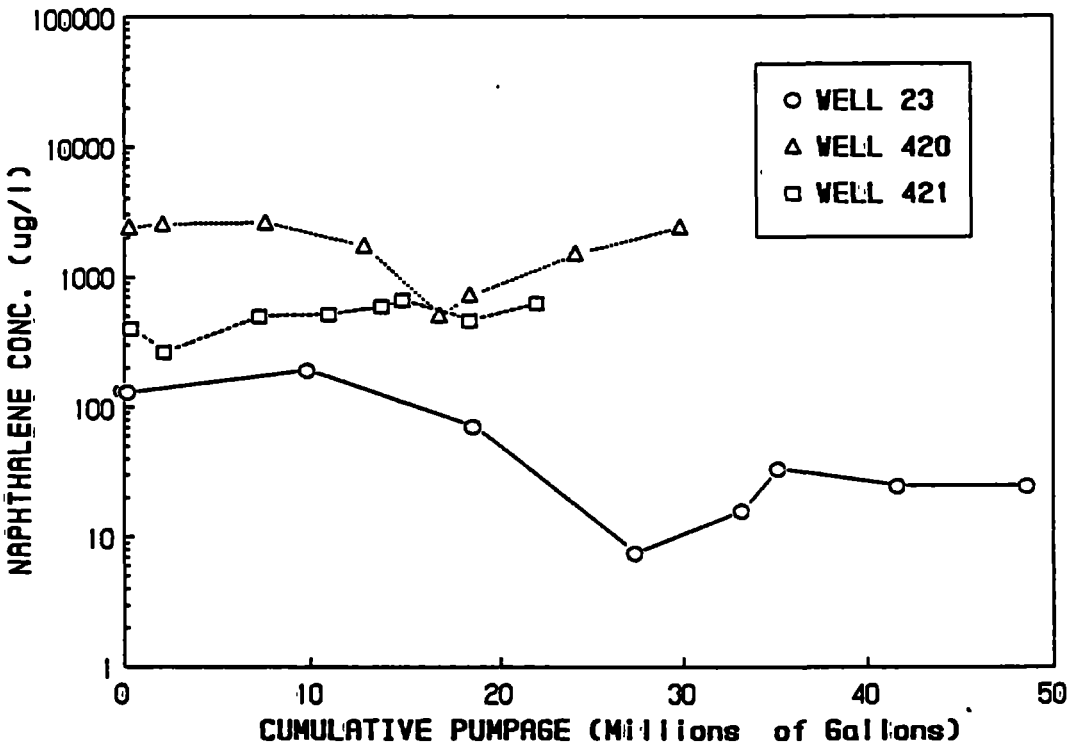
TOTAL OTHER PAHs
-VS-
CUMULATIVE PUMPAGE



NOTE: Only Detectable Concentrations Are Plotted.

FIGURE 2-4

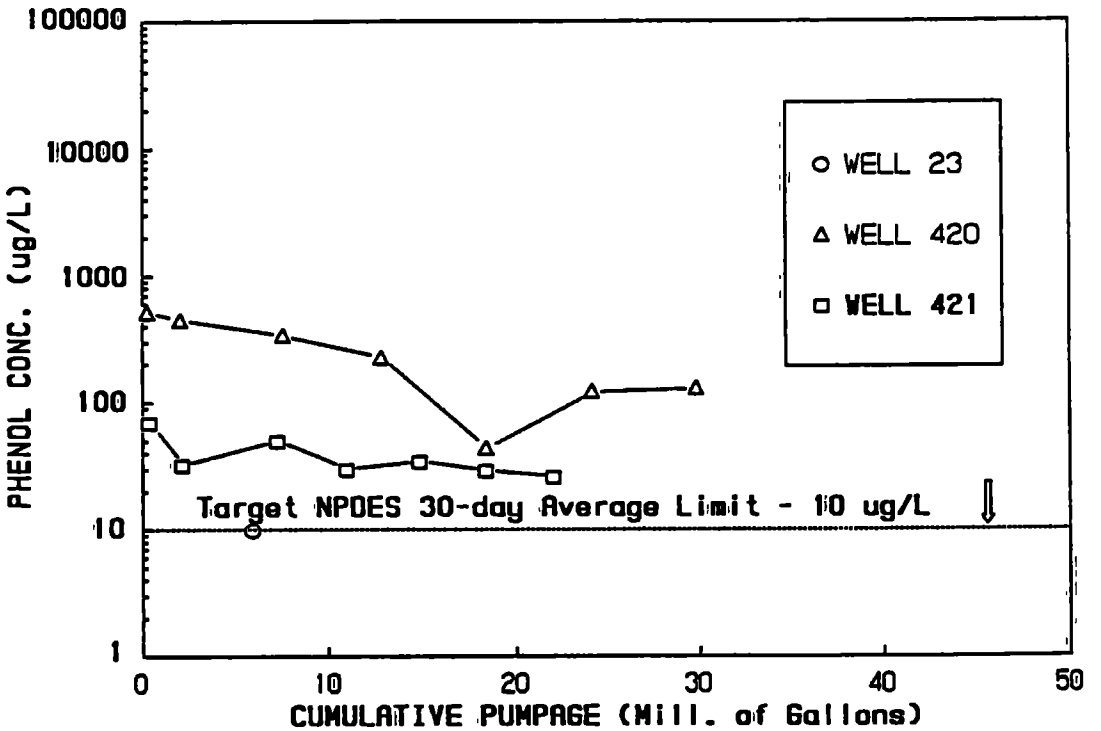
NAPHTHALENE
-VS-
CUMULATIVE PUMPAGE



NOTE: For Purposes of NPDES Discharge Monitoring. Naphthalene is Considered as a Member of the Other PAHs Grouping. Only Detectable Quantities are Plotted.

FIGURE 2-5

PHENOLICS
-VS-
CUMULATIVE PUMPAGE



NOTE: Daily Maximum Limit Is Not Applicable.
Only Detectable Concentrations Are Plotted.

Referring to Figure 2-2, potentially carcinogenic PAHs were not detected in the well discharges at method detection limits (i.e., reporting limits) ranging between 10 to 200 $\mu g/L$; thus, it is not quantifiably known if the anticipated 30-day average target NPDES requirement of 0.31 $\mu g/L$ is exceeded or not. To measure such low concentrations, a method detection limit of 0.01 $\mu g/L$ must be achieved. This is analytically difficult to achieve for the site groundwaters in question given the fact that the groundwaters are relatively contaminated in terms of other PAH parameters. As cited in Figure 2-2, based on quantifiable data, the targeted NPDES requirements of 0.07 or 0.31 $\mu g/L$ were exceeded on only one occasion with Total Potentially Carcinogenic PAHs measured only once at approximately 0.57 $\mu g/L$. As cited in Table A-2 of Appendix A, this sampling event corresponded to PAH analysis by HPLC which was able to detect PAHs at lower quantifiable limits than the GC/MS Selective Ion Method (SIM) routinely used by Rocky Mountain Analytical Laboratories (Arvada, Colorado) as part of the routine monitoring specified by the RAP. The HPLC analysis was performed by Keystone Environmental Resources, Inc. (KER) Laboratory (Monroeville, Pennsylvania) as part of ReTeC's treatability studies. The fact that potentially carcinogenic PAHs were not routinely detected using the GC/MS-SIM method is not an important issue since activated carbon treatment will remove these PAHs to levels below 0.01 $\mu g/L$ detection. As cited later in this report, carbon exhaustion will be determined by Other PAHs (i.e., naphthalene) and phenolics (4-AAP).

In terms of the other parameters, Figures 2-3 through 2-5 illustrate that all three well discharges require treatment. In terms of Total Other PAH and naphthalene, Figures 2-3 and 2-4 indicate steadily declining concentrations in well W23. It is not certain as to when the discharge quality will drop below 10 $\mu g/L$, at which point W23 could be shut down after pumping for at least five years. Contrary to this, Total Other PAH and phenolic concentrations in wells W420 and W421 have remained steady or increased over time, with no indication that they may decline in the near term. As cited in Table A-2 of Appendix A, phenolics were monitored twice in W23 with a detectable quantity measured only once, thus no line plot appears in Figure 2-5 with respect to W23.

These data indicate that the full-scale treatment system design should be capable of treating varying influent organic concentrations from all three wells and be considered as a permanent (a decade or more) installation.

2.2 PRELIMINARY ENGINEERING EVALUATION

Given the preceding design constraints and historic groundwater quality data, ReTeC performed an engineering screening evaluation with biological fluidized bed, ozone/UV, hydrogen peroxide/UV, and activated carbon treatment considered as potential options based on technical feasibility. This evaluation focused on: (i) combined treatment of W420/W421 with single treatment of W23, and (ii) combined treatment of all three wells at the location of W420/W421. In terms of economic considerations (i.e., capital and O&M costs), activated carbon treatment of all three wells combined was selected as the preferred treatment scheme. This report presents the engineering evaluation of a treatment system for the three well discharges combined at the location of wells W420/W421 (shown in Figure 2-1) with a connecting pipe from W23.

2.3 TREATABILITY TESTING

Treatability testing was performed to further evaluate activated carbon column treatment of site groundwaters and provide information to evaluate technical and economic issues. Technical issues relate to: (i) the need for iron and manganese removal via a pretreatment process, (ii) the extent to which site chemicals-of-interest are removed by the treatment system, (iii) potential operational issues associated with extended treatment, and (iv) additional control processes (e.g., pH control and backwash tanks). Economic issues relate to engineering design optimization of the treatment system in terms of associated capital and O&M costs. Such information includes: (i) representative carbon exhaustion rates, (ii) quantifying required Empty Bed Contact Times (EBCT), (iii) quantifying dosages of treatment chemicals if required, and (iv) establishing proper hydraulic loading rates.

To answer these questions, laboratory and on-site pilot-scale testing was performed. The laboratory work was performed from December, 1988 through February, 1989 and focused on further groundwater characterization and pretreatment testing for iron and manganese reduction.

Based on the laboratory testing results, an on-site pilot-scale treatment system was designed, constructed, set up and operated from March 28, 1989 through October 17, 1989. The system consisted of the following sequential components:

- Chemical oxidation with potassium permanganate ($KMnO_4$),
- Anthracite/sand filtration via a downflow packed bed column, and
- Activated carbon column treatment via three in-series downflow packed bed columns.

For practicality and convenience, the on-site pilot-scale work was limited to wells W420 and W421. The pilot unit was located in the pump house at that locale and tested a flow proportioned influent from wells W420 and W421. To incorporate W23 groundwater into the on-site pilot-scale testing would have required water to be transported manually to the location of the pilot unit on a daily or weekly basis. The fact that W23 groundwater was not used is not considered a critical factor since wells W420 and W421 contain basically the same chemicals-of-interest at higher concentrations than W23 (see Figures 2-2 through 2-5).

This contention is also valid in light of the fact that well W23 groundwater analyses (See Table 2-3) did show detectable concentrations (by HPLC) of some individual Potentially Carcinogenic PAHs in the fraction of the part per billion (ppb) level while sample analyses from wells W420 and W421 did not show any detectable concentrations. Regardless of this fact, it is felt that this very low level of Potentially Carcinogenic PAHs will be sufficiently removed by activated carbon treatment when W23 groundwater is treated jointly with groundwaters from wells W420 and W421. Even though groundwater from well W23 was not used in the pilot-scale treatability work, it should be noted that the Potentially Carcinogenic PAHs, which are relatively insoluble compared to the Other PAH compounds, are adsorbed onto carbon to a much greater degree than the Other

PAH compounds measured in wells W420 and W421. This fact is supported by the fact that the existing activated carbon treatment system treating similar site groundwaters from wells W10 and W15 are meeting drinking water criteria with published isotherm data and theory [5]. Such references cite that of the St. Louis Park PAH list, carbon usage will be determined based upon naphthalene adsorption. Naphthalene is the PAH compound present in the highest concentration in all three wells and is also the PAH compound which is expected to first be detected in the carbon column effluent with all of the other PAHs not being detectable. The Potentially Carcinogenic PAHs will be the very last to be detected in the effluent if allowed. However, this is not expected to occur based upon the fact that a particular carbon column will be replaced once it is exhausted for either naphthalene or phenolics, which ever occurs first. Exhaustion is defined as that point during treatment where the effluent concentration equals the influent concentration for a particular parameter. Additionally, once W23 groundwater is added to flows from W420 and W421, the Total Potentially Carcinogenic PAH concentration in the combined flow will be near 0.024 μg/L as cited in the treatability report (Table 4-7) [1]. This is below the anticipated permit requirement range of 0.07 to 0.31 μg/L average. Thus, the fact that W23 groundwater was not used in the pilot work should not be an issue.

The results of the treatability work performed serve as the engineering design basis for the full-scale treatment system presented in the subsequent sections of this report. Specifics of the treatability work performed are documented in an associated treatability report [1].

2.4 SCHEDULE OF COMPLIANCE EVENTS

In order to comply with the provisions of the Reilly/City agreements, a full-scale groundwater treatment system must be operating with an NPDES discharge to Minnehaha Creek by September, 1990. To this end, Reilly contracted ReTeC in November, 1988, to provide assistance in evaluating and designing an appropriate treatment system which would meet the requirements of the RAP. Table 2-4 lists the main events associated with meeting this goal. These events are listed in chronological order and are separated into "completed" and "to be completed" categories.

TABLE 2-4

SCHEDULE OF COMPLIANCE EVENTS

Tasks Completed:

- Reilly Industries awarded contract to ReTeC - 11/88.
- Laboratory work began - 11/88.
- Conceptual design for pilot system completed - 2/89.
- Pilot-Scale Treatability Testing conducted - 3/89 through 10/89.
- Engineering evaluation completed (draft report) - 11/89.
- Permit Application completed and submitted to Reilly for review - 11/89.
- ReTeC field trial work of DynaSand Filter - 10/89.
- Permit Application to be submitted to MPCA - 11/89.
- Final Engineering Evaluation Report - 3/90

Tasks to be Completed:

- Agency's tentative approval of NPDES Permit Application by 3/90.
- Detailed process design/bid package to be completed by 2nd Quarter of 1990.
- Construction during 3rd Quarter of 1990.
- System on line and operating in 4th Quarter of 1990.

As cited, laboratory treatability work was begun immediately, followed by on-site pilot-scale testing which began in March, 1989. With the issuance of the draft of this report, in November, 1989, the engineering evaluation of a full-scale groundwater treatment system was completed. Application for an NPDES permit was made to the MPCA in November, 1989. Construction of a full-scale system is anticipated to begin in the third quarter of 1990 with the system coming on-line in the fourth quarter of 1990.

3.0 ENGINEERING DESIGN BASIS

This section presents the design parameters of the full-scale treatment system in terms of flow rates, chemicals-of-interest concentrations, the chemical oxidation/sand filtration pretreatment process, and the activated carbon column treatment process. The design parameters cited are based upon the results of the treatability work described in the associated treatability report [1] and results of the quarterly well discharge monitoring performed by the City of St. Louis Park.

3.1 FLOWRATES

The design flowrate for all three wells (W23/W420/W421) combined is given at 140 gpm. Respective individual design flowrates are given in Table 3-1 and cite W23 at 60 gpm, W420 at 50 gpm, and W421 at 30 gpm. These design flowrates are higher than the respective values specified in the RAP and very close to, if not greater than, the Upper 95% Confidence Interval Limits (U95%) of the monthly averages computed for the time periods that the three individual wells were pumping. These same conditions also apply to the total design flowrate of 140 gpm. Thus, it is statistically supported that the total design flowrate given represents a conservative value for design purposes, as well as being substantially higher than the total flowrate given in the RAP.

Figure 3-1 plots the monthly averages of the flowrates for the three individual wells and all three combined for the period November, 1987 through September, 1989. Pumping of W23 started in November, 1987, and W420/W421 in January, 1988. As cited, the monthly flowrates for all three individual wells remained relatively constant except for W23 which increased above its design flowrate of 60 gpm to near 70 gpm during July through September, 1988. This resulted in the total flow for all three wells slightly exceeding the design rate of 140 gpm during the same period. Generally speaking, the flowrates from the three wells remained somewhat constant during the pumping period with the total combined flow averaging 127 gpm.

TABLE 3-1

DESIGN FLOWRATES

CONDITION	FLOW RATES (GPM) W23	W420	W421	TOTAL
RAP SPECIFIED	50	40 [a]	25	115
MONTHLY AVG [b]	56	40	31	127
U95% [b]	60	43	34	137
DESIGN	60	50	30	140

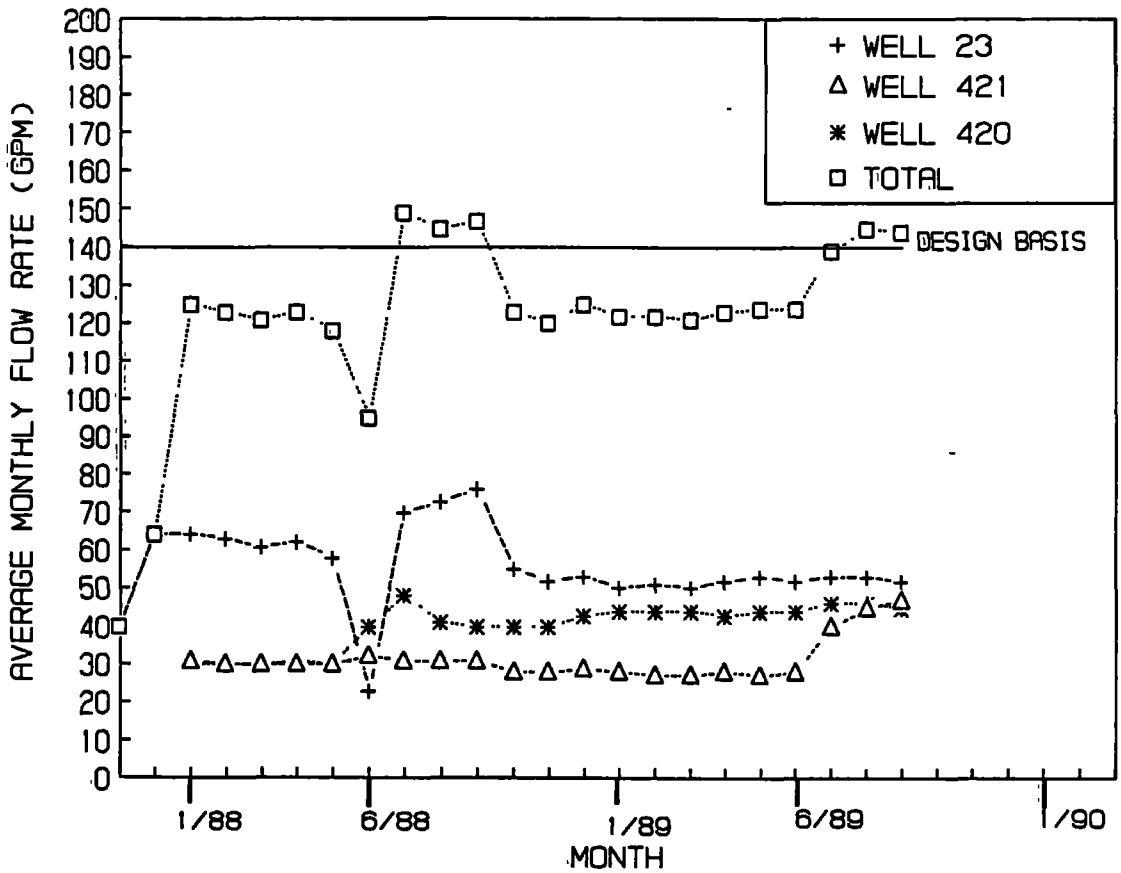
NOTES:

[a] - Per ERT August, 1988 report entitled, "Evaluation Report for Drift Aquifer Source Control Well Pumping Rate" and W.M. Gregg (ENSR) letter of May 22, 1989 to J.N. Grube (SLP), D. Wilson (EPA) and M.K. Vennervity (MCPA).

[b] - Mean and Upper 95% Confidence Interval Limit taken from the Statistical Evaluation of Average Monthly Flow Rates (see Table A-1 in Appendix A).

FIGURE 3-1

GRAPHICAL PRESENTATION OF WELL DISCHARGES FLOWRATES



3.2 CHEMICALS-OF-INTEREST CONCENTRATIONS

Table 3-2 gives the chemicals-of-interest concentrations used in the engineering design of the full-scale treatment system. As cited, the respective data given for the combined flow of W23/W420/W421 are calculated based upon flow-proportioned measured concentrations for W23 and W420/W421. Measured W23 data are taken from both quarterly monitoring results and initial characterization results of the treatability study. Measured W420/W421 data are taken from the on-site pilot-scale treatability work performed. These two well discharges were combined on a flow-proportioned basis for the pilot testing with several data points collected. The values of the upper 95 percent confidence interval limits of the respective averages were used for the design as a conservative approach.

Of the specific parameters cited, naphthalene and phenolics are to be used to estimate carbon exhaustion rates for the full-scale system. Treatability results showed that these two parameters will potentially breakthrough first to the extent that respective targeted NPDES permit limits will be exceeded. This observation is also consistent with published isotherm data [5].

The calculated iron (Fe) and manganese (Mn) values are to be used to estimate $KMnO_4$ requirements in the chemical oxidation/sand filtration pretreatment step of the full-scale system. As cited in Table 3-2, the naphthalene and phenolics statistical values for W420/W421 are from samples taken of the influent to the pilot-scale sand filtration column while the iron and manganese statistical values are from the combined influent flow to the pilot-scale unit prior to $KMnO_4$ addition.

3.3 CHEMICAL OXIDATION/SAND FILTRATION PRETREATMENT

Design parameters for the pretreatment step are cited in Table 3-3 for both the on-site pilot-scale work and the full-scale implementation. Respective treatability study results used are given in Appendix B as taken from the treatability study report [1].

TABLE 3-2

SUMMARY OF ENGINEERING DESIGN CHEMICALS-OF-INTEREST CONCENTRATIONS

PARAMETER	MEASURED W23 [a]	MEASURED W420/W421 [b]	CALCULATED W23/W420/W421 [c]
FLOW RATE (% Total Design Flow)	43	57	100
POTENTIALLY CARCINOGENIC PAH CONCENTRATION (ug/l)	0.570	0.033 [d]	0.263
TOTAL OTHER PAH CONCENTRATION (ug/l)	365.3	849.0 [d]	641.7
NAPHTHALENE CONCENTRATION (ug/l)	109.0	743.0	471.3
PHENOLICS (4-AAP) CONCENTRATION (mg/l)	0.010	0.030	0.021
IRON CONCENTRATION (mg/l)	1.310	2.328	1.892
MANGANESE CONCENTRATION (mg/l)	0.082	0.388	0.257

NOTES:

[a] - W23 measured concentrations given represent Upper 95% Confidence Interval Limit of respective values taken from Table A-2 in Appendix A for all parameters except Iron and Manganese; data (Upper 95% Confidence Interval Limit) for these two parameters were taken from Table B-1 in Appendix B, Treatability Study Results.

[b] - W420/W421 measured concentrations given represent Upper 95% Confidence Interval Limit of respective values taken from Table B-4 in Appendix B, for all parameters except Iron and Manganese; data (Upper 95% Confidence Interval Limit) for these two parameters were taken from Table B-3 in Appendix B, Treatabilty Study Results.

[c] - Calculated values given represent respective flow proportioned concentrations using given values.

[d] - Only detectable SLP list PAHs by HPLC included.

TABLE 3-3

ENGINEERING DESIGN BASIS FOR CHEMICAL OXIDATION/ SAND FILTRATION

PARAMETER	PILOT-SCALE (Measured)	FULL-SCALE (Calculated)
DESIGN FLOW RATE (gpm)	0.1	140
YEARLY FLOW		
(Millions of Gallons)	NA	73.6
INFLUENT IRON CONCENTRATION (mg/L)	1.980 [a]	1.892 [b]
INFLUENT MANGANESE CONCENTRATION (mg/l)	0.370 [a]	0.257 [b]
CHEMICAL OXIDATION		
$KMnO_4$ DOSAGE (Ratio $KMnO_4$:Parameter)		
IRON (c)	1.16:1	1:1
MANGANESE (c)	2.16:1	2:1
$KMnO_4$ DOSAGE (mg/l)		
TOTAL	3.1	2.2
$KMnO_4$ USAGE		
(lbs/1000 gallon)	0.03	0.02
(lbs/day)	NA	4.03
(lbs/year)	NA	1,473

SAND FILTRATION				(DynaSand Filter)
MEDIA TYPE	Anthracite -	0.9 mm E.S. 1.70 U.C.	Sand -	0.9 mm E.S. < 1.5 U.C.
	Sand -	0.48 mm E.S. 1.46 U.C.		
BED DEPTH (inches)	Anthracite -	18	Sand -	80
	Sand -	18		
OPERATION	Downflow		Upflow	
SUPERFICIAL FLOW RATE (gpm/ft^2)		1.15		3 - 5
BACKWASH				
TYPE	Intermittent		Continuous	
RATE (% of Applied Flow)		21.0		5 - 7
CROSS-SECTIONAL AREA (ft^2)		0.09		38.5
DIAMETER (ft)		0.33		7

NOTES:

[a] - Values given are averages obtained from the Treatability Study Results cited in Table B-3 in Appendix B.

[b] - Values given represent respective design values given in Table 3-2.

[c] - Taken from Table B-5 in Appendix B.

With regard to the influent iron and manganese concentrations, it is shown that the average values given for the pilot testing are relatively similar to the estimated full-scale treatment system values. Thus, this fact supports that the pilot-scale treatability results are valid in terms of their being used in the full-scale design.

With regard to chemical oxidation requirements, a $KMnO_4$ chemical oxidation dosage corresponds to a requirement of approximately 0.02 lb./1000 gallons or 4 pounds per day. For sand filtration, specifications of the full-scale system are cited for a Parkson Corporation DynaSand filter. The main differences between the pilot-scale sand filter used and the DynaSand are: (i) the pilot unit used a mixed media of sand and anthracite whereas the DynaSand uses only one media type, and (ii) the DynaSand operates in the upflow mode with continuous backwashing while the pilot unit operated in the gravity downflow mode with daily intermittent backwashing required. Regardless of these differences, it is felt that the DynaSand filter should obtain comparable results in terms of Fe and Mn removal for the reason that the effective size (E.S.) of the media are comparable as well as the superficial flowrate with the DynaSand being a bit higher. Lastly, the amount of continuous backwash water from the DynaSand filter represents a much smaller percentage of the applied flowrate than a conventional downflow type filter with intermittent backwash.

To demonstrate the effectiveness of the DynaSand filter for Fe and Mn removal, a pilot study was conducted at the St. Louis Park site during the time period October 26 through November 6, 1989. Further discussions of the DynaSand filter and the pilot testing performed are given in Section 4.0 with a detailed pilot-scale testing report given as Appendix C.

3.4 ACTIVATED CARBON COLUMN TREATMENT

Design parameters for the activated carbon column treatment process are given in Table 3-4 for both the on-site pilot-scale work performed and the full-scale system design. Respective treatability results used are given in Appendix B as taken from the treatability study report [1].

TABLE 3-4

ENGINEERING DESIGN BASIS FOR ACTIVATED CARBON COLUMN TREATMENT

PARAMETER	PILOT-SCALE (Measured)	FULL-SCALE (Calculated)
DESIGN FLOW RATE		
(gpm)	0.1	140
(ft^3/min)	0.013	18.72
YEARLY FLOW		
(Millions of Gallons)	NA	73.6
INFLUENT PHENOLICS CONCENTRATION (mg/L)	0.022 [a]	0.021 [b]
INFLUENT NAPHTHALENE CONCENTRATION (ug/l)	541 [a]	471.3 [b]
UNIT SIZING CONDITIONS		
MEDIA TYPE	Activated Carbon	Activated Carbon
MESH SIZE	12 x 40	12 x 40
OPERATION	Downflow	Downflow
DENSITY OF CARBON (lbs./ft^3)	27.5	27.5
SIZE SYSTEM (lbs.)	9.4	10,000. [c]
TOTAL BED DEPTH (ft)	10.0	10.0 (5 ft. per column)
DIAMETER (ft)	0.21	6
CROSS-SECTIONAL AREA (ft^2)	0.034	28.3
SUPERFICIAL FLOW RATE (gpm/ft^2)	2.9	4.95
BACKWASH	Intermittent	Intermittent
EMPTY BED CONTACT TIME (minutes)		
CARBON EXHAUSTION (First Column)	7.5 [d]	7.6 [f]
NPDES SAMPLING (Last Column)	25.0 [e]	15.2 [g]
BASIS FOR CARBON USAGE		
PHENOLICS REMOVED (lbs/yr)	NA	12.9
PHENOLICS LOADING [h]		
(lbs/lb Carbon)	0.0018 - 0.0014	0.0018 - 0.0014
(lbs Carbon/1000 gallons)	0.103 - 0.133	0.097 - 0.125
PHENOLICS CARBON USAGE RATE (lbs/yr)	NA	7,166 - 9,213
NAPHTHALENE REMOVED (lbs/yr)	NA	289
NAPHTHALENE LOADING [h]		
(lbs/lb Carbon)	0.047	0.047
(lbs Carbon/1000 gallons)	0.096	0.084
NAPHTHALENE CARBON USAGE RATE (lbs/yr)	NA	6,182

TABLE 3-4

ENGINEERING DESIGN BASIS FOR ACTIVATED CARBON COLUMN TREATMENT

(Continued)

NOTES:

[a] - Values given are averages obtained from the Treatability Study Results cited in Table B-3 in Appendix B.

[b] - Values given represent respective design values given in Table 3-2.

[c] - Represents two (2) 5,000 pound units in series.

[d] - Represents value for Column 1 as shown in Figure B-1 in Appendix B.

[e] - Represents value for Columns 1 through 3 as shown in Figure B-1 in Appendix B.

[f] - Represents value for Column 1 as shown in Figure 4-1.

[g] - Represents value for Columns 1 and 2 as shown in Figure 4-1.

[h] - Taken from Table B-5 in Appendix B.

As with Fe and Mn influent concentrations, the data show that the average influent concentrations given for naphthalene and phenolics for the pilot testing are very similar to the estimated full-scale treatment system design values. Based on treatability study results [1], naphthalene and phenolics are expected to break through first and at basically the same rate, in terms of exceeding respective targeted NPDES permit requirements. On this basis, the carbon exhaustion rates measured for naphthalene and phenolics during the pilot-scale testing are directly applicable to the full-scale system design. As given in Table 3-4, these values are 0.0014-0.0018 lb. phenolics/lb. carbon and 0.047 lb. naphthalene/lb. carbon. Using published isotherm data [5] and the respective pilot-scale influent concentrations given in Table 3-4, the carbon exhaustion rate for phenolics is given at 0.0026 lb. phenolics adsorbed per lb. carbon and 0.102 lb. naphthalene adsorbed per lb. carbon for naphthalene. These empirically computed adsorption rates are just slightly higher than those determined from the pilot-scale testing for the reason that the isotherm data used are based on single solute adsorption with the lower respective pilot-scale results due to competition from other solutes present in the groundwater for available adsorption sites.

Relating the pilot-scale numbers to the respective design influent concentration values gives 0.097-0.125 lb. carbon/1000 gallons treated for phenolics and 0.084 lb. carbon/1000 gallons treated for naphthalene. In terms of strict quantifiable numbers, it is expected that carbon usage will be determined by the lower range for phenolics. However, the respective carbon usage estimate based on naphthalene is too close for a definite determination to be made. Due to the variability associated with the influent concentrations of phenolics and naphthalene (based on treatability and quarterly monitoring results), it can only be estimated that the yearly carbon usage will be somewhere between approximately 6,200 pounds to 9,200 pounds at the specified total design flowrate of 140 gpm.

With regard to unit sizing, three factors need to be considered in determining the appropriate size for the carbon system. These include: (i) an economical carbon exhaustion rate, (ii) maintaining a minimum Empty Bed Contact Time (EBCT) of 15 minutes, and (iii) having a superficial flowrate between 3 to 5 gpm/ft^2. The EBCT is especially critical because it determines the amount of carbon based on flow alone; thus,

it determines the number of in-series columns required. Based on these constraints, it is shown in Table 3-4 that a 10,000 pound (two-5,000 pound units in series) carbon system is adequate at a carbon usage rate of 6,200 to 9,200 pounds per year. With two carbon units in series, carbon utilization efficiency will approach 100%. This is because only the carbon in the lead absorber is replaced and the order of flow between the two columns is switched after each carbon change. The expected operating pattern would be to change the carbon in the lead 5,000 pound carbon unit and switch the flow order on the average of once every 10 months based on a carbon usage rate of 6,200 pounds per year, or once every 6.5 months based on a carbon usage rate of 9,200 pounds per year. With this frequency, adequate timing will be provided to arrange for delivery of fresh carbon, and thus assuring final effluent quality will never exceed the NPDES target limitations.

In practice, a minimum EBCT of no less than 15 minutes is designed into an activated carbon adsorption system. EBCT is determined by calculating the time required to pump an amount of water through an equivalent volume of the carbon. The on-site pilot study demonstrated that a 7.5 minute EBCT for column 1 was capable of adsorbing the chemicals-of-interest at an economically feasible rate. Thus, a design EBCT of 15 minutes yields a conservative design basis. For the full-scale carbon unit specified, the first in series 5,000 pound column will have design EBCT of approximately 7.5 minutes and a total system EBCT of approximately 15 minutes. With both the first in-series pilot-scale column and the first in-series full-scale system having EBCTs near 7.5 minutes supports that the pilot-scale results are directly applicable toward full-scale design. Thus, no difference in adsorption characteristics should result even though the pilot-scale carbon unit was loaded at a hydraulic rate of 2.9 gpm/ft^2 and the full-scale unit will be loaded at approximately 5 gpm/ft^2. The EBCTs for both columns are the same because the depth of carbon in the pilot column was 3 feet and the full-scale unit is designed at 5 feet with the percent increase in bed depth corresponding to the same increase in hydraulic loading for the full-scale system.

With regard to superficial flowrate, a range of 3-5 gpm/ft^2 is the proper design for a downflow packed bed activated carbon adsorption system with not much difference in adsorption characteristics measured between the two rates [6]. Superficial flowrate is determined by dividing the total flowrate (gpm) by the cross-sectional area of the

contactor (ft^2). A range for the contactor diameter can be calculated by determining the cross-sectional area required over the superficial flow range. The calculated diameter range is 6-8 ft. diameter. On this basis, 6 ft. diameter columns are chosen for design.

4.0 TREATMENT SYSTEM DESCRIPTION

This section describes the treatment system process train, identifies the major equipment items with associated O&M requirements, and provides a proposed schematic layout for the building which is to house the treatment system.

It should be noted that this section is not intended as a detailed process design but only presents a general conceptual approach. Once the treatment system proposed is approved in concept, then detailed design work will proceed.

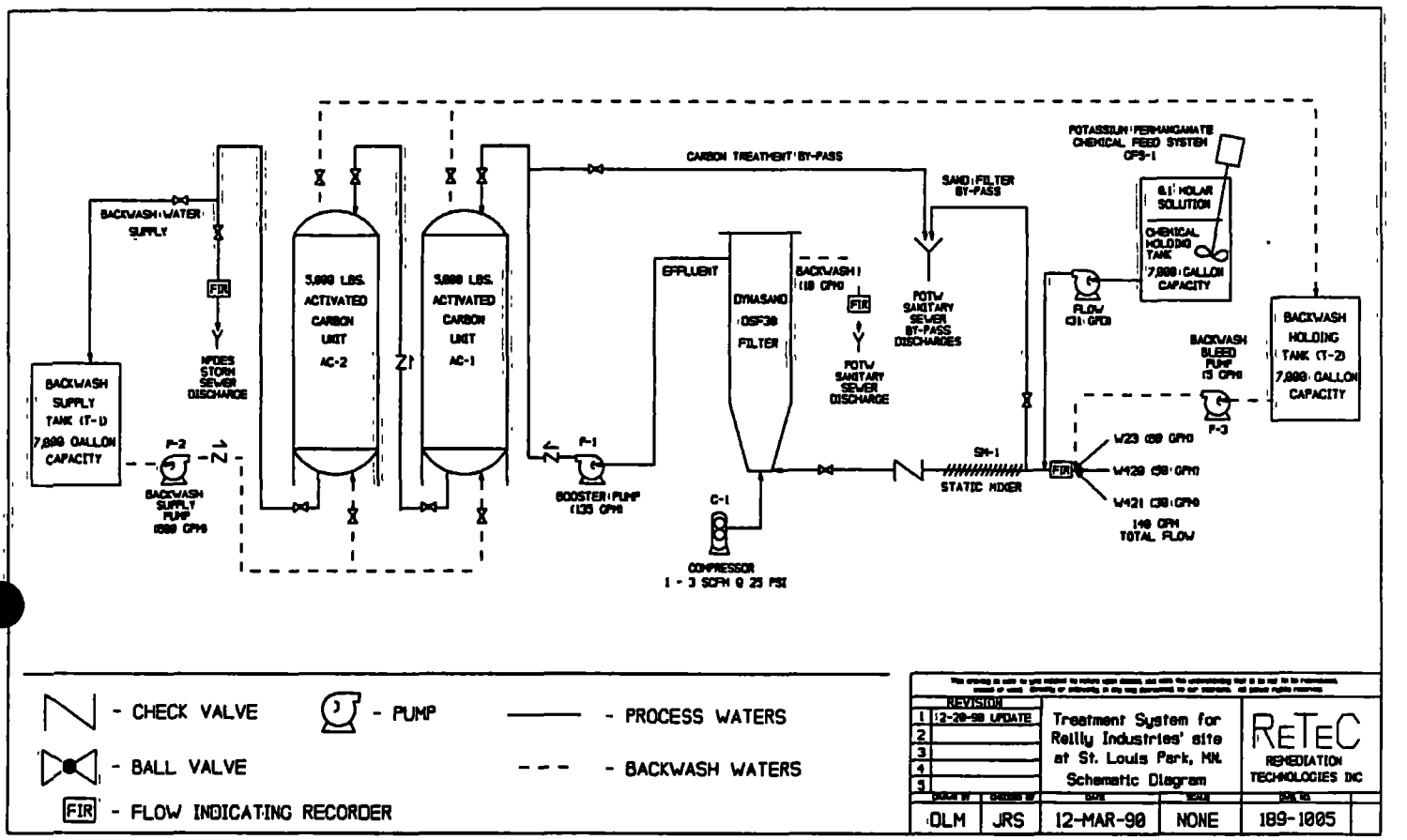
4.1 GENERAL DESCRIPTION

A conceptual schematic diagram of the proposed treatment system is given in Figure 4-1. Figure 4-1 is not intended to serve as a detailed process flow diagram. As shown, pumped groundwaters from wells W23, W420 and W421 will be combined by means of a 1200 foot underground connecting pipe as previously shown in Figure 2-1. This connecting pipe will be buried and run from the W23 location to the W420/W421 location and will require passing underneath a four lane highway. Initial engineering evaluation indicates that this line will be 3-4 inches in diameter with an adequate pumping head already available from the existing groundwater pump at W23. The treatment system will be located in the vicinity of the existing W420/W421 pump house. The system will be operated continuously as this is needed for hydraulic gradient control.

The combined influent from W23, W420 and W421 will pass through an in-line static mixer (SM-1) where potassium permanganate ($KMnO_4$) will be added via a chemical feed system (CFS-1) at a ratio of 1:1 for iron (Fe) and 2:1 for manganese (Mn). This chemical oxidation step will cause the soluble metals (i.e., Fe and Mn) of interest to precipitate, forming insoluble suspended particulate matter. These waters will then pass on to a continuous backwashing type sand filter where the particulates will be removed via upflow packed

FIGURE 4-1

FULL-SCALE TREATMENT SYSTEM CONCEPTUAL SCHEMATIC



bed filtration. At this time, it is proposed that the Parkson Corporation, Inc. DynaSand filter (Model DSF38) be used.

The DynaSand filter has several operating advantages for this application over a conventional downflow type filter with intermittent backwash. These include:

(1) Continuous Operation - no need to intermittently stop operations for backwashing cycles.

(2) Simplicity - no moving parts which would require operator attention.

(3) Elimination of Auxiliary Equipment - no need for pumps, tanks, valves and instrumentation associated with backwashing.

(4) Minimal Space Requirement - smaller foot print than that associated with conventional downflow packed bed sand filters.

(5) Low Power Consumption - gravity feed or low pressure feed pump and small air compressor are all that is required for operation.

(6) Minimal Reject - a relatively small reject stream, 5-7% of total feed stream, is continuously bled from the filter. This permits easier handling and discharge to sanitary sewers than conventional downflow filters, which require intermittent backwashing rate 3-4 times that of the total process rate, thus, necessitating the need for a backwash bleed tank to minimize hydraulic surges to sanitary sewers.

During October 26, 1989, through november 6, 1989, a 40 gpm pilot test of a DynaSand filter was performed at the St. Louis Park site treating a flow proportioned volume of wells W20 and W421. Results of this testing support the efficiency of using a

DynaSand filter to remove precipitated iron and manganese from the groundwater prior to carbon adsorption. A detailed report of this on-site pilot-scale filtration testing is given as Appendix C.

For the full-scale treatment system, effluent from the DynaSand filter will continue on to a booster pump (P-1) which will feed a downflow packed bed activated carbon treatment system (AC-1/2). The activated carbon will remove organic chemicals-of-interest (i.e., phenolics and PAHs) to levels below targeted NPDES discharge requirements. Such an activated carbon system is a standard package design supplied by various manufacturers. The specific system identified for the St. Louis Park site will consist of two-5,000 lb. carbon units in-series. This system is capable of treating the entire flow stream of 140 gpm, and should possess the ability to add or remove activated carbon in a slurry and provide backwashing capabilities, if needed, along with switching flow direction between units. With regard to backwashing, treated effluent will be stored in a 7,000 gallon capacity backwash water supply tank (T-1) with backwash supply water provided to either carbon unit via a 600 gpm backwash water supply pump (P-2). Backwash water from the carbon system will be directed into a 7,000 gallon capacity backwash holding tank (T-2). This backwash water will be bled back into the treatment system at a flowrate of approximately 3 gpm via a bleed pump (P-3). Treated effluent from the activated carbon column treatment system will be directed into a storm sewer.

Figure 4-1 also depicts by-pass lines for both the sand filter and the activated carbon system to sanitary sewer discharge. The by-pass will allow gradient control wells W23, W420 and W21 to continue pumping in the event of process failure or equipment maintenance.

4.2 MAJOR EQUIPMENT ITEMS

The major pieces of equipment cited in Figure 4-1 are further described in Table 4-1. Manufacturer's brochures and related information for the DynaSand filter and the activated carbon system are provided in Appendix D.

TABLE 4-1

SUMMARY OF THE MAJOR EQUIPMENT AND UTILITY REQUIREMENTS

I.D. NUMBER [a]	DESCRIPTION	GENERAL SPECIFICATION	O&M REQUIREMENTS [b]
PRETREATMENT WITH POTASSIUM PERMANGANTE AND SAND FILTRATION			
CFS-1	$KMnO_4$ Chemical Feed System	7,000 gallon tank with mixer and metering pump.	1,473 pounds $KMnO_4$ per year.
SM-1	In Line Static Mixer	145 GPM.	NA
DSF38	Sand Fliter	DynaSand continuous backwasing filter with sand media of 0.9 mm Effective Size and < 1.5 Uniformity Coeffiecient.	10 gpm reject stream to sanitary sewer (POTW).
C-1	Air Compressor	6 SCFM @ 50 PSI, 2 Stage, 1-1/2 HP, 3 Phase, 230/460 Volt.	1.2 Kilowatt/hr
ACTIVATED CARBON COLUMN TREATMENT			
P-1	Booster Pump	150 GPM @ 25 PSI, Centrifugal, 5 HP, 3 Phase, 230/460 Volt.	3.7 Kilowatt/hr
AC-1, AC-2	Carbon Columns	2 - 5,000 lbs. units in series with backwash capability, 6' x 10' (diameter x height) with a 5' bed depth.	6,200 - 9,200 pounds per year. [c]
P-2	Backwash Supply Pump	600 GPM @ 25 PSI, Centrifugal, 15 HP, 3 Phase, 230/460 Volt.	11.2 Kilowatt/hr
T-1	Backwash Supply Tank	7,000 gallon capacity.	NA
T-2	Backwash Holding Tank	7,000 gallon capacity.	NA
P-3	Backwash Bleed Pump	5 GPM @ 25 PSI, Centrifugal, 3 HP, 3 Phase, 230/460 Volt.	2.2 Kilowatt/hr

NOTES:

[a] - Refer to Figures 4-1 and 4-2.

[b] - Refers to Chemical, Carbon and Utility Requirements.

[c] - Taken from Table 3-4.

