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Section 4
Detailed Analysis of Media-Specific Remedial Alternatives

4.1 Introduction

The technology-specific remedial action alternatives that remained after the initial screening in Section 3 are combined in this section into overall remedial alternatives addressing the two media of concern at the Fischer and Porter site: contaminated soil and contaminated groundwater. These overall medium-specific remedial action alternatives are then evaluated against nine criteria defined in the NCP. The first seven criteria are addressed in this FS. The last two criteria will be addressed by EPA in the ROD for the site. The nine criteria are:

- Protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

As previously noted, to provide maximum flexibility in selecting a remedial action alternative for contaminated soil independent of the alternatives selected for contaminated groundwater, the remedial action alternative for soil are evaluated separately from the remedial action alternatives for groundwater.

4.2 Evaluation Criteria

The detailed alternative analysis is the method for assembling and evaluating technical and policy considerations to develop the rationale for selecting a remedy for a site. The following paragraphs describe each of the nine criteria.

4.2.1 Overall Protection of Human Health and the Environment

This evaluation criterion is an assessment of whether each alternative achieves and maintains adequate protection of human health and the environment. The overall appraisal of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and

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compliance with ARARs. Another consideration is the statutory preference for onsite remedial actions.

4.2.2 Compliance with ARARs

This evaluation criterion is used to determine whether an alternative will meet federal, state, and local ARARs that have been previously identified. Significant ARARs are identified for each alternative, and descriptions on how they are met are given. A discussion of the compliance of each alternative with chemical-, location-, and action-specific ARARs is included.

Chemical-specific ARARs for each affected media include federal maximum contaminant levels (MCLs) for groundwater, limits established by PADEP for discharges to surface water, and state air pollutant emission limits (or PADEP *de minimis* levels). In addition, the preliminary remediation goals (PRGs) for soil and groundwater were determined as the limits that remedial alternatives should attain. Tables 2-2 through 2-4 summarize the chemical-specific, location-specific, and action-specific ARARs for the affected media. Table 2-7 summarizes the selected PRGs for contaminated soil and groundwater at the site.

4.2.3 Long-Term Effectiveness and Permanence

Under this criterion, the results of a remedial action alternative are evaluated in terms of the risk remaining at the site after response objectives have been met. The primary focus of the evaluation is the extent and effectiveness of the actions or controls that may be required to manage the risk posed by treatment residuals or untreated wastes. Factors to be considered and addressed are magnitude of residual risk, adequacy of controls, and reliability of controls. Magnitude of residual risk is the assessment of the risk remaining from untreated waste or treatment residuals after remediation. Adequacy and reliability of controls is the evaluation of the controls that can be used to manage treatment residuals or untreated wastes that remain at the facility. The evaluation may include an assessment of containment systems and institutional controls to determine whether they are sufficient to maintain exposure to human and environmental receptors within protective levels.

4.2.4 Reduction of Toxicity, Mobility, and Volume

This evaluation criterion addresses the statutory preference for selecting remedial actions that use, as their principal element, technologies that permanently treat and significantly reduce the toxicity, mobility, or volume of the hazardous substances. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic chemicals, reduction of the total mass of toxic chemicals, irreversible reduction of contaminant mobility, or reduction of total volume of contaminated media. When evaluating this criterion, an assessment is made as to whether treatment is used to reduce principal threats, including the extent to which toxicity, mobility, or volume are reduced either separately or in combination with one another. Critical factors include the following:

- Treatment processes used by the remedy
- Amount of hazardous materials to be treated
- Degree of expected reduction in toxicity, mobility, or volume

- Degree to which the treatment would be irreversible
- Type and quantity of treatment residuals that would remain following treatment
- Whether the alternative would satisfy the statutory preference for treatment as a principal element

4.2.5 Short-Term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial action (RA) objectives are met. Alternatives would be evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The following factors would be addressed for each alternative:

- Protection of the community during remedial actions
- Protection of workers during remedial actions
- Environmental impact during remedial actions
- Amount of time to achieve remedial objectives
- Air pollutant emissions

4.2.6 Implementability

The implementability criterion addresses the technical and administrative feasibility of executing an alternative and the availability of various services and materials required during its implementation. Technical feasibility includes construction, operation, reliability of technology, ease of undertaking additional remedial action, and monitoring. Administrative feasibility refers to the activities needed to coordinate with other offices and agencies (local permits, for example). Availability of services and materials includes availability of adequate off-facility treatment, storage capacity, and disposal services; necessary equipment and specialists; services and materials; and prospective technologies.

4.2.7 Cost

For the detailed cost analysis of alternatives, the expenditures required to complete each measure are estimated both in terms of capital and annual operation and maintenance (O&M) costs. Given these values, a present-worth calculation for each alternative is made for comparison.

Capital costs consist of direct and indirect costs. Direct costs include the cost of construction, equipment, land and site development, treatment, transportation, and disposal. Indirect costs include engineering expenses, license or permit costs, and contingency allowances.

Annual O&M costs are the post-construction costs required for the continued effectiveness of the remedial action. Components of annual O&M cost include the cost of operating labor, maintenance materials and labor, auxiliary materials and energy, residue disposal, purchased services, administration, insurance, taxes, licensing, maintenance reserve and contingency funds, rehabilitation, monitoring, and periodic site reviews.

Expenditures that occur over different periods were analyzed using present-worth, which discounts all future costs to a common base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 5 percent before taxes and after inflation, cost estimates in the planning years in constant dollars, and a 30-year period of performance.

The cost estimates for this section are provided to an accuracy of +50 percent to -30 percent. The alternative cost estimates are in 1997 dollars and are based on conceptual design from information available at the time of this study. The actual cost of the project would depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. Most of these factors are not expected to affect the relative cost differences between alternatives.

4.2.8 State Acceptance

This assessment evaluates the technical and administrative issues and concerns the state may have regarding each of the alternatives. This criterion is not discussed in this report, but would be addressed in the ROD once comments on the RI/FS have been received.

4.2.9 Community Acceptance

This assessment evaluates the issues and concerns the public may have regarding each of the alternatives. As with state acceptance, this criterion is not discussed in this report, but would be addressed in the ROD once comments on the RI/FS have been received.

4.3 Analysis of Soil Alternatives

In Section 3, three technology-based remedial action alternatives, including the no further action alternative, were developed and screened on the basis of effectiveness, implementability, and cost. All three alternatives were retained for detailed evaluation. In this section, these three alternatives are grouped into the following three overall alternatives for contaminated soil at the site:

- Alternative 1—No Action
- Alternative 2—Institutional Controls
- Alternative 3—Institutional Controls and Capping

The components of these three overall soil remedial alternative are described below followed by an evaluation of each alternative against the seven criteria discussed above. The components of the three overall soil alternatives, the results of the performed detailed evaluation for each alternative, and the costs of implementing each alternative are summarized in Tables 4-1, 4-2, and 4-3, respectively.

4.3.1 Alternative 1—No Action

Under this alternative, no additional controls or remedial action would take place. Soil containing PAHs and PCBs above PRGs would remain in place with the majority of the soil

Table 4-1 Components of Soil Remedial Alternatives Fischer and Porter Site			
Components	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Institutional Controls and Capping
S-1—No Action	X		
S-2—Institutional Controls		X	X
S-2—Capping			X

Table 4-2 Summary of Soil Remedial Alternatives Evaluation Fischer and Porter Site			
Evaluation Criteria	**Alternative 1 No Action**	**Alternative 2 Institutional Controls**	**Alternative 3 Institutional Controls and Capping**
Overall Protection of Human Health and the Environment	Would not provide protection of public health or the environment and is considered not to be responsible to the remedial action objectives established for the site.	Would provide protection by prohibiting uncontrolled exposures to chemicals left in the soil. This alternative is considered to be partially responsive to the remedial action objectives for the site.	Would provide protection by prohibiting uncontrolled exposures to chemicals left in the soil as well as restricting the exposures by providing an asphalt cap. In addition to preventing exposures, the cap will minimize rainfall infiltration and leaching of PAHs and PCBs to groundwater although the results of the Phase II RI have indicated that this is not a significant pathway. This alternative is considered to be responsive to the remedial action objectives for the site.
Compliance with ARARs	Would not achieve PRGs. There are no chemical-specific, action-specific, or location-specific ARARs applicable to this alternative.	Would not achieve PRGs. There are no chemical-specific, action-specific, or location-specific ARARs applicable to this alternative.	Would not achieve PRGs. There are no chemical-specific, action-specific, or location-specific ARARs applicable to this alternative.
Long-Term Effectiveness and Performance	Would not be effective over the long-term. Monitoring is required to determine if chemicals have migrated from soil to groundwater.	Would be effective over the long-term by prohibiting uncontrolled exposures to chemicals left in the soil. Monitoring is required to determine if chemicals have migrated from soil to groundwater. Effectiveness depends on the enforcement of the deed restrictions. Future residential use of the site would be prohibited.	Would be effective over the long-term by limiting the potential for exposures to the contaminated soil by using a cap and deed restrictions. Monitoring is required to determine if chemicals have migrated from soil to groundwater. Effectiveness depends on cap maintenance and the enforcement of deed restrictions. Future residential use of the site would not be prohibited.
Reduction of Toxicity, Mobility, and Volume	Would not achieve any immediate reduction in chemical toxicity, mobility, or volume.	Would not achieve any immediate reduction in chemical toxicity, mobility, or volume.	Would not achieve any immediate reduction in chemical toxicity, mobility, or volume.

Table 4-2
Summary of Soil Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Institutional Controls and Capping	
Short-Term Effectiveness	There are no short-term risks associated with this alternative as no remedial action will be undertaken.	There are no short-term risks associated with this alternative as no remedial action will be undertaken.	The short-term risks associated with this alternative can be minimized by using engineering, air monitoring, and personal protection controls.	
Implementability	Very easy to implement. Administrative resources are required to perform the 5-year site reviews.	Administrative resources are required to enforce deed restrictions and perform the 5-year site reviews.	Services and materials for the design, construction, and maintenance of the cap are readily available. Administrative resources are required to maintain the cap, enforce the deed restrictions, and perform the 5-year site reviews.	
Cost (Present Worth)	$14,000	$14,000	$312,000 Future Residential Site Use	$148,000 Current Site Use

Table 4-3
Summary of Present-Worth Costs for Soil Remedial Alternatives
Fischer and Porter Site

Components	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Institutional Controls and Capping	
S-1—No Action	$14,000*	—	—	
S-2—Institutional Controls	—	$14,000[1]	$14,000[1]	
S-3—Capping (Future Residential Site Use)	—	—	$312,000	
S-3—Capping (Current Site Use)	—	—	$148,000	
Total	$14,000	$14,000	$326,000 Future Residential Site Use	$162,000 Current Site Use

*This is the cost of the 5-year site reviews.
Refer to Table 3-7 for capital and O&M costs.

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located beneath the existing pavement and the remainder in uncovered areas. Because this alternative results in contaminated media remaining on the site, CERCLA, as amended by SARA (1986), requires that the site be reviewed every 5 years. Alternative 1 serves as the baseline against which other alternatives are evaluated.

4.3.1.1 Overall Protection of Human Health and the Environment

This alternative would entail no removal, containment, or treatment of contaminated soil at the site. Therefore, this alternative would not contribute to protection of human health and the environment because there would not be any immediate reduction in risk by limiting exposures to contaminated soil or by reducing the toxicity, mobility, or volume of the chemicals found in the soil. Natural degradation, adsorption, and leaching of chemicals to groundwater would take many years to reduce chemical concentrations to the selected PRGs Therefore, the PAHs and PCBs would persist in the soil for many years. This alternative is not considered responsive to the remedial action objectives established for the site.

Note, however, that the majority of the PAHs and PCBs are found in subsurface soil at the site. In addition, parts of the area where these chemicals are found are paved, which would limit the potential for contact with these chemicals in these areas. No protection would be provided under any potential future residential use of the site.

4.3.1.2 Compliance with ARARs

Chemical-Specific ARARs. There are no chemical-specific ARARs for soil. With regard to the selected PRGs, this alternative is expected to require many years to attain these levels. Natural degradation and leaching may eventually result in achievement of the PRGs for some of the chemicals. Other may persist for many years. In general, the time frame to reach the PRGs is unknown but is expected to take many years.

Location-Specific ARARs. There are no activities under this alternative that can trigger any location-specific ARARs.

Action-Specific ARARs. There are no applicable action-specific ARARs because no remedial action will be undertaken under this alternative.

4.3.1.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risk. This alternative would not remove or contain chemicals in soil. Instead, it relies on natural attenuation through degradation, adsorption, and leaching to reduce chemical levels. Because of their persistent nature, PAHs and PCBs are expected to be found in the soil for many years. Therefore, this alternative would require many years to attain the selected PRGs. During this time, some PAHs and PCBs may leach to groundwater although this process is expected to be limited as indicated by the current limited presence of these classes of compounds in groundwater at the site.

This alternative would not prevent ingestion, inhalation, or direct contact with the contaminated soil. Therefore, this alternative would not reduce the risks associated with soil contamination by restricting the potential for exposures to the soil. The long-term risks posed by the contaminated soil at the site are described in the baseline risk assessment contained in the RI report (CH2M HILL, 1997).

Adequacy and Reliability of Controls. This alternative will require long-term sampling of soil and groundwater. As required by SARA, a 5-year review must be performed to evaluate site conditions. If justified by the review, remedial actions may need to be implemented at the site. This alternative is not considered to be effective over the long-term because contaminated soil will be left on-site without any controls to reduce the risks by restricting the potential for exposures to the contaminated soil.

4.3.1.4 Reduction of Toxicity, Mobility, and Volume

This alternative would not involve any containment, removal, treatment, or disposal of contaminated soil. Therefore, this alternative would not result in any immediate reduction in the toxicity, mobility, or volume of the chemicals. The PAHs and PCBs are expected to persist in the soil for many years. Although some PAHs and PCBs may migrate from the soil to the groundwater as a result of rainfall infiltration, this migration pathway is not expected to be significant. This is supported because these classes of compounds either were detected at concentrations below levels of concern (PAHs) or not detected at all (PCBs) in groundwater samples collected from onsite monitoring wells during the Phase II RI.

4.3.1.5 Short-Term Effectiveness

No construction is involved as part of this alternative. Therefore, no short-term threats to neighboring communities would be associated with its implementation. Workers performing the 5-year site review may be exposed to contaminated soil. Therefore, these workers may require personal protective equipment to minimize the risks as a result of direct contact with the soil. This alternative would not result in substantial improvement of current site conditions.

Because the chemicals are expected to remain in the soil for many years, it is not possible to develop a time frame during which this alternative would achieve the remedial action objectives. However, it is likely that chemical concentrations would require many years to approach the selected PRGs.

4.3.1.6 Implementability

Technical Feasibility. This alternative does not require any construction, but sampling may be required during the 5-year site reviews. There are several monitoring wells at the site that can be used for groundwater monitoring to determine whether the PAHs and PCBs have migrated to groundwater at levels that may present a concern. Soil borings would be needed to sample the soil. Sampling of soil (surface and subsurface) and monitoring wells is a relatively simple task that could be performed by local contractors. Little difficulty would be involved in the implementation of these tasks and the work could be completed within a relatively short time. Minimal effort would be required to monitor and maintain the elements of this alternative. If it is determined by the 5-year reviews that contaminant migration is threatening human health or the environment, site remediation could be easily implemented.

Administrative Feasibility. Long-term management and administrative attention would be associated with this alternative, since reviews would be conducted every 5 years. Some coordination between federal, state, and local authorities would be required to review data and make decisions in the future. This alternative does not require any permits.

Availability of Services and Materials. This alternative does not involve treatment, storage, or disposal. Existing monitoring wells would be used to monitor contaminated groundwater at the site. Soil borings would be used to sample subsurface soil, if desired. No special sampling techniques are anticipated to be needed. The work can be performed by local contractors. Equipment and specialists for sampling, analytical work, and data evaluation are locally available.

4.3.1.7 Cost

Taking no action would require no expenditure of money for capital purposes. As part of the 5-year review process, samples may be required and time expended on preparing a report detailing the risk associated with the site. The present-worth cost, based on a 5 percent discount rate for a 30-year duration, is $14,000.

4.3.2 Alternative 2—Institutional Controls

This alternative leaves the contaminated soil in place but imposes deed restrictions to prohibit future residential use of the site. In addition, the deed restrictions would restrict excavation in areas where PAHs and PCBs are found above the selected PRGs to situations where personal protection is provided (depending on the chemical concentration anticipated to be encountered) and any exposed contaminated soil is covered with clean fill. The reason for restricting future residential use is that since no cap over contaminated soil is provided, it would be relatively easy for site residents (i.e., children) to dig into the contaminated soil.

Alternative 2 includes the deed restrictions described under the technology-based alternative S-2, which remained following the preliminary screening of alternatives in Section 3. As with Alternative 1 (no action), soil containing PAHs and PCBs above PRGs would remain in place with the majority of the soil located beneath the existing pavement and the remainder in uncovered areas. Because this alternative results in contaminated soil remaining on the site, CERCLA, as amended by SARA (1986), requires that the site be reviewed every 5 years. The key components of this alternative are as follows:

- Impose and maintain deed restrictions
- Perform site review every 5 years

4.3.2.1 Overall Protection of Human Health and the Environment

This alternative would entail no removal, containment, or treatment of contaminated soil at the site. Deed restrictions would restrict future residential use of the site and excavation into contaminated soil unless personal protective equipment is provided and any exposed contaminated soil is covered with clean fill. Therefore, although contaminated soil would remain in place, this alternative would provide protection of human health and the environment by restricting the potential for contact with the contaminated soil. Therefore, this alternative would be considered responsive to the remedial action objectives for the site.

As with Alternative 1 (no action), this alternative would not achieve any reduction in the toxicity, mobility, or volume of the chemicals found in the soil. Natural degradation, adsorption, and leaching of chemicals to groundwater would take many years to reduce chemical concentrations to the selected PRGs. Therefore, the PAHs and PCBs would persist in the soil for many years.

Note, however, that the majority of the PAHs and PCBs are found in subsurface soil at the site. In addition, portions of the area where these chemicals are found are paved, which would limit the potential for contact with these chemicals in these areas.

4.3.2.2 Compliance with ARARs

Chemical-Specific ARARs. There are no chemical-specific ARARs for soil. With regard to the selected PRGs, this alternative is expected to require many years to attain these levels. Natural degradation and leaching may eventually result in achievement of the PRGs for some of the chemicals. Others may persist for many years. In general, the time frame to reach the PRGs is unknown but is expected to take many years.

Location-Specific ARARs. There are no activities under this alternative that can trigger any location-specific ARARs.

Action-Specific ARARs. There are no applicable action-specific ARARs because no remedial action will be undertaken under this alternative.

4.3.2.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risk. Similar to Alternative 1, this alternative would not remove or contain chemicals in soil. This alternative would, however, impose deed restrictions to prevent the ingestion, inhalation, or direct contact with the contaminated soil. Therefore, this alternative would reduce the risks associated with soil contamination by restricting the potential for exposures to the soil.

Adequacy and Reliability of Controls. This alternative will require long-term sampling of soil and ground water. As required by SARA, a 5-year review must be performed to evaluate site conditions. If justified by the review, remedial actions may need to be implemented at the site. If maintained, institutional controls should be effective over the long-term in reducing the risks associated with the site by restricting the potential for contact with the chemicals found in the soil.

4.3.2.4 Reduction of Toxicity, Mobility, and Volume

The reduction in toxicity, mobility, and volume of chemicals achieved by Alternative 2 is the same as that achieved by Alternative 1.

4.3.2.5 Short-Term Effectiveness

The short-term effectiveness of Alternative 2 is the same as that of Alternative 1.

4.3.2.6 Implementability

Technical Feasibility. This alternative does not require any construction, but sampling may be required during the 5-year site reviews. The technical feasibility of implementing this alternative is the same as that for Alternative 1.

Administrative Feasibility. Implementation of a deed restriction would be feasible but would require some coordination with Fischer and Porter if current site use continues. The deed restriction should prohibit excavation or other activities that will result in contact with contaminated soil without the appropriate protective measures. Long-term management and administrative attention would be associated with this alternative for the 5-year reviews and for maintaining the deed restrictions. The long-term effectiveness of this alternative would depend on the maintenance and enforcement of the deed restrictions.

Availability of Services and Materials. This alternative does not involve any construction, treatment, storage, or disposal. The services and materials for the 5-year reviews are the same as for Alternative 1 and would be readily available.

4.3.2.7 Cost

There are no capital costs associated with this alternative. For the 5-year site reviews the present-worth cost, based on a 5 percent discount rate for a 30-year duration, is $14,000.

4.3.3 Alternative 3—Institutional Controls and Soil Capping

Soil Alternative 3 combines institutional controls (described under technology-based Alternative S-2 in Section 3 and under soil Alternative 2 in this section) with soil capping (described under technology-based Alternative S-3). Under Alternative 3, areas where PAHs and PCBs are found above PRGs in soil would be covered with asphalt pavement to prevent direct contact with the soil. As with Alternatives 1 and 2, soil containing PAHs and PCBs above PRGs would remain in place but all of this soil would be covered by pavement. In addition, deed restrictions would be instituted to restrict excavation into contaminated soil unless personal protective equipment is provided (depending on the chemical concentrations anticipated to be encountered) and the asphalt cap is repaired after the excavation is complete. Note that this alternative does not restrict developing the site for residential use in the future as was the case under Alternative 2. Finally, as with Alternatives 1 and 2, the site must be reviewed every 5 years. The major components of Alternative 3 include the following:

- Implement deed restriction to restrict excavation in areas where PAHs and PCBs are found above PRGs unless personal protection is provided.
- Construct an asphalt cap over the areas where PAHs and PCBs were detected in soil borings above the PRGs.
- Remove the top layer of soil (grass) and regrade and prepare the ground surface for the cap.
- Place 6 inches of base stone underneath 4 inches of asphalt. The cap would be sloped to promote runoff and minimize infiltration.
- Annually inspect the integrity of the cap and resurface approximately every 5 years.
- Perform site reviews every 5 years.

Two scenarios are evaluated in this FS for the asphalt cap. The first scenario reflects future residential use of the site where the existing asphalt pavement has been demolished and new asphalt pavement must be constructed over all soil with PAH and PCB concentrations above PRGs. The area of the cap required for Scenario 1—Future residential site use was estimated to be approximately 43,000 square feet. The second scenario assumes current site use continues. Under this scenario, the existing asphalt pavement is left in place but additional pavement is constructed to cover soil that is currently uncovered but contains PAH and PCB concentrations above PRGs. This additional pavement would provide added protection to onsite workers and site visitors. The area of the cap for Scenario 2—Current site use- is estimated to be approximately 13,700 square feet. The basis for developing the estimates of the areas requiring capping under both scenarios and the conceptual design of the asphalt cap are described in Appendix D.

4.3.3.1 Overall Protection of Human Health and the Environment

This alternative would entail no removal or treatment of contaminated soil at the site. This alternative, however, would manage the risks associated with the site by installing a cap that would prevent contact with the contaminated soil by current facility workers and future site residents. The implementation of institutional controls would further restrict future excavations into the soil unless personal protection is provided. The cap is expected to be reliable in preventing exposures provided that the cap is maintained and the deed restrictions are enforced. Cap maintenance would require periodic (probably annual) inspections, replacement of damaged areas, and resurfacing approximately every 5 years. There do not appear to be any significant obstacles to imposing deed restrictions for future excavations at the site.

Therefore, although contaminated soil would remain in place, Alternative 3 would provide protection to human health and the environment by restricting the potential for contact with the contaminated soil. Therefore, this alternative would be considered responsive to the remedial action objectives for the site.

As with Alternatives 1 and 2, this alternative would not achieve any reduction in the toxicity, mobility, or volume of the chemicals found in the soil. Natural degradation, adsorption, and leaching of chemicals to groundwater would take many years to reduce contaminant concentrations to the selected PRGs Therefore, the PAHs and PCBs would persist in the soil for many years.

4.3.3.2 Compliance with ARARs

Chemical-Specific ARARs. There are no chemical-specific ARARs for soil. With regard to the selected PRGs, this alternative is expected to require many years to attain these levels. Natural degradation and leaching may eventually result in achievement of the PRGs for some of the chemicals. Other may persist for many years. In general, the time frame to reach the selected PRGs is unknown but is expected to take many years. In the meantime, however, protection of public health and the environment would be provided by limiting the potential for contact with the soil.

Location-Specific ARARs. There are no activities under this alternative that can trigger any location-specific ARARs.

Action-Specific ARARs. Earthmoving activities may require an erosion and sedimentation control plan and a plan to control fugitive dust.

During the Phase I and II RI activities, soil generated from boring and well installation at the site was classified as nonhazardous for disposal. Therefore, this alternative would not need to meet the requirements for hazardous waste under RCRA.

This alternative can be designed to meet action-specific ARARs.

4.3.3.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. Similar to Alternatives 1 and 2, Alternative 3 would not remove chemicals currently found in onsite soil. This alternative would, however, prevent contact with the soil through the installation of a cap and the implementation of deed restrictions. Therefore, this alternative would reduce the risks associated with soil contamination by restricting the potential for exposures to the soil. Alternative 3 would be effective in managing the long-term risks associated with contaminated onsite soil if the cap is maintained properly and if the deed restrictions are enforced consistently. Installing the cap also would reduce rainfall infiltration and the potential for migration of PAHs and PCBs from the soil to the groundwater although this pathway appears not to be significant based on the Phase II RI groundwater data.

Adequacy and Reliability of Controls. Long-term risks could result from poor maintenance of the cap or noncompliance with deed restrictions. While the likelihood of such problems is small, failure to address them could result in direct contact with the contaminated soil and in unacceptable risks particularly if the site were to be developed for residential use. Therefore, the adequacy of the controls established as part of this alternative should be reviewed once every 5 years, as required by SARA.

4.3.3.4 Reduction of Toxicity, Mobility, and Volume

This alternative does not provide for the removal or treatment of PAHs and PCBs found in onsite soil. Therefore, it would not reduce the volume or toxicity of chemicals. The mobility of these chemicals is already relatively low due to their sorptive nature. This alternative would further reduce their mobility by reducing the infiltration of precipitation and subsequent possible leaching of the PAHs and PCBs from the soil to the groundwater.

As previously noted, however, migration of PAHs and PCBs from soil to groundwater is not expected to be a significant pathway as indicated by the fact that these compounds were either detected at concentrations below levels of concern (PAHs) or not detected at all (PCBs) in groundwater samples collected from onsite monitoring wells during the Phase II RI.

4.3.3.5 Short-Term Effectiveness

There would be limited short-term adverse effects associated with construction of this alternative. Access restrictions can be used during construction to protect the community from contact with contaminated soil during cap construction. Some areas may need grading and filling before cap construction. Grading may be done with clean fill to minimize dust generation. However, some contaminated dust may be generated and present short-term adverse public health and environmental concerns. Therefore, dust generation may need to be controlled during construction. Grading activities may also be limited during windy days. Dust generation could be controlled by applying, for example, water sprays to dry areas before earthmoving. The potential for vehicular transport of soil particles offsite could be mitigated by vehicle decontamination.

Air monitoring for dust may be needed during construction to determine any potential risks to the community and indicate whether additional measures are necessary to control emissions. Soil erosion and site runoff controls also may be needed to minimize releases of sediments to the onsite culvert. However, because the source area is relatively flat, no significant grading activities are anticipated.

Risks to construction workers include direct contact with contaminated soil and inhalation of contaminated dust. Construction workers should be appropriately trained and protective equipment should be available, if needed, based on the results of the air monitoring.

The cap is relatively easy to design and construct. Therefore, the time frame expected to be needed to complete the cap design and construction is expected to be relatively short.

4.3.3.6 Implementability

Technical Feasibility. Constructing an asphalt cap is expected to be relatively easy to implement. Grading and placement of the cap are common construction activities that can be performed using standard construction equipment and procedures, and contractors capable of performing the work are locally available. Therefore, design and construction of the cap should not pose any significant obstacles.

Some areas may require bringing clean fill from offsite. Health and safety measures, including the use of personal protective equipment, may be required to control construction workers' exposure to PAHs and PCBs in soil during regrading of the ground surface. Weather conditions could delay grading or cap placement in the winter but are not expected to result in major delays. The asphalt cap is operationally reliable, and occasional maintenance may be required to repair portions of the cap that become damaged due to weather or onsite activities. Construction and maintenance of the cap installed under Scenario 2—Current site use would require some coordination with Fischer and Porter.

Administrative Feasibility. Implementation of a deed restriction would be feasible but would require some coordination with Fischer and Porter if current site use continues. The deed restriction should prohibit excavation or other activities that will result in contact with contaminated soil without the appropriate protective measures. Following any excavation into the capped areas, the deed restriction should require cap rehabilitation. Contaminated material would remain at the site under this alternative and would require long-term administrative resources to maintain the deed restriction and to conduct the 5-year site reviews. The long-term effectiveness of this alternative would depend on the maintenance of the cap and the enforcement of deed restrictions.

Availability of Services and Materials. The services and materials required for design and construction of the cap are readily available from local sources. Contractors are available who can supply the necessary equipment and construct the asphalt cap.

4.3.3.7 Cost

The present-worth cost, based on a 5 percent discount rate, is $326,000 for Scenario 1—Future residential site use and $162,000 for Scenario 2—Current site use.

4.4 Analysis of Groundwater Alternatives

In Section 3, eleven technology-based remedial action alternatives, including the no further action alternative, were developed and screened on the basis of effectiveness, implementability, and cost. Seven alternatives were retained for detailed evaluation. In this section, these seven alternatives are grouped into the following five overall alternatives for contaminated groundwater:

- Alternative 1—No Action
- Alternative 2—Institutional Controls; Source Control by Extraction Wells; Air Stripping; Catalytic Oxidation; and Discharge to Surface Water
- Alternative 3—Institutional Controls; Source Control by Extraction Wells; Chemical Oxidation; and Discharge to Surface Water
- Alternative 4—Institutional Controls; Sitewide Capture Including Source Control and Downgradient Capture by Extraction Wells; Air Stripping; Catalytic Oxidation; and Discharge to Surface Water
- Alternative 5—Institutional Controls; Sitewide Capture Including Source Control and Downgradient Capture by Extraction Wells; Chemical Oxidation; and Discharge to Surface Water

The components of these five overall groundwater remedial alternative are described below followed by an evaluation of each alternative against the seven criteria discussed above. The components of the five overall groundwater alternatives, the results of the performed detailed evaluation for each alternative, and the costs of implementing each alternative are summarized in Tables 4-4, 4-5, and 4-6, respectively.

4.4.1 Alternative 1—No Action

Under this alternative, groundwater extraction or treatment technologies beyond the operation of the existing system at the site would not be implemented. As noted in previous sections, this existing system consists of groundwater extraction from onsite wells FP1, FP2, and FP7 followed by treatment of the extracted groundwater through the existing onsite air stripper. In addition to onsite pumping, this alternative includes groundwater extraction followed by treatment in the towns surrounding the site. The treated groundwater is then used in the water supply systems of the towns. All other groundwater remedial action alternatives will be compared against this no action alternative. Because contamination in the groundwater would remain on the site, a review of site conditions would be required every 5 years.

