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EVALUATION OF ALTERNATIVES FOR PRETREATMENT OF EXTRACTED GROUNDWATER

FOR THE PHASE I REMEDIAL ACTION

AT THE NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT FRIDLEY, MINNESOTA

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Engineering and Environmental Management Services

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Section 1
INTRODUCTION

1.1 Background

The Naval Industrial Reserve Ordnance Plant (NIROP) site in Fridley, Minnesota, was placed on the U.S. Environmental Protection Agency (USEPA) National Priorities List (NPL) under CERCLA and SARA due to contamination of soil and groundwater at the site, primarily by trichloroethene (TCE). A Record of Decision (ROD) for groundwater remedial action was signed by the USEPA, the Minnesota Pollution Control Agency (MPCA), and the Navy in September 1990. The selected remedial action for groundwater includes installation and operation of a groundwater containment and extraction system (including groundwater extraction wells) for pumping groundwater from the unconsolidated sand and gravel aquifer, with a two-phase plan for disposal of groundwater from the well system. Under Phase I, the contaminated groundwater will be discharged to an existing sanitary sewer for treatment at a municipal wastewater treatment facility owned by the Metropolitan Waste Control Commission (MWCC). Under Phase II, a groundwater treatment system (GWTS) will be designed, constructed at the NIROP Fridley, and operated to treat the contaminated groundwater, with the GWTS effluent discharged to the Mississippi River via an existing National Pollutant Discharge Elimination System (NPDES)–permitted storm sewer outfall.

During Phase I, the system will include four extraction wells (AT-1A, AT-2, AT-3A, and AT-4), and piping from these wells through a combined discharge to the sanitary sewer. A Control House will be used to monitor and control the operation of the Phase I system pumps. The MWCC has established the following limits for the combined discharge from the Phase I system to the sanitary sewer:

- TCE $\leq$ 3 mg/L
- Total VOCs $\leq$ 10 mg/L

The Phase I discharge to the sanitary sewer was designed by the U.S. Army Corps of Engineers (USACE) - Omaha District, and is presently being constructed. The extraction system is expected to start up in mid-1992. Within approximately 3 years after startup of the groundwater extraction system, the GWTS will be designed and constructed. During this period, the effectiveness of the groundwater extraction system will also be evaluated. If this

evaluation indicates that the groundwater extraction system must be modified to improve capture effectiveness of the contaminated groundwater, the system improvements would be constructed concurrently with construction of the on-site GWTS.

Because the Phase I extraction system is not yet in operation, flow rates and groundwater quality from each of the four extraction wells have not yet been determined. However, based on limited water quality data from groundwater monitoring wells at the NIROP site, and from the four extraction wells during pump capacity tests performed in early 1992, there is a likelihood that the TCE concentration in the combined untreated discharge from the Phase I system to the sanitary sewer may exceed the 3 mg/L discharge limit. The data also show that TCE concentrations in the groundwater are much higher than those for other VOCs, which is consistent with previous investigation findings. The data indicate that the 10 mg/L discharge limit for total VOCs will easily be achieved if the TCE discharge limit of 3 mg/L is achieved.

1.2 Purpose and Scope

The purpose of this report is to summarize an evaluation of alternatives for pretreatment of groundwater during the Phase I remedial action, assuming that the combined untreated discharge to the sanitary sewer will exceed the MWCC's discharge limits.

The scope of this evaluation included the following:

- Estimation of the flow rates from each of the four extraction wells based on the Phase I system design by the USACE, and a preliminary evaluation by RMT of the flow rates from each extraction well needed to obtain hydraulic containment of contaminated groundwater.
- Estimation of the concentrations of TCE and other VOCs in the untreated groundwater to be pumped from each of the four extraction wells.
- Identification of which extraction wells would need pretreatment, and the extent of pretreatment needed to achieve the MWCC limits for the combined discharge.
- Identification of alternatives which could be potentially cost-effective for pretreatment.

- Evaluation of alternatives, with recommendations for a specific system to be installed, assuming that the combined discharge to the sanitary sewer will continue to exceed the MWCC discharge limits after sustained operation of the Phase I groundwater extraction system for several weeks.

Section 2
DISCUSSION

2.1 Untreated Groundwater Flow Rates and Quality

As noted in Subsection 1.1, the extraction wells are not yet in operation. Therefore, the actual flow rate and quality of groundwater to be pumped from each of the four wells (and, therefore, the flow rate and quality of the combined discharge to the sanitary sewer) are not yet known. However, information is available concerning flow rates and TCE concentrations to allow a prediction of the actual flow rates and groundwater quality at startup of the Phase I system.

Based on information obtained from the USACE concerning the pumps to be installed in the four extraction wells, flow rates for the Phase I system are estimated to be as follows:

Extraction Well	Flow Rate at Phase I System Design Point (gpm)
AT-1A	50
AT-2	150
AT-3A	250
AT-4	50
Total (to sanitary sewer)	500

The following water quality data from the four extraction wells during the pump capacity tests were provided to RMT by the USACE:

Extraction Well	TCE Concentration (mg/L)
AT-1	0.240
AT-2	0.052
AT-3A	31.0
AT-4	1.40
Combined discharge to sanitary sewer*	15.7

* Based on the well pump capacities shown above.

Based on these data, the combined discharge to the sanitary sewer would exceed the MWCC discharge limits for both TCE and total VOCs.

2.2 Pretreatment System Design Basis

Based on the information in Subsection 2.1, the MWCC discharge limits could be achieved by pretreating the total flow from the four extraction wells. However, the data also show that pretreatment is required only because of the high concentration and mass of TCE in the discharge from well AT-3A (99% of the total TCE mass is attributable to well AT-3A). Therefore, a more cost-effective solution would be to pretreat only the water from well AT-3A, and then blend the pretreated water with the untreated water from the other wells before discharge to the sanitary sewer.