NA - Not Applicable

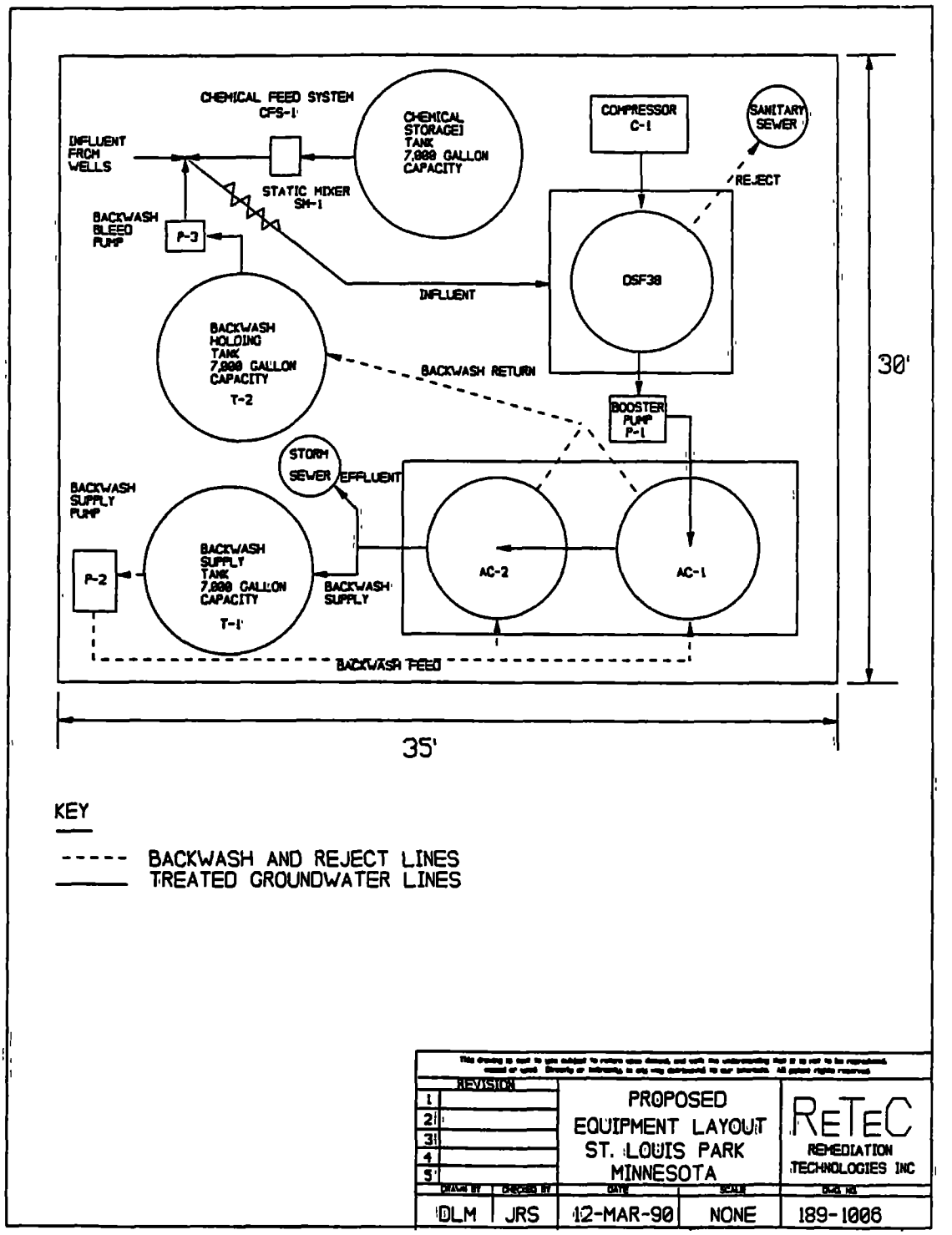
The general specifications of the major equipment items cited in Table 4-1 are based on the design basis given in Section 3.0 as derived from treatability study results and respective manufacturer's design information. The O&M requirements given relate to $KMnO_4$ and carbon usages along with electrical utility requirements to help estimate O&M costs associated with the full-scale system. Not included with this major equipment list are miscellaneous items such as related flow meters, valves, alarms, and operational and NPDES permit monitoring equipment.

4.3 BUILDING REQUIREMENTS

The area required to house the entire proposed treatment system is a two-story brick building approximately 30 ft. x 35 ft. in floor size. A suggested layout for the treatment system is shown in Figure 4-2.

FIGURE 4-2

SUGGESTED PLANT LAYOUT



5.0 OPERATIONAL AND PERMIT MONITORING CONSIDERATIONS

To help insure that the proposed groundwater treatment system operates efficiently and meets all discharge permit requirements, operational monitoring and discharge permit monitoring must be performed. Operational monitoring refers to routine analysis performed internally by the City with results used to help determine treatment efficiency. This includes determining how effectively the chemical oxidation/sand filtration pretreatment step is working in terms of iron, manganese and suspended solids removal, as well as determining when exhaustion of the first in-series carbon column occurs. Discharge permit monitoring refers to routine sampling analyses of effluent streams regulated under either NPDES or POTW discharge requirements. Such monitoring is used to verify compliance with applicable permits.

The following two sub-sections respectively address operational and permit monitoring issues related to the proposed groundwater treatment system. Specifics given are based on the associated treatability work performed and ReTeC's in-house data base and experience with similar situations. On this basis, it should be noted that the monitoring programs proposed represent ReTeC's best judgement at this time and are intended as a starting point for regulatory negotiations.

5.1 OPERATIONAL MONITORING

Operational monitoring relates to sampling of both the chemical oxidation/sand filtration process and the activated carbon process for respective indicator parameters.

Table 5-1 provides a summary of the proposed operational monitoring frequency. As cited, the results of this monitoring are only intended for the use of St. Louis Park personnel to aid them in running the treatment system as efficiently as possible in terms of treated the pumped groundwater. Results of this monitoring will not be formally submitted to the MPCA but will be kept and available at the site for their review. As cited in Table 5-1, operational monitoring refers to both onsite measurements as well as selected sample analyses by an outside laboratory.

TABLE 5-1

PROPOSED OPERATIONAL MONITORING FREQUENCY SUMMARY

PARAMETER	DYNASAND FILTER[a]			CARBON PROCESS[a]	
	Influent[b]	Effluent[c]	Backwash	Column 1 Effluent	Column 2 Effluent
On-Site					
pH	W	W	W	W	W
Iron (Test Kit)	W	W	W	W	-
Manganese (Test Kit)	W	W	W	W	-
Flowrate[d]	D	-	D	-	D
Pressure[e]	D	-	D	D	D
Air Rate[e]	-	-	D	-	-
Analyses by Outside Laboratory					
Iron	M	M	M	-	-
Manganese	M	M	M	-	-
Phenolics (4-AAP)	-	M	-	M	M
Naphthalene (by HPLC)	-	M	-	M	M

NOTE:
D - Daily
W - Weekly
M - Monthly
[a] Refers to grab sample analyses.
[b] Influent refers to sample taken prior to $KMnO_4$ addition.
[c] Effluent flow from sand filter corresponds to influent flow to carbon process.
[d] Continuous recording with daily totalizing.
[e] Instantaneous reading.

The operational monitoring frequency given represents a rather aggressive schedule mainly aimed at the initial operating period of the treatment system. However, after historical operating data becomes available, then this schedule may be modified in terms of less monitoring frequency.

DynaSand Filter Process

Related to the DynaSand filter, on-site monitoring relates to weekly pH and test kit analyses for Fe and Mn. This will provide qualitative information related to how well the system is operating. It is noteworthy that the sand filter effluent is the same as the carbon column influent, and thus is not repeated. With regard to flowrate, monitoring of the sand filter will not be provided by specific measurements of the total combined influent groundwater flow and the backwash flow. Referring to Figure 4-1, each of these two individual flows are to be measured by a flow indicating recorder with totalizer fluctuation. If needed, the effluent flow from the sand filter (i.e., the carbon column influent) can be computed by the difference of the measured influent flow and the backwash flow. The sand filter effluent flowrate subsequently becomes the carbon column influent with the flowrate not changing across the carbon columns. Thus, the final carbon column discharge effluent flowrate measured (See Figure 4-1) will also be the same for the measured sand filter effluent.

In terms of outside laboratory sample analyses, the three respective sand filter flows will be grab sampled and analyzed monthly for iron and manganese. The effluent will be analyzed monthly for phenolics (4-AAP) and naphthalene (HPLC) as needed to provide an indication of what concentrations are being applied to the carbon treatment process.

Activated Carbon Treatment Process

For operational monitoring of the carbon treatment process, Table 5-1 gives that on-site monitoring parameters will include pH and test kit Fe and Mn analyses. Flowrate will be the same as the sand filter effluent as previously discussed. Pressure will be addressed by daily gauge readings. In terms of analytical sampling, the influent (i.e., sand filter effluent) and effluents of the first and second in-series carbon columns should be sampled on a monthly basis and analyzed for phenolics (4-AAP) and naphthalene (HPLC). It was determined from the treatability study [1] that of the site groundwater chemicals-of-interest, phenolics and naphthalene are the two organics expected to break through first and thus determine carbon exhaustion. Monitoring of the lead column for these two parameters will provide a relatively inexpensive method of determining when carbon exhaustion has occurred and replacement is needed. When carbon exhaustion is indicated in the first in-series column, the second in-series column will continue to provide treatment until the spent carbon in the first in-series column is replaced. The second in-series column will also be checked by the same monthly analyses. When the carbon is replaced in the first in-series column, the flow direction will be changed applying the influent to the second column, thus becoming the first in-series column. Thus, the first column containing the newly replaced carbon will become the second in-series column. In this operational mode, the NPDES treated effluent will always be from the column containing the most recently replaced carbon. In addition to water quality monitoring, daily inspection should be made related to flowrates and pressure across the treatment system. Spent carbon can be removed and regenerated by the particular carbon supplier.

5.2 PERMIT MONITORING

As previously cited in Figure 4-1, two continuous streams from the proposed treatment system will require permit sampling. One stream is the sand filter backwash which will be discharged into the Minneapolis/St. Paul Metropolitan sewer system (i.e, POTW discharge). The second is the carbon process treated effluent which will be discharged into Minnehaha Creek under an NPDES permit issued by the MPCA.

During upset conditions with either the sand filter or the carbon treatment processes, the possibility also exists for the pumped groundwater flow to by-pass either process and be routed into the POTW as cited in Figure 4-1. For the reason that such discharge will only occur under upset conditions, only flowrate and pH will be monitored. This by-pass capability was requested by the MPCA. Such a by-pass to the carbon treatment process could occur during backwashing of one of the carbon filters with the groundwater still receiving chemical oxidation/sand filtration treatment. With such by-pass capability, groundwater pumping will not have to be interrupted in the event of upset conditions.

Table 5-2 provides a summary of the monitoring frequency proposed for both the DynaSand filter backwash stream POTW discharge and the carbon process effluent NPDES discharge.

DynaSand Filter Process

Related to the DynaSand filter, on-site monitoring will be done for pH, D.O. and flowrate at the respective frequencies cited. Backwash flowrate will be specifically monitored by a flow indicating recorder with a totalizer.

In terms of grab sampling and analysis of the backwash stream, it is proposed that pH, suspended solids, phenolics, chemical oxygen demand, and PAHs by HPLC (i.e., EPA Method 610) be done on a monthly basis. Related to anticipated water quality of the backwash stream, Table 5-3 gives measured values obtained during the carbon column treatability work [1] and the DynaSand filter pilot testing (See Appendix C). It is anticipated that the average flowrate will be approximately 10 gpm, with a range between 7 to 20 gpm. Based on the measured analytical results, the backwash stream represents a low organic loading in terms of BOD_5, COD and PAHs. The PAH values given show that only the Other PAHs are present as soluble compounds with respective concentrations similar to those in the pumped groundwaters. Thus, there appears to be no accumulation of PAHs onto the backwash suspended solids as supported by the fact

TABLE 5-2

PROPOSED DISCHARGE MONITORING FREQUENCY SUMMARY

PARAMETER	POTW DYNASAND FILTER BACKWASH[a]	NPDES CARBON PROCESS EFFLUENT[a]
On-Site		
pH	W	W
Dissolved Oxygen (D.O.)	M	M
Flowrate[b]	D	D
Analysis by Contract Laboratory		
pH	M	M
Suspended Solids (TSS/VSS/FSS)	M	M
Iron	-	M
Manganese	-	M
Phenolics (4-AAP)	M	M
Chemical Oxygen Demand	M	-
PAH (HPLC)	M	M
SLP-PAH (GC/MS)	-	BA
Oil & Grease	-	M

NOTE:
D - Daily
W - Weekly
M - Monthly
BA - Bi-Annually
[a] Grab samples to be taken
[b] Continuous recording

TABLE 5-3

MEASURED SAND FILTER BACKWASH WATER QUALITY

PARAMETERS	MEASURED BACKWASH WATER QUALITY [a]	MEASURED BACKWASH WATER QUALITY [b]
CONVENTIONAL (mg/L):		
pH	6 - 9	6 - 9
Total Suspended Solids	292 - 2270	17 - 224
Chemical Oxygen Demand	NA	38 - 43
Iron, mg/L	NA	4.66 - 77.2
Manganese, mg/L	NA	0.89 - 16
Phenolics, mg/L	NA	0.01 - 0.08
POTENTIALLY CARCINOGENIC (P.C.) PAH (ug/L)		
Quinoline	NA	BDL
Benzo(a)anthracene	BDL	BDL
Chrysene	BDL	BDL
Benzo(b)fluoranthene	BDL	BDL
Benzo(a)pyrene	BDL	BDL
Indeno(1,2,3-c,d)pyrene	BDL	BDL
Dibenz(a,h)anthracene	BDL	BDL
Benzo(g,h,i)perylene	BDL	BDL
Total Detectable P C. PAH	BDL	BDL
OTHER PAH (ug/L):		
2,3 Benzofuran	NA	33 - 55
2,3-dihydropindene	NA	180 - 300
Indene	NA	180 - 320
Naphthalene	7.71 - 462	1600 - 2000
Benzo(b)thiophene	NA	130 - 210
Indole	NA	BDL
2-Mehtylnaphthalene	NA	82 - 120
1-Mehtylnaphthalene	NA	110 - 220
Biphenyl	NA	17 - 28
Acenaphthylene	BDL	BDL
Acenaphthene	2.45 - 10.9	80 - 130
Dibenzofuran	NA	27 - 43
Fluorene	2.15 - 9.23	27 - 43
Dibenzothiophene	NA	BDL
Phenanthrene	0.80 - 6.99	19 - 31
Anthracene	BDL	BDL
Acridine	NA	BDL
Carbazole	BDL	50 - 82
Fluoranthene	BDL	BDL
Pyrene	BDL	BDL
Benzo(e)pyrene	NA	BDL
Perylene	NA	BDL
Total Detectable Other PAH (ug/L)	13 - 489	2535 - 3582

Note: NA - Not Analyzed.
BDL - Below Detection Level.
[a] - Data taken from Treatability Study Report [1]-Table 5-14 PAHs by HPLC, Minimum and Maximum values given.
[b] - Data taken from DynaSand Pilot Test Report [Appendix C]-Tables 3-5 and 3-6, PAHs by GC/MS, Minimum and Maximum values given.

that a sample of filtered backwash solids from the treatability pilot sand filter contained non-detectable concentrations of the St. Louis Park (SLP) - PAH list [1]. Additionally, no Potentially Carcinogenic PAH compounds were detected during either the treatability or the DynaSand pilot testing. The last noteworthy point is that the suspended solids concentration range cited for the DynaSand pilot test is more representative of what should be expected for the full-scale system. This is due to the fact that the high suspended solids concentration of 2,270 mg/L cited for the carbon column treatability work represents a surge flow while the much lower range of 17 to 224 mg/L cited for the DynaSand pilot test represents a continuous backwash flowrate.

Activated Carbon Treatment Process

Referring back to Table 5-2, permit monitoring of the carbon column treated effluent will be the same as that for the DynaSand filter in terms of on-site monitoring. With regard to NPDES sampling and analysis, it is proposed that monthly samples be taken for pH, suspended solids, iron, manganese, phenolics, PAH (by HPLC), and oil & grease. In addition, bi-annual analysis of the St. Louis Park - PAH (by GC/MS) list will be performed for QA/QC purposes. However, results of the carbon column treatability work performed demonstrated that PAH analysis by HPLC is a good substitute for the SLP-PAH analysis by GC/MS.

In terms of anticipated water quality, Table 5-4 summarizes the projected effluent quality based on treatability study results [1]. As cited, the effluent may contain near or less than detectable concentrations of conventional parameters, nutrients and metals; and less than detectable concentrations of the St. Louis Park - PAH list at a reporting limit of 0.01 μg/L. Thus, it is expected that the treatment system will be able to meet all targeted NPDES requirements. This is based on the fact that the on-site pilot unit column 2 effluent, operated at an EBCT of 15 minutes, contained non-detectable levels of phenolics and PAHs just as the column 3 effluent. Thus, it can be inferred that the water quality of columns 2 and 3 are similar and representative of the water quality which will be achieved in the full-scale operating at a total EBCT of 15 minutes. An exception should be noted for phenolics (4-AAP) for the reason that the target NPDES permit requirement of 0.01 mg/L is just above the method detection limit of 0.005 mg/L. Thus,

TABLE 5-4

MEASURED CARBON COLUMN PROCESS EFFLUENT QUALITY

PARAMETERS	MEASURED EFFLUENT QUALITY
CONVENTIONAL (mg/L):	
Phenolics (4-AAP)	< 0.005-0.02
pH (units)	7.5 - 7.8
Total Dissolved Solids	360 - 730
Total Suspended Solids	< 1.00 - 16.0
Biochemical Oxygen Demand	< 1.00 - 5.00
Chemical Oxygen Demand	< 10 - 28
Total Organic Carbon	< 1 - 6
Oil and Grease	< 6.00 - 10.0
Hardness (as $CaCO_3$)	443 - 475
Dissolved Oxygen	> 2.0
NUTRIENTS (mg/L):	
Orthophosphate as P	< 0.01 - 0.03
Ammonia Nitrogen as N	< 1.00
Nitrite as N	< 0.02
Nitrate as N	< 0.02
METALS (mg/L):	
Iron-Total	< 0.100
Manganese-Total	0.034 - 0.091

PARAMETERS	NO. OF PAH RINGS	MEASURED EFFLUENT QUALITY
POTENTIALLY CARCINOGENIC (P.C.) (ug/L):		
Quinoline	2	< 0.01
Benzo(a)anthracene	4	< 0.01
Chrysene	4	< 0.01
Benzo(b)fluoranthene	5	< 0.01
Benzo(k)fluoranthene	5	< 0.01
Benzo(a)pyrene	5	< 0.01
Indeno(1,2,3-c,d)pyrene	6	< 0.01
Dibenzo(a,h)anthracene	5	< 0.01
Benzo(g,h,i)perylene	6	< 0.01
Total Detectable P.C.PAH		0.0
OTHER PAH (ug/L):		
2,3-Benzofuran		
2,3-Dihydroindene	2	< 0.01
Indene	2	< 0.01
Naphthalene	2	< 0.01
Benzo(b)thiophene	2	< 0.01
Indole	2	< 0.01
2-Methylnaphthalene	2	< 0.01
1-Methylnaphthalene	2	< 0.01
Biphenyl	2	< 0.01
Acenaphthylene	2	< 0.01
Acenaphthene	3	< 0.01
Dibenzofuran	3	< 0.01
Fluorene	3	< 0.01
Dibenzothiophene	3	< 0.01
Phenanthrene	3	< 0.01
Anthracene	3	< 0.01
Acridine	3	< 0.01
Carbazole	3	< 0.01
Fluoranthene	4	< 0.01
Pyrene	4	< 0.01
Benzo(a)pyrene	5	< 0.01
Perylene	5	< 0.01
Total Detectable Other PAH		0.0

Note: < = [illegible] less than detectable concentrations.

Data taken from Tables 5-10 and 5-11 in the St. Louis Park Treatability Report.

Study Report [1] with ranges corresponding to minimum and maximum values.

a slight interference with the analytical method may cause the target concentration of 0.01 mg/L to be exceeded. Such interferences were observed during the carbon column treatability work [1] with ranges between 0.01 to 0.015 noted. For this reason it is proposed that the phenolics NPDES requirement be set at 0.05 mg/L.

REFERENCES

[1] Remediation Technologies, Inc. (Pittsburgh, PA) "Treatability Study Report for Treatment of Pumped Groundwaters at St. Louis Park, Minnesota", Report prepared for Reilly Industries, Inc., October, 1989.

[2] Remediation Technologies, Inc. (Pittsburgh, PA) NPDES Permit Application for Submittal to the Minnesota Pollution Control Agency for Treatment of Pumped Groundwaters from a St. Louis Park, Minnesota Site, Prepared for Reilly Industries, Inc., October, 1989.

[3] City of St. Louis Park, "Annual Monitoring Report for 1988 - Reilly Tar & Chemical Corporation, NPL Site - St. Louis Park, Minnesota", March 15, 1988, pg. 2.

[4] Miller, I. and Freund, J.E., Probability and Statistics for Engineers, Pretice-Hall, Inc., Englewood Cliff, New Jersey, 1965.

[5] U.S. EPA, Office of Research and Development, "Treatability Manual - Volume 1, Treatability Data", U.S. EPA Document No. EPA-600/2-82-001a, U.S. Government Printing Office, Washington, D.C., September, 1981.

[6] U.S. EPA, "Process Design Manual for Carbon Adsorption," Document No. EPA 625/1-71-002a, U.S. Government Printing Office, Washington, D.C., October, 1973.

APPENDIX A

FLOW AND WATER QUALITY DATA FOR WELLS W23/W420/W421 BASED ON QUARTERLY MONITORING

- TABLE A-1: WELL FLOW DATA
- TABLE A-2: W23 WATER QUALITY DATA
- TABLE A-3: W420 WATER QUALITY DATA
- TABLE A-4: W421 WATER QUALITY DATA

TABLE A-1

WELL FLOW DATA

	W23		W420		W421	
	PRAIRIE DU CHEIN JORDAN		DRIFT		PLATTEVILLE	
DATE (MONTH - YEAR)	AVERAGE (GPM)	TOTAL (mm GAL.)	AVERAGE (GPM)	TOTAL (mm GAL.)	AVERAGE (GPM)	TOTAL (mm GAL.)
NOV 87	40	1.48				
DEC	64	4.33				
JAN 88	64	7.20	30	0.85	31	0.91
FEB	63	9.90	30	2.10	30	2.14
MAR	61	12.50	30	3.40	30	3.40
APR	62	15.30	31	4.70	30	4.70
MAY	58	17.80	30	6.00	30	5.00
JUN	23	18.90	40	7.80	32	7.40
JUL	70	21.90	48	9.80	31	8.70
AUG	73	25.10	41	11.70	31	10.10
SEP	76	28.50	40	13.40	31	11.50
OCT	55	31.00	40	15.20	28	12.70
NOV	52	33.30	40	16.90	28	13.90
DEC	53	35.50	43	18.70	29	15.10
JAN 89	50	37.60	44	20.60	28	16.30
FEB	51	39.80	44	22.40	27	17.40
MAR	50	41.90	44	24.30	27	18.60
APR	52	44.20	43	26.20	28	19.80
MAY	53	46.50	44	28.00	27	20.90
JUN	52	48.80	44	30.00	28	22.10
JUL	53	50.10	46	31.90	40	23.80
AUG	53		46		45	
SEP	53		45		47	

STATISTICAL EVALUATION OF AVERAGE MONTHLY FLOWS FROM WELLS FOR 1987 THROUGH 1889

MONTHLY FLOW (GPM)	W23	W420	W421	TOTAL
AVERAGE	56	40	31	127
MAXIMUM	76	48	47	171
MINIMUM	23	30	27	80
L95%	51	37	29	117
UP95%	60	43	34	137

TABLE A-2

W23 WATER QUALITY DATA

PRAIRIE DU CHIEN/JORDAN (W23) (ug/l)

SAMPLE NO.	49845	49846	51519,24,29	59387-2	648-02	1815-01	2872-01	88120975	3187-01	4100-01	5560-01	STATISTICAL EVALUATION BASED UPON DETECTABLE QUANTITIES					
SAMPLE DATE	11/11/87	11/11/87	1/18/88	3/1/88	6/29/88	9/21/88	11/30/88	12/28/88	12/28/88	3/29/89	6/29/89	n	AVG	MAX	MIN	L95%	U95%
LABORATORY	ERT	ERT	ERT	RMA	RMA	RMA	RMA	KEYSTONE	RMA	RMA	RMA						
CARCINOGENS																	
Quinoline	< 2.8	< 2.8		< 10	< 9.5	< 9.9	< 1	NA	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
Benzo(a)anthracene	< 3.1	< 3.1		< 10	< 9.5	< 9.9	< 1	0.235	< 10	< 9.4	< 10	1	0.235	0.235	0.235	0.235	0.235
Chrysene	< 3.1	< 3.1		< 10	< 9.5	< 9.9	< 1	0.283	< 10	< 9.4	< 10	1	0.283	0.283	0.283	ND	ND
Benzofluoranthenes	< 10	< 10		< 10	< 9.5	< 9.9	< 1	0.024	< 10	< 9.4	< 10	1	0.024	0.024	0.024	ND	ND
Benzo(a)pyrene	< 2	< 2		< 10	< 9.5	< 9.9	< 1	0.028	< 10	< 9.4	< 10	1	0.028	0.028	0.028	0.028	0.028
Indeno(1,2,3-cd)pyrene	< 2.4	< 2.4		< 10	< 9.5	< 9.9	< 1	< 0.05	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	< 2	< 2		< 10	< 9.5	< 9.9	< 1	< 0.03	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
Benzo(ghi)perylene	< 2	< 2		< 10	< 9.5	< 9.9	< 1	< 0.05	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
TOTAL	0	0		0	0	0	0	0.57	0	0	0	1	0.570	0.570	0.570	0.570	0.570
OTHER PAH																	
2,3-Benzofuran	10.9	10.9		3	1.3	< 10	< 1	NA	< 10	< 9.4	< 10	4	6.5	10.9	1.3	0.0	13.6
2,3-Dyhydroindene	50.2	49.9		23	15	14	8.6	NA	12	16	14	9	22.5	50.2	8.6	10.9	34.2
Indene	61.1	62.5		18	7.3	4.8	2.3	NA	2.8	3.1	3.2	9	18.3	62.5	2.3	0.1	36.5
Naphthalene	> 135	> 130		190	70	7.5	16	28.8	34	25	25	10	66.1	190.0	7.5	23.2	109.0
Benzo(b)thiophene	31.7	31.5		15	7.4	3.2	3.8	NA	4.4	4	4.3	9	11.7	31.7	3.2	3.1	20.3
Indole	< 2.7	< 2.7		< 10	< 9.5	< 9.9	< 1	NA	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
2-Methylnaphthalene	50.4	51.4		10	4.2	2.5	2.4	NA	3.4	3.5	3.6	9	14.6	51.4	2.4	0.0	29.6
1-Methylnaphthalene	53.5	56.3		22	12	9.8	6	NA	7.7	8.3	8.2	9	20.4	56.3	6.0	5.9	35.0
Biphenyl	14.4	15.4		7	4.3	3.8	2.1	NA	2.9	2.9	2.7	9	6.2	15.4	2.1	2.4	9.9
Acenaphthylene	7.4	8.1		5	3.3	2.6	1.7	15.2	2.4	2.3	2.6	10	5.1	15.2	1.7	2.2	7.9
Acenaphthene	39.6	40.6		25	17	15	9.3	21.4	12	14	13	10	20.7	40.6	9.3	13.1	28.3
Dibenzofuran	24.2	25.8		11	6.7	6.4	4.7	NA	5.1	5.3	5.1	9	10.5	25.8	4.7	4.3	16.6
Fluorene	26.8	26.1		18	12	12	7.5	9.3	9.8	11	11	10	14.4	26.8	7.5	9.6	19.1
Dibenzothiophene	< 3.1	< 3.1		2	1.4	1.3	< 1	NA	1.2	1.3	1.2	6	1.4	2.0	1.2	1.1	1.7
Phenanthrene	33.5	32		22	14	14	8.3	9.9	12	11	11	10	16.8	33.5	8.3	10.5	23.0
Anthracene	4	4.1		3	1.8	1.8	1.1	1.8	1.6	1.4	1.5	10	2.2	4.1	1.1	1.5	2.9
Acridine	< 3.4	< 3.4		< 10	< 9.5	< 9.9	< 1	NA	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
Carbazole	< 2.7	< 2.7		7	3.2	2.8	1.5	2.6	2.2	2.1	2.1	8	2.9	7.0	1.5	1.6	4.3
Fluoranthene	8.2	8.3		6	5.9	6.2	2.9	2.5	5.2	4.8	4.9	10	5.4	8.3	2.5	4.1	6.7
Pyrene	6.2	6.4		5	4.8	4.4	2.5	2	4.4	4.2	4.2	10	4.4	6.4	2.0	3.5	5.3
Benzo(e)pyrene	< 2.5	< 2.5		< 10	< 9.5	< 9.9	< 1	NA	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
Perylene	< 2.6	< 2.6		< 10	< 9.5	< 9.9	< 1	NA	< 10	< 9.4	< 10	0	ND	ND	ND	ND	ND
TOTAL	> 557	> 559		392	191.6	111.1	80.7	93.5	123.1	120.2	117.6	10	234.6	559.0	80.7	103.9	365.3
OTHER PARAMETERS (mg/l)																	
Oil & Grease			5					< 0.005				1	5	5	5	5	5
Phenolics			0.01									1	0.010	0.010	0.010	0.010	0.010
TSS			2									1	2	2	2	2	2
CUMULATIVE PUMPAGE (Millions of Gallons)		0.29	5.92	9.87	18.65	27.41	33.19	35.24	35.24	41.72	48.65						

Note: < - Indicates less than detectable concentrations.
NA - Not Analyzed.
ND - Not Detected.
n - # of values used in statistical computations
AVG - Average of reported values.
MAX - Maximum of reported values.
MIN - Minimum of reported values.
L95% - Lower 95% Confidence Interval Limit.
U95% - Upper 95% Confidence Interval Limit.

TABLE A-3

W420 WATER QUALITY DATA

DRIFT SCW (W420) (ug/l)

SAMPLE NO.	51534	59397-6	648-03	1815-02 & 59620-01	2972-02	3197-02 & 59819-01	88120976	59946-02 & 4100-02	60034-01 & 5560-02	STATISTICAL EVALUATION BASED UPON DETECTABLE QUANTITIES				
SAMPLE DATE	1/18/88	3/1/88	6/29/88	9/21/88	11/30/88	12/29/88	12/29/88	3/29/89	6/29/89					
LABORATORY	ERT	RMA	RMA	RMA	RMA	RMA	KEYSTONE	RMA	RMA	n	AVG	MAX	MIN	L95%	U95%
CARCINOGENS															
Quinoline	< 2.8	< 100	< 9.5	< 189	< 100	< 10	NA	< 9.4	< 200	0	NO	NO	NO	NO	NO
Benzo(a)anthracene	< 3.1	< 100	< 9.5	< 189	< 100	< 10	< 0.02	< 9.4	< 200	0	NO	NO	NO	NO	NO
Chrysene	< 3.1	< 100	< 9.5	< 189	< 100	< 10	< 0.15	< 9.4	< 200	0	NO	NO	NO	NO	NO
Benzofluoranthenes	< 10	< 100	< 9.5	< 189	< 100	< 10	< 0.02	< 9.4	< 200	0	NO	NO	NO	NO	NO
Benzo(a)pyrene	< 2	< 100	< 9.5	< 189	< 100	< 10	< 0.02	< 9.4	< 200	0	NO	NO	NO	NO	NO
Indeno(1,2,3-cd)pyrene	< 2.4	< 100	< 9.5	< 189	< 100	< 10	< 0.05	< 9.4	< 200	0	NO	NO	NO	NO	NO
Dibenzo(a,h)anthracene	< 2	< 100	< 9.5	< 189	< 100	< 10	< 0.03	< 9.4	< 200	0	NO	NO	NO	NO	NO
Benzo(ghi)perylene	< 2	< 100	< 9.5	< 189	< 100	< 10	< 0.05	< 9.4	< 200	0	NO	NO	NO	NO	NO
TOTAL	0	0	0	0	0	0	0	0	0	0	NO	NO	NO	NO	NO
OTHER PAH															
2,3-Benzofuran	83	61	56	30	< 100	9.6	NA	21	32	7	41.9	83.0	9.6	19.9	63.8
2,3-Dyhydroindene	18	120	150	130	130	130	NA	180	160	8	127.3	180.0	18.0	89.4	165.1
Indene	65	380	330	180	120	74	NA	230	250	8	203.6	380.0	65.0	113.2	294.0
Naphthalene	> 2400	2500	2600	1700	500	730	626	1500	2400	9	1661.8	2500.0	500.0	1034.5	2289.9
Benzo(b)thiophene	27	170	160	110	< 100	71	NA	98	150	7	112.3	170.0	27.0	67.8	156.3
Indole	< 2.7	< 100	< 9.5	< 189	< 100	< 10	NA	< 9.4	< 200	0	NO	NO	NO	NO	NO
2-Methylnaphthalene	24	170	150	88	< 100	13	NA	80	87	7	87.4	170.0	13.0	37.6	137.3
1-Methylnaphthalene	25	130	110	82	< 100	37	NA	100	110	7	84.9	130.0	25.0	50.9	118.9
Biphenyl	25	25	20	< 189	< 100	6.4	NA	14	21	6	18.6	25.0	6.4	11.7	25.5
Acenaphthylene	< 2.5	< 100	< 9.5	< 189	< 100	< 10	61.7	< 9.4	< 200	1	61.7	61.7	61.7	NO	NO
Acenaphthene	94	110	92	68	< 100	33	34.1	69	90	8	73.8	110.0	33.0	51.6	95.9
Dibenzofuran	36	34	32	25	< 100	6.8	NA	23	32	7	27.0	36.0	6.8	18.4	35.6
Fluorene	26	31	29	22	< 100	6.8	6.8	22	30	8	21.7	31.0	6.8	14.0	29.4
Dibenzothiophene	< 3.1	< 100	1.4	< 189	< 100	< 10	NA	2.2	< 200	2	1.8	2.2	1.4	0.0	5.4
Phenanthrene	11	15	15	< 189	< 100	3.5	3.4	11	< 200	6	9.8	15.0	3.4	4.8	14.3
Anthracene	< 2.3	< 100	< 9.5	< 189	< 100	< 10	< 0.5	< 9.4	< 200	0	NO	NO	NO	NO	NO
Acridine	< 3.4	< 100	< 9.5	< 189	< 100	< 10	NA	< 9.4	< 200	0	NO	NO	NO	NO	NO
Carbazole	57	56	55	42	< 100	27	INTRFRNC	39	56	7	47.4	57.0	27.0	37.5	57.4
Fluoranthene	< 2.2	< 100	< 9.5	< 189	< 100	< 10	< 0.2	< 9.4	< 200	0	NO	NO	NO	NO	NO
Pyrene	< 2.2	< 100	< 9.5	< 189	< 100	< 10	< 0.2	< 9.4	< 200	0	NO	NO	NO	NO	NO
Benzo(e)pyrene	< 2.5	< 100	< 9.5	< 189	< 100	< 10	NA	< 9.4	< 200	0	NO	NO	NO	NO	NO
Perylene	< 2.6	< 100	< 9.5	< 189	< 100	< 10	NA	< 9.4	< 200	0	NO	NO	NO	NO	NO
TOTAL	> 2891	3802	3800	2477	750	1148.1	732	2387	3418	9	2378.3	3802.0	732.0	1480.6	3276.1
OTHER PARAMETERS (mg/l)															
Oil & Grease	10									1	10	10	10	10	10
Phenolics	0.51	0.44	0.33	0.222		0.044	0.041	0.12	0.129	8	0.230	0.510	0.041	0.083	0.370
TSS	9									1	9	9	9	9	9
CUMULATIVE PUMPAGE (Millions of Gallons)	0.3	2.1	7.61	12.88	16.86	18.49	18.49	24.14	29.33						

Note: < - Indicates less than detectable concentrations.
NA - Not Analyzed.
ND - Not Detected.
n - # of values used in statistical computations.

AVG - Average of reported values.
MAX - Maximum of reported values.
MIN - Minimum of reported values.
L95% - Lower 95% Confidence Interval Limit.
U95% - Upper 95% Confidence Interval Limit.

TABLE A-4

W421 WATER QUALITY DATA

PLATTEVILLE SCW (W421) (ug/l)

SAMPLE NO.	51674	59387-7	648-04	1815-03 & 59680-02	2972-03	3187-05 & 59818-02	88120977	59946-03 & 4100-03	60034-02 & 5560-03	STATISTICAL EVALUATION BASED UPON DETECTABLE QUANTITIES					
SAMPLE DATE	1/20/88	3/1/88	6/29/88	9/21/88	11/30/88	12/29/88	12/29/88	3/29/89	6/29/89						
LABORATORY	ERT	RMA	RMA	RMA	RMA	RMA	KEYSTONE	RMA	RMA	n	AVG	MAX	MIN	L95%	U95%
CARCINOGENS															
Quinoline	< 2.9	< 100	< 9.5	< 95	< 100	< 10	NA	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(a)anthracene	< 3.1	< 100	< 9.5	< 95	< 100	< 10	< 0.02	< 9.4	< 50	0	ND	ND	ND	ND	ND
Chrysene	< 3.1	< 100	< 9.5	< 95	< 100	< 10	< 0.15	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzofluoranthenes	< 10	< 100	< 9.5	< 95	< 100	< 10	< 0.02	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(a)pyrene	< 2	< 100	< 9.5	< 95	< 100	< 10	< 0.02	< 9.4	< 50	0	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	< 2.4	< 100	< 9.5	< 95	< 100	< 10	< 0.05	< 9.4	< 50	0	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	< 2	< 100	< 9.5	< 95	< 100	< 10	< 0.03	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(ghi)perylene	< 2	< 100	< 9.5	< 95	< 100	< 10	< 0.05	< 9.4	< 50	0	ND	ND	ND	ND	ND
TOTAL	0	0	0	0	0	0	0	0	0	0	ND	ND	ND	ND	ND
OTHER PAH															
2,3-Benzofuran	5	< 100	1.9	< 95	< 100	1.8	NA	1.5	< 50	4	2.6	5.0	1.5	0.3	4.8
2,3-Dyhydroindene	83	81	120	120	170	180	NA	130	140	8	129.0	180.0	81.0	100.0	156.0
Indene	69	47	78	81	140	75	NA	110	88	8	86.0	140.0	47.0	64.0	108.0
Naphthalene	410	270	510	520	600	670	424	470	630	9	500.4	670.0	270.0	410.2	590.7
Benzo(b)thiophene	41	42	67	67	< 100	80	NA	75	73	7	63.6	80.0	41.0	50.1	77.1
Indole	< 2.7	< 100	< 9.5	< 95	< 100	< 10	NA	< 9.4	< 50	0	ND	ND	ND	ND	ND
2-Methylnaphthalene	3	< 100	< 9.5	< 95	< 100	1.3	NA	1.3	< 50	3	1.9	3.0	1.3	-0.1	3.9
1-Methylnaphthalene	18	15	24	26	< 100	36	NA	34	38	7	27.3	38.0	15.0	19.6	35.0
Biphenyl	< 2.8	< 100	2.2	< 95	< 100	4.1	NA	3.7	< 50	3	3.3	4.1	2.2	1.3	5.4
Acenaphthylene	< 2.5	< 100	< 9.5	< 95	< 100	< 10	44.2	< 9.4	< 50	1	44.2	44.2	44.2	44.2	44.2
Acenaphthene	10	< 100	15	16	< 100	25	12.6	22	26	7	18.1	26.0	10.0	12.7	23.4
Dibenzofuran	< 2	< 100	1.4	< 95	< 100	3.7	NA	3.5	< 50	3	2.9	3.7	1.4	0.3	5.5
Fluorene	< 3	< 100	1.9	< 95	< 100	4.2	2.9	4.3	5.4	5	3.7	5.4	1.9	2.2	5.2
Dibenzothiophene	< 3.1	100	< 9.5	< 95	< 100	< 10	NA	< 9.4	< 50	1	100.0	100.0	100.0	100.0	100.0
Phenanthrene	< 2.6	< 100	< 9.5	< 95	< 100	1.4	1.2	1.4	< 50	3	1.3	1.4	1.2	1.1	1.6
Anthracene	< 2.3	< 100	< 9.5	< 95	< 100	< 10	< 0.5	< 9.4	< 50	0	ND	ND	ND	ND	ND
Acridine	< 3.4	< 100	< 9.5	< 95	< 100	1.1	NA	1	< 50	2	1.1	1.1	1.0	0.6	1.5
Carbazole	10	11	15	15	< 100	23	INTRFR	20	24	7	16.9	24.0	10.0	12.1	21.6
Fluoranthene	< 2.2	< 100	< 9.5	< 95	< 100	< 10	< 0.2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Pyrene	< 2.2	< 100	< 9.5	< 95	< 100	< 10	< 0.2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(e)pyrene	< 2.5	< 100	< 9.5	< 95	< 100	< 10	NA	< 9.4	< 50	0	ND	ND	ND	ND	ND
Perylene	< 2.6	< 100	< 9.5	< 95	< 100	< 10	NA	< 9.4	< 50	0	ND	ND	ND	ND	ND
TOTAL	649	566	836	845	910	1106.6	485	877.7	1024.4	9	811.1	1106.6	485.0	661.3	960.8
OTHER PARAMETERS (mg/l)															
Oil & Grease	7									1	7	7	7	7	7
Phenolics	0.07	0.033	< 0.05	0.03		0.035	0.033	0.029	0.026	7	0.037	0.070	0.026	0.024	0.049
TSS	1									1	1	1	1	1	1
CUMULATIVE PUMPAGE (Millions of Gallons)	0.38	2.14	7.3	11.07	13.88	14.97	14.97	18.49	22.03						

Note: < - Designates less than detectable concentrations.
NA - Not Analyzed.
ND - Not Detected.
n - # of values used in statistical computations.
AVG - Average of reported values.
MAX - Maximum of reported values.
MIN - Minimum of reported values.
L95% - Lower 95% Confidence Interval Limit.
U95% - Upper 95% Confidence Interval Limit.

PRAIRIE DU CHIEN/JORDAN (W23) (ug/1)

SAMPLE NO.		49845		49846	STATISTICAL EVALUATION BASED UPON DETECTABLE QUANTITIES					
SAMPLE DATE		11/11/87		11/11/87						
LABORATORY		ERT		ERT	n	AVG	MAX	MIN	L95%	U95%
CARCINOGENS										
Quinoline	<	2.8	<	2.8	0	ND	ND	ND	ND	ND
Benzo(a)anthracene	<	3.1	<	3.1	1	0.235	0.235	0.235	0.235	0.235
Chrysene	<	3.1	<	3.1	1	0.283	0.283	0.283	ND	ND
Benzofluoranthenes	<	10	<	10	1	0.024	0.024	0.024	ND	ND
Benzo(a)pyrene	<	2	<	2	1	0.028	0.028	0.028	0.028	0.028
Indeno(1,2,3-cd)pyrene	<	2.4	<	2.4	0	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	<	2	<	2	0	ND	ND	ND	ND	ND
Benzo(ghi)perylene	<	2	<	2	0	ND	ND	ND	ND	ND
TOTAL		0		0	1	0.570	0.570	0.570	0.570	0.570
OTHER PAH										
2,3-Benzofuran		10.9		10.9	4	6.5	10.9	1.3	0.0	13.6
2,3-Dyhydroindene		50.2		49.9	9	22.5	50.2	6.6	10.9	34.2
Indene		61.1		62.5	9	18.3	62.5	2.3	0.1	36.5
Naphthalene	>	135	>	130	10	66.1	190.0	7.5	23.2	109.0
Benzo(b)thiophene		31.7		31.5	9	11.7	31.7	3.2	3.1	20.3
Indole	<	2.7	<	2.7	0	ND	ND	ND	ND	ND
2-Methylnaphthalene		50.4		51.4	9	14.6	51.4	2.4	0.0	29.6
1-Methylnaphthalene		53.5		56.3	9	20.4	56.3	6.0	5.9	35.0
Biphenyl		14.4		15.4	9	6.2	15.4	2.1	2.4	9.9
Acenaphthylene		7.4		8.1	10	5.1	15.2	1.7	2.2	7.9
Acenaphthene		39.6		40.6	10	20.7	40.6	9.3	13.1	28.3
Dibenzofuran		24.2		25.8	9	10.5	25.8	4.7	4.3	16.6
Fluorene		26.8		26.1	10	14.4	26.8	7.5	9.6	19.1
Dibenzothiophene	<	3.1	<	3.1	6	1.4	2.0	1.2	1.1	1.7
Phenanthrene		33.5		32	10	16.8	33.5	8.3	10.5	23.0
Anthracene		4		4.1	10	2.2	4.1	1.1	1.5	2.9
Acridine	<	3.4	<	3.4	0	ND	ND	ND	ND	ND
Carbazole	<	2.7	<	2.7	8	2.9	7.0	1.5	1.6	4.3
Fluoranthene		8.2		8.3	10	5.4	8.3	2.5	4.1	6.7
Pyrene		6.2		6.4	10	4.4	6.4	2.0	3.5	5.3
Benzo(e)pyrene	<	2.5	<	2.5	0	ND	ND	ND	ND	ND
Perylene	<	2.6	<	2.6	0	ND	ND	ND	ND	ND
TOTAL	>	557	>	559	10	234.6	559.0	80.7	103.9	365.3
OTHER PARAMETERS (mg/1)										
Oil & Grease					1	5	5	5	5	5
Phenolics					1	0.010	0.010	0.010	0.010	0.010
TSS					1	2	2	2	2	2
CUMULATIVE PUMPAGE (Millions of Gallons)				0.23						

Note: < - Indicates less than detectable concentratio
NA - Not Analyzed.
ND - Not Detected.
n - # of values used in statistical computation
AVG - Average of reported values.
MAX - Maximum of reported values.
MIN - Minimum of reported values.
L95% - Lower 95% Confidence Interval Limit.
U95% - Upper 95% Confidence Interval Limit.