Table 4-4
Components of Groundwater Remedial Alternatives
Fischer and Porter Site

Components	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
G-1—No Action	X				
G-2—Institutional Controls		X	X	X	X
GC-1—Source Control by Extraction Wells		X	X		
GC-2—Sitewide Capture by Extraction Wells				X	X
GT-2—Air Stripping		X		X	
GT-4—Chemical Oxidation			X		X
GT-6—Catalytic Oxidation		X		X	
GD-1—Discharge to Surface Water		X	X	X	X

Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
Overall Protection of Human Health and the Environment	This alternative is not considered responsive to the remedial action objectives established for the site.	This alternative is considered responsive to the remedial action objectives established for the site and is expected to provide overall protection of public health and the environment.	Same as Alternative 2 except that there would not be any significant emissions from the chemical oxidation unit. Also, if oxidation is complete, VOCs would be reduced to innocuous compounds in the effluent from the unit such as water, carbon dioxide, and salts. Often, however, oxidation is incomplete due to the variability in the influent.	This alternative is considered responsive to the remedial action objectives established for the site and is expected to provide overall protection of public health and the environment. The effectiveness is expected to be higher than that of Alternatives 2 and 3 due to the larger area of groundwater capture where VOC toxicity, mobility, and volume would be decreased.	Same as Alternative 4 except that there would not be any significant emissions from the chemical oxidation unit and if the oxidation unit is complete, VOCs would be reduced to innocuous compounds such as water, carbon dioxide, and salts. Often, however, oxidation is incomplete due to the variability in the influent.
— Extraction System	Current extraction system has limited effectiveness in the shallow bedrock groundwater system and its effectiveness in the intermediate system is uncertain. VOC concentrations would continue to migrate horizontally and vertically in the	Extraction system would capture the highest VOC concentrations at the site. VOCs outside of the zone of influence of the system would continue to migrate to the site boundary and offsite. Modifications to FP1,	Same as Alternative 2.	Extraction system would capture the highest VOC concentrations as well as the lower (but still above PRGs) concentrations along the site boundary. Therefore, this extraction system provides a higher level of protection than the systems under Alternatives 2 and 3.	Same as Alternative 4.

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Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
	groundwater bedrock systems underlying the site. VOC concentrations that have already migrated offsite will be treated at the municipal wellheads.	FP2, and FP7 would prevent further vertical migration of contaminants and remove the LNAPL from well FP7. VOC concentrations that have already migrated offsite will be treated at the municipal wellheads. Extraction system will require 97 and 70 years to achieve PRGs in the shallow and intermediate bedrock groundwater systems, respectively. If DNAPL is present, system may never achieve PRGs and long-term hydraulic control may be a more appropriate objective. In addition, due to uncertainties in bedrock systems, VOCs may be left in the groundwater at the end of the		Modifications to FP1, FP2, and FP7 would prevent further vertical migration of contaminants and remove the LNAPL from well FP7. VOC concentrations that have already migrated offsite will be treated at the municipal wellheads. Extraction system will require 121 and 95 years to achieve PRGs in the shallow and intermediate bedrock groundwater systems, respectively. If DNAPL is present, system may never achieve PRGs and long-term hydraulic control may be a more appropriate objective. In addition, due to uncertainties in bedrock	

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Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
		implementation period of any alternative.		systems, VOCs may be left in the groundwater at the end of the implementation period of any alternative.	
— Treatment System	Effluent from air stripper meets permissible limits in current discharge permit. However, air emissions were estimated to present a potential risk to onsite workers.	Air stripping would reduce VOCs in the extracted groundwater to permissible levels and catalytic oxidation would lower the air emissions to levels at which they no longer present a concern.	Chemical oxidation, if complete, would convert the VOCs in the extracted groundwater to innocuous compounds. Often, however, chemical oxidation is uncomplete. Treatability study is required to determine the optimum system design.	Same as Alternative 2.	Same as Alternative 3.
Compliance with ARARs	Complies with ARARs but not with PRGs.	Complies with ARARs and can comply with PRGs within the zone of influence of the extraction system. Achieving PRGs is expected to require a significant time and is contingent upon the absence of DNAPL.	Same as Alternative 2	Same as Alternative 2 except that the zone of influence of the extraction system would be larger than under Alternatives 2 and 3 due to the additional wells at the boundary of the site.	Same as Alternative 4.
-- Chemical-specific ARARs	Effluent from the treatment system	Treatment system can be designed to meet	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
	achieves the permissible limits in current discharge permit. Air emissions from the air stripper are below the PADEP *de minimis* level. Treatment at offsite wells would lower VOC concentrations to permissible levels (i.e., MCLs) before use of the water in the water supply systems. PRGs in groundwater are expected to be achieved. Achieving PRGs is expected to require a significant time and is contingent upon the absence of DNAPL.	chemical specific ARARs for discharges to surface water and air emissions. Treatment at offsite wells would lower VOC concentrations to permissible levels (i.e., MCLs) before use of the water in the water supply systems. PRGs in groundwater are not expected to be achieved. Achieving PRGs is expected to require a significant time and is contingent upon the absence of DNAPL.			
—Location-specific ARARs	None.	None.	None.	None.	None.
—Action-specific	None.	Can be designed and operated to meet action-	Can be designed and operated to meet action-	Can be designed and operated to meet action-	Can be designed and operated to meet action-

Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
ARARs		specific ARARs.	specific ARARs.	specific ARARs.	specific ARARs.
Long-Term Effectiveness and Performance	Limited long-term effectivess as this alternative does not address the remedial action objectives.	This alternative would lower the residual risk associated with VOCs present in groundwater and in the effluent and air emissions discharges from the treatment system.	Same as Alternative 2 except that if chemical oxidation is complete, VOCs could be destroyed to innocuous compounds such as carbon dioxide, water, and salts.	This alternative would lower the residual risk associated with the site further than Alternatives 2 and 3 because of the capture and treatment of VOCs over a larger area than Alternatives 2 and 3.	Same as Alternative 4 except that if chemical; oxidation is complete, VOCs could be destroyed to innocuous compounds such as carbon dioxide, water, and salts.
—Extraction System	Long-term risks will remain at the site due to the limited effectivess of the groundwater extraction system.	Long-term risks would be managed by capturing the highest VOC concentrations. VOC concentrations above PRGs outside the zone of influence of the extraction system would continue to migrate offsite. Long-term risks associated with VOCs that have migrated off the site would be addressed by the treatment at the supply wells.	Same as Alternative 2.	Long-term risks would be managed by capturing the highest VOC concentrations as well as lower (but above PRGs) VOC concentrations along the site boundary. VOC concentrations above PRGs outside the zone of influence of the extraction system would continue to migrate offsite. Long-term risks associated with VOCs that have migrated off	Same as Alternative 4.

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Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
		Water level monitoring is required to monitor the capture achieved by the extraction system		the site would be addressed by the treatment at the supply wells. Water level monitoring is required to monitor the capture achieved by the extraction system	
—Treatment System	Air stripper is effective in limiting the residual risks associated with the discharge of the treated effluent. Air emissions from the air stripper were shown to present a potential health risk to onsite workers.	Air stripping and catalytic oxidation are effective in managing the risks associated with the discharge of effluent and air emissions from the treatment unit. Monitoring is required to monitor the effectiveness of the treatment system to comply with chemical-specific ARARs and the substantive requirements of any permits.	Chemical oxidation is effective in managing the risks associated with the discharge of effluent. No significant air emissions are expected from this treatment unit. Monitoring is required to monitor the effectiveness of the treatment system to comply with chemical-specific ARARs and the substantive requirements of any permits.	Same as Alternative 2.	Same as Alternative 3.
Reduction of Toxicity, Mobility, and Volume					

Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
—Extraction System	Will achieve limited reduction in the toxicity, mobility, and volume of VOCs in groundwater due to the limited effectiveness of the current extraction system.	Will achieve reduction in the toxicity, mobility, and volume of VOCs within the zone of influence of the extraction system.	Same as Alternative 2.	Will achieve reduction in the toxicity, mobility, and volume of VOCs within the zone of influence of the extraction system. The area of groundwater over which the reduction in toxicity, mobility, and volume would be achieved is larger under this alternative than under Alternatives 2 and 3.	Same as Alternative 4.
—Treatment System	Air stripper reduces the toxicity and volume of VOCs in the treated effluent. The VOCs, however, are transferred to ambient air.	Air stripper would reduce the toxicity and volume of VOCs in the treated effluent. VOC toxicity and volume in the emissions from the air stripper would be reduced by the catalytic oxidation unit. VOC concentrations at or below the permissible discharge limits for surface water would be discharged from the system.	Chemical oxidation would reduce the toxicity and volume of VOCs in the treated effluent. No VOC emissions are expected from this unit. If oxidation is complete, VOCs would not be discharges to the environment. If oxidation is uncomplete, VOC concentrations at or below the permissible discharge limits for	Same as Alternative 2.	Same as Alternative 4.

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Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
		VOC toxicity and volume at the municipal wellheads are reduced to permissible levels for drinking water use.	surface water would be discharged from the system. VOC toxicity and volume at the municipal wellheads are reduced to permissible levels for drinking water use.		
Short-Term Effectiveness —Extraction System	There are no short-term risks associated with this alternative.	The short-term risks associated with construction of this alternative can be managed through engineering, air monitoring, and personal protection controls. Failure of the system would not result in any immediate public health concerns because the water used in the supply systems of the towns is	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Excraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
		treated by air stripping.			
—Treatment System	There are no short-term risks associated with this alternative other than the air emissions from the air stripper which were estimated to represent a potential risk to onsite workers.	The short-term risks associated with construction of this alternative can be managed through engineering, air monitoring, and personal protection controls. Failure of the system will result in discharges of VOCs to surface water through the stormwater culvert at the site. The impacts of such discharges depend on VOC concentrations and volume of the discharge. Failures should be detected as part of routine system maintenance.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Implementability					
—Extraction System	The components of the extraction system under this alternative are already in place.	System can be easily implemented. Operation is easy. Services and materials required to design, construct, and	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

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Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
	Administrative resources are required to perform the 5-year site reviews.	operate the system are readily available. A remedial design investigation must be completed before extraction system design to select the optimum locations for the extraction wells. The design of the extraction system is the most challenging task in implementing a remedial action at the Fischer and Porter site. Administrative resources are required to perform the 5-year site reviews and enforce the deed restrictions.			
—Treatment System	The components of the treatment system under this alternative are already in place.	System can be easily implemented. Operation is easy but regular maintenance is essential for proper operation. Services and materials required to design,	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Table 4-5
Summary of Groundwater Remedial Alternatives Evaluation
Fischer and Porter Site

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
		construct, and operate the system are readily available.			
Cost (Present-Worth)	$14,000	$3,559,000	$3,510,000	$5,110,000	$5,576,000

Table 4-6
Summary of Present-Worth Costs for Groundwater Remedial Alternatives
Fischer and Porter Site

Components	Alternative 1 No Action	Alternative 2 Institutional Controls; Source Control Extraction; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 3 Institutional Controls; Source Control Extraction; Chemical Oxidation; Discharge to Surface Water	Alternative 4 Institutional Controls; Sitewide Capture; Air Stripping; Catalytic Oxidation; Discharge to Surface Water	Alternative 5 Institutional Controls; Sitewide Capture; Chemical Oxidation; Discharge to Surface Water
G-1—No Action	$14,000				
G-2—Institutional Controls		$450,000	$450,000	$450,000	$450,000
GC-1—Source Control by Extraction Wells		$1,479,000	$1,479,000		
GC-2—Sitewide Capture by Extraction Wells				$2,581,000	$2,581,000
GT-2—Air Stripping (90 gpm)		$674,000			
GT-2—Air Stripping (195 gpm)				$919,000	
GT-4—Chemical Oxidation (90 gpm)			$1,581,000		
GT-4—Chemical Oxidation (195 gpm)					$2,545,000
GT-6—Catalytic Oxidation (90 gpm)		$956,000			
GT-6—Catalytic Oxidation (195 gpm)				$1,160,000	
GD-1—Discharge to Surface Water		$0	$0	$0	$0
Total	$14,000	$3,559,000	$3,510,000	$5,110,000	$5,576,000

Refer to Table 3-7 for capital and O&M costs.

NJO/TABLE4-6

4.4.1.1 Overall Protection of Human Health and the Environment

The no action alternative includes the continued operation of the existing onsite groundwater extraction and treatment system and the wellhead treatment at the municipal supply wells in the towns surrounding the site. The RI report concluded that the existing extraction system has limited effectiveness in capturing contaminated groundwater in the shallow bedrock groundwater system and its effectiveness in the intermediate bedrock groundwater system cannot be determined based on the available information. In addition, VOCs in the shallow bedrock groundwater system would continue to migrate to the intermediate and deep bedrock groundwater systems through the open-hole extraction wells FP1, FP2, and FP7.

Therefore, this alternative does not limit the horizontal and vertical migration of the elevated VOC concentrations in the shallow and intermediate bedrock groundwater systems at the site. No significant reduction in VOC toxicity, mobility, or volume in groundwater at the site is expected through this alternative although the wellhead treatment at the municipal supply wells would provide protection of human health by preventing human exposures to VOC concentrations above MCLs. Because this alternative does not prevent further offsite migration of the VOCs in the groundwater bedrock systems at the site, it is not considered responsive to the remedial action objectives established for the site.

In addition to chemicals continuing to migrate vertically and horizontally in groundwater, this alternative would also not address emissions from the existing onsite air stripper. Specifically, the baseline human health risk assessment completed for the site indicated that inhalation of air emissions from this air stripper may pose a risk to onsite workers. Because this alternative does not provide for any treatment of the off-gas from the existing air stripper, the no action alternative does not provide adequate protection of human health and the environment by restricting exposures to these air emissions.

4.4.1.2 Compliance with ARARs

Chemical-Specific ARARs. This alternative is not expected to meet chemical-specific ARARs and PRGs for chemicals in groundwater at the site. The effluent from the existing air stripper currently meets the discharge limits established in the permit for the system and the treated water from the municipal wells meets the permissible limits for drinking water use (i.e., MCLs). Finally, the total VOC emissions from the air stripper are estimated to be 2 lbs/hr, which is below the PADEP *de minimis* level of 3 lbs/hr, although the human health risk assessment concluded that these emissions present a potential human health risk.

Location-Specific ARARs. Activity under this alternative is not anticipated to trigger any location-specific ARAR.

Action-Specific ARARs. There are no applicable action-specific ARARs since no further action will be undertaken at the site.

4.4.1.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risk. The long-term risks associated with the use of groundwater for public water supply would be addressed by the treatment systems provided at the municipal wells. These treatment systems would lower the residual risk associated with drinking the groundwater by lowering VOC concentrations to permissible concentrations for drinking water use (i.e., to MCLs).

The existing onsite extraction and treatment system would only capture, remove, and treat a portion of the VOCs found in groundwater at the site. The remaining VOCs would continue to migrate offsite and to the deeper bedrock groundwater systems. Therefore, this alternative relies on the continued operation of the wellhead treatment at the municipal supply wells to lower the residual risk associated with the site. Natural attenuation would help in reducing VOC concentrations but is expected to take many years. Because of limitations, this alternative is not expected to result in the attainment of PRGs for groundwater at the site.

The air emissions from the existing onsite air stripper will continue to pose a risk to onsite workers.

The long-term risks associated with the no action alternative are described in the baseline risk assessment contained in the RI report (CH2M HILL, 1997).

Adequacy and Reliability of Controls. This alternative is not considered to be adequate and reliable over the long-term because it would not control migration of elevated VOC concentrations from the site and thus, it would not provide protection of public health and the environment. Air stripping is a common and reliable technology for VOCs removal. However, air emissions controls are not provided. Because VOCs would remain in onsite groundwater, a 5-year site review will be required to evaluate site conditions. If justified by the review, additional remedial actions may be implemented to capture and treat the VOCs in groundwater at the site.

4.4.1.4 Reduction of Toxicity, Mobility, and Volume

The existing onsite extraction system would only partially capture the VOCs in the shallow bedrock groundwater system and its effectiveness in the intermediate bedrock groundwater system is uncertain. Therefore, this alternative would only partially reduce the toxicity, mobility, and volume of VOCs in groundwater. The VOCs would continue to migrate vertically and horizontally in the groundwater bedrock systems at the site. Natural attenuation through degradation, sorption, volatilization, dispersion, dilution, and transport also would help reduce the toxicity, mobility, and volume of the VOCs in groundwater. However, these natural processes are slow and would require many years before any noticeable decrease in VOC concentrations. In the meantime, the volume of contaminated groundwater would increase due to VOC migration.

This alternative would decrease the volume of VOCs in the discharge from the air stripper by treating the extracted groundwater. However, the VOCs removed from the influent groundwater would be released to the ambient air where they were shown to pose a potential health risk to onsite workers.

4.4.1.5 Short-Term Effectiveness

There are no short-term risks associated with construction of the onsite system because this system is already in place. As noted above, this system, however, does not provide long-term protection to human health and the environment as emissions from the air stripper continue to be released to the ambient air and VOCs are allowed to migrate vertically and horizontally in the groundwater bedrock systems at the site. The wellhead treatments at the municipal supply wells are effective in preventing exposures to VOCs in groundwater. Because the effectiveness of the existing groundwater extraction system is uncertain, it is not possible to develop a time frame during which this alternative would achieve the remedial action objectives. However, it is likely that chemical concentrations would require many years to approach the selected PRGs.

4.4.1.6 Implementability

Technical Feasibility. This alternative does not require any construction, but sampling will be required to document compliance with the terms of the current discharge permit and during the 5-year site reviews. Several monitoring wells are at the site that can be used for groundwater monitoring during the 5-year site reviews. As part of the consent decree and discharge permit for the treatment system, the three extraction wells and the effluent from the existing air stripper are sampled monthly and the results provided to PADEP. These wells would continue to be sampled in the future under the no action alternative. Sampling is a relatively simple task that could be performed by local contractors. Minimal effort would be required to monitor and maintain the elements of this alternative. However, sampling of the three extraction wells would not provide sufficient information on VOC migration and concentration changes over time at the site. If it is determined by the 5-year site reviews that contaminant migration is threatening human health or the environment, site remediation could be easily implemented.

Administrative Feasibility. Long-term management and administrative attention would be associated with this alternative, since reviews would be conducted every 5 years. Some coordination between federal, state, and local authorities would be required to review data and make decisions in the future. This alternative does not require any additional permits.

Availability of Services and Materials. Existing monitoring wells would be used to monitor groundwater at the site. No special sampling techniques are anticipated to be needed. The work can be performed by local contractors. Equipment and specialists for sampling, analytical work, and data evaluation are locally available.

4.4.1.7 Cost

There are no capital costs for the no action alternative. The O&M costs for operating the current system are paid for by Fischer and Porter. The O&M costs for the wellhead treatment at the Hatboro and Warminster Water Authorities' municipal supply wells are paid for by the water authorities. Therefore, there are no O&M costs associated with the no action alternative other than the costs for conducting the 5-year reviews of the site. The present-worth cost, calculated at a 5 percent discount rate for a 30-year duration, is $14,000.

4.4.2 Alternative 2— Institutional Controls; Source Control by Extraction Wells; Air Stripping; Catalytic Oxidation; and Discharge to Surface Water

This alternative includes extracting groundwater from the shallow and intermediate bedrock groundwater systems in the source area; treating the groundwater onsite by air stripping; treating the air stripper off-gas with catalytic oxidation; and discharging the treated water to the stormwater culvert. In addition, the current onsite extraction and treatment system would be disabled, and the three current extraction wells (FP1, FP2, and FP7) modified to serve as monitoring wells (FP1 and FP2) and an LNAPL recovery well

(FP7). Finally, institutional controls in the form of groundwater use deed restrictions and 5-year site reviews will be implemented.

The technology-based remedial alternatives from Section 3 included to form overall groundwater remedial Alternative 2 include institutional controls (G-2); source control by extraction wells (GC-1); air stripping (GT-2); catalytic oxidation (GT-6); and discharge to surface water (GD-1).

The key components of the extraction system under Alternative 2 are as follows:

- Conduct a remedial design investigation to determine the precise locations of the extraction wells, capture zones, and design contaminant concentrations and flow rates from the wells. Appendix B discusses the objectives and scope of the remedial design investigation.

- Install and develop three extraction well couplets (one shallow well and one intermediate well at each location to anticipated depths of 120 feet and 220 feet bgs, respectively). The wells, designated as SW-1 through SW-3 and IW-1 through IW-3 in Figures 3-2 and 3-3, are located along the centerline of the TCE plume in the shallow bedrock groundwater system. Appendix B describes the rationale used in selecting the locations of the extraction wells and the well construction details. The well configuration was designed to capture the portion of the shallow groundwater plume with the highest TCE concentrations (greater than 100 µg/L). In the intermediate bedrock groundwater system, the well configuration was designed to capture TCE in the area where the highest TCE concentrations are expected to migrate from the shallow to the intermediate bedrock groundwater systems.

- Extract 15 gpm from each of the six extraction wells for a total flow rate of 90 gpm.

- Pipe the extracted groundwater from the extraction wells to the treatment location shown in Figure 3-4.

- Discontinue the use of the current air stripper system.

- Partially seal using grout current extraction well FP1 to a depth of 220 feet bgs. Then, install two monitoring wells in the existing holes for wells FP1 and FP2 to monitor the shallow (20 to 120 feet bgs) and intermediate (120 to 220 feet bgs) bedrock groundwater systems. Appendix B describes the construction details for these wells.

- Partially seal using grout well FP7 to a depth of 220 feet bgs to use the well as an LNAPL recovery well. This well depth was selected to allow for groundwater table fluctuations as a result of pumping at nearby extraction wells installed as part of this alternative.

- Remove any accumulated LNAPL from well FP7 on a quarterly basis. Although this frequency is assumed for the purpose of estimating the costs of this alternative, the frequency may need to be increased or decreased depending on the rate of oil accumulation in the well.

- Collect water level measurements from all existing and new monitoring wells at the site. The frequency of water level monitoring should be higher during the startup of the system and decrease over time. For example, water levels may be collected monthly for the first 6 months, quarterly for the next 1 year, semiannually for the next 3 years, and annually thereafter. The data will be used to evaluate the effectiveness of the new extraction system to achieve hydraulic containment.

- Continue extraction and treatment of groundwater at the offsite municipal supply wells.

The key components of the treatment system (groundwater and air) under Alternative 2 are as follows:

- Install an air stripping tower to treat VOCs in the extracted groundwater at a process flow rate of 90 gpm.

- Install a catalytic oxidation unit and wet scrubber to remove VOCs from air emissions.

- Construct a shed to house the blowers, catalytic oxidizer, and scrubber system.

- Discharge treated water to the stormwater culvert.

- Conduct quarterly maintenance (acid wash) on the air stripper to prevent clogging.

- Sample quarterly the effluent and air emissions from the air stripper to determine compliance with the substantive requirements of any permits. Prepare annual reports to document compliance.

The key components of the institutional controls under Alternative 2 are as follows:

- Collect annual samples from select monitoring wells in the source area for VOCs, PAHs, and PCBs. Collect annual samples from select monitoring wells outside of the source area for VOCs. At the time of sampling, collect water levels from the sampled wells.

- Prepare 5-year site review reports.

- To limit access to the contaminated groundwater, implement restrictions on the use of untreated groundwater on the site as well as offsite, if appropriate, and enforce these restrictions.

4.4.2.1 Overall Protection of Human Health and the Environment

As with Alternative 1, the continued operation of the wellhead treatment at the municipal supply wells would provide protection of public health and the environment also under this alternative.

In addition to the wellhead treatment, Alternative 2 includes onsite extraction and treatment of the highest VOC concentrations found in groundwater at the site. Specifically, the extraction system to be installed under this alternative is designed to control the horizontal migration of the highest VOC concentrations in the shallow and intermediate bedrock groundwater systems. In addition, this alternative would prevent further vertical migration of VOCs to the deeper bedrock groundwater systems through the open boreholes of wells FP1, FP2, and FP7. The extracted groundwater would be treated by air stripping and the emissions from the air stripper would be treated by catalytic oxidation. Treatment systems can be designed to meet chemical-specific ARAR, which would provide protection of public health and the environment.

In general, the toxicity, mobility, and volume of VOCs in groundwater would be reduced within the pumping radius of the wells. Outside of the zone of influence of the extraction system, however, TCE and other VOCs present at concentrations above PRGs would continue to migrate to the site boundary in both the shallow and intermediate bedrock groundwater systems. This is because the locations of the extraction wells under this alternative were selected along the centerline of the TCE plume in the shallow bedrock groundwater system and not at the downgradient edge of the plume. This layout is thus expected to capture TCE concentrations up to approximately the 100 μg/L isopleth (Figure 3-2). Therefore, it is possible for the area and volume of VOC-contaminated groundwater to increase. By controlling further migration of the highest VOC concentrations, however, future VOC concentrations migrating from the site should decrease although the area and volume of contaminated groundwater may increase due to the VOCs currently found in groundwater outside of the zone of influence of the extraction system.

Within the zone of influence of the extraction system, TCE and other VOC concentrations should slowly decrease to the PRGs. For example, calculations in Appendix B estimate that the time required for the extraction system to achieve PRGs would be approximately 97 years in the shallow bedrock groundwater system and 70 years in the intermediate bedrock groundwater system. Although this is a considerable length of time, if DNAPL is present, the PRGs may never be achieved. Instead, long-term hydraulic control to prevent offsite migration of the highest TCE groundwater concentrations would be a more appropriate objective for the selected remedial alternative. Finally, because of the complexities of bedrock systems, it is uncertain how much contaminated groundwater would remain in bedrock fractures at the end of any implementation period.

Because VOC concentrations above PRGs would be allowed to migrate offsite, this alternative relies on the pumping and treatment at the offsite municipal supply wells to remove the TCE and other VOCs to permissible levels (i.e., MCLs) before use of the groundwater as drinking water in the water supply systems of the surrounding towns.

In addition to the groundwater extraction wells, LNAPL accumulated in well FP7 would be manually removed from the well on a quarterly basis under this alternative. This would increase the overall effectiveness of the extraction system by reducing and eventually, eliminating this source of TCE to the groundwater system.

This alternative includes collecting a variety of information that will support an evaluation of its effectiveness. For example, water level measurements would provide information on the TCE plume capture achieved as a result of the operation of the extraction wells. Sampling of onsite monitoring wells would provide information on the achieved decrease in VOC concentrations in groundwater at the site as well as whether any of the PAHs and PCBs found in onsite soil have migrated to groundwater. The quarterly sampling of the effluent and air emissions from the air stripper is required to ensure that the treatment system is effective in reducing VOC releases to the environment to the desired levels.

On the basis of the above discussion, this remedial alternative reduces the human health risks associated with exposures to the highest VOC concentrations in groundwater by preventing further offsite migration of these concentrations. This alternative also reduces

VOC concentrations in the effluent and air emissions from the new treatment system to levels considered protective of public health and the environment. The institutional controls, if implemented, would further help the effectiveness of this alternative by restricting the use of untreated groundwater and by monitoring the effectiveness of both the extraction and treatment components of the alternative. The extracted LNAPL from well FP7 will be drummed and sent for offsite incineration, which would be protective of public health and the environment so long as properly permitted facilities are used. Based on the above, this alternative is considered to be responsive to the remedial action objectives established for the site.

4.4.2.2 Compliance with ARARs

Chemical-Specific ARARs. This alternative would achieve compliance with chemical-specific ARARs at the point of groundwater use (i.e., water supply system) and treatment system discharges (i.e., stormwater culvert and ambient air). This alternative is expected to decrease VOC concentrations to the PRGs in the shallow and intermediate bedrock groundwater systems. The time frame for this alternative to achieve the PRGs is estimated in Appendix B but is typically considered to be uncertain in complex bedrock groundwater systems such as that underlying the Fischer and Porter site. As previously noted, the time to achieve PRGs also may be significantly affected by the presence of DNAPL; if DNAPL is present, PRGs may never be achieved and long-term hydraulic control may be a more appropriate objective for the selected groundwater extraction system.

Location-Specific ARARs. Activity under this alternative is not anticipated to trigger any location-specific ARARs.

Action-Specific ARARs. It is expected that this alternative can be designed to meet action-specific ARARs.

4.4.2.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risk. The long-term risks associated with the use of groundwater for public water supply would be addressed by the treatment systems provided at the municipal wells. These treatment systems would lower the residual risk to permissible concentrations for drinking water use (i.e., the MCLs).

In addition to the wellhead treatment, Alternative 2 includes onsite extraction and treatment of the highest VOC concentrations in groundwater at the site. This alternative would be effective in managing the long-term risks associated with the highest VOC concentrations captured by the extraction system. Within the zone of influence of the extraction system, TCE and other VOC concentrations should slowly decrease to the PRGs. Outside of the zone of influence of the extraction system, however, TCE and other VOCs at concentrations above PRGs would continue to migrate to the site boundary in both the shallow and intermediate bedrock groundwater systems. Note that there are many uncertainties related to the performance of extraction systems in complex bedrock systems such as that underlying the Fischer and Porter site. This uncertainty is increased if DNAPL is present, which may be the case at this site based on the elevated TCE concentrations measured in some of the wells. If DNAPL is present, as previously noted, the system may never achieve the established PRGs.

This alternative also is considered effective in managing the long-term risks associated with treatment of the extracted groundwater. Specifically, VOC concentrations in the effluent and air emissions from the new treatment system would be reduced to levels considered protective of public health and the environment. This treatment would manage the residual risk associated with the extracted groundwater. The institutional controls also would help the effectiveness of this alternative by restricting the use of untreated groundwater. Finally, the extracted LNAPL from well FP7 will be drummed and sent for offsite incineration which would be an effective long-term management of the risks associated with this waste stream as long as properly permitted facilities are used.

Adequacy and Reliability of Controls. Proper operation of the onsite extraction system is relatively simple and the system is expected to be reliable. Failure of the system is not expected to result in any immediate human exposures to VOCs because groundwater at the municipal supply wells is treated before its use in the water supply systems. Elevated VOC concentrations would, however, be allowed to migrate during the time the extraction system is down.

Air stripping is a reliable treatment technology. The existing air strippers at the municipal supply wells have been reliable and effective in reducing VOC concentrations in the extracted groundwater to MCLs. Air stripping also is expected to be effective in treating groundwater from the onsite extraction system. Finally, catalytic oxidation is a reliable technology and is expected to be effective in treating the off-gas from the air stripper.

Proper maintenance and operation of the air stripper are required to achieve the established discharge limits. In particular, maintenance of the air stripper (i.e., periodic acid washing) to prevent clogging from scaling and fouling is important to ensure proper operation. Failure of the air stripper, if undetected, may result in the discharge of contaminated groundwater through the storm sewer system to offsite surface water. Such discharge may be associated with environmental impacts, depending on the VOC concentrations and the volume of the discharge. Failure of the catalytic oxidation unit would result in the release of VOCs to ambient air. Failures of the treatment system should be detected during the routine maintenance performed on the units.

If there is sufficient dilution in the drinking water supply system with water from clean wells, failure of any of the offsite treatment systems may not affect the overall long-term effectiveness of this alternative in protecting public health.

The adequacy and reliability of deed restrictions depend on their continued enforcement.

4.4.2.4 Reduction of Toxicity, Mobility, and Volume

Continued groundwater extraction and treatment at the municipal supply wells would reduce VOC toxicity before use of the groundwater in the public water supply systems.

The modifications to the existing extraction wells would prevent further vertical VOC migration from the shallow to the deeper bedrock groundwater systems. The source control extraction system would prevent further migration of the highest groundwater VOC concentrations at the site. This system would reduce the toxicity, mobility, and volume of VOCs in groundwater within the pumping radius of the wells. Outside of the zone of influence of the extraction system, however, TCE and other VOCs would continue to migrate to the site boundary in both the shallow and intermediate bedrock groundwater systems. Therefore, outside the zone of influence of the extraction system, VOC toxicity, mobility, and volume would not be affected. Periodic removal of LNAPL is expected to increase the effectiveness of the groundwater extraction system in reducing VOC toxicity, mobility, and volume by removing this continuing source of TCE to the groundwater system. As previously noted, some VOCs probably would remain in bedrock fractures at the site.