Therefore, the pretreatment alternatives were evaluated on the following design basis:

- Pretreating water from well AT-3A only
- Flow rate from AT-3A = 250 gpm
- Untreated water quality from AT-3A = 31 mg/L TCE
- Treated water quality from AT-3A = 1.5 mg/L TCE

The design basis treated effluent quality of 1.5 mg/L from AT-3A, when blended with the untreated water from the other three extraction wells, would result in a TCE concentration in the combined discharge to the sanitary sewer of less than 1 mg/L. This conservative design basis was selected for the following reasons:

- Uncertainty in the actual concentration of TCE in well AT-3A when the Phase I system becomes operational.
- Variability in the performance of the pretreatment system equipment.

2.3 Alternatives Evaluated

Based on experience with removal of TCE and other VOCs from groundwater, and discussions with groundwater remediation treatment equipment suppliers, the following pretreatment alternatives were identified:

Alternative	Description
1	Air stripping, with vapor-phase granular activated carbon (GAC) treatment of the air stripper emissions
2	Liquid-phase GAC
3	Chemical oxidation

2.3.1 Air Stripping with Vapor-Phase GAC

For this alternative, the groundwater would be treated using the existing air stripping system constructed for use during the pump capacity tests. While these tests occurred only for a few days, the Phase I system will operate for an extended time period (approximately 3 years). The MPCA has indicated that air emissions from an air stripping system which occur for an extended time period (i.e., more than a few weeks), must meet the MPCA air emission requirements. The MPCA has developed an "Air Stripper Screening Evaluation Form" to evaluate the need for controlling air emissions from air stripping systems. If the emission rate of a particular contaminant from the air stripping system (as calculated using this form) is greater than the Significant Emission Rate (SER) for that contaminant, the MPCA will typically require emission controls (e.g., vapor-phase, granular activated carbon) to reduce the air stripping system emissions.

Based on the estimated flow rate and untreated groundwater quality from well AT-3A, the uncontrolled air emissions from an air stripping system would have a TCE emission rate of 473,200 μg/sec, which is above the MPCA SER of 22,600 μg/sec for TCE. A completed MPCA Air Stripper Screening Evaluation Form for this option is included in Appendix A. Therefore, vapor-phase GAC adsorption is included in the design for this option to meet the expected MPCA air emission requirements. The system would include a single air stripping system (including the existing air stripping column and a replacement air blower), one vapor-phase GAC unit, and an electric dehumidifier. The dehumidifier provides heating of the air from the stripping column prior to the GAC unit to prevent condensation of water in the GAC unit, and in the associated piping and ductwork.

The existing air stripping column would remain inside the existing building. It is likely that the existing capacity of the air blower is too high, and that the blower cannot be operated at the lower capacity needed to minimize airflow (and thus minimize the frequency of GAC regeneration). Therefore, it is assumed that the existing air blower would be replaced by an air blower with a lower capacity, which will allow the TCE effluent design basis of 1.5 mg/L to be met while minimizing the frequency of GAC regeneration. New piping would need to be installed from the well AT-3A discharge piping (inside the Control House) to the inlet of the air stripping column. The vapor-phase GAC unit would be located in a new building adjacent to the air stripper building. This new building would be provided with heating and lighting. Spent GAC would be regenerated off-site; the entire GAC vessel would be removed from the building and loaded onto a truck for off-site regeneration. Another GAC unit with regenerated GAC would then be placed in service. The new building would have a double door to facilitate moving GAC units into and out of the building. The outdoor piping would be insulated and electric heat–traced to prevent freezing. The outdoor ductwork would be insulated and electric heat–traced to prevent condensation of water vapor and to minimize electric power consumption by the dehumidifier.

It is assumed that the treated effluent from the air stripper could flow by gravity to the existing Phase I system discharge piping, where it would combine with the untreated water from the other three wells before discharge to the sanitary sewer. The system pressures must be checked to determine whether this is feasible. If not, a pump (with appropriate instrumentation and controls) should be installed to pump the treated air stripper effluent to the sanitary sewer. The design of the existing Phase I system should also be modified to include a location for sampling the combined discharge to the sanitary sewer for confirming compliance with the MWCC discharge limits.

Each vapor-phase GAC unit would hold approximately 5,000 pounds of GAC. Based on treating only the groundwater from well AT-3A, and the design basis flow rate and concentrations described in Subsection 2.2, a GAC unit would need to be removed for off-site regeneration approximately every 60 days (i.e., six times per year).

Information available in the FS Addendum Report (RMT, 1988), and other sources, indicates that the untreated groundwater contains constituents which would likely result in fouling of the air stripping column packing and other components due to deposition of calcium carbonate scale and iron and manganese precipitates. Therefore, this alternative would include a chemical cleaning pump and accessories for periodic off-line chemical cleaning of the air stripper to remove the deposition. The cleaning procedure would be as follows:

- The groundwater flow to the air stripper would be stopped, and the air blower turned off.
- A suitable chemical cleaning solution for removing the deposits would be added to the air stripper effluent sump, and a chemical cleaning pump would be used to recirculate the solution through the air stripper column to remove the deposits.
- After cleaning, the spent solution and deposits would be collected in the air stripping column sump, neutralized (if necessary to meet any MWCC pH limits), and then discharged to the sanitary sewer.

After cleaning, the air stripper would be returned to service, and the groundwater flow to the air stripper would be resumed. Typical off-line chemical cleaning would take approximately 1 day, and can occur at a frequency of approximately once per month to once every 6 months, depending on the amount of fouling constituents in the groundwater and the particular stripper design and operating conditions. For purposes of evaluating this alternative, it was assumed that off-line chemical cleaning would occur for 1 day every 3 months.

Additional information concerning the design of an air stripper system with vapor-phase GAC is included in Appendix B. This information was obtained from Carbonair Services, the supplier of the existing air stripper at the NIROP Fridley site. Carbonair Services is a major supplier of air stripping systems, vapor-phase GAC units, and liquid-phase GAC systems.