-3

W420 LITY DATA

DRIFT SCW (W420) (ug/l)

SAMPLE NO.	51534	59397-6	648-03	1815-02 & 59620-01	-02 & 3-01	88120976	59946-02 & 4100-02	60034-01 & 5560-02		STATISTICAL EVALUATION BASED UPON DETECTABLE QUANTITIES				
SAMPLE DATE	1/18/88	3/1/88	6/29/88	9/21/88	3/88	12/29/88	3/29/89	6/29/89	n	AVG	MAX	MIN	L95%	U95%
LABORATORY	ERT	RMA	RMA	RMA	RMA	KEYSTONE	RMA	RMA						
CARCINOGENS														
Quinoline	< 2.9	< 100	< 9.5	< 189	< 10	NA	< 9.4	< 200	0	ND	ND	ND	ND	ND
Benzo(a)anthracene	< 3.1	< 100	< 9.5	< 189	< 10	< 0.02	< 9.4	< 200	0	ND	ND	ND	ND	ND
Chrysene	< 3.1	< 100	< 9.5	< 189	< 10	< 0.15	< 9.4	< 200	0	ND	ND	ND	ND	ND
Benzofluoranthenes	< 10	< 100	< 9.5	< 189	< 10	< 0.02	< 9.4	< 200	0	ND	ND	ND	ND	ND
Benzo(a)pyrene	< 2	< 100	< 9.5	< 189	< 10	< 0.02	< 9.4	< 200	0	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	< 2.4	< 100	< 9.5	< 189	< 10	< 0.05	< 9.4	< 200	0	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	< 2	< 100	< 9.5	< 189	< 10	< 0.03	< 9.4	< 200	0	ND	ND	ND	ND	ND
Benzo(ghi)perylene	< 2	< 100	< 9.5	< 189	< 10	< 0.05	< 9.4	< 200	0	ND	ND	ND	ND	ND
TOTAL	0	0	0	0	0	0	0	0	0	ND	ND	ND	ND	ND
OTHER PAH														
2,3-Benzofuran	83	61	56	30	<9.6	NA	21	32	7	41.9	83.0	9.6	19.9	63.8
2,3-Dyhydroindene	18	120	150	130	130	NA	180	160	8	127.3	180.0	18.0	89.4	165.1
Indene	65	380	330	180	74	NA	230	250	8	203.6	380.0	65.0	113.2	294.0
Naphthalene	> 2400	2500	2600	1700	730	626	1500	2400	9	1661.8	2500.0	500.0	1034.5	2298.9
Benzo(b)thiophene	27	170	160	110	< 71	NA	98	150	7	112.3	170.0	27.0	67.8	156.3
Indole	< 2.7	< 100	< 9.5	< 189	< 10	NA	< 9.4	< 200	0	ND	ND	ND	ND	ND
2-Methylnaphthalene	24	170	150	88	< 13	NA	80	87	7	87.4	170.0	13.0	37.6	137.3
1-Methylnaphthalene	25	130	110	82	< 37	NA	100	110	7	84.9	130.0	25.0	50.9	113.9
Biphenyl	25	25	20	< 189	<6.4	NA	14	21	6	18.6	25.0	6.4	11.7	25.5
Acenaphthylene	< 2.5	< 100	< 9.5	< 189	< 10	61.7	< 9.4	< 200	1	61.7	61.7	61.7	ND	ND
Acenaphthene	94	110	92	68	< 33	34.1	69	90	8	73.9	110.0	33.0	51.6	95.9
Dibenzofuran	36	34	32	25	<6.8	NA	23	32	7	27.0	36.0	6.8	18.4	35.6
Fluorene	26	31	29	22	<6.8	6.8	22	30	8	21.7	31.0	6.8	14.0	29.4
Dibenzothiophene	< 3.1	< 100	1.4	< 189	< 10	NA	2.2	< 200	2	1.8	2.2	1.4	0.0	5.4
Phenanthrene	11	15	15	< 189	<3.5	3.4	11	< 200	6	9.8	15.0	3.4	4.8	14.3
Anthracene	< 2.3	< 100	< 9.5	< 189	< 10	< 0.5	< 9.4	< 200	0	ND	ND	ND	ND	ND
Acridine	< 3.4	< 100	< 9.5	< 189	< 10	NA	< 9.4	< 200	0	ND	ND	ND	ND	ND
Carbazole	57	56	55	42	< 27	INTRFRNC	39	56	7	47.4	57.0	27.0	37.5	57.4
Fluoranthene	< 2.2	< 100	< 9.5	< 189	< 10	< 0.2	< 9.4	< 200	0	ND	ND	ND	ND	ND
Pyrene	< 2.2	< 100	< 9.5	< 189	< 10	< 0.2	< 9.4	< 200	0	ND	ND	ND	ND	ND
Benzo(a)pyrene	< 2.5	< 100	< 9.5	< 189	< 10	NA	< 9.4	< 200	0	ND	ND	ND	ND	ND
Perylene	< 2.6	< 100	< 9.5	< 189	< 10	NA	< 9.4	< 200	0	ND	ND	ND	ND	ND
TOTAL	> 2891	3802	3800	2477	3.1	732	2387	3418	9	2378.3	3802.0	732.0	1480.6	3276.1
OTHER PARAMETERS (mg/l)														
Oil & Grease	10								1	10	10	10	10	10
Phenolics	0.51	0.44	0.33	0.222	344	0.041	0.12	0.129	8	0.230	0.510	0.041	0.083	0.370
TSS	9								1	9	9	9	9	9
CUMULATIVE PUMPAGE (Millions of Gallons)	0.3	2.1	7.61	12.88	49	18.49	24.14	29.83						

Note: < - Indicates less than detectable concentrations.
NA - Not Analyzed.
ND - Not Detected.
n - # of values used in statistical computations.

AVG - Average of rep
MAX - Maximum of rep
MIN - Minimum of rep
L95% - Lower 95% Conf.
U95% - Upper 95% Conf.

PLATTEVILLE SCW (W421) (ug/l)

SAMPLE NO.	51674	59387-7	648-04	1815 59627	59946-03 & 4100-03	60034-02 & 5560-03	n	AVG	MAX	MIN	L95%	U95%
SAMPLE DATE	1/20/88	3/1/88	6/29/89	9/28	3/29/89	6/29/89						
LABORATORY	ERT	RMA	RMA	E	RMA	RMA						
								STATISTICAL EVALUATION BASED UPON DETECTABLE QUANTITIES				
CARCINOGENS												
Quinoline	< 2.9	< 100	< 9.5	< 8	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(a)anthracene	< 3.1	< 100	< 9.5	< 2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Chrysene	< 3.1	< 100	< 9.5	< 5	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzofluoranthenes	< 10	< 100	< 9.5	< 2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(a)pyrene	< 2	< 100	< 9.5	< 2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	< 2.4	< 100	< 9.5	< 5	< 9.4	< 50	0	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	< 2	< 100	< 9.5	< 3	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(ghi)perylene	< 2	< 100	< 9.5	< 5	< 9.4	< 50	0	ND	ND	ND	ND	ND
TOTAL	0	0	0	0	0	0	0	ND	ND	ND	ND	ND
OTHER PAH												
2,3-Benzofuran	5	< 100	1.9	< 8	1.5	< 50	4	2.6	5.0	1.5	0.3	4.8
2,3-Dyhydroindene	83	81	120	8	130	140	8	129.0	180.0	81.0	100.0	156.0
Indene	69	47	78	8	110	88	8	86.0	140.0	47.0	64.0	108.0
Naphthalene	410	270	510	4	470	630	9	500.4	670.0	270.0	410.2	590.7
Benzo(b)thiophene	41	42	67	8	75	73	7	63.6	80.0	41.0	50.1	77.1
Indole	< 2.7	< 100	< 9.5	< 8	< 9.4	< 50	0	ND	ND	ND	ND	ND
2-Methylnaphthalene	3	< 100	< 9.5	< 8	1.3	< 50	3	1.9	3.0	1.3	-0.1	3.9
1-Methylnaphthalene	18	15	24	8	34	38	7	27.3	38.0	15.0	19.6	35.0
Biphenyl	< 2.8	< 100	2.2	< 8	3.7	< 50	3	3.3	4.1	2.2	1.3	5.4
Acenaphthylene	< 2.5	< 100	< 9.5	< 2	< 9.4	< 50	1	44.2	44.2	44.2	44.2	44.2
Acenaphthene	10	< 100	15	5	22	26	7	18.1	26.0	10.0	12.7	23.4
Dibenzofuran	< 2	< 100	1.4	< 8	3.5	< 50	3	2.9	3.7	1.4	0.3	5.5
Fluorene	< 3	< 100	1.9	< 8	4.3	5.4	5	3.7	5.4	1.9	2.2	5.2
Dibenzothiophene	< 3.1	100	< 9.5	< 8	< 9.4	< 50	1	100.0	100.0	100.0	100.0	100.0
Phenanthrene	< 2.6	< 100	< 9.5	< 2	1.4	< 50	3	1.3	1.4	1.2	1.1	1.6
Anthracene	< 2.3	< 100	< 9.5	< 5	< 9.4	< 50	0	ND	ND	ND	ND	ND
Acridine	< 3.4	< 100	< 9.5	< 8	1	< 50	2	1.1	1.1	1.0	0.6	1.5
Carbazole	10	11	15	8	20	24	7	16.9	24.0	10.0	12.1	21.6
Fluoranthene	< 2.2	< 100	< 9.5	< 2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Pyrene	< 2.2	< 100	< 9.5	< 2	< 9.4	< 50	0	ND	ND	ND	ND	ND
Benzo(e)pyrene	< 2.5	< 100	< 9.5	< 8	< 9.4	< 50	0	ND	ND	ND	ND	ND
Perylene	< 2.6	< 100	< 9.5	< 8	< 9.4	< 50	0	ND	ND	ND	ND	ND
TOTAL	649	566	836	5	877.7	1024.4	9	811.1	1106.5	485.0	661.3	960.8
OTHER PARAMETERS (mg/l)												
Oil & Grease	?						1	?	?	?	?	?
Phenolics	0.07	0.033	< 0.05	0	0.029	0.026	7	0.037	0.070	0.026	0.024	0.049
TSS	1						1	1	1	1	1	1
CUMULATIVE PUMPAGE (Millions of Gallons)	0.38	2.14	7.3	1?	18.49	22.03						

Note: < - Designates less than detectable concentrations.
NA - Not Analyzed.
ND - Not Detected.
n - # of values used in statistical computations.
AVG - Ave
MAX - Maxi
MIN - Mini
L95% - Low
U95% - Upp

APPENDIX B

APPLICABLE ST.LOUIS PARK TREATABILITY STUDY SUMMARY TABLES

- **TABLE B-1:** CHARACTERIZATION RESULTS FOR SLP-PAH LIST, CONVENTIONAL, METALS, NUTRIENTS
- **TABLE B-2:** INFLUENT TANK (INFTNK) SAMPLING RESULTS
- **TABLE B-3:** STATISTICAL COMPILATION OF INFLUENT IRON AND MANGANESE SAMPLE RESULTS PRIOR TO POTASSIUM PERMANGANATE ADDITION
- **TABLE B-4:** SAND FILTRATION COLUMN EFFLUENT (SCFEFF) SAMPLING RESULTS
- **TABLE B-5:** PILOT-SCALE OPERATION DESIGN PARAMETERS

TABLE B-1

CHARACTERIZATION RESULTS FOR SLP-PAH LIST (NOVEMBER 30, 1988 GRAB SAMPLES)

PARAMETER	WELL DISCHARGE		
	U23	U420	U421
Reporting Limit (ug/L)	1.0	100	100
POTENTIAL CARCINOGENIC PAH (ug/L):			
Quinoline	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND
Chrysene	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND
Total Detectable	0	0	0
OTHER PAH (ug/L):			
2,3 Benzofuran	ND	ND	ND
2,3-dihydroindene	8.6	130	170
Indene	2.3	120	140
Naphthalene	16.0	500	600
Benzo(b)thiophene	3.8	ND	ND
Indole	ND	ND	ND
2-Methylnaphthalene	2.6	ND	ND
1-Methylnaphthalene	6.0	ND	ND
Biphenyl	2.1	ND	ND
Acenaphthylene	1.7	ND	ND
Acenaphthene	9.3	ND	ND
Dibenzofuran	4.7	ND	ND
Fluorene	7.5	ND	ND
Dibenzothiophene	ND	ND	ND
Phenanthrene	8.3	ND	ND
Anthracene	1.1	ND	ND
Acridine	ND	ND	ND
Carbazole	1.5	ND	ND
Fluoranthene	2.9	ND	ND
Pyrene	2.5	ND	ND
Benzo(e)pyrene	ND	ND	ND
Perylene	ND	ND	ND
Total Detectable	80.7	750	910

Note: Analyses by RMAL
ND - Not Detectable in terms of reporting limited cited.
Tables B-1, B-1 cont. correspond to Tables 4-1 and 4-2 respectively in the St. Louis Park Treatability Study Report.

TABLE B-1
(Continued)

CHARACTERIZATION RESULTS OF CONVENTIONAL, METALS AND NUTRIENT ANALYSES (NOVEMBER 30, 1988 GRAB SAMPLES)

PARAMETER	WELL DISCHARGE		
	W23	W420	W421
CONVENTIONAL (mg/L)			
Phenolics (4-AAP)	0.006	0.033	0.039
pH (units)	7.4	7.1	7.2
Total Dissolved Solids	342	644	556
Total Suspended Solids	8.77	10.0	6.00
Fixed Suspented Solids	8.77	7.00	3.00
Volatile Suspended Solids	<1.00	3.00	3.00
Chemical Oxygen Demand	50.0	<10.0	16.0
Total Organic Carbon	3.65	6.53	6.86
Oil and Grease	<6.00	<5.00	<5.00
METALS (mg/L)			
Iron-Total	1.310	2.320	1.310
Iron-Ferrous	0.129	0.148	2.820
Manganese-Total	0.082	0.466	0.287
NUTRIENTS (mg/L)			
Ortho-Phosphate as P	<0.100	<0.100	<0.100
Ammonia as N	<1.00	<1.00	<1.00
Nitrate as N	<0.020	<0.020	<0.020
Nitrite as N	<0.020	<0.020	<0.020

Note: Analyses by KER.
< - represents less than detectable concentrations.
Tables B-1, B-1 cont. correspond to Tables 4-1 and 4-2 respectively in the St. Louis Park Treatability Study Report.

TABLE B-2

INFLUENT TANK (INFTNK) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		< 0.005	0.026	0.022	0.007	*	0.009	< 0.005	< 0.005	0.024
pH (units)		7.4	7.3	7.3	7.7	7.2	7.4	7.5	7.5	7.3
Total Suspended Solids		14.0	8.00	12.0	15.0	14.0	19.0	29.0	15.0	17.0
Total Organic Carbon		6.86	17.3	101	6.14	5.68	33.0	6.59	7.35	7.48
METALS (mg/L):										
Iron-Total		1.730	1.610	1.700	1.840	1.800	1.790	2.010	1.880	1.710
Iron-Ferrous		0.166	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Iron-Filtered		< 0.100	1.750	1.890	1.820	1.800	< 0.100	< 0.100	1.920	1.700
Manganese		3.480	2.280	3.390	4.660	6.080	5.460	7.310	5.050	3.610
PAH by HPLC (ug/L):										
Carbazole	3	2.38	<2.00	<2.00	34.8	<2.00	<2.00	<2.00	23.7	<2.00
Naphthalene	2	866	885	4.22	8.18	631	494	598	691	57.2
Acenaphthylene	3	40.6	39.9	4.93	<20.0	3.70	INT	INT	<20.0	INT
Acenaphthene	3	35.9	41.3	24.9	31.9	19.0	7.39	5.68	<20.0	10.0
Fluorene	3	12.5	12.2	10.8	12.6	6.79	5.84	4.45	10.6	9.97
Phenanthrene	3	8.17	7.47	6.48	8.37	5.3	3.31	3.22	7.09	6.48
Anthracene	3	2.65	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		968.2	985.9	51.3	95.9	663.8	510.5	611.4	732.4	83.7

Note: Analyses by KER.
INT - indicates interference.
< - represents less than detectable concentrations.
* - indicates sample was damaged in shipment.
Table B-2 corresponds to Table 5-5 in the St. Louis Park Treatability Study Report.
Samples taken after potassium permanganate addition.

TABLE B-2
(Continued)

STATISTICAL COMPILATION OF INFLUENT TANK (INFTNK) SAMPLING RESULTS

PARAMETERS	n	AVG	MAX	MIN	STD	L95%	U95%
CONVENTIONAL (mg/L):							
Phenolics (4-AAP)	5	0.018	0.026	0.007	0.009	0.007	0.029
pH (units)	9	7.4	7.7	7.2	0.150	7.3	7.5
Total Suspended Solids	9	16	29	8	5.798	11	20
Total Organic Carbon	9	21	101	6	31.204	0	45
	0						
METALS (mg/L):	0						
Iron-Total	9	1.786	2.010	1.610	0.117	1.696	1.875
Iron-Ferrous	1	0.166	0.166	0.166			
Iron-Filtered	6	1.813	1.920	1.700	0.083	1.726	1.900
Manganese	9	4.591	7.310	2.280	1.564	3.389	5.793
	0						
PAH by HPLC (ug/L):	0						
Carbazole	3	20.293	34.800	2.380	16.476	0.000	61.226
Naphthalene	9	471	885	4	357.315	196	745
Acenaphthylene	4	22.283	40.600	3.700	20.755	0.000	55.304
Acenaphthene	8	22.009	41.300	5.680	13.653	10.592	33.425
Fluorene	9	9.528	12.600	4.450	3.067	7.170	11.885
Phenanthrene	9	6.210	8.370	3.220	1.910	4.742	7.678
Anthracene	1	2.650	2.650	2.650			
Fluoranthene	0	ND					
Pyrene	0	ND					
Benzo(a)anthracene	0	ND					
Chrysene	0	ND					
Benzo(b)fluoranthene	0	ND					
Benzo(k)fluoranthene	0	ND					
Benzo(a)pyrene	0	ND					
Dibenzo(a,h)anthracene	0	ND					
Benzo(g,h,i)perylene	0	ND					
Indeno(1,2,3-c,d)pyrene	0	ND					
Total Detectable PAH		523	986	51	0		

Note: Influent Tank statistical data through week 9.
n - # of values used in statistical computations.
AVG - Average of reported values.
MAX - Maximum of reported values.
MIN - Minimum of reported values.
STD - Sample standard deviation.
L95% - Lower 95% Confidence Interval Limit.
U95% - Upper 95% Confidence Interval Limit.
ND - Not Detected.

TABLE B-3

STATISTICAL COMPILATION OF INFLUENT IRON AND MANGANESE SAMPLE RESULTS PRIOR TO POTASSIUM PERMANGANATE ADDITION

PARAMETER	WEEK 1	WEEK 7	WEEK 13	n	AVG	MAX	MIN	STD	L95%	U95%
METALS (mg/l):										
Iron	1.84	2.12	1.98	3	1.980	2.120	1.840	0.140	0.000	2.328
Manganese	0.374	0.361	0.374	3	0.370	0.374	0.361	0.008	0.000	0.388

NOTE:
AVG - Average of reported values.
MAX - Maximum of reported values
MIN - Minimum of reported values.
STD - Sample standard deviation.
L95% - Lower bound 95% confidence interval limit.
U95% - Upper bound 95% confidence interval limit.
n - # of values used in statistical computations.
Analyses by Keystone Environmental Resources.

TABLE B-4

SAND FILTRATION COLUMN EFFLUENT (SFCEFF) SAMPLING RESULTS

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		0.038	0.025	0.028	0.019	< 0.005	0.009	0.044	< 0.005	0.009
pH (units)		7.2	7.5	7.4	7.5	7.6	7.8	7.5	7.5	7.4
Total Suspended Solids		8.00	4.00	1.00	< 1.00	< 1.00	5.00	3.00	1.00	3.00
Total Organic Carbon		7.35	4.41	101	11.7	5.59	7.98	6.99	7.16	8.52
METALS (mg/L):										
Iron-Total		< 0.100	6.540	< 0.100	< 0.100	< 0.100	< 0.100	0.150	< 0.100	< 0.100
Iron-Ferrous		< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Iron-Filtered		< 0.100	2.180	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Manganese		0.022	7.060	0.165	0.041	0.031	0.256	0.248	0.160	0.095
PAH by HPLC (ug/L):										
Carbazole	3	2.49	<2.00	<2.00	<2.00	INT	INT	INT	18.7	INT
Naphthalene	2	749	950	311	110	554	672	10.2	732	876
Acenaphthylene	3	34.0	44.9	17.3	<2.00	6.07	INT	INT	<20.0	INT
Acenaphthene	3	31.0	50.2	38.0	<2.00	19.9	14.4	<2.00	<20.0	14.7
Fluorene	3	9.83	13.8	11.6	9.63	6.74	11.4	13.1	9.25	11.3
Phenanthrene	3	5.66	9.16	5.43	1.81	4.76	6.73	4.72	7.02	8.25
Anthracene	3	<0.500	0.503	<0.500	<0.500	<0.500	<0.500	2.21	<0.500	<0.500
Fluoranthene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	0.218	<0.200	<0.200
Pyrene	4	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	0.262	0.204	<0.200
Benzo(a)anthracene	4	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		825.98	1068.5	383.33	121.44	591.47	704.58	30.71	767.17	910.25

PARAMETERS	NO. OF PAH RINGS	ANALYTICAL WEEK WK13	WK17	WK21	WK28	WK30
CONVENTIONAL (mg/L):						
Phenol (4-AAP)		0.016	< 0.005	0.012	0.017	<0.5
PAH by HPLC (ug/L):						
Carbazole	3	9.12	8.97	<2.00	471	65
Naphthalene	2	583	47.5	<2.00	960	460
Acenaphthylene	3	55.6	137	<2.00	<20.0	<20.0
Acenaphthene	3	44.7	<20.0	31.8	<20.0	88
Fluorene	3	12.7	13.7	11.3	22.4	22.2
Phenanthrene	3	8.73	11	6.96	13.4	9.5
Anthracene	3	<0.500	<0.500	<0.500	1.200	1.270
Fluoranthene	4	0.355	<0.200	<0.200	<0.200	0.560
Pyrene	4	<0.200	<0.200	<0.200	0.854	1.710
Benzo(a)anthracene	4	0.039	<0.020	<0.020	<0.020	<0.020
Chrysene	4	<0.150	<0.150	<0.150	<0.150	<0.150
Benzo(b)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(k)fluoranthene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Benzo(a)pyrene	5	<0.020	<0.020	<0.020	<0.020	<0.020
Dibenzo(a,h)anthracene	5	<0.030	<0.030	<0.030	<0.030	<0.030
Benzo(g,h,i)perylene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050	<0.050	<0.050	<0.050
Total Detectable PAH		714.23	218.17	50.06	1488.8	648.24

Note: Analyses by KER
INT - indicates Interference.
< - represents less than detectable concentrations.
Table B-3 corresponds to Table 5-6 in the St. Louis Park Treatability Study Report.

TABLE B-4
(Continued)

STATISTICAL COMPILATION OF SAND FILTRATION COLUMN EFFLUENT (SFCEFF) SAMPLING RESULTS

PARAMETERS	n	AVG	MAX	MIN	STD	L95%	U95%
CONVENTIONAL (mg/L):							
Phenolics (4-AAP)	9	0.022	0.044	0.009	0.012	0.013	0.030
PAH by HPLC (ug/L):							
Carbazole	6	95.5	471	2.49	185	0	306
Naphthalene	13	541	980	10.2	334	339	743
Acenaphthylene	6	49.1	137	6.07	47	0	98
Acenaphthene	9	36.9	88.0	14.4	22.9	19.4	54.6
Fluorene	14	12.8	22.4	6.74	4.5	10.3	15.3
Phenanthrene	14	7.36	13.4	1.81	2.9	5.7	9.0
Anthracene	3	1.29	2.21	0.503	0.7	0.2	2.4
Fluoranthene	3	0.378	0.560	0.218	0.172	0	0.805
Pyrene	4	0.758	1.710	0.204	0.700	0	1.871
Benzo(a)anthracene	1	0.033	0.033	0.033			
Chrysene		ND					
Benzo(b)fluoranthene		ND					
Benzo(k)fluoranthene		ND					
Benzo(a)pyrene		ND					
Dibenzo(a,h)anthracene		ND					
Benzo(g,h,i)perylene		ND					
Indeno(1,2,3-c,d)pyrene		ND					
Total Detectable PAH		609	1489	31	417	368	849

Note: Sand Filter Column Effluent statistical data through week 30.
n - Number of samples used to compute respective statistics.
AVG - Average of reported values.
MAX - Maximum reported value.
MIN - Minimum reported value.
STD - Sample standard deviation.
U95% - Upper bound 95% confidence limit.
L95% - Lower bound 95% confidence limit.
ND - Not Detected.
Table B-4 corresponds to Table 6-4 in the Engineering Evaluation Report [1].

TABLE B-5

PILOT-SCALE OPERATION DESIGN PARAMETERS

I.	**CHEMICAL OXIDATION/SAND FILTRATION PRETREATMENT**	
•	$KMnO_4$ Dosage	1.16 mg/$KMnO_4$/mg Fe 2.16 mg/$KMnO_4$/mg Mn
•	Sand Filter Hydraulic Loading	1.15 gpm/ft^2 (downflow)
•	Filter Media	
	- Anthracite	
	Effective Size	0.9 mm
	Uniformity Coefficient	1.70
	- Pool Sand	
	Effective Size	0.48
	Uniformity Coefficient	1.46
•	Intermittent Daily Backwash	21% of Applied Daily Flowrate
II.	**ACTIVATED CARBON COLUMN TREATMENT**	
•	Mesh Size	12 x 40
•	Hydraulic Loading	2.9 gpm/ft^2
•	Empty Bed Contact Times	AC1 = 7.5 minutes AC2 = 7.5 minutes AC3 = 10 minutes Total = 25 minutes
•	Carbon Usage	
	- Phenolics (week 22 through 28)	0.133 - 0.103 lb. carbon/1000 gal. treated 0.0014 - 0.0018 lb. phenolics/lb. carbon
	- Naphthalene (week 30)	0.096 lb. carbon/1000 gal. treated 0.047 lb. naphthalene/lb. carbon

NOTE: Table B-5 corresponds to Table 6-2 in St. Louis Park Treatability Study Report.

APPENDIX C

DYNASAND FILTER PILOT-SCALE TEST REPORT

DYNASAND FILTER PILOT-SCALE TEST REPORT FOR TREATMENT OF PUMPED GROUNDWATERS AT ST. LOUIS PARK, MINNESOTA

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ReTeC Project No: E90-352-300

MARCH, 1990

TABLE OF CONTENTS

NO.	DESCRIPTION	PAGE
1.0	INTRODUCTION	1
2.0	PROCEDURES	2
3.0	RESULTS AND DISCUSSION	12
3.1	On-Site Operational Monitoring Results	12
3.2	Influent and Effluent Analytical Results	17
3.3	Backwash Analytical Results	26
4.0	SUMMARY AND CONCLUSIONS	32

LIST OF TABLES

NO.	DESCRIPTION	PAGE
2-1	DynaSand Pilot Test Operating Parameters	5
2-2	Sample and Analysis Summary for DynaSand Filter	8
2-3	Sample of Daily Monitoring Record Sheet	9
2-4	Analytical Methods and Detection Limits	11
3-1	Daily Monitoring Record - DynaSand Pilot Test (10/26/89 through 10/28/89)	13
3-2	Daily Monitoring Record - DynaSand Pilot Test (10/29/89 through 10/31/89)	14
3-3	Daily Monitoring Record - DynaSand Pilot Test (11/01/89 through 11/03/89)	15
3-4	Daily Monitoring Record - DynaSand Pilot Test (11/04/89 through 11/06/89)	16
3-5	Summary of Analytical Results from DynaSand Filter Pilot Test	18
3-6	St. Louis Park - PAH Results from DynaSand Pilot Test	19
3-7	Statistical Compilation of Influent and Effluent Data	20
3-8	Statistical Compilation of Backwash Stream Data	27

LIST OF FIGURES

NO.	DESCRIPTION	PAGE
2-1	Pilot-Scale DynaSand Filter System Schematic	3
2-2	Pilot-Scale Activated Carbon Treatment System Schematic	4
2-3	Sampling Schedule for DynaSand Pilot Test	7
3-1	Influent and Effluent TSS Concentration -vs- Operating Days	22
3-2	Influent and Effluent Iron Concentration -vs- Operating Days	23
3-3	Influent and Effluent Manganese Concentrations -vs- Operating Days	25
3-4	Backwash Stream TSS Concentration -vs- Operating Days	28
3-5	Backwash Stream Iron Concentration -vs- Operating Days	29
3-6	Backwash Stream Manganese Concentration -vs- Operating Days	31

1.0 INTRODUCTION

A study was conducted in order to evaluate the performance of a continuous backwashing type sand filter on pumped groundwaters associated with the St. Louis Park, Minnesota, Superfund site. This study was conducted by Remediation Technologies, Inc. (ReTeC) for Reilly Industries, Inc., during October/November, 1989. The purpose of the study was to specifically field test a Parkson Corporation DynaSand continuous backwashing type filter and to evaluate its performance with respect to suspended solids, iron, and manganese removal.

This study was conducted in conjunction with a pilot carbon column treatment system study for the treatment of pumped groundwaters from the St. Louis Park site. The objectives of the DynaSand study were:

(i) to evaluate suspended solids removal and thus protect the carbon column treatment process from operation problems;

(ii) to evaluate iron and manganese removal; and

(iii) to generate permit monitoring data with respect to the DynaSand filter continuous backwash stream.

This report presents the procedures and results of the DynaSand filter study. Section 2.0 presents the study methods and procedures. This is followed by Section 3.0 which presents the results of the study. Section 4.0 provides a summary and conclusions.

2.0 PROCEDURES

The on-site study was conducted from October 26, 1989, through November 6, 1989, by ReTeC personnel with assistance from St. Louis Park City personnel. The study was performed at the St. Louis Park site at the location of gradient control wells W420 and W421. A pilot-scale DynaSand filter was set up, operated, and monitored for a period of approximately twelve days in order to collect performance data. A schematic diagram of the DynaSand filter set-up is presented in Figure 2-1 and the pilot carbon column treatability set-up performed concurrently is presented in Figure 2-2. Table 2-1 summarizes the operating parameters for both a full-scale 140 gpm DynaSand filter proposed for this application and the 39 gpm pilot unit operated.

As cited in Table 2-1 and Figure 2-1, the total influent flowrate to the DynaSand unit was approximately 39 gpm of flow proportioned groundwater from wells W420 and W421 at 62.5 percent and 37.5 percent, respectively. A 0.1 molar potassium permanganate ($KMnO_4$) solution was added to the influent stream at 28 ml/minute corresponding to an assumed $KMnO_4$:Iron (Fe) ratio of approximately 1:1 and an assumed $KMnO_4$:Manganese (Mn) ratio of approximately 2:1. At these cited flowrates, the concentration of $KMnO_4$ in the influent line to the sand filter is computed at approximately 3 mg/L. After mixing of the applied flow and the $KMnO_4$ via an in-line static mixer, the flow was applied to the bottom of the pilot sand filter at a hydraulic loading of approximately 3.6 gpm/ft^2. A continuous 8 gpm backwash stream was discharged to a sanitary sewer as was the remaining 31 gpm of filtered effluent. A minimal flowrate of approximately 0.1 gpm was also fed to the second in-series pilot-scale carbon column system illustrated in Figure 2-2.

At an influent flowrate of 39 gpm, the backwash flowrate was 8 gpm, or approximately 21 percent of the applied flow. For a full-scale process treating 140 gpm, the backwash flow would be 10 gpm, or approximately 7 percent of the applied flow. The reason for these two different backwash flowrates being approximately the same with different applied flowrates is because the backwashing mechanism in any DynaSand filter is basically the same unit requiring nearly the same backwash rate. Operation and monitoring of the DynaSand filter was performed to evaluate its performance with

FIGURE 2-1

PILOT-SCALE DYNASAND FILTER SYSTEM SCHEMATIC

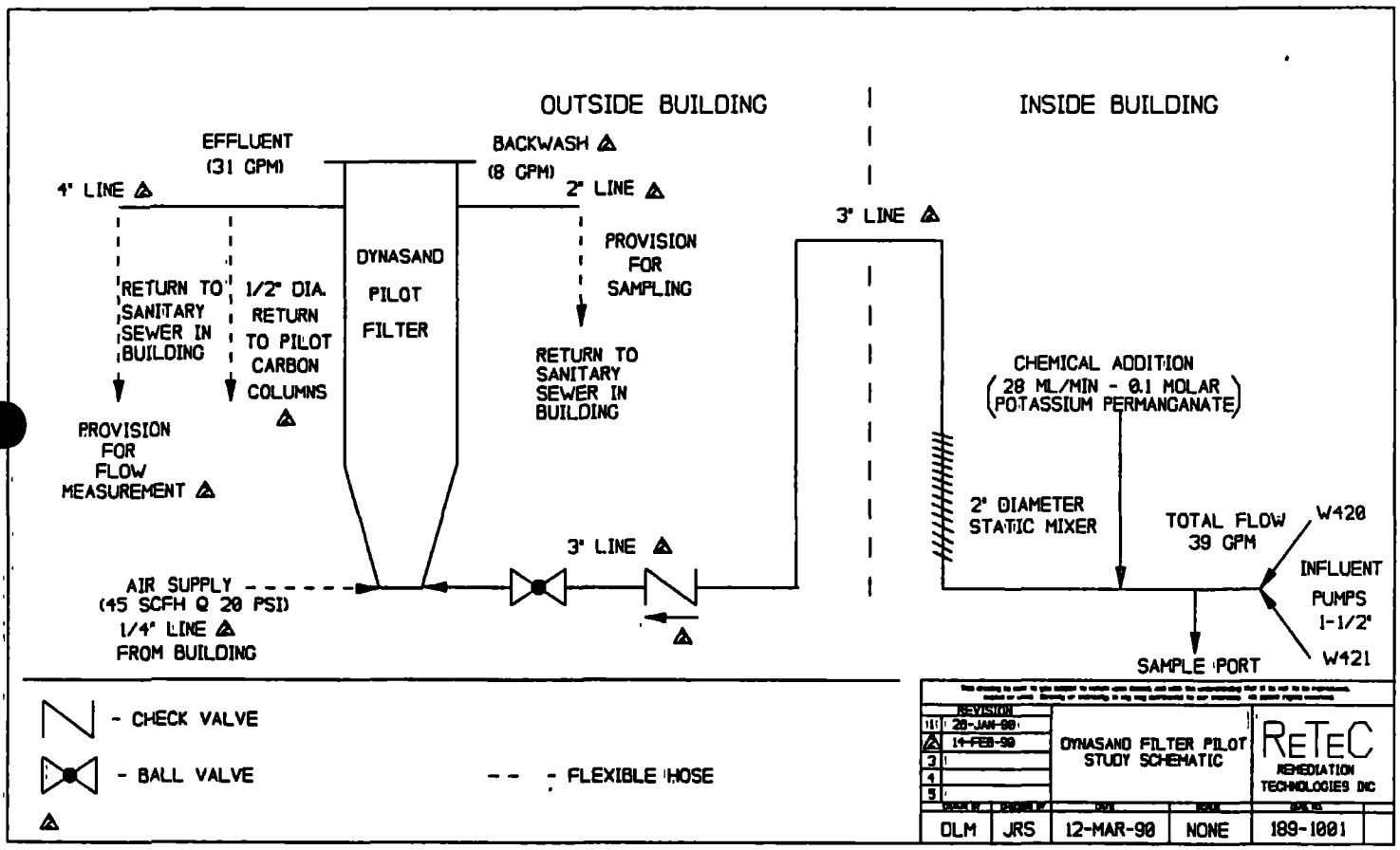


FIGURE 2-2

PILOT-SCALE ACTIVATED CARBON TREATMENT SYSTEM SCHEMATIC

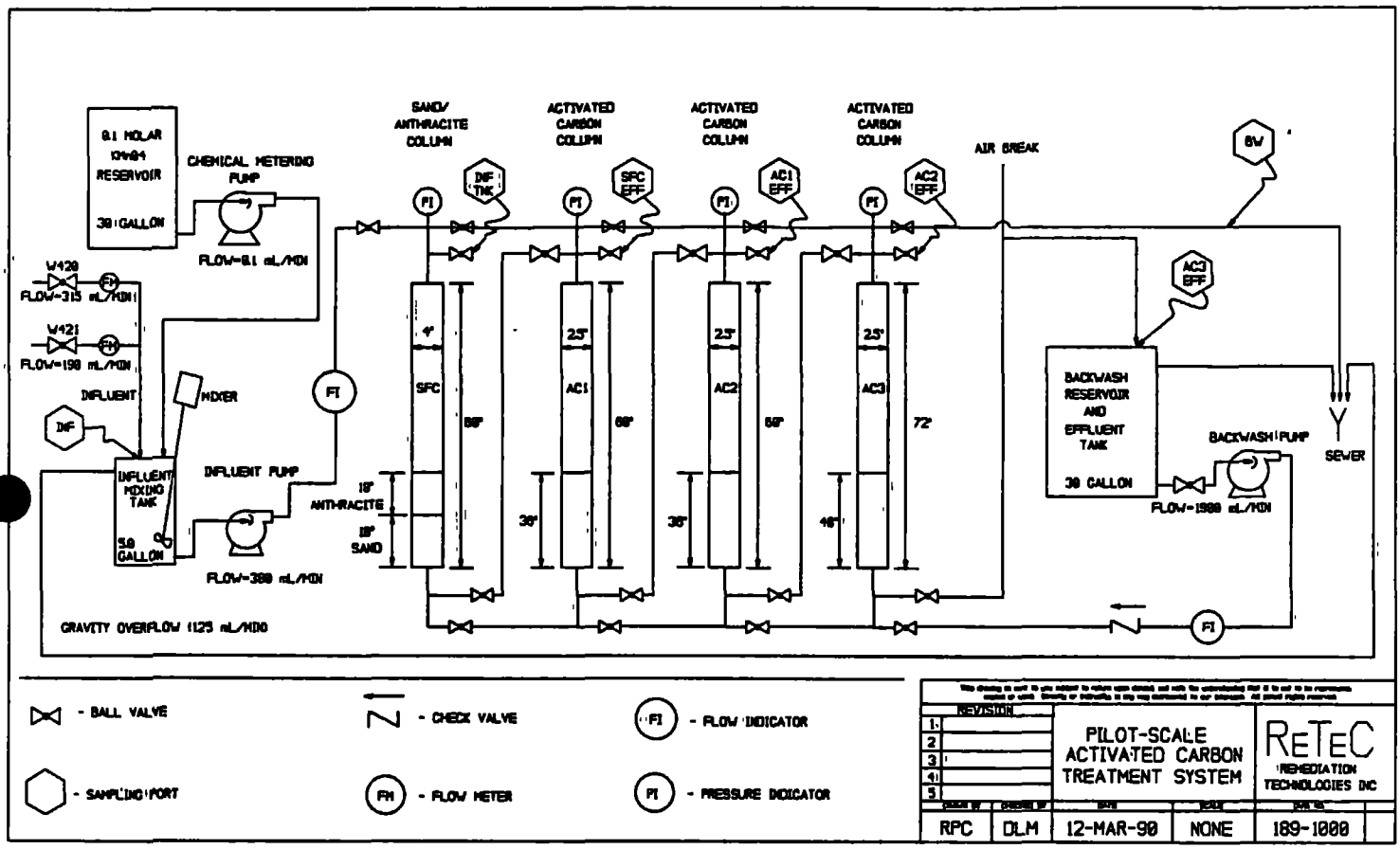


TABLE 2-1

DYNASAND PILOT TEST OPERATING PARAMETERS

PARAMETERS	FULL-SCALE	PILOT-SCALE
W420 Flow (gpm)	50 (62.5%)[a]	24.5 (62.5%)[a]
W421 Flow (gpm)	30 (37.5%)[a]	14.5 (37.5%)[a]
Total Flow (gpm)	140[b]	39
Hydraulic Loading (gpm/ft^2)	3.6	3.6
Backwash Flowrate (gpm)	10 (7%)[c]	8 (21%)[c]
$KMnO_4$ Dosage ($KMnO_4$:X)		
X = Iron	1:1	1:1
X = Manganese	2:1	2:1
Sand Media		
Effective Size (E.S.) (mm)	0.9	0.9
Uniformity Coefficient (U.C.)	< 1.5	< 1.5

NOTE: [a] % of total flow of W420 and W421.
[b] Total design flow of W23, W420 and W421.
[c] % of backwash flowrate as respective total flowrate.

regard to the effluent quality attainable and to determine the chemical characteristics of the backwash stream for POTW permitting considerations. Figure 2-3 details a sampling schedule for the pilot-test and Table 2-2 provides an analytical summary of the different streams monitored. As cited, monitoring involved both periodic analysis by outside laboratories and on-site operational monitoring performed daily. Table 2-3 is a sample of the record sheet used to record all on-site daily measurements. All on-site measurements and samples were obtained by ReTeC personnel, while all analytical work was performed by Keystone Environmental Resources, Inc. (KER) laboratory and Rocky Mountain Analytical Laboratory (RMAL) location in Monroeville, Pennsylvania, and Arvada, Colorado, respectively. Table 2-4 shows the analytical parameters, test methods, and detection limits used by each laboratory. All respective samples taken were grab samples with the samples packed on ice and shipped overnight delivery to the respective laboratory under proper chain-of-custody procedures.

FIGURE 2-3

SAMPLING SCHEDULE FOR DYNASAND PILOT TEST

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
OCT. 22	OCT. 23 UNIT TO ARRIVE	OCT. 24 SET-UP	OCT. 25 PIPE	OCT. 26 START-UP [I-1] [E-1] [B-1]	OCT. 27	OCT. 28 [I-1,3,4] [E-1,3,4] [B-1,2,3,4]
OCT. 29	OCT. 30 [I-1] [E-1] [B-1]	OCT. 31 [I-1] [E-1] [B-1]	NOV. 1 [I-1] [E-1] [B-1,2,3,4]	NOV. 2	NOV. 3 [I-1] [E-1] [B-1]	NOV. 4 [I-1] [E-1] [B-1]
NOV. 5	NOV. 6 [I-1,3,4] [E-1,3,4] [B-1,2,3,4] SHUT-DOWN	NOV. 7	NOV. 8 UNIT TO SHIP	NOV. 9	NOV. 10	NOV. 11

NOTES: [X-X] DESIGNATES [STREAM-PARAMETER]

I - INFLUENT
E - EFFLUENT
B - BACKWASH

1 - pH, TSS/VSS/FSS, TOTAL Fe, TOTAL Mn.
2 - COD
3 - SLP-PAH (ppt DETECTION LIMIT)
4 - PHENOLICS (4-AAP)

REVISION				
1	15-FEB-90	SAMPLING SCHEDULE FOR DYNASAND PILOT FILTER FIELD TEST		RETEC REMEDIATION TECHNOLOGIES INC
2				
3				
4				
5				
DRAWN BY	CHECKED BY	DATE	SCALE	DWG. NO.
BJH	DLM	17-OCT-89	NONE	199-1997

TABLE 2-2

SAMPLE AND ANALYSIS SUMMARY FOR DYNASAND FILTER

	NUMBER OF ANALYSIS				
WASTE STREAM	INFLUENT	EFFLUENT	BACKWASH	DYNASAND FILTER	PILOT CARBON COLUMN
Analysis:					
pH	8	8	8	--	--
Total Suspended Solids (TSS)	8	8	8	--	--
Fixed Suspended Solids (FSS)	8	8	8	--	--
Volatile Suspended Solids (VSS)	8	8	8	--	--
Iron (Fe)	8	8	8	--	--
Manganese (Mn)	8	8	8	--	--
Phenolics (4-AAP)	2	2	3	--	--
Chemical Oxygen Demand (COD)	---	---	3	--	--
PAH (St. Louis Park list)	2	2	3	--	--
On-Site Measurements:					
pH	12	12	12	--	11
Dissolved Oxygen (D.O)	12	12	12	--	10
Iron (test kit)	12	12	12	--	--
Manganese (test kit)	12	12	11	--	--
$KMnO_4$ Dosage	12	--	--	--	--
Headloss	--	--	--	12	11
Water Flowrate	12	12	12	--	--
Air Flowrate	--	--	--	12	--
Conductivity	--	--	--	--	11

TABLE 2-3

SAMPLE OF DAILY MONITORING RECORD SHEET

DynaSand Pilot Test - St. Louis Park, MN

Day: _____ Date: _____

Wells - Influent (I):

	W420	W421
Flow Each	_____ GPM	_____ GPM
Total Combined Flow	_____ GPM	
Iron Concentration	_____ mg/L	
Manganese Concentration	_____ mg/L	
pH	_____ Units	
Dissolved Oxygen	_____ mg/L	

Potassium Permanganate:

Dosage	_____ ml/min	_____ Molar

DynaSand Filter Backwash(B):

Flow (Time in Bucket)	_____ GPM
Iron Concentration	_____ mg/L
Manganese Concentration	_____ mg/L
pH	_____ Units
Dissolved oxygen	_____ mg/L

TABLE 2-3 (Continued)

SAMPLE OF DAILY MONITORING RECORD SHEET

DynaSand Pilot Test - St. Louis Park, MN

Day: _____ Date: _____

DynaSand Filter - Effluent:

Flow (Influent - Backwash)	_____	GPM
Iron Concentration	_____	mg/L
Manganese Concentration	_____	mg/L
pH	_____	Units
Dissolved Oxygen	_____	mg/L

Headloss:

DynaSand Filter	_____	Inches
Carbon Column #2	_____	PSIG
Carbon Column #3	_____	PSIG

Air Rate - DynaSand Filter:	_____	SCFH on Filter
	_____	PSIG on Compressor

Carbon Column Effluent:

pH	_____	Units
Dissolved Oxygen	_____	mg/L
Note Time of Day	_____	HR:MIN (24 Hour Clock)

TABLE 2-4

ANALYTICAL METHODS AND DETECTION LIMITS

KEYSTONE ENVIRONMENTAL RESOURCES, INC.

PARAMETER	METHOD	DETECTION LIMIT
pH	EPA 150.1	--
Suspended Solids	EPA 160.2	1 mg/L
Iron	EPA 200.7	0.1 mg/L
Manganese	EPA 200.7	0.015 mg/L

ROCKY MOUNTAIN ANALYTICAL LABORATORY

PARAMETER	METHOD	DETECTION LIMIT
Phenolics (4-AAP)	EPA 420.1	10 μg/L
Chemical Oxygen Demand	EPA 410.4	5 mg/L
Polynuclear Aromatic Hydrocarbons (SLP-PAH List)	EPA 8270	10-20 μg/L

3.0 RESULTS AND DISCUSSION

This section presents results of the on-site operational monitoring, and analytical monitoring of the DynaSand filter influent, effluent, and backwash streams.

3.1 ON-SITE OPERATIONAL MONITORING RESULTS

The on-site monitoring results are presented in Tables 3-1 through 3-4 with each table providing recorded data for three consecutive days. Results indicate that the influent flowrate ranged between 35 through 39 gpm, the backwash flowrate remained near 8 gpm and the treated effluent ranged between 27 and 31 gpm. Test kit iron and manganese (EM Science) results showed that the influent iron concentration ranged from 0 to 10 mg/L and was not detected in the effluent except for the last day where an effluent concentration of less than 3 mg/L was noted. However, the backwash iron concentrations normally ranged from 3 to 25 mg/L by test kit analysis. This indicated that the iron was in fact being removed from the sand column and discharged with the solids in the backwash stream.