Approximately 45 to 50 million gallons of groundwater would be extracted and treated yearly. The VOCs would be transferred from the liquid to the vapor phase by the air stripper and destroyed in the vapor phase by the catalytic oxidation unit. The air stripper and catalytic oxidation unit would be effective in reducing or eliminating the toxicity, mobility, or volume of the VOCs in the effluent groundwater and the emissions from the air stripper.

4.4.2.5 Short-Term Effectiveness

The offsite component of this alternative is not expected to have any short-term impacts to the community because the systems are already operational.

For the onsite system, earth work (i.e., trenching) is needed to construct the piping from the extraction wells to the treatment system and to prepare the ground for the construction of the storage shed. The extraction well installation would be of short duration and is not expected to result in any significant VOCs releases. Therefore, fugitive dust would be the main concern during construction activities. Vehicle traffic over potentially contaminated onsite surface soil also may be a concern and could be mitigated by vehicle decontamination. Dust generation may need to be controlled during construction. Air monitoring for dust may be needed to determine any potential risks and indicate whether additional measures are needed to control emissions or potential exposures. Finally, some soil erosion and site runoff controls may be needed to minimize releases of sediments to the onsite culvert.

Risks to construction workers include direct contact with contaminated soil and inhalation of contaminated dust. Construction workers should be appropriately trained and protective equipment should be available, if indicated to be needed by the air monitoring results. Worker training also is needed to familiarize workers with the potential risks associated with maintenance of the treatment system and how to avoid them.

4.4.2.6 Implementability

Technical Feasibility. The offsite components of this alternative are already in place.

The onsite extraction and treatment system can be installed and operated relatively easy. A design investigation for the extraction system is required before implementation to determine the optimal locations of the extraction wells. The groundwater extraction system can be designed to capture the highest VOC concentrations in the shallow and intermediate bedrock groundwater systems. There are many uncertainties, however, related to the performance of extraction systems in complex bedrock systems, such as that underlying the Fischer and Porter site. Selection of the locations and design of the extraction wells to best meet the remedial action objectives may be the most challenging task in the design of this alternative. In addition, installation and operation of the system would require long-term coordination with Fischer and Porter.

As part of this alternative, water level measurements would be collected from onsite monitoring wells to evaluate the effectiveness of the extraction system in achieving its objectives. Monitoring wells also would be sampled for VOCs to determine the degree to which the system is effective in reducing VOC concentrations in groundwater. Bedrock monitoring to evaluate the effectiveness of the system and detect any new contamination is associated with many uncertainties due to the variability in interconnecting fractures in bedrock system.

Groundwater treatment technologies are proven and easily implemented with all the equipment readily available from vendors. Air stripping is a reliable technology to treat high concentrations of VOC in groundwater. The catalytic oxidation unit would prevent VOC emissions to the atmosphere by destroying the VOCs. The effectiveness of the treatment system to remove VOCs can be monitored by quarterly sampling of the effluent and air emissions from the system.

Administrative Feasibility. This alternative would require the assignment of administrative and institutional responsibilities for the operation and maintenance of the onsite pumping and treatment system and enforcement of the groundwater use restriction. Although actual permits may not bee needed for the system, compliance with the substantive requirements in applicable permits must be verified. The responsibilities for the offsite treatment systems lie with the towns owning these systems. Implementation of deed restrictions would be feasible but would require administrative resources to ensure that the deed restrictions are enforced. Because contaminated groundwater would remain at the site under this alternative, 5-year site reviews would need to be conducted.

Availability of Services and Materials. All the components for the onsite extraction and treatment system (i.e., air stripper, catalytic oxidation unit, wells, etc.) are readily available from vendors. Necessary specialists are available to design, construct, operate, and monitor the performance of the systems.

4.4.2.7 Cost

The present-worth cost, based on a 5 percent discount rate, is $3,559,000. These costs do not include the cost of the remedial design investigation. Appendix E contains detailed data used to prepare the cost estimate.

4.4.3 Alternative 3— Institutional Controls; Source Control by Extraction Wells; Chemical Oxidation; and Discharge to Surface Water

As with Alternative 2, this alternative includes extracting groundwater from the shallow and intermediate bedrock groundwater systems in the source area; disabling the existing extraction and treatment system; modifying the three current extraction wells to serve as monitoring wells (FP1 and FP2) and an LNAPL recovery well (FP7); imposing institutional controls in the form of groundwater use deed restrictions; and performing 5-year site reviews. The difference between Alternatives 2 and 3 is in the type of groundwater treatment provided. Alternative 3 uses chemical oxidation rather than air stripping.

The technology-based remedial alternatives from Section 3 included to form overall groundwater remedial Alternative 3 include institutional controls (G-2); source control by extraction wells (GC-1); chemical oxidation with hydrogen peroxide (GT-4); and discharge to surface water (GD-1).

The key components of the extraction system and institutional controls under Alternative 3 are the same as under Alternative 2. The key components of the treatment system under Alternative 3 are as follows:

- Install specialty equipment, such as a reactor, control systems, and chemical units, for oxidant storage and feed.
- Construct a shed to house the chemical storage.
- Quarterly sample the effluent from the unit to determine compliance with the substantive requirements of any permits. Prepare annual reports to document compliance.

4.4.3.1 Overall Protection of Human Health and the Environment

Alternative 3 provides the same overall protection of human health an the environment as Alternative 2. The onsite treatment system for Alternative 3 would employ a chemical oxidation unit that would aim at completely destroying the VOCs in the extracted groundwater and would not produce any off-gas for treatment. If the oxidation process is complete, the VOCs would be reduced to carbon dioxide, water, and salts. Oxidation can be incomplete, however, and some VOCs may be discharged in the effluent from the unit. A treatability study would be needed before design of the system to determine the appropriate oxidizer, its doze, and needed reaction time for the most complete oxidation of the VOC types and concentrations in groundwater at this site.

4.4.3.2 Compliance with ARARs

Compliance with ARARs and PRGs is expected to be the same under this alternative as under Alternative 2.

4.4.3.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. The magnitude of the residual risks for this alternative will be the same as for Alternative 2. If complete oxidation is achieved, this alternative would completely destroy the VOCs in the extracted groundwater and there would be no air emissions from the system.

Adequacy and Reliability of Controls. The adequacy and reliability of the onsite extraction system and offsite municipal wellhead treatment are the same as for Alternative 2.

In general, chemical oxidation is a reliable technology for treatment of the types and concentrations of VOCs in groundwater at the site. This technology is expected to be effective in treating groundwater from the onsite extraction system. Proper maintenance and operation of the treatment system are required. As with Alternative 2, failure of the onsite treatment system, if undetected, may result in the discharge of VOCs through the storm sewer system to a surface water body. This may result in environmental impacts, depending on the VOC concentrations and volumes discharged. Failure of the system, however, should be detected during the routine maintenance performed on the units.

4.4.3.4 Reduction of Toxicity, Mobility, and Volume

With this alternative, the reduction of VOC toxicity, mobility, and volume in groundwater would be the same as for Alternative 2. The only difference between Alternative 2 and Alternative 3 is the means of reducing VOC toxicity and volume in the extracted groundwater. Alternative 3 would aim at destroying the VOCs in the extracted groundwater to carbon dioxide, water and salts. Oxidation may be incomplete, however, and some VOCs may be discharged with the treated groundwater. No air emissions are expected with this treatment unit.

4.4.3.5 Short-Term Effectiveness

Short-term effectiveness for this alternative is the same as for Alternative 2. Installation of the chemical oxidation unit would not result in community or worker exposures additional to those that would be associated with Alternative 2.

4.4.3.6 Implementability

Technical Feasibility. The technical feasibility of implementing this alternative is the same as for Alternative 2 except for the method of groundwater treatment. Chemical oxidation is a reliable technology to treat high concentrations of VOCs in groundwater. A treatability study is essential for optimum system design.

Administrative Feasibility. The administrative feasibility of implementing this alternative is similar to that of Alternative 2 except that air sampling would not be required because off-gas would not be generated by the chemical oxidation unit.

Availability of Services and Materials. As with Alternative 2, all the components for the onsite extraction and treatment system are readily available from vendors. The necessary specialists are available to design, construct, operate, and monitor the performance of the systems.

4.4.3.7 Cost

The present-worth cost, based on a 5 percent discount rate, is $3,510,000. Appendix E contains detailed data used to prepare the cost estimate.

4.4.4 Alternative 4—Institutional Controls; Sitewide Capture Including Source Control and Downgradient Capture by Extraction Wells; Air Stripping; Catalytic Oxidation; and Discharge to Surface Water

This alternative includes extracting groundwater from the shallow and intermediate bedrock groundwater systems in the source area and at the downgradient edges of TCE the plumes in these systems; treating the groundwater onsite by air stripping; treating the air stripper off-gas with catalytic oxidation; and discharging the treated water to the stormwater culvert. In addition, the current onsite extraction and treatment system would be disabled, and the three current extraction wells modified to serve as monitoring wells (FP1 and FP2) and an LNAPL recovery well (FP7). Finally, institutional controls in the form of groundwater use deed restrictions and 5-year site reviews will be implemented.

The technology-based remedial alternatives from Section 3 included to form overall groundwater remedial Alternative 4 include institutional controls (G-2); sitewide capture by extraction wells (GC-2); air stripping (GT-2); catalytic oxidation (GT-6); and discharge to surface water (GD-1).

The key components of the extraction system under Alternative 3 are as follows:

- Install and develop three extraction well couplets (one shallow well and one intermediate well at each location to anticipated depths of 120 feet and 220 feet bgs, respectively). The wells, designated as SW-1 through SW-3 and IW-1 through IW-3 in Figures 3-5 and 3-6, are located along the centerline of the TCE plume in the shallow bedrock groundwater system.

- The locations of the source control extraction wells SW-3 and IW-3 (shallow and intermediate, respectively) would be moved closer to the source area as shown in Figures 3-5 and 3-6 compared to the locations for these wells under the source control extraction system.

- Two additional extraction wells (SW-4 and SW-5; Figure 3-5) would be installed to an anticipated depth of 120 feet bgs on the downgradient edge of the TCE plume in the shallow bedrock groundwater system. These wells are designed to limit further offsite migration of VOCs in the shallow bedrock groundwater system. Appendix B describes the rationale used in selecting the locations of the extraction wells and the well construction details. The well configuration was designed to capture TCE concentrations greater than 10 μg/L in the shallow bedrock groundwater system.

- Five additional extraction wells (IW-4 through IW-8; Figure 3-6) would be installed to an anticipated depth of 220 feet bgs at the site boundary as close as possible to the downgradient edge of the TCE plume in the intermediate bedrock groundwater system. These wells are designed to limit further offsite migration of VOCs in the intermediate bedrock groundwater system. Appendix B describes the rationale used in selecting the locations of the extraction wells and the well construction details. The well configuration was designed to capture TCE concentrations above PRGs currently found at the site boundary in order to limit further offsite migration of TCE above these concentrations.

- Extract 15 gpm from each of the 13 extraction wells for a total flow rate of 195 gpm.

- Pipe the extracted groundwater from the extraction wells to the treatment location shown in Figure 3-5.

- Discontinue the use of the current air stripper system.

- Partially seal using grout current extraction well FP1 to a depth of 220 feet bgs. Then, install two monitoring wells in the existing holes for wells FP1 and FP2 to monitor the shallow (20 to 120 feet bgs) and intermediate (120 to 220 feet bgs) bedrock groundwater systems. Appendix B describes the construction details for these wells.

- Partially seal using grout well FP7 to a depth of 220 feet bgs to use the well as an LNAPL recovery well. This well depth was selected to allow for groundwater table fluctuations as a result of pumping at nearby extraction wells installed as part of this alternative.

- Remove any accumulated LNAPL from well FP7 on a quarterly basis. Although this frequency is assumed for estimating the costs of this alternative, the frequency may need to be increased or decreased depending on the rate of oil accumulation in the well.

- Collect water level measurements from all existing and new monitoring wells at the site. The frequency of water level monitoring should be higher during the startup of the system and decrease over time. For example, water levels may be collected monthly for the first 6 months, quarterly for the next 1 year, semiannually for the next 3 years, and annually thereafter. The data will be used to evaluate the effectiveness of the new extraction system to achieve hydraulic containment.

- Continue extraction and treatment of groundwater at the offsite municipal supply wells.

The key components for the treatment system and institutional controls under this alternative will be the same as under Alternative 2 except that the treatment system will be sized for a process flow rate of 195 gpm.

4.4.4.1 Overall Protection of Human Health and the Environment

Alternative 4 would provide protection of human health and the environment similar to Alternative 2, except for the additional controls at the site boundary to prevent offsite migration of VOC concentrations in groundwater above PRGs. Specifically, the sitewide capture extraction system builds on the source control extraction system. This system includes the wells installed as part of the source control system where the TCE concentrations are expected to be the highest. In addition, wells would be installed at the anticipated downgradient edges of the TCE plumes in the shallow and intermediated bedrock groundwater systems to capture the TCE concentrations migrating off the site. Therefore, this alternative would lower the toxicity, mobility, and volume of VOCs in groundwater over a wider area than Alternative 2. Thus, this alternative would provide an added protection to public health and the environment over Alternative 2.

Note that although the wells installed at the downgradient edge of the plume may capture the TCE before it migrates offsite, not using wells in the area of highest TCE concentrations (i.e., the source control wells) would draw these highest concentrations closer to the boundary of the site when the downgradient wells are pumped. Therefore, the sitewide capture system includes the source control wells in addition to the wells at the downgradient edges of the plumes. Using wells to capture the highest TCE concentrations before they can migrate further downgradient to the site boundary, is expected to increase the overall effectiveness of the extraction system and provide protection to public health and the environment in addition to that provided by Alternative 2.

As with Alternative 2, this alternative would also prevent further vertical migration of VOCs to the deeper bedrock groundwater systems through the open boreholes of wells FP1, FP2, and FP7 as well as remove any LNAPL accumulated in well FP7. The extracted groundwater would be treated by air stripping and the emissions from the air stripper would be treated by catalytic oxidation. Treatment systems can be designed to meet chemical-specific ARARs, which would provide protection of public health and the environment.

Within the zone of influence of the extraction system on the site, TCE and other VOC concentrations should slowly decrease to the PRGs. For example, calculations in Appendix B estimate that the time required for the extraction system to achieve PRGs would be approximately 121 years in the shallow bedrock groundwater system and 95 years in the intermediate bedrock groundwater system. The times to achieve PRGs under this alternative are higher than under Alternative 2 because of the wider area covered by the extraction system. However, as previously noted, if DNAPL is present, the PRGs may never be achieved. Instead, long-term hydraulic control to prevent offsite migration of the highest TCE groundwater concentrations would be a more appropriate objective for the selected remedial alternative. As with Alternative 2, because of the complexities of bedrock systems, it is uncertain how much contaminated groundwater will remain in bedrock fractures at the end of any implementation period.

Because VOC concentrations above PRGs have already migrated offsite, this alternative relies on the pumping and treatment at the offsite municipal supply wells to remove the TCE and other VOCs to permissible levels (i.e., MCLs) before use of the groundwater in the water supply systems.

On the basis of the above discussion, this remedial alternative reduces the human health risks associated with exposures to the highest VOC concentrations in groundwater and prevents further offsite migration of VOCs by capturing the VOCs at the downgradient edges of the plumes in both the shallow and intermediate bedrock groundwater systems. The downgradient capture of VOCs is an added benefit over Alternative 2. As with Alternative 2, Alternative 4 reduces VOC concentrations in the effluent and air emissions from the new treatment system to levels considered protective of public health and the environment. The institutional controls, if implemented, would further help the effectiveness of this alternative by restricting the use of untreated groundwater and by monitoring the effectiveness of both the extraction and treatment components of the alternative. The extracted LNAPL from well FP7 will be drummed and sent for offsite incineration, which would be protective of public health and the environment so long as properly permitted facilities are used. On the basis of the above, Alternative 4 is considered to be responsive to the remedial action objectives established for the site and to be more protective of public health and the environment than Alternative 2.

4.4.4.2 Compliance with ARARs

Compliance with chemical, location, and action specific ARARs for Alternative 4 will be identical to Alternative 2.

4.4.4.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. The magnitude of residual risks for this alternative is similar to Alternative 2. The additional downgradient extraction wells under Alternative 4 would lower the long-term residual risks associated with VOCs in onsite groundwater. These downgradient wells would increase the overall effectiveness of the extraction system but would also increase the time required to achieve PRGs because these would be achieved over a larger area than under Alternatives 2 and 3.

Adequacy and Reliability of Controls. The adequacy and reliability of controls for this alternative are the same as for Alternative 2.

4.4.4.4 Reduction of Toxicity, Mobility, and Volume

Alternative 4 would reduce VOC toxicity, mobility, and volume over a greater area of groundwater than Alternative 2. The source control and downgradient onsite extraction wells would capture the VOCs before they can migrate offsite at concentrations above PRGs. Approximately 100 million gallons of groundwater would be extracted and treated yearly. The VOCs would be transferred from the liquid to the vapor phase by the air stripper and destroyed in the vapor phase by the catalytic oxidation unit. The air stripper and catalytic oxidation unit would be effective in reducing or eliminating the toxicity, mobility, or volume of the VOCs in the effluent groundwater and the emissions from the air stripper. As with Alternative 2, the offsite treatment would reduce VOC toxicity and volume at the point of groundwater consumption.

4.4.4.5 Short-Term Effectiveness

The short-term risks of exposure associated with this alternative are similar to those associated with Alternative 2 except that this alternative would require a longer construction period because of the higher number of wells, extent of piping, and size of treatment system. These short-term risks could be minimized by using engineering controls and personal protection similar to those that may be used under Alternative 2.

4.4.4.6 Implementability

Technical Feasibility. The technical feasibility of this alternative is similar to that of Alternative 2. Although the onsite extraction and treatment system would be larger for this alternative than for Alternative 2, the system can be installed and operated relatively easy. As with Alternative 2, a design investigation must be completed before implementation of the system to determine the optimal locations of the extraction wells.

Administrative Feasibility. The administrative feasibility of this alternative is similar to that of Alternative 2

Availability of Services and Materials. The availability of services and materials for this alternative are similar to those under Alternative 2

4.4.4.7 Cost

The present-worth cost, based on a 5 percent discount rate, is $5,110,000. Appendix E contains detailed data used to prepare the cost estimate.

4.4.5 Alternative 5— Institutional Controls; Sitewide Capture Including Source Control and Downgradient Capture by Extraction Wells; Chemical Oxidation; and Discharge to Surface Water

As with Alternative 4, this alternative includes extracting groundwater from the shallow and intermediate bedrock groundwater systems in the source area as well as at the downgradient edges of the plumes in the shallow and intermediate bedrock groundwater systems; disabling the existing extraction and treatment system; modifying the three current extraction wells to serve as monitoring wells (FP1 and FP2) and an LNAPL recovery well (FP7); imposing institutional controls in the form of groundwater use deed restrictions; and performing 5-year site reviews. The difference between Alternatives 4 and 5 is in the type of groundwater treatment provided. Alternative 5 uses chemical oxidation rather than air stripping.

The technology-based remedial alternatives from Section 3 included to form overall groundwater remedial Alternative 5 include institutional controls (G-2); sitewide capture by extraction wells (GC-2); chemical oxidation with hydrogen peroxide (GT-4); and discharge to surface water (GD-1).

The key components of the extraction system and institutional controls under Alternative 5 are the same as under Alternative 4. The key components of the treatment system under Alternative 5 are as follows:

- Install specialty equipment, such as a reactor, control systems, and chemical units for oxidant storage and feed.
- Construct a shed to house the chemical storage.
- Quarterly sample the effluent from the unit to determine compliance with the substantive requirements of any permits. Prepare annual reports to document compliance.

4.4.5.1 Overall Protection of Human Health and the Environment

Alternative 5 provides the same overall protection of human health an the environment as Alternative 4. The onsite treatment system for Alternative 5 would employ a chemical oxidation unit that would aim at completely destroying the VOCs in the extracted groundwater and would not produce any off-gas for treatment. If the oxidation process is complete, the VOCs would be reduced to carbon dioxide, water, and salts. Oxidation can be incomplete, however, and some VOCs may be discharged in the effluent from the unit. A treatability study would be needed before design of the system to determine the appropriate oxidizer, its doze, and needed reaction time for the most complete oxidation of the VOC types and concentrations in groundwater at this site.

4.4.5.2 Compliance with ARARs

Compliance with ARARs and PRGs is expected to be the same under this alternative as under Alternative 4.

4.4.5.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. The magnitude of the residual risks for this alternative will be the same as for Alternative 4. If complete oxidation is achieved, this alternative would completely destroy the VOCs in the extracted groundwater and there would be no air emissions from the system.

Adequacy and Reliability of Controls. The adequacy and reliability of the onsite extraction system and offsite municipal wellhead treatment are the same as for Alternative 4.

In general, chemical oxidation is a reliable technology for treatment of the types and concentrations of VOCs in groundwater at the site. This technology is expected to be effective in treating groundwater from the onsite extraction system. Proper maintenance and operation of the treatment system are required. As with Alternative 4, failure of the onsite treatment system, if undetected, may result in the discharge of VOCs through the storm sewer system to a surface water body. This may result in environmental impacts, depending on the VOC concentrations and volumes discharged.

4.4.5.4 Reduction of Toxicity, Mobility, and Volume

With this alternative, the reduction of VOC toxicity, mobility, and volume in groundwater would be the same as for Alternative 4. The only difference between Alternative 4 and Alternative 5 is the means of reducing VOC toxicity and volume in the extracted groundwater. Alternative 5 would aim at destroying the VOCs in the extracted groundwater to carbon dioxide, water, and salts. Oxidation may be incomplete, however, and some VOCs may be discharged with the treated groundwater. No air emissions are expected with this treatment unit.

4.4.5.5 Short-Term Effectiveness

Short-term effectiveness for this alternative is the same as for Alternative 4. Chemical oxidation does not require operational activities that could result in community or worker exposures additional to those that would be associated with Alternative 4.

4.4.5.6 Implementability

Technical Feasibility. The technical feasibility of implementing this alternative is the same as that of Alternative 4 except for the method of groundwater treatment. Chemical oxidation is a reliable technology to treat high concentrations of VOCs in groundwater. A treatability study is essential for optimum system design.

Administrative Feasibility. The administrative feasibility of implementing this alternative is similar to that of Alternative 4 except that air sampling would not be required because off-gas would not be generated by the chemical oxidation unit.

Availability of Services and Materials. As with Alternative 4, all the components for the onsite extraction and treatment system are readily available from vendors. The necessary specialists are available to design, construct, operate, and monitor the performance of the systems.

4.4.5.7 Cost

The present-worth cost, based on a 5 percent discount rate, is $5,576,000. Appendix E contains detailed data used to prepare the cost estimate.

4.5 Comparative Analysis of Alternatives for Both Soil and Groundwater

In the following analysis, the overall remedial alternatives are evaluated in relation to one another and to each of the seven criteria required by the NCP. This analysis identifies the relative advantages and disadvantages of each alternative and is conducted separately for the two media of concern at the site, soil and groundwater. Tables 4-2 and 4-3 and Tables 4-5 and 4-6 summarize the results of this analysis for contaminated soil and groundwater, respectively.

4.5.1 Comparative Analysis of Soil Alternatives

The following three overall remedial action alternatives were assembled and evaluated for contaminated soil at the site:

- Alternative 1—No Action
- Alternative 2—Institutional Controls
- Alternative 3—Institutional Controls and Capping

4.5.1.1 Protection of Human Health and the Environment

All three alternatives entail no removal, containment, or treatment of contaminated soil at the site. Alternative 2 uses deed restrictions to restrict future residential use of the site and excavation into contaminated soil. In addition to deed restrictions, Alternative 3 uses an asphalt cap to prevent exposures to contaminated soil at the site. The deed restrictions under Alternative 3 restrict excavation into contaminated soil but not the potential future residential use of the site and thus, would be less restrictive than the deed restrictions under Alternative 2.

Therefore, although contaminated soil would remain in place under both Alternatives 2 and 3, they would both contribute to protection of human health and the environment by restricting the potential for contact with the contaminated soil. As such, both alternatives would be considered responsive to the remedial action objectives for the site. The main difference between the two alternatives is the provision of the asphalt cap under Alternative 3 in comparison to Alternative 2.

As with Alternative 1 (no action), both Alternatives 2 and 3 would not achieve any reduction in the toxicity or volume of the chemicals found in the soil. Natural degradation, adsorption, and leaching of chemicals to groundwater would take many years to reduce chemical concentrations to the selected PRGs Therefore, the PAHs and PCBs would persist in the soil for many years. Under Alternative 3, there will be some reduction in the mobility of the chemicals due to reduced infiltration as a result of the cap. This migration pathway, however, does not appear to be significant even under current site conditions as indicated by the limited presence of these classes of compounds in groundwater at the site during the Phase II RI. Specifically, during the Phase II RI, these compounds were either detected at concentrations below levels of concern (PAHs) or not detected at all (PCBs) in groundwater samples collected from onsite monitoring wells.

4.5.1.2 Compliance with ARARs

Chemical-Specific ARARs. There are no chemical-specific ARARs for soil. With regard to the selected PRGs, all three alternatives are expected to require many years to attain these levels. Natural degradation and leaching may eventually result in achievement of the PRGs for some of the chemicals. Others may persist for many years. In general, the time frame to reach the PRGs is unknown but is expected to take many years. In the meantime, however, Alternatives 2 and 3 would provide protection by restricting the potential for contact with the contaminated soil.

Location-Specific ARARs. There are no activities under all three alternatives that would trigger any location-specific ARARs.

Action-Specific ARARs. There are also no applicable action-specific ARARs to Alternatives 1 and 2. Alternative 3 may require plans to control erosion, sedimentation, and dust during earth-moving activities. These plans are easy to implement, and thus the alternative can meet the action-specific ARARs.

4.5.1.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risks. All three alternatives would not remove the chemicals currently found in onsite soil. Alternatives 2 and 3 would, however, prevent contact with the soil by installing of a cap or by implementing of deed restrictions. Therefore, both alternatives would reduce the risks associated with soil contamination by restricting the potential for exposures to the soil. Alternative 3 is expected to be more effective than Alternative 2 because of the added protection provided by the asphalt cap. The effectiveness of Alternative 3 would depend, however, on proper cap maintenance and consistent enforcement of the deed restrictions. Installing the cap also would reduce rainfall infiltration and the potential for migration of PAHs and PCBs from the soil to the groundwater although this pathway appears not to be significant based on the Phase II RI groundwater data.

Adequacy and Reliability of Controls. All three alternatives will require long-term sampling of soil and ground water. As required by SARA, 5-year reviews must be performed to evaluate site conditions because contaminated soil would remain in place under all three alternatives. If justified by the reviews, further remedial actions may need to be implemented at the site.

If maintained, the institutional controls under Alternative 2 should be effective over the long-term in reducing the risks associated with the site by restricting the potential for contact with the chemicals found in the soil. Alternative 3 would, however, provide a higher degree of reliability of the imposed controls over Alternative 2 because of the addition of the asphalt cap. Although long-term risks could result from poor cap maintenance or noncompliance with deed restrictions under this alternative, the likelihood of such problems is small. The adequacy of the controls established as part of both Alternatives 2 and 3 would be reviewed as part of the 5-year site reviews.

4.5.1.4 Reduction of Toxicity, Mobility, and Volume

All three alternatives do not provide for the removal or treatment of PAHs and PCBs found in onsite soil. Therefore, they would not reduce the volume or toxicity of chemicals. The mobility of these chemicals is already relatively low due to their sorptive nature. Alternative 3 would further reduce their mobility by reducing the infiltration of precipitation and subsequent possible leaching of the PAHs and PCBs from the soil to the groundwater although this pathway appears not to be significant based on the Phase II RI groundwater data.

4.5.1.5 Short-Term Effectiveness

There would be no short-term effects associated with Alternatives 1 and 2 because they do not involve remedial activities at the site. There would be limited short-term adverse effects associated with the construction of the asphalt cap under Alternative 3. The construction of this alternative, however, can be easily managed to minimize these short- term effects to nearby residents, facility personnel, and construction workers. The cap is relatively easy to design and construct. Therefore, the time frame expected to be needed to complete the cap design and construction is expected to be relatively short.

4.5.1.6 Implementability

Technical Feasibility. All three alternatives will require site reviews every 5 years. These reviews are expected to be simple to implement and would not require any specialized technical expertise. There are several monitoring wells at the site that can be used for groundwater monitoring under all three alternatives. Soil borings would be needed to sample the soil. Sampling of soil and monitoring wells is a relatively simple task that could be performed by local contractors. Little difficulty would be involved in the implementation of these tasks and the work could be completed within a relatively short period.

Constructing an asphalt cap under Alternative 3 also is expected to be relatively easy to implement. Grading and placement of the cap are common construction activities that can be performed using standard construction equipment and procedures, and contractors capable of performing the work are locally available. Therefore, design and construction of the cap should not pose any significant obstacles. The cap is operationally reliable, and occasional maintenance may be required to repair portions of the cap that become damaged due to weather or onsite activities. Construction and maintenance of the cap installed under current site use would require some coordination with Fischer and Porter.

Administrative Feasibility. Long-term management and administrative attention would be required under all three alternatives since site reviews would be conducted every 5 years. Some coordination between federal, state, and local authorities would be required to review data and make decisions in the future.

Implementation of the deed restrictions under Alternatives 2 and 3 would be feasible but would require some coordination with Fischer and Porter if current site use continues. The deed restriction should prohibit excavation or other activities that will result in contact with contaminated soil without the appropriate protective measures. Following any excavation into capped areas, the deed restriction should require cap rehabilitation.

Availability of Services and Materials. The services and materials required for implementation of all three alternatives are readily available from local sources. Contractors are available who can supply the necessary technical expertise, equipment, and supplies to implement all three alternatives.

4.5.1.7 Cost

Table 4-3 presents a comparative cost summary of the three overall soil alternatives. The costs for Alternative 3 are the highest because of the addition of the asphalt cap over Alternative 2.

4.5.2 Comparative Analysis of Groundwater Alternatives

The following five overall remedial action alternatives were assembled and evaluated for contaminated groundwater at the site:

- Alternative 1—No Action

- Alternative 2—Institutional Controls; Source Control by Extraction Wells; Air Stripping; Catalytic Oxidation; and Discharge to Surface Water

- Alternative 3— Institutional Controls; Source Control by Extraction Wells; Chemical Oxidation; and Discharge to Surface Water

- Alternative 4— Institutional Controls; Sitewide Capture Including Source Control and Downgradient Capture by Extraction Wells; Air Stripping; Catalytic Oxidation; and Discharge to Surface Water

- Alternative 5— Institutional Controls; Sitewide Capture Including Source Control and Downgradient Capture by Extraction Wells; Chemical Oxidation; and Discharge to Surface Water

4.5.2.1 Protection of Human Health and the Environment

With the exception of Alternative 1, all remaining alternatives (2 through 5) include the design and operation of a new groundwater extraction system at the site. The alternatives differ mainly on the extent of capture that the new extraction system aims at achieving. Specifically, Alternatives 2 and 3 include extraction of the highest VOC concentrations found in groundwater at the site. Alternatives 4 and 5 include extraction of these highest VOC concentrations as well as capture of the lower (but still above PRGs) VOC concentrations found along the site perimeter. Therefore, Alternatives 4 and 5 would lower the toxicity, mobility, and volume of VOCs in groundwater over a larger area than Alternatives 2 and 3. Thus, Alternatives 4 and 5 would provide an added protection to public health and the environment over Alternatives 2 and 3.