2.3.2 Liquid-Phase GAC

For this alternative, the groundwater would be treated by a liquid-phase GAC system consisting of two liquid-phase GAC vessels. During normal operation, the two GAC

vessels would operate in series. When the GAC in the first vessel becomes saturated with TCE, the first vessel would be taken out of service. The spent GAC would be transferred from the vessel to a truck for off-site regeneration, and a fresh supply of GAC would then be transferred into the vessel. This vessel would then be put back into service as the second vessel in series. The piping at these GAC vessels would be designed with the flexibility so that either vessel could be used as the first vessel in series, or either vessel could be used alone (when one vessel is out of service).

New piping would need to be installed from the well AT-3A discharge piping to the inlet of the GAC system, and from the outlet of the GAC system to the sanitary sewer. The liquid-phase GAC system would be located inside a new building near the Control House. This new building would be provided with heating and lighting. Pressure GAC vessels would be used so that the groundwater could be pumped directly from well AT-3A through the vessels and into the sanitary sewer. This would avoid having to repump the groundwater. However, the well pump at well AT-3A may not have sufficient head to overcome the additional head loss through the GAC system. If so, the pump at well AT-3A would need to be replaced with a higher-head pump. The design of the existing Phase I system should also be modified to include a location for sampling the combined discharge to the sanitary sewer for compliance with the MWCC discharge limits.

Each liquid-phase GAC vessel would hold approximately 20,000 pounds of GAC. Based on treating only the groundwater from well AT-3A, and the design basis flow rate and concentrations described in Subsection 2.2, a vessel would need regeneration approximately every 45 days (i.e., nine times per year).

Additional technical information concerning the design of a liquid-phase GAC system is included in Appendix B.

2.3.3 Chemical Oxidation

TCE can theoretically be destroyed by oxidation with a variety of chemical oxidants, including the following:

- Hydrogen peroxide (H_2O_2)
- Potassium permanganate ($KMnO_4$)
- Ozone (O_3)

The pretreatment system utilizing chemical oxidation would include equipment for feeding the chemical oxidant, a mixing tank (with a sufficient volume to allow time for the oxidant to react with TCE and other organic compounds), and mixing equipment (to provide thorough mixing of the chemical oxidant with the groundwater). For H_2O_2, additional equipment would be needed to add an acid to lower the pH to approximately 5 to optimize the oxidation reaction rate, and to add an alkali to neutralize the treated groundwater (after the reaction has occurred) prior to discharge to the sanitary sewer. Because O_3 cannot be stored, an on-site O_3 generation system would be needed to generate and feed O_3 to the mixing tank.

A chemical oxidation system would be located indoors in a new building to protect the equipment during severe weather. The new building would be constructed adjacent to the Control House. This new building would be comparable in size or larger than the new building which would be required for a liquid-phase GAC system.

Section 3
COMPARISON OF ALTERNATIVES

3.1 Introduction

Each of the three alternatives were evaluated based on the following criteria:

- Technical acceptability:
  - Experience in removing TCE at other facilities
  - Ability to be installed in a timely fashion
- Economics:
  - Initial construction costs
  - Operation and maintenance costs over the operating life of the Phase I system
  - Costs for demolition of the system at the conclusion of Phase I
- Other criteria:
  - Flexibility to meet changing groundwater conditions
  - Ease of construction
  - Ease of operation and maintenance
  - Reliability

3.2 Technical Acceptability

All three alternatives were evaluated against the technical acceptability criteria. Both air stripping with vapor-phase GAC alternative and the liquid-phase GAC alternative have been used at numerous facilities to remove TCE from groundwater. Both use standard-design equipment which can be rented or purchased, with a relatively short lead time for delivery. Therefore, these two alternatives are technically acceptable.

Information from major suppliers of H_2O_2 and $KMnO_4$ and from laboratory studies indicates that these chemical oxidants can remove and destroy TCE to easily meet the MWCC discharge limits. However, the chemical suppliers contacted by RMT were not aware of any significant full-scale facilities using H_2O_2 or $KMnO_4$ to remove TCE from groundwater. Therefore, additional investigations (including bench-scale treatability studies to determine factors such as chemical dosage and reaction time required) would be needed before the size and type of pretreatment equipment required could be established. There is insufficient time available to

perform those additional investigations before the pretreatment system equipment must be purchased or rented in order to have the system available for operation at the start of Phase I. O_3 (unlike H_2O_2 and $KMnO_4$) has been used in full-scale systems to destroy TCE. Sufficient information is presently available to design and purchase the O_3 generation equipment and other pretreatment system equipment. However, the size of the O_3 generation equipment required is large enough so that "off-the-shelf" equipment for rental or purchase and delivery is not available. Therefore, the O_3 generation equipment would need to be purchased, with lead times for delivery in the range of 8 to 12 weeks. Additional time would be required to specify the O_3 generation equipment, receive bids, and select the supplier before purchase. Additional time would also be required to install the system at the site after delivery. Therefore, sufficient time is not available to have the O_3 system ready for operation at the start of Phase I. Based on these factors, chemical oxidation by H_2O_2, $KMnO_4$, or O_3 is not technically acceptable for the Phase I system.

3.3 Economics

Based on the design concepts presented in Subsection 2.3, and the equipment design and operating information in Appendix B, costs were developed for Alternative 1 (air stripping with vapor-phase GAC) and Alternative 2 (liquid-phase GAC). These costs are summarized in Table 3-1.

The costs for both alternatives include the following:

- Initial system construction, including the following:
  - Mobilization
  - Construction on-site, including new piping from the well AT-3A discharge pipe to the inlet of the new pretreatment system, erection of the system, and construction of a new building to house the pretreatment equipment.
  - Initial fill of activated carbon (5,000 lb. for the single vapor-phase GAC unit versus a total of 40,000 lb. for the two liquid-phase GAC vessels).