Additionally, pH remained relatively constant in the influent, effluent, and backwash streams. Also, dissolved oxygen increased across the DynaSand unit with both the effluent and backwash values being approximately 2-3 mg/L higher than the influent. In terms of $KMnO_4$, a computed concentration ranging between 3.0 to 3.34 mg/L was maintained in the influent to the sand filter.

In terms of headloss, the data in Tables 3-1 through 3-4 show that the headloss generally remained within 17.0 to 17.5 inches of water for the majority of the days monitored. The most notable exception is to be noted for November 3, 1989, when the headloss increased to 19.5 inches of water. This drastic increase was attributed to the fact that the air flowrate associated with the backwashing mechanism dropped to 30 SCFH due to a sudden drop in air temperature which affected the operating efficiency of the air compressor. This situation was rectified on November 4, 1989, with the air flowrate back up to 60 SCFH; generally the air flowrate operated near 45 SCFH at 20 psig pressure.

TABLE 3-1

DAILY MONITORING RECORD - DYNASAND PILOT TEST (10/26/89 THROUGH 10/28/89)

DYNASAND PILOT FILTER TEST ST. LOUIS PARK, MN	10-26-89			10-27-89			10-28-89		
	Influent	Backwash	Effluent	Influent	Backwash	Effluent	Influent	Backwash	Effluent
Sampler's Name	Dan Miller			Dan, Scott Anderson, Mike Higgins			Scott		
Flow Rates (gpm) Well 420 Well 421 Total	 26 18 39	 0	 31	 26 18 39	 0	 31	 26 18 39	 0	 31
Iron Conc. - test kit (mg/l) Manganese Conc. - test kit (mg/l)	3-10 ND	10-25 NS	ND ND	3-10 ND	10-25 ND	ND ND	3-10 ND	10-25 ND	ND ND
pH (units)	6.9	7.2	7.0	6.9	6.9	6.9	6.9	7.0	7.0
DO (mg/l)	1.0	0.5	7.5	2.6	7.9	6.9	4.3	8.0	7.0
Potassium Permanganate Dosage (molar) (ml/min) (mg/L)		0.1 20 3			0.1 20 3			0.1 20 3	
Headloss DynaSand Filter (inches water) Carbon Column #2 (PSIG) Carbon Column #3 (PSIG)		17.0 NA NA			17.0 <1.0 <1.0			17.5 1.0 <1.0	
Air Rate DynaSand Filter (SCFM) (PSIG)		45 20			44 20			44 20	
Carbon System Effluent pH (units) DO (mg/l) Conductivity (umhos)		NA NA NA			7.1 2.5 NS			7.0 0.9 1100	
Time of Day (24 hour clock)		19:43			14:24			11:20	
COMMENTS:	Effluent from the sand filter is going directly to the sanitary sewer. No Sample for analytical work will be taken tonight, due to the unavailability of a refrigerator this evening.			A bleed stream of the effluent from the sand filter is being passed through carbon columns 2 and 3 of the treatability pilot unit. Conditions are the same as during the treatability testwork. Day 1 analytical samples were collected today. Influent, Effluent and Reject to Keystone Environmental. (a)			Everything is operating fine. Mixed a batch of potassium permanganate per instructions. Analytical sample taken. Influent, Effluent and Reject to Keystone Environmental. (a) Influent, Effluent and Reject to Rocky Mountain Analytical. (b)		

NOTES:

NA - Not Applicable.
ND - Not Detectable.
NS - No Sample Taken.

(a) - Analyzed for pH, TSS/VSS/FSS, Total Iron and Manganese.
(b) - Analyzed for SLP-PAHs, Phenolics and COD (Reject only).

TABLE 3-2

DAILY MONITORING RECORD - DYNASAND PILOT TEST (10/29/89 THROUGH 10/31/89)

DYNASAND PILOT FILTER TEST ST. LOUIS PARK, MN	10-29-89			10-30-89			10-31-89		
	Influent	Backwash	Effluent	Influent	Backwash	Effluent	Influent	Backwash	Effluent
Sampler's Name	Scott			Mike			Mike		
Flow Rates (gpm)									
Well 420	26			25			25		
Well 421	15			14			15		
Total	36	9	27	36	8	28	36	8	28
Iron Conc. - test kit (mg/l)	3	25	ND	10	10-25	ND	3-10	3-10	ND
Manganese Conc. - test kit (mg/l)	ND	ND	ND	ND	0-5	ND	0-5	0-5	0-5
pH (units)	7.0	7.1	7.1	6.8	6.9	6.9	6.8	7.0	7.0
DO (mg/l)	3.4	8.4	7.5	6.7	8.7	NS	4.5	8.2	7.6
Potassium Permanganate Dosage									
(molar)		0.1			0.1			0.1	
(ml/min)		28			28			28	
(mg/L)		3.25			3.25			3.25	
Headloss									
DynaSand Filter (inches water)		17.5			17.0			17.5	
Carbon Column #2 (PSIG)		1.0			1.5			1.5	
Carbon Column #3 (PSIG)		<1.0			<1.0			1.0	
Air Rate DynaSand Filter									
(SCFM)		40			45			45	
(PSIG)		20			20			20	
Carbon System Effluent									
pH (units)		7.1			7.0			7.0	
DO (mg/l)		1.8			1.8			2.0	
Conductivity (umhos)		1100			1050			1025	
Time of Day (24 hour clock)		11:10			10:45			10:40	
COMMENTS:	Reject color is darker. Mixed a batch of potassium permanganate per instructions. Day 5 samples taken today. Influent, Effluent and Reject to Keystone Environmental. (a)			Samples taken Day 4.			Samples taken. Influent, Effluent and Reject to Keystone Environmental. (a)		

NOTES:

NA - Not Applicable.
ND - Not Detectable.
NS - No Sample Taken.

(a) - Analyzed for pH, TSS/VSS/FSS, Total Iron and Manganese.
(b) - Analyzed for SLP-PAHs, Phenolics and COD (Reject only).

TABLE 3-3

DAILY MONITORING RECORD - DYNASAND PILOT TEST (11/01/89 THROUGH 11/03/89)

DYNASAND PILOT FILTER TEST ST. LOUIS PARK, MN	11-1-89			11-2-89			11-3-89		
	Influent	Backwash	Effluent	Influent	Backwash	Effluent	Influent	Backwash	Effluent
Sampler's Name	Mike			Mike			Mike		
Flow Rates (gpm)									
Well 420	25			25			26		
Well 421	14			14			14		
Total	35	8	27	36	7	29	36	17	19
Iron Conc. - test kit (mg/l)	0-3	3-10	ND	3-10	10-25	ND	3-10	3-10	ND
Manganese Conc. - test kit (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND
pH (units)	6.9	6.9	7.0	6.8	6.8	6.8	6.9	6.9	6.9
DO (mg/l)	3.2	8.9	8.0	4.3	8.3	8.2	4.2	7.9	8.0
Potassium Permanganate Dosage									
(molar)		0.1			0.1			0.1	
(ml/min)		28			28			28	
(mg/L)		3.34			3.25			3.25	
Headloss									
DynaSand Filter (inches water)		17.0			15.5			15.5	
Carbon Column 02 (PSIG)		2.0			2.5			3.5	
Carbon Column 03 (PSIG)		1.0			1.5			1.5	
Air Rate DynaSand Filter									
(SCFM)		60			45			30	
(PSIG)		20			20			20	
Carbon System Effluent									
pH (units)		7.0			6.9			7.0	
DO (mg/l)		1.0			NS			1.2	
Conductivity (umhos)		1050			1050			1050	
Time of Day (24 hour clock)		12:40			12:40			13:20	
COMMENTS:		Adjusted air rate back to 45 SCFM. Reject very dark. Samples taken. Influent, Effluent and Reject to Keystone Environmental. (a) Reject to Rocky Mountain Analytical. (b)						Could not increase air rate to filter. Very cold. Sand not moving properly. Reject flow high, effluent rate low. Took steps to correct problem. Wrapped with heat tape and added weir to reject. 8 degree F, wind chill. Headloss gauge on filter frozen. Samples taken. Influent, Effluent and Reject to Keystone Environmental. (a)	

NOTES:

NA - Not Applicable.
ND - Not Detectable.
NS - No Sample Taken.

(a) - Analyzed for pH, TSS/VSS/FSS, Total Iron and Manganese.
(b) - Analyzed for SLP-PAHs, Phenolics and COD (Reject only).

TABLE 3-4

DAILY MONITORING RECORD - DYNASAND PILOT TEST (11/04/89 THROUGH 11/06/89)

DYNASAND PILOT FILTER TEST ST. LOUIS PARK, MN	11-4-89			11-5-89			11-6-89		
	Influent	Backwash	Effluent	Influent	Backwash	Effluent	Influent	Backwash	Effluent
Sampler's Name	Mike			Mike			Scott		
Flow Rates (gpm)									
Well 420	22			22			24		
Well 421	14			15			15		
Total	36	6	30	35	7	28	35	8	28
Iron Conc. - test kit (mg/l)	3-10	10-25	ND	3-10	3-10	ND	3-10	3-10	0-3
Manganese Conc. - test kit (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND
pH (units)	6.9	7.1	7.0	7.0	7.0	7.0	7.0	7.1	7.1
DO (mg/l)	5.0	6.7	8.0	2.6	9.0	7.5	3.0	8.0	7.0
Potassium Permanganate Dosage									
(molar)	0.1			0.1			0.1		
(ml/min)	26			26			28		
(mg/L)	3.25			3.34			3.25		
Headloss									
DynaSand Filter (inches water)	17.0			18.0			18.0		
Carbon Column 02 (PSIG)	5.5			10.0			1.5		
Carbon Column 03 (PSIG)	3.0			4.0			1.0		
Air Rate DynaSand Filter									
(SCFM)	60			45			45		
(PSIG)	20			20			20		
Carbon System Effluent									
pH (units)	7.0			7.0			6.9		
DO (mg/l)	1.7			7.5			1.5		
Conductivity (umhos)	1000			1025			1000		
Time of Day (24 hour clock)	11:00			10:40			07:45		
COMMENTS:	Reject very dark. Everything else okay. 45 degrees F. Sample taken. Influent, Effluent and Reject to Keystone Environmental. (a)			Carbon column 02 very low of water. Also, 03 is low. Water on floor, bad hose on feed pump. Changed hose. Backwashed columns 02 and 03. This removed any air. Pressures now at 1 and 1.			Everything okay. Samples taken. Influent, Effluent and Reject to Keystone Environmental. (a) Influent, Effluent and Reject to Rocky Mountain Analytical. (b)		

NOTES:

NA - Not Applicable.
ND - Not Detectable.
NS - No Sample Taken.

(a) - Analyzed for pH, TSS/VSS/FSS, Total Iron and Manganese.
(b) - Analyzed for SLP-PAHs, Phenolics and COD (Reject only).

This sudden drop in air flowrate affected the air lift mechanism within the DynaSand filterwhich is needed for removal of accumulated suspended solids via the backwash stream. Without a sufficient air flowrate to properly lift and wash suspended solids from the filtration media, suspended solids accumulated. Rectifying the situation on November 4, 1989, resulted in the accumulated suspended solids being present in both the backwash and effluent streams at higher than normal concentrations. This also resulted in the headlosses for Carbon Column 2 and 3 having significant increases on November 4 and November 5, 1989. On November 5, 1989, the carbon columns were backwashed with the situation returned to normal on November 6, 1989. Thus, it is concluded, based on operational monitoring data, that the DynaSand filter was operated for approximately nine (9) days without incident and when an upset condition did manifest itself, it was easily rectified. Further discussions as to the effect the reduced air flowrate had on the analytical parameters monitored (e.g., TSS) for are provided in the next two sub-sections.

Lastly, on-site monitoring data show that the dissolved oxygen (D.O.) concentration did decrease across the pilot-scale carbon columns generally within a range of 1 to 2 mg/L, substantially lower than the sand filter effluent range of 7 to 8 mg/L. Such a decrease in D.O. was not observed during the pilot-scale treatability work performed. In terms of pH, no change was noted across the sand filter or carbon columns.

3.2 INFLUENT AND EFFLUENT ANALYTICAL RESULTS

All analytical results for the twelve (12) day study period are given in Tables 3-5 and 3-6. Table 3-5 gives a summary of the influent, effluent, and backwash streams; Table 3-6 gives the individual SLP-PAH results for these same three streams.

Table 3-7 gives a statistical compilation summary of data given in Table 3-5. The influent values support that the respective concentrations cited did not change significantly over the twelve day study period. As expected, no Potentially Carcinogenic PAHs were detected with naphthalene being the predominant Other PAH compound as cited in Table 3-6.

TABLE 3-5

SUMMARY OF ANALYTICAL RESULTS FROM DYNASAND FILTER PILOT TEST

DATE SAMPLED	10-27-89	10-28-89	10-29-89	10-31-89	11-01-89	11-03-89	11-04-89	11-06-89
INFLUENT								
pH, units	7.1	7.3	7.4	7.4	7.2	7.3	7.3	7.3
Total Suspended Solids, mg/L	11	7	4	8	2	3	9	1
Fixed Suspended Solids, mg/L	0	0	0	0	0	0	0	0
Volatile Suspended Solids, mg/L	11	7	4	8	2	3	9	1
Iron, mg/L	2.12	2.16	2.13	2.16	2.12	2.21	2.12	2.14
Manganese, mg/L	0.38	0.38	0.38	0.39	0.38	0.38	0.38	0.38
Phenolics, mg/L	-	0.18	-	-	-	-	-	0.09
Total Detectable Potential Carcinogenic PAH μg/L	-	BDL	-	-	-	-	-	BDL
Total Detectable Other PAH, μg/L[a]	-	2755	-	-	-	-	-	2661
EFFLUENT								
pH, units	7.3	7.4	7.3	7.5	7.4	7.4	7.4	7.3
Total Suspended Solids, mg/L	4	2	1	2	1	0	6	5
Fixed Suspended Solids, mg/L	0	0	0	0	0	0	0	0
Volatile Suspended Solids, mg/L	4	2	1	2	1	0	6	5
Iron, mg/L	< 0.1	< 0.1	< 0.1	0.39	< 0.1	< 0.1	1.67	1.46
Manganese, mg/L	0.93	0.9	0.29	1.06	0.73	1.08	1.13	0.72
Phenolics, mg/L	-	0.31	-	-	-	-	-	0.1
Total Detectable Potential Carcinogenic PAH, μg/L	-	BDL	-	-	-	-	-	BDL
Total Detectable Other PAH, μg/L[a]	-	3059	-	-	-	-	-	3080
BACKWASH								
pH, units	7.3	7.4	7.3	7.4	7.5	7.3	7.3	7.3
Total Suspended Solids, mg/L	37	32	82	27	23	17	224	14
Fixed Suspended Solids, mg/L	23	12	53	18	6	3	157	3
Volatile Suspended Solids, mg/L	14	20	29	9	17	14	67	11
Iron, mg/L	7.68	7.48	12.20	9.29	4.66	5.26	77.2	5.20
Manganese, mg/L	3.78	2.86	16.0	1.47	3.67	1.69	2.49	0.89
Phenolics, mg/L	-	0.03	-	-	0.01	-	-	0.08
Chemical Oxygen Demand, mg/L	-	40	-	-	43	-	-	38
Total Detectable Potential Carcinogenic PAH, μg/L	-	BDL	-	-	BDL	-	-	BDL
Total Detectable Other PAH, μg/L[a]	-	2961	-	-	3132	-	-	2882

NOTE: BDL - Below Detection Limit
See Table 3-6 for individual PAH data.
< indicates less than detectable concetration.
[a] Does not include "Less Than" values.

TABLE 3-6

ST. LOUIS PARK - PAH RESULTS FROM DYNASAND FILTER PILOT TEST

STREAM	INFLUENT		EFFLUENT		BACKWASH		
DATE SAMPLED	10-28	11-6	10-28	11-6	10-28	11-1	11-6
POTENTIALLY CARCINOGENIC (P.C.) PAH (ug/L):							
Quinoline	<10	<10	<10	<10	<10	<20	<10
Benzo(a)anthracene	<10	<10	<10	<10	<10	<20	<10
Chrysene	<10	<10	<10	<10	<10	<20	<10
Benzo(b)fluoranthene	<10	<10	<10	<10	<10	<20	<10
Benzo(k)fluoranthene	<10	<10	<10	<10	<10	<20	<10
Benzo(a)pyrene	<10	<10	<10	<10	<10	<20	<10
Indeno(1,2,3-c,d)pyrene	<10	<10	<10	<10	<10	<20	<10
Dibenz(a,h)anthracene	<10	<10	<10	<10	<10	<20	<10
Benzo(g,h,i)perylene	<10	<10	<10	<10	<10	<20	<10
Total Detectable P.C. PAH	0	0	0	0	0	0	0
OTHER PAH (ug/L):							
2,3 Benzofuran	35	30	36	36	33	55	36
2,3-dihydroindene	180	160	160	160	190	300	180
Indene	210	190	210	230	180	320	220
Naphthalene	1800	1800	2100	2100	2000	1600	1900
Benzo(b)thiophene	120	120	110	130	130	210	130
Indole	<10	<10	<10	<10	<10	<20	<10
2-Methylnaphthalene	86	69	100	90	82	120	86
1-Methylnaphthalene	110	96	120	120	120	170	110
Biphenyl	17	16	17	17	17	28	18
Acenaphthylene	<10	<10	<10	<10	<10	<20	<10
Acenaphthene	78	72	81	77	81	130	80
Dibenzofuran	26	23	27	26	28	43	27
Fluorene	27	24	27	26	28	43	27
Dibenzothiophene	<10	<10	<10	<10	<10	<20	<10
Phenanthrene	18	17	19	18	19	31	19
Anthracene	<10	<10	<10	<10	<10	<20	<10
Acridine	<10	<10	<10	<10	<10	<20	<10
Carbazole	48	44	52	50	53	82	50
Fluoranthene	<10	<10	<10	<10	<10	<20	<10
Pyrene	<10	<10	<10	<10	<10	<20	<10
Benzo(e)pyrene	<10	<10	<10	<10	<10	<20	<10
Perylene	<10	<10	<10	<10	<10	<20	<10
Total Detectable Other PAH	2755	2661	3059	3080	2961	3132	2883

Note: < values indicate less than detectable concentrations.

TABLE 3-7

STATISTICAL COMPILATION OF INFLUENT AND EFFLUENT DATA

PARAMETER	N	AVG	L95%	U95%	MIN	MAX
INFLUENT (10/27 thru 11/6)						
pH, units	8	7.3	7.2	7.4	7.1	7.4
Total Suspended Solids, mg/L	8	5.6	2.6	8.7	1.0	11.0
Fixed Suspended Solids, mg/L	8	0	0	0	0	0
Volatile Suspended Solids, mg/L	8	5.6	2.6	8.7	1.0	11.0
Iron, mg/L	8	2.13	2.12	2.14	2.11	2.16
Manganese, mg/L	8	0.38	0.37	0.39	0.37	0.39
Phenolics, mg/L	2	0.14	0	0.71	0.09	0.18
Total Potentially Carcinogenic PAH, µg/L	2	BDL	-	-	-	-
Total Other PAH, µg/L	2	2708	2111	3305	2661	2755
EFFLUENT (10/27 thru 11/6)						
pH, units	8	7.4	7.3	7.4	7.3	7.5
Total Suspended Solids, mg/L	8	2.8	1.1	4.5	1.0	6.0
Fixed Suspended Solids, mg/L	8	0	0	0	0	0
Volatile Suspended Solids, mg/L	8	2.8	1.1	4.5	1.0	6.0
Iron, mg/L	3	1.17	0.23	2.1	0.39	1.67
Manganese, mg/L	8	0.86	0.63	1.09	0.29	1.13
Phenolics, mg/L	2	0.21	0	1.54	0.10	0.31
Total Potentially Carcinogenic PAH, µg/L	2	BDL	-	-	-	-
Total Other PAH, µg/L	2	2670	0	7885	2259	3080
EFFLUENT (10/27/ thru 11/3)						
pH, units	6	7.4	7.5	7.3	7.3	7.5
Total Suspended Solids, mg/L	0	1.8	4.0	1.0	0.6	3.1
Fixed Suspended Solids, mg/L	6	0.0	0.0	0.0	0.0	0.0
Volatile Suspended Solids, mg/L	6	1.8	4.0	1.0	0.6	3.1
Iron, mg/L	1	0.4	-	-	0.53	1.16
Manganese, mg/L	6	0.8	1.080	0.29	-	-
Phenolics, mg/L	1	0.31	-	-	-	-
Total Potentially Carcinogenic, µg/L	1	3059	-	-	-	-
Total Other PAH, µg/L	1	BDL	-	-	-	-
BACKWASH (10/27 thru 11/6)						
pH, units	6	7.4	7.3	7.5	7.3	7.5
Total Suspended Solids, mg/L	6	1.8	0.6	3.0	1.0	4.0
Fixed Suspended Solids, mg/L	6	0	0	0	0	0
Volatile Suspended Solids, mg/L	6	1.8	0.6	3.0	1.0	4.0
Iron, mg/L	1	0.39	-	-	-	-
Manganese, mg/L	6	0.84	0.53	1.15	0.29	1.08

NOTE: Statistical compilation of data given in Table 3-5; only detectable concentration used.

BDL - Below Detectable Levels
N - Number of samples
AVG - Average of reported values
L95%- Lower bound 95% confidence limit
U95% - Upper bound 95% confidence limit
MIN - Minimum of reported values
MAX - Maximum of reported values

Based on only two samples, Table 3-7 data shows that there were basically no reductions measured across the sand filter for either phenolics or PAHs. It should also be noted that the PAHs which were analyzed included only those on the "St. Louis Park" list, with no Potentially Carcinogenic PAHs detected in the influent groundwater.

Additionally, based on the influent iron (Fe) and manganese (Mn) average concentrations of 2.13 mg/L and 0.38 mg/L, respectively, and the $KMnO_4$ dosage ratios of 1:1 for iron and 2:1 for manganese (i.e., $KMnO_4$: Fe or Mn), gives an applied $KMnO_4$ influent concentration of approximately 2.9 mg/L. This is very close to the applied $KMnO_4$ concentration range of 3.0 to 3.3 previously cited in Tables 3-1 through 3-4. Thus, sufficient $KMnO_4$ was added to oxidize the Fe and Mn present.

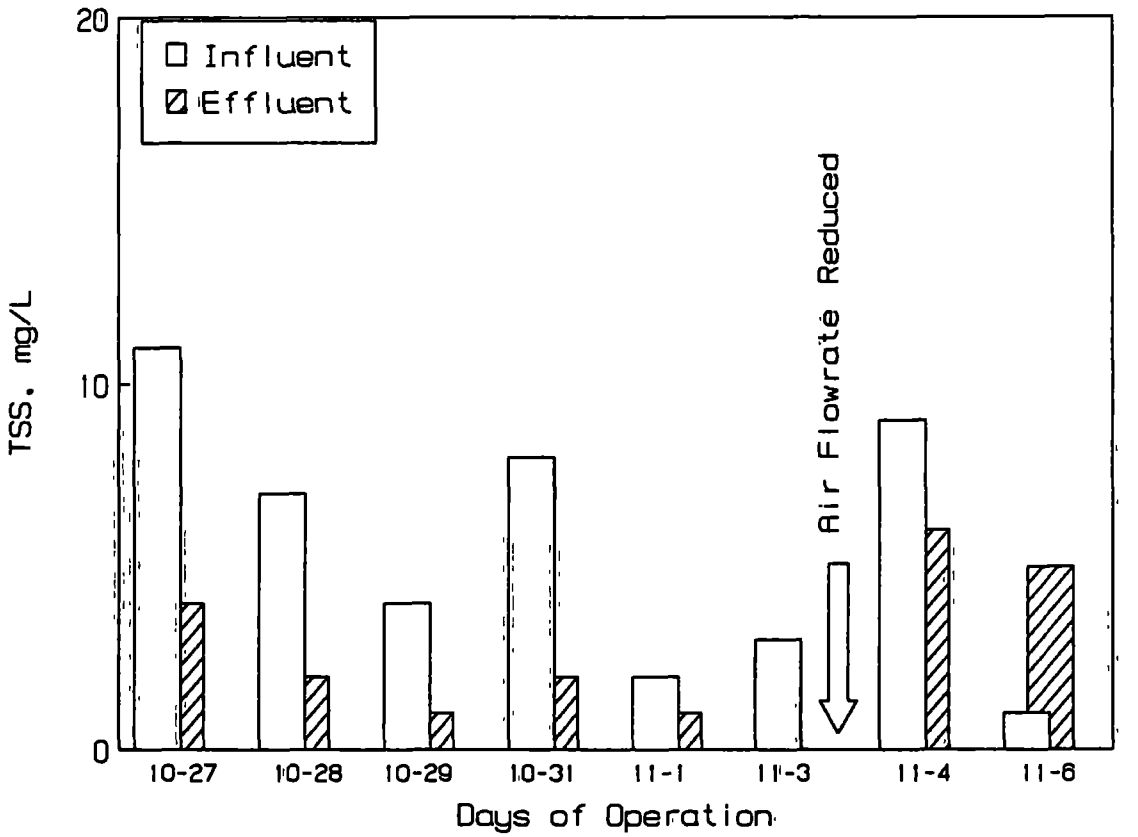
Two sets of effluent values are cited in Table 3-7. One set corresponds to all data collected from October 27 through November 6, 1989, and thus includes data for days 11/4 and 11/6 which are after the day 11/3 upset, where the air flowrate to the filter was reduced and solids accumulated in the filter as previously discussed. For this reason, the second effluent data set only includes days 10/27 through 11/3.

Comparing respective parameters between the two effluent sets in Table 3-7 shows that the accumulation of solids in the filter did affect iron and suspended solids removal significantly. This fact is further illustrated in Figures 3-1 and 3-2. Figure 3-1 plots the influent and effluent TSS values and shows that the DynaSand filter was working quite well in terms of TSS removal. As cited, solids accumulation occurred in the filter due to a reduced air flowrate on day 11/3 as evidenced by the increase in effluent TSS values for days 11/4 and 11/5. Even though the low air flowrate situation was rectified on day 11/4, residual accumulated solids were still impregnated in the filter media as evidenced by the effluent solids.

The data plotted in Figure 3-2 also supports that the DynaSand filter was working quite well in terms of Fe removal (i.e., generally non-detectable concentrations) until the low air flowrate condition occurred on day 11/3. The higher Fe concentrations on days 11/4 and 11/6 are most likely in the form of precipitated $Fe(OH)_3$ present as accumulated suspended solids in the sand filter and also detected in the effluent as suspended solids.

FIGURE 3-1

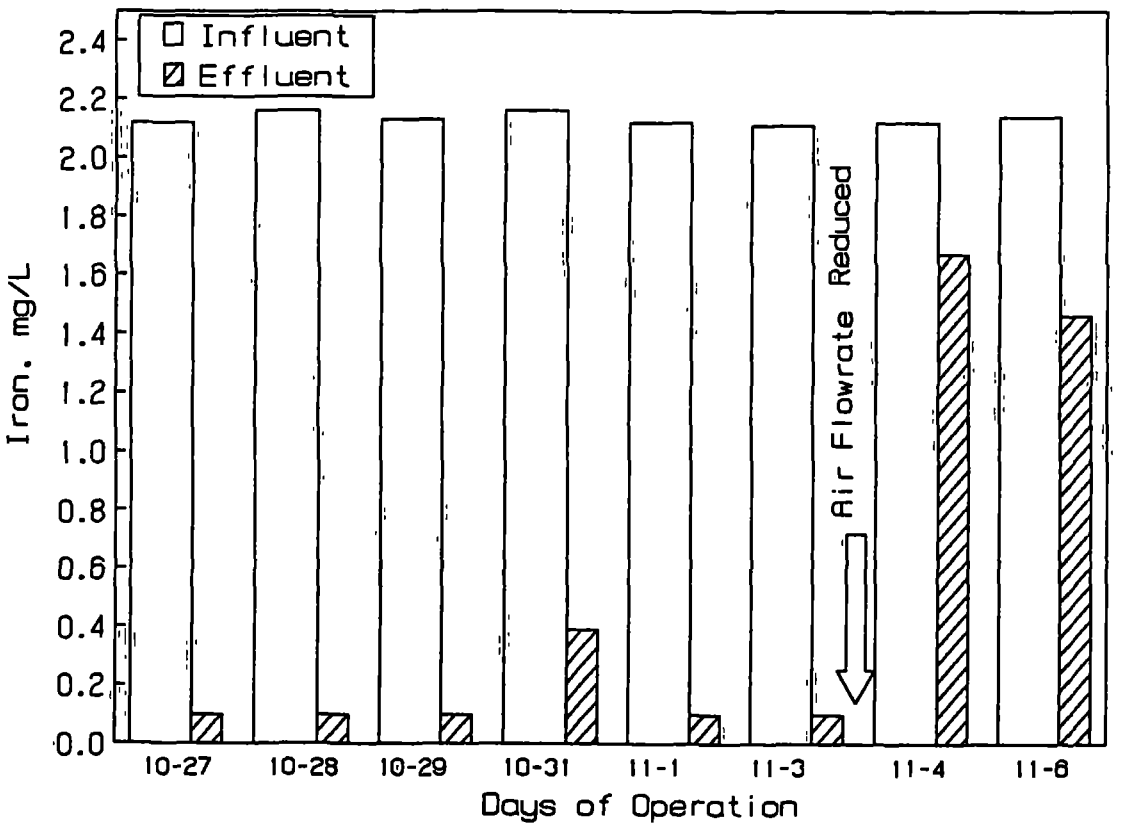
INFLUENT AND EFFLUENT TSS CONCENTRATIONS
-VS-
OPERATING DAYS



NOTE: See Table 3-5 for data.

FIGURE 3-2

INFLUENT AND EFFLUENT IRON CONCENTRATIONS
-VS-
OPERATING DAYS



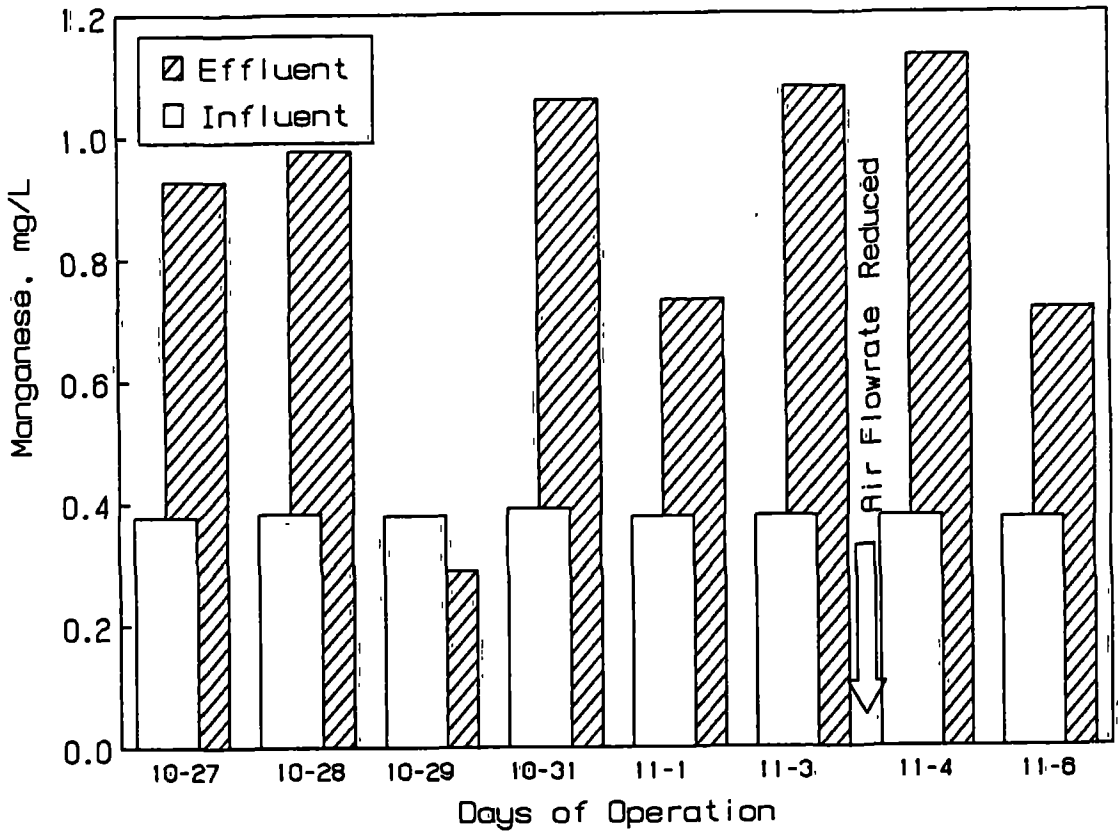
NOTE: See Table 3-5 for data.

For the case of Mn removal, Figure 3-3 shows that the effluent concentrations generally increased across the DynaSand filter. Such an increase is primarily due to two reasons. The first reason is that Mn was added to the influent as the chemical oxidant $KMnO_4$. Based on an applied $KMnO_4$ concentration of approximately 3 mg/L, the associated Mn concentration is computed at 1.04 mg/L. Adding this concentration of applied manganese to the average influent concentration of 0.38 mg/L (Table 3-7) gives a total Mn concentration of approximately 1.42 mg/L being applied to the sand filter. This computed value is slightly higher than that measured in the effluent during the test period. In fact, the average Mn effluent concentration measured is given as 0.86 ±0.23 (±95% CI) as cited in Table 3-7. Thus, some Mn removal across the sand filter is occurring, but not enough to cause the effluent concentration to be lower than the influent concentration prior to $KMnO_4$ addition.

The second reason for the analytically measured Mn increase across the DynaSand unit may be due in part to the fact that the effective size (E.S.) of the sand used in the pilot unit was 0.9 mm. The fact that the Mn effluent concentration remained rather constant during the study (Figure 3-3) supports that the 0.9 mm E.S. sand used was allowing some small Mn precipitates to pass through the filter , where as the iron was substantially removed. Furthermore, the sand used in the on-site carbon column evaluation work achieved Mn concentrations in the sand filter effluent consistently below 0.3 mg/L with sand having an effective size of 0.5 mm. Sand with a smaller effective size would result in greater Mn removal, however, Parkson Corporation does not recommend operation of the DynaSand unit using sand with an E.S. less than 0.9 mm. Alternatively, supplemental polymer addition may aid in Mn removal. Based on discussions with Parkson technical personnel, it is felt that addition of the polymer prior to the in-line static mixer will cause agglomeration of Mn floc particles which will then be subsequently removed in a filter having media with an effective size of 0.9 mm. Regardless of the fact of the slight Mn concentration increase across the DynaSand unit, the average effluent concentration achieved for the entire study period was 0.86 mg/L ±0.23 (±95% CI) as given in Table 3-7; this average is below the target NPDES requirement of 1.0 mg/L. Thus, the situation is controllable without having to use a smaller E.S. sand and/or polymer addition. Additionally, reducing the mass of $KMnO_4$ added will also reduce the effluent sand filter Mn level. It is also noteworthy that Mn, at a concentration less than 0.5 mg/L,

FIGURE 3-3

INFLUENT AND EFFLUENT MANGANESE CONCENTRATIONS
-VS-
OPERATING DAYS



NOTE: See Table 3-5 for data.

was not removed across the pilot-scale carbon columns operated during onsite treatability work.

3.3 BACKWASH ANALYTICAL RESULTS

Table 3-8 gives a statistical summary of the specific backwash data results cited in Table 3-5. These results given support that the DynaSand filter did achieve removal of Fe and Mn species, and that the quality of the backwash stream is suitable for POTW discharge.

Table 3-8 gives two sets of data for the backwash stream. One set corresponds to a statistical compilation of data for the entire study period, and the second set corresponds to a statistical compilation of data through November 3, 1989, just prior to a reduction of the air flowrate as previously discussed. Based on these data, there appears to be significant differences between the two sets in terms of TSS, VSS, FSS, and Fe, but not for pH and Mn. The differences for TSS and Fe are illustrated in Figures 3-4 and 3-5, respectively.

Figure 3-4 shows that TSS levels were consistently below 100 mg/L prior to day 11/4. The drastic increase to above 200 mg/L on day 11/4 is attributable to the fact, as previously discussed, that the air flowrate to the DynaSand unit was reduced to a rate where effective backwashing was not being achieved with suspended solids accumulating in the filter. When the air flowrate was increased back to a normal level on day 11/4, the accumulated solids were flushed from the filter as indicated by the sharp increase in TSS. On day 11/6, the situation was rectified back to normal conditions in terms of backwash TSS concentration.

As illustrated in Figure 3-5, backwash Fe concentrations somewhat follow the same trend as that for TSS. This is because removed Fe precipitated as $Fe(OH)_3$ and thus was detected as TSS.

TABLE 3-8

STATISTICAL COMPILATION OF BACKWASH STREAM DATA

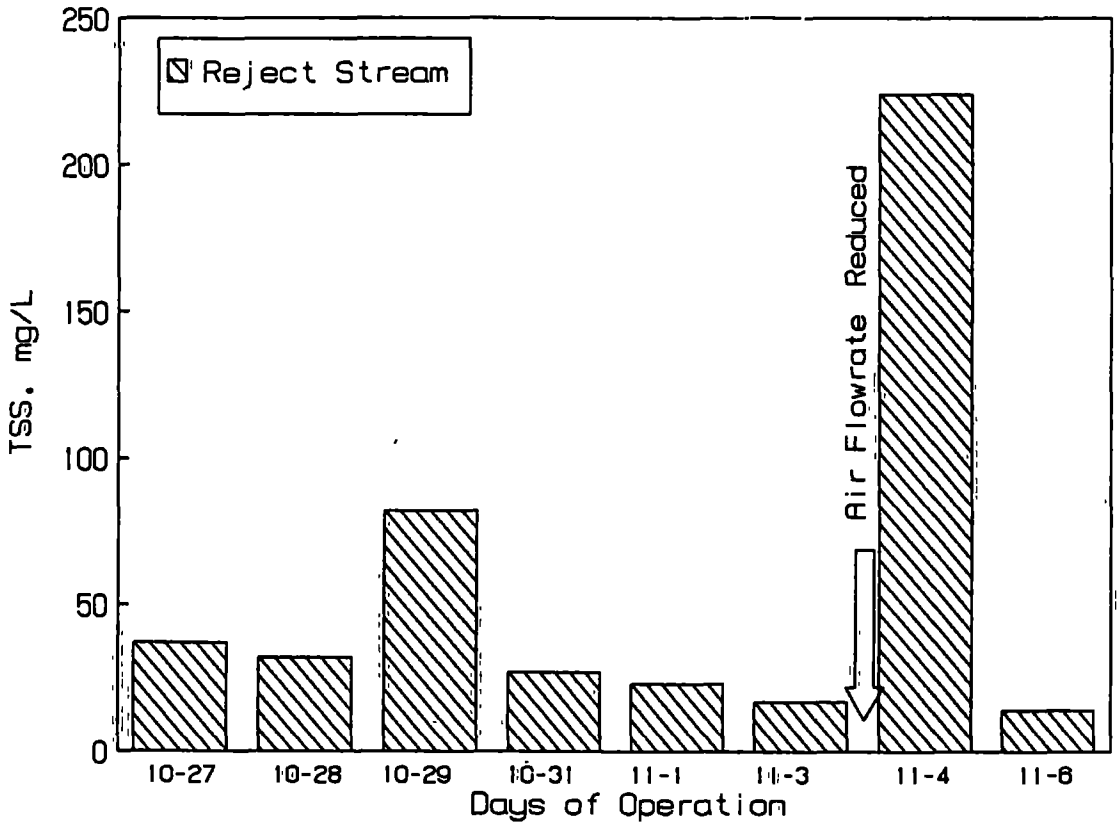
PARAMETER	N	AVG	L95%	U95%	MIN	MAX
PERIOD: 10/27 THRU 11/6						
pH, units	8	7.4	7.3	7.5	7.3	7.5
Total Suspended Solids, mg/L	8	57	0	116	17	224
Fixed Suspended Solids, mg/L	8	34	0	78	3	157
Volatile Suspended Solids, mg/L	8	23	7	39	14	67
Iron, mg/L	8	16.12	0	36.86	4.66	77.20
Manganese, mg/L	8	4.11	0	8.22	1.47	16.00
Phenolics, mg/L	3	0.04	0	0.13	0.01	0.08
Chemical Oxygen Demand, mg/L	3	40	34	46	38	43
Total Potentially Carcinogenic PAH, μg/L	3	BDL	-	-	-	-
Total Other PAH, μg/L	3	2992	2674	3309	2882	3132
PERIOD: 10/27 THRU 11/3						
pH, units	6	7.4	7.3	7.5	7.3	7.5
Total Suspended Solids, mg/L	6	36	12	60	17	82
Fixed Suspended Solids, mg/L	6	19	0	38	3	53
Volatile Suspended Solids, mg/L	6	17	10	24	9	29
Iron, mg/L	6	7.76	4.87	10.65	4.66	12.20
Manganese, mg/L	6	4.91	0	10.70	1.47	16.00

NOTE: Statistical compilation of data given in Table 3-5; only detectable concentration used.

BDL - Below Detectable Levels
AVG - Average of reported values
L95%- Lower bound 95% confidence interval limit
U95% - Upper bound 95% confidence interval limit
MIN - Minimum of reported values
N - Number of reported values used in statistical compilations.

FIGURE 3-4

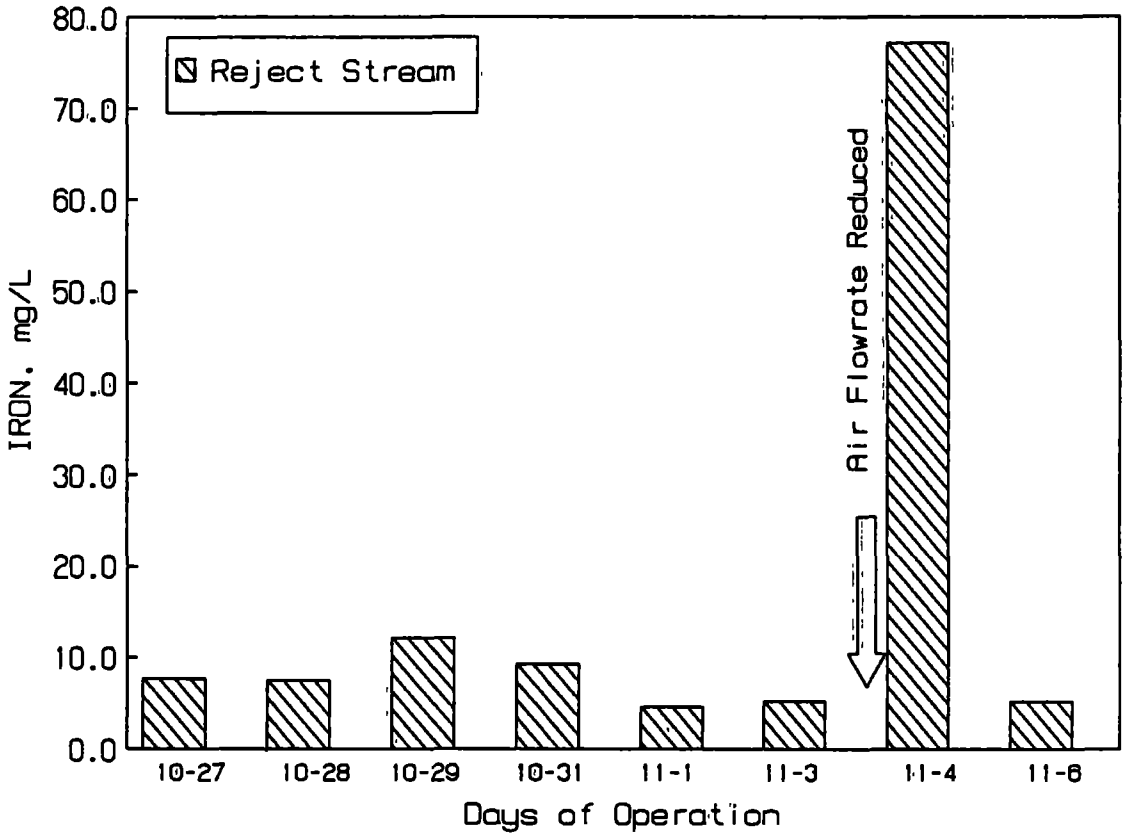
BACKWASH STREAM TSS CONCENTRATION
-VS-
OPERATING DAYS



NOTE: See Table 3-5 for data.

FIGURE 3-5

BACKWASH STREAM IRON CONCENTRATION
-VS-
OPERATING DAYS



NOTE: See Table 3-5 for data.