Calculations in Appendix B estimate the time required for both the source control and sitewide capture extraction systems to achieve PRGs. For the source control extraction system, this time would be approximately 97 years in the shallow bedrock groundwater system and 70 years in the intermediate bedrock groundwater system. For the sitewide capture extraction system, this time would be approximately 121 years in the shallow bedrock groundwater system and 95 years in the intermediate bedrock groundwater system. As can be expected, the time to achieve PRGs is higher for the sitewide capture extraction system than for the source control extraction system because the sitewide capture system covers a larger area of groundwater contamination.

Under all alternatives, the time to achieve PRGs is high. This is because of the elevated VOC concentrations found in groundwater at the site and the hydraulic characteristics of the bedrock groundwater systems, which limit the rate at which groundwater can be extracted. However, if DNAPL is present, this time may be even higher and, in fact, the PRGs may never be achieved. Instead, long-term hydraulic control to prevent offsite migration of the highest TCE groundwater concentrations would be a more appropriate objective for the selected extraction system. In addition, because of the complexities of bedrock systems, it is uncertain how much VOCs will remain in bedrock fractures at the end of the implementation period for any of the alternatives.

Because VOC concentrations above PRGs have already migrated offsite, all alternatives rely on the pumping and treatment at the offsite municipal supply wells to remove the TCE and other VOCs to permissible levels (i.e., MCLs) before use of the groundwater in the water supply systems.

In addition to controlling the horizontal migration of VOCs, with the exception of the no action alternative, the remaining four alternatives would prevent further vertical migration of VOCs to the deeper bedrock groundwater systems through the open boreholes of wells FP1, FP2, and FP7 as well as remove any LNAPL accumulated in well FP7.

The extracted groundwater would be treated under all alternatives. Under the no action alternative, VOCs from the existing air stripper would continue to be released to ambient air and present a potential health concern to onsite workers. The extracted groundwater under the remaining alternatives would be treated either by air stripping or chemical oxidation. Off-gas treatment would be required for alternatives that involve air stripping (alternatives 2 and 4). No off-gas treatment would be needed for alternatives involving chemical oxidation of the extracted groundwater (Alternatives 3 and 5). The treatment systems for both groundwater and air would reduce the toxicity, mobility, and volume of VOCs in the extracted groundwater and air emissions from the air stripping units. These treatment systems can be designed to meet chemical-specific ARARs, which would provide protection of public health and the environment.

The institutional controls, if implemented under Alternatives 2 through 4, also would help the effectiveness of these alternatives by restricting the use of untreated groundwater and by monitoring the effectiveness of both the extraction and treatment components of the alternatives. The extracted LNAPL from well FP7 will be drummed and sent for offsite incineration under all four alternatives, which would be protective of public health and the environment so long as properly permitted facilities are used.

On the basis of the above, Alternatives 2 through 4 are considered to be responsive to the remedial action objectives established for the site. However, the degree of protection offered by Alternatives 4 and 5 is expected to be higher than that offered by Alternatives 2 and 3 because of the larger area of groundwater contamination covered by the sitewide capture extraction system. Between Alternatives 4 and 5, there is no apparent difference in the protection provided because all treatment components can be designed to meet chemical-specific ARARs. If oxidation is complete, however, this process should permanently destroy the VOCs in the extracted groundwater to carbon dioxide, water, and salts. Oxidation can, however, be incomplete due to variability in the influent concentrations and groundwater quality. If complete oxidation is achieved, there would be no VOC releases from the chemical oxidation unit.

4.5.2.2 Compliance with ARARs

Chemical-Specific ARARs. All alternatives would achieve compliance with chemical-specific ARARs at the point of groundwater use (i.e., water supply system) and treatment system discharges (i.e., stormwater culvert and ambient air). Alternatives differ on the time estimated to be needed to decrease VOC concentrations in groundwater to PRGs.

Location-Specific ARARs. None of the alternatives are anticipated to trigger any location-specific ARARs.

Action-Specific ARARs. It is expected that all alternatives can be designed to meet action-specific ARARs.

4.5.2.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risk. Under all alternatives, the long-term risks associated with the use of groundwater for public water supply would be addressed by the treatment systems provided at the municipal wells. These treatment systems would lower the residual risk to permissible concentrations for drinking water use (i.e., the MCLs).

In addition to the wellhead treatment, Alternatives 2 through 5 include onsite extraction and treatment of VOCs in groundwater at the site. Alternatives 2 and 3 would be effective in managing the long-term risks associated with the highest VOC concentrations captured by the source control extraction system. The additional downgradient extraction wells under Alternatives 4 and 5 would further lower the long-term residual risks associated with the site. This will be achieved by preventing the offsite migration of the lower (but still above PRGs) VOC concentrations found in groundwater outside of the zone of influence of the source control extraction system under Alternatives 2 and 3 but within the zone of influence of the extraction system under Alternatives 4 and 5. Thus, the downgradient wells under Alternatives 4 and 5 would result in a higher overall effectiveness of these alternatives compared to Alternatives 2 and 3.

Note that there are many uncertainties related with the performance of extraction systems in complex bedrock systems, such as those underlying the Fischer and Porter site. These uncertainties are increased if DNAPL is present, which may be the case at this site based on the elevated TCE concentrations (greater than 1 percent of the solubility of TCE) measured in some of the wells. If DNAPL is present, as previously noted, both the source control as well as the sitewide extraction systems may never achieve the established PRGs.

All five alternatives are considered effective in managing the long-term risks associated with discharge of the extracted groundwater. Under the no action alternative, the extracted groundwater is treated by air stripping and the effluent from the air stripper meets the limits set in the current discharge permit for the system. Emissions from the air stripper are below the PADEP *de minimis* level of 3 lbs/hr. However, these emissions were still shown to present potential risks to onsite workers (CH2M HILL, 1997).

The treatment systems included under Alternatives 2 through 4 would reduce the VOC concentrations in the effluent and air emissions from the systems to levels considered protective of public health and the environment. These treatment systems would manage the residual risks associated with the extracted groundwater. The institutional controls also would help their effectiveness by restricting the use of untreated groundwater. Finally, the extracted LNAPL from well FP7 will be drummed and sent for offsite incineration, which would be an effective long-term management of the risks associated with this waste stream as long as properly permitted facilities are used.

The only difference between the performance of the treatment components of Alternatives 2 through 5 is if chemical oxidation of the VOCs under Alternatives 3 and 5 is complete. Specifically, if oxidation is complete, the VOCs in the extracted groundwater would be converted to carbon dioxide, water, and salts. In addition, there are no significant air emissions from chemical oxidation units. A treatability study is required to determine the optimum design of this unit.

Adequacy and Reliability of Controls. Proper operation of extraction systems is relatively simple and the systems are expected to be reliable. Failure of both the source control and sitewide capture extraction systems is not expected to result in any immediate human exposures to VOCs because groundwater at the municipal supply wells is treated before its use in the water supply systems. Elevated VOC concentrations would, however, be allowed to migrate during the time the extraction system is down.

Air stripping is a reliable treatment technology. The existing air strippers at the municipal supply wells have been reliable and effective in reducing VOC concentrations in the extracted groundwater to MCLs. Air stripping also is expected to be effective in treating groundwater from the onsite extraction system under Alternatives 2 and 4. Catalytic oxidation, part of Alternatives 2 and 4, is also a reliable technology and is expected to be effective in treating the off-gas from the air stripper. Finally, chemical oxidation, used under Alternatives 3 and 5, is a reliable technology for treatment of the types and concentrations of VOCs in groundwater at the site although a treatability study is required to determine the optimum system design.

Proper maintenance and operation of all treatment systems is important to achieve the established discharge limits. In particular, maintenance of the air stripper (i.e., acid washing) must be performed periodically to prevent clogging from scaling and fouling. Failure of any of the treatment systems, if undetected, may result in the discharge of contaminated groundwater through the storm sewer system to offsite surface water. Such discharge may be associated with environmental impacts, depending on the VOC concentrations and the volume of the discharge. Failure of the catalytic oxidation unit would result in the release of VOCs to ambient air. Failures of the treatment systems should be detected during the routine maintenance performed on the units.

Under all alternatives, there is sufficient dilution in the drinking water supply system with water from clean wells, failure of any of the offsite treatment systems may not affect the overall long-term effectiveness of the alternatives in protecting public health.

The adequacy and reliability of deed restrictions are dependent on their continued enforcement under all alternatives.

4.5.2.4 Reduction of Toxicity, Mobility, and Volume

Continued groundwater extraction and treatment at the municipal supply wells would reduce VOC toxicity before use of the groundwater in the public water supply systems.

Alternatives 4 and 5 would reduce VOC toxicity, mobility, and volume over a larger area of groundwater than Alternatives 2 and 3. The source control and downgradient onsite extraction wells (FP1, FP2, and FP7) would capture the VOCs before they can migrate offsite at concentrations above PRGs. Under Alternatives 2 through 5, the modifications to the existing extraction wells (FP1, FP2, and FP7) would prevent further vertical VOC migration from the shallow to the deeper bedrock groundwater systems. In addition, all four alternatives include removing the LNAPL in well FP7, which currently acts as a continuing source of TCE to groundwater. As previously noted, some VOCs would probably remain in bedrock fractures at the site at the end of the implementation period under all alternatives.

Under Alternatives 2 and 4, the VOCs would be transferred from the liquid to the vapor phase by the air stripper and destroyed in the vapor phase by the catalytic oxidation unit. The air stripper and catalytic oxidation unit would be effective in reducing or eliminating the toxicity, mobility, or volume of the VOCs in the extracted groundwater and the emissions from the air stripper. Under Alternatives 3 and 5, the chemical oxidation unit would also be effective in reducing the toxicity, mobility, and volume of the VOCs in the extracted groundwater. If oxidation is complete, this unit should convert the VOC to innocuous substances like carbon dioxide, water, and salts.

4.5.2.5 Short-Term Effectiveness

The offsite component of all alternatives is not expected to have any short-term impacts to the community because the systems are already operational.

There are no short-term risks associates with the no action alternative because the components of this alternative are already in place. The short-term risks to the community, facility employees, construction workers, and the environment under Alternatives 2 through 5 can be managed by implementing engineering, monitoring, and personal protection controls.

4.5.2.6 Implementability

Technical Feasibility. The offsite components of all alternatives are already in place.

Under Alternatives 2 through 5, the onsite extraction system can be installed and operated relatively easy. A design investigation, however, is required to determine the optimal locations of the extraction wells under both extraction scenarios. Note that there are many uncertainties related to the performance of extraction systems in complex bedrock systems such as those underlying the Fischer and Porter site. Selection of the locations and design of the extraction wells to best meet the remedial action objectives is the most challenging task in the implementation of a remedial action at the Fischer and Porter site. In addition, installation and operation of any new extraction system would require long-term coordination with Fischer and Porter.

The treatment technologies under Alternatives 2 through 5 are proven and easily implemented with all the equipment readily available from vendors. Both air stripping and chemical oxidation are reliable technologies to treat high concentrations of VOC in groundwater. The catalytic oxidation unit would prevent VOC emissions to the atmosphere by destroying the VOCs. The effectiveness of any treatment system to remove VOCs can be monitored through the quarterly sampling of the effluent and air emissions from the system.

As part of Alternatives 2 through 5, water level measurements would be collected from onsite monitoring wells to evaluate the effectiveness of the implemented extraction system to achieve its objectives. Monitoring wells also would be sampled for VOCs to determine the degree to which the system is effective in reducing VOC concentrations in groundwater.

Administrative Feasibility. Alternatives 2 through 5 would require the assignment of administrative and institutional responsibilities for the operation and maintenance of the selected onsite pumping and treatment system and enforcement of institutional controls. Although actual permits may not be needed for the systems, compliance with the substantive requirements in applicable permits must be verified for all alternatives. The responsibilities for the offsite treatment systems lie with the towns operating these systems.

There would be no administrative responsibilities associated with operation of the existing extraction and treatment system under the no action alternative because this system is operated by Fischer and Porter.

Because contaminated groundwater would remain at the site under all alternatives, 5-year site reviews would need to be conducted.

Availability of Services and Materials. The components of all five alternatives are readily available from vendors. Necessary specialists are available to design, construct, operate, and monitor the performance of the systems.

4.5.2.7 Cost

Table 4-6 presents a comparative cost summary of the five overall groundwater Alternatives. From the source control Alternatives 2 and 3, Alternative 3 involving treatment of the extracted groundwater using chemical oxidation provides the lower costs. From the site-wide capture Alternatives 4 and 5, Alternative 4 involving treatment of the extracted groundwater using air stripping and catalytic oxidation provides the lower costs.

Section 5
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Appendix A
Estimates of the Extent and Volume of Soil, LNAPL, and Groundwater Requiring Remedial Action

1. Introduction

This appendix presents estimates of the areas and volumes of soil, LNAPL, and groundwater requiring remedial action. These estimates were developed based on the sampling results presented in the RI report and summarized in Section 1 of the FS report and the PRGs identified in Section 2 of the FS report. These estimates were developed for estimating cost because the total area of each medium requiring remedial action has not been fully delineated.

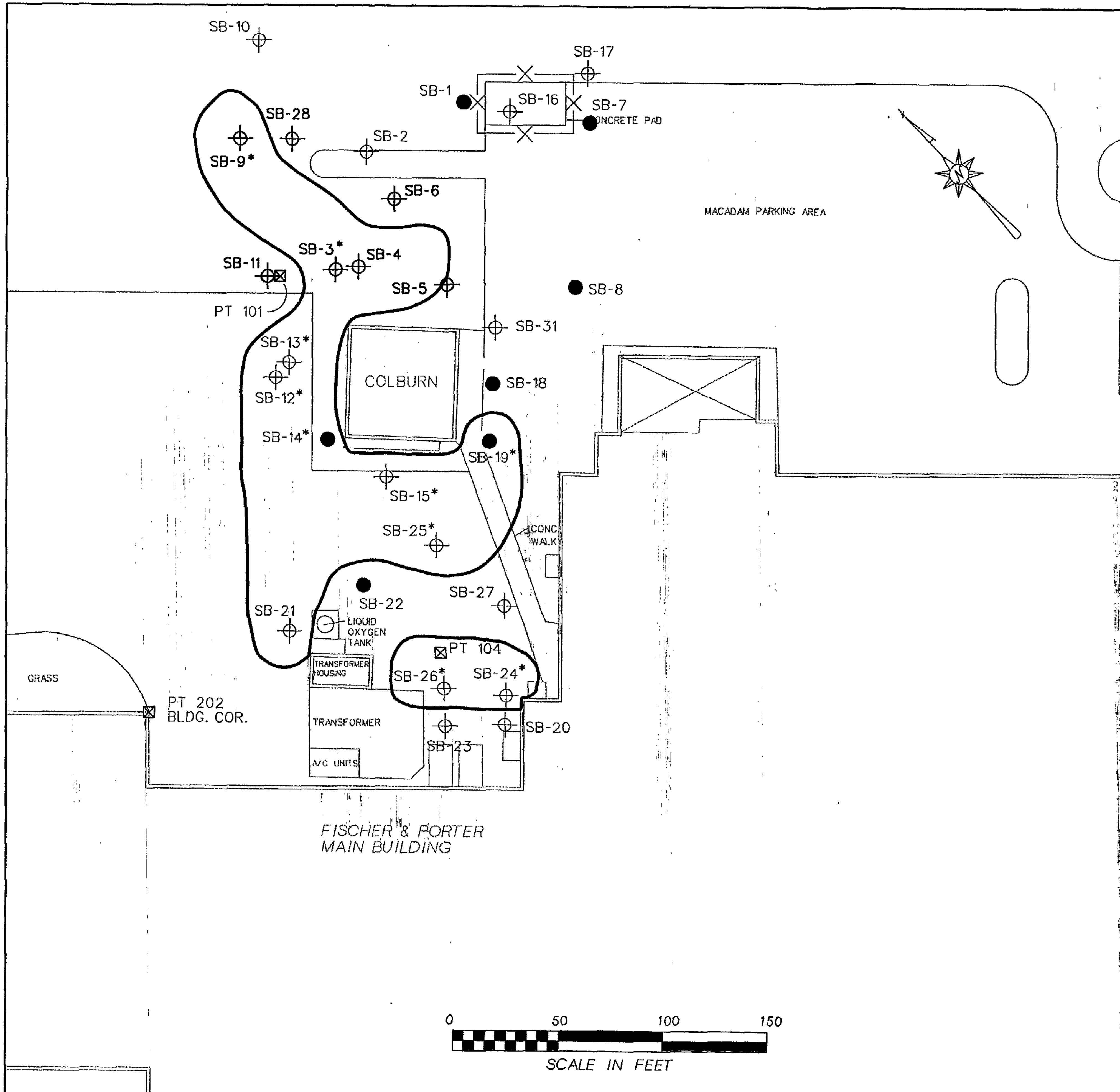
2. Soil

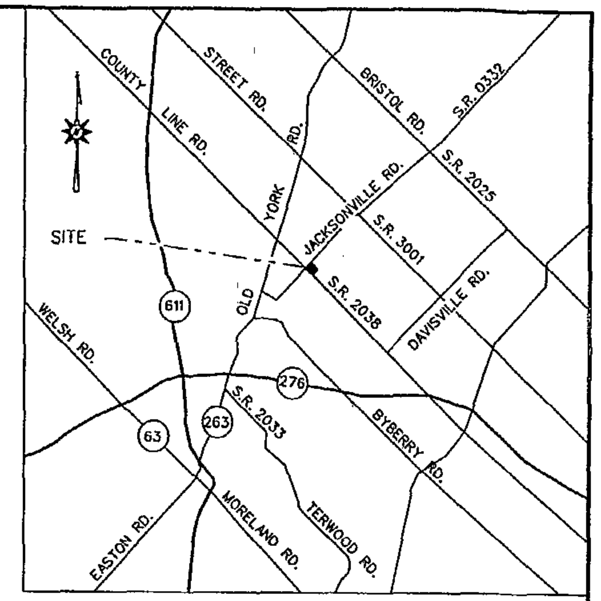
The area and volume of soil requiring remedial action was determined based on soil borings containing PAHs and PCBs above PRGs. PAHs and PCBs were identified as the COPCs requiring remedial action in Section 2 of the FS report.

Figure A-1 shows the locations of borings where PAHs and PCBs were detected above their respective PRGs. To determine the areal extent of contamination, PAHs and PCBs concentrations in soils were assumed to decrease away from a sampling location containing these COPCs above the PRGs and reach the PRGs at half the distance between that sampling location and the nearest location where the PRGs were not exceeded. For boring locations where there was not another boring in a certain direction to determine the extent of contamination, soil concentrations above the PRGs were assumed to extend approximately 15 feet from the boring in that direction.

For example, some of the borings along the northern and eastern boundaries of the source area contained PCBs and PAHs above the PRGs (SB-9, SB-13, and SB-12). However, there were no borings to the north or east to determine the horizontal extent of soil concentrations above PRGs. In such instances, the concentrations above PRGs were assumed to extend 15 feet from the borings in the direction of the missing data.

In some instances, there were no borings containing PAHs and PCBs below the PRGs between borings with concentrations above the PRGs. For example, there were no such borings between borings SB-21 and SB-12, SB-14, and SB-15. Because all of the borings contained PAHs and PCBs above the PRGs, the soil in the entire area between the borings was considered to contain these COPCs above the PRGs.





LOCATION MAP
(N.T.S.)

LEGEND

- ⌖ SURVEYED SOIL BORING LOCATION
- ● APPROXIMATE SOIL BORING LOCATION
- ⊠ SURVEY REFERENCE POINTS
- ⌒ AREA OF SOIL REQUIRING REMEDIAL ACTION

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBRUARY 12, 1991.
3. HORIZONTAL DATUM ARE ASSUMED & ROTATED TO PLAN BOUNDARY MERIDIAN.
4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. ALL BORING LOCATIONS WERE SURVEYED EXCEPT FOR THE FOLLOWING: SB-1, SB-7, SB-8, SB-14, SB-18, SB-19, SB-22, SB-29 AND SB-30.
7. * INDICATES BORING IN WHICH CONCENTRATIONS OF PAHs OR PCBs EXCEED THE PRGs.

● SB-29

SB-30 ●

Figure A-1
AREA OF SOIL REQUIRING REMEDIAL ACTION
FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

CH2M HILL

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The extent of soil containing PAHs and PCBs above the PRGs, determined by extrapolating between boring locations, is shown in Figure A-1. PAH and PCB concentrations are not extrapolated underneath the buildings because no data were collected underneath these structures. Borings SB-4 and SB-5 were located between borings SB-3 and SB-8; however, no samples were collected from borings SB-4 and SB-5. Therefore, soil concentrations above PRGs are assumed to occur from SB-3 up to half the distance between SB-3 and SB-8.

Two distinct areas emerged as containing PAH and PCB concentrations above the PRGs. The first large area is estimated to be approximately 17,325 square feet and the second smaller area is estimated to be 1,800 square feet. The depth of contamination is assumed to be 10 feet in the large area based on the depth to soil samples containing PAHs and PCBs below the PRGs. The depth of contamination in the smaller area is assumed to be 14 feet because that was the depth of the deepest sample containing concentrations above the PRGs. The volume of soil requiring remedial action in the first large area is estimated to be approximately 164,250 cubic feet (6,803 cubic yards) and in the second smaller area, approximately 25,200 cubic feet (933 cubic yards).

A shown in Figure A-1, the small area and a portion of the large area are already under pavement, which would meet the RA objectives for the site. The extent of new pavement required to meet the RA objectives for the areas which are not currently paved is shaded in the figure.

There are several important uncertainties associated with the methodology used to estimate the areas of soil requiring remedial action. The first relates to the actual source of the PAHs found in the soil. As previously noted, PAHs are often associated with industrial areas, urban fill materials containing coal and ash, and asphalt pavement. There are no other known sources of PAHs at the site (e.g., open burning). Therefore, it is possible that some of the PAHs found at the site are the result of the use of various fuel oils in site operations while other PAHs are occurring in the fill materials, are associated with the industrial nature of the area, or are associated with the asphalt pavement covering the majority of the site. The latter would explain the presence of PAHs in samples from the background borings (SB-29 and SB-30).

The second uncertainty relates to the fact that the PRGs are based on the RBCs developed during the human health risk assessment. These RBCs, in turn were based on a future residential use of the site. Therefore, under current site conditions, the RBCs provide a conservative estimate of the areas of soil requiring remedial action. In addition, the RBC for BaP was based on the saturation concentration of the compound which is below the CRDL. If the CRDL is used as the PRG, only two borings (SB-3 and SB-13) and one surface soil sampling location would exceed this level. In this case, PCB occurrence would be used as the basis for deciding on the area of soil requiring remedial action.

The last uncertainty relates to the assumptions about how far contamination extends both vertically and horizontally around a boring. To address this uncertainty, additional soil samples may be collected during the remedial design phase of the project to delineate the extent of soil requiring remedial action.

3. LNAPL

The areal extent of the LNAPL at the Fischer and Porter site was estimated based on data collected from soil borings, monitoring well FP7, and the PH-series monitoring wells as well as information on potential past sources that could have introduced the LNAPL into the subsurface. The following considerations provided the basis for estimating the areal extent of the LNAPL:

- Four underground storage tanks located under the scrap room floor were formerly used to store oil, waste oil, and TCE. Past activities in the scrap room also involved the handling of oil and solvents. Therefore, although there is no definitive supporting documentation, it is likely that the source of the LNAPL in well FP7 was located in the area of the scrap room. In addition to the LNAPL in well FP7, some LNAPL may also be found on the soil/bedrock interface although there is currently no evidence that LNAPL is present on this interface. The surface elevation of the bedrock in the source area (i.e. bedrock highs and lows), which can control the distribution of any LNAPL is currently not known.

- The logs of soil borings installed near the scrap room during the Phase I RI (SB-20, SB-23, SB-24, SB-26, and SB-27) indicate that there is no LNAPL present within the unsaturated overburden and uppermost weathered bedrock. This suggests that the LNAPL source may be restricted to an isolated area located south of these borings. These soil borings were not advanced into the saturated competent bedrock. Therefore, the presence or absence of LNAPL at the interface between the saturated and unsaturated bedrock zones is unknown at these boring locations.

- Monitoring well FP7 originally was drilled through the unsaturated overburden, the upper weathered bedrock, the unsaturated bedrock, and the saturated bedrock to a terminal depth of 45 feet below ground surface (bgs). At the time of drilling, no LNAPL was encountered in the well (SMC-Martin, 1980). Sometime between the submission of the SMC-Martin report (1980) and the initiation of pumping as part of the consent decree in 1984, well FP7 was deepened to approximately 300 feet bgs. On September 20, 1990, the USGS observed LNAPL in well FP7 during its downhole geophysical survey of the well. The observed LNAPL may have been caused by the pumping-induced depressed water table at FP7, which allowed the well to act as a sump for the collection of the LNAPL. Data collected during the Phase II RI and presented in the RI report suggest that the rate of LNAPL recharge into well FP7 under non-pumping conditions is slow. Because LNAPL was not detected during the drilling of FP7, this suggests that the LNAPL source may be restricted to an isolated area which may be located in the vicinity of the well (e.g., under the scrap room).

- During the Phase II RI, LNAPL was not observed in the any of the PH-series monitoring wells. No LNAPL has also been observed in these wells since completion of the RI activities and upto the time of preparation of the RI report. The lack of LNAPL in the PH-series wells indicates that the material may be restricted to an area smaller than that defined by the locations of the PH-series monitoring wells.

On the basis of the above information, the areal extent of the LNAPL is assumed to encompass the location of well FP7, which is the only well where the LNAPL was observed during the Phase II RI, and the area of the scrap room where the LNAPL could have been historically released. Based on these assumptions, the area of LNAPL was estimated to be approximately 200 square feet. This area is shown in Figure A-2. The main uncertainty with this estimate is associated with the lack of data to confirm any of the assumed LNAPL boundaries. In addition, the thickness of oil measured in well FP7 during the Phase II RI is not indicative of the thickness of oil that may be present on the groundwater table. Therefore, the volume of LNAPL cannot be estimated.

4. Groundwater

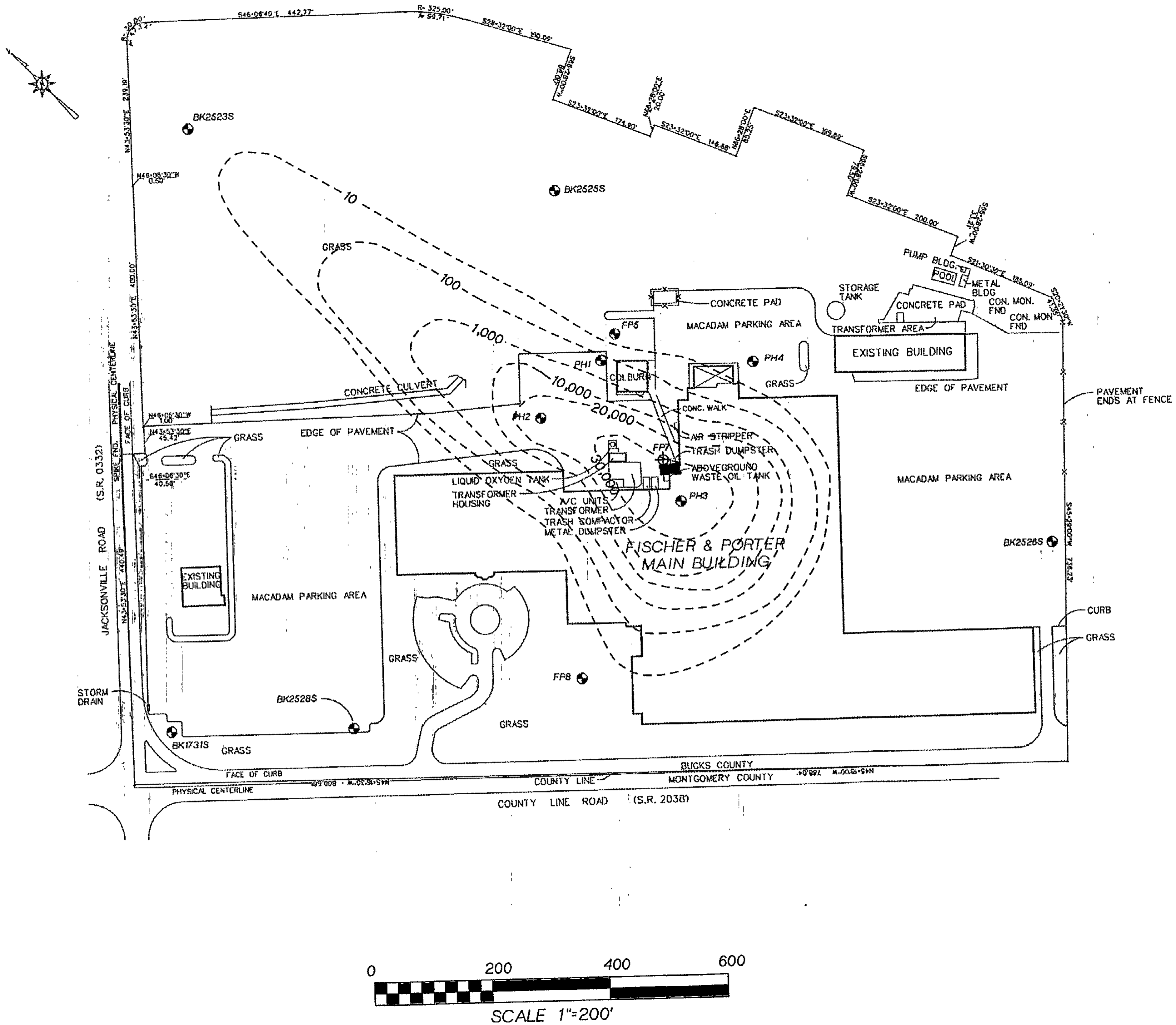
Currently, a limited network of shallow bedrock groundwater system monitoring wells is available to delineate the leading edge and the lateral edges of the VOC plume in the shallow bedrock groundwater system. In addition, the upgradient edge of the plume is poorly defined because, with the exception of well PH3, there are no monitoring wells screened in the shallow bedrock groundwater system beneath the Fischer and Porter manufacturing building. Figure A-2 presents the TCE isopleths for the shallow bedrock groundwater system; these isopleths were extrapolated from existing wells screened in the shallow bedrock groundwater system.

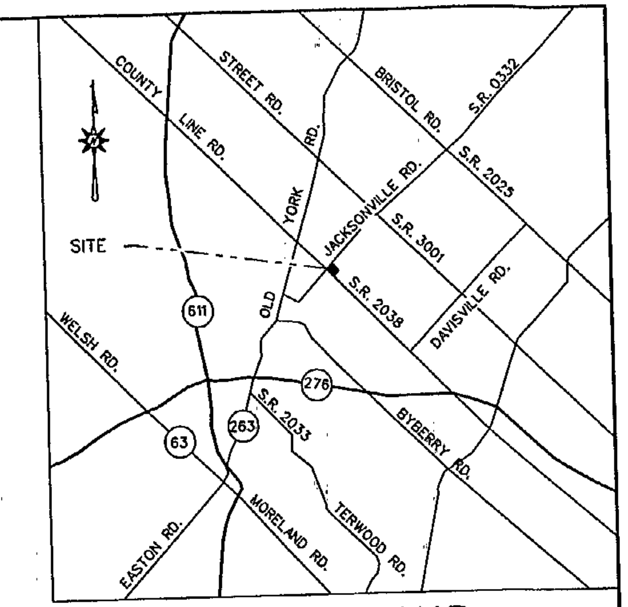
The volume of TCE-contaminated groundwater in the shallow bedrock groundwater system was estimated as one pore volume of the bedrock within this system or approximately 99,000,000 gallons. This assumes a 20 percent porosity, 660,000 square foot areal extent of the plume (groundwater within the estimated 10 µg/L TCE isopleth) and an aquifer thickness of 100 feet. The actual volume of groundwater that will need to be extracted to reduce TCE concentrations to below the established PRGs is expected to be significantly higher. Appendix B provides estimates of the cleanup time required to achieve PRGs.