TABLE 3-1

COMPARISON OF COSTS FOR PRETREATMENT ALTERNATIVES[1][2]

	Alternative 1 (Air Stripping w/ Vapor-Phase GAC)	Alternative 2 (Liquid-Phase GAC)
1. Initial Construction Costs:		
1.1 Mobilization	$ 3	$ 4
1.2 System Construction	$ 21	$ 37
1.3 Activated Carbon (Initial Fill)	$ 7	$ 48
Subtotal	$ 31	$ 89
2. Operation and Maintenance (O&M) Costs[3]:		
2.1 Equipment Rental	$ 84	$126
2.2 Activated Carbon Regeneration	$159	$650
2.3 Electric Power	$ 9	$ 4
2.4 Packing Maintenance	$ 12	$ 0
Subtotal	$264	$780
3. Final Costs:		
3.1 Activated Carbon Disposal (final load)	$ 5	$ 18
3.2 Demobilization	$ 2	$ 3
Subtotal	$ 7	$ 21
4. Total Cost[4]:	$302	$890
5. Differential Cost[4]:	Base	+$588

NOTES:

(1) See text and Appendix B for details of the assumptions upon which these costs are based.

(2) All costs are expressed in thousands ($1,000's).

(3) Over a 3-year operating life of the system.

(4) Costs are differential costs developed only for determining the most economical pretreatment alternative. Costs which are common to both alternatives are not included.

- O&M costs for the system, over a 3-year operating life of the system, including the following:
  - Equipment rental. For Alternative 1, this includes the air stripper column and packing, column chemical cleaning pump, air blower, dehumidifier, vapor-phase GAC unit, and associated system control panel. For Alternative 2, this includes the two liquid-phase GAC vessels and associated interconnecting piping.
  - Activated carbon regeneration, including costs for laboratory analysis of spent carbon, on-site exchange of spent carbon, transportation of carbon to and from an off-site permitted regeneration facility, carbon regeneration, and make-up carbon.
  - Electric power. For Alternative 1, costs include power for the air blower and dehumidifier. For Alternative 2, costs include the differential power for well pump AT-3A to overcome the additional pressure drop through the liquid-phase GAC vessels and piping.
  - Chemical cleaning of the air stripper packing to remove deposits which reduce system performance. It was assumed that this cleaning would be performed for 1 day every 3 months.
- Final costs after Phase I is completed, including the following:
  - Final disposal of the activated carbon remaining in the vapor-phase GAC unit or the two liquid-phase GAC vessels at the end of Phase I. Costs include transportation of carbon to an off-site permitted facility, and disposal or regeneration of the carbon.
  - Demobilization, including removal of the rental equipment.

The costs for air stripping with vapor-phase GAC (Alternative 1) would be approximately $0.6 million less than for liquid-phase GAC (Alternative 2).

Note that the costs in Table 3-1 are differential costs for the two systems, and do not include the following:

- Indirect costs (e.g., for engineering, legal/administrative, construction management, or regulatory activities associated with the Phase I system).
- Costs which would be similar for both alternatives. These include costs for system O&M labor, effluent monitoring, supervision, and demolition of the remaining system components after the rental equipment has been removed.

The indirect and similar costs for the two alternatives are expected to be small compared to the total costs in Table 3-1. Therefore, these excluded costs would not affect the relative ranking of the two alternatives.

Because the costs in Table 3-1 are differential costs, and do not include the costs described above, the costs in Table 3-1 should only be used for selection of a pretreatment alternative.

A detailed economic evaluation of chemical oxidation (Alternative 3) was not performed because this alternative was determined to be not technically acceptable. However, a brief evaluation of costs was made. This evaluation indicated that the total costs for chemical oxidation would be substantially higher than the costs for air stripping with vapor-phase GAC.

3.4 Other Criteria

Criteria other than technical acceptability and economics were used to evaluate the pretreatment alternatives. The evaluation of Alternatives 1 and 2 for these criteria is summarized in Table 3-2.

3.5 Summary and Conclusions

Based on the technical acceptability, economic, and other criteria evaluated, Alternative 1 (air stripping with vapor-phase GAC) would be the most cost-effective alternative for pretreatment to meet the MWCC limits during Phase I. Although this alternative will require somewhat more operation and maintenance and more system downtime than Alternative 2, the total cost for Alternative 1 would be approximately $0.6 million less than that for Alternative 2 over an expected 3-year life of the Phase I system.

3.6 Considerations for Phase II

An evaluation was also made to determine whether a Phase I air stripping system could be incorporated into the design of the Phase II system, thus saving construction costs for

TABLE 3-2

COMPARISON OF OTHER EVALUATION CRITERIA

Alternative 1 - Air Stripping with Vapor-Phase GAC

Advantages:

- Can adjust air-to-liquid ratio to limit amount of VOC removal to meet the level necessary to meet discharge limits. This provides operating flexibility to adjust to changes in untreated groundwater quality, and to minimize costs for GAC regeneration.
- Provides full-scale experience for design of both the air stripping and the exhaust air treatment equipment to be used in the Phase II groundwater treatment system.
- Air stripper, building, and some system piping are already installed.

Disadvantages:

- Requires two separate buildings (i.e., the existing air stripper building and a new building to house the vapor-phase GAC unit).
- Additional electric power wiring required for dehumidifier and for heating, lighting, and ventilation of new building to house the vapor-phase GAC unit.
- More operating labor required for monitoring and adjusting system to achieve desired performance.
- No spare treatment equipment. Therefore, there is more potential for unexpected downtime due to equipment failure.
- More system downtime and labor for regular maintenance, including periodic cleaning of column packing and change-out of vapor-phase GAC unit.
- Must shut down well AT-3A whenever any part of pretreatment equipment is down. However, other wells can continue to run, and discharge directly to sanitary sewer without pretreatment.
- May have to pump effluent to sanitary sewer.
- Changes in flow rate or TCE concentration in the untreated groundwater from well AT-3A may require airflow rate adjustments.