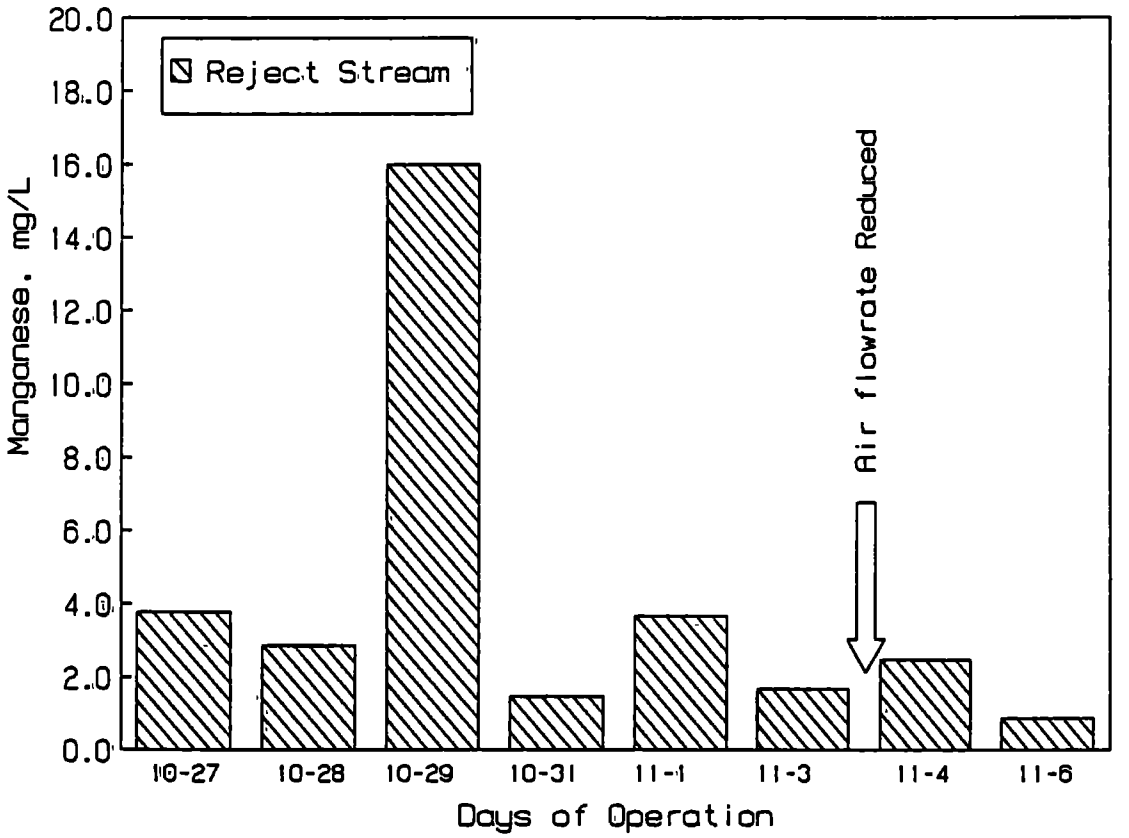
No such relationship is indicated for Mn as supported by the data illustrated in Figure 3-6 which shows Mn concentrations being somewhat constant during the entire study period, including days 11/4 and 11/6. While the relatively high Mn concentrations support that Mn is being removed via sand filtration and being discharged in the backwash stream, there is no association with TSS as there was for Fe. This further explains why Mn was not removed across the DynaSand filter to the extent iron was.

Referring to Table 3-8, the data for pH and Total Other PAH is not significantly different than the same parameter values cited in Table 3-7 for the influent and effluent. However, the phenolics concentration is less when measured in the backwash stream. The fact that PAH concentrations are somewhat the same among the three streams (Table 3-6) is due to the fact that the respective Other PAHs detected exist as relatively soluble compounds (i.e., >1.0 mg/L) and are not easily adsorbed onto suspended solids.

In terms of permitting considerations, the data presented supports that a discharge of approximately 10 gpm into the City of St. Louis Park's POTW should be acceptable. Specifically, the only parameter of any potential issue is TSS which will be below 100 mg/L under normal operating conditions. No significant impact should be felt in terms of organic loading based on phenolics, chemical oxygen demand (COD) and Total Other PAH. The data given in Table 3-8 should be used in terms of providing guidance related to developing discharge requirements. Specifically, data for days 10/27 through 11/6 should be used as being appropriate. Since these values represent a conservative estimate.

FIGURE 3-6

BACKWASH STREAM MANGANESE CONCENTRATION
-VS-
OPERATING DAYS



NOTE: See Table 3-5 for data.

4.0 SUMMARY AND CONCLUSIONS

An on-site chemical oxidation/sand filtration pilot study was conducted for a twelve day period. The pilot system treated pumped groundwater via potassium permanganate ($KMnO_4$) addition for removal of iron (Fe) and manganese (Mn). This step was then followed by sand filtration via a Parkson Corporation DynaSand filter with continuous backwashing. Groundwater was treated at a flowrate of approximately 39 gpm with a continuous backwash flowrate of approximately 8 gpm.

Summary and conclusions of this test work follows.

(1) Under normal operating conditions, this treatment system produced a treated effluent suitable for subsequent activated carbon column treatment.

(2) Based on average concentrations under normal operating conditions (10/27 through 11/3), the system consistently achieved Fe reductions from 2.1 mg/L to less than 0.4 mg/L, and total suspended solids (TSS) reduction from 5.6 mg/L to 1.8 mg/L.

(3) There was an increase in Mn across the treatment system due to $KMnO_4$ addition. However, accounting for the Mn added as $KMnO_4$, sand filtration reduced average Mn levels from 1.4 mg/L to 0.9 mg/L. There is potential for concentration to be further reduced by using a polymer addition to enhance Mn floc formation.

(4) Potassium permanganate dosage ratios of 1:1 (mg $KMnO_4$: mg Fe) for iron and 2:1 (mg $KMnO_4$: mg Mn) for manganese were verified.

(5) A reduction in air flowrate to the DynaSand filter for a 24-hour period resulted in accumulation of TSS in the filter unit. This subsequently resulted in higher than normal Fe and TSS concentrations in both the treated effluent and backwash flows until the solids were flushed out of the unit. However, once discovered, the situation was easily rectified.

(6) Phenolics (4-AAP) and polynuclear aromatic hydrocarbons (PAHs) were not significantly removed across the pilot system nor were they concentrated in the backwash stream. Likewise, pH was also not affected. However, dissolved oxygen (D.O.) did increase across the DynaSand filter from levels between 1-2 mg/L to levels between 7-8 mg/L.

(7) In terms of POTW discharge of the backwash stream, anticipated characteristics are:

- pH between 6-9;
- D.O. greater than 2;
- TSS between 17-224 mg/L;
- COD between 38-43 mg/L;
- phenolics (4-AAP) between 0.01-0.08 mg/L; and
- Total Other PAH between 2882-3132 μg/L.

These concentration ranges given correspond to the respective "min" and "max" values given in Table 3-8 for the period 10/27 through 11/6, and thus, represent the entire ranges expected for the respective parameters.

APPENDIX D

MANUFACTURER'S INFORMATION ON SELECTED EQUIPMENT ITEMS

ATTACHMENT 1:	ACTIVATED CARBON COLUMN SYSTEM (CALGON CORPORATION)
ATTACHMENT 2:	ACTIVATED CARBON COLUMN SYSTEM (GMG) ASSOCIATES/TIGG)
ATTACHMENT 3:	UPFLOW FIXED BED SAND FILTER WITH CONTINUOUS OPERATION (PARKSON CORPORATION DYNASAND FILTER)
ATTACHMENT 4:	LIST OF PARKSON DYNASAND FILTER INSTALLATIONS
ATTACHMENT 5:	PARKSON DYNASAND PILOT TEST REPORT ON IRON REMOVAL

APPENDIX D

ATTACHMENT 1

ACTIVATED CARBON COLUMN SYSTEM

(CALGON CORPORATION)

MODEL 7-1/2 ADSORPTION SYSTEM

CALGON CARBON CORPORATION

1. SCOPE OF WORK

1.1 GENERAL: The following specification describes all equipment, materials and services necessary to provide a complete Granular Activated Carbon Adsorption System. The Adsorption System shall consist of multiple units and all related appurtenances required for a completely operational system. The total system must be designed for economical carbon usage and ease and completeness of Granular Activated Carbon transfers.

The Carbon Adsorption System Supplier must take unit responsibility for the complete system. The Supplier shall be responsible for design, fabrication and assembly of all mechanical components including, but not limited to, adsorber (vessels), piping, instrumentation and controls. The Supplier shall also be responsible for supply, delivery and loading of Granular Activated Carbon and unloading and environmentally approved disposal of the spent carbon. Removal and disposal of spent carbon must be in accordance with all applicable local, state, and Federal Regulations regarding solid waste materials.

The Carbon Adsorption System Supplier shall be able to guarantee a supply of Granular Activated Carbon. The Supplier shall also be able to remove and transport spent Granular Activated Carbon classified as hazardous under RCRA regulations, so that it can be transported to a reactivation facility as required.

1.2 DESIGN: The total system shall contain a minimum installed capacity of 10,000 pounds of Granular Activated Carbon in each of two adsorbers. Overall system design flow will be up to 350 gpm at a total pressure drop of less than or equal to 30 psi with both adsorbers operated in series. A maximum system pressure drop of 30 psi (with clean water and clean bed -- either fresh carbon or following backwash) will be measured beginning with the influent piping and ending with the effluent piping at the battery limits. [OPTION: System design flow will be up to 700 gpm with two adsorbers operated in parallel]. The system shall be designed to treat all waters equal to or above pH 7, or that are otherwise not corrosive to carbon steel material.

Battery Limits for the Adsorption System shall be defined as beginning at the influent connection for the system and ending with the effluent connection for the system. All equipment between these two points shall be provided as part of the complete design by the system Supplier.

1.3 WORK INCLUDED: The work covered by this specification includes the furnishing of all equipment, materials, carbon and services to comprise a complete Adsorption System.

1.3.1 Two (2) downflow asorbers including a water collection system and all internals.

1.3.2 4" influent and effluent piping to the adsorbers and interconnecting pipe and valves to allow placing either adsorber in the lead position in a series arrangement, or allowing both adsorbers to be operated in parallel. Valving shall be able to isolate any adsorber for carbon exchange operations and maintain operation through the remaining adsorber.

6" backwash supply and discharge piping to each adsorber, to be combined to single connection at Battery Limits.

1.3.3 2" Granular Activated Carbon discharge piping with valves, flush lines and hose connections. 6" x 8" Elliptical handhole on the adsorber top for Granular Activated Carbon fill. [OPTION: 4" Granular Activated Carbon fill piping with valves, flush lines and hose connections].

1.3.4 Integral vent and safety relief piping, water piping and utility connections. Vent piping directed to single point to be connected to unrestricted drain.

1.3.5 6,500 pounds of Granular Activated Carbon, as specified, installed per adsorber if system is to be backwashed.

1.3.6 Air distribution piping complete with all related appurtenances for properly functioning air system (i.e., pressure gauges, check valves, and shut-off valves) in order to receive air from a compressor and supply it to each adsorber for carbon transfers.

1.3.7 Water spray nozzle to wash granular activated carbon from the adsorber internals during transfer to assure complete spent media removal.

1.3.8 Installation of all equipment items on structural steel skid for delivery and installation as a complete treatment unit.

1.3.9 Complete set of technical specifications and operating manual.

1.3.10 Experienced technical assistance as required.

1.4 WORK NOT INCLUDED: The following work is not covered by this specification and is to be the responsibility of others:

1.4.1 Foundations

1.4.2 Receipt, off-loading and setting of adsorption system

1.4.3 Influent supply, effluent disposition and utility water supply.

1.4.4 Freeze protection and/or insulation.

1.4.5 Anchor bolts or templates.

1.4.6 Air compressor or compressed air supply at proper pressure and rate.

2. BID SUBMITTALS

2.1 GENERAL: In order to insure the supply of a Granular Activated Carbon (GAC) Adsorption System that will be fully effective in meeting effluent requirements, potential suppliers of the Adsorption System shall provide the following information with the bid. These submittals shall show the ability to design and supply a GAC Adsorption System in a timely manner, supply GAC media when required, provide safe and legal removal of spent GAC when required and provide on-going technical support.

2.2 EXPERIENCE QUALIFICATIONS: The potential system supplier shall submit the following information for four (4) existing adsorption systems which demonstrate the ability to design and supply an effective GAC Adsorption System and meet the qualifications noted above.

2.2.1 Provide Adsorption System description including flow, contact time, system design (flow diagrams or general arrangement), adsorber sizing.

2.2.2 Provide process design information including contaminants, system performance (operating results, actual contaminant influents and effluents), effluent water usage, GAC usage rates.

2.2.3 Provide references for each of the systems described.

2.3 GAC ADSORPTION SYSTEM DESIGN: The potential Adsorption System supplier shall submit the following information with the proposal, utilizing catalog cuts, standard designs or recent designs on file, for GAC adsorption systems of similar size or adaptable to this size using a minimum number of multiple units.

2.3.1 Provide adsorber vessel design drawings, showing ASME code requirements.

2.3.2 Provide underdrain design showing ability to remove water across GAC cross-section for effective use of GAC contained in unit.

2.3.3 Provide Adsorption System flow diagram utilizing adsorbers in Item 2.3.1, showing actual flow rates to be treated for this site.

2.3.4 Provide Adsorption System general arrangement for this site, showing space utilized, influent and effluent locations.

2.3.5 Provide operating weight of Adsorption System for this site, so that combined with information in Item 2.3.4, foundation design can be prepared.

2.4 GAC ADSORPTION SYSTEM PROCESS DESIGN: The potential supplier shall submit the following information with the proposal to exhibit capability to assume total process design capability for the Adsorption System.

2.4.1 Provide pressure drop information across system as designed (Section 2.3.3) to enable proper feed pump design.

2.4.2 Provide interpretation of carbon adsorption isotherms to show ability of GAC to remove contaminants and fix dynamic test parameters.

2.4.3 Provide capability to obtain a dynamic pilot simulation of field performance of the proposed system. This dynamic pilot simulation is a column study conducted on actual water from the treatment site. The column study will simulate the contact time to be encountered in the full-scale treatment operation and identify the carbon utilization rate in a simulation of up to one year's field performance.

2.4.4 Provide analytical procedures used to support Items 2.4.2 and 2.4.3.

2.5 GAC SUPPLY: The potential Adsorption System supplier shall demonstrate ability to supply acceptable GAC media, and, therefore, provide the following information with the proposal:

2.5.1 Supply specifications of GAC to be utilized in system. Show that this GAC is in all respects equivalent to that used in testing (Section 2.4). Provide recent lot analysis that exhibit that GAC supplier is providing media according to published specifications.

2.5.2 Demonstrate ability to supply complete GAC fill in a timely manner upon system completion or notification by client. Demonstrate that inventory of GAC proposed is adequate to meet the initial fill requirements in a timely manner.

2.5.3 Demonstrate ability to transport GAC to site in a reasonable time frame and transfer into adsorbers in a safe and timely manner.

2.6 GAC REACTIVATION: The potential Adsorption System supplier shall demonstrate ability to handle the spent activated carbon by non-destructive reactivation so that spent GAC can be removed from the site and handled in an environmentally safe and legally approved manner. Landfill of spent GAC shall not be an approved manner of GAC disposition. The following information shall be required of reactivation capability and submitted with the proposal.

2.6.1 Provide reactivation testing procedures showing that the spent GAC will be received at the facility and reactivated in an environmentally safe manner.

2.6.2 Identify spent GAC transportation equipment showing transport of spent GAC in enclosed, DOT approved equipment. Provide transportation equipment drawings and necessary permits to transport hazardous waste.

2.6.3 Demonstrate ability to transport and receive RCRA manifested material. Provide facility RCRA identification numbers.

2.6.4 The adsorption system supplier or provider of reactivation services ("contractor") shall, to the extent of its negligence, indemnify and hold harmless the owner for any liability that may arise after the spent carbon is loaded into contractor's trailers and signed for by contractor at the owner's facility, provided that the spent carbon contains no PCB, dioxin, DBCP or any other compounds that, due to government regulation, may preclude handling the spent carbon in a RCRA approved and permitted facility. The adsorption system supplier shall provide a statement to this effect in the proposal submittal.

2.6.5 The provider of reactivation services (reactivation contractor) shall provide a certificate of insurance evidencing sudden and accidental pollution liability of insurance in excess of 2 million dollars at the reactivation contractor's reactivation site.

2.7 <u>FIELD SUPPORT AND OPERATING ASSISTANCE QUALIFICATIONS</u>: The potential system supplier shall submit the following information exhibiting ability to provide on-going support to the client to insure effective operation of the Adsorption System for the foreseeable future.

2.7.1 Provide typical analytical programs to assist on-going applications.

2.7.2 Provide per diem rate for engineering (process) support and technical (operations) support. Provide organization chart showing technical (operations) support groups and resumes of key personnel in Operations and Engineering departments.

3. POST AWARD SUBMITTALS

3.1 GENERAL: Upon award of the purchase order, the Adsorption System supplier shall submit the following information in the time and manner specified. Information provided by the supplier that is considered by the supplier to be confidential in nature must be clearly marked and so designated.

3.2 APPROVAL SUBMITTAL: Two weeks after receipt of the order the following submittals shall be made:

3.2.1 Project schedule indicating submittals, equipment delivery, installation and start-up.

3.2.2 Flow schematic drawing indicating line sizes, valving, utility line sizes and connections.

3.2.3 Adsorber vessel shop or fabrication drawings.

3.3 CONSTRUCTION SUBMITTAL: Two weeks after return of approved first submittal to the supplier, the following submittals shall be made:

3.3.1 Equipment arrangement and weights - detailed drawing(s) and listing of all required anchor bolts and nuts and a dimensional setting plan to conform to the requirements of the furnished equipment.

3.3.2 General arrangement plans and elevations including detail and location of required interface connections to the system to be made by others.

3.3.3 Specifications for all supplied equipment.

3.3.4 List of recommended spare parts.

3.4 OPERATING MANUAL SUBMITTAL: Prior to scheduled start-up, the following submittals shall be made:

3.4.1 Operating and maintenance manual incorporating all necessary information from previous submittals. Operating section shall include complete instruction on unloading spent carbon and loading fresh virgin grade carbon, including any auxiliary utilities required.

3.4.2 Names, functional titles, addresses and phone numbers of technical personnel available for on-going technical support.

3.5 AS-BUILT SUBMITTAL: Four weeks after start-up and final system acceptance the following submittals shall be made:

3.5.1 Complete set of final drawings and specifications

4. PROCESS DESCRIPTION

4.1 CARBON ADSORPTION: The Adsorption System utilizes Granular Activated Carbon (GAC) for efficient removal of dissolved organic compounds from water. Adsorption is a physical process in which the compounds adhere to the surface of the carbon particle. The large surface area contained within the internal pore structure of the granular carbon particle provide the Carbon Adsorption System with a substantial capacity for the organic compounds to be removed. The Adsorption System provides effective exposure of the contaminated water to a quantity of Granular Activated Carbon.

The Granular Activated Carbon Adsorption System shall consist of two (2) process vessels (adsorbers) operated in series or parallel. Each adsorber shall contain ten thousand pounds (10,000#) of Granular Activated Carbon (GAC). [OPTION: 6,500 pounds of GAC -- backwashable system]. Water shall be conveyed to the Adsorption System from the source, enter the adsorbers at the top and flow downward through the carbon bed. An internal collector system shall be provided to collect the treated water and retain the granular media in the bed. In series configuration, the effluent from the lead adsorber is directed to the second, or polish adsorber. The treated water is discharged from the Adsorption System through the effluent piping.

The Adsorption System design shall provide for a contact time of ten (10) minutes given a flow of 250 gpm through each adsorber vessel, or a total contact time of twenty (20) minutes for series operation. The contact time is calculated on a "superficial" or "empty bed contact time" basis. The pressure drop across the entire Adsorption System (within Battery Limits) is estimated to be 20 psig during series operation.

4.2 CARBON EXCHANGE: When the carbon in an adsorber becomes saturated with contaminants adsorbed from the water, this adsorber shall be taken out of service to replace the spent Granular Activated Carbon with fresh Granular Activated Carbon. The flow can be diverted to the remaining adsorber allowing the treatment system to remain in service. The adsorber is pressurized with compressed air and the spent carbon is displaced into the

transfer tank or receiving trailer. A water spray nozzle shall be located at the top of the adsorber to introduce water into the adsorber at the end of the transfer operation and wash spent granular activated carbon from the sides and heads and assure complete media removal. Fresh carbon can be transferred to the empty adsorber utilizing the top fill manway.

After the adsorber has been recharged, the adsorber receiving the fresh carbon shall be placed on-line with the remaining adsorber.

Spent carbon transfer shall be able to be accomplished hydraulically in slurry form and without human contact, in a closed loop piping system, in order to minimize environmental exposure. The carbon transfer shall be able to be conducted with air pressure as the motive force in order to minimize the amount of water utilized in the operation.

Disposal of spent carbon must be performed in an environmentally safe manner. If the carbon is reactivated, it must be accomplished in a facility permitted to accept RCRA manifested material. If unsuitable for reactivation and reuse, the Carbon Adsorption system supplier shall assist the owner in the proper disposition. Therefore, a Procedure for Qualification of Materials to RCRA permitted TSDF, should be made available.

5. EQUIPMENT DESCRIPTION

5.1 ADSORBER VESSELS: Adsorbers shall be vertical cylindrical pressure vessels with flanged and dished heads. The adsorbers shall be designed, constructed and stamped in accordance with the ASME Code, Section VIII for a design pressure rating of 75 psig. [OPTIONAL: 125 psig] at 150°F. The adsorber shall be equipped with a manway located on the adsorber straight side. All nozzle connections must be flush on the inside of the shell and provided with 150 pound flat face flanges on the outside.

Adsorbers shall be constructed of carbon steel and shall have all welds and any other sharp edges ground smooth, and all imperfections such as skip welds, delaminations, scabs, slivers and slag corrected prior to abrasive blasting. All surfaces are to be degreased prior to sandblasting. The adsorber internal surface shall be blasted to a white metal surface (SSPC-SP5) to provide an anchor pattern in the metal corresponding to approximately 20% to 25% of the film thickness of the coating. The exterior of the adsorber shall be sandblasted to a commercial blast cleaning (SSPC-SP6).

The interior of the adsorbers shall be lined in order to prevent corrosion that will occur when wet activated carbon is in contact with carbon steel. This lining shall also exhibit abrasion-resistant qualities to prevent erosion by movement of the granular media. The finished lining shall be a minimum 35 mil dry film thickness to insure protection of the steel surface for a satisfactory period. A coating shall be used which exhibits excellent chemical resistance to a wide range of water solutions, and meets requirements of the U.S. Federal Register, Food and Drug Regulations Title 21, Chapter 1, Paragraph 175.300.

Following sandblasting of the exterior, a rust inhibitive primer shall be applied to a dry film thickness of 3.0 mil before any rust can form. The finish exterior painting using an alkyd resin based paint for outside service must be applied to the exterior of the adsorber before rust can form beneath the primer coat.

5.2 UNDERDRAIN COLLECTION SYSTEM: There shall be a collection system at or near the bottom of the carbon bed to collect treated water across the carbon bed cross section. The water velocity profile across the diameter of each bed shall be uniform in the downward direction at the underdrain location. The collection device(s) shall have slots of a determined width to retain the Granular

Activated Carbon and allow free passage of treated water with a minimum of pressure drop. The treated water is collected by this system and discharged from the adsorber to convey the treated water to the effluent pipe. In no case will material foreign to Granular Activated Carbon, i.e., sand or gravel, be installed inside the adsorber to assist treated water collection. The underdrain collection system shall be constructed of suitable corrosion resistant materials such as PVC, Polypropylene or Kynar. In no case shall carbon steel be directly exposed to the granular activated carbon media.

5.3 PIPING NETWORK: A process piping network shall be provided for each set of adsorbers that will enable the following functions to be performed:

5.3.1 Treatment - Under normal operation, the full flow of up to 350 gpm shall be accepted at the system battery limits and directed to the two units operating in parallel or to the lead adsorber if operating in series. The interconnecting piping shall allow for parallel operation or for either adsorber to be operated as the lead adsorber in a

series operation. The effluent from the two units operating in parallel or from the polish adsorber (either adsorber) shall be directed to the system battery limits for a single system effluent connection.

5.3.2 Carbon Exchange - During carbon exchange, the adsorber being exchanged shall be isolated completely from the treatment process with valving on influent and effluent lines. The process flow shall then either be reduced by 50% if operation is in parallel, or directed solely to the polish adsorber (to be lead adsorber after carbon exchange) in a series operation.

5.3.3 Adsorber Backwash - The adsorption system piping shall enable the unit to be backwashed should an unacceptable pressure drop develop across the carbon bed due to introduction of filterable solids to the system. In case of backwash, the adsorber being backwashed shall be isolated from the process flow, as during the carbon exchange procedure. Carbon treated water at a rate of 550 gpm shall be introduced to the underdrain collection system, and, upon the top of the adsorber, be directed to a single connection point for all backwash connections at the system battery limits. NOTE: If units are to be backwashed, each adsorber shall contain only 6,500 pounds of Granular Activated Carbon].

5.4 PROCESS/UTILITY PIPING: The process and utility piping on the Adsorption System shall include influent water to the system and treated water (4"), adsorber vent lines, (3" normal, 6" with backwash) and Granular Activated Carbon discharge piping (2"). The process or influent/treated water piping shall be installed such that the adsorbers can be operated in parallel or series. Each adsorber shall have independent vent, and carbon discharge lines. The design of the piping system is meant to treat water equal to or less than pH 7, or otherwise not corrosive to carbon steel material.

With the exception of GAC discharge piping, all piping shall be carbon steel piping, constructed of ASTM A53, Grade B carbon steel rated for 150 psig at 500°F. For 1½" or smaller, pipe shall be threaded, Schedule 80 pipe, and for 2" and larger, pipe shall be plain end, Schedule 40 Pipe.

Carbon discharge piping to and including the shut-off valve and fittings shall be polypropylene lined steel per Dow chemical Company's MORAF PPL brand, rated at 150 psig to 225°F. Piping shall be Schedule 40, ASTM A53 steel pipe with 125 pound ASTM A126, Class A cast iron flanges and fittings.

Compressed air and wash (spray) water piping (1½") shall be threaded, Schedule 40 galvanized carbon steel pipe per ASTM A120, rated for 125 psig at 350°F for air service. Air supply to the carbon adsorption system shall be via a single point connection.

The exterior of the piping shall be cleaned to a power tool grade (mechanical grade) finish and a rust inhibitive alkyd metal primer shall be applied before any rust can form. A finish exterior painting of an alkyd resin based paint for outside service must be applied to the exterior of the piping before rust can form beneath the primer coat.

5.5 PROCESS/UTILITY VALVES: The process and utility piping, excluding GAC fill and discharge piping shall be equipped with butterfly valves for flow control purposes. Butterfly valves to be cast iron, one piece wafer type body with aluminum-bronze disc and stainless steel one piece through shaft to mate with 150 pound ANSI flanges. Valve to be rated for 200 psig in closed position at 212°F, and to meet or exceed all of the design strength, testing and performance requirements of AWWA Specification C-504-70.

Valves on the GAC discharge pipe shall be full port, Type 316 stainless steel ball valves with TFE seats and seals, wrench operated, with 150 lb. ANSI flanged ends.

Valving for the compressed air supply shall be bronze or forge brass or barstock brass body regular port ball valves, rated for 500 psig at 100°F.

5.6 AUTOMATIC SIPHON BREAK: The effluent from the Adsorption System shall be equipped with an automatic vacuum breaker to prevent draining of the Adsorption System and maintain the water level in the adsorbers above the carbon bed should influent flow be stopped.

5.7 TRANSFER HOSE CONNECTORS: The Granular Activated Carbon piping shall be fitted with hose connectors, such that carbon transfer from the adsorbers can be facilitated with transfer hoses. These connectors shall be 2" Quick Disconnector Adapters constructed of corrosion resistant material as manufactured by OPW Division of Dover Corporation as Kamlok Part No. 633-F or equal.

5.8 FLUSH CONNECTIONS: Two flush connections shall be provided on each GAC discharge line, one upstream and one downstream of the valve. Connections shall be welded into steel pipe or supplied in solid polypropylene "spacers" for lined pipe. Flush connections shall consist of a short section of 3/4" pipe, and a 3/4" full port ball valve and 3/4" quick disconnect adapter to match with water hose.

5.9 PRESSURE RELIEF: A pressure relief device shall be provided, with relief capacity as required by ASME Code and hydraulic system analysis. Relief venting shall be integral to Adsorption System piping and directed to a common collection point.

5.10 PRESSURE GAUGES: The process piping shall be equipped with pressure gauges to indicate the pressure of water entering and exiting each adsorber to provide information on pressure drops across each adsorber and the system. The pressure indicating gauge shall be 4½: (face diameter size) with a stainless steel bourdon tube in a glycerin filled housing. The gauge shall read 0-100 psig with an accuracy of 1% of full range, and shall be a Weksler AA44P - liquid fill or equal.

5.11 STRUCTURAL STEEL SUPPORT SKID: Each adsorber shall be contained on a single structural steel skid. All steel contained in the skid shall be grade A36 carbon steel. The skid shall consist of two outside channels (MC 12 x 50) with slotted holes in the bottom flange for anchor bolt installation, with all necessary cross bracing. The skid shall also include a superstructure consisting of vertical channels (C 8 x 11.5) and horizontal channels (C 12 x 25) for lifting of the entire unit and pipe support. An operating area shall be provided on the skid including safety plate (at top elevation of outside channels) and location on the superstructure for attachment of pressure gauges and operating valves.

All structural steel shall be cleaned to a power tool grade (mechanical grade) and a rust inhibitive alkyd metal primer shall be applied before any rust can form. A finish exterior painting of an alkyd resin based paint for outside service must be applied to the exterior of the piping before rust can form beneath the primer coat.

All equipment items shall be installed on the structural steel skid and secured for shipment. Minor field connections shall be clearly noted, with any extra materials secured to, and shipped with the skid system.

6. GRANULAR ACTIVATED CARBON DESCRIPTION

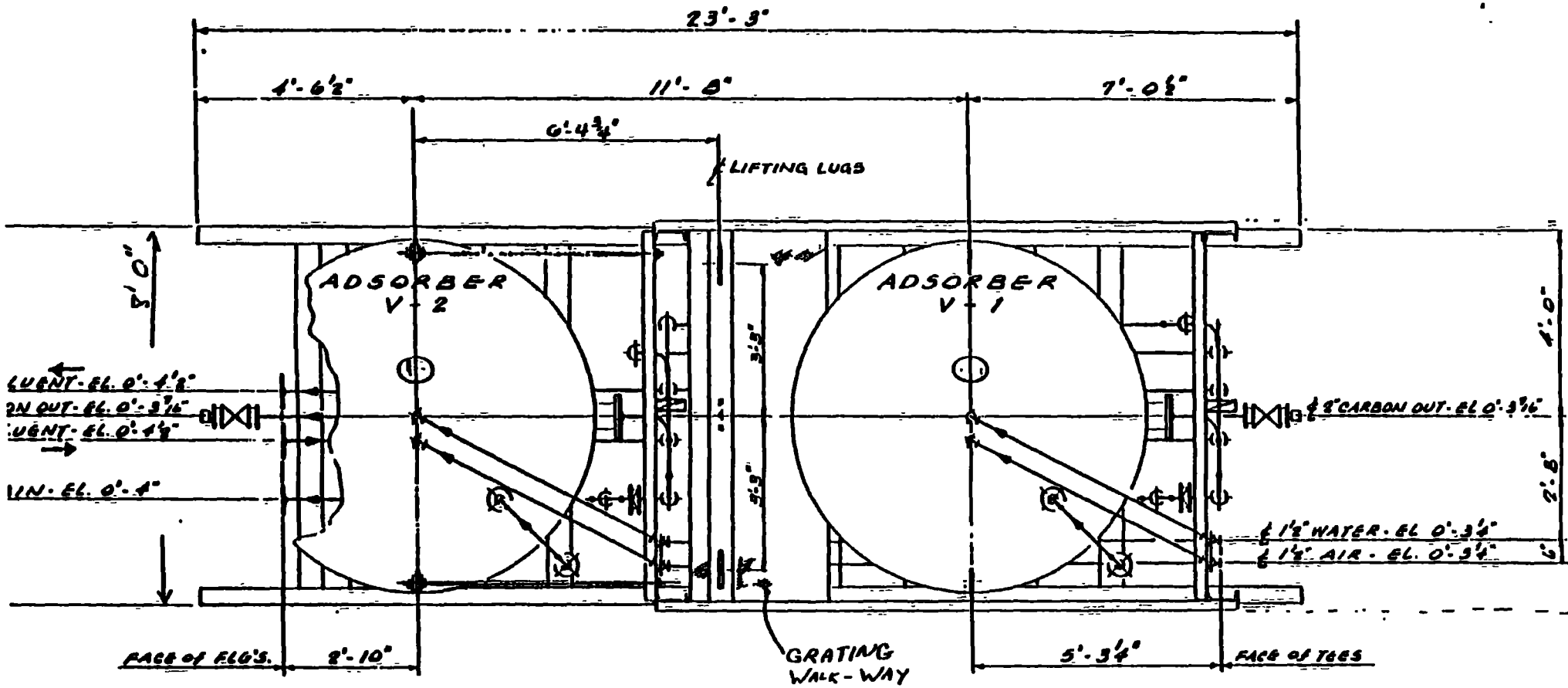
6.1 GENERAL: Ten thousand (6,500) pounds of Granular Activated Carbon shall be provided and installed within each adsorber vessel.

7. SERVICES

7.1 START-UP ASSISTANCE: The system supplier shall be able to provide the services of a field engineer who will be responsible for inspection of the adsorption system, mechanical trouble-shooting, system start-up and operator training.

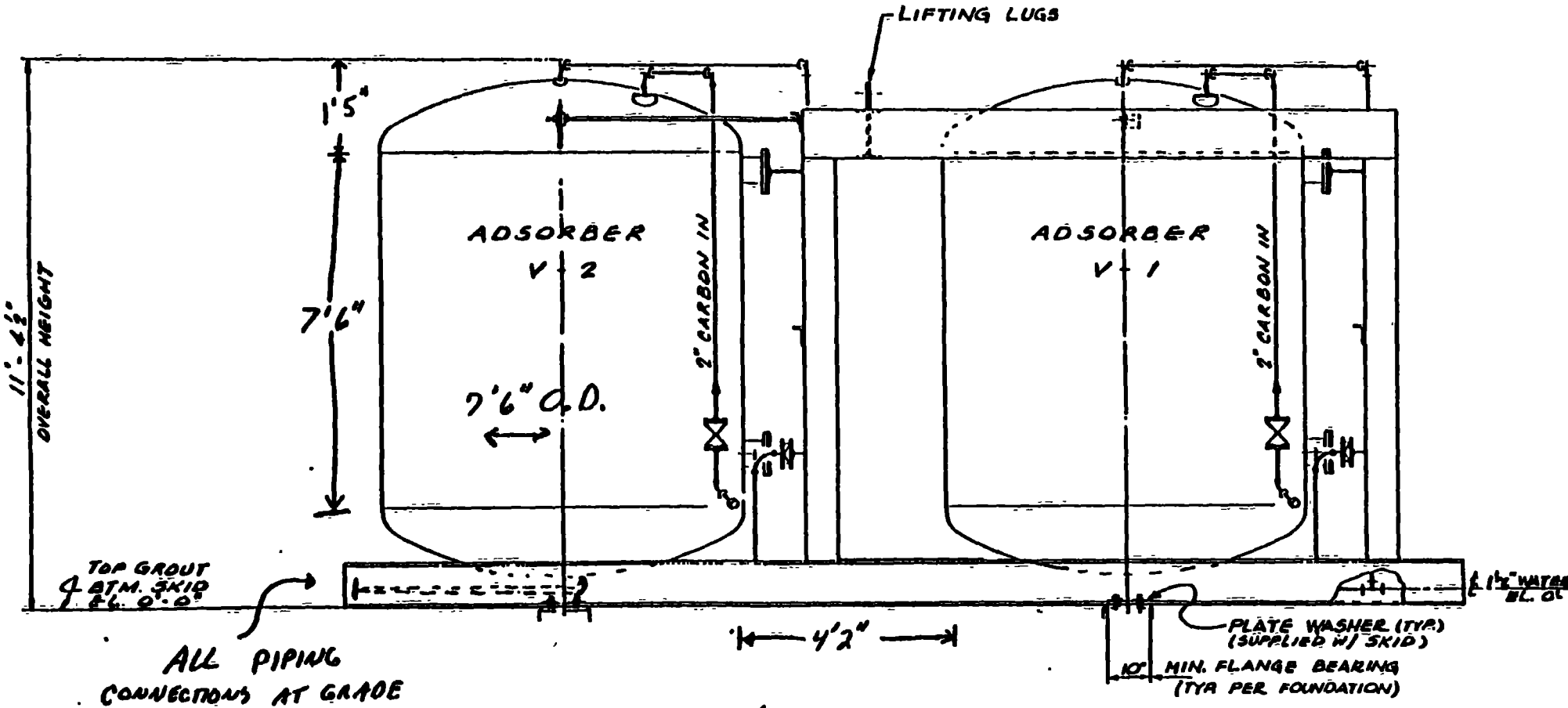
8. WARRANTIES

8.1 GENERAL: Equipment Warranties - Contractor will warrant the system to be free from defects in materials and workmanship for a period of 1 year from delivery of equipment.



PLAN

MODEL 7.5



ELEVATION

MODEL 7.5

APPENDIX D

ATTACHMENT 2

ACTIVATED CARBON COLUMN SYSTEM

(GMG ASSOCIATES/TIGG)

GMG

GMG ASSOCIATES

PROPOSAL FOR: Remediation Technologies, Inc.
3040 William Pitt Way
Pittsburgh, PA 15238

DATE: October 30, 1989

PROPOSAL NO: 89-0101

Attn: Dr. John R. Smith

GMG Associates is please to provide a quotation for a modular carbon adsorption system consisting of two (2) adsorbers containing 5,000 lbs of carbon each. The adsorbers will be supplied with all necessary piping and valving to allow series or parallel operation.

I-A DESIGN BASIS:

- o 5,000 lbs granular activated carbon/adsorber. Each adsorber to be 6'-0" diameter x 10'-0" straight side. A 5 foot freeboard for backwashing is provided.
- o ASME pressure vessels, coded for 100 psig
- o Carbon steel construction (ASTM A516, Grade 70), with interior lining (15-20 mils) of Plasite #7122 AR epoxy-phenolic. Exterior painted with Sherwin Williams Tri-Clad II epoxy-enamel.
- o ASME flanged and dished top head; ASME toriconical (120 degree) bottom head.
- o Effluent collection system consisting of eight (8) collector nozzles discharging into a 30" diameter stainless steel Type 304 flanged and dished head.
- o Design flow rate - 150 gpm. Influent and effluent flanged nozzles to be 4" diameter. Carbon inlet/discharge nozzles to be 4" diameter. 18" x 22" elliptical manway and two (2) 1" npt fittings for level indicators. Nozzles to be stainless steel with cbn. stl. lap joint flanges
- o Piping to be carbon steel, Schedule 40, with butterfly valves (lever operated).
- o Both adsorbers to mount to a structural steel frame which will be equipped with all piping and instrumentation. Framework to be painted with Sherwin Williams Tri-Clad II epoxy enamel.

2501 CHELSEA ROW, MURRYSVILLE, PA 15668
OFFICE: (412) 325-3462 FAX: (412) 327-9692

MODULAR ADSORBERS

ACTIVATED CARBONS, OTHER SORBENTS

ad•sorb *vt:* **1** to take up and hold by the adsorption process
2 effective, versatile purification method with TIGG systems

ad•sor•bent *adj:* **1** the capacity to adsorb
2 characteristic of all TIGG filters

ad•sorp•tion *n:* **1** adhesion of gas or solute molecules to solids
2 the speciality of TIGG equipment

. . . By any definition, TIGG Corporation products provide the unique advantages of adsorption in highly cost effective designs.

NIXTOX® *AIR POLLUTION CONTROL, PROCESS GASES*

CANSORB® *WATER POLLUTION CONTROL, PROCESS LIQUIDS*

ENVIROSORB® *LABORATORY, INDUSTRIAL AND MEDICAL WORK SPACE*

TIGG

TIGG CORPORATION - WORLD LEADER IN MODULAR ADSORPTION

Bulletin NCE 117

NIXTOX® MODULAR ACTIVATED CARBON ADSORBERS FOR AIR POLLUTION CONTROL, PROCESS GASES

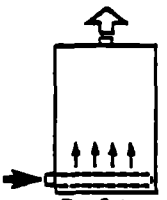
Cost effective, preengineered units for permanent and disposable adsorber needs.

- Soil Venting
- Tank/Separator Vents
- Air Exhausts
- Vacuum Pump Exhausts
- Drumming Stations
- Sewage Odors
- Air Stripper Discharges

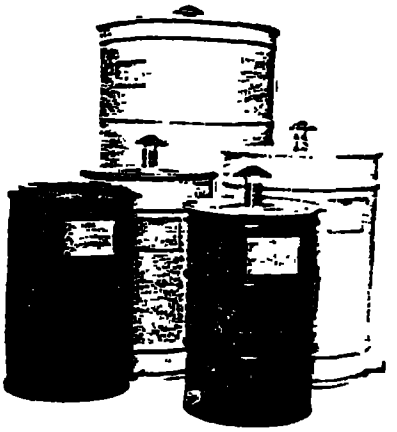
NIXTOX Disposable/Refillable Models to 1500 CFM

N50, 100 & 100XP, 150, 250; N500DB, 750DB, 1500DB.

Economical deep bed units may be refilled or discarded with spent adsorbent. Model numbers designate maximum flow in CFM. All feature TIGG's patented vapor distributors to permit full adsorbent utilization and peak removal efficiency, at low pressure drop and low operating cost (for example, N100, 55 gallon, contains 40% more adsorbent than competitive models with gravel bed supports, giving N100 improved performance and service life, half the flow resistance and lower shipping weight). Rain shields and condensate drains are standard. Saturation indicator option shows when the unit is about 70% exhausted, minimizing test expense, excess inventory, and noncompliance concerns. Standard construction is corrosion resistant steel with stainless distributor. N100XP is built of cross-linked polyethylene for extraordinarily corrosive duty, D.O.T. Specification 34. N100 is a D.O.T. 5B hazardous waste container.



Flow Pattern N50-N1500DB

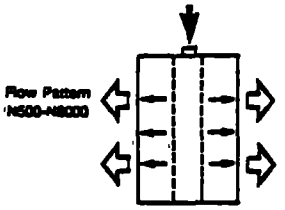


Left to right (Foreground) N100 XP N100; (Middle) N150, N250; (Rear) N500 DB. Smaller N50 and larger N750DB, N1500 DB are not shown

NIXTOX Radial Flow Models to 8000 CFM

N500, 1000, 1500, 3000, larger segmented models

This popular design treats large flows at very low pressure drop and small space requirements. Flow is from a central stainless screened distributor, outward through adsorbent, exhausting through side stainless screened ports to atmosphere or into cabinets at right. Flow may be reversed as preferred. Units in this series are normally recharged, with arrangements of disposable units used if adsorbent and vessel are to be discarded together. Condensate drains are standard; saturation indicators are available options. Construction is corrosion resistant steel, with stainless steel available on special order. N3000 is the largest standard unit, with special segmented versions of the design available for larger flows as ordered.

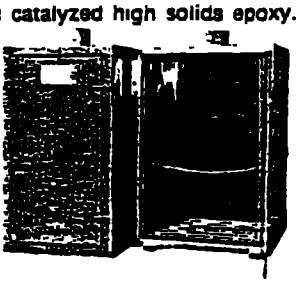


Flow Pattern N500-N8000

Front to rear: N500, N1000, N3000. N1500, with the same external appearance and size as N1000, is not shown. Similar larger N5000, N8000 are not shown.

Accumulator Cabinets

To collect flow from radial units at left, for direction to exhaust stack, downstream processing or recycle. Roller conveyors (except N3000, which requires forklift) assist in adsorber placement. Cabinets include gasketed door adsorber retainer chain, pressure relief disc, inlet/outlet stacks, flex connection for adsorber inlet, and condensate drain. Construction is steel finished with catalyzed high solids epoxy.

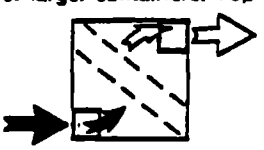


Accumulator Cabinets for N500, left, and N1000/1500. The cabinet for N3000 is of similar appearance but of larger size.

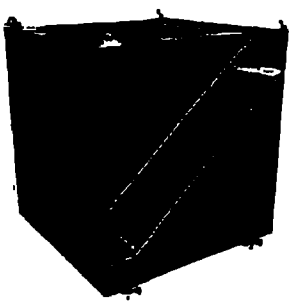
NIXTOX BOXSORBER™ Models to 4000 CFM

Boxsorber 6x6, 8x8

Newest of the NIXTOX series, BOXSORBER (Patent Applied) facilitates rapid response to spills and other heavy adsorption workloads. Standard units are cubic, six or eight feet on a side, suitable for flows to 2200 and 4000 CFM respectively. The unique design adapts well to trailer mounting; or permanent installation on leg assemblies supplied by TIGG. The diagonal adsorbent bed allows complete removal of spent material by gravity, with provisions for collection in drums or larger containers. Top hatches permit adding fresh adsorbent by gravity or airveying equipment. BOXSORBER features a proprietary inlet/outlet baffle design to produce even flow distribution over varied flow rates, at minimal flow resistance. Units may be operated upflow or downflow, singly or in series, with air inlet/outlet provisions at front, back or at either end. Condensate drains, pressure relief disc, lifting and tie-down lugs and inspection hatches are standard. Construction is catalyzed high solids epoxy coated steel with stainless steel adsorbent screens. All-stainless units are available on special order.



Boxsorber Flow Pattern (Reversible as desired) Inlets/outlets may also be at either end of distribution baffles (dark lines)



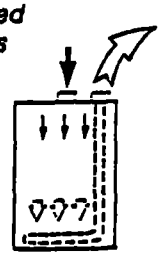
Boxsorber 8x8 during fabrication prior to installing air and adsorbent inlets/outlets, showing the unique diagonal adsorbent retaining/discharge system.

*U.S. PATENT 4,378,750
CANADA PATENT 1,197,075
See *Specifications and Properties* page for detail on NIXTOX Models

CANSORB® *MODULAR ACTIVATED CARBON ADSORBERS FOR WATER POLLUTION CONTROL, PROCESS LIQUIDS*

The wide selection of activated carbon CANSORBs is also supplied with activated aluminas, molecular sieves and ion exchange resins as purification needs require.

- Waste Minimization
- Aquifer Remediation
- Laboratory Wastes
- Process Streams/Solvents
- Spill Control
- Protect IX, RO Units
- Waste Water/Wash Water
- Radioactive Waste Water
- Pump Tests



Flow pattern— all CANSORB models

Left to right: (Foreground) C15, C15 XP; (Middle) C20, C25, (Rear) C30. C5, C35, C100 and C200 not shown.

Disposable/Refillable CANSORB Models to 200 GPM

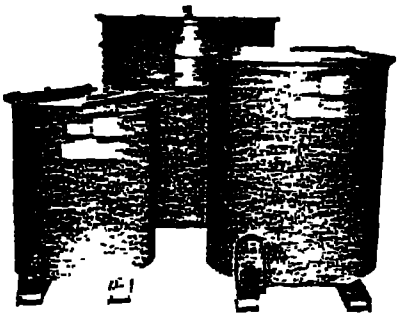
C5, 15 & 15XP, 20, 25, 35, 50, 100, 200.