Similarly to the shallow bedrock groundwater system, there are an insufficient number of intermediate bedrock monitoring wells to delineate the leading edge and lateral edges of the VOC plume in the intermediate bedrock groundwater system. This is especially true in the source area where there are no intermediate monitoring wells. In addition, the upgradient edge of the plume cannot be determined because there are no monitoring wells screened in the intermediate bedrock groundwater system beneath the Fischer and Porter manufacturing building. However, to develop groundwater extraction alternatives for the intermediate bedrock groundwater system, this FS assumes that similarly to the shallow bedrock groundwater system, elevated TCE concentrations, potentially on the order of 1,000 to 10, 000 µg/L, exist within the intermediate bedrock groundwater system in the source area. Note that there are no data to confirm this.

Figure A-3 presents TCE isopleths for the intermediate bedrock groundwater system; the isopleths were extrapolated from existing wells screened in the intermediate bedrock groundwater system.

The volume of TCE-contaminated groundwater in the intermediate bedrock groundwater system was estimated as one pore volume of the bedrock within this system or approximately 181,000,000 gallons. This assumes a 20 percent porosity, 1,210,000 square foot areal extent of the plume on the Fischer and Porter property (groundwater within the estimated 10 µg/L TCE isopleth) and an aquifer thickness of 100 feet. The actual volume of





LOCATION MAP
(N.T.S.)

LEGEND

- BK2525S — MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN SHALLOW WATER-BEARING ZONE.
- FP7 — OIL RECOVERY WELL
- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH
- ASSUMED EXTENT OF LNAPL

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBURARY 12,1991.
3. HORIZONTAL DATUM ARE ASSUMED & ROTATED TO PLAN BOUNDARY MERIDIAN.
4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDIX B.

Figure A-2
TCE CONCENTRATION ISOPLETHS - SHALLOW ZONE
FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

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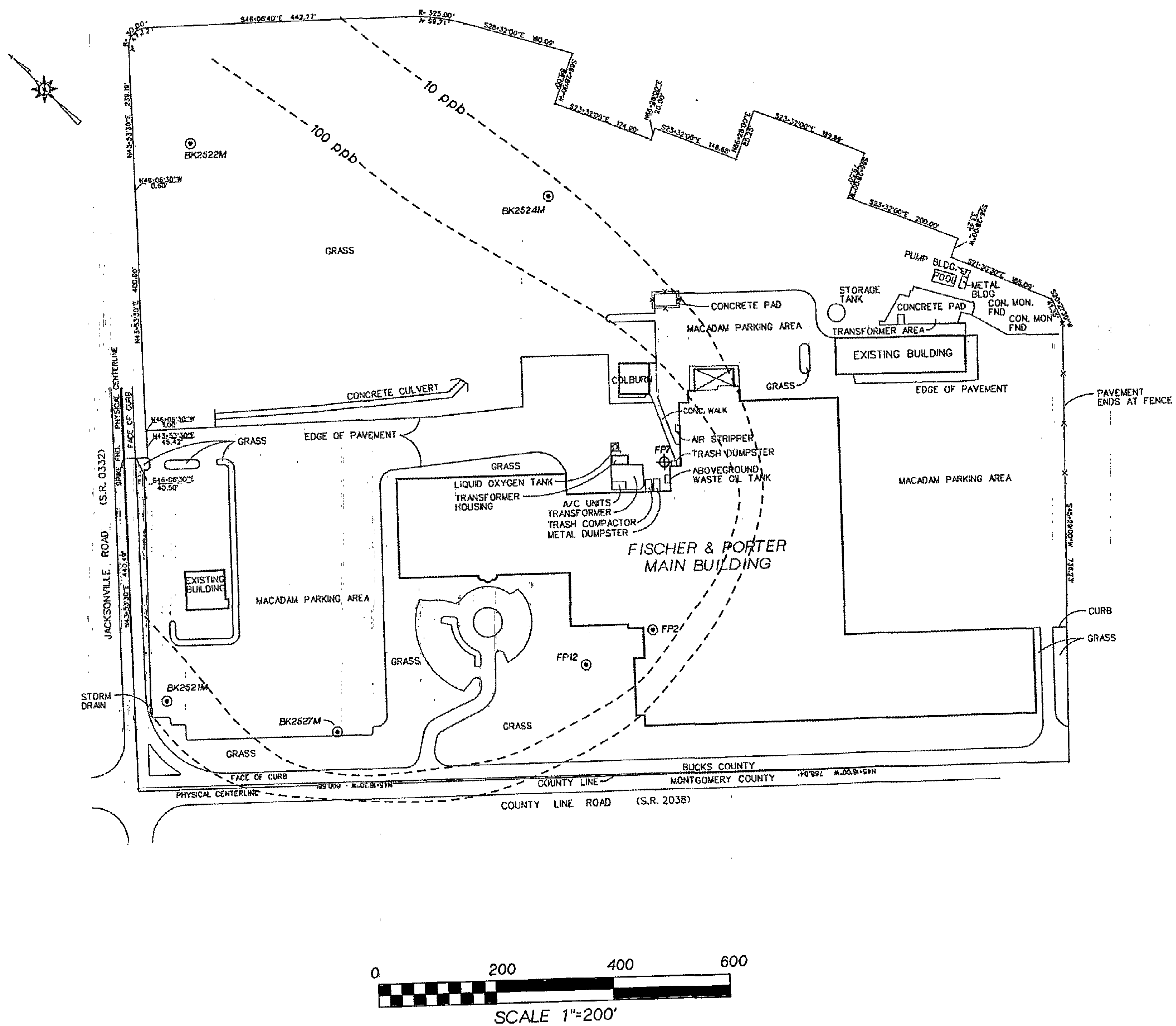

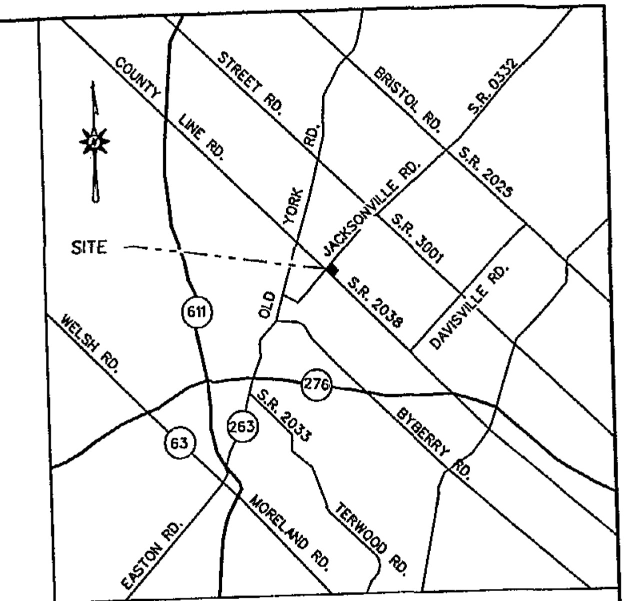

LOCATION MAP
(N.T.S.)

LEGEND

BK2525M ⊙ MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN INTERMEDIATE WATER-BEARING ZONE.

FP7 ⊕ OIL RECOVERY WELL

- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH

NOTES:

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5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure A-3
TCE CONCENTRATION ISOPLETHS - INTERMEDIATE ZONE
FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

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groundwater that will need to be extracted in order to reduce TCE concentrations to below the established PRGs is expected to be significantly higher. Appendix B provides estimates of the cleanup time required to achieve PRGs.

Appendix B
Groundwater Capture Analysis and Conceptual Design of Extraction System

1. Introduction

The purpose of this appendix is to develop and evaluate alternatives for groundwater capture for areas of the Fischer and Porter site with elevated TCE concentrations in the groundwater. Capture zone analysis is used to determine the approximate placement of extraction wells. Two alternatives for groundwater capture are evaluated:

- Alternative GC-1: Source control of the highest TCE concentrations in the shallow and intermediate bedrock groundwater systems.
- Alternative GC-2: Sitewide capture of TCE-contaminated groundwater in the shallow and intermediate bedrock groundwater systems.

The capture zone analysis for these two alternatives was performed separately for the shallow and the intermediate bedrock groundwater systems.

Collection and removal of LNAPL from the shallow bedrock groundwater system at the location of well FP7 are also discussed. Finally, the time needed to achieve PRGs in the shallow and intermediate bedrock groundwater systems is estimated based on the presented assumptions.

2. Capture Zone Analysis

A graphical technique (Javendel and Tsang, 1986) was employed to simulate capture zone fields in the shallow and intermediate bedrock groundwater systems at the Fischer and Porter site. This is because accurate site-specific aquifer coefficients and an understanding of the hydraulic relationship between the shallow and intermediate bedrock groundwater systems could not be obtained during the Phase II RI. For example, the ability to obtain accurate aquifer coefficients at the site from the pumping test was affected by interferences caused by municipal pumping. In addition, the relationship between the shallow and intermediate bedrock groundwater systems (i.e., leakance) can not be quantified based on the existing monitoring well network at the site (i.e., lack of monitoring well couplets in the source area). Because of these data limitations, many assumptions would have had to be made to accurately execute two-dimensional or three-dimensional groundwater modeling programs for the Fischer and Porter site. Because of the many assumptions that would need to be made, the results of these modeling efforts would be of limited use. Therefore, the graphical technique described below was used.

2.1 Capture Zone Method

A graphical technique (Javendel and Tsang, 1986) was employed to simulate capture zone fields in the shallow and intermediate bedrock groundwater systems at the Fischer and Porter site. This method was used to estimate the number of pumping wells and pumping well spacing required for:

- Sitewide capture of TCE concentrations exceeding 10 μg/L
- Source control capture of TCE concentrations exceeding 100 μg/L

Assumptions that are specific to the Javendel and Tsang (1986) method include:

- The aquifer is homogeneous, isotropic, and confined
- There is two-dimensional flow within the aquifer
- The extraction wells penetrate and are open over the entire thickness of the aquifer
- There is no leakance between the groundwater systems

The equation for dividing streamlines from a single extraction well that separate the capture zone of the well from the rest of the groundwater system is defined by Javendel and Tsang (1986) as:

$$y = \pm \frac{Q}{2BU} - \frac{Q}{2\pi BU} \tan^{-1} \frac{y}{x}$$

where: the pumping well is at the origin of an xy cartesian coordinate system and

Q = pumping rate (ft^3/min)
B = aquifer thickness (ft)
U = regional flow velocity (ft/min)

Table B-1 summarizes some characteristic distances in flow regimes for one, two, and three pumping wells under a uniform regional groundwater flow (Javendel and Tsang, 1986).

Table B-1
Characteristic Distances in Flow Regimes for One, Two, and Three Pumping Wells Under a Uniform Regional Groundwater Flow (Javendel and Tsang, 1986)
Fischer and Porter Site

Number of pumping wells	Optimum distance between each pair of pumping wells	Distance between dividing streamlines at the line of wells	Distance between streamlines far upstream from the wells
One	NA	$\frac{Q}{2BU}$	$\frac{Q}{BU}$
Two	$\frac{Q}{\pi BU}$	$\frac{Q}{BU}$	$\frac{2Q}{BU}$
Three	$\frac{^3\sqrt{2}Q}{\pi BU}$	$\frac{3Q}{2BU}$	$\frac{3Q}{BU}$

NA - Not applicable

The dividing streamlines represent the boundary of each capture zone. Solutions to these formulas were used to define the capture zones presented in this analysis.

2.2 Hydrogeologic Input Parameters

Site-specific hydrogeologic input parameters for the Fischer and Porter site that were used in the determination of the capture zones are presented in Table B-2. The basis and assumptions for these input parameters are discussed below.

Table B-2
Site-Specific Hydrogeologic Input Parameters for Capture Zone Analyses
Fischer and Porter Site

Parameter	Value	Units
Pumping Rate per Well (Q)	2.0	ft^3/min.
Aquifer thickness (B)	100	ft
Regional Flow Velocity (U)	6.98 x 10-5	ft/min.
Hydraulic Conductivity (K)	1.34	ft/day
Transmissivity (T)	1003	gpd/ft
Hydraulic Gradient (dh/dl)	0.015	NA
Porosity (n)	0.20	NA

NA - Not applicable

2.2.1 Pumping Rate per Well

It is assumed that the well yield (Q) for each shallow extraction well and each intermediate extraction well at the Fischer and Porter site is 15 gpm. This assumption is based on the observed performance of the 4-inch internal diameter (I.D.) PH-series shallow monitoring wells during well development and of monitoring well FP7 during the packer/pump testing program.

2.2.2 Aquifer Thickness

Although the boundary between the shallow and intermediate bedrock groundwater systems at the Fischer and Porter site is not clearly defined, and probably irregular, the shallow bedrock groundwater system is assumed to extend from approximately 20 feet bgs to 120 feet bgs, and the intermediate bedrock groundwater system is assumed to extend from approximately 120 feet bgs to 220 feet bgs. Therefore the saturated thickness (B) of each of the groundwater systems is assumed to be 100 feet.

2.2.3 Regional Flow Velocity

The regional flow velocity (U) for the Fischer and Porter site was calculated from the following formula:

$$U = \left(\frac{K}{n}\right) x \ \frac{dh}{dl}$$

All variables in this equation are assumed to be the same for the shallow and the intermediate bedrock groundwater systems. Therefore, the regional flow velocity for both groundwater systems is 6.98×10^{-5} ft/min. These variables are discussed below.

2.2.4 Hydraulic Conductivity

The hydraulic conductivity (K) at the Fischer and Porter site was calculated using the following equation:

$$K = \frac{T}{B}$$

The hydraulic conductivity for the shallow and the intermediate groundwater systems is 1.34 ft/day.

2.2.5 Transmissivity

The transmissivity (T) for the shallow bedrock groundwater system at the Fischer and Porter site was calculated by the following formula:

$$T=308(S_c)$$

where : S_c (specific capacity) of each of the PH-series monitoring wells obtained during well development.

These specific capacities ranged from 0.1 gpm/ft to 1.15 gpm/ft. The geometric mean of the transmissivity values from each PH-series well, 1003 gpd/ft, is a conservative estimate of the transmissivity in the shallow bedrock groundwater system at the Fischer and Porter site. Although published values of wells greater than 100 feet deep within the Middle Arkose member of the Stockton Formation (Rima et al., 1962) indicate an average specific capacity of 4.8 gpm/ft, the same transmissivity value, 1003 gpd/ft, is applied to the intermediate bedrock groundwater system. The assumption is conservative estimate of transmissivity in the intermediate bedrock groundwater system at the Fischer and Porter site.

2.2.6 Hydraulic Gradient

On the basis of the groundwater contour maps of the shallow (Figure 3-5) and intermediate bedrock (Figure 3-6) groundwater systems presented in the RI report (CH2M HILL, 1997), the average hydraulic gradient (dh/dl) in both systems at the Fischer and Porter site is 0.015. These contour maps depict the groundwater gradients and flow directions for both groundwater systems at the Fischer and Porter site when extraction wells FP1, FP2, and FP7 were not operating.

2.2.7 Porosity

On the basis of published values (Rima et al., 1962), the porosity (n) of the Stockton Formation at the Fischer and Porter site is estimated to be 0.20.

2.3 Alternative GC-1: Source Control Extraction System

Using the methodology described above, the components for the first groundwater extraction alternative were developed. The alternative focuses on source control and will include a total of six 6-inch I.D. stainless steel groundwater extraction wells. Three of the wells will be installed in the shallow bedrock groundwater system and the other three wells will be installed in the intermediate bedrock groundwater system. The assumption is that the shallow and intermediate extraction wells will be screened 20 to 120 feet bgs and 120 to 220 feet bgs, respectively. The six wells will be installed as three well couplets.

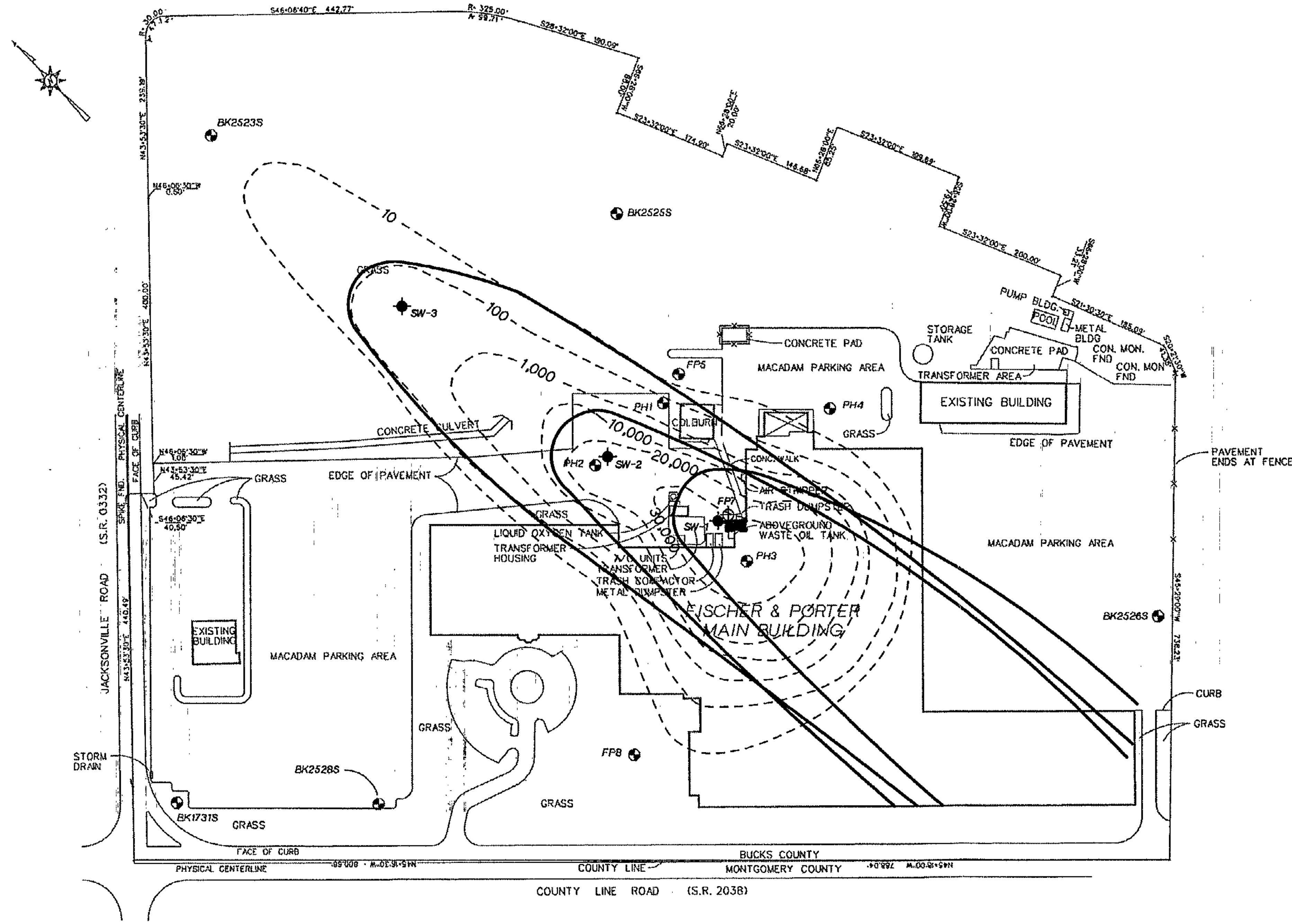
The source control extraction system is designed to capture TCE concentrations greater than 100 µg/L within the shallow bedrock groundwater system. On the basis of the results of the capture zone calculations, three shallow extraction wells (SW-1, SW-2, and SW-3) will be required to lower the TCE plume concentrations within the shallow bedrock groundwater system to 5 µg/L, the selected PRG. This assumes that there is no TCE DNAPL which continues to contribute dissolved TCE concentrations to the groundwater system. The conceptual layout of the source control extraction system in the shallow bedrock groundwater system, the assumed extent of the TCE plume in this system, and the estimated extent of groundwater capture are shown in Figure B-1.

The three intermediate groundwater extraction wells (IW-1, IW-2, and IW-3) were sited to capture groundwater within the intermediate bedrock groundwater system where the TCE concentrations were the highest in the shallow bedrock groundwater system. The objective of the system is to capture the elevated TCE concentrations that may be migrating vertically from the shallow to the intermediate bedrock groundwater systems in this area. The three extraction wells will be installed as couplets with the shallow groundwater extraction wells SW-1, SW-2, and SW-3.

The conceptual layout of the source control extraction system in the intermediate bedrock groundwater system, the assumed extent of the TCE plume in this system, and the estimated extent of groundwater capture are shown in Figure B-2. Note that additional wells may be needed for long-term monitoring of the effectiveness of the extraction system to achieve the desired capture. Wells for long-term monitoring are not included in the FS. Every effort should be made to use existing monitoring wells to collect the long-term monitoring data.

2.4 Alternative GC-2: Sitewide Capture Extraction System

Using the methodology described above, the components for the second groundwater extraction alternative were developed. This alternative aims at sitewide groundwater capture and will include 13 6-inch I.D. stainless steel groundwater extraction wells. Five of the wells will be installed in the shallow bedrock groundwater system and the other eight wells will be installed in the intermediate bedrock groundwater system. The assumption is that the shallow and intermediate extraction wells will be screened 20 to 120 feet bgs and 120 to 220 feet bgs, respectively. The groundwater extraction system will be used to lower the current TCE plume concentrations within the shallow and intermediate bedrock groundwater system to 5 µg/L, the selected PRG. This assumes that there is no TCE DNAPL which continues to contribute dissolved TCE concentrations to the groundwater system.



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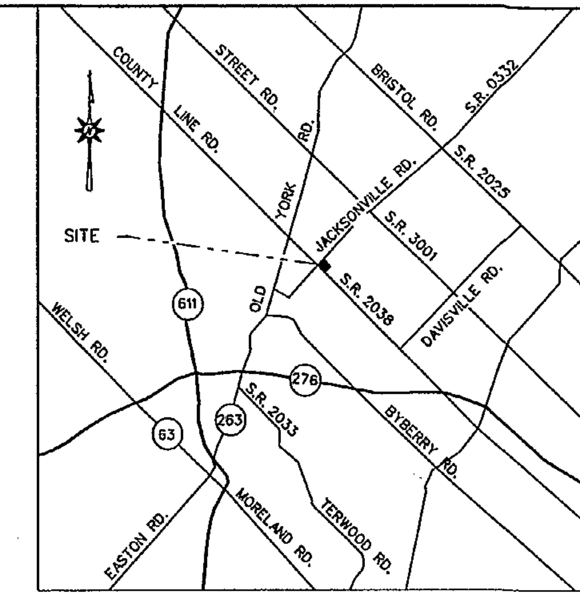

LOCATION MAP
(N.T.S.)

LEGEND

- BK2525S — MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN SHALLOW WATER-BEARING ZONE.
- SW-1 — EXTRACTION WELL WITH SCREENED INTERVAL IN SHALLOW WATER-BEARING ZONE.
- FP7 — OIL RECOVERY WELL
- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH
- ——— ESTIMATED EXTENT OF GROUNDWATER CAPTURE
- ASSUMED EXTENT OF LNAPL

NOTES:

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6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure B-1
CONCEPTUAL LAYOUT OF SOURCE CONTROL EXTRACTION SYSTEM - SHALLOW ZONE

FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

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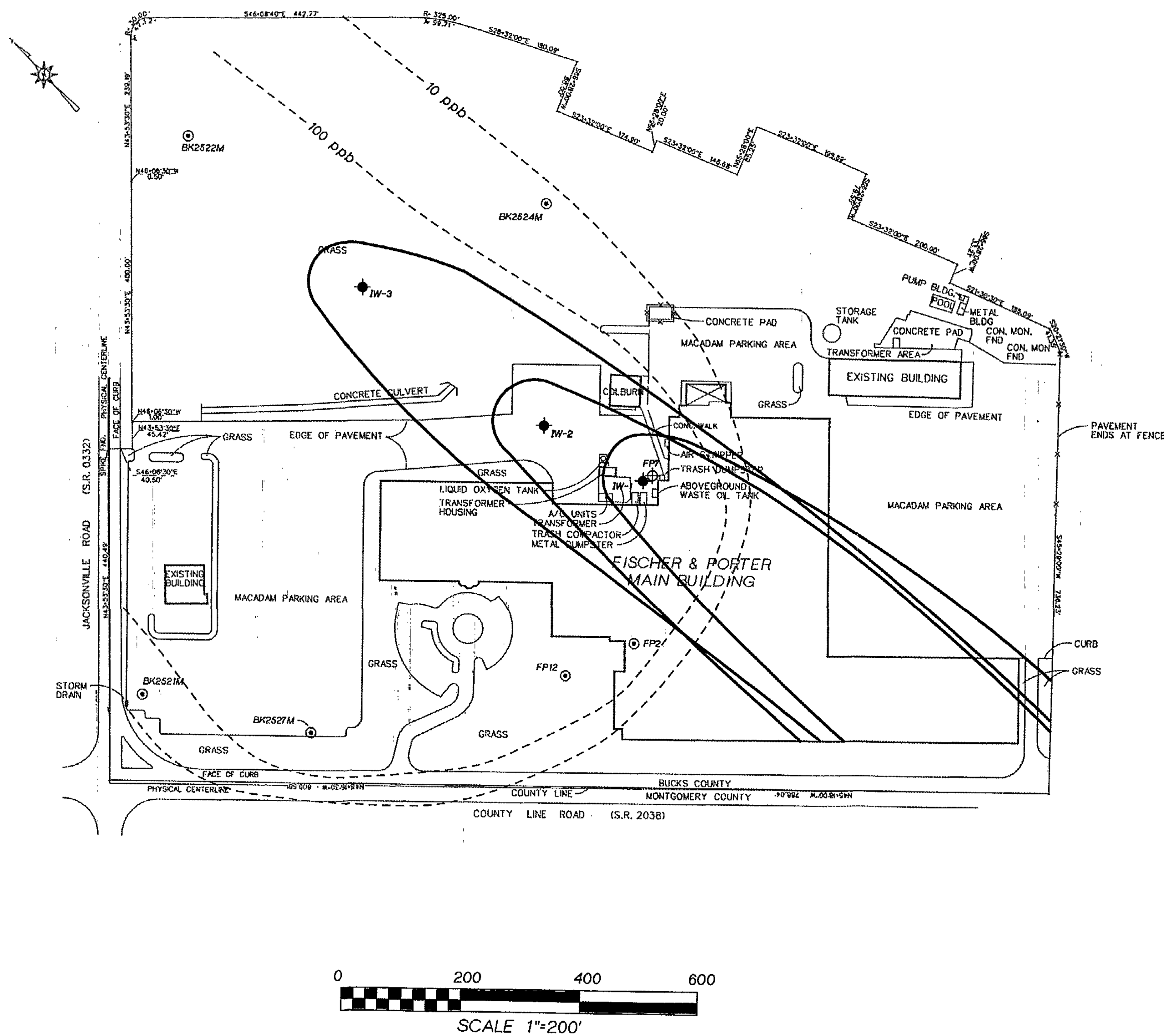

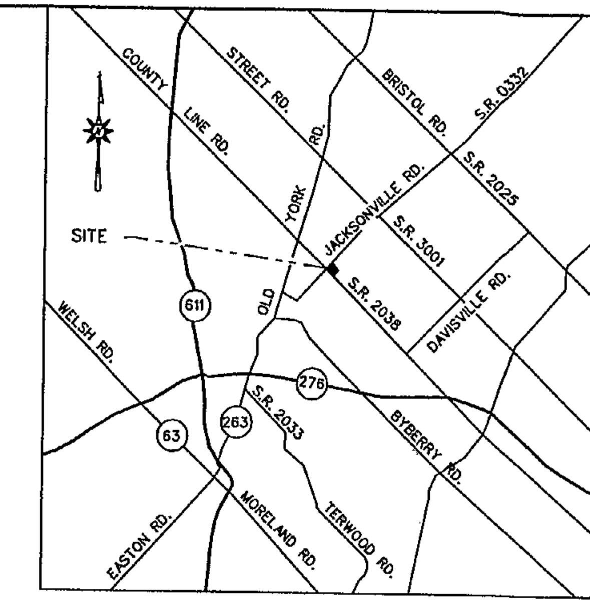

LOCATION MAP
(N.T.S.)

LEGEND

- BK2525M ⊙ MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN INTERMEDIATE WATER-BEARING ZONE.
- IW-1 ✦ EXTRACTION WELL WITH SCREENED INTERVAL IN SHALLOW AND INTERMEDIATE WATER-BEARING ZONES.
- FP7 ⊕ OIL RECOVERY WELL
- ----- ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH
- ——— ESTIMATED EXTENT OF GROUNDWATER CAPTURE

NOTES:

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6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure B-2

CONCEPTUAL LAYOUT OF SOURCE CONTROL EXTRACTION SYSTEM - INTERMEDIATE ZONE

FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

CH2MHILL

19-MAY-1997 5600f029.dgn

Note that the sitewide capture extraction system builds on the source control extraction system. Specifically, the sitewide extraction system includes the wells installed as part of the source control alternative in the shallow and intermediate systems where the TCE concentrations are expected to be the highest. In addition, under the sitewide capture alternative, wells are planned at the anticipated downgradient edge of the TCE plume on the site to capture the TCE concentrations migrating off the site. Although the wells installed at the downgradient edge of the plume may capture the TCE before it migrates offsite, not using wells in the area of highest TCE concentrations would draw these highest concentrations closer to the boundary of the site when the downgradient wells are pumped. Therefore, the sitewide capture alternative includes the source control wells under the source control alternative in addition to the wells at the downgradient edge of the plume. Using wells to capture the highest TCE concentrations before they can migrate further downgradient to the site boundary, also is expected to increase the overall effectiveness of the extraction system to lower TCE concentrations in groundwater at the site.