TABLE 3-2 (CONTINUED) COMPARISON OF OTHER EVALUATION CRITERIA
Alternative 2 - Liquid-Phase GAC
Advantages: • No equipment or machinery - no moving parts. • Virtually no treatment downtime. • No scaling and related maintenance problems. • Minimal operating labor for monitoring system performance. • Minimal labor required for change-out of GAC in vessels. • No electric power or controls required. • Slightly shorter delivery and installation time than Alternative 1. • Would not have to pump effluent into sanitary sewer. However, may require that well pump AT-3A be replaced with a pump having a higher head. • Backup equipment provided by two GAC vessels in series. Either vessel can be used alone for a period of time and still achieve the MWCC limits. • Single enclosure (building) required. • Treatment efficiency not affected by changes in flow rate or untreated groundwater quality over the expected range of operating conditions for Phase I.
Disadvantages: • Impractical to control VOC removal efficiency, so it would provide virtually 100% VOC removal. This would result in "overtreatment" compared to MWCC discharge limits. • Would not provide useful information for design or operation of the Phase II treatment system.

Phase II. This evaluation determined that it could not cost-effectively be incorporated into the Phase II system for the following reasons:

- The Phase I system would not have sufficient hydraulic capacity for the increased flow rate for Phase II (250 gpm for Phase I versus 650 gpm required for Phase II).
- The Phase I system TCE removal efficiency would not be sufficient for Phase II (95% removal for Phase I versus 99.96% removal expected to be needed for Phase II).
- The Phase I air emission control equipment (including the vapor-phase GAC units) would not have sufficient capacity for handling the increased air emissions from the Phase II air stripper. The annual quantity of vapor-phase GAC to be regenerated for Phase II is expected to be approximately 2-1/2-times that for Phase I.

Therefore, while the pretreatment system installed for Phase I will provide information useful for design and operation of the Phase II system, the actual Phase I equipment will likely not be used in the Phase II system. Therefore, consideration should be given to renting, rather than purchasing, the Phase I equipment.

Section 4

RECOMMENDATIONS

The following recommendations are based on the information in this report, assuming that pretreatment is needed to meet the MWCC limits for discharge to the sanitary sewer during Phase I:

1. The pretreatment system should be designed to pretreat the groundwater from well AT-3A, and then mix the pretreated water with the groundwater from wells AT-1A, AT-2, and AT-4 before discharge to the sanitary sewer.

2. The pretreatment system should be designed based on the following performance requirements:

   - Flow rate = 250 gpm
   - TCE concentration (influent) = 31 mg/L
   - TCE concentration (effluent) = 1.5 mg/L

3. The pretreatment system should include an air stripping system with vapor-phase GAC (to meet the MPCA air emission standards). System components should include the following:

   - An air stripping system, including the following:

     - Air stripping column, with packing
     - Air blower
     - Chemical cleaning pump
     - Control panel for operating the air blower and chemical cleaning pump

     (**Note**: The air stripping column and building presently at the site are expected to be adequate to meet the performance requirements in Recommendation #2 above. However, the capacity of the existing air blower is likely to be too high; the blower should be replaced with an air blower which more nearly matches the airflow rate requirement. In addition, a chemical cleaning pump and accessories should be added for periodic chemical cleaning of the air stripper column.)

   - A vapor-phase GAC system, including the following:

     - An electric dehumidifier
     - A vapor-phase GAC unit with approximately 5,000 pounds of GAC.

- Piping, ductwork, and electrical wiring for a complete system. Outdoor piping and ductwork should be insulated and heat-traced to allow year-round operation.

- A new building to house the vapor-phase GAC unit. The building should be located adjacent to the existing air stripper building, and include heating, ventilation, and lighting appropriate for year-round operation of the vapor-phase GAC unit. The building and ductwork should also be designed to allow easy removal of the spent vapor-phase GAC unit from the building for loading onto a truck for off-site regeneration, and replacement with a unit with regenerated GAC.

4. Equipment for system described in Recommendation #3 could be purchased or rented from Carbonair Services (the supplier of the existing air stripping system at the site). Specific equipment proposed by Carbonair to meet the requirements of Recommendations #2 and #3 above are identified in Appendix B. It is likely that this system would not have sufficient capacity to meet the expected Phase II requirements. Therefore, it is recommended that the equipment be rented.

5. System hydraulics should be checked to confirm that the well AT-3A pump has sufficient head to pump 250 gpm to the top of the air stripping column. If the well AT-3A pump does not have sufficient head, it should be replaced by a pump with sufficient head at this capacity.

6. System hydraulics should be checked to confirm that the pretreated effluent can flow by gravity from the air stripping column sump to the sanitary sewer. If it cannot, a discharge pump (with associated instrumentation and controls) should be included as part of the air stripping system to pump the pretreated effluent into the sanitary sewer. The new building for the GAC unit should have sufficient space to house a pump for the air stripping column effluent, if pumping of the effluent is determined to be necessary during design or from actual operation.

7. The design should include a location for monitoring the combined discharge to the sanitary sewer to confirm compliance with the MWCC discharge limits.