Model numbers give maximum design GPM for water and other low viscosity liquids. Maximum flow may be lower for viscous liquids or to obtain ultralow impurity levels through extended adsorbent: liquid contact time. A patented liquid collection system promotes even flow distribution for efficient purification and adsorbent utilization, at low flow resistance. Construction is double epoxy/phenolic or high solids epoxy lined steel. The C15XP vessel is cross-linked polyethylene for severely corrosive duty, D.O.T. Specification 34. C15 is a D.O.T. 5B hazardous waste container. These units are particularly useful for collecting hazardous organic and radioactive wastes.

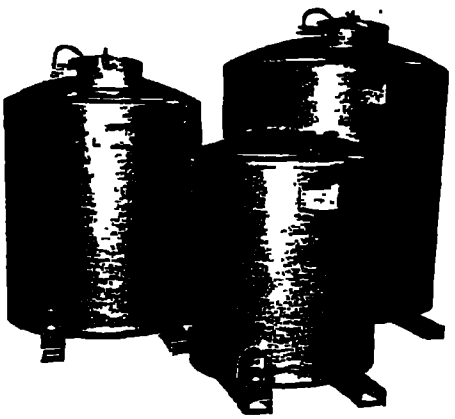
Polyethylene Lined CANSORB HDS Models to 200 GPM

C25HDS, 35HDS, 50HDS, 75HDS, 100HDS, 200HDS.

Designed for permanent installation or reuse on successive field jobs, HDS units have the flow geometry advantages described above, with extra refilling convenience due to separate adsorbent make-up and spent adsorbent discharge fittings. Model numbers refer to maximum water viscosity GPM per unit (see contact time comments above). Construction is heavy steel shell completely lined with thick HD polyethylene. The separate adsorbent addition fitting and bottom side discharge valve allow refilling without disconnecting liquid piping or removing the bolted flange top. Units include fork channels for handling, which double as a self-contained installation skid.



Left to right: C50HDS, C100HDS, C75HDS. C25HDS, C35HDS, C200HDS not pictured.



Left to right: C75SSL, C300SSL, C100SSL. C25SSL, C35SSL, C200SSL not shown.

CANSORB SSL Stainless Steel Models to 200 GPM

C25SSL, 35SSL, 50SSL, 75SSL, 100SSL, 200SSL.

Dished head and bottom SSL models are constructed of 304 L stainless steel, with separate adsorbent replacement fittings and liquid collection/flow advantages as described for HDS units above. All-welded construction is suited for permanent installations, transport for repeat use at various point sources, or quick-response trailer mounting. Larger units are provided with access manways, and all SSL models include steel skids for fork truck handling and support after installation. Model numbers give maximum design water flow, although operational flow may be subject to contact time considerations as well.

See Specifications and Properties page for details on CANSORB models.

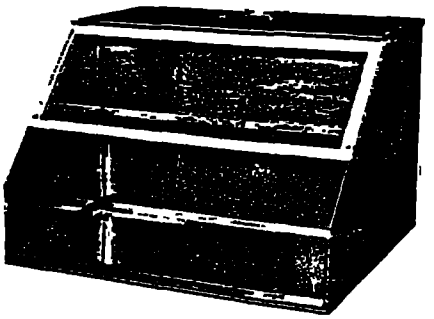
*U.S. PATENT 4,379,750
CANADA PATENT 1,197,075

WARRANTY

TIGG Corporation warrants these products to be in accordance with specifications and descriptions herein. Due to the wide variety of possible applications and conditions of use, no additional express or implied warranty is made for performance, safety, or suitability for particular purpose.

ENVIROSORB® LABORATORY, INDUSTRIAL AND MEDICAL WORK SPACE ADSORBENT AIR FILTERS

Activated carbon, other sorbent filters minimize exposure to:
Odors • Plastic Monomers • Metal Vapors • Anesthetics • Formaldehyde • Ammonia

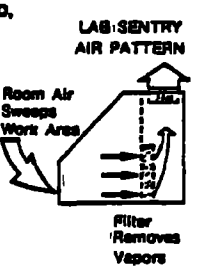


The EL-2 LAB SENTRY model is pictured. The larger EL-3 BENCH SENTRY™, for electronic soldering and other work stations, is of similar design.

Specifications on other side of this page.

ENVIROSORB LAB SENTRY™ Adsorbent Air Filter

For laboratories in which dedicated fume ventilation is not available, or in which hazardous vapors require control prior to the chemical hood system. LAB Sentry™ may be placed on counter or bench top, under a standard hood, or may be fitted with connections to an exhaust duct. Construction is of brushed stainless steel, with tempered safety plate observation window. The unit includes switch for work light and quiet electronic fan, electrical plug and cord, spill tray, filter grille, rinsable dust filter, and activated carbon or other sorbent filter.



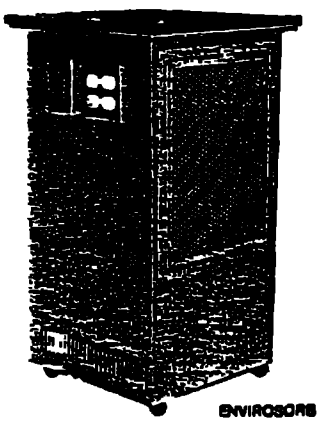
Tigg ADSORBOND™ Bonded Activated Carbon Filters

ENVIROSORB® laboratory and room air filters are available with an innovative adsorbent system in which the exclusive ADSORBOND™ process unites adsorbent particles into a porous panel. The result is a lighter, dust-free filter that eliminates handling spent adsorbent; since the entire panel is fully disposable and combustible for safety and convenience. Replacement ADSORBOND™ panels, or steel-framed punched plate panels for loose adsorbent particles, are available from TIGG.

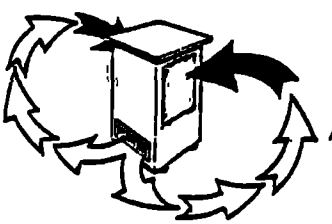
ENVIROSORB ODOR MAGNET™ Room/Work Space Adsorbent Air Filter

For spaces in which air fresheners or small activated carbon filters are insufficient. Typical applications include hospital and nursing home rooms, indoor pollution common to energy-conserving buildings, or areas in which workers are exposed to uncomfortable levels of anesthetics, solvents, fragrances or similar occupational contamination. Construction is pebbled aluminum with stainless steel top for work or shelf surface. Casters provide easy movement over carpeted floors. A resilient bumper avoids damaging walls or furniture. The unit contains dual rinsable dust filters and active carbon panels. A unique air pattern produces effective air exchange and odor control at minimal power and noise level. Included are night light, electrical outlet for radio/TV or humidifier, and rheostatic control for varied fan speed. Industrial versions may be ordered without night light, electrical outlet.

—A customer put it best:
"It's like opening a window, but without the energy loss."



ENVIROSORB ODOR MAGNET
See reverse of this page for specifications.



ODOR MAGNET
AIR EXCHANGE PATTERNS
Indicated Flow Duplicated
On Other Side Of Unit

CAUTIONS

NIXTOX - Certain airborne materials such as isocyanates can undergo oxidation, polymerization or other chemical reactions with, or in the presence of, activated carbon (activated charcoal), often with the liberation of heat. If there is doubt concerning the compatibility of activated carbon in your application, TIGG Corporation will be happy to comment or to supply a sample of adsorbent for appropriate tests. NIXTOX is not recommended for ozone or concentrated oxidants such as oxygen or chlorine. If a NIXTOX unit is to be connected to a source of flammable material, the precautionary use of a suitable flame arrestor in the connection line is recommended.

CANSORB filter piping should be pressure relieved, particularly if the adsorbers are fed by a positive displacement pump or other potential sources of high system pressure in upset conditions. Similarly, CANSORB units should be vented during extended shut-downs, to remove gases that might result from biological action on adsorbates.

ENVIROSORB LAB SENTRY, BENCH SENTRY and ODOR MAGNET filters are designed to reduce concentrations of objectionable odors and other undesirable adsorbable gases and vapors. *This largely cosmetic purpose is not intended to substitute for good safety or ventilation practices, nor to substitute for devices such as individual respirators or filters designed to remove poisonous adsorbed substances such as carbon monoxide.*

LOW OXYGEN HAZARD - Most activated carbon readily removes oxygen from air, creating an extreme hazard for workers inside adsorber vessels or in other poorly ventilated spaces. Good safety procedure demands that any activated carbon in a restricted space be assumed to have lowered oxygen to hazardous levels. All samplers, safety procedures and regulations for low oxygen environments should be followed.

Lifting Adsorbers - As further explained by labels on the units, hoist fittings on lids of larger NIXTOX (OB series), CANSORB and CANSORB HOS units are for assistance in removing lids only, not for lifting the entire unit. Fork lifts or appropriate slings under the unit should be used to lift as but the following models, which have standard lifting lugs: NIXTOX N1500OB, BOXSORBER 6 x 6, BOXSORBER 8 x 8.

SPECIFICATIONS and PROPERTIES

- TIGG products use no recycled materials or adsorbents. Installation/Operating instructions sent with each unit.
- Standard adsorbents are activated carbons. See *SELECTIVE ADSORPTION* on back page for other sorbents offered.

Unit	Design Maximum CFM (GPM)	Design Maximum psig. [a]	Design Maximum °F	Connections NPT (Duct)	Diameter/ Height, Inches [b]	Adsorbent pounds	Minimum Contact. [c] Sec. (Min.)	Shipping [d] Pounds
NIXTOX[e]								
N50	50	10	350	2"M	19/29	110	4.3	175
N100	100	10	350	2"M	24/35	200	3.9	270
N100XP	100	10	165	2"M	24/35	200	3.9	228
N150	150	10	350	2"M	27/40	300	3.9	385
N250	250	8	350	2"M	32/44	400	3.1	540
N500DB	500	6	350	4"M	57/67	1900	7.4	2375
N750DB	750	6	350	(5")	66/67	3200	8.3	4200[f]
N1500DB	1500	6	350	(6")	82/75	5700	7.4	7100[f]
N500	500	Open	350	(4")	24/35	200	0.8	300
N1000	1000	Open	350	(6")	32/44	400	0.8	565
N1500	1500	Open	350	(7")	32/44	300	0.4	475
N3000	3000	Open	350	(10")	48/72	1600	1.1	2050
Boxsorber 6x8'	2200	3	350	(10")	72" cube	3000	2.8	5800[f]
Boxsorber 8x8'	4000	3	350	(12")	96" cube	5300	2.8	9800[f]
CANSORB								
C5	(5)	12	230	3/4"F	19/29	80	(4.5)	145
C15	(15)	12	230	3/4"F	24/35	150	(2.8)	220
C15XP	(15)	12	165	3/4"F	24/37	150	(2.8)	180
C20	(20)	12	230	1"F	27/40	225	(3.1)	310
C25	(25)	8	230	1 1/4"F	32/44	300	(3.3)	415
C35	(35)	8	230	1 1/2"F	47/54	1000	(7.9)	1420
C50	(50)	6	230	2"F	48/72	1600	(8.9)	2120
C100	(100)	6	230	3"F	66/72	3000	(8.3)	4000[f]
C200	(100)	6	230	4"F	90/78	6000	(8.3)	7800[f]
C25HDS/C25SSL	(25)	12	165/230	1 1/4"M	33/49	300	(3.3)	635
C35HDS/C35SSL	(35)	12	165/230	1 1/2"M	42/55	600	(4.8)	1140
C50HDS/C50SSL	(50)	12	165/230	2"M	47/55	800	(4.4)	1440
C75HDS/C75SSL	(75)	12	165/230	2 1/2"M	57/67	1600	(5.9)	2860
C100HDS/C100SSL	(100)	10	165/230	3"M	73/80	3000	(8.3)	5325[f]
C200HDS/C200SSL	(200)	8	165/230	4"M	90/80	6000	(8.3)	8900[f]

(a) Per unit. Series pressure additive on upstream unit(s).
(b) Primary adsorber vessel. Stacks or fittings, premounted fans, skid supports change overall dimensions.
(c) Superficial at maximum flow.
(d) Active carbon basis. Other adsorbents, prewetting, premounted fans will change.
(e) Available with nonsparking fans, explosion proof motors.
(f) Adsorbent normally shipped to fill on-site.

ENVIROSORB	CFM	Volts/Hz	Amps	L/W/H, Inches	Shipping lbs.
LAB SENTRY	25	115/50-60	0.1	22/20/15	43
BENCH SENTRY	45	115/50-60	0.2	30/28/20	58
ODOR MAGNET	125	115/50-60	1.0	18/18/31	48

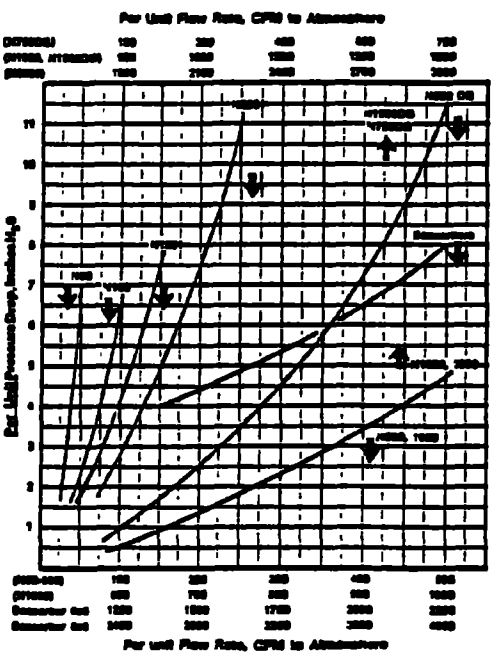
Note: 20% lower CFM at 50 Hz.

STANDARD ACTIVATED CARBONS

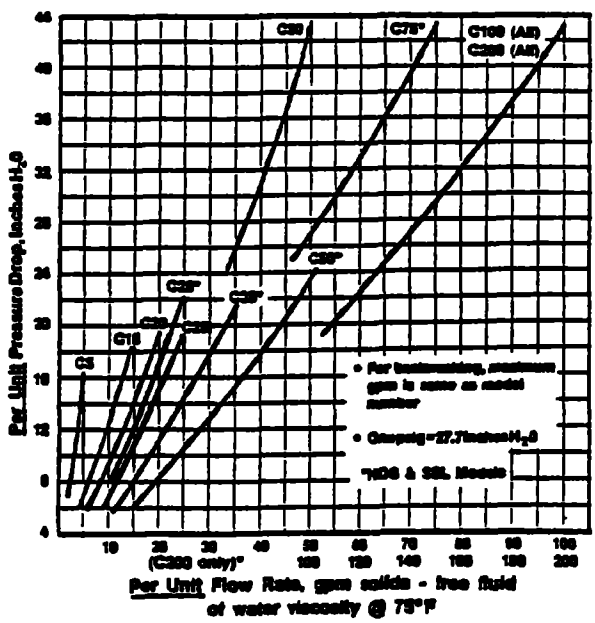
Type	Iodine No. mg./g. min.	Carbon Tetrachloride Weight % min.	Molasses No. min.	U.S. Sieve 90% min.	Bulk Density lbs./cu. ft. approx.
TIGG 5C 0410 (NIXTOX)	1050	60	—	4 X 10	31
TIGG 5D 1240 (CANSORB)	1000	—	230	12 X 40	27
ENVIROSORB	1050	60	—	4 X 8	31

FLOW RESISTANCE

NIXTOX MODELS



CANSORB MODELS



- ***PREDICTING ADSORPTION PERFORMANCE***

TIGG Corporation's proprietary ADSORPTION PREDICTIVE TECHNIQUE (APT)™ computer programs can be very helpful outlining the activated carbon requirements for given air or water purification applications. The programs are derived from experimental data, but are based on fundamental correlative relationships that link adsorption by carbons of known characteristics to the properties of individual contaminants. Thus given a complete and accurate analysis (generalized descriptions such as VOC, BOD, or COD are not useful, but ppm or ppb analyses of individual components are) of the expected impurities in a defined flow, the resulting adsorbent needs can be predicted. The resulting savings in time and test expense may be significant. A modest charge is made for this service, reimbursable on purchase of TIGG adsorbers.

- ***SELECTIVE ADSORPTION***

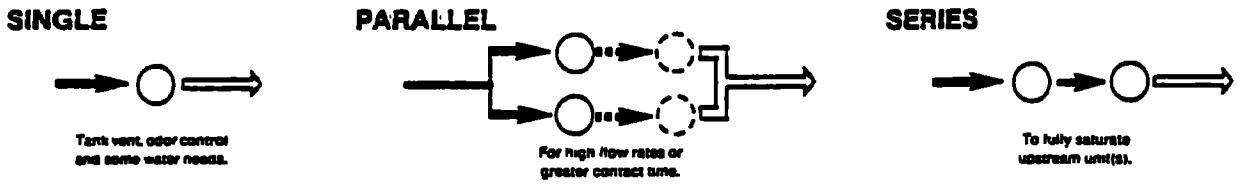
Activated carbons are very versatile adsorbents, such that it would be impractical to list the many thousands of adsorbable organics. In general, the higher an adsorbate's molecular weight and the lower its vapor pressure or water solubility versus other components or the carrying stream, the more physical adsorption is enhanced. In addition, chemisorbents have been developed to remove certain problem materials that would otherwise be poorly adsorbed; including hydrogen sulfide, lighter mercaptans and amines, ammonia, formaldehyde, mercury vapor and some radioactive compounds. TIGG also employs activated aluminas, ion exchange resins, molecular sieves and other desiccants according to the purification challenge.

- ***ACCESSORIES/OPTIONS***

NIXTOX and CANSORB models are available with fan/motor or pump/motor combinations, rigid or flex prepiping, valves, quick disconnects, prefilters, postfilters, totalizers, rotometers, flame arrestors, temperature and pressure gauges, adsorbents prewetted with water or other process fluids, specialized adsorbents and chemisorbents.

- ***INSTALLATION/OPERATION***

All NIXTOX, CANSORB and ENVIROSORB models include the initial adsorbent fill and arrive ready for operation. NIXTOX units typically go on stream immediately, while CANSORB models are usually liquid backfilled and then put in service. ENVIROSORB models need only be unpacked and plugged into an electrical outlet. Detailed instructions are sent with each unit. For NIXTOX and CANSORB, common adsorber configurations are:



- ***REPLACEMENT/RECHARGING***

Many NIXTOX and CANSORB models may be replaced when permitted by economics of extended service life or for added convenience in disposing of wastes. N100 and C15 convert to D.O.T. 5B hazardous waste containers. NIXTOX and CANSORB have no gravel, screens or other loose components to complicate removing spent adsorbent or refilling vessels. Larger NIXTOX and CANSORB units are most conveniently emptied by water/adsorbent slurry or vacuum wand; BOXSORBER by gravity. Make-up adsorbents are available from TIGG. Replacement of ENVIROSORB filters is simply a matter of removing the spent filter panel and replacing or refilling it.

Spent adsorbent may be discarded, added to boiler coal or otherwise incinerated, or may justify reactivation if available in sufficient volume. The disposal method may be governed by the nature of adsorbate(s) on the spent material.

SPECIAL PRODUCTS/SERVICES

TIGG can design and fabricate products with custom modifications, to produce private label or other unique adsorption products and systems. TIGG designs have won *IR 100* and *Pollution Engineering's* 5-Star Product Advancement awards. The ADSORBOND bonding process creates additional innovative adsorption possibilities. If these capabilities might help solve a unique problem or attain your marketing goals, please write or call.

NIXTOX, CANSORB and ENVIROSORB filters are shipped F.O.B. TIGG Southcentral Operations, Heber Springs, Arkansas. This modern facility is dedicated solely to the fabrication of adsorbent products, modular adsorbers, and adsorption systems.

TIGG CORPORATION
BOX 11661
PITTSBURGH, PA 15228

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TELEX: 289312 TIGG PITT (RCA)
CABLE: TIGGCOR PITTSBURGH
TELEFAX: (412) 563-6156

"An informed buyer is the quality supplier's best friend."

SELECTION CRITERIA FOR GRANULAR ACTIVATED CARBON (GAC)

Foreword

Although the term activated carbon is used generically, it can refer to dozens of similar - but not identical - adsorbents. Depending on raw material, method and degree of activation and other factors, carbons can perform differently in various applications. TIGG Corporation does not manufacture activated carbons, but has over 30 years of experience in carbon market development, product development, research and applications technology. Further, as the leading manufacturer of modular adsorbers, it is in TIGG's interest that prospects have a means for assessing the characteristics of carbon adsorbents they may be considering, so they might avoid selecting an inappropriate type, or so they can acquire a preengineered adsorber with the optimum adsorbent contents. Within constraints of brevity, this commentary is designed to objectively summarize key selection criteria.

Introduction

Activated Carbons are a very versatile group of adsorbents, with capability for selectively adsorbing thousands of organic, and certain inorganic, materials. From medicinal uses of powdered carbons in ancient Egypt, through charred interiors of whiskey barrels, carbon has been activated and used as an adsorbent for centuries. Granular vapor phase carbons were first widely used in WWI military gas masks and, in the years between World Wars, commercially in solvent recovery systems. Granular liquid phase carbons achieved their first prominent applications following WWII, in sugar decolorization and in purification of antibiotics. Today, there are hundreds of applications—if diverse uses under the general heading of environmental control are counted separately, ongoing applications number in the thousands.

Adsorption/Adsorbents/Activated Carbon

Since adsorption is a comparatively specialized technology, a capsule definition of terms may be helpful. Adsorption is a surface phenomenon, in which molecules of adsorbate are attracted and held to the surface of an adsorbent until an equilibrium is reached between adsorbed molecules and those still freely distributed in the carrying gas or liquid. While the atoms within the structure of the adsorbent are attracted in all directions relatively equally, the atoms at the surface exhibit an imbalanced attractive force which the adsorbate molecules help to satisfy. Adsorption can then be understood to occur at any surface, such as window glass or a table top. The characteristic which typifies an adsorbent is the presence of a great amount of surface area; normally via the wall area of slots, capillaries or pores permeating its structure, in a very small volume and unit weight.

The type of adsorption which is dependent primarily on surface attraction, in which factors such as system heat, pressure, or impurity concentration may shift the adsorption equilibrium, is given the further classification of physical adsorption. The electronic forces (Van der Waal's forces) responsible for adsorption are related to those which cause like molecules to bind together, producing the phenomena of condensation and surface tension. Conceptually, some prefer the analogy of physical adsorption being like iron particles attracted to, and held by, a magnet. Physical adsorption is the most commonly applied type, but an important sub-classification is chemisorption. Chemisorption refers to a chemical reaction between the adsorbate and the adsorbent per se, or often reaction with a reagent which may be impregnated on the extensive adsorbent surface (see Impregnated Carbons, below). Thus physical adsorption/desorption retains the chemical nature of the adsorbate, while chemisorption alters it.

The surface phenomenon of adsorption may now be contrasted with absorption, in which one material intermingles with the physical structure of the other; for example, phenol dissolving into fibers of cellulose acetate (absorption) versus being adhered by surface attraction to the outer layer of the fibers (adsorption).

Activated Carbon (activated charcoal) is an adsorbent derived from carbonaceous raw material, in which thermal or chemical means have been used to remove most of the volatile non-carbon constituents and a portion of the original carbon content, yielding a structure with high surface area. The resulting carbon structure may be a relatively regular network of carbon atoms derived from the cellular arrangement of the raw material, or it may be an irregular mass of crystallite platelets, but in either event the structure will be laced with openings to appear, under electronmicrographic magnification, as a spongelike structure. The carbon surface is characteristically nonpolar, that is, it is essentially electrically neutral. This nonpolarity gives the active carbon surface high affinity for comparatively nonpolar adsorbates, including most organics. As an adsorbent, activated carbon in this respect contrasts with polar desiccating adsorbents such as silica gel and activated alumina. Activated carbon will show limited affinity for water via capillary condensation, but not the surface attraction for water of a desiccant.

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Activity Level

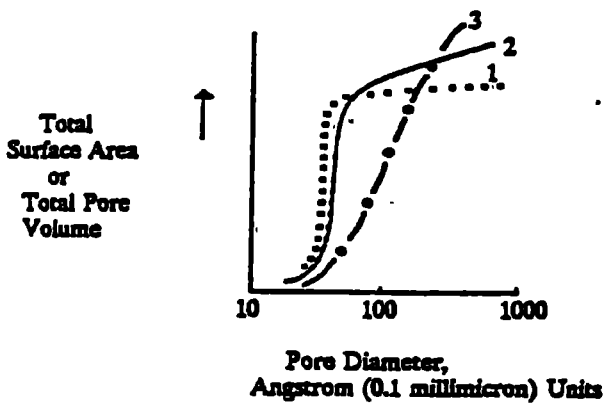
Activity level is often expressed as total surface area per unit weight, usually in square meters per gram. This total exposed surface will typically be in the range of 600-1200 m2/g. Toward the higher end of this range, one might better visualize one pound, about a quart in volume, of GAC with a total surface area of 125 acres.

To be useful in adsorption, surface area must be present in openings large enough to admit the adsorbate molecule(s). To provide some guidance on this topic, and for quality control purposes, the carbon industry has developed additional standardized vapor and liquid adsorption tests, using adsorbates of varying molecular size and chemical nature such as iodine, phenol, methylene blue, carbon tetrachloride, benzene and the color in standard black strap molasses. However activity level is measured, it is most meaningful when considered with additional characteristics covered below.

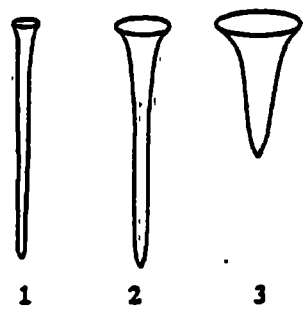
Pore Structure

While openings into the carbon structure may be of various shapes, the term "pore," implying a cylindrical opening, is widely used. A description of the minute distances between walls of these pores, normally expressed as a function of the total surface area or total pore volume presented by pores of various "diameters," is the pore structure curve. The following sketches show some sample pore structure curves and what approximate pore shapes are described by the curves. Please note that the average pore shape depicted is derived from a summation of pores of various sizes and shapes. Thus no pore within the carbon is likely to have precisely the average shape, but the carbon overall will often perform as if all its surface area were in pores of that shape.

Pore Structure Curve Illustrations



Depiction of "Average" Pore Shapes



The smallest diameter pores make up the micropore structure, and are the highest adsorption energy sites. Microporosity is helpful in adsorbing lower molecular weight, lower boiling point organic vapors, as well as in removing trace organics in water to nondetectable levels. Larger pore openings make up the macroporosity, which is useful in adsorbing very large molecules and aggregates of molecules, such as "color bodies" in raw sugar solutions. Another important function of the macropore structure is in assisting diffusion of fluids to adsorption sites in the interior of the carbon particle.

Given the above, pore structure 1 would be effective in adsorbing high volatility solvents, for certain types of odor control, and in removing trace organics from water; the latter with the liability of marginal diffusion characteristics. Pore structures along the lines of 2 offer a good balance of selectivity for molecules of various sizes, ability to reduce vaporous and liquid contamination to ultralow levels, and good diffusion characteristics. Structure 3 would allow excellent diffusion and can accommodate very large molecular sizes, but has little micropore structure and would have very poor retentivity for most organics.

Raw Material

Activated carbon can be produced from various carbonaceous raw materials, each of which will impart typical qualities to the finished product. Commercial grades are normally prepared from coconut and other nut shells, bituminous and lignite coals, petroleum coke, and sawdust, bark and other wood products. In general, nut shells and petroleum cokes will produce very hard carbons with a pore structure characterized by 1 above, coals a 2 type structure in comparatively hard carbons, and wood a 3 structure in carbons lacking great crush and abrasion resistance. It should be emphasized that specific production techniques may yield carbons that depart from the norm of a given raw material.

Apparent Density

The solid, or skeleral, density of most activated carbons will range between 2.0-2.1 g./cc., or about 125-130 lbs./cubic foot. However, this would describe a material with essentially no surface area and no adsorptive capacity. For GAC, a much more practical density is the apparent density (A.D.), or mass of a given volume of adsorbent particles. This density will be significantly lower than the solid density, due to the presence of pores within particles, and void space between particles. In most commercial GACs, the A.D. variation is between 0.4-0.5 g./cc., or between 25-31 lbs./cubic foot.

Since GACs are used in adsorbers of fixed volume, apparent density values can be used to calculate volume activity, which may help determine the work capacity of an adsorber with alternative carbon loadings. For example, assume that carbon A adsorbs iodine to produce a standardized Iodine Number of 1100 mg/g., and has an A.D. of 0.4 g./cc. Carbon B has an Iodine Number of 950 mg./g and an A.D. of 0.5 g./cc. Multiplying the A.D. by the weight basis activity value, carbon A has a volume iodine capacity of 440 mg./cc. while carbon B has a value of 475 mg./cc. Therefore, carbon B, which has lower activity, might actually do more work and therefore have a longer service life than carbon A of an equal volume. If the price of carbon B permitted filling a given adsorber with the greater weight required, it could thus be the most economical of these adsorbents on a net cost basis.

Since standard activity tests are run with oven dried carbon, it will be immediately apparent why high A.D. values that reflect added moisture will not produce the benefit illustrated above. Similarly, high densities due to significantly low activity levels, or ash or inactive char residue from reactivation, or any noncarbon adulterants will not normally benefit service life nor the adsorbent's capability to produce highly purified fluids.

Particle Size

The size of most GACs is given by the U.S. Sieve range that will include the majority of the particles in a distribution of sizes. Typically the range will cover 85-95% of the total product, with a few percent slightly larger and smaller sizes permitted by specification. A similar approach is occasionally used with Tyler Screen or other screen sizes. Pelletized carbon, although not truly granular, often is described by the sieve range method, or by diameter of the pellets.

Common vapor phase U.S. Sieve size ranges are 4x6, 4x8, 4x10, 6x16 and 12x30. Liquid phase GACs are usually somewhat smaller, with 8x30, 12x20, 12x40 and 20x50 being common. Detailed sieve descriptions are found in engineering handbooks, so only a few representative sizes are given here:

U.S. Sieve #	Tyler Screen Equivalent	Opening	
		Inch	Millimeter
4	4	0.187	4.76
6	6	0.132	3.36
8	8	0.094	2.38
12	10	0.066	1.68
20	20	0.066	0.84
30	28	0.023	0.59
40	35	0.017	0.42
50	48	0.012	0.30

Since impurity removal requires the diffusion of adsorbate into the intraparticle structure, the rate of adsorption will increase as the particle size decreases. As fluid flows through an adsorber, increased rate of adsorption will require less adsorbent bed depth and contact time for the region in which the adsorbate is being removed. This functional adsorption region is termed the adsorption wave front or mass transfer zone. However, with any given fluid, decreasing particle size carries the liability of increasing flow resistance or pressure drop. In practice, particle sizes are selected to produce a reasonable balance between the competitive benefits of rapid rate of adsorption and effective removal, versus the liabilities of increased flow resistance and attendant higher pumping costs.

Hardness

Hardness and abrasion resistance are generally beneficial in all GACs, although their operational usefulness can vary greatly. Within common adsorber designs and operating ranges, all commercial GACs can withstand their own weight and the pressure effects induced by fluid flow. Thus in systems in which the GAC will be used once or handled very infrequently, hardness characteristics may be of little or no import. Conversely, if the carbon will be subject to frequent handling for a regeneration step, is subjected to thermal excursions by regeneration in place, or must resist excessive vibration, hardness may become quite important. For example, fines (dust) from handling a soft carbon in a system using thermal reactivation may double or treble the losses in the reactivation furnace itself. In solvent recovery systems using steaming cycles for regeneration, carbons that fracture easily can frequently raise pressure drop enough to require that the adsorbent be rescreened and replenished, or replaced.

In evaluating hardness numbers, it should be remembered that the GAC hardness test has no relation to the hardness scales used for plastics, metals or minerals. A carbon of 98 hardness is appreciably harder than one of 80, but even harder materials such as diamond, steel and copper, even though they differ in actual hardness, will all report as 100 on the basis of the GAC hardness test.

Ash

If part of the carbon raw material, ash generally varies between 2-20 weight percent in commercial GACs. A portion of total ash may be water soluble, normally a greater amount acid soluble, and the remainder deeper within the skeletal structure of the carbon to be effectively insoluble. Ash from wood and nut shell carbons tends to be rich in alkaline metals, while that from coal largely oxides of aluminum, silicon and iron. For the limited instances in which traces of soluble or reactive ash are objectionable, GACs prewashed with water or acids are available, or grades based on certain raw materials may minimize the total ash level or particular ash components.

Natural ash is normally not detrimental to the adsorption process, and standard activity tests report GAC efficiency including the weight of the ash. However, in certain regenerated GACs, ash that is a residue of previous uses may block some or all of the micropore structure that is vital for removing organics to ultralow levels. Similarly, if ash is due to previous impregnation for another use, or due to any other adulterant, the carbon performance may be seriously compromised.

pH

Water extracts of activated carbons are used for reporting pH. Untreated coal base carbons are typically close to neutrality, while nut shell and wood carbons are more alkaline. Most untreated GACs vary between pH 6-10, but added acids or alkalis may further extend this range.

In purifying water and aqueous solutions, the pH of the GAC should be contrasted with the preferred pH of the solution. Most organics are best adsorbed from slightly acid, pH 5-7, solution. However, the beginning pH of the GAC will not influence the pH of the treated solution very long (although adsorbates being removed may alter solution pH).

Impregnated Carbons

High surface area per unit weight or volume can make GAC an effective substrate for dispensing other materials in a manageable form. Impregnants may be catalysts, or they might be reactive chemicals added to improve the rate of adsorption, selectivity, or capacity for certain adsorbates. Examples of the latter would include carbons with a faster rate of removal for hydrogen sulfide and other acid gases, some with capability to remove ammonia and lighter amines, and some with enhanced capacity for reduction of mercury vapor. Impregnated carbons usually retain 75% or more of the physical adsorption capability of the base carbon, so they are often used for combined physical adsorption and chemisorption. Whether an impregnated GAC will be cost effective frequently depends on whether a particular adsorbate is the only, or primary, removal candidate.

Reactivation

As explained earlier, carbon activation is frequently carried out in high temperature furnaces, under mildly oxidizing conditions. As the name implies, reactivation refers to using a similar process to volatilize and oxidize the adsorbates on spent carbons. The term reactivation might be contrasted with regeneration, which refers to steaming or other methods to restore a portion of the GAC adsorptive capacity, although the terms are commonly interchanged. Reactivation will almost always produce measurable changes in pore structure, due to additional oxidative sculpturing of the carbon surface and, frequently, deposits of residual chars or inorganic materials. In a few cases, reactivated GACs perform better than or as well as the virgin material, but in many others there may be a defined loss of comparative efficiency or a gradually increasing loss of efficiency. When loss of efficiency is encountered, it is normally most pronounced in the micropore structure, therefore it is most significant operationally when the last traces of contamination must be removed.

Dedicated reactivation, in which a GAC will be segregated and returned to the same use, tends to be more predictable than employing a reactivated GAC from a different previous use, or a mixture of reactivated GACs from a variety of previous uses. However, dedicated reactivation is impractical for spent GAC quantities under several tons. The cost effectiveness of reactivated versus virgin carbons can be understood to vary with the performance requirements, the comparative volume service life, and the volume cost of the material (cost per unit weight may be misleading, as reactivated carbons frequently have higher apparent densities). Given the possible variations in reactivated carbons, it will also be understood that a reputable supplier should always specify if virgin or reactivated GAC is being offered.

Quality Assurance

GAC quality and uniformity will fundamentally relate to characteristics involving: (1) adsorption capacity and (2) a physical description of the product. The activated carbon industry, often in cooperation with A.S.T.M. and other standards organizations, has developed a series of tests that measure these characteristics. As would be expected, such tests can be used both as production controls and, as published specifications, assurance for prospective buyers.

Not all GAC manufacturers and distributors publish adsorption specifications. Among those that adhere to specifications, the same precise group of tests may not be used. However, some correlation of values is usually possible as, for example, between the vapor phase carbon tetrachloride test used in the U.S. and the benzene and acetone tests more common in Europe and the Far East.

Among physical tests, the methods to determine moisture, apparent density and particle size or distribution are relatively standard among manufacturers. Hardness or abrasion values may require some interpretation or correlation, as above.

Terms such as "high quality; excellent adsorption characteristics; hard; dense; etc." are inadequate substitutes for specifications. They offer no guidance for comparison, no assurance of quality, and no confidence of uniformity.

Predicting Performance

Many prospective GAC users will be considering applications that are unique to some extent. Perhaps the mix of impurities is unusual, or the system conditions or performance required may be new. The uncertainty of these situations has historically been resolved by testing. More recently, vapor and liquid computer-assisted correlative techniques have been developed for use when urgency, lack of test fluids, or costs make tests impractical; or to help establish test protocols that will yield the most useful information. A description of TIGG Corporation's Adsorption Predictive Technique (APT™) computer service is available on request.

Experimental GAC tests include adsorption isotherms and column tests. Isotherms are batch tests which require careful evaluation before eventual GAC performance in continuous adsorbers may be predicted. Column tests may vary from laboratory bench to pilot or semi-commercial scale. Sometimes results of such tests are termed "treatability studies," and many useful results have been published. Unfortunately, some published data do not describe the methodology or adsorbents used; others employ test methods or data interpretations that are suspect. Therefore the literature can be a risky basis for determining GAC efficiency, although tests performed and interpreted properly are quite dependable. Major GAC manufacturers, as well as firms such as TIGG Corporation which specialize in GAC equipment, can recommend test procedures and may have small scale adsorbers available.

A very important evaluation caveat is that different GACs have differing efficiencies for different applications. Thus a test, literature search or computer projection based on a particular GAC will not necessarily describe the performance to be anticipated from another GAC.

Price

Readers will appreciate that, while not to be ignored, GAC price is rarely the leading factor in selecting an adsorbent. GACs of diverse efficiencies, qualities, sources and prices are in the marketplace. Price per pound or per cubic foot should be interpreted in terms of cost effectiveness. Cost effectiveness, in turn, may relate both to the GAC and the adsorber in which it will be applied, since even the optimum GAC will not overcome a deficient adsorber design. We hope that some of the commentary in this guide will assist in selection of the most cost effective adsorbent.

GAC Selection Checklist

Individual applications may entail many questions that cannot be anticipated in a brief checklist. The following generalized points are pertinent to almost any application, and might at least provide a point of departure for more focused inquiry.

1. Is there a complete and accurate description of the application?
2. Will GAC adsorption work in the application?
3. Any tests or knowledgeable performance projections of GAC efficiency?
4. Any guidance on the most efficient among alternative GACs?
5. Does candidate GAC have standard published specifications, prices?
6. Do specifications support expectation of good performance in the application?
7. If make-up is needed, is GAC source uniform and dependable?
8. Is GAC virgin or reactivated? If reactivated, what are the characteristics?
9. How much of apparent density may be due to moisture, residue from reactivation, or low activity? What is volume activity (see Apparent Density)?
10. Will GAC be applied in a well designed adsorber?

An overriding factor in outlining the proper GAC to use, and predicting expected results, is the clearest possible definition of the application. Eventual performance typically reflects the quality of information used for initial technical judgments, and selecting a GAC follows this truism.

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APPENDIX D

ATTACHMENT 3

UPFLOW FIXED BED SAND FILTER WITH CONTINUOUS OPERATION

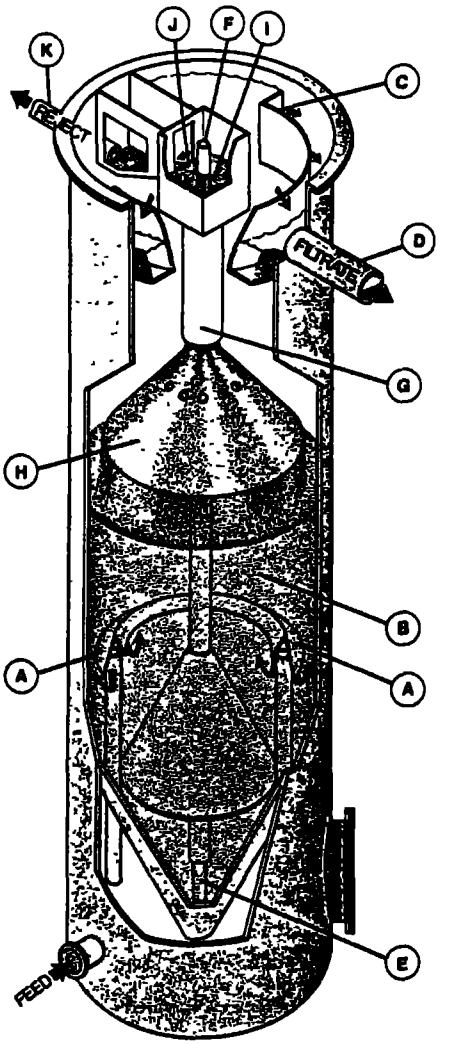
(PARKSON CORPORATION DYNASAND FILTER)

DynaSand® Filter

PARKSON CORPORATION

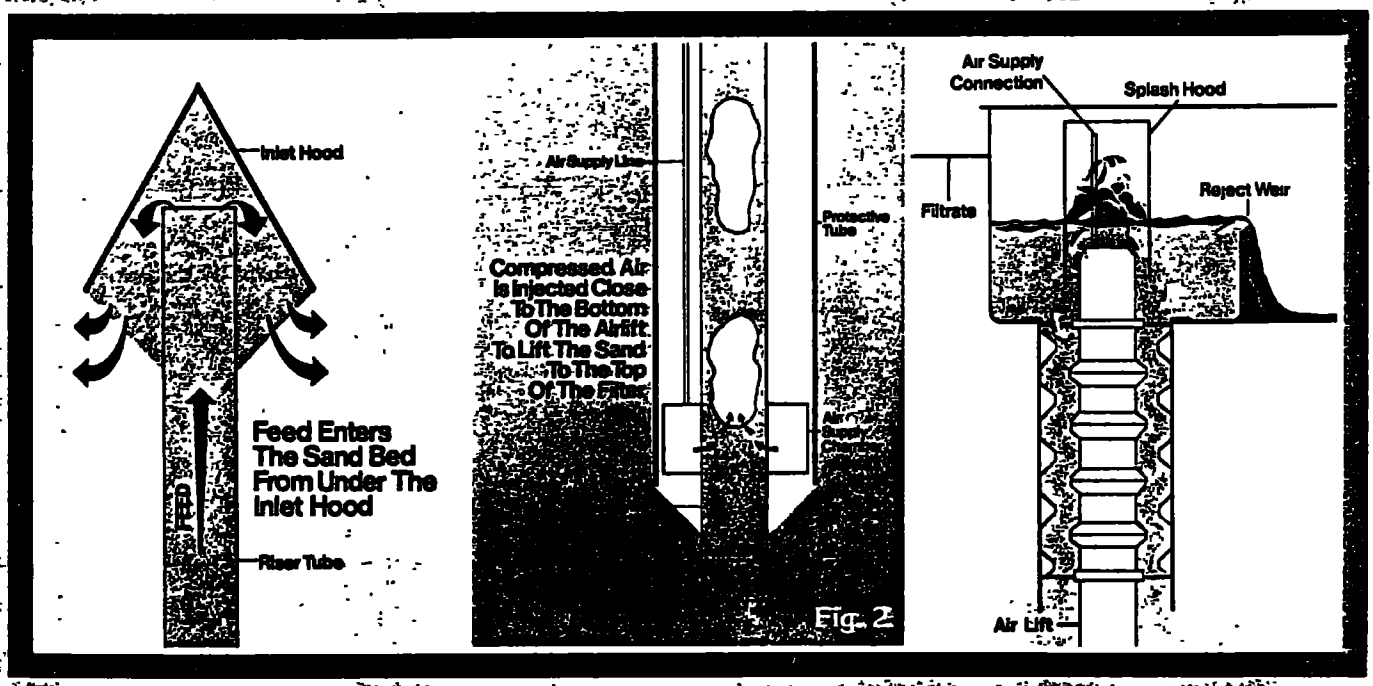
DynaSand® Filter
A Unique Concept in Sand Filtration...

The DynaSand® Filter is a continuous backwash, upflow, deep bed granular media filter. The filter media is continuously cleaned by recycling the sand internally through an airlift pipe and sand washer. The regenerated sand is redistributed (see Cover) on top of the sand bed allowing for a continuous uninterrupted flow of filtrate and reject water.



Feed is introduced into the bottom of the filter, then flows upward through a series of riser tubes and is evenly distributed into the sand bed through the open bottom of an inlet distribution hood (A) (Fig. 1). The influent flows upward through the downward moving sand bed (B) with the solids being removed. The clean filtrate exits from the sand bed, overflows a weir (C) and is discharged from the filter (D). Simultaneously the sand bed, along with the accumulated solids, is drawn downward into the suction of an airlift pipe (see Fig. 2) which is positioned in the center of the filter. A small volume of compressed air is introduced into the bottom of the airlift (E). The sand, dirt, and water are transported upward through the pipe at a rate of about 200 gpm/ft^2. The impurities are scoured loose from the sand during this violently turbulent upward flow. Upon reaching the top of the airlift (F), the dirty slurry spills over into the central reject compartment (I). The sand is returned to the sand bed through the gravity washer/separator (G) which allows the fast settling sand to penetrate, but not the dirty liquid. The washer/separator is placed concentrically around the upper part of the airlift and consists of several stages to prevent short circuiting (Fig. 3). By setting the filtrate weir (C) above the reject weir (J) a steady stream of clean filtrate flows upward, countercurrent to the sand, through this washer section and acts as a liquid barrier that carries away the dirt and reject water (K). Since the sand has a higher settling velocity than the dirt particles, it is not carried out of the filter. The sand is redistributed by the means of a sand distribution cone (H). The sand bed is continuously cleaned while both a continuous filtrate and a continuous reject stream are produced.

©1980 Parkson Corp.



What do you mean Continuous Uninterrupted Operation?

When other filters are clogging, plugging or in need of backwashing, the DynaSand Filter is *continuously* cleaning its sand and producing an *uninterrupted* flow of *filtrate*.

Oh? What about system upsets?

No problem – the DynaSand Filter can handle *influent solids* loadings up to *200-800 ppm* and still produce a *continuous filtrate* – thus enabling the entire system to stay on line during upset conditions.