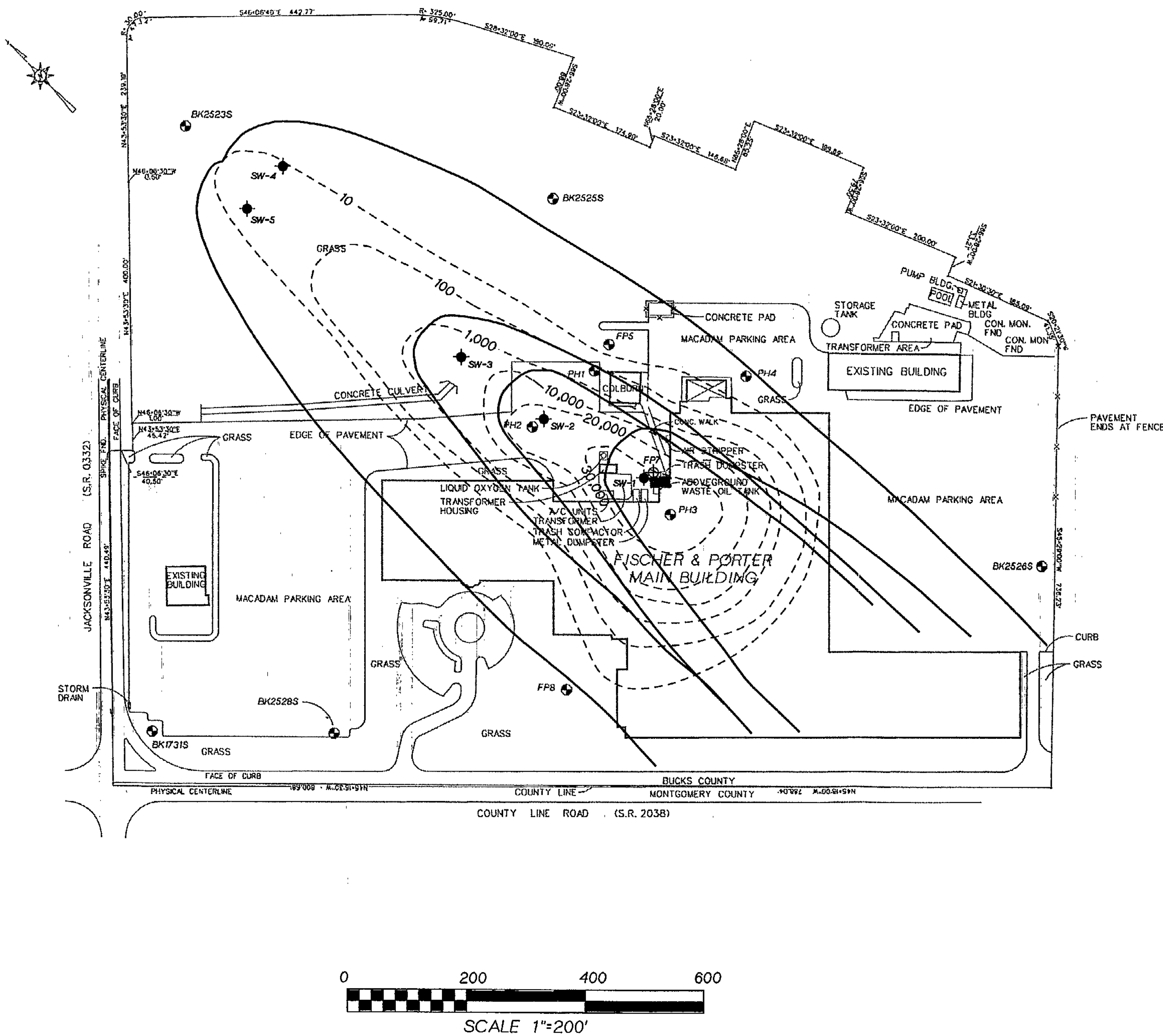
With the above objective in wind, the sitewide capture extraction system is designed to capture TCE concentrations greater than 10 µg/L within the shallow bedrock groundwater system. On the basis of the results of the capture zone calculations, three shallow extraction wells (SW-1, SW-2, and SW-3) will be installed in the portion of the plume that has TCE concentrations greater than 1,000 µg/L. The additional two shallow groundwater extraction wells (SW-4 and SW-5) will be installed furthest downgradient and primarily capture TCE concentrations of 10 µg/L to 100 µg/L. The conceptual layout of the sitewide extraction system in the shallow bedrock groundwater system, the assumed extent of the TCE plume in this system, and the estimated extent of groundwater capture are shown in Figure B-3.

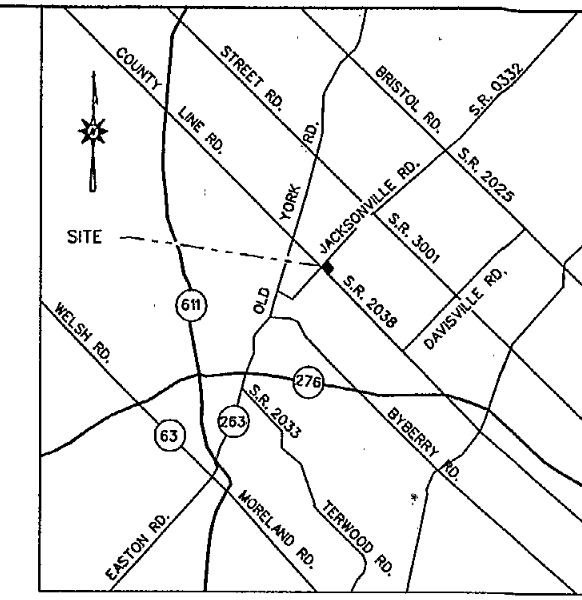
For the sitewide capture extraction system, three of the intermediate groundwater extraction wells (IW-1, IW-2, and IW-3) were sited to capture groundwater within the intermediate bedrock groundwater system where TCE concentrations are anticipated to be highest As under the source control alternative, these three extraction wells will be installed with SW-1, SW-2, and SW-3, respectively, as couplets. Intermediate groundwater extraction wells IW-4 and IW-5 will be installed in the northern corner of the Fischer and Porter site to capture the northern portion of the TCE plume in the intermediate bedrock groundwater system. At the northwest boundary of the site, intermediate groundwater extraction wells IW-6, IW-7, and IW-8 will be installed to primarily capture the north western portion of the TCE plume in the intermediate bedrock groundwater system.

The conceptual layout of the sitewide extraction system in the intermediate bedrock groundwater system, the assumed extent of the TCE plume in this system, and the estimated extent of groundwater capture are shown in Figure B-4. As noted above under Alternative GC-1, additional monitoring wells to monitor the long-term effectiveness of the extraction system may be needed.

2.5 LNAPL Recovery

An LNAPL recovery well will be used in conjunction with both the source control and the sitewide groundwater extraction systems. Existing groundwater extraction well FP7 will be modified to serve as the LNAPL recovery well. This location was chosen because this is the only well location at the Fischer and Porter site where the LNAPL was observed during the





BK2525S — MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN SHALLOW WATER-BEARING ZONE.

SW-1 — EXTRACTION WELL WITH SCREENED INTERVAL IN SHALLOW WATER-BEARING ZONE.

FP7 — OIL RECOVERY WELL

- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH

——— ESTIMATED EXTENT OF GROUNDWATER CAPTURE

ASSUMED EXTENT OF LNAPL

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBURARY 12,1991.
3. HORIZONTAL DATUM ARE ASSUMED & ROTATED TO PLAN BOUNDARY MERIDIAN.
4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure B-3
CONCEPTUAL LAYOUT OF SITE WIDE EXTRACTION SYSTEM - SHALLOW ZONE

FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

CH2MHILL

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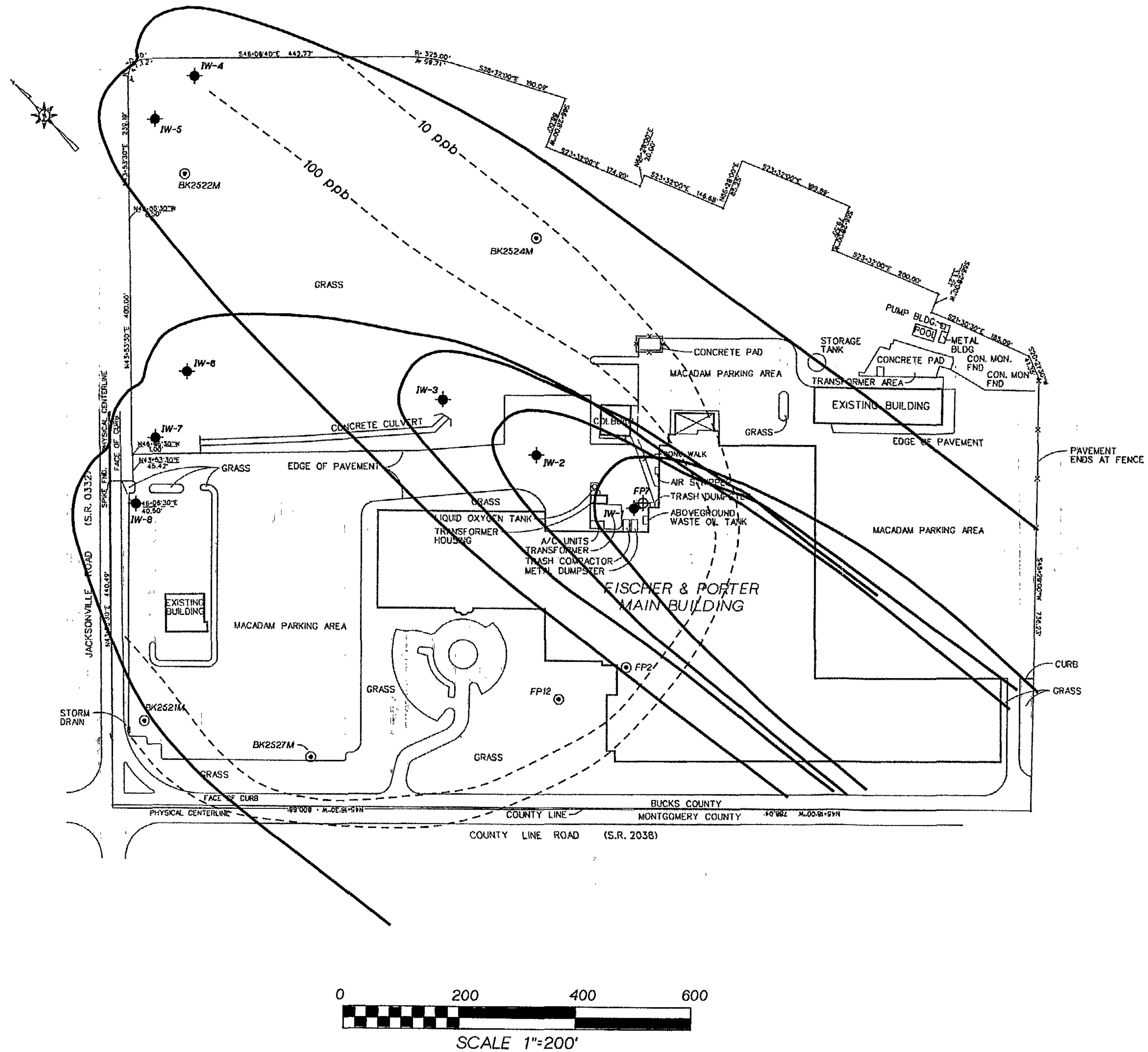

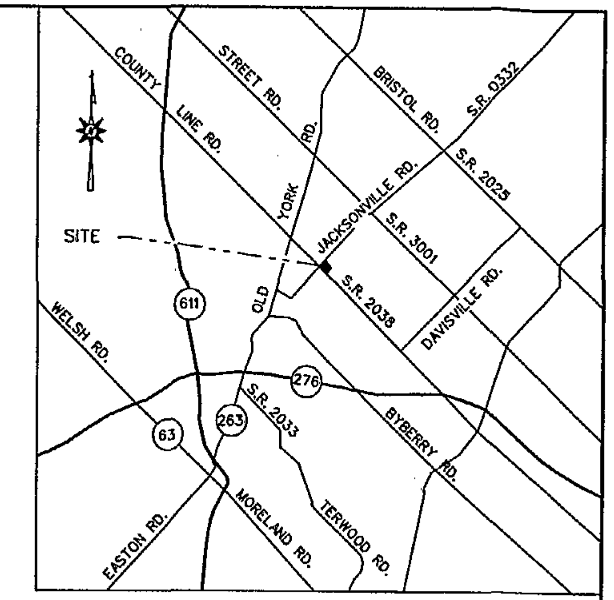

LOCATION MAP

LEGEND

- BK2525M ⊙ MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN INTERMEDIATE WATER-BEARING ZONE.
- IW-1 ◆ EXTRACTION WELL WITH SCREENED INTERVAL IN SHALLOW AND INTERMEDIATE WATER-BEARING ZONES.
- FP7 ⊕ OIL RECOVERY WELL
- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH
- ——— ESTIMATED EXTENT OF GROUNDWATER CAPTURE

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBURARY 12,1991.
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4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure B-4
CONCEPTUAL LAYOUT OF SITE WIDE EXTRACTION SYSTEM - INTERMEDIATE ZONE
FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

CH2M HILL

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Phase II RI activities. In addition, LNAPL historically has been recovered from this location. Over a 1 week period at the end of 1989, Fischer and Porter installed and activated a skimmer pump and removed approximately 110 gallons of LNAPL from FP7 (personal communication with Bill Gross, April 1997). Because of large fluctuations in the water level in FP7, Fischer and Porter was unable to continue to recover oil. On April 30, 1996, and May 17, 1996, CH2M HILL manually bailed approximately 20 gallons and 6 gallons, respectively, of LNAPL from FP7. Because of the water table fluctuations and the relatively slow LNAPL recharge rates to FP7 observed during the Phase II RI activities (CH2M HILL, 1997), the recommendation is that LNAPL be manually removed from FP7 during the future operation of the selected groundwater extraction system at the Fischer and Porter site.

Existing groundwater extraction well FP7 will be modified so that it does not act as a groundwater extraction well but serve both as an LNAPL extraction well and a location for the collection of groundwater level and product thickness data. Therefore, the well will be modified so that access is maintained for the bailers for LNAPL removal and for probes for LNAPL thickness measurements. The interval between 300 feet and 220 feet bgs in the well will be abandoned (i.e., grouted) to minimize future dissolved VOC releases from the LNAPL to the deep bedrock groundwater system. The well will remain open from the bottom of the casing (approximately 19 feet bgs) to 220 feet bgs to accommodate localized drawdown induced by municipal pumping (WH1 and or WH2) and onsite pumping from the shallow bedrock groundwater system (SW1, SW2, SW3, etc.) and the intermediate bedrock groundwater system (IW1, IW2, IW3, etc.). The location of FP7 relative to the proposed shallow and intermediate groundwater extraction wells is shown in Figures B-1 through B-4.

2.6 Modifications to the Existing Fischer and Porter Extraction System

On the basis of the results of the Phase II RI (CH2M HILL, 1997), use of the existing groundwater extraction system (wells FP1, FP2, and FP7) at the Fischer and Porter site will likely be discontinued. As discussed above in subsection 2.5, well FP7 will be modified and maintained as an LNAPL recovery well. Wells FP1 and FP2 should need to be modified to serve as water level and product thickness measuring locations beneath the manufacturing building. The modifications recommended for these wells are described below.

At wells FP1 and FP2, the submersible pumps, plumbing, and controls should be removed. Well FP1 should be abandoned (i.e., grouted) up to approximately 220 feet bgs. No grouting is anticipated to be needed for well FP7 because existing information indicates that the well extends to approximately 190 feet bgs. A couplet, which consists of two 2-inch I.D. PVC wells, should be installed in both of the existing open boreholes at FP1 and FP2. At each couplet, one of the 2-inch-diameter wells should be installed to monitor water levels and product thicknesses in the shallow bedrock groundwater system (i.e., approximately 20 to 120 feet bgs) and the other 2-inch-diameter well will be installed to monitor the water levels and product thicknesses in the intermediate bedrock groundwater system (i.e., approximately 120 to 220 feet bgs). The construction of the couplets also will provide the ability to obtain discrete groundwater samples from both the shallow and intermediate bedrock groundwater systems at the FP1 and FP2 locations, if necessary.

2.7 Remediation Time

This section estimates the time required for both the source control and sitewide capture alternatives to reduce TCE concentrations in both the shallow and intermediate groundwater bedrock systems to below PRGs. These estimates assume that there is no source continuing to contribute to the dissolved TCE concentrations currently found in these systems. For example, the LNAPL present in well FP7 has been removed and there is no TCE DNAPL present in the vadose zone or groundwater systems at the site. Note that the Phase II RI did not definitively identify the presence of DNAPL at the site although the TCE concentrations detected in some of the wells indicated the potential for its presence. If DNAPL is present, achieving groundwater restoration to PRGs may not be practical objective for the selected groundwater extraction system (EPA, 1993b). Instead, its objective should be to provide long-term hydraulic capture and prevent further migration of dissolved TCE concentrations in groundwater from the site.

With the above limitations in mind, approximate remediation times were calculated for the shallow bedrock groundwater system and the intermediate bedrock groundwater system at the Fischer and Porter site using the Mixed-Reactor approach (Zheng et al., 1991). This approach assumes that TCE concentrations are removed by flushing the groundwater system with clean water that mixes completely within the groundwater system as it migrates through it. This approach considers both the natural retardation of TCE and an asymptotic (i.e., logarithmic) removal curve. The analytical solution for estimating the pore volume exchanges using the mixed reactor approach (Zheng et al., 1991) is:

$$PV = -R \ln \frac{Ct}{Co}$$

where:

- PV = the number of pore volumes
- R = the retardation factor
- Co = the initial groundwater contaminant concentration
- Ct = the groundwater contaminant cleanup target concentration

The retardation factor, R, is defined as:

$$R = 1 + \left(\frac{P}{n}\right) Kd$$

where:

- P = the bulk density of the bedrock
- n = the porosity of the bedrock
- Kd = the water partition coefficient of the bedrock

The water partion coefficient, Kd, is defined as the organic carbon partition coefficient (Koc) multiplied by the fraction of organic carbon (foc).

Site-specific input parameters for the Fischer and Porter site that were used in the determination of the remediation times are presented in Table B-3. The basis and assumptions for these input parameters are discussed below.

2.7.1 One Pore Volume; Shallow Zone

One pore volume of the shallow bedrock groundwater system for the source control scenario, equals 44,883,000 gallons, and assumes an approximate area of 300,000 ft^2, an aquifer thickness of 100 ft, and a porosity of 0.20.

One pore volume of the shallow bedrock groundwater system for the sitewide extraction scenario, equals 98,742,600 gallons, and assumes an approximate area of 660,000 ft^2, an aquifer thickness of 100 ft, and a porosity of 0.20.

Table B-3
Site-Specific Input Parameters for Remediation Time Analyses
Fischer and Porter Site

Parameter	Value	Units
One pore volume; shallow zone (PV)	44,883,000 (source control) 98,742,600 (sitewide)	gallons gallons
One pore volume; intermediate zone (PV)	44,883,000 (source control) 181,028,100 (sitewide)	gallons gallons
Initial groundwater contaminant concentration; shallow zone (Co)	18,833 (source control) 12,204 (sitewide)	µg/L µg/L
Initial groundwater contaminant concentration; intermediate zone (Co)	2,033 (source control) 1,004 (sitewide)	µg/L µg/L
Groundwater contaminant cleanup target concentration (Ct)	5	µg/L
Retardation factor (R)	6.2	-
Bulk density of bedrock (P)	1.65	$\mu g/cm^3$
Porosity (n)	0.20	-
Water partition coefficient of bedrock (Kd)	0.063	mL/g
Organic carbon partition coefficient (Koc)	126	mL/g
Fraction of organic carbon (foc)	0.00050	g/g

2.7.2 One Pore Volume; Intermediate Zone

One pore volume of the intermediate bedrock groundwater system for the source control scenario, equals 44,883,000 gallons, and assumes an approximate area of 300,000 ft^2, an aquifer thickness of 100 ft, and a porosity of 0.20.

One pore volume of the intermediate bedrock groundwater system for the sitewide extraction scenario, equals 181,028,100 gallons, and assumes an approximate area of 1,210,000 ft^2, an aquifer thickness of 100 ft, and a porosity of 0.20.

2.7.3 Initial groundwater TCE Concentration; Shallow Zone

The initial groundwater TCE concentration for the shallow bedrock groundwater system for the source control scenario is the average of the estimated TCE concentrations for SW-1, SW-2, and SW-3 shown in Table B-4. This average TCE concentration is 18,833 µg/L. This table also presents the estimated TCE and other select COPCs concentrations in the influent to the treatment system for VOCs removal under the source control groundwater extraction alternative.

The initial groundwater TCE concentration for the shallow bedrock groundwater system for the sitewide extraction scenario is the arithmetic average of the estimated TCE concentrations for SW-1, SW-2, SW-3, SW-4, and SW-5 shown in Table B-5. This average TCE concentration is 12,204 µg/L. The table also presents the estimated TCE and other select COPCs concentrations in the influent to the treatment system for VOCs removal under the sitewide capture groundwater extraction alternative.

2.7.4 Initial Groundwater TCE Concentration; Intermediate Zone

The initial groundwater TCE concentration for the intermediate bedrock groundwater system for the source control scenario is the arithmetic average of the estimated TCE concentrations for IW-1, IW-2, and IW-3 shown in Table B-4. This average TCE concentration is 2,033 µg/L. The table also presents the estimated TCE and other select COPCs concentrations in the influent to the treatment system for VOCs removal under the source control groundwater extraction alternative.

The initial groundwater TCE concentration for the intermediate bedrock groundwater system for the sitewide extraction scenario is the arithmetic average of the estimated TCE concentrations for IW-1, IW-2, IW-3, IW-4, IW-5, IW-6, IW-7, and IW-8 shown in Table B-5. This average TCE concentration is 1,004 µg/L. The table also presents the estimated TCE and other select COPCs concentrations in the influent to the treatment system for VOCs removal under the sitewide capture groundwater extraction alternative.

2.7.5 Groundwater TCE Preliminary Cleanup Goal

According to the *Drinking Water Regulations and Health Advisories* (EPA, 1996d), the groundwater TCE PRG was established at 5 µg/L (see Section 2). This TCE concentration is the federal maximum contaminant level (MCL), which is the maximum permissible concentration of TCE in water that is delivered to any user of a public water supply system.

2.7.6 Retardation Factor

The retardation factor used for the shallow and the intermediate bedrock groundwater systems at the Fischer and Porter site is 6.2. This calculated value assumes the bulk density, the porosity, and the water partition coefficient are the same for the bedrock of the shallow and intermediate groundwater systems.

Table B-4
Calculation of Source Control Groundwater Extraction System Concentrations
Fischer and Porter Site

Extraction Well	Estimated Flow Rate (gpm)	Estimated TCE Concentration ($\mu g / L$)	Estimated Vinyl chloride Concentration ($\mu g / L$)	Estimated 1,2-DCE Concentration ($\mu g / L$)	Estimated PCE Concentration ($\mu g / L$)	Assumptions
SW-1	15	34,000	920	7,700	470	Data taken from well PH3
SW-2	15	22,000	970	17,000	970	Data taken from well PH2
SW-3	15	500	100	450	30	Assumed from contours
IW-1	15	3,400	92	770	47	Assumed one order of magnitude less than SW-1
IW-2	15	2,200	97	1,700	97	Assumed one order of magnitude less than SW-2
IW-3	15	500	10	450	30	Assumed from contours
Total	90	10,433	365	4,678	274	Influent to treatment system for VOCs removal

Arithmetic mean for TCE:
Shallow system = 18,833 ($\mu g / L$)
Intermediate system = 2,033 ($\mu g / L$)
VC - Vinyl chloride

P:\DOCS\F_P(FS)\Gw-conc\90 gpm

Table B-5
Calculation of Sitewide Capture Groundwater Extraction System Concentrations
Fischer and Porter Site

Extraction Well	Estimated Flow Rate (gpm)	Estimated TCE Concentration ($\mu g / L$)	Estimated Vinyl chloride Concentration ($\mu g / L$)	Estimated 1,2-DCE Concentration ($\mu g / L$)	Estimated PCE Concentration ($\mu g / L$)	Assumptions
SW-1	15	34,000	920	7700	470	Data taken from well PH3
SW-2	15	22,000	970	17,000	970	Data taken from well PH2
SW-3	15	5,000	500	1,200	70	TCE assumed from contours, VC assumed
SW-4	15	10	5	5	5	TCE assumed from contours, half the VC detection limit assumed
SW-5	15	10	5	5	5	TCE assumed from contours, half the VC detection limit assumed
IW-1	15	3,400	92	770	47	Assumed one order of magnitude less than SW-1
IW-2	15	2,200	97	1,700	97	Assumed one order of magnitude less than SW-2
IW-3	15	750	50	600	50	Assumed from contours
IW-4	15	390	5	220	21	TCE data taken from well BK2522M, half theVC detection limit assumed
IW-5	15	390	5	220	21	TCE data taken from well BK2522M, half theVC detection limit assumed
IW-6	15	300	5	120	15	Average of BK2522M and BK2527M, half the VC detection limit assumed
IW-7	15	300	5	120	15	Average of BK2522M and BK2527M, half the VC detection limit assumed
IW-8	15	300	5	120	15	Average of BK2522M and BK2527M, half the VC detection limit assumed
Total	195	5,312	205	2,291	139	Influent to treatment system for VOCs removal

Arithmetic mean for TCE:
Shallow system = 12, 204 ($\mu g / L$)
Intermediate system = 1,004 ($\mu g / L$)
VC - Vinyl chloride

2.7.7 Bulk Density of Bedrock

The bulk densities of the bedrock in the shallow and the intermediate bedrock groundwater systems at the Fischer and Porter site are assumed to be equal. A default value of 1.65 g/cm was intermediate between the default values for a medium sandstone and a siltstone, 1.68 g/cm and 1.61 g/cm, respectively (EPA, 1993a).

2.7.8 Porosity

On the basis of published values (Rima et al., 1962), the porosity of the Stockton Formation at the Fischer and Porter site is estimated to be 0.20.

2.7.9 Water Partition Coefficient of Bedrock

The water partition coefficient was assumed to be equal for the bedrock in the shallow and intermediate groundwater systems at the Fischer and Porter site. This water partition coefficient, 0.063 mL/g, is the product of the estimated default values for the organic carbon partition coefficient and the fraction of organic carbon.

2.7.10 Organic Carbon Partition

A default value of 126 mL/g for the organic carbon partition coefficient for TCE was applied to the Fischer and Porter site (Schwille, 1988).

2.7.11 Fraction of Organic Carbon

The fraction of organic carbon was assumed to be equal for the bedrock in the shallow and the intermediate groundwater systems at the Fischer and Porter site. This value, 0.00050 g/g, was estimated from published default values for glacio-fluvial fine to medium sands (Gillham et al., 1987).

2.7.12 Required Number of Pore Volumes and Time of Retardation

The results of the Mixed Reactor approach calculations for the required number of pore volumes to be extracted needed to reduce TCE concentrations and the estimated time needed to reduce TCE concentrations in the shallow and intermediate bedrock groundwater systems to the PRGs under both the source control and the sitewide capture alternatives are summarized in Table B-6.

Table B-6
Required Number of Pore Volumes and Time of Remediation
Fischer and Porter Site

Groundwater Extraction Alternative	Required Number of Pore Volumes	Estimated Time of Remediation (Years)
Shallow Bedrock Groundwater System		
Source control alternative	51	97
Sitewide alternative	48	121
Intermediate Bedrock Groundwater System		
Source control alternative	37	70
Sitewide alternative	33	95

2.8 Remedial Design Investigation

The source control and sitewide capture alternatives presented in this FS report are developed based on several assumptions. Additional data are needed to support the actual design of a groundwater extraction system for both the shallow and intermediate bedrock groundwater systems at the site. These data can be collected as part of the remedial design of the extraction system. This section presents a scope for the remedial design investigation. Depending on whether the source control or sitewide capture alternative is chosen and the acceptable degree of uncertainty in the effectiveness of the extraction system, the actual scope (and costs) of the design investigation can be reduced or increased. A phased approach where a groundwater extraction system is constructed and actual data on its effectiveness is collected before the system is modified, also may be appropriate at this site because of the uncertainties on the presence of DNAPL (EPA, 1992). Adopting a phased approach on installing the system also will affect the scope (and costs) of the remedial design investigation. The following sections present objectives, key assumptions, and a brief scope of work for the additional design data gathering efforts. The estimated costs for implementing these efforts are presented in Table B-7.

2.8.1 Task 1: Monitoring Well Installation

The objective of the monitoring well installation task is to obtain a more accurate delineation of the TCE plume in the shallow bedrock groundwater system and determination of the presence of the TCE plume in the intermediate bedrock groundwater system. Figures B-5 and B-6 show conceptually the locations of the remedial design investigation wells in relation to the TCE plume and existing monitoring wells in these systems.

This task assumes the installation of three additional shallow monitoring wells and six additional intermediate monitoring wells. These wells will be located downgradient (i.e., north) of existing monitoring well PH2. One shallow monitoring well is located to identify the leading edge of the TCE plume in the shallow bedrock groundwater system. The other two wells are located to identify the extent of the plume in the east and west directions in this system. Three of the monitoring wells in the intermediate bedrock groundwater system follow the spine of the TCE plume in the shallow bedrock groundwater system. This is because this is the area where the highest TCE concentrations may migrate from the shallow to the intermediate groundwater bedrock systems. The remaining three wells are located to identify the extent of the TCE plume in the east and west directions and at the site boundary in the intermediate system. Because TCE presence in the intermediate bedrock groundwater system is likely more widespread than in the shallow system, the spacing between the monitoring wells in this system is greater than that between the monitoring wells in the shallow system.