APPENDIX A

MPCA AIR STRIPPER SCREENING EVALUATION FORM

DRAFT 7/8/91

Air Stripper Screening Evaluation Form

Site Name: NIROP	Responsible Party Contact	MPCA Project Mgr.:
Address: Fridley, Minnesota	Name: Eric Gredell	Division/Section:
	Affiliation: RMT, Inc.	Form completed by:
	Phone #: (608) 831-4444	Date completed:

Contaminant (CAS #)	A Contaminant Concentration (IC) (µg/liter)	B Air stripper influent flow rate (IFR) (liters/sec)	C Removal Factor (RF)	D Emission Rate (ER) (µg/sec)	E Significant Emission Rate (SER) (µg/sec)	F Is ER ≥ SER? (yes/no)
benzene (71-43-2)					4603	
chloroform (67-66-3)					1649	
dichlorodifluoromethane (75-71-8)					767165	
1,1-dichloroethane (75-34-3)	16	15.77*	1.0	300	1917913	No
1,2-dichloroethane (107-06-2)					1458	
1,1-dichloroethylene (75-35-4)					767	
1,2-dichloroethylene (540-59-0)	1,000	15.77*	1.0	15,800	2168681	No
dichlorofluoromethane (75-43-4)					114861	
ethylbenzene (100-41-4)					497704	
methylene chloride (75-09-2)					80552	
1,1,2,2-tetrachloroethane (79-34-5)					652	
tetrachloroethylene (127-18-4)	120	15.77*	1.0	1,900	65209	No
1,1,1-trichloroethane (71-55-6)					3835827	
1,1,2-trichloroethane (79-00-5)					2417	
trichloroethylene (79-01-6)	31,000	15.77*	0.968	473,200	22631	Yes
trichlorofluoromethane (75-69-4)					2685079	
1,1,2 trichlorotrifluoroethane (76-13-1)					20975770	
toluene (108-88-3)					429835	
vinyl chloride (75-01-4)					9206	
xylene [mixed] (1330-20-7)					497704	
Other[1]						

* 250 gal/min

1. Contact MPCA Division of Air Quality Staff (296-7757) regarding any contaminants which are not on this list.

APPENDIX B

AIR STRIPPING SYSTEM INFORMATION

CARBONAIR™

P.O. Box 5117 · Hopkins, MN 55343-1117
(612) 425-2992 FAX (612) 425-6882

March 12, 1992

Mr. Robert Chiesa
RMT, Inc.
P. O. Box 8923
Madison, WI 53708-8923

Dear Bob:

We have worked closely under your direction these past two weeks, analyzing the various options for extended temporary treatment at the Naval Industrial Reserve Ordnance Plant (NIROP). We have looked at three flow rates, two performance levels, and two processes.

After the discussion with you Tuesday, I have prepared a detailed cost estimate on the two best approaches: (1) packed-column airstripper and (2) liquid-phase carbon.

System 1 Modification of Existing Airstripper

This system would include the repiping of the 4' diameter airstripper now on site so that it will treat well AT-3A only. In addition, vapor-phase carbon will be added to treat the off-gas from the stripper in order to meet state air emission requirements.

Considerations with this system include humidity control of the off-gas, electrical connection with the well control, winterization of the vapor equipment, and maintenance of the airstripper packing. Carbon consumption for this system will be as shown on Sheet #1.

The cost of this equipment is also noted on Sheet #1. Theses costs assume that a single contract, lump sum, would be let to Carbonair Services. Employees of Carbonair are non-union and would perform much of the work with some sub-contract assistance. All field service Carbonair employees have 40 hours of hazardous waste site training and are medically monitored. Compensation meets the requirements of the Davis-Bacon Act.

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System 2 Liquid-Phase Adsorption

This system would replace the existing system with two pressure type carbon adsorbers treating the water. This system is much simpler, having only one stage of operation, no electrical control, and little maintenance. The system is considerably larger than the modifications required to the airstripper, however, and carbon consumption is higher.

Details are shown on Sheet #2.

Thank you for considering Carbonair. Let me know if I can be of further assistance.

Very truly yours,

Jeffrey B. Hill
President

JBH:cb:290

Option 1: Airstripping with Vapor-Phase Carbon

Airstripping

Well	AT-3A
Design Flow	250 gpm
Design Compound	trichloroethylene
Henry's Constant	0.3
Recommended Airstripper	AS 250
Column Diameter	4 ft.
Packing Height	20 ft.
Packing Type	3½" Jaeger Tripack

Vapor-Phase Carbon Adsorption

Recommended Adsorber	One GPC 48
Design Compound	trichloroethylene
Freundlich Parameters	K = 2400*, 1/n = 0.5
Adsorber Dimension	6 ft. 8 in.
Amount of Carbon	5000 lbs.
Expected Change-Out Frequency	59 days
Carbon Loading	1046 mg/g

Cost

Construction, including piping, electrical control interconnection with well, electrical power to duct heater, pad, building, winterization, crane and freight	$ 21,000
Equipment Lease; airstripper, insulated ducting, humidity control, carbon adsorber:	
Mobilization	$ 2,500
36-month rental	84,000
Activated Carbon, initial fill	$ 7,500
Carbon exchanges for 36 months	159,000
Carbon disposal, final	5,000

The estimates of carbon costs include project management, analytical work, inbound freight for fresh carbon, outbound freight for spent carbon as hazardous waste, reactivation at a permitted facility, make-up carbon and local site work during the exchange. On rental contracts, a second vessel is provided by Carbonair at no charge during the replacement.

Demobilization	$ 2,000
Electricity, 36 months	9,000
Packing maintenance, 36 months	12,000
Total, 36 Months	$302,000

$$\left(\frac{\text{u mole}}{\text{g}} \Big/ \frac{\text{L}}{\text{u mole}}\right)^{1/n}$$

CARBONAIR

Naval Industrial Reserve Ordnance Plant
Fridley, Minnesota
Sheet #2

Liquid-~~Vapor~~-Phase Carbon Adsorption

Recommended Adsorber	(2) PC 78s in series
Design Compound	trichloroethylene
Freundlich Parameters	K = 100, 1/n = 0.5
Design Flow	250 gpm
Adsorber Diameter	10 ft.
Amount of Carbon	20,000 lbs. each vessel
Expected Change-Out Frequency	44 days
Carbon Loading	195 mg/g

Cost

Construction, including piping, building electrical, pad, building, winterization, crane, erection and freight	$ 37,000
Equipment Lease:	
Mobilization	$ 3,500
36-month rental	126,000
Activated Carbon, initial fill	$ 48,000
Carbon exchanges for 36 months	650,000
Carbon disposal, final	18,000

The estimates of carbon costs include project management, analytical work, inbound freight for fresh carbon, outbound freight for spent carbon as hazardous waste, reactivation at a permitted facility, make-up carbon and local site work during the exchange.