But we don't have trained operators.

So what – the DynaSand Filter has *no moving parts* – once the reject weir has been set and the air flow rate is determined there is no further operator attention required. This *simplicity* insures *continuous* operation even in a poorly operated system.

Yeah? But we've had problems with our auxiliary backwash equipment.

We don't need any backwash valves, storage tanks, instrumentation or pumps. We continuously *wash* the sand bed *internally*. There is no chance for auxiliary backwash equipment problems to interrupt the operation.

Come On. You mean to tell me that this filter continuously backwashes itself, produces a continuous uninterrupted filtrate, requires no backwash pumps, valves, instrumentation, tanks, etc., has no moving parts, can handle my upset conditions without shutting down my system, yet produce a filtrate quality equal to or better than conventional deep bed filters?

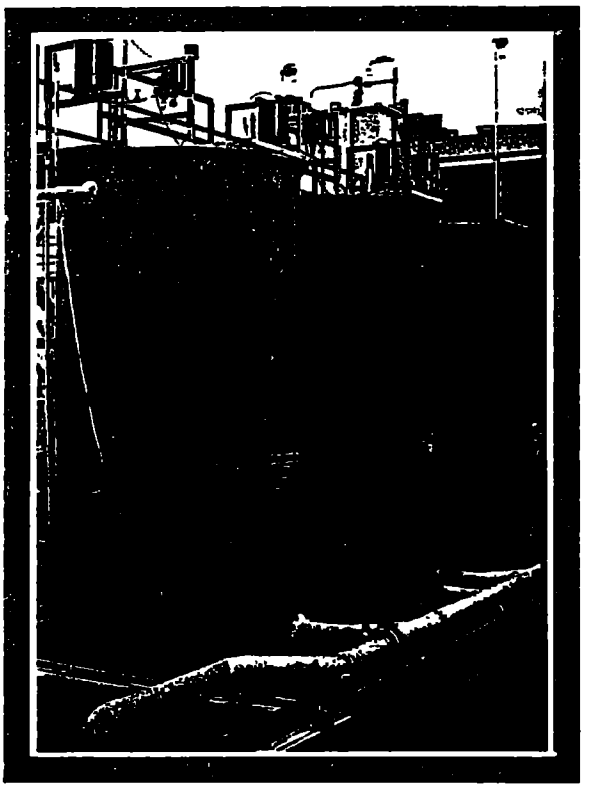
Yes. That's what we mean: *Continuously*.

Standard Features

- Epoxy Painted Carbon Steel or FRP Tanks
- All Stainless & FRP Internals
- Air Control Panel
- No Moving Parts
- Fully Assembled - Ready to Install Upon Arrival
- Seismic 2 Design
- Deep Bed Filtration

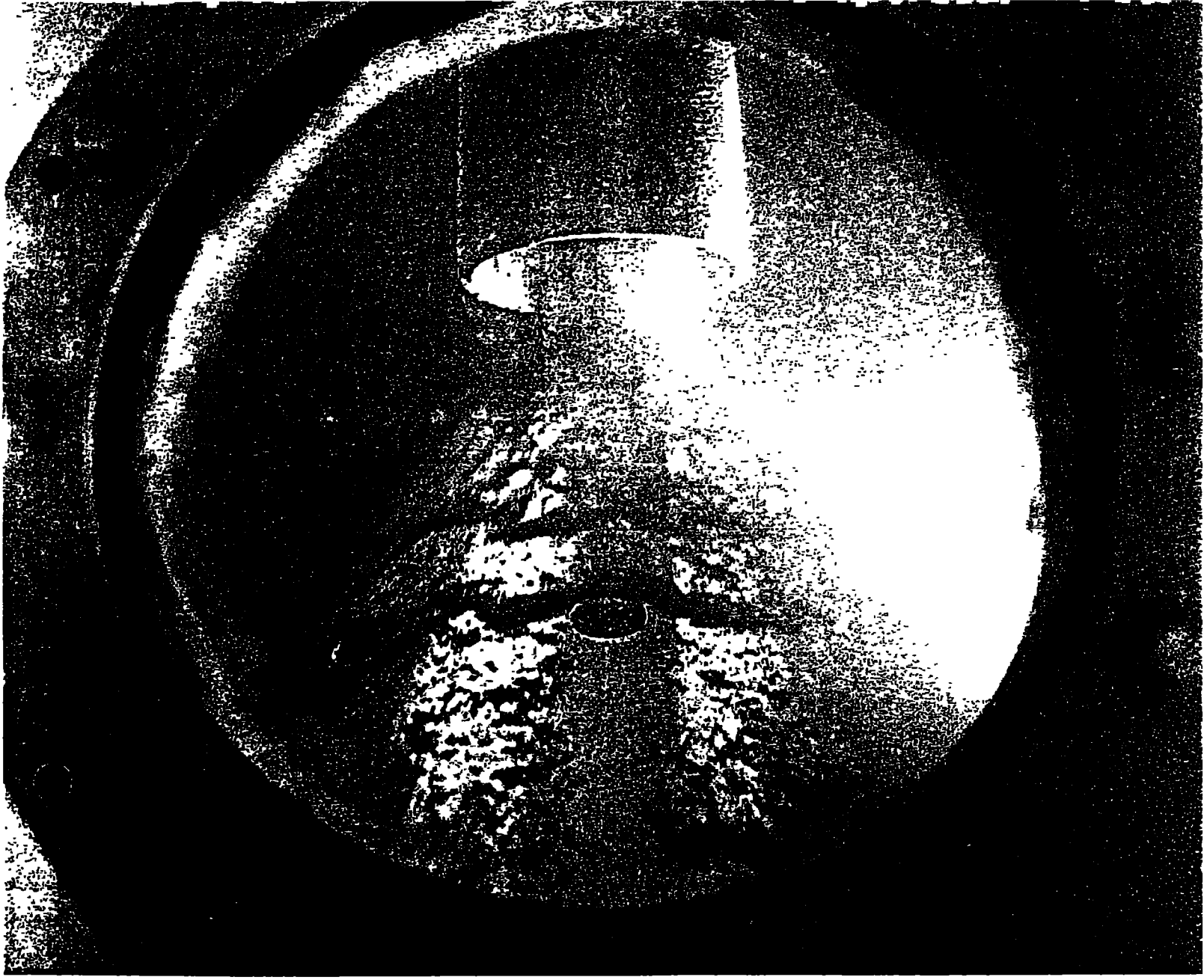
Optional Features

- Access Platforms & Ladders
- Tank Covers or Screens
- Seismic 4 Design



Typical Data

	DSF-7	DSF-12	DSF-19	DSF-38	DSF-64	DSF-100	DSF-150	DSF-200
	7	12	19	38	64	100	150	200
	3'0"	4'0"	5'0"	7'0"	9'0"	10' × 10'	10' × 15'	10' × 20'
	9'6"	12'0"	12'6"	17'11"	23'3"	15'6"*	15'6"*	15'6"*
	28-56	48-96	76-152	152-304	250-500	300-900	450-1300	600-1800
	1.5-4	2-8	2-10	3-15	5-25	10-50	15-75	20-100
	1.6	3.3	6.6	11	20	22	32	42
	30"	40"	40"	40"	40"	40"	40"	40"
	0.5-1	0.5-1.5	1-2	1-3	1.5-4	4-10	6-15	8-20
	15"-20"	18"-24"	18"-24"	18"-24"	18"-24"	18"- 24"	18"-24"	18"-24"



Applications: Typical Data

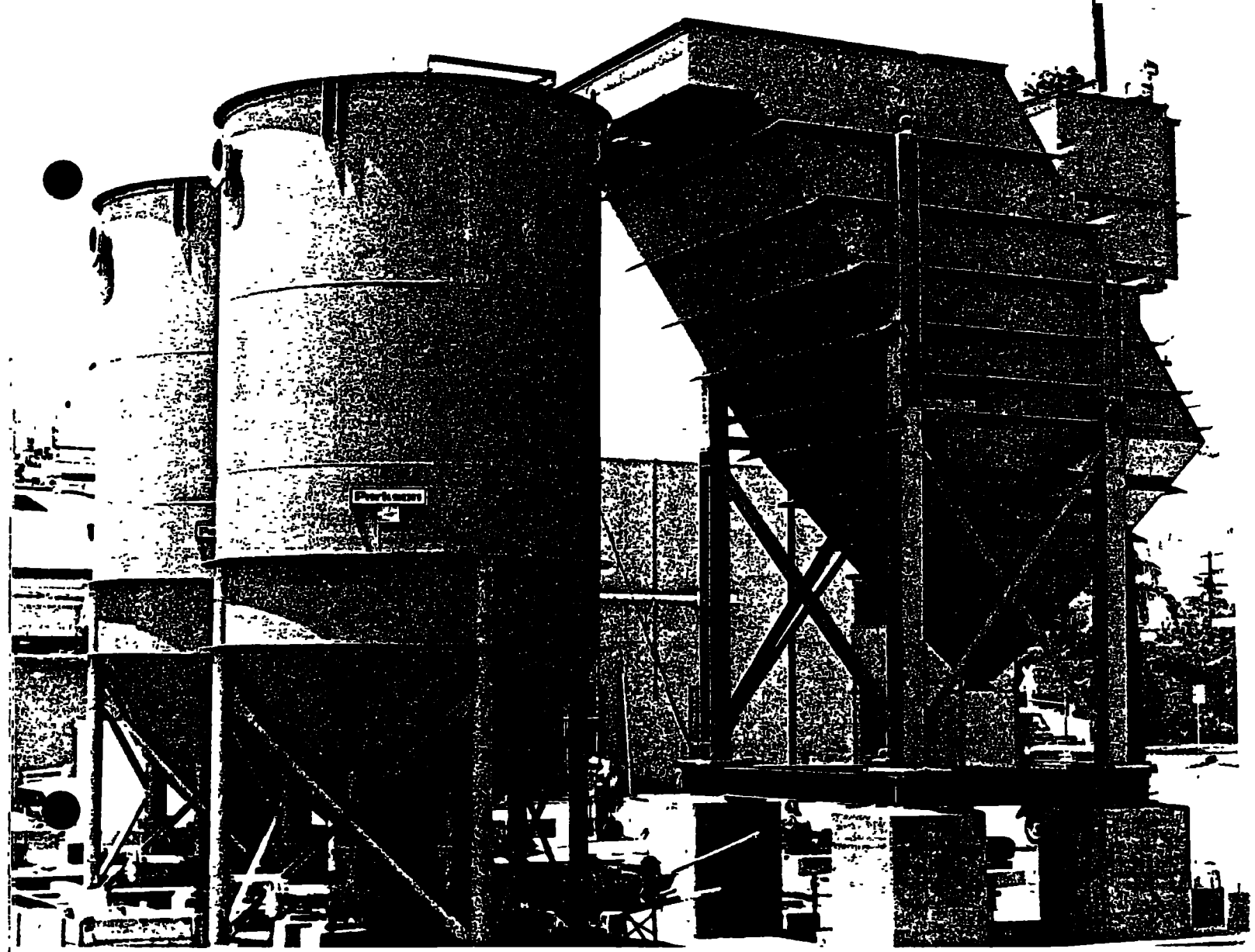
[illegible]	Influent Solids* (ppm)	Filtrate* (ppm)
[illegible]	20–100	2–5
[illegible]	20–150	5–10
[illegible]	10–200 NTU	<1 NTU
[illegible]	50–100	1–3 (TSS); <0.3 P
[illegible]	50–800	5–10
[illegible]	50–150	10
[illegible]	20–200 Free Oil	5–10 Free Oil

- Brine Filtration
- Laundry Wastewater
- Black Liquor Filtration
- Pregnant Liquor Filtration
- Cooling Tower Blowdown
- Various CPI Filtration Applications

- **Continuous Operation**
  No need to shut down filters for backwash cycles.
- **Elimination of Auxiliary Equipment**
  There is no need for backwash tanks, pumps, valves, instrumentation, etc.
- **Simplicity**
- No moving parts – no operator attention required.
- **High Solids Capability**
  Can handle up to 800 ppm solids in the influent for some applications.
- **Low Pressure Drop**
  Less than 24" pressure drop – easy to gravity feed.
- **Low Power Consumption**
  Gravity feed or low pressure feed pump and small air compressor are all that is required.
- **Single Media**
  No need for internal screens, grids, underdrains, etc.
- **Continuously Cleaned Sand Bed**
  No mudball formation.
- **No need for Continuous Chlorination**
- **Improved surface loading rates where the loading rates are limited by solids capacity.**
- **No requirement for flow control valves or splitter box arrangements.**

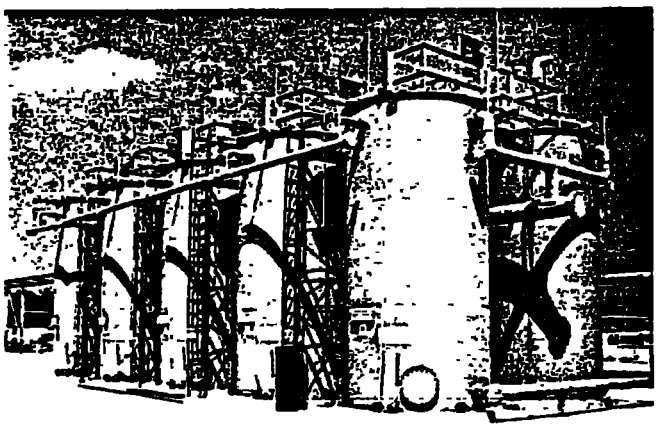
Comparison of Pressure Filters vs Gravity Filters

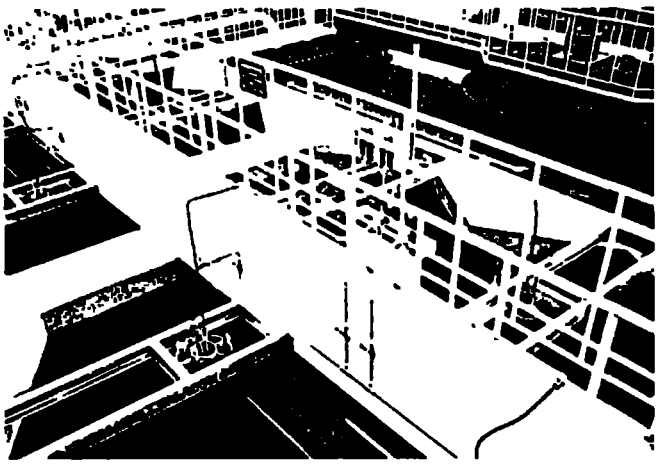
	Pressure Filters	Downflow Gravity Filters	Upflow Filters	ABW
	No	Yes	Yes	Yes
	No	Yes	Yes	No
	Yes	No	Medium	No
	Yes	No	No	Yes
	Yes	No	No	Yes
	Low	Low/Moderate	High	Low
	No	Yes	Yes	Yes
	Yes	Yes	Yes	No
	Yes	Yes	Yes	No



Combination Lamella® Gravity Settlers/Thickeners & DynaSand® Filters

The DynaSand Filter can readily be used as a polishing filter following the Parkson Lamella Gravity Settler/Thickener. The system is designed such that the feed is pumped to the LGS/T. The overflow from the LGS/T is gravity fed to the DynaSand Filter. The filtrate can then be gravity fed as a direct discharge stream or for reuse purposes. The reject stream is gravity fed back to the holding sump upstream of LGS/T. Thus the entire flash-mixing, flocculation, clarification and filtration process can be accomplished on an uninterrupted, no operator attention basis using only one feed pump.





Multiple units can be installed and still maintain system simplicity (top photo). The pressure drop across the sand bed insures an even feed to each filter without the need for splitter boxes. A header pipe with the appropriate number of Teed Connections is all that is required.

For large flow applications, our concrete basin design consisting of multiple cells is available. Cells can be custom arranged to fit individual plant configurations. The concrete designs are particularly well suited for large flow surface water and tertiary filtration applications (bottom photo).

All equipment described in this brochure is protected by patents, and additional patents may be pending.

PARKSON CORPORATION ™

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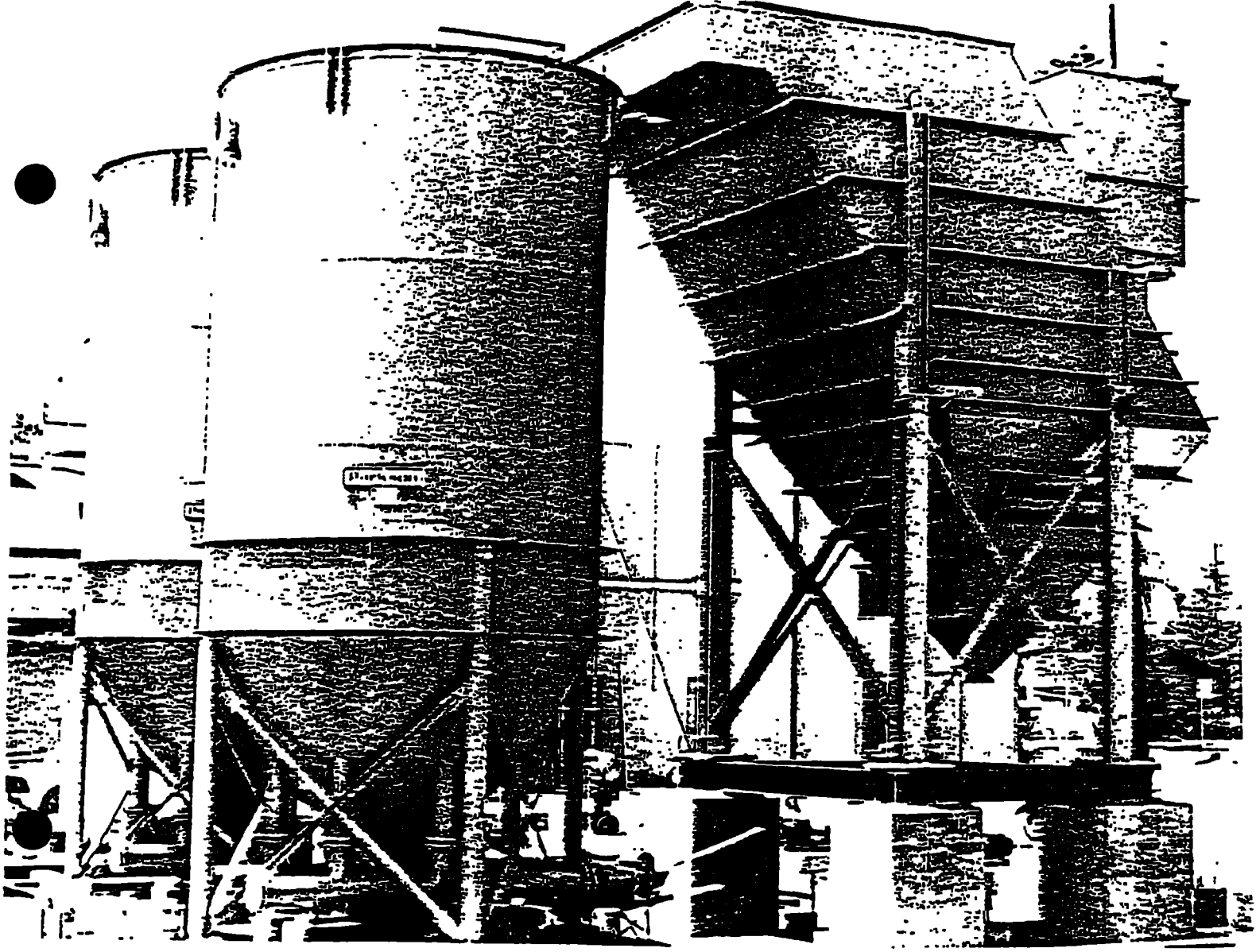
Phone: (305) 974-6610

A Subsidiary of A. Johnson & Co., Inc.

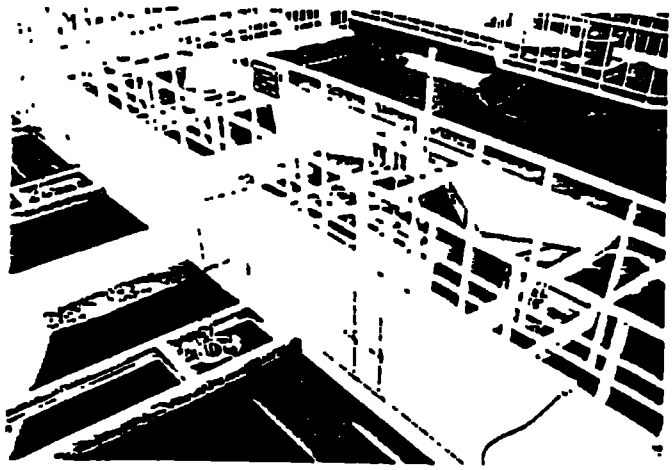
Other Parkson Products

Aqua Guard™ Screen - a self cleaning bar/filter screen
Roto-Guard™ Screen - a fine screening system for waste water
Lamella® Gravity Settler/ Thickener - a compact inclined plate separator
OxyCharger™ Static Aerator - for energy-free aeration
Magnum® Press - continuous belt press
Wyss® Flex-A-Tube® - fine bubble diffuser
Industrial Filter Clothing - for belt filter presses



Combination Lamella® Gravity Settlers/Thickeners & DynaSand® Filters

The DynaSand Filter can readily be used as a polishing filter following the Parkson Lamella Gravity Settler Thickener. The system is designed such that the feed is pumped to the LGS/T. The overflow from the LGS/T is gravity fed to the DynaSand Filter. The filtrate can then be gravity fed as a direct discharge stream or for reuse purposes. The reject stream is gravity fed back to the holding sump upstream of LGS/T. Thus the entire flash-mixing, flocculation, clarification and filtration process can be accomplished on an uninterrupted, no operator attention basis using only one feed pump.



Multiple units can be installed and still maintain system simplicity (top photo). The pressure drop across the sand bed insures an even feed to each filter without the need for splitter boxes. A header pipe with the appropriate number of Teed Connections is all that is required.

For large flow applications, our concrete basin design consisting of multiple cells is available. Cells can be custom arranged to fit individual plant configurations. The concrete designs are particularly well suited for large flow surface water and tertiary filtration applications (bottom photo).

All equipment described in this brochure is protected by patents, and additional patents may be pending.

PARKSON CORPORATION

2727 N.W. 62nd Street
P.O. Box 408399
Fort Lauderdale, Florida 33340-8399
Phone: (305) 974-6610

A Subsidiary of A. Johnson & Co., Inc.

Other Parkson Products

Aqua Guard™ Screen - a self cleaning bar/filter screen
Roto-Guard™ Screen - a fine screening system for waste water
Lamella® Gravity Settler/ Thickener - a compact inclined plate separator
OxyCharger™ Static Aerator - for energy-free aeration
Magnum® Press - continuous belt press
Wyss® Flex-A-Tube® - fine bubble diffuser
Industrial Filter Clothing - for belt filter presses

APPENDIX D

ATTACHMENT 4

LIST OF PARKSON DYNASAND FILTER INSTALLATIONS

BissNuss Inc

LDE COURTHOUSE BUILDING • SUITE 260 • CANFIELD, OHIO 44406 • PHONE 216/533-5531

July 17, 1989
Fax #216-533-6857

TO: DAN MILLER
RETEC
412-826-3409

DynaSand™ Filter

EUROPEAN REFERENCE LIST

Company/Location	Size	Application
Gunnebo Bruks AB Gunnebo Bruk, Sweden	11 ft^2	Galvanizing Waste
Gunnebo Bruks AB Gunnebo Bruk, Sweden	11 ft^2	Galvanizing Waste
Vestre Royse STP Norway	22 ft^2	Primary Clarifier Overflow
Bergshamra, Norrtalje Sweden	(4) 16 ft^2	Tertiary Direct Filtration (Phosphorus Removal)
Hesslingen Resort Sweden	22 ft^2	Tertiary Direct Filtration (Phosphorus Removal)
Swedish Steel Company SSAB, Oxelosund, Sweden	(12) 32 ft^2	Continuous Caster Scale Pit Filtration
Enhorna Municipality Södertalje, Sweden	(4) 16 ft^2	Tertiary Direct Filtration (Phosphorus Removal)
Papierfabrik Friesland	11 ft^2	Paper Industry White Water
Mjosa Project Tryggve Elind A/S, Norway	16 ft^2	Tertiary Direct Filtration (Phosphorus Removal)
SKF Steel Hofors, Sweden	(20) 32 ft^2	Steel Industry Mill Scale and Oil

Parkson CORPORATION

P.O. BOX 24407 • FT. LAUDERDALE, FLOR[illegible] (305) 772-6850

PAGE.002 FROM-THRHGHER MARKETING

Company/Location	Size	Application
Granges Vasteras, Sweden	16 ft^2	Copper and Brass Mill Scale
Ciba-Geigy Brunsbuttel, Germany	(2) 22 ft^2	Chemical Waste
Fagersta AB Langshyttan, Sweden	(8) 32 ft^2	Steel Industry Mill Scale and Oil
Alfa-Laval Tumba, Sweden	16 ft^2	Metal Finishing
Town of Ulricehamn Sweden	(4) 32 ft^2	Phosphorus Removal Polishing
Avesta Steel Sweden	(6) 32 ft^2	Continuous Caster Scale Pit Filtration

BISSNUSS, INC.
OLDE COURTHOUSE BLDG.
SUITE 280
CANFIELD, OHIO 44406
(216) 533-5531

DYNA SAND® FILTER

INDUSTRIAL BIOLOGICAL FILTRATION REFERENCE LIST

INSTALLATION	FLOW (GPM)	LOADING RATE	NUMBER & MODEL	APPLICATION
Alcoa Lafayette, IN	275	4.3	(1) DSF-64	Biological
Austin Co. Blokyowa Cape Girardeau, MO	624	3.1	(2) DSF-100	Biological Activated Sludge
BASF-Wyandotte Geismar, LA	1,600	2.8	(10) DSF-64	Biological
B.F. Braun/Houston Tool Base Houston, TX	20	2.8	(1) DSF-7	Biological Activated Sludge
Brush Wellman Elmore, OH	90	5.6	(1) DSF-16	Biological
CAM-OR, Inc. Westville, IN	35	3.0	(1) DSF-12	Biological
Cheeseborough Ponds Clinton, CT	18	2.6	(1) DSF-7	Biological
Diamond Shamrock Cedartown, GA	400	3.1	(2) DSF-64	Biological
Dow Chemical Joliet, IL	10	1.4	(1) DSF-7	Biological
B.F. Goodrich Convent, LA	100	3.2	(1) DSF-32	Biological Activated Sludge
B.F. Goodrich Calvert City, KY	1,000	5.0	(2) DSF-100	Biological & Metal Hydroxide
Harmon Yard STP Croton-on-Hudson, NY	200	5.3	(1) DSF-38	Railroad Yard

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Fort Lauderdale, Florida 33340

INSTALLATION	FLOW (GPM)	LOADING RATE	NUMBER & MODEL	APPLICATION
Hubinger Co. Keokuk, IA	500	5.0	(1) DSF-100	Biological
IBM Endicott, NY	150	2.0	(2) DSF-38	Biological
IBM Fishkill, NY	2,400	6.0	(4) DSF-100	Biological
Kimberly-Clark Paris, TX	125	6.6	(1) DSF-19	Biological
Louisville Cement Speed, IN	10	1.4	(1) DSF-7	Biological
Monsanto Luling, LA	150	4.0	(1) DSF-38	Chemical/Biological
Monsanto Research Corp. Miamisburg, OH	208	5.5	(2) DSF-19	Biological
New Departure Hyatt Bearing Sandusky, OH	65	2.8	(2) DSF-12	Biological
Pennwalt Corporation Geneseo, NY	150	3.9	(1) DSF-38	Biological
Smith, Kline & French Swedeland, PA	20	1.3	(1) DSF-16	Biological RBC Overflow
Union Carbide Woodbine, GA	350	5.5	(1) DSF-64	Biological Activated Sludge
Vlasic Foods Millsboro, DE	403	3.1	(2) DSF-64	Biological
Washington Steel Houston, PA	75	6.3	(1) DSF-12	Biological RBC Overflow
Whey Processing Georgia, VT	425	3.7	(3) DSF-38	P-Removal
Wilco Chemical Petrolia, PA	450	2.25	(2) DSF-100	Biological

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OLD COURTHOUSE BLDG.
SUITE 280
CANTFIELD, OHIO 44406
(216) 533-5531

DYNA SAND® FILTER

45

MUNICIPAL/DOMESTIC WASTES
BIOLOGICAL FILTRATION REFERENCE LIST

PACKAGED UNIT INSTALLATIONS

INSTALLATION	FLOW	MODEL	LOADING RATE (GPM/SQ. FT.)
City of Alton STP Alton, MO	100 gpm	(2) DSF-38	2.6
American Bottoms Regional Sauget, IL	200 gpm	(6) DSF-64	5.2
City of Apollo Beach Apollo Beach, FL	695 gpm	(1) DSF-150	4.6
Aquarina Melbourne Beach, FL	210 gpm	(2) DSF-38	2.8
Town of Boqueron Puerto Rico	175 gpm	(1) DSF-38	4.6
Town of Cayey, Pridco Puerto Rico	105 gpm	(1) DSF-19	5.5
Town of Cayey, LaPlata El Torito, Puerto Rico	175 gpm	(1) DSF-38	4.6
Central County Utilities Sarasota, FL	690 gpm	(1) DSF-150	4.6
Cumberland Industrial Park Bluefield, WV	35 gpm	(1) DSF-12	2.9
Dolomite Utilities Corp. Sarasota, FL	140 gpm	(1) DSF-38	3.7
City of Eminence Eminence, MO	500 gpm	(3) DSF-38	4.4
Erie County Geriatric Center Erie, PA	100 gpm	(1) DSF-19	5.3

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INSTALLATION	FLOW	MODEL	LOADING RATE (GPM/SQ. FT.)
City of Eveleth Eveleth, MN	500 gpm	(4) DSF-38	3.7
City of Forrest City Forrest City, AR	1314 gpm	(4) DSF-150	2.2
Fort Morgan WWTP Gulf Shores, AL	420 gpm	(1) DSF-100	4.2
Freshwater District #11 Houston, TX	800 gpm	(2) DSF-100	4.0
City of Gravel Ridge Gravel Ridge, AR	420 gpm	(1) DSF-150	2.8
City of Harrisburg Harrisburg, AR	300 gpm	(1) DSF-100	3.0
Hunter Creek Ranch Hunter Creek, AZ	35 gpm	(1) DSF-7	5.0
City of Kings Grant Kings Grant, NJ	228 gpm	(2) DSF-38	3.0
City of Kings Grant Kings Grant, NJ	382 gpm	(2) DSF-50	3.8
City of Mena Mena, AR	1800 gpm	(3) DSF-200	3.0
Montauk Manor WWTP Montauk, NY	42 gpm	(1) DSF-7	6.0
City of Milton Milton, DE	245 gpm	(3) DSF-38	3.2
City of Mountain View Mountain View, MO	275 gpm	(3) DSF-38	3.7
City of Navarre Beach Navarre Beach, FL	625 gpm	(4) DSF-38	4.1
City of Newport Newport, AR	1575 gpm	(3) DSF-150	3.5
Orange County University of Central Florida Orlando, FL	347 gpm	(2) DSF-64	2.7

INSTALLATION	FLOW	MODEL	LOADING RATE (GPM/SQ. FT.)
Rancho Del Oro Sedona, AZ	50 gpm	(1) DSF-12	4.2
Ridley Creek East Gosten, PA	278 gpm	(2) DSF-38	3.7
Roadhaven Resort Phoenix, AZ	120 gpm	(2) DSF-12	5.0
Mesa Del Sol III Yuma, AZ	36 gpm	(1) DSF-7	5.1
Picacho Peak Picacho, AZ	36 gpm	(1) DSF-7	5.1
Red Rock Resort Sedona, AZ	36 gpm	(1) DSF-7	5.1
Rouge Riders Landing Montauk, NY	89 gpm	(1) DSF-19	4.7
South Wayne County Water & Sewer Authority Lake Ariel, PA	70 gpm	(2) DSF-12	2.9
Sun & Fun Resort Sarasota, FL	100 gpm	(1) DSF-19	5.3
The Trails Ormond Beach, FL	140 gpm	(1) DSF-38	3.7
Treasure Lake WWTP Vandergrift, PA	190 gpm	(1) DSF-38	5.0
Vets Hospital Northport, NY	278 gpm	(2) DSF-38	3.6
Town of Villalba Puerto Rico	210 gpm	(1) DSF-64	3.3
City of Watertown Watertown, NY	70 gpm	(1) DSF-19	3.7
Wayland-Sudbury Sudbury, MA	76 gpm	(1) DSF-19	4.0
White River White River, UT	35 gpm	(1) DSF-7	5.0
City of Woodstock Woodstock, NY	[illegible]	(2) DSF-38	3.9

CONCRETE MODULE INSTALLATIONS

INSTALLATION	FLOW	# OF MODULES	LOADING RATE (GPM/SQ. FT.)
DuPage County Wheaton, IL	1.5 MGD	(4) Modules	5.0
City of Green Forest Green Forest, AR	2.4 MGD	(12) Modules	2.8
City of Johnstown Johnstown, OH	1.9 MGD	(8) Modules	3.8
City of Kissimmee Kissimmee, FL	7.5 MGD	(24) Modules	4.3
City of Merritt Island Merritt Island, FL	3.0 MGD	(12) Modules	4.1
City of Norwalk Norwalk, OH	3.5 MGD (Ave) 8.5 MGD (peak)	(24) Modules	2.0 4.9
City of Strongville Strongville, OH (2 Plants)	4.6 MGD (each)	(40) Modules	5.0

April, 1987

BISSNUSS, INC.
OLDE COURTHOUSE BLDG.
SUITE 260
CANFIELD, OHIO 44406
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DYNA SAND® FILTER

215

METAL FINISHING REFERENCE LIST

Customer/Location	No. of Units	Model	Total Flow (GPM)
ABC Plating - Melbourne, FL	2	DSF-64	384
AMF - Olney, IL	1	DSF-12	140
Aeroquip - Van Wert, OH	1	DSF-64	350
Airpax - Cambridge, MD	1	DSF-19	120
Alchemtron - Cleveland, OH	1	DSF-32	150
Allen Bradley - Milwaukee, WI	1	DSF-12	60
Allied Finishing - Grand Rapids, MI	1	DSF-12	72
American Electro-Products - Waterbury, CT	2	DSF-19	200
Anaconda - Miami, FL	1	DSF-16	90
Anchor Fasteners - Waterbury, CT	1	DSF-38	200
Appleton Electric - Racine, WI	1	DSF-38	150
Axelson - Colorado Springs, CO	1	DSF-7	42
Baldwin Hardware - Reading, PA	1	DSF-64	350
Bell Helicopter - Amarillo, TX	1	DSF-7	42
Bendix - Newport News, VA	1	DSF-32	100
Bendix - Sidney, NY	1	DSF-100	400
Bestlock Corporation - Indianapolis, IN	1	DSF-12	60
Blue Grass Plating - Richmond, KY	1	DSF-19	100
Brass Craft - Thomasville, NC & Lancaster, TX	2	DSF-19	228
Bristol Compressor - Bristol, VA	1	DSF-7	30
Bronze Way Plating - Los Angeles, CA	1	DSF-12	72
Burnished Metals - Ellenville, NY	1	DSF-38	200
Burroughs - Carlsbad, CA	1	DSF-16	100
CTS - Elkhart, IN	1	DSF-50	300
CTS Printex - San Jose, CA	1	DSF-19	114
CTS Printex - San Jose, CA	1	DSF-38	228
Cadon - Wyandotte, MI	1	DSF-38	228
Capitol Products - Kentland, IN	1	DSF-38	225
Champion Spark Plugs - Toledo, OH	1	DSF-19	114
Cherry Fasteners - Santa Ana, CA	1	DSF-64	350
Chicago Finished Metals - Bridgeview, IL	2	DSF-7	42
Coating Equipment - Sudbury, MA	1	DSF-19	80
Columbia Metal - Los Angeles, CA	1	DSF-16	75
Continental Circuits - Orlando, FL	1	DSF-19	100
Crouse Hinds - Amarillo, TX	1	DSF-12	50
Darling Store - Paragould, AR	1	DSF-64	275
Daystrom Furniture - Boston, VA	1	DSF-16	80
Delta Faucet - Chickasha, OK	1	DSF-38	228
Deutsch ECD - Oceanside, CA	1	DSF-64	300
Dexter Locke - Auburn, AL	1	DSF-16	100
Diamond Shamrock - LaPorte, TX	1	DSF-32	60

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P.O. Box 408399
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Telephone: 305 974-6610

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Customer/Location	No. of Units	Model	Total Flow (GPM)
Diversified Products - Opalaka, AL	1	DSF-7	30
Dresser Industries - Defiance, OH	1	DSF-7	25
Eaton Corporation - Belmund, IA	1	DSF-7	30
Eaton Corporation - Belmund, IA	1	DSF-7	20
Everest & Jennings - Camarillo, CA	1	DSF-19	115
Federal Mogul - Blacksburg, VA	1	DSF-64	250
Federal Mogul - Frankford, IN	1	DSF-7	42
Ferroxcube - Saugerties, NY	1	DSF-12	60
Flint Ink - Elizabethtown, KY	1	DSF-12	50
Ford Motor Company - Connorsville, IN	1	DSF-100	625
Ford Motor Company - St. Paul, MN	2	DSF-64	750
Ford Motor Company - Saline, MI	1	DSF-100	625
Formosa Plastics - Pt. Comfort, TX	1	DSF-38	230
Fortin Laminating - Sylmar, CA	1	DSF-16	75
Fortin Laminating - Sylmar, CA	1	DSF-38	200
Frantz Manufacturing - Sterling, IL	1	DSF-7	30
GAMCO - Henderson, KY	1	DSF-12	60
Garrett Turbo - Phoenix, AZ	1	DSF-38	200
O. Z. Gedney - Terryville, CT	1	DSF-7	40
General Defense Corporation - Red Lion, PA	1	DSF-19	100
General Electric Company - Florence, SC	4	DSF-38	600
General Electric Company - Milwaukee, WI	1	DSF-38	70
General Electric Company - Salem, VA	1	DSF-19	85
General Electric Company - Syracuse, NY	1	DSF-7	42
General Electric Company - West Burlingame, IA	1	DSF-7	30
General Motors Corp. - Cadillac Div., Lavonia, MI	3	DSF-38	450
Gillette - Boston, MA	1	DSF-19	120
Gould Valve & Fitting - Chicago, IL	1	DSF-38	150
Graphic Products - Fort Lauderdale, FL	1	DSF-16	80
Gridcarft - Fort Wayne, IN	1	DSF-7	30
H. H. Electronics - Twinsburg, OH	1	DSF-12	50
Hadco Printed Circuits - Watsonville, CA	1	DSF-12	60
Hall Chemical - Arab, AL	1	DSF-32	50
Harris Government Services - Melbourne, FL	1	DSF-38	150
Hawaiian Electric - Pearl City, HI	1	DSF-19	60
Honda of America - Marysville, OH	2	DSF-64	450
Honeywell - Chandler, AZ	1	DSF-12	50
Hughes Aircraft - El Segundo, CA	1	DSF-19	100
Hughes Aircraft - Los Angeles, CA	3	DSF-64	750
Hughes Tool - Houston, TX	1	DSF-7	42
Hughes Tool - Houston, TX	1	DSF-12	60
Hughes Tool - Shanghai, China	1	DSF-7	42
IBM - Bromont, Quebec	2	DSF-19	114
IBM - Poughkeepsie, NY	2	DSF-38	208
IBM - San Jose, CA	2	DSF-38	400
IBM - Tucson, AZ	3	DSF-38	325
ITT - Lawrence, MA	1	DSF-12	72
ITT Cannon - Phoenix, AZ	1	DSF-12	55
ITT Courier - Tempe, AH	2	DSF-32	325
ITT Grinnell - Columbia, PA	1	DSF-19	100
ITT United Plastics - Bainbridge, GA	1	DSF-32	150
Imperial Clevite - McConnellsville, OH	1	DSF-19	114
Indiana Industrial Plating - Michigan City, IN	1	DSF-38	114
Industrial Circuits - San Marco, CA	1	DSF-12	72
Ingersoll Rand - Wichita Falls, TX	[illegible]	DSF-12	30
[illegible] - Wyandanch, NY		DSF-19	120
[illegible] - Fullerton, CA		DSF-38	150
[illegible] - Middlebury, IN		DSF-16	100

Customer/Location	No. of Units	Model	Total Flow (GPM)
Kenmore Research - Ravenna, OH	1	DSF-7	20
Keymark Aluminum - Fonda, NY	1	DSF-19	114
King Radio - Olathe, KS	1	DSF-19	100
King Radio - Olathe, KS	1	DSF-19	114
Koltron - Sunnyvale, CA	1	DSF-19	114
Kuhlman Diecast - Kansas City, MO	1	DSF-38	200
Kwikset - Los Angeles, CA	2	DSF-64	750
Latronics - Latrobe, PA	1	DSF-7	42
Lawrence Brothers - Sterling, IL	1	DSF-12	50
Lear Siegler - Mendon, MI	1	DSF-19	100
Lexington Metal Products - Lexington, TN	1	DSF-19	120
Lithostrip - Houston, TX	1	DSF-12	75
McColluch Hilti - Tulsa, OK	1	DSF-32	150
Magnavox - Fort Wayne, IN	1	DSF-12	50
Memorex - Eau Claire, WI	2	DSF-38	530
Memorex - Eau Claire, WI	1	DSF-19	114
Metropolitan Circuits - Bridgeport, NJ	1	DSF-32	150
Microfab - Amesbury, MA	1	DSF-38	114
Molex, Inc. - Lincoln, NE	1	DSF-7	30
Morningstar Manufacturing - Jacksonville, FL	1	DSF-12	72
Motorola - Plantation, FL	1	DSF-32	150
Multaplex - Santa Clara, CA	2	DSF-38	228
Multicircuits - Manchester, CT	1	DSF-38	175
National Can - St. Paul, MN	1	DSF-32	150
National Lock - Mauldin, SC	1	DSF-19	120
National Lock - Spartanburg, SC	1	DSF-38	200
National Semi Conductor - San Jose, CA	1	DSF-32	200
New England Plating - Worcester, MA	2	DSF-38	300
Newport News Shipbuilding - Newport News, VA	2	DSF-19	150
Norris Industries - Los Angeles, CA	1	DSF-12	72
Norris Industries - Newberry, SC	1	DSF-12	60
Norris Industries - Vernon, CA	2	DSF-64	750
Norris Industries - Vernon, CA	2	DSF-64	500
Northern Metal Specialties - Menomonee Falls, MN	1	DSF-19	114
Northern Telecom - West Palm Beach, FL	1	DSF-100	275
OMC Johnson - Waukegan, IL	1	DSF-19	100
Omark - Milwaukie, OR	1	DSF-7	40
PDI - Racine, WI	1	DSF-38	228
Parker Hannifin - Cleveland, OH	1	DSF-7	40
Perkin Elmer - Norwalk, CT	1	DSF-19	100
Perkin Elmer - Norwalk, CT	1	DSF-19	100
Pfarrer - Walton, IN	1	DSF-7	35
Phelps Dodge - El Paso, TX	1	DSF-19	120
Phelps Dodge - Fort Wayne, IN	1	DSF-32	100
Phelps Dodge - Norwich, CT	1	DSF-32	150
Piedmont Circuits - Raleigh, NC	1	DSF-32	100
Plymouth Plating - Plymouth, MI	1	DSF-7	42
Progress - Philadelphia, PA	1	DSF-38	200
Progress Equipment - Dayton, OH	1	DSF-38	225
Progress Lighting - Cowpens, SC	1	DSF-7	40
Quincy Products - Quincy, MI	1	DSF-7	42
RCA - Circleville, OH	3	DSF-64	700
RCA - Circleville, OH	3	DSF-64	800
RCA - Indianapolis, IN	1	DSF-12	60
Raymark - Crawfordsville, IN	1	DSF-12	60
Raytheon - Lowell, MA	1	DSF-03	28
Revere Copper - [illegible], NY	1	[illegible]	114
Reynolds Metal - [illegible] Beach, Hawaii	1	[illegible]	100

Customer/Location	No. of Units	Model	Total Flow (GPM)
Reynolds Metal - Puerto Rico	1	DSF-19	114
Riverside Plating - Jamesville, WI	1	DSF-19	100
Robertshaw Controls - CA	1	DSF-32	150
Rogate Industries - Fort Wayne, IN	1	DSF-32	200
Rohr Industries - San Diego, CA	1	DSF-19	90
SPS Technologies - Jenkintown, PA	2	DSF-64	750
Saft America - Valdosta, GA	1	DSF-38	150
Shinko - Manteca, CA	1	DSF-19	42
Sigma Plating - La Puente, CA	1	DSF-64	345
Smith Kline & French - Swedenland, PA	1	DSF-16	75
Snap On Tool - Elizabethton, TN	1	DSF-38	200
Snap On Tool - Kenosha, WI	1	DSF-12	200
Solid State Circuits - Springfield, MO	1	DSF-38	228
Specified Plating Company - Commerce, GA	1	DSF-19	120
Sperry Flight - Phoenix, AZ	1	DSF-64	370
Sperry Univac - Bristol, TN	1	DSF-38	200
Sperry Univac - St. Paul, MN	1	DSF-32	150
Square D - Asheville, NC	1	DSF-19	80
Square D - Smyrna, TN	1	DSF-7	19
Stanadyne - Sanford, NC	1	DSF-38	225
Stanley Flagg - Stowe, PA	1	DSF-38	245
Starlite - Pierceton, IN	1	DSF-7	25
Stewart Warner - Winston Salem, NC	1	DSF-38	20
Sumitomo - Fremont, CA	1	DSF-38	150
Sunstrand - Denver, CO	1	DSF-38	150
Sun World - Alarmonte, FL	1	DSF-32	140
Surtronics - Raleigh, NC	1	DSF-16	80
Surtronics - Raleigh, NC	1	DSF-38	228
T & B - Elizabeth, NJ	1	DSF-19	114
Tawas Plating - Tawas City, MI	1	DSF-38	170
Tektronix, Inc. - Beaverton, OR	3	DSF-64	1000
Tektronix - Forrest Grove, OR	1	DSF-38	188
Teledyne Adams - Union, NJ	1	DSF-12	72
Texas Department of Corrections - Orlando, TX	1	DSF-7	40
Texas Instrument - Stafford, TX	2	DSF-32	200
Textron - Cincinnati, OH	1	DSF-12	72
Thermoking - Puerto Rico	1	DSF-7	40
Torpedo Wire - Pittsfield, PA	1	DSF-7	30
Townsend Textron - Pontiac, SC	1	DSF-7	40
Transcircuits - Falls Church, VA	1	DSF-19	100
Travari - Providence, RI	1	DSF-38	144
Tricot - Buffalo, NY	1	DSF-12	72
Tropical Circuits - Pompano Beach, FL	2	DSF-38	400
Twin City Plating - Benton Harbor, MI	1	DSF-38	200
USBI - Huntsville, AL	1	DSF-7	42
U.S. Brass - Plano, TX	1	DSF-16	75
Volkswagen of American - New Stanton, PA	1	DSF-38	100
Varian - Palo Alto, CA	1	DSF-12	40
Varian Eimac - San Carlos, CA	1	DSF-38	210
Wang Labs - Lowell, MA	1	DSF-38	228
Wang Labs - Metheun, MA	1	DSF-16	100
Warner Lambert - Milford, CT	1	DSF-19	100
Warsaw Black Oxide - Burnet, IN	1	DSF-38	100
[illegible]per Metals - Fairmont, CA	1	DSF-7	40
[illegible]born - Mason City, IA	1	DSF-12	80
[illegible]e Aluminum - Moultrie, GA	1	DSF-12	[illegible]
[illegible]nghouse - Puerto Rico	1	DSF-12	[illegible]

APPENDIX D

ATTACHMENT 5

PARKSON DYNASAND PILOT TEST REPORT ON IRON REMOVAL

BissNuss Inc

OLDE COURTHOUSE BUILDING • SUITE 260 • CANFIELD, OHIO 44406 • PHONE 216/533-5531

March 23, 1989

Dr. John Smith
RETEC
1034 5th Avenue
Suite 100
Pittsburgh, PA

Subject: Parkson Corporation
DynaSand Filter

Dear John,

Please find enclosed a copy of the Parkson DynaSand pilot test report as discussed.

Let us know if you have any questions.

Yours very truly,

Paul Bissell /pw

Paul Bissell

Enc.

PARKSON CORPORATION

DYNA SAND® FILTER

DYNASAND® FILTER

PILOT TEST FINAL REPORT

For

DuPAGE COUNTY - Chicago, Illinois

Knollwood Site

APPLICATION:	Well Water Iron Removal
TEST DATES:	5/12/87 - 5/20/87
REPORT DATE:	5/27/87
PREPARED BY:	T. K. Harris

2727 N.W. 62nd Street
P.O. Box 408399
Fort Lauderdale, Florida 33340
Telephone: 305 974-6610

A subsidiary of
A. Johnson & Co., Inc.

OBJECTIVE

The objective of this test was the removal of iron from well water to meet the limits of less than 0.3 ppm.

CONCLUSIONS

1. During the day of May 12, 1987, a loading rate of 5.1 gpm/sq.ft. was run. This was done with the addition of 3.1 ppm of chlorine. The media was 0.9 mm silica sand. The influent iron ranged from 3.0 to 5.0 ppm (10 to 46 NTU), yielding an effluent quality of 0.3 ppm (3.1 to 33 NTU). The pH was 7.2 to 7.4 with water temperature of 54°F. During this operational period, the Delta P was 27 inches. The effluent residual chlorine was 0.6 ppm.

2. During the day of May 12, 1987, a short run was made at a loading rate of 5.6 and 5.8 gpm/sq.ft. This resulted in a Delta P increase up to 35 inches and 36 inches plus respectively.

3. During the day of May 19, 1987, a loading rate of 5.3 gpm/sq.ft. was run. The media at this time had been changed to 1.3 mm silica sand. The influent iron was 3.0 ppm (4.0 NTU) during this period. With the addition of 3.1 ppm of chlorine, an effluent quality of 1.6 ppm iron (1.0 NTU) was attained. The Delta P was 11 inches. The pH was 7.1 with water temperature being 53°F. The effluent residual chlorine was 0.6 ppm.

4. During the day of May 19, 1987, a loading rate of 7.0 gpm/sq.ft. was run. This was done with 1.3 mm silica sand. The Delta P during this period was 15 inches. With influent iron in the range of 3.0 ppm (3.3 NTU) and after the addition of 3.0 ppm of chlorine, an effluent quality of 1.8 ppm iron (1.2 NTU) was attained.

5. During the day of May 19, 1987, loading rates of 4.4 gpm/sq.ft. and 3.3 gpm/sq.ft. were run. The Delta P during these periods were 9 inches and 7 inches respectively. With influent iron of 3.0 ppm (2.0 NTU) and after the addition of 3.1 ppm of chlorine, an effluent quality of 2.0 ppm iron (0.6 NTU) was attained.

6. During the day of May 20, 1987, a loading rate of 5.0 gpm/sq.ft. was run. The Delta P was 10 inches. After the addition of 3.1 ppm of chlorine and 0.5 ppm of Nalco 8100 polymer, the influent iron of 4.5 ppm (2.8 NTU) was reduced to 2.8 ppm (0.6 NTU). The pH was 7.1 with a water temperature of 54°F. The effluent residual chlorine was 1.0 ppm.

7. During the day of May 20, 1987, a loading rate of 4.7 gpm/sq.ft. was run. After the addition of 3.1 ppm of chlorine and 0.5 ppm of Nalco 8100 polymer, the influent iron of 4.0 ppm (2.6 NTU) was reduced to 2.5 ppm iron (0.4

NTU).

8. Due to the piping to the DynaSand Filter pilot unit, the retention time for chlorine contact was limited to about 45 seconds. By jar test, a longer retention time revealed better floc formation. The floc is fairly fragile, thus caution should be taken when designing flow velocities. A dosage of 0.25 to 0.50 ppm of Nalco 8100 produced a stronger floc. This will also reduce turbidity.

9. With the use of the 1.3 mm silica sand media and the addition of 3.1 ppm chlorine, the iron was not significantly reduced, but the turbidity was. This was also true after the addition of 0.5 ppm of Nalco 8100 polymer.

RECOMMENDATIONS

1. It is recommended that 0.9 mm silica sand be used for this application.

2. At a maximum flow rate of 325 gpm, the loading rate to one DynaSand Filter, Model DSF-64 unit will be 5.1 gpm/sq.ft. With the addition of 3.1 ppm of chlorine and influent iron of 3.0 ppm, an effluent quality of 0.3 ppm may be obtained. The Delta P at this condition will be 26 inches.

3. At a nominal flow rate of 280 gpm, the loading rate to one DynaSand Filter, Model DSF-64 will be 4.4 gpm/sq.ft. With the addition of 3.1 ppm chlorine and influent iron of 3.0 ppm, an effluent quality of 0.3 ppm may be obtained. The Delta P at this loading rate will be somewhat lower.

4. The retention time for floc formation is very important in this application. By jar testing, approximately three to five minutes revealed good formation for filterable particles.

5. The feed velocities must be considered due to the fairly low shear rate of the flocced particles.

DISCUSSION

The tests were run using the DynaSand Filter trailer mounted 10.6 square-foot unit. Feed to the unit was taken from a fire hydrant located about 100 feet from the trailer. The chlorine was added at the hydrant and injected via a chemical pump. When polymer addition was required, this was injected just prior to an in-line mixer located about 15 feet from entering the unit. The effluent and reject were gravity fed to a stream.

The major difference between adding polymer and not addint it was the size and strength of the floc and not the amount of iron removed. With the addition of polymer, the floc was still fairly small (less than 1/8 inch).

TKH/gl

DATE TIME	LOADING RATE gpm/ft.2	DELTA P	pH	TEMP °F	IRON INFL.	IRON EFFL.	NTU INFL.	NTU EFFL.	CHEMICAL ADD. CHLORINE	CHEMICAL ADD. POLYMER	COMMENTS
5-12-87											
1000	5.1	31			5.0	1.5	46	33	3.2	---	0.9 mm sand
1130	5.1	31	7.4	54	5.0	0.9	14	8.7	3.1		Air 30 psi/45 45 SCFH
1300	5.0	28			5.0	0.6	10	3.1	3.3		Residual chlorine 0.6
1330		26	7.4	54							
1340	5.6	35									
1400	5.8	36+									Sand bed +5"
1430	5.1	26			3.0	0.3	5.9	1.5	3.2		Resid.chl. 0.
1530	5.1	27	7.2	54	3.0	0.3	5.9	1.2	3.2		Resid.chl.0.6
1630						0.3		1.3			
5-19-87											
0830	5.3	11	7.1	53	3.0	1.8	4.3	1.2	3.0		1.3 mm sand
0900	5.3				3.0	1.6	4.0	1.0	3.2		
1000	5.5	11	7.1	53		1.6		0.9	3.1		Resid.chl. 0.
1100		11				1.6		0.9			
1200	7.0	15							3.0		
1300	7.0	15			3.0	2.0	3.8	1.7			Resid.chl. 0.
1330	7.0	15	7.1	54	3.0	1.8	3.3	1.2	3.0		Resid.chl. 1.
1400	4.1	9							3.0		
1430	4.4	9			3.0	2.2	3.4	0.6	3.0		

DATE TIME	LOADING RATE gpm/ft.2	DELTA P	pH	TEMP °F	IRON INFL.	IRON EFFL.	NTU INFL.	NTU EFFL.	CHEMICAL ADD. CHLORINE	CHEMICAL ADD. POLYMER	COMMENTS
1500					3.0		2.0	0.6			
1515	3.3	7									
1600	3.3	7	7.1	54	3.0	2.0	3.3	0.5	3.1		
5-20-87											
0700	5.0								3.2	0.5	Polymer Nalco 8100
0730	5.0	10	7.2	54							
0830	5.0	10			4.5	2.8	3.4	0.6	3.1	0.5	Resid.chl. 0.
0915	4.9	10	7.1	54	4.5	2.8	2.7	0.7	3.5	0.5	Resid.chl. 1.
0930	4.7										
1015	4.6	10							3.1	0.5	
1100		9				2.9		0.5	3.1	0.5	
1130	4.1										
1200	4.7				4.0	2.5	2.6	0.4	3.2	0.4	Resid.chl. 1.
1300	4.7				4.0	2.5	2.6	0.5			

TKH/gl

ATTACHMENT D

COPY OF THE NPDES PERMIT APPLICATION TO BE SUBMITTED TO THE MINNESOTA POLLUTION CONTROL AGENCY FOR TREATMENT OF PUMPED GROUNDWATERS FROM A ST. LOUIS PARK, MINNESOTA SITE

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
AND STATE DISPOSAL SYSTEM PERMIT APPLICATION
MPCA SHORT FORM C

Application Number
Date Received
Year Mo. Day
For Agency Use

Please type or use black ink pen to complete this form.

1. Applicant, Authorized Agent, Consulting Engineer, and Facility information

A. Applicant
Name City of St. Louis Park, Department of Public Works
Street 5005 Minnetonka Blvd. City St. Louis Park
State Minnesota Zip 55416 Telephone (612) 924-2551

B. Applicant's Technical Agent
Name Mr. James N. Grube Title Director of Public Works
Street 5005 Minnetonka Blvd. City St. Louis Park
State Minnesota Zip 55416 Telephone (612) 924-2551

C. Applicant's Consulting Engineer
Name Dr. John R. Smith, P.E. Firm Remediation Technologies, Inc.
City Pittsburgh Telephone (412) 826-3340

D. Facility Producing Discharge
Name Groundwater Treatment Facility
Street 7120 West Lake Street City St. Louis Park
State Minnesota Zip 55416 Telephone (612) 924-2555
County _____ Township _____ Range _____ Section _____
Quarter _____
Attach a map showing above location.

2. Principal Activity/Product of Business

A. Principal Product Produced or Raw Material Consumed	Average Amount/ Unit Time	Maximum Amount/ Unit Time
NA	NA	NA

Quantities above represent: (check one)
Principal Product Produced NA Raw Material Consumed NA

B. Number of Employees NA
C. Brief Description of the Disposal System: Pretreatment of pumped groundwater with potassium permanganate and sand filtration for iron and manganese removal. To be follwed by activated carbon column treatment for removal of organic contaminants. Discharge into storm sewer to Minnehaha Creek.

3. Current or previous permit number (NPDES or State Disposal System Permit)

POTW Permit Application made - Letter of authorization granted by Louis J. Breimhurst, Metropolitan Waste Control Commission - 6/19/87.

NA - not Applicable

4. Reason for Application (check one)

A. New Facility ____
B. Expiration of Existing Permit xxx
C. Modification to Existing Facility ____
D. Agency Request ____
E. Other, specify xxx

If this is a new facility, give date discharge began or is expected to begin: September, 1990

Groundwater pumping is required at the St. Louis Park superfund site as part of a consent decree between the City of St. Louis Park, U.S. EPA, MPCA, and Reilly Industries, Inc.

5. Has an Environmental Impact Statement (EIS), Environmental Assessment (EA), or an Environmental Report ever been written for this facility? Yes xx No ____

6. Water Treatment

A. Identify all water treatment additives used, including commercial names of the products, amount used (concentration), frequency of treatment, and the use of the treated water (e.g. non-contact cooling water treated with 10 ppm "Watco 999" for two hours once a week). Potassium permanganate - between 7 to 17 ppm continuous dosage to be added to pumped groundwater prior to sand filtration and activated carbon column treatment prior to discharge to Minnehaha Creek. Exact amount of KMnO4 depends upon influent concentrations of iron and manganese.

☐ No water treatment additives used.

B. Attach information on the aquatic toxicity and/or chemical composition of the products listed above (see instructions). See Attached MSDS

7. System Modifications

A. If submission of application is due to the expiration of your permit (4B above), and there have been no significant changes to your system (production increases or decreases, facility expansion, process modifications, including waste treatment facility changes, etc.), check here ____, complete the date, title and signature blocks on last page and return the original application to the Minnesota Pollution Control Agency without completing the remainder of the questions. If this is not the case proceed to item(7.B.)

B. If changes/modifications such as those listed in (7.A.) have been made to your system since issuance of your last permit, give a brief description of these changes and continue to item (8.): Treatment for pumped groundwater has been provided as described in 6A. Previous discharge was to POTW, no treatment was required.

8. Water Data

A. Water Source — Quantities (Gallons Per Day)

(1) Municipal or commercial water supply ____ ____
(2) Surface water, name ____ ____
(3) Groundwater, intake location Platteville, Drift & 0.2 MGD
(4) Other, specify Prairie du Chien/Jordan Aquifers ____
(5) Quantities above are: (check one) Estimated average ____ Actual averages ____
Estimated Maximums xxx Actual Maximums ____

B. Water Use

Type of Wastewater	Quantities (Gallons/ Day)	E/A*	Treatment System (e.g. aerated pond, settling pond, cooling tower, septic tank, drainfield, spray irrig)	Final Disposal (e.g. munic. sanitary sewer, storm sewer, tile, ditch, Rum River, soil)
(1) Process water - Describe: _____	_____avg _____max _____avg _____max			
(2) Contact cooling water once-through ___ recycled ___ barometric condensor ___	_____avg _____max _____avg _____max			
(3) Non-contact cooling water once-through ___ recycled ___	_____avg _____max			
(4) Sanitary waste	_____avg _____max			
(5) Floor drains	_____avg _____max			
(6) Surface runoff collected before discharge ___ not collected ___	_____avg _____max			
(7) Other, specify: Groundwater	0.18MGD avg 0.2MGD max	E	Potassium Permanganate/Sand Filtration & Activated Carbon Column Treatment	Storm Sewer

* E = Estimated Flows A = Actual Flows

(8) On a separate page, provide a schematic diagram (flow chart) showing the route(s) of wastewater flow through the treatment facility from the water source to the discharge point.

See attached Figure 4-1 (Drawing Number 189-1005)

9. Discharge Frequency

	Type of Water Discharged	Hours/Day	Days/Week	Weeks/Year	Other, specify
A.	Point Source Well	24	7	365	
	Months of Discharge: Ongoing				
B.					
	Months of Discharge:				
C.					
	Months of Discharge:				

10. Check the appropriate space(s) if your discharge contains or it is possible for your discharge to contain one or more of the following substances as a result of your operations, activities, or processes.

algaecides	___	chromium	___	polychlorinated biphenyls (PCBs)	___		
aluminum	___	copper	___	radioactivity	___		
ammonia	___	lead	___	selenium	___		
beryllium	___	mercury	___	zinc	___		
cadmium	___	nickel	___	none of the above	___		
chlorine (residual)	___	oil & grease	xx*	others, specify	xx*	See attached St. Louis Pa PAH List	
		phenols	xx*				

11. If no wastewaters are discharged to surface waters, check here ___, complete the date, title, and signature blocks on the last page and return the original application to the Minnesota Pollution Control Agency without completing the remainder of the questions. If wastewaters are discharged to surface waters, proceed to item 12.

12. Number of separate discharge points to surface waters: 1

13. Route to receiving water (e.g., ditch to Mississippi River, storm sewer to Twin Lake, city tile system to ditch to Rice Creek, etc.): Storm sewer to Minnehaha Creek.

* Raw water to treatment system would contain these parameters. The treatment system as described in 6A is designed to remove them.

14. If this facility has never been issued an NPDES permit and if any of the following parameters apply to your discharge, indicate present concentrations measured at the point of discharge from the facility for each discharge point. Samples shall be collected during periods of representative discharge.

A. Type of wastewater analyzed: Pilot Study Discharge - Post Treatment of contaminated groundwater

Parameters	G/C*	Concentration	
1. BOD_5 (5-day Biological Oxygen Demand)	G	1.0	mg/l
2. Total Suspended Solids	G	1.0-20	mg/l
3. Fecal Coliform**	NA	---	MPN/100 ml
4. pH	G	6-8	standard units
5. Temperature - winter	G	50	°F
6. Temperature - summer	G	70	°F
7. Turbidity	---	---	JTU
8. Nutrients, specify:			
	G	Not Detected	mg/l
9. Other, specify:***			
PAH - SLP List	G	10 ng/L	
Phenolics	G	0.005 mg/L	
Dissolved Oxygen	G	2.0 mg/L	

B. Type of wastewater analyzed: _____

1. BOD_5 (5-day Biological Oxygen Demand)			mg/l
2. Total Suspended Solids			mg/l
3. Fecal Coliform**			MPN/100 ml
4. pH			standard units
5. Temperature - winter			°F
6. Temperature - summer			°F
7. Turbidity			JTU
8. Nutrients, specify:			
			mg/l
9. Other, specify:***			

C. Type of wastewater analyzed: _____

1. BOD_5 (5-day Biological Oxygen Demand)			mg/l
2. Total Suspended Solids			mg/l
3. Fecal Coliform**			MPN/100 ml
4. pH			standard units
5. Temperature - winter			°F
6. Temperature - summer			°F
7. Turbidity			JTU
8. Nutrients, specify:			
			mg/l
9. Other, specify:***			

* Sample type: G=Grab sample C=Composite sample
** Fecal Coliforms shall be expressed as a geometric mean (see instructions)
*** Analysis should be completed for all items checked in question 10.

 NA - Not Applicable

15. Attachments (check attachments enclosed)

Location map	xxx
Flow diagram	xxx (DWG 189-1005) Figure 4-1
Other, specify	St. Louis Park PAH List
	Analytical Results
	Potassium Permanganate MSDS

I certify under penalty of law that I have personally examined and am familiar with the information submitted in the attached document; and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature of Applicant

Printed Name of Person Signing

Title

Date Application Signed

MPCA SHORT FORM C - SPECIFIC INSTRUCTIONS

Instructions for completing the National Pollutant Discharge Elimination System (NPDES) and State Disposal System Permit Application - MPCA Short Form C.

Complete this form being sure that each item is considered and the required data submitted. Check the items which most nearly apply to you and your operation. If an item does not apply, please enter in the appropriate place "Not Applicable" or "NA" to show that the item was given consideration.

1. A. Applicant - The person, agency, firm, municipality, or any other entity which owns or is responsible for any disposal system. Enter the name of the applicant as it is officially or legally referred to. Do not use colloquial names as a substitute for the official name. Use the complete mailing address of the applicant's main office. (This often will not be the same address used to designate the location of the facilities.)

   B. Applicant's Technical Agent - Give the name of a person who is thoroughly familiar with the facts reported on the application form and who can be contacted by the State offices, and other agencies involved in permit application processing and review.

   C. Applicant's Consulting Engineer - Give the name, firm name, city, and telephone number of the engineer who prepared reports, plans and specifications for the facility if different than 1.B. (If same, so indicate.)

   D. Facility Producing Discharge - Give the name and address of the facility producing the wastewater if different than 1.A. (If same, so indicate). Also provide a legal description and map of the facility.

2. State the product produced or service provided at this facility, the average amount of product produced, raw material consumed, or any other type of measurement to indicate the size of the operation during a given period of time (e.g., milk distribution, 20,000 lbs/day: mining of iron ore, 5,000 tons/day; slaughterhouse, 10 beef/day etc.). Also include the number of employees and a brief description of the disposal system.

3. List any previous application or permit, NPDES or State Disposal System, for the facility and give the date of application or permit issuance date.

4. Indicate the reason for submission of this application.

5. Indicate whether or not an Environmental Impact Statement, Environmental Assessment, or Environmental Report was ever written for this facility.

6. A. Identity all water treatment additives used in flows which discharge to waters of the state. Include the commercial name of the product, the amount or concentration of the product used, the frequency of treatment, and the use of the treated water (process, cooling water, or other usage - specify). Additives used in flows which discharge to municipal sewage treatment systems need not be reported here.

   B. Obtain aquatic toxicity and/or chemical composition information on all water treatment additives used. This information should be obtained through your water treatment consultant or supplier. Attach this information to the permit application.

7. A. If this application is submitted because an existing permit is expiring (4.B.) and no significant changes have been made since the last issuance (e.g., facility expansions, production increases or decreases, process modification or wastewater treatment facility changes which will result in new, different, increased, or decreased discharge of pollutants), check the block, provide authorized signature, and return the original application to:

Minnesota Pollution Control Agency
Division of Water Quality
ATTN: Regulatory Compliance Section
520 Lafayette Road North
St. Paul, MN 55155

If significant changes have been made to your facility proceed to 7.B.

B. Briefly describe any significant changes that have occurred to your facility since the last permit issuance. Proceed to item 8.

8. A. The volume per day of intake water may be estimated from water supply meter readings or from billing statements from a water supply utility. If water is not metered, estimate from pump capacity (in gallons per minute) times 60 times average number of hours the pump operates per day.

B. (1) thru (7) Explanation of Column Headings:

Type of Wastewater -

-Process Water = Water that comes in contact with any raw material, intermediate material, or end product.
-Non-contact Cooling Water = Water used to reduce temperature which does not come in contact with any raw material, intermediate, or end product.
-Sanitary Water = Wastewater discharged from the sanitary conveniences (e.g., toilets, sinks, showers) of dwellings, office buildings, industrial plants, or institutions.

Quantities - Indicate the volume discharged per day at the facility for each type of water used. Do not count it twice when water is reused. If water is subsequently used for one or more other purposes, indicate the volume per day of the last designated use before treatment and/or discharge. For examole, if water is initially used as non-contact cooling water, then as process water, (before being treated or discharged), the quantity of water given should be indicated as process water.

E/A - The accuracy of all volumes should be identified as either actual (A) or estimate (E)

Treatment System - This includes those items such as settling ponds, aerated ponds, chemical treatment, filtering systems, cooling towers, septic tanks, drainfields, spray irrigations, ridge and furrow, etc. If none, so indicate.

Location of Final Disposal - This would include the actual name of a body of water, storm sewers, municipal sanitary sewer, tile system, ditches, soil, or commercial haulers.

B.(8) Schematic Diagram - A flow chart should be attached showing routes and treatment units for all water used in the facility, prior to discharge.

9. A. Indicate how often the facility discharges wastewater to the final disposal areas.

B. If this facility does not discharge 12 months per year, specify the months when discharge occurs.

10. Check any of the listed items that are present or may be present in the wastewater as a result of your facility's operation.

11. If your facility does not discharge wastewater to surface waters (e.g., a lake, creek, river, swamp, ditch, storm sewer, etc.), check the block, proceed to last page and complete signature, title, and date blocks. Return the original application to the Minnesota Pollution Control Agency's address shown in 7.A. above. If any wastewaters are discharged to surface waters, proceed to item twelve (12) and complete the application form.

12. Separate discharge points are defined as an easily identifiable, completely or partly enclosed container or channel through which the wastewater is discharged into a body of water; for example, a pipe, ditch, culvert, tile system, refuse container, barge, boat, etc.

13. Describe the methods of conveyance used to transport the wastewaters from the discharge point to the first main surface water. Whenever possible use the name of the waterway as shown on published maps. If the discharge is to an unnamed tributary, give the name of the waterbody fed by the tributary and identify as "tributary to (name of waterbody)," (e.g., "ditch to Mississippi River", "Unnamed Creek to Spruce Lake", etc.).

14. If your discharge waters come in contact with any of your processes, are used as a cooling agent, or are contaminated in any way, measure appropriate parameter concentrations and indicate the type of wastewaters in which the concentrations occurred (e.g., process, cooling, sanitary wastewaters).

    **Geometric mean - the nth root of the product of n factors. For example, given the measurements of 4 MPN/100 ml, 7 MPN/100 ml, and 5 MPN/100 ml, n = 3. Therefore, the geometric mean= $\sqrt[3]{(4x7x5)} = \sqrt[3]{40}$ = 5.2 MPN/100 ml.

15. Please check or specify the attached maps, diagrams, etc.

<u>Signature of Application</u> - The person who signs the application form will often be the applicant himself; when another person signs on behalf of the applicant, his title or relationship to the applicant should be shown in the space provided. In all cases, the person signing the form should be authorized to do so by the applicant. An application submitted by a corporation must be signed by a principal executive officer of at least the level of vice president. In the case of a partnership or a sole proprietorship, the application must be signed by a general partner or the proprietor, respectively. In the case of a municipal, state, federal, or other public facility, the application must be signed by either a principal executive officer or ranking elected official.

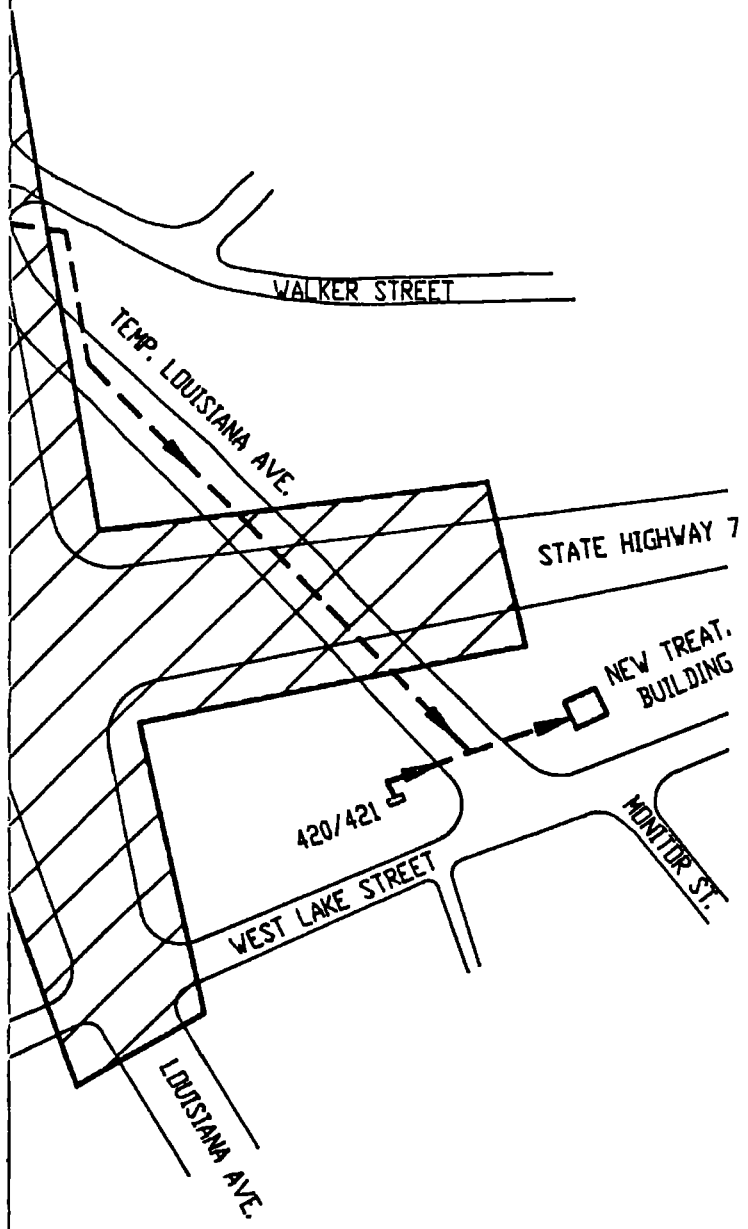
Return the original copy of this application to the Minnesota Pollution Control Agency address listed in item 7.A.

Effective April 7, 1986, the Minnesota Legislature adopted rules requiring the Minnesota Pollution Control Agency to collect fees for all applications submitted for permit issuance. This fee is required under Minnesota Laws 1985, First Special Session, Chapter 13. A fee of $50.00 is required for this application.

PLEASE REMIT THE $50.00 ALONG WITH THIS APPLICATION, PAYABLE TO THE MINNESOTA POLLUTION CONTROL AGENCY

FIGU

WELL LOCATIONS



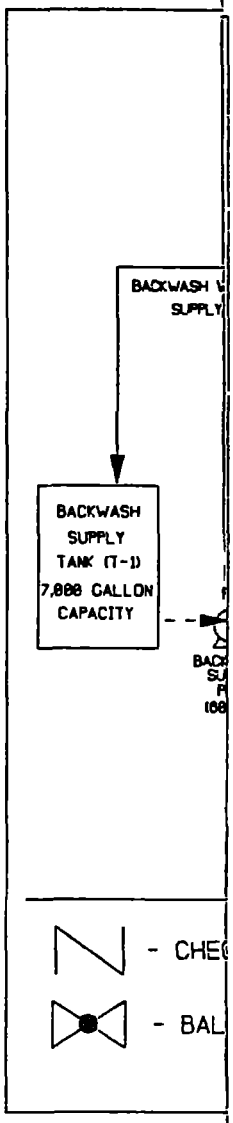
This drawing is sent to you subject to return upon demand, and with the understanding that it is not to be reproduced, copied or used, directly or indirectly, in any way detrimental to our interests. All patent rights reserved.

REVISION					
1		WELL LOCATIONS W23, W105, W420 & W421 St. Louis Park, MN		ReTeC REMEDIATION TECHNOLOGIES INC.	
2					
3					
4					
5					
DRAWN BY	CHECKED BY	DATE	SCALE	DWG. NO.	
L.M.	D.L.M.	11-20-89	1"=200'	189-1004	0

Engineering Evaluation Report for Treatment of Pumped Groundwaters at St. Louis Park, Minnesota

FIGUR

FULL-SCALE TREATM
REILLY INDUS



Engineering Evaluation Report for
Treatment of Pumped Groundwaters
at St. Louis Park, Minnesota

ST. LOUIS PARK - PAH LIST

PARAMETER

POTENTIAL CARCINOGENS

Quinoline
Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-c,d)pyrene
Dibenzo(a,h)anthracene
Benzo(g,h,i)pyrene

OTHER PAH

2,3-Benzofuran
2,3-DHI
Indene
Naphthalene
Benzo(b)thiophene
Indole
2-Methylnaphthalene
1-Methylnaphthalene
Biphenyl
Acenaphthalene
Acenaphthene
Bibenzofuran
Flourene
Dibenzothiophene
Phenathrene
Anthracene
Acridine
Carbazole
Fluoranthene
Pyrene
Benzo(e)pyrene
Perylene
7,12-Dimethylbenzanthracene
Dibenz(a,c)anthracene
3-Methylcholanthrene

TABLE 5-10
ST. LOUIS P[illegible] TREATABILITY STUDY
NPDES PERMI[illegible]MPLING RESULTS FOR:
CONVENTIONAL/NUTRIENTS/METALS/PAH by HPLC

PARAMETERS	NO. OF PAH RINGS	WEEK 1 INFLUENT	WEEK 1 EFFLUENT	WEEK 1 BLANK	WEEK 7 INFLUENT	WEEK 7 EFFLUENT	WEEK 7 BLANK	Week 13 INFLUENT	Week 13 EFFLUENT	Week 13 BLANK
CONVENTIONAL (mg/L):										
Phenolics (4-AAP)		0.074	< 0.005	< 0.005	0.06	< 0.005	< 0.005	0.124	0.012	< 0.005
pH (units)		7.9	7.8	7.6	7.5	7.5	6.6	7.6	7.6	5.8
Total Dissolved Solids		673	560	< 1.00	711	693	< 1.00	715	730	4.00
Total Suspended Solids		10.0	16.0	1.00	14.0	2.0	< 1.00	1.00	< 1.00	< 1.00
Biochemical Oxygen Demand		5.43	< 1.00	< 1.00	4.42	< 1.00	< 1.00	7.20	< 1.00	< 1.00
Chemical Oxygen Demand		16.0	< 10.0	< 10.0	32.0	10.0	< 10.0	20.0	28.0	< 10.0
Total Organic Carbon		7.15	< 1.00	< 1.00	7.06	2.53	< 1.00	2.46	5.26	< 1.00
Oil and Grease		< 6.00	< 6.00	< 6.00	< 5.00	9.11	< 5.00	< 5.00	< 6.00	< 6.00
Hardness (as CaCO3)		453	443	< 1.00	471	475	2.20	501	454	< 1.00
NUTRIENTS (mg/L):										
Orthophosphate as P		< 0.010	0.030	0.014	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Ammonia Nitrogen as N		< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	1.05	< 1.00	< 1.00
Nitrite as N		< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
Nitrate as N		< 0.020	< 0.020	0.033	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
METALS (mg/L):										
Iron-Total		1.840	< 0.100	< 0.100	2.120	< 0.100	< 0.100	1.980	< 0.100	< 0.100
Iron-Ferrous		0.411	< 0.100	< 0.100	< 0.100	< 0.100	0.110	0.118	< 0.100	< 0.100
Iron-Filtered		< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	0.100	< 0.100	< 0.100
Manganese-Total		0.374	0.034	< 0.015	0.361	0.244	< 0.015	0.374	0.691	< 0.015
PAH by HPLC (ug/L):				NA	NA		NA			NA
Carbazole	3	2.30	<2.00			<2.00		11.1	<2.00	
Naphthalene	2	765	<2.00			<2.00		747	<2.00	
Acenaphthylene	3	84.0	<2.00			<2.00		106	<2.00	
Acenaphthene	3	48.9	<2.00			<2.00		60.2	<2.00	
Fluorene	3	13.3	<0.200			<0.200		14.4	<0.200	
Phenanthrene	3	7.21	<0.500			<0.500		7.03	<0.500	
Anthracene	3	<0.500	<0.500			<0.500		0.691	<0.500	
Fluoranthene	4	<0.200	<0.200			<0.200		<0.200	<0.200	
Pyrene	4	<0.200	<0.200			<0.200		<0.200	<0.200	
Benzo(a)anthracene	4	<0.020	<0.020			<0.020		<0.020	<0.020	
Chrysene	4	<0.150	<0.150			<0.150		<0.150	<0.150	
Benzo(b)fluoranthene	5	<0.020	<0.020			<0.020		<0.020	<0.020	
Benzo(k)fluoranthene	5	<0.020	<0.020			<0.020		<0.020	<0.020	
Benzo(a)pyrene	5	<0.020	<0.020			<0.020		<0.020	<0.020	
Dibenzo(a,h)anthracene	5	<0.030	<0.030			<0.030		<0.030	<0.030	
Benzo(g,h,i)perylene	6	<0.050	<0.050			<0.050		<0.050	<0.050	
Indeno(1,2,3-c,d)pyrene	6	<0.050	<0.050			<0.050		<0.050	<0.050	
Total Detectable PAH		920.7	0.0			0.0		946.4	0.0	

Note: Analyses by KER.
NA - indicates not analyzed.
< - represents less than detectable concentrations.

POTASSIUM PERMANGANATE
POTASSIUM PERMANGANATE
POTASSIUM PERMANGANATE

MATERIAL SAFETY DATA SHEET

FISHER SCIENTIFIC
CHEMICAL DIVISION
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FAIR LAWN NJ 07410
(201) 796-7100

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CAT NO: P279500

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SUBSTANCE IDENTIFICATION

CAS-NUMBER 7722-64-7

SUBSTANCE: POTASSIUM PERMANGANATE

TRADE NAMES/SYNONYMS:
CHAMELEON MINERAL, C.I. 77755, PERMANGANATE OF POTASH, CONDY'S CRYSTALS, CAIROX, PERMANGANIC ACID POTASSIUM SALT, STCC 4918740, UN 1490, P-279, P-287, ACC19520

CHEMICAL FAMILY:
INORGANIC SALT

MOLECULAR FORMULA: K-MN-O4

MOLECULAR WEIGHT: 158.04

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=0 PERSISTENCE=3
NFPA RATINGS (SCALE 0-4): HEALTH=1 FIRE=0 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: POTASSIUM PERMANGANATE PERCENT: 100

EXPOSURE LIMITS:
POTASSIUM PERMANGANATE:
5 MG(MN)/M3 ACGIH CEILING

100 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY

PHYSICAL DATA

DESCRIPTION: ODORLESS, DARK PURPLE OR BRONZE-LIKE RHOMBIC CRYSTALS WITH A BLUE METALLIC SHEEN; SWEETISH, ASTRINGENT TASTE

MELTING POINT: 464 F (240 C) DECOMPOSES SPECIFIC GRAVITY: 2.703

SOLUBILITY IN WATER: 6.38%

SOLVENT SOLUBILITY: METHYL ALCOHOL, ACETONE, SULFURIC ACID, DECOMPOSES BY ALCOHOL AND OTHER ORGANIC SOLVENT AND CONCENTRATED ACIDS.

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD:
DANGEROUS FIRE AND EXPLOSION HAZARD BY CHEMICAL REACTION. POWERFUL OXIDIZING AGENT; INCREASES FLAMMIBILITY OF COMBUSTIBLE MATERIALS. EXPLOSION MAY OCCUR WITH ORGANIC OR READILY OXIDIZABLE MATERIALS, EITHER WHEN DRY OR IN SOLUTION.

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, HALON OR WATER SPRAY
(1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FOR LARGER FIRES, USE WATER SPRAY OR FOG
(1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FIREFIGHTING:
MOVE CONTAINERS FROM FIRE AREA IF POSSIBLE. COOL CONTAINERS EXPOSED TO FLAMES WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM STORAGE TANK ENDS. FOR MASSIVE FIRE IN STORAGE AREA, USE UNMANNED HOSE HOLDER OR MONITOR NOZZLES; ELSE WITHDRAW FROM AREA AND LET FIRE BURN (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4, GUIDE PAGE 35)

USE FLOODING AMOUNTS OF WATER. COOL CONTAINERS WITH FLOODING QUANTITIES OF WATER, APPLY FROM AS FAR A DISTANCE AS POSSIBLE. EVACUATE TO A RADIUS OF 2500 FEET FOR UNCONTROLLABLE FIRES.

TRANSPORTATION DATA

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49CFR172.101:

OXIDIZER

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49CFR172.101 AND 172.402:
OXIDIZER

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49CFR173.154 AND
49CFR173.194
EXCEPTIONS: 49CFR173.153

TOXICITY

POTASSIUM PERMANGANATE:
2400 UG/KG/DAY ORAL-WOMAN TDLO; 143 MG/KG ORAL-HUMAN LDLO; 1090 MG/KG ORAL-RAT LD50; 600 MG/KG ORAL-RABBIT LDLO; 400 MG/KG ORAL-DOG LDLO; 500 MG/KG SUBCUTANEOUS-MOUSE LD50; 70 MG/KG INTRAVENOUS-RABBIT LDLO; MUTAGENIC DATA DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS);
CARCINOGEN STATUS: NONE.
POTASSIUM PERMANGANATE IS A SEVERE EYE, SKIN, AND MUCOUS MEMBRANE IRRITANT. POISONING MAY AFFECT THE KIDNEYS.

HEALTH EFFECTS AND FIRST AID

INHALATION:
POTASSIUM PERMANGANATE:
CORROSIVE.
ACUTE EXPOSURE- MAY CAUSE SEVERE IRRITATION OF THE RESPIRATORY TRACT, SHORTNESS OF BREATH, LABORED BREATHING, CHOKING, STRIDOR, PERSISTENT, SPASMODIC COUGH, PAIN IN THE NOSE, MOUTH AND THROAT, AND BURNS OF THE MUCOUS MEMBRANES. IF SUFFICIENT QUANTITIES ARE INHALED, PULMONARY EDEMA MAY DEVELOP, OFTEN WITH A LATENT PERIOD OF 5-72 HOURS. THE SYMPTOMS MAY INCLUDE TIGHTNESS IN THE CHEST, DYSPNES, FROTHY SPUTUM, CYANOSIS, AND DIZZINESS. PHYSICAL FINDINGS MAY INCLUDE WEAK, RAPID PULSE, HYPOTENSION, MOIST RALES AND HEMOCONCENTRATION. RECOVERY MAY BE PROLONGED AND RELAPSES ARE POSSIBLE. IN SEVERE EXPOSURES, DEATH DUE TO ANOXIA MAY OCCUR WITHIN A FEW HOURS AFTER ONSET OF PULMONARY EDEMA SYMPTOMS OR FOLLOWING A RELAPSE.
CHRONIC EXPOSURE- DEPENDING ON THE CONCENTRATION AND DURATION OF EXPOSURE, REPEATED OR PROLONGED EXPOSURE TO ACIDIC SUBSTANCES MAY CAUSE EROSION OF THE TEETH AND INFLAMMATORY AND ULCERATIVE CHANGES IN THE MOUTH. BRONCHIAL AND GASTROINTESTINAL DISTURBANCES ARE ALSO POSSIBLE.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL RESPIRATION. MAINTAIN AIRWAY AND BLOOD PRESSURE AND ADMINISTER OXYGEN IF AVAILABLE. KEEP AFFECTED PERSON WARM AND AT REST. ADMINISTRATION OF OXYGEN SHOULD BE PERFORMED BY QUALIFIED PERSONNEL. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
POTASSIUM PERMANGANATE:
CORROSIVE.
ACUTE EXPOSURE- DILUTE AQUEOUS SOLUTIONS MAY BE MILDLY IRRITATING. DIRECT CONTACT WITH THE SOLID MAY CAUSE SEVERE BURNS WITH REDNESS AND PAIN.
CHRONIC EXPOSURE- EFFECTS DEPEND ON THE CONCENTRATION AND DURATION OF EXPOSURE. REPEATED OR PROLONGED CONTACT WITH CORROSIVE SUBSTANCES MAY RESULT IN DERMATITIS OR EFFECTS SIMILAR TO ACUTE EXPOSURE.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). IN CASE OF CHEMICAL BURNS, COVER AREA WITH STERILE, DRY DRESSING. BANDAGE SECURELY, BUT NOT TOO TIGHTLY. GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
POTASSIUM PERMANGANATE:
CORROSIVE.
ACUTE EXPOSURE- DILUTE AQUEOUS SOLUTIONS MAY BE ONLY MILDLY IRRITATING, HOWEVER, DIRECT CONTACT WITH THE SOLID MAY CAUSE BURNS WITH REDNESS, PAIN, LACRIMATION AND BLURRED VISION. CONTACT WITH STRONG SOLUTIONS OR CRYSTALS MAY CAUSE A HARDENED, ERODED LESION ACCOMPANIED BY SWELLING OF THE LIDS AND CONJUNCTIVAE AND SUBCONJUNCTIVAL HEMORRHAGE.
CHRONIC EXPOSURE- EFFECTS DEPEND ON THE CONCENTRATION AND DURATION OF EXPOSURE. REPEATED OR PROLONGED EXPOSURE TO CORROSIVE SUBSTANCES MAY CAUSE CONJUNCTIVITIS OR EFFECTS AS IN ACUTE EXPOSURE. TURBIDITY AND BROWN DISCOLORATION OF THE CORNEA IS POSSIBLE WITH PROLONGED CONTACT.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (AT LEAST 15-20 MINUTES). IN CASE OF BURNS, APPLY STERILE BANDAGES LOOSELY WITHOUT MEDICATION. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
POTASSIUM PERMANGANATE:
CORROSIVE.
ACUTE EXPOSURE- MAY CAUSE DISCOLORATION, INFLAMMATION, AND CORROSION OF THE LIPS, GUMS, TEETH, TONGUE, TONSILS, PHARYNX AND THE LARYNX. THE COLOR MAY BEGIN AS A PURPLE-BROWN, BUT WITHIN MINUTES THIS CHANGES TO DARK BROWN AND LATER IT MAY BE A COAL BLACK. A SLIGHT METALLIC LUSTRE MAY ALSO BE APPARENT. A BURNING PAIN FROM THE MOUTH TO THE PIT OF THE STOMACH BEGINS WITH NAUSEA AND VOMITING FOLLOWING. THE VOMIT MAY CONTAIN PURPLE-BROWN OR BROWN MATERIAL. OTHER SYMPTOMS MAY INCLUDE DIFFICULTY IN SPEAKING OR SWALLOWING WHICH MAY PERSIST FOR SEVERAL DAYS, BLACK STOOLS, AND EPIGASTRIC PAIN AND TENDERNESS WHICH MAY BE ACCOMPANIED AND EXAGGERATED BY TYMPANIC DISTENSION OF THE ABDOMEN. SLOW PULSE, SHOCK WITH FALL OF BLOOD PRESSURE AND DEATH MAY ALSO OCCUR. IF DEATH IS NOT IMMEDIATE JAUNDICE AND OLIGURIA OR ANURIA MAY APPEAR. IF THIS CHEMICAL IS INADVERTENTLY INHALED

MAY ALSO
GESTION OF
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OCELLULOSE:
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