The shallow monitoring wells are assumed to be approximately 120 feet deep, whereas the intermediate monitoring wells are assumed to be 220 feet deep. All wells will be constructed of 2-inch I.D. PVC and have a 100-foot screen interval. Because bedding plane fractures typically control groundwater flow in bedrock formations of the Newark Basin (Michalski, 1990), an oriented rock core will be obtained during the drilling of one of the

Table B-7
Estimated Remedial Design Investigation Costs
Fischer and Porter Site

Labor	Rate ($/hr)	1	2	3	4	5	6	7	8	9	Total Hours	Total Cost
P4	$123.00	0	0	0	0	1	0	8	116	0	125	$15,375.00
P3	$91.00	2	2	1	1	1	1	1	2	1	12	$1,092.00
P3	$91.00	79	105	6	15	6	23	64	26	14	338	$30,758.00
P3	$91.00	38	4	2	4	2	4	2	4	2	62	$5,642.00
P2	$69.00	283	12	33	55	12	11	249	32	36	723	$49,887.00
P1	$60.00	45	318	0	0	0	88	120	0	50	621	$37,260.00
T2	$61.00	0	316	0	36	16	38	0	0	0	406	$24,766.00
T1	$43.00	16	48	0	4	2	4	30	0	2	106	$4,558.00
Outside Consultant	$123.00	0	0	0	0	0	0	0	0	0	0	$0.00
P2	$69.00	2	0	2	2	4	0	4	12	8	34	$2,346.00
Clerical	$42.00	4	4	0	2	0	2	4	0	0	16	$672.00
Clerical	$42.00	54	8	2	4	4	4	8	8	2	94	$3,948.00
Clerical	$42.00	0	0	0	0	0	0	0	0	0	0	$0.00
P2	$69.00	4	2	0	4	0	2	4	0	0	16	$1,104.00
Total Hours		527	819	46	127	48	177	494	200	115	2553	
Total Labor		$36,594	$51,991	$3,318	$8,649	$3,276	$11,467	$33,808	$20,552	$7,753		$177,408

Expenses	1	2	3	4	5	6	7	8	9	Total Cost
Field Equipment & Misc. Exp.	$6,380.00	$32,639.00	$100.00	$2,713.00	$762.50	$2,497.00	$24,498.00	$250.00	$900.00	$70,739.50
Travel	$6,760.00	$12,750.00	$184.00	$1,125.00	$134.00	$611.00	$6,250.00	$0.00	$869.00	$28,683.00
Office	$5,526.10	$16,946.30	$726.60	$1,284.90	$928.60	$2,346.90	$5,091.80	$2,333.80	$1,258.70	$36,443.70
Total Expenses	$18,666	$62,335	$1,011	$5,123	$1,825	$5,455	$35,840	$2,584	$3,028	$135,866

Task Descriptions

- Task 1: Well Installation & Development
- Task 2: Groundwater Sampling
- Task 3: Municipal Pumping Record Data Collection
- Task 4: In-well Tracer Testing
- Task 5: Site Wide Well Surveying
- Task 6: Slug Testing
- Task 7: Step Testing & 72-hr Pump Testing
- Task 8: Groundwater Modeling
- Task 9: Borehole Utility Clearance and Siesmic Survey

Subcontractor Costs	
Laboratory	$2,500
Drilling & Well Installation	$123,132
Surveyor	$13,500
Management of IDW	$114,750
Utility Clearance & Geophysics	$15,500
Subcontractor Total	$269,382

Labor Total	$177,408
Expenses Total	$135,866
Subcontractor Total	$269,382
Total Cost	$582,656

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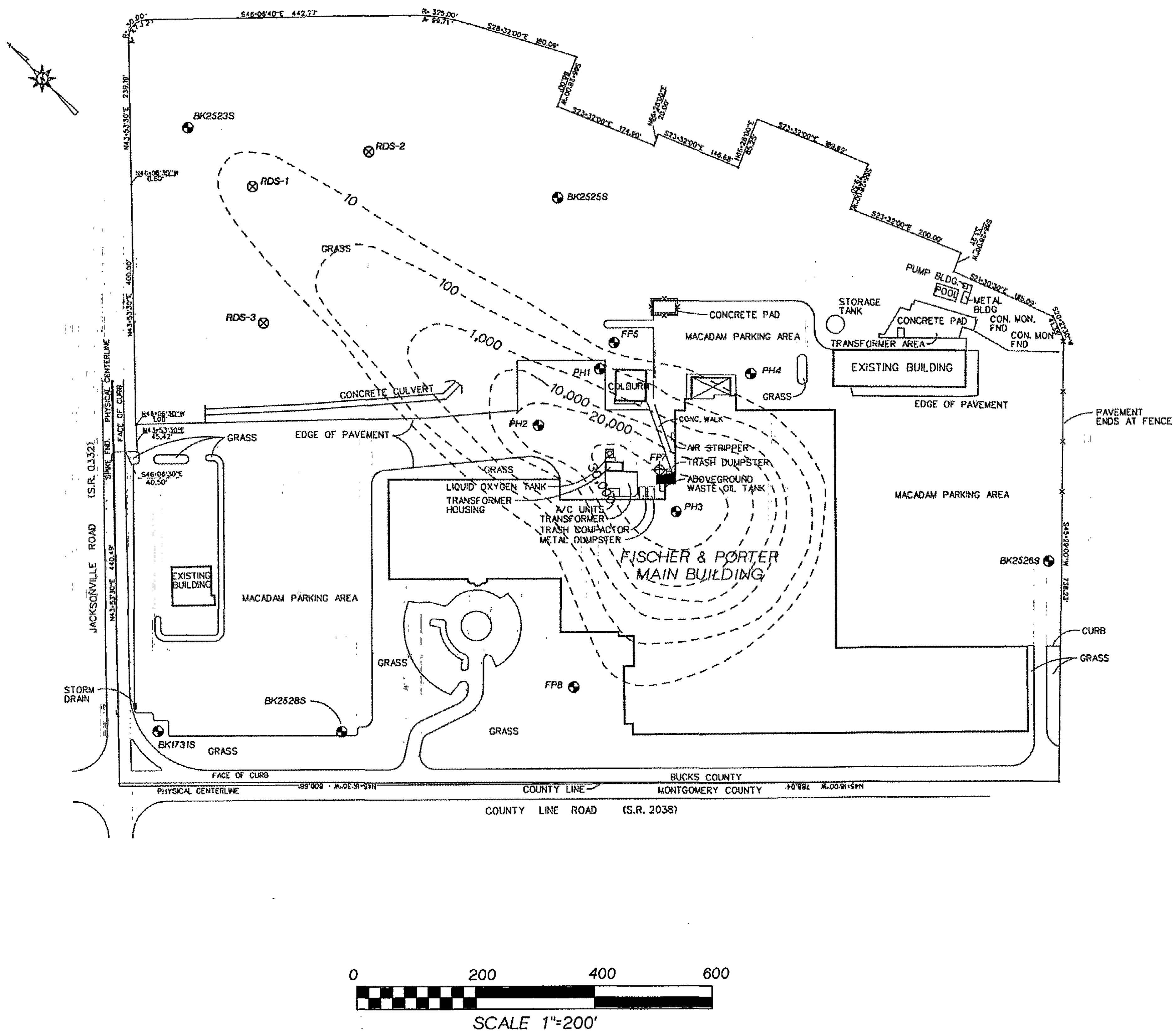

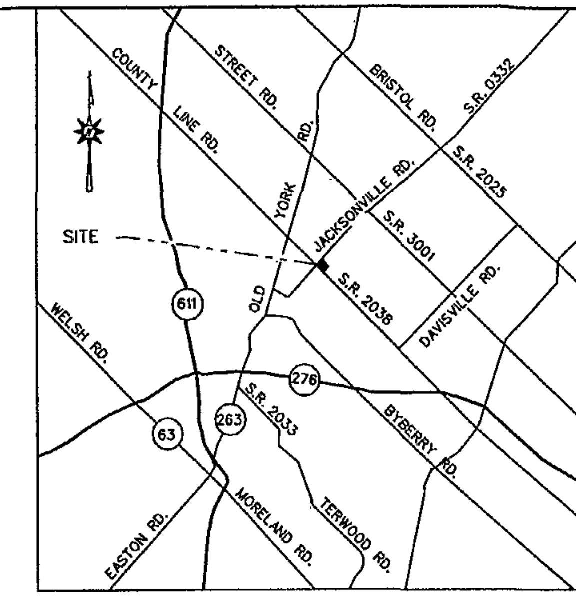

LOCATION MAP
(N.T.S.)

LEGEND

- RDS-1 ⊗ CONCEPTUAL LOCATION OF REMEDIAL DESIGN INVESTIGATION WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN SHALLOW WATER-BEARING ZONE
- BK2525S MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN SHALLOW WATER-BEARING ZONE.
- FP7 OIL RECOVERY WELL
- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH
- ■ ASSUMED EXTENT OF LNAPL

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBURARY 12,1991.
3. HORIZONTAL DATUM ARE ASSUMED & ROTATED TO PLAN BOUNDARY MERIDIAN.
4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDIX B.

Figure B-5
CONCEPTUAL LOCATIONS OF REMEDIAL DESIGN INVESTIGATION WELLS - SHALLOW ZONE

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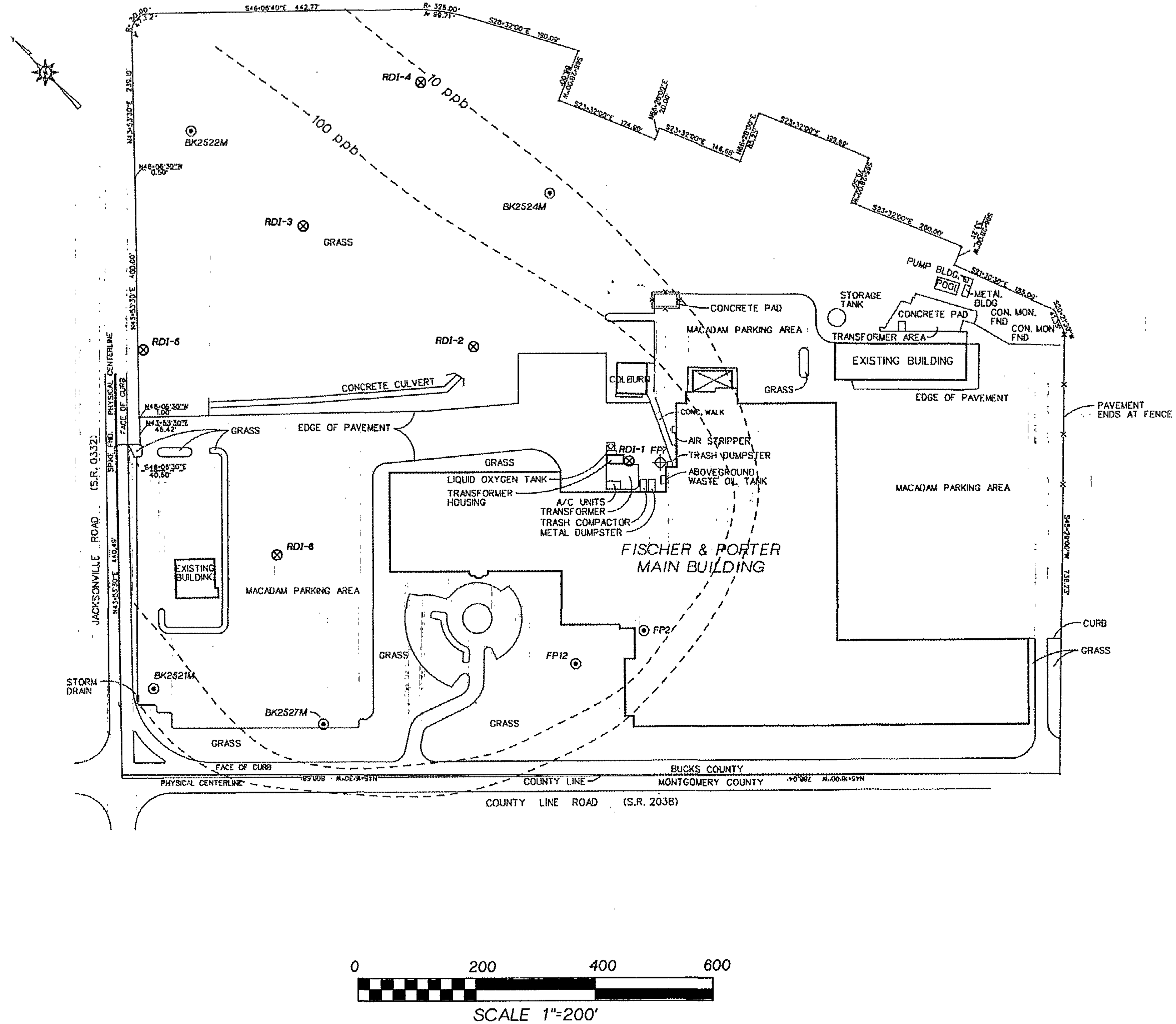

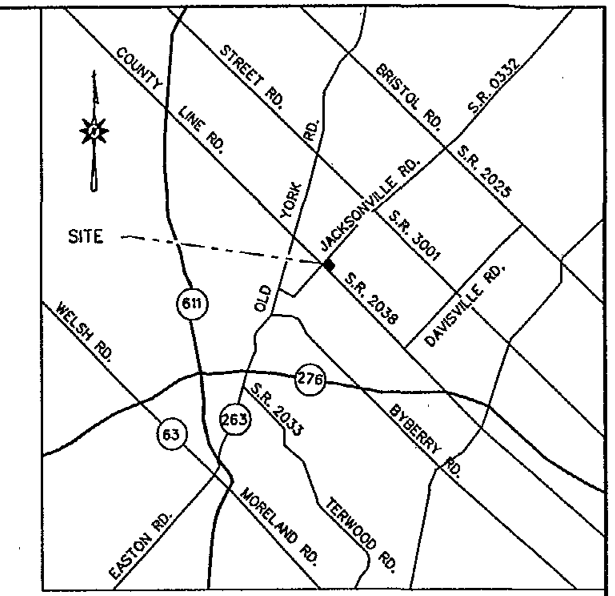

LOCATION MAP

(N.T.S.)

LEGEND

RDI-1 ⊗ CONCEPTUAL LOCATION OF REMEDIAL DESIGN INVESTIGATION WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN INTERMEDIATE WATER-BEARING ZONE

BK2525M ⊙ MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN INTERMEDIATE WATER-BEARING ZONE.

FP7 ⊕ OIL RECOVERY WELL

- - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES, INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBURARY 12,1991.
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4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure B-6
CONCEPTUAL LOCATIONS OF REMEDIAL DESIGN INVESTIGATION WELLS - INTERMEDIATE ZONE
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intermediate wells to confirm the site-specific average strike and dip of the shallow and intermediate bedrock. Several representative lithologies from this core would subsequently be analyzed for effective porosity (n), bulk density (P), and the fraction of organic carbon (foc). During the development of the thirteen monitoring wells specific capacities will be calculated.

The costs presented in Table B-7 reflect drilling, well installation and development, well materials, analysis of the oriented rock core, creation of boring logs, well development logs, handling of the investigation derived waste, and the production of a technical memorandum at the completion of this task. This task assumes that well development water will be contained in a temporary storage tank and treated through the existing air stripper.

2.8.2 Task 2: Well Sampling

The objective of the well sampling task is to delineate the TCE plume more accurately in the shallow and intermediate bedrock groundwater systems at the site and to evaluate trends in TCE concentrations in groundwater over time. This task includes collecting samples from the 16 existing shallow and intermediate monitoring wells (BK-series, PH-series, and FP-series without FP1 and FP2), as well as the 9 new monitoring wells described under Task 1. Samples will be analyzed for VOCs. In addition, to evaluate the need for pretreatment before treatment for VOCs removal, select number of shallow and intermediate wells within the proposed pumping area will be sampled for select water quality parameters (e.g., iron, manganese, etc.).

The costs presented in Table B-7 reflect the preparation of an addendum to the existing sampling plan, well sampling, data entry, and the preparation of a technical memorandum at the completion of this task. No costs are included for laboratory analyses as these analyses are assumed to be performed through the Contract Laboratory Program (CLP). The assumption is that well development water will be stored in a temporary storage tank at the site and treated through Fischer and Porter's existing air stripper.

2.8.3 Task 3: Municipal Pumping Records

The objective of the municipal pumping records task is to obtain and interpret municipal pumping records for Warminster Heights wells WH1 and WH2 to better understand the interelationships of municipal pumping to the shallow and intermediate bedrock groundwater systems at the Fischer and Porter site. The pumping records will be evaluated relative to the Phase II hydrogeologic data. It is assumed, based on the findings of the USGS investigation (Sloto, et al., 1995), that the Warminster Heights wells WH1 and WH2 are the only municipal wells that impact the shallow, intermediate, and deep monitoring wells at the Fischer and Porter site.

The costs presented in Table B-7 reflect the labor associated with obtaining and evaluating the municipal pumping records for Warminster Heights wells WH1 and WH2, and preparing a technical memorandum at the completion of this task.

2.8.4 Task 4: In-Well Tracer Tests

The objective of the in-well tracer tests is to evaluate the hydraulics (i.e., identify in-flow zones, out-flow zones, aquifers, and aquitards) at wells screened in the shallow and intermediate bedrock groundwater systems at the Fischer and Porter site. This information will assist in the selection of the most appropriate screen intervals, although 100-foot screen intervals are assumed for the purpose of this FS. Data associated with the in-well tracer tests will likely reduce the cost of the extraction wells by limiting the length of the well screen.

The recommendation is that the tracer tests be performed instead of the downhole geophysical logging that was used during the remedial investigation. This task assumes that the tracer tests will be conducted in at least three of the shallow and three of the intermediate monitoring wells, which are described in Task 1. A baseline temperature and temperature-compensated conductivity profile will be generated for each well. Saline slugs will be released at appropriate depths in each well based on the results of the baseline profiles. Subsequent to the release of each saline tracer, conductivity profiles will be collected over time to monitor the behavior of the tracer.

The costs presented in Table B-7 reflect the equipment and labor associated with acquiring, plotting, and evaluating baseline and in-well tracer data for six wells and the preparation of a technical memorandum at the completion of this task.

2.8.5 Task 5: Well Survey

The objective of the well survey task is to prepare a site map with accurately surveyed monitoring well locations at the Fischer and Porter site. Two phases of surveying will be required. The first phase of surveying will include the 23 existing monitoring wells (including wells FP1 and FP2) and the 9 monitoring wells described in Task 1. Monitoring wells will be surveyed (located and elevated) by a qualified and licensed surveyor. The elevations of the ground surface, outer casing, and inner casing will be surveyed for each well. During the second phase of surveying, 13 extraction wells will be elevated and located. This number of extraction wells assumes that the sitewide capture alternative is implemented.

The costs presented in Table B-7 reflect the survey services (i.e., field survey, electronic and hard copies of the completed well survey following each phase). Labor costs associated with procuring and overseeing surveying services also are included.

2.8.6 Task 6: Slug Tests

The objective of the slug test task is to obtain site-specific hydraulic conductivities (k) in the 9 2-inch I.D. monitoring wells described in Task 1. This information will assist in the selection of the locations of the extraction wells at the site. Based on the results of the Phase II RI, areal hydrogeologic heterogeneities are suspected across the site. The assumption is that rising head slug tests will be performed in all nine monitoring wells.

The costs presented in Table B-7 reflect the equipment and labor associated with acquiring, plotting, and evaluating the rising head slug test data for nine wells and the preparation of a technical memorandum at the completion of this task.

2.8.7: Task 7: Step Drawdown Tests and 72-Hour Pumping Tests

The objective of the step drawdown tests task is to approximate the optimum long-term pumping rate, the specific capacity, and the transmissivity at each monitoring well tested at the Fisher and Porter site. A step drawdown tests will be performed on two shallow wells and two intermediate wells installed as part of Task 1. Two of the wells will be the same wells and will be tested during the 72-hour pumping test. The assumption is that specific capacities for all nine monitoring wells installed during the remedial design investigation will be obtained during the development of the wells.

The objective of the 72-hour pumping tests is to obtain aquifer coefficients for the shallow and intermediate bedrock groundwater systems, define the relationship (i.e., leakance) between the two groundwater systems, and attempt to define the area of influence for the two wells that will tested. The results of the tests will be used in Task 8, groundwater modeling. This task assumes that two pumping tests (one shallow zone and one intermediate zone) will be conducted at one selected location at the Fischer and Porter site. The 72-hour pumping tests should be conducted at wells where step tests were performed. At a minimum, five observation wells should be used during each pumping test with four of the five observation wells being screened within the groundwater system being pumped. Background water level data would be collected before the beginning of the tests. This will be accomplished by installing dataloggers in select monitoring wells in both the shallow and intermediate systems before beginning the tests.

Assuming the shallow bedrock groundwater system is being pumped, one shallow observation well and one intermediate observation well should be monitored within 10 feet of the pumping well. In addition, two shallow observation wells should be monitored approximately 150 feet from the pumping well. The second of these two observation wells should be perpendicular to a line drawn between the pumping well and the first observation well. One of these two observation wells should be oriented so that a line drawn between the observation well and the pumping well is parallel to the site-specific bedding strike. Finally, a shallow observation well, approximately 500 feet from the pumping well also should be monitored.

Assuming the intermediate bedrock groundwater system is being pumped, one intermediate observation well and one shallow observation well should be monitored within 10 feet of the pumping well. In addition, two intermediate observation wells should be monitored approximately 150 feet from the pumping well. The second of these two intermediate observation wells should be perpendicular to a line drawn between the pumping well and the first intermediate observation well. One of these two intermediate observation wells should be oriented so that a line drawn between the observation well and the pumping well is parallel to the site-specific bedding strike. Finally, an intermediate observation well, approximately 500 feet from the pumping well, should also be monitored.

Although this cost estimate assumes that the 72-hour pumping tests will be performed at one location, two pumping test locations are recommended because hydrogeology is non-uniform across the Fischer and Porter site. The 72-hour pumping tests should be coordinated with shutdowns of Warminster Heights municipal wells WH1 and WH2. The assumption is that the monitoring wells can be located so that no additional observation wells are needed during the hydrogeologic testing. Because municipal pumping interferes with observations of drawdown, additional observation wells may be needed.

The costs presented in Table B-7 reflect the equipment and labor associated with acquiring, plotting, and evaluating the four step drawdown test data and the two 72-hour pumping test data and the preparation of a technical memorandum at the completion of the task.

2.8.8 Task 8: Groundwater Modeling

CH2M HILL recognizes that vertical interaction between the shallow and intermediate bedrock groundwater systems is likely to occur. In addition, hydraulic interferences between wells need to be defined and accounted to determine the configuration of anticipated capture zones. A computer code that accounts for vertical interaction between the groundwater systems and hydraulic interferences should be used. An example of such a computer code would be MODFLOW. The objective of this task is to use the aquifer coefficients, leakance factors, and hydraulic communication information obtained during Task 7, to select locations and determine pumping rates of the extraction wells to be installed at the Fischer and Porter site. A three-dimensional modeling (e.g., MODFLOW) of the shallow and intermediate bedrock groundwater systems is assumed.

The costs presented in Table B-7 reflect the labor and expenses associated with performing the groundwater modeling and creating the necessary graphics for the preparation of a technical memorandum at the completion of the task.

2.8.9 Task 9: Borehole Utility Clearance and Geophysical Survey

The objective of the borehole utility clearance task is to ensure that the drilling associated with monitoring and extraction well installation at the Fischer and Porter site does not encounter and damage any underground utilities. On the basis of the Phase II RI activities, the facility appears to have incomplete information on the locations of the underground utilities, especially in the source area. This task assumes two phases: one before the monitoring well installation (Task 1) and another before the extraction well installation following the completion of the remedial design investigation.

The costs presented in Table B-5 reflect the costs for procuring and overseeing subcontractor services for borehole clearance.

The objective of the geophysical survey is to map the bedrock structures within the shallow and intermediate groundwater systems at the Fischer and Porter site. The bedrock structures (.eg., faults and folds) may affect the direction of groundwater flow at the Fischer and Porter site. The results of previous studies at the site indicate the potential for hydraulic control by bedrock structure. A high fold shallow seismic reflection survey is assumed within and downgradient of the source area at the site. The survey is assumed to include a minimum of one strike line and three dip lines. The results of the survey will indicate the presence, attitude, and orientation of faults and folds present within the bedrock at the site that likely control flow within the shallow and intermediate bedrock groundwater systems.

The costs presented in Table B-7 reflect the subcontractor costs associated with data acquisition, processing, and mapping and labor associated with procuring and overseeing the subcontractor services. In addition, labor associated with the evaluation of the geophysical survey and the preparation of a technical memorandum is included in the estimated costs.

2.8.10 Task 10: Miscellaneous

Section 7 of the RI report for the Fischer and Porter site (CH2M HILL, 1997) contains additional recommendations, such as establishing the hydraulic relationship between Pennypack Creek and the shallow bedrock groundwater system and conducting a search for private potable wells within a 2-mile radius and downgradient of the Fischer and Porter site. Costs of these tasks are not presented in Table B-7.

Appendix C
Conceptual Design Of Groundwater Treatment System

1 Introduction

During the Phase II RI, concentrations of several VOCs, including TCE and its degradation products were detected in groundwater at the site above RBCs (see Section 6 in the RI report). As stated in Section 2 of this report, the site-specific remedial action objectives established for groundwater at the site are:

- Prevent potential future human exposure to VOCs present in the shallow, intermediate, and deep bedrock groundwater systems above health-based criteria through ingestion, inhalation, and dermal contact with the groundwater.
- Limit further migration of dissolved-phase VOCs horizontally within the shallow and intermediate bedrock groundwater systems and vertically between the shallow, intermediate, and deep bedrock groundwater systems within the source area at the site.

To achieve these objectives, two groundwater extraction alternatives, source control and sitewide capture, were developed in Appendix B. The extracted groundwater from both alternatives would not be accepted by either of the two local publicly owned treatment works (POTWs), the Upper Moreland-Hatboro Joint Sewer Authority, and Warminster Sewer Authority. Therefore, this water would require treatment to remove VOCs before its discharge to surface water. This appendix presents conceptual designs for the groundwater treatment systems consisting of the treatment technologies identified as applicable to the site in Section 3 of this FS report.

2 Design Basis

2.1 Flow

A design flow of 90 gallons per minute (gpm) was developed for the source control alternative based on the following assumptions:

- 6 extraction wells
- 15 gpm per extraction well

A design flow of 195 gpm was developed for the sitewide capture alternative based on the following assumptions:

- 13 extraction wells
- 15 gpm per extraction well

2.2 Influent Groundwater Characteristics

The concentrations of various VOCs were estimated for each extraction well, as discussed in Appendix B. From these concentrations, treatment system influent concentrations were developed by using a flow-weighted average. Table C-1 summarizes the VOCs concentrations expected in the treatment system influent based on the above flow-weighted method.

Table C-1
Estimated Influent Treatment System Concentrations
Fischer and Porter Site

Parameter	Groundwater Extraction Alternative	
	Source Control	Sitewide Capture
	Flow: 90 gpm	Flow: 195 gpm
TCE	10,433	5,312
PCE	274	139
1,2-DCE	4,678	2,291
Vinyl chloride	365	205

All concentrations in µg/L.

Although the presence of metals in groundwater is believed to be associated with the geochemistry of the bedrock, pretreatment for metals removal may be necessary before air stripping because of the potential for fouling/scaling of the air stripping systems.

Currently, data are limited to determine the need for metals removal. The existing air stripper at the site treats groundwater extracted from the three existing extraction wells (FP1, FP2, and FP7) without any pretreatment for metals removal. The three wells, however, extract groundwater from all three groundwater bedrock systems at the site. During the Phase II RI, the metals concentrations measured in the monitoring wells installed in the shallow groundwater bedrock system (PH1, PH2, PH3, and PH4) were significantly higher than those measured in the sample from the combined flow from existing extraction wells FP1 and FP2. Therefore, the metals concentrations in the influent to a new treatment system were estimated by averaging the metals concentrations from the four shallow monitoring wells. The influent metals concentrations estimated using this approach are believed to be conservative in that they do not account for dilution. For example, the groundwater extracted from the shallow bedrock groundwater system is assumed not to be diluted with the groundwater with potentially lower metals concentrations extracted from the intermediate groundwater bedrock system.

During the remedial design, data should be obtained on metals concentrations in the intermediate groundwater bedrock system. The determination on the need for pretreatment for metals removal should be made after these additional data are collected. Pretreatment for metals removal is not included with any of the other groundwater treatment technologies for VOCs removal (e.g., carbon adsorption, chemical oxidation).

This is because, as noted above, the metals detected above MCLs in the groundwater (barium, manganese, and iron) are believed to be associated with the geochemistry of the bedrock. For these treatment technologies, a cartridge filter for particulate removal may be used to reduce metal concentrations associated with suspended matter. Finally, if metals removal is determined to be needed for the air stripping system, the estimated costs for this technology should be compared to the estimated costs for regular chemical washing of the air stripping system to remove precipitated metals. Depending on the frequency at which the washing would need to be performed, it may be a cheaper alternative to the capital cost-intensive metals precipitation technology.

The metals concentrations in wells PH1, PH2, PH3, and PH4; their estimated concentrations in the treatment system influent; and their corresponding MCLs are summarized in Table C-2.

Table C-2
Estimated Influent Concentrations for Selected Metals
Fischer and Porter Site

Parameter	Well PH1	Well PH2	Well PH3	Well PH4	Design Influent Concentration	MCL
Aluminum	0.256	0.0608	0.0616	0.086	0.12	2.0
Barium	2.92	0.762	1.64	0.116	1.4	0.2
Calcium	88.0	92.6	57.3	101	85	N/A
Iron	3.75	0.025[a]	0.16	0.025[a]	1	0.3
Magnesium	31.6	46.2	29.8	34.1	35	N/A
Manganese	8.4	0.256	4.25	0.0168	3.2	0.050

All concentrations in mg/L.
N/A - Not available.
Note:
[a] Concentration reflects the detection level of the analytical method used since iron was not detected above this level.

2.3 Effluent Criteria

The existing air stripping tower at the Fischer and Porter site has a permit discharge limit of 35 µg/L for TCE and 10 µg/L for PCE. These concentrations are above the current MCLs for these compounds. Conversations with PADEP have indicated that the above permit discharge limits are water-quality-based limits. Such limits typically are calculated from a mass balance using the discharge flow rate (i.e., 75 gpm for the current system). PADEP stated that an amendment request would have to be submitted to alter the current permit to include the higher discharge flows, which in turn could alter the required discharge limits. At this time, according to PADEP, it is likely that the discharge limits will be changed to the MCLs for the compounds of interest. Therefore, the effluent limits required to be achieved by the new treatment system were assumed to be the MCLs for both the VOCs and metals, when pretreatment for metals removal is provided.

3 VOCs Removal from Groundwater

Three treatment alternatives for the reduction of VOC concentrations in the extracted groundwater remained after the screening of remedial technologies in Section 3:

- Alternative GT-1: Liquid-Phase Carbon Adsorption
- Alternative GT-2: Air Stripping
- Alternative GT-3: Chemical Oxidation

3.1 Alternative GT-1: Carbon Adsorption (Liquid Phase)

Liquid-phase adsorption involves the transfer of a chemical in solution to the solid phase. Typically, granular activated carbon (GAC) in a fixed bed is used for organic chemical treatment. Water is pumped to the top of a vessel and is distributed across the diameter of the vessel. The water passes through the GAC bed. Organic chemicals are adsorbed physically in the microscopic pores and chemically to the carbon. After the carbon becomes saturated with contaminants, the contaminants can no longer be adsorbed and "break through" occurs. At that point, the carbon would have to be replaced with virgin or regenerated carbon. Figure C-1 shows a schematic of the carbon adsorption system.

The liquid-phase carbon adsorption units are sized based on several factors, including liquid flow rate, chemical concentrations, and loading rates for each chemical. Examination of the isotherms indicated that vinyl chloride governed the carbon usage rate, because it would be the first constituent to break through the carbon beds. The following carbon usage rates were estimated:

- 8.9 pounds of carbon per 1,000 gallons of treated groundwater for the 90 gpm system
- 5.8 pounds of carbon per 1,000 gallons of treated groundwater for the 195 gpm system

The estimated carbon usage rate is higher for the sitewide alternative because the estimated VOC loadings are higher than the source control alternative. The carbon usage rates for both alternatives are high and, therefore, the rate of carbon changeout will be frequent. To minimize the required changeout frequency, the largest standard diameter carbon vessel was used. Table C-3 summarizes selected design criteria for each flow rate.

Table C-3
Groundwater Treatment for VOCs Using Liquid-Phase Carbon Adsorption
Fischer and Porter Site

Parameter	Groundwater Extraction Alternative	
	Source Control	Sitewide Capture
Process Feed Pumps		
No. of Pumps	2	2
Type of Pump	Centrifugal	Centrifugal
Capacity/Head (ft)	50	50
Horsepower	2	5
GAC Units		
Flow (gpm)	90	195
Number of Vessels	2	2
Vessel Diameter (ft)	10	10
Vessel Height (ft)	24	24
Skid Dimensions (ft)	27L x 11 W x 24 H	27L x 11 W x 24 H
Carbon Usage (lb/day)	1,150	1,630
Pounds GAC Per Vessel	20,000	20,000
Changeout Frequency (days)	17	12

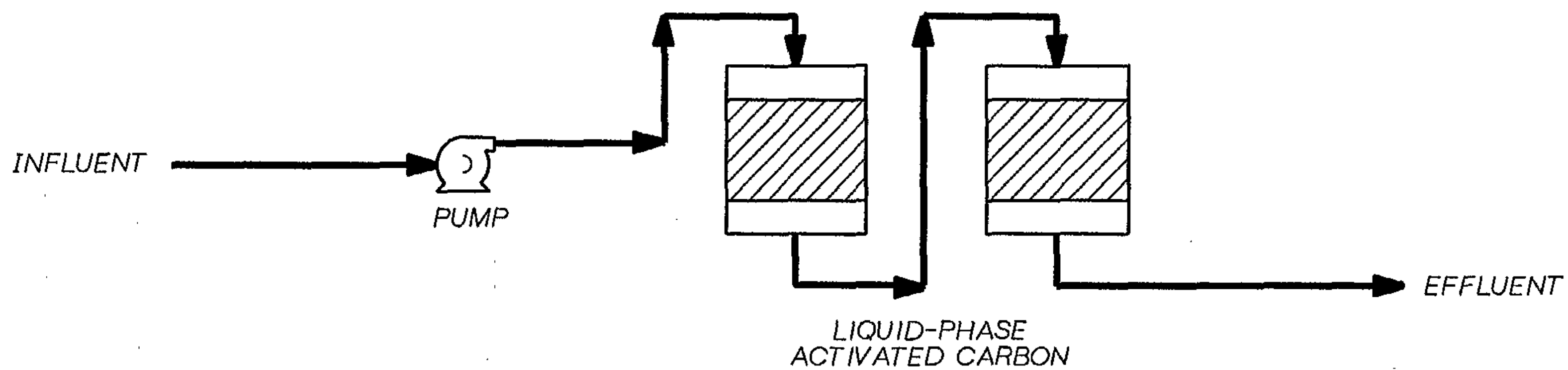

Figure C-1
GROUNDWATER TREATMENT
ALTERNATIVE GT-1
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3.2 Alternative GT-2: Air Stripping

Air stripping is the transfer of a volatile substances in solution in the liquid phase to a solution in the gas (air) phase. Types of units include packed towers, tray towers, spray systems, diffused aerators, and mechanical aerators. Two of these types, packed tower and diffused aerator, were evaluated for this FS. These units were sized based on the following criteria:

- Effluent discharge limit of 5 µg/L (drinking water MCL)
- Influent TCE concentration of 10,433 ppb for the 90 gpm system (99.95 percent removal)
- Influent TCE concentration of 5,312 ppb for the 195 gpm system (99.90 percent removal)

3.2.1 Packed Tower

Typically, a packed tower is a column with a bed of packing material. The packing material provides increased surface area to allow transfer of the volatile constituents from the liquid to the gas phase. Water is pumped to the top of the tower where it is distributed across the diameter of the column. As the water flows down the column, it forms a thin film over the packing, creating a larger surface area for mass transfer to occur. Clean air is blown counter current to the water from the bottom of the column. As the air passes across the thin film of water on the packing, mass transfer of VOCs from water to the air stream occurs. Air flow and the depth of packing are optimized based upon the Henry's law constants (a parameter that indicates how easily or difficult it is to transfer the compound from the liquid to the vapor phase) and the required removal efficiency. Figure C-2 presents a schematic of the air stripper system.

A computer model was used to determine the required air-to-water ratio, column diameter, and packing height to achieve the treatment objectives for both flow rates. In addition, the use of one column or two columns in series also was modeled. The following design assumptions were used for the air stripper for each system:

- One air stripper column would be provided
- The column would be located outside, to minimize the height of any treatment building, if a building were required
- Two blowers (100 percent redundancy) would be provided and located within a building

Table C-4 summarizes the selected design criteria for each flow rate.

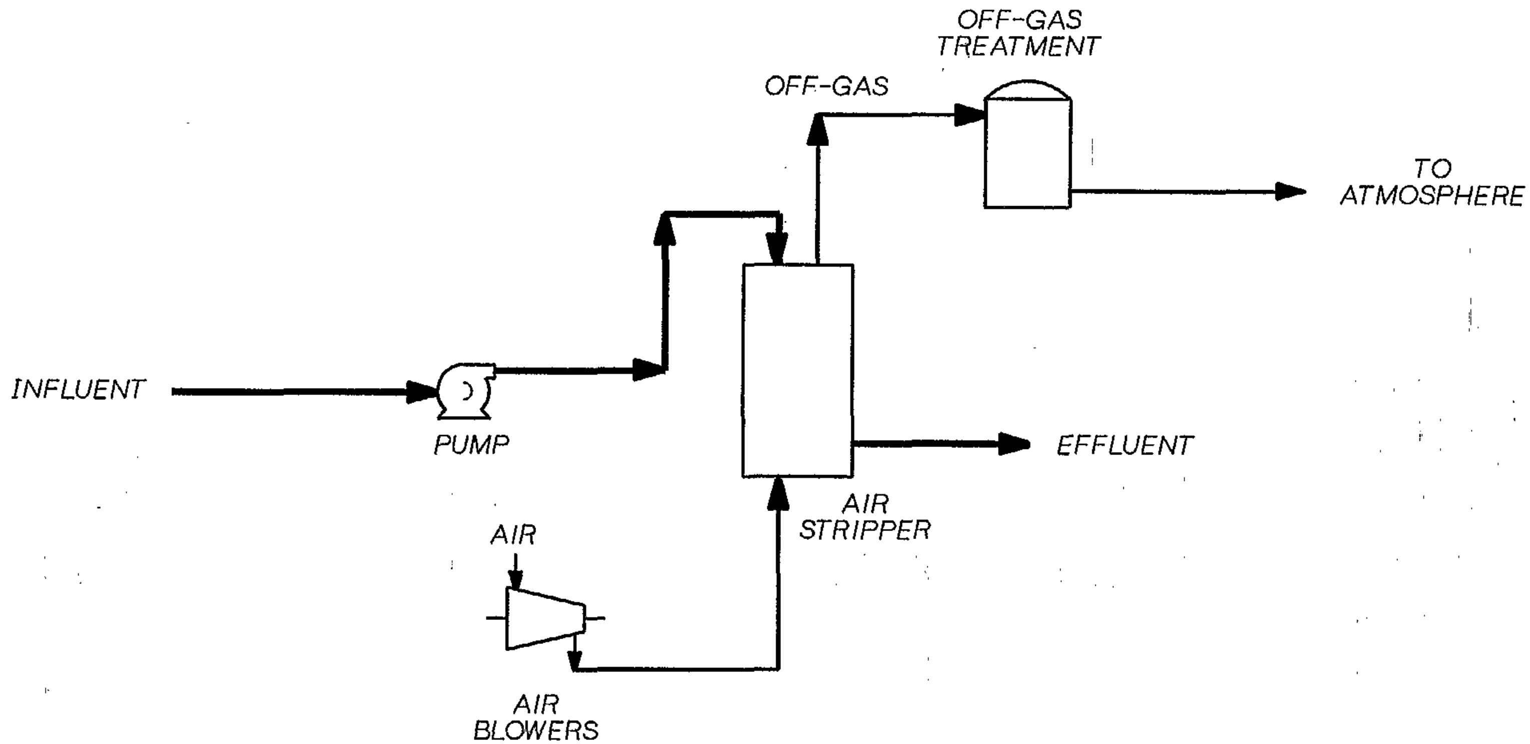

Figure C-2
GROUNDWATER TREATMENT
ALTERNATIVE GT-2

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Table C-4 Groundwater Treatment for VOCs Removal Using Packed Tower Air Stripper Fischer and Porter Site		
	Groundwater Extraction Alternatives	
Parameter	Source Control	Sitewide Capture
Process Feed Pumps		
Flow (gpm)	90	195
No. of Pumps	2	2
Type of Pump	Centrifugal	Centrifugal
Capacity/Head (ft)	50	50
Horsepower	2	5
Air Stripper		
Number of Columns	1	1
Column Diameter (ft)	4	5
Packing Depth (ft)	30	30
Air Flow Rate (cfm)	1,200	2,600
Liquid Loading (gpm/ft^2)	7	10
Air/Water Ratio	100	100
Packing Type: 2" Jaeger Tri-Packs		

3.2.2 Diffused Aerators

Diffused aerators, often called low-profile units, apply similar mass transfer principles as packed towers. Aeration trays, baffles, or nozzles in distinct stages are used to create a thin film of water instead of random packing. Water typically is pumped to the top of the rectangular unit where it cascades through a series of baffles or trays. Air is bubbled through the tray bottoms or diffused through nozzles in the water stream. Several trays can be stacked on top of each other or several units can be operated in series to achieve the desired removals. Many vendors are available that supply various types of diffused aeration systems.

As with the packed tower, the diffused aerator design was based on the desired percentage of TCE removal. Table C-5 summarizes the selected design criteria for each flow rate.

Table C-5 Groundwater Treatment for VOCs Removal Using Diffused Aeration Fischer and Porter Site		
	Groundwater Extraction System	
Parameter	Source Control	Sitewide Capture
Process Feed Pumps		
Flow (gpm)	90	195
No. of Pumps	2	2
Type of Pump	Centrifugal	Centrifugal
Capacity/Head (ft)	50	50
Diffused Aerators		
Number of Units	2	4
Air Flow Rate per Unit (cfm)	480	1,035
Air-to-Water Ratio	158.8	158.8
Equipment Installation Area (ft)	15Lx12Wx10H	15Lx20Wx10H

3.3 Alternative GT-4: Chemical Oxidation

Oxidation is a chemical process that converts VOCs to simpler by-products, such as carbon dioxide, water, and hydrochloric acid (from chlorinated VOCs). Chemical oxidation using ozone or hydrogen peroxide is commonly used for treatment of water supply wells and for groundwater remediation. An advantage of chemical oxidation over air stripping is that the VOCs are destroyed, whereas the off-gas from the air stripper may require subsequent treatment because the VOCs are not destroyed. Typically, the oxidant is injected directly into the pipeline upstream on an in-line static mixer. The required contact time for complete reaction is approximately 5 minutes. Hydrogen peroxide was considered for treatment at the Fischer and Porter site because it is less expensive and safer to administer than ozone. Treatability testing would be needed to determine the most appropriate oxidizer, its dose, and needed reaction time.

Figure C-3 presents a schematic of the chemical oxidation system. The components and selected design criteria for the system for each flow rate are summarized in Table C-6.

4 Alternative GT-3: Metals Precipitation

The chemical composition of the groundwater from the four shallow wells indicates that naturally occurring metals, such as calcium, iron, and manganese, could precipitate out of the groundwater, foul the air stripper packing material, and in turn reduce the effectiveness of VOC removal. In addition, the iron and manganese concentrations of the groundwater also could result in the growth of iron bacteria on the packing material and reduce the effectiveness of the stripper. The average concentrations of iron and manganese from wells PH1, PH2, PH3, and PH4 are greater than the MCLs for those metals.

The processes recommended for metals removal are proven technologies that are easily implemented using equipment that is readily available through vendors. However, because of the limited groundwater data available (filtered metals concentrations versus total metals concentrations, TSS concentrations, hardness, and alkalinity), additional

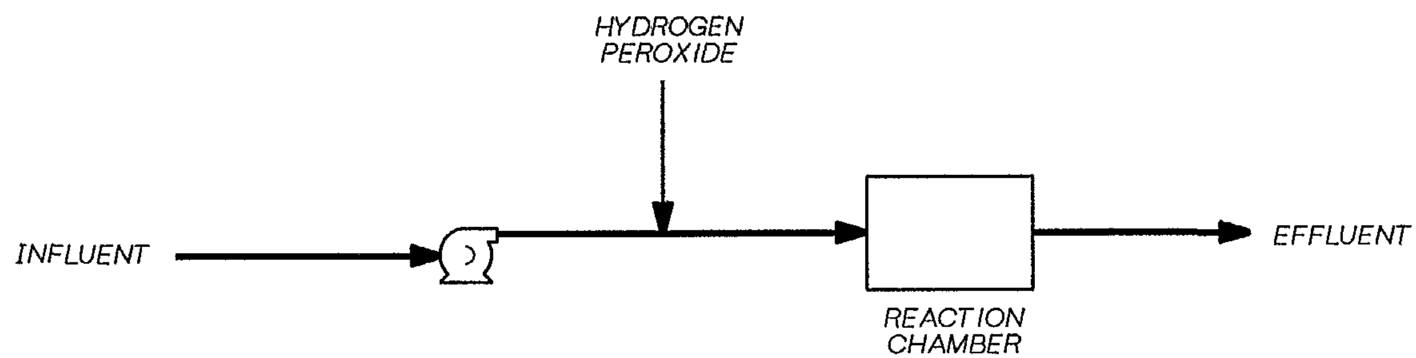

Figure C-3
GROUNDWATER TREATMENT
ALTERNATIVE GT-4

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groundwater data should be obtained from both the shallow and intermediate groundwater bedrock systems to determine total versus dissolved metals concentrations as well as whether the metals influent concentrations expected into the VOC treatment unit require any pretreatment for metals removal (i.e., whether insufficient dilution has occurred of the higher metals concentrations expected in the groundwater from the shallow groundwater bedrock system with the lower metals concentrations expected in the groundwater from the intermediate groundwater bedrock system, such that the combined influent to the VOCs treatment unit requires pretreatment for metals removal). The recommendation also is that a treatability test is performed on a composite groundwater sample to determine the expected life of the air stripper packing before implementing chemical softening. It may be that the metals may already be in particulate form such that the use of cartridge filters upstream of the air stripper and routine chemical cleaning (i.e., acid washing) of the air stripper packing would be sufficient for the effective removal of the hardness in the groundwater, rather than the installation of a large and expensive treatment system for metals removal. Cartridge filters also may be used with the other VOCs treatment technologies evaluated in this FS (e.g., carbon adsorption, chemical oxidation). The cartridges would filter particulate matter with which some of the metals are likely to be associated.

Table C-6
Groundwater Treatment for VOCs Using Chemical Oxidation
Fischer and Porter Site

Parameter	Groundwater Extraction System	
	Source Control	Sitewide Capture
Influent Pumping		
Flow (gpm)	90	195
No. of Pumps	2	2
Type	Centrifugal	Centrifugal
Capacity/Head (ft)	50	50
Reactor		
Retention Time (min.)	5	5
Volume (gal.)	450	875
Dimensions (ft)	4Dx6H	5Dx8H
Hydrogen Peroxide System		
Type	Inline	Inline
Dosage (mg/L)	10	10
Usage Rate (lb/day)	11	24

Chemical precipitation would reduce the concentrations of naturally occurring metals. A treatment system for metals precipitation would include the following unit processes: flow equalization, chemical addition, flocculation, clarification, gravity filtration, final pH adjustment, backwash storage, sludge dewatering, and chemical feed systems. A polishing step for metals removal is not anticipated. The selected design criteria for each flow rate are provided in Table C-7. Figure C-4 presents a schematic of the metals treatment system. Each of the processes required for the metals precipitation is described below.

Table C-7
Groundwater Treatment for Metals Removal
Fischer and Porter Site

Equipment Item/Criteria	Design Value
Transfer Pumping	
Pumps	
No. of Pumps	4
Type of Pump	Centrifugal
Capacity/Head	50 ft
Horsepower	2 hp for 90 gpm system; 5 hp for 195 gpm system
Material	Ductile Iron
Equalization	
Tank	
Volume	14,000 gal. for 90 gpm system; 2 tanks, 14,000 gal. each for 195 gpm system
Detention Time	2 hours plus backwash flows
Material	Fiberglass-reinforced plastic (FRP)
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	1 hp for 90 gpm system; 2 hp for 195 gpm system
Material	Stainless Steel
Reaction Tank (Through Flow @ 100 and 200 gpm [includes recycles])	
Tank	
Volume	1,000 gal. for 90 gpm system; 2,000 gal. for 195 gpm system
Detention Time	10 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	1 hp for 90 gpm system; 2 hp for 195 gpm system
Material	Stainless Steel
Chemical Feed System	
Chemical	Caustic - 50%
Chemical Feed Rate	1.6 gph for 90 gpm system; 4 gph for 195 gpm system

Table C-7 Groundwater Treatment for Metals Removal Fischer and Porter Site	
Equipment Item/Criteria	**Design Value**
Chemical Feed System	
Chemical	Soda Ash - 30%
Chemical Feed Rate	1.5 gph for 90 gpm system; 3.0 gph for 195 gpm system
Flocculation Tank	
Tank	
Volume	1,500 gal. for 90 gpm system; 3,000 gal. for 195 gpm system
Detention Time	15 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	1 hp for 90 gpm system; 2 hp for 195 gpm system
Material	Stainless Steel
Chemical Feed System	
Chemical	Polymer
Chemical Feed Rate	0.4 gph for 90 gpm system; 0.8 gph for 195 gpm system
Clarifier - Inclined Plate	
Tank	
Effective Settling Area	380 sf for 90 gpm system; 760 sf for 195 gpm system
Hydraulic Loading	0.26 gpm/sf
Sludge Production	540 lbs/day for 90 gpm system; 1,170 lbs/day for 195 gpm system
Material	Steel
Sludge Pumps - Waste	
No. of Pumps	2
Type of Pump	Air diaphragm
Horsepower	1.5 hp for 90 gpm system; 3 hp for 195 gpm system
Material	Stainless Steel
Gravity Filtration	
Filter	
Type of Filter	Gravity
Number of Bays	2
Normal Loading Rate	2 gpm/ft^2 (both); 4 gpm/ft^2 (one)

Table C-7 Groundwater Treatment for Metals Removal Fischer and Porter Site	
Equipment Item/Criteria	**Design Value**
Area, per bay	50 ft^2 for 90 gpm system; 100 ft^2 for 195 gpm system
pH Adjustment Tank	
Tank	
Volume	1,000 gal. for 90 gpm system; 2,000 gal. for 195 gpm system
Detention Time	10 minutes
Material	FRP
Mixer	
No. of Mixers	1 per tank
Type of Mixer	Vertical
Horsepower	1 hp for 90 gpm system; 2 hp for 195 gpm system
Material	Stainless Steel
Chemical Feed System	
Chemical	Sulfuric Acid - 93%
Chemical Feed Rate	0.8 gph for 95 gpm; 3.2 gph for 195 gpm system
Filter Backwash	
Tank	
Volume	1,500 gal. for 90 gpm system; 3,000 gal. for 195 gpm system
Detention Time	15 minutes
Material	FRP
Backwash Pumps	
No. of Pumps	1 per tank
Type of Pump	Horizontal Centrifugal
Flow Rate	150 gpm for 90 gpm system; 300 gpm for 195 gpm system
Horsepower	5 hp for 90 gpm system; 15 hp for 195 gpm system
Material	Stainless Steel (wetted parts)
Sludge Dewatering	
Sludge Storage Tank	
Volume	5,000 gal. for 90 gpm system; 10,000 gal. for 195 gpm system
Storage Time	7 days
Material	FRP, cone bottom

Table C-7 Groundwater Treatment for Metals Removal Fischer and Porter Site	
Equipment Item/Criteria	**Design Value**
Plate and Frame Press	
Press Capacity	50 ft^3 for 90 gpm system; 100 ft^3 for 195 gpm system
Cycles Per Day	1
Building for Equipment	
Area for 90 gpm Flow	10,000 ft^2
Area for 195 gpm Flow	15,000 ft^2
Chemical Storage Tanks	
Caustic Storage Tank - 50%	
Material	FRP
Size	5,000 gal.
Refill Frequency	4 months for 90 gpm system; 2 months for 195 gpm system
Sulfuric Acid Storage Tank	
Material	Carbon Steel
Size	500 gal.
Refill Frequency	2 months for 90 gpm system; 1 month for 195 gpm system
Soda Ash Storage (35%)	
Material	Coated Carbon Steel
Size	4,500 gal.
Refill Frequency	2 months for 90 gpm system; 1 month for 195 gpm system
Polymer/Blender Feeders	
Quantity	2
Type	Conditioner/Feeder
Flow (dilute)	25 gph for 90 gpm system; 50 gph for 195 gpm system
Air Compressor	
Quantity	2
Type	Skid
Flow	75 scfm
Horsepower	20

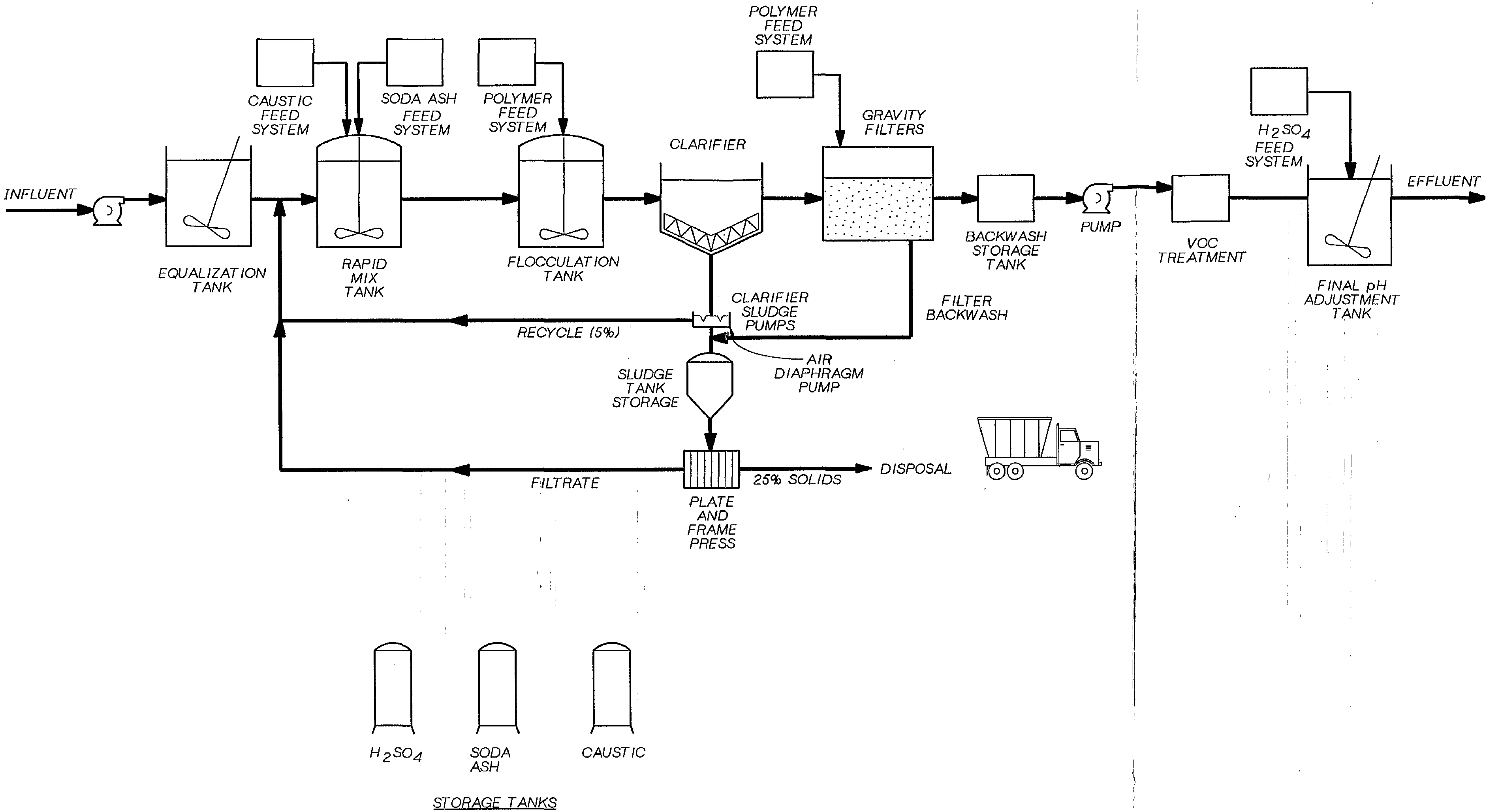

Figure C-4
GROUNDWATER TREATMENT
ALTERNATIVE GT-3
FISCHER & PORTER
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BUCKS COUNTY, PENNSYLVANIA

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Flow Equalization. Flow equalization would be required to dampen flow from the groundwater extraction system and from return process flows. In addition, influent equalization would allow the extraction system to continue to operate for a short period for maintenance. A fiberglass-reinforced tank with a residence time of 2 hours at design flow plus capacity for filter backwash water would be required. The tank will be gently mixed to dampen higher concentration recycle streams from the treatment processes (e.g., dirty filter backwash water).

Metals Precipitation. Hardness is the measure of polyvalent cations (calcium, manganese, and iron) in water as expressed by calcium carbonate. Hardness is removed by adding sodium hydroxide and sodium carbonate (soda ash). Raising the pH of the wastewater with sodium hydroxide reduces the solubility of many metals. Adding soda ash converts the relatively insoluble bicarbonate to the precipitate calcium carbonate. The process will target the removal of calcium, iron, and manganese in a controlled environment, rather than fouling the air stripper.

The first stage of metals removal is the addition of sodium hydroxide to raise the pH to approximately 11 and to add soda ash. Chemical addition and rapid mixing would occur in the reaction tank. The second stage involves a slow mix flocculation tank to which polymer is added to encourage floc formation. From the flocculation tank, water flows by gravity to an inclined plate clarifier where solids settle and are removed. After the clarifier, the wastewater flows to the mixed-bed gravity sand filter to remove suspended particles that did not settle in the clarifier. The water from the gravity filter flows to a backwash storage tank. After solids build up in the filter, it is backwashed with water from the backwash storage tank. The 'dirty' backwash water is returned to the equalization tank. Water is pumped from the dirty backwash tank to the air stripper.

Final pH Adjustment. Effluent from the air stripper is pumped to the final pH adjustment tank. The pH would be lowered to the neutral range with sulfuric acid before discharge.

Sludge Dewatering. Metal hydroxide sludge will be generated by the clarifier. Approximately 500 mg/L of solids would be generated in the reaction tank (this would have to be confirmed through additional solids testing of the untreated groundwater and/or by treatability testing). Assuming that all of the solids are removed by the clarifier, approximately 540 dry pounds per day (for the 90 gpm system) and 1,140 dry pounds per day (for the 195 gpm system) would be generated and will require dewatering. The sludge from the clarifier would be transferred by air diaphragm pumps to a cone-bottom sludge storage tank. Water would be decanted from the storage tank as further settling occurs.

A plate-and-frame filter press would be used to dewater metal hydroxide sludges to a filter cake of 25 to 35 percent solids. The press is operated on a batch basis. The press consists of multiple chambers, the solids are retained by the cloth and water passes through. During the filter press cycle, the plates are held together by pneumatic or hydraulic pressure so that neither sludge nor filtrate leaks out between the plates. The cycle is completed when the pressure loss through the filter cloth and retained solids have reached the maximum for the system and filtrate flow, therefore, is minimized. At the end of the cycle, the press is opened to allow the accumulated sludge cake to fall into a container. Then, the sludge is removed for offsite disposal. Because the sludge may contain high concentrations of heavy metals, the assumption is that it will require disposal as hazardous waste.

5 Off-Gas Treatment

Off-gas from the air stripper requires treatment to reduce the emissions of VOCs to ambient air. Two alternatives remained after the remedial technologies screening in Section 3:

- Alternative GT-5: Vapor-Phase Carbon Adsorption
- Alternative GT-6: Catalytic Oxidation

5.1 Alternative GT-5: Vapor-Phase Carbon Adsorption

Preliminary sizing of vapor-phase carbon vessels is based upon air flow from the air stripper and the chemical concentrations in the influent and effluent from the air stripping system. The vapor-phase carbon system would be designed to achieve 90 percent removal of the contaminants of concern. Two vessels would be provided in series. Of the VOCs detected, vinyl chloride is the most difficult to adsorb. For the source control alternative (90 gpm influent flow rate), approximately 1,060 pounds of carbon per day would be required given the flow-weighted vinyl chloride concentration in the extracted groundwater. A vessel containing 12,500 pounds of carbon would require carbon replacement approximately every 12 days, thus the number of carbon changeouts per year would be about 31 times. For the sitewide capture alternative (195 gpm influent flow rate), approximately 1,300 pounds of carbon per day would be required. A vessel containing 12,500 pounds of carbon would require carbon replacement approximately every 10 days, thus the number of carbon changeouts per year would be about 37 times. Table C-8 presents the selected design criteria for both flow rates. Figure C-5 presents a schematic of the vapor-phase carbon adsorption system.

Table C-8
Off-Gas Treatment With Vapor-Phase Carbon
Fischer and Porter Site

Parameter	Groundwater Extraction Alternative	
	Source Control	Sitewide Capture
Number of Vessels in Series	2	2
Loading Rate (cfm/ft^2)	50-100	50-100
Pounds of Carbon per vessel	12,500	12,500
Changeout Frequency (days)	12	10
Vessel Diameter (ft)	8	8
Skid Dimensions (ft)	22.5L x 8 W x 8.5 H	22.5L x 8 W x 8.5 H

5.2 Alternative GT-6: Catalytic Oxidation

VOCs in the off-gas from the air stripper may be catalytically oxidized to products of combustion, namely carbon dioxide, water, and hydrochloric acid (HCl) in a catalytic oxidizer. The off-gas from the air stripper flows through a heat exchanger to a burner,

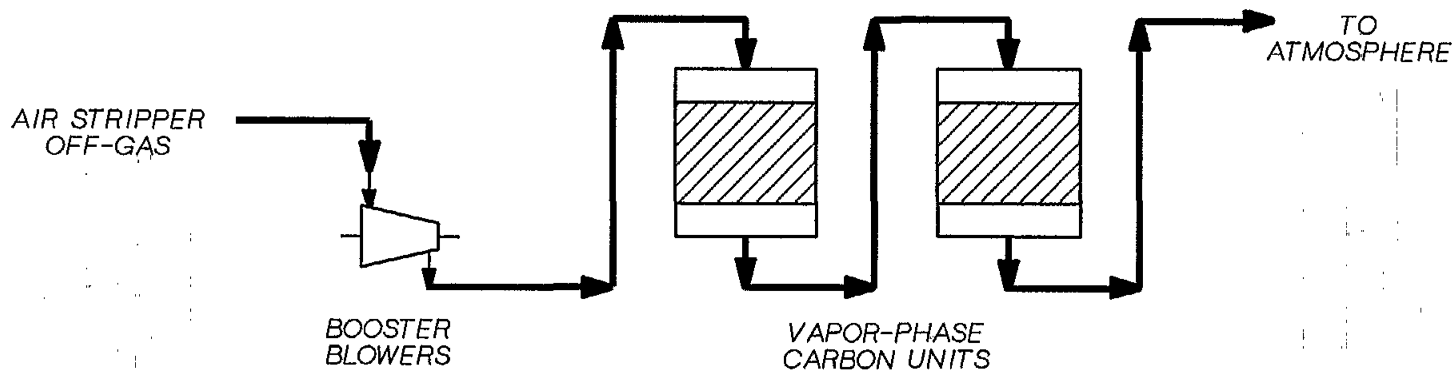

Figure C-5
VAPOR-PHASE TREATMENT
ALTERNATIVE GT-5

FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

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where it is heated to approximately 600°F, by a natural gas burner. The air stream is then passed through a catalyst bed, which initiates, promotes, and accelerates oxidation of chlorinated VOCs. The catalyst, without itself being altered, significantly reduces the oxidation activation energy, thus allowing the oxidation reaction to occur at much lower temperatures than would be required with conventional thermal oxidation. Because oxidation is an exothermic reaction, it heats up the exiting gases and the catalyst bed. The amount of natural gas is controlled to limit temperatures of the catalyst bed to approximately 840°F to protect the catalyst from damage.

The catalytic oxidation system also will have nitrogen oxides (NO_x) emissions. NO_x generation is an exponential function of temperature and generally only becomes significant at temperatures higher than 1,800°F. Because catalytic oxidation units operate at lower temperatures, NO_x generation would be nominal.

Oxidation system vendors typically guarantee a 95 percent destruction efficiency for organic vapors. However, based on performance history, the actual destruction efficiency could be more than 99 percent at catalyst bed temperatures higher than 820°F. A wet scrubber may be required to remove the HCl from the vapor stream. Note that as concentrations of VOCs decrease in the groundwater, a wet scrubber may not be required.

Off-gas from the catalytic oxidation unit would be directed to an eductor/quencher section. A recirculation pump would pump water from the reservoir of the unit into the quencher to cool the hot gases and to induce flow through the scrubber. A portion of the HCl is removed. Quenched air flows from the eductor down through the sump and up through a packed bed. Water from the sump is pumped to the top of the bed and flows down through the bed, and HCl vapors are further removed from the air stream. Scrubbed air would pass through a mist eliminator and discharged to the atmosphere. The pH of the water in the reservoir/sump would be monitored, and sodium hydroxide would be metered into the sump for neutralization. Some of the treated effluent from the air stripper could be used as make-up water to scrub the HCl. Water could be purged off the recirculating water line to the influent of the air stripper unit to ensure that any VOCs that might be transferred from the treated air stream would be removed before reinjection.

Preliminary sizing of the catalytic oxidation unit is based on the air flow rates for the packed column air stripper and the flow-weighted VOC concentrations. Table C-9 summarizes the preliminary size for this unit. Figure C-6 presents a schematic of