Demobilization	$ 3,000
Electricity, 36 months	4,500
Total, 36 months	$890,000

AS 250 Packed Column Airstripper

The AS 250 Packed Column Airstripper by Carbonair offers the highest performance available in a maximum-flow airstripper. Skid-mounting of the AS 250 enables the unit to be wired and plumbed before shipment, requiring only electrical and influent/effluent connections for quick mobilization and installation. Carbonair's unique skid-mounted design together with the exceptionally durable FRP and welded-steel construction make the AS 250 suitable for all emergency response remediations, pilot tests and full-scale treatment systems.

Carbonair packed column airstrippers are available with a variety of options according to purchaser's specifications.

OPTIONS

Optional materials of construction.

Guy wire kit.

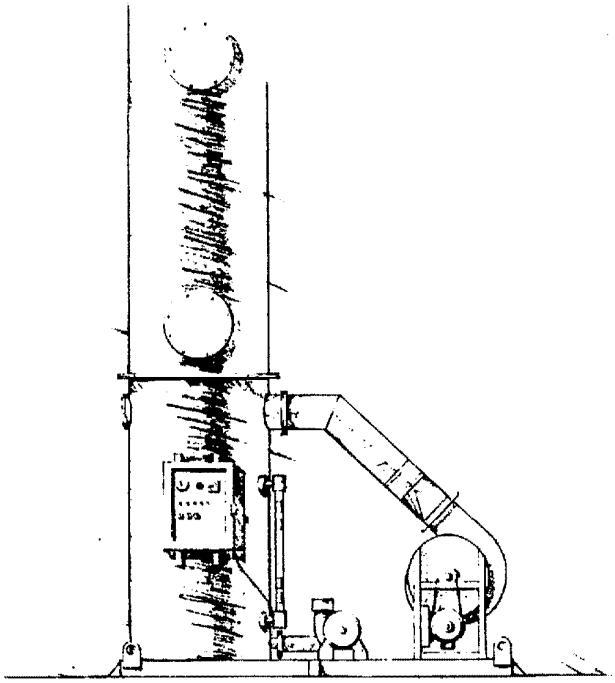
Additional 10-ft. packing sections.

Discharge pump, level controls, control panel.

Air-flow dampers.

Optional blowers.

Off-gas treatment ducting kit.



FEATURES

Skid-mounted design enables quick field mobilization and installation.

Epoxy-coated carbon steel sump and skid provide superior strength and high chemical resistance. Coating conforms to AWWA D 102 Inside System No. 1 and AWWA C 210-84 for immersion service, and has been tested and approved in accordance with FDA Regulations, Title 21, Section 175,300. It also meets U.S. EPA regulations for VOCs, as well as the abrasion resistance criteria established by ASTM D 4060.

Corrosion-resistant FRP and PVC internals provide exceptional durability.

15 horse-power blower ensures optimal air-to-water ratios at maximum liquid loadings.

Large access ports make packing exchanges and internal maintenance quick and easy.

3½-inch polypropylene Jaeger Tri-pack tower packing ensures optimum performance.

SPECIFICATIONS

DIMENSIONS	4 ft. diameter x 22 ft. 4 in. overall height (1.2 m x 6.9 m)
LIQUID FLOW	25-875 gpm (95-3,325 L/min)
AIR FLOW	7,900 cfm maximum (237 m^3/min)
FITTINGS	See drawing #113238
BLOWER	15 h.p., 240/480v, 3-phase, ODP
PACKING VOLUME	113 $ft.^3$ 3½-in. Jaeger Tri-pack per section (3.4 m^3)
EMPTY WEIGHT	3,835 lbs. (1,725 kg)
OPERATING WEIGHT	12,000 lbs. (5,400 kg)

GPC 48 Gas Phase Carbon Adsorber

The GPC 48 Gas Phase Carbon Adsorber by Carbonair is one of the most high performing gas phase carbon adsorbers of its size. Its welded-steel construction provides exceptional strength and durability, while the skid mounting and forklift compatibility of the unit make transportation and installation quick and trouble-free. The interior is double-coated with a corrosion-resistant epoxy polyamide ideal for the corrosive and abrasive conditions of gas phase service. The unit's superior design and remarkable portability make the GPC 48 suitable for any gas phase application, including airstripper and soil-venting off-gas treatment.

Carbonair adsorbers are available with a variety of options according to purchaser's specifications.

OPTIONS

Optional materials of construction.

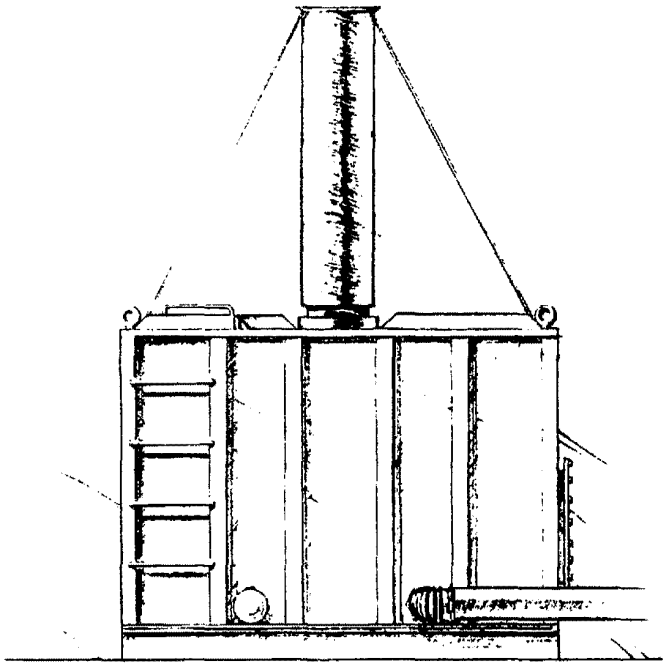
Blower(s) and controls.

Humidity control.

Influent/effluent ducting.

Additional sampling couplings and valves.

Discharge stacks.



FEATURES

Skid-mounted, welded-steel construction provides superior durability and convenience in transportation and handling.

Interior epoxy coating, stainless steel and FRP internals offer extraordinary chemical resistance. Coating conforms to AWWA D 102 Inside System No. 1 and AWWA C 210-84 for immersion service, and has been tested and approved in accordance with FDA Regulations, Title 21, Section 175,300. It also meets U.S. EPA regulations for VOCs, as well as the abrasion resistance criteria established by ASTM D 4060.

5,000-pound carbon capacity provides extended bed life.

8-inch inlet ports enable maximum carbon utilization.

16-inch discharge stacks promote optimum discharge of treated effluent.

Easy-access, stainless steel screen on FRP grate ensures full drainage of condensation.

Built-in sample couplings afford easy sampling of both the influent and effluent streams.

SPECIFICATIONS

DIMENSIONS	8 ft. 6 in. length x 6 ft. 6 in. width x 6 ft. 3¼ in. overall height (2.6 m x 2.0 m x 1.9 m)
BED AREA	48 ft.^{2} (4.5 m^2)
FLOW RANGE	480-4,800 cfm (14-140 m^3/min)
CARBON CAPACITY	5,000 lbs. (2,250 kg)
FITTINGS	Four (4) 8-in. quick-connect air inlet ports One (1) 16-in. quick-disconnect off-gas stacks with weather shields One (1) ¾-in. condensation drain Two (2) ¾-in. full-coupling sample ports
EMPTY WEIGHT	3,000 lbs. (1,400 kg)
OPERATING WEIGHT	10,000 lbs. (4,500 kg)

PC 78 Liquid Phase Pressure Carbon Adsorber

With a carbon capacity of 20,000 pounds, the PC 78 Pressure Carbon Adsorber by Carbonair is one of the largest and most high-performing single-bed adsorbers available. Constructed of welded steel for exceptional durability, the PC 78 has demonstrated proven reliability in municipal, industrial and potable applications. The conical-bottom collection system enables full use of the carbon bed, while the carbon-slurry piping provides for complete removal of spent carbon. The interior is double-coated with a corrosion-resistant epoxy tested and approved in accordance with AWWA, FDA and EPA regulations.

Carbonair carbon adsorbers are designed and manufactured in accordance with the engineering standards set forth by the American Society of Mechanical Engineers. Each PC 78 adsorber is individually inspected and stamped by an ASME authorized inspector. Carbonair adsorbers are available with a variety of options according to purchaser's specifications.

OPTIONS

Optional materials of construction.

Decon/3 piping package with quick connectors.

Influent/effluent quick connect kit.

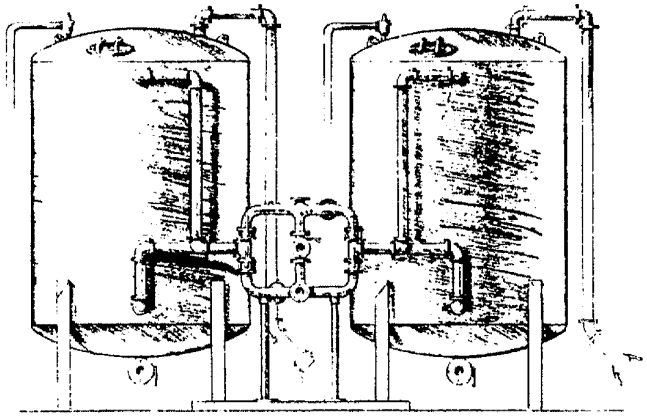
Influent/effluent sampling and pressure indicator kits.

Internal sampling kit.

Non-aerating sample ports.

Flow instrumentation, including meters, gauges and valves.

Carbon disposal and replacement program for full compliance with environmental regulations.



FEATURES

Welded-steel construction provides superior toughness and durability.

Interior epoxy coating and PVC or stainless steel internals offer high chemical resistance. Coating conforms to AWWA D 102 Inside System No. 1 and AWWA C 210-84 for immersion service, and has been tested and approved in accordance with FDA Regulations, Title 21, Section 175,300. It also meets U.S. EPA regulations for VOCs, as well as the abrasion resistance criteria established by ASTM D 4060.

20,000-pound carbon capacity provides extended bed life at a full range of flow rates.

Conical-bottom collection system enables total carbon performance and greater overall operating efficiency.

Large carbon-slurry lines permit fast removal of spent carbon.

Four access ports afford easy inspection and enable trouble-free maintenance.

SPECIFICATIONS

DIMENSIONS	10 ft. diameter x 12 ft. side sheet (3.0 m x 3.7 m) 18 ft. 6 in. overall height (5.6 m)
BED AREA	78.5 ft.^{2} (7.3 m^2)
FLOW RANGE	40-550 gpm (150-2,100 L/min)
CARBON CAPACITY	20,000 lbs. (9,000 kg)
FITTINGS	Two (2) 6-in. influent/effluent flanges Four (4) 12-in. x 16-in. access ports One (1) 4-in. carbon slurry flange
DESIGN PRESSURE	80 psi, ASME inspected and stamped (5.5 bar)
EMPTY WEIGHT	10,900 lbs. (4,900 kg)
OPERATING WEIGHT	67,900 lbs. (30,800 kg)

CARBONAIR
Creative Solutions to Environmental Problems

8640 Monticello Lane
Maple Grove, MN 55369-4547
612-425-2992
Fax 612-425-6882

Carbonair's liquid and gas adsorption units and packed column airstrippers are fully modular and can be designed and installed to individual specifications for any size system. These units and other Carbonair environmental treatment components are fully interconnecting for an integrated approach to the treatment of water and air.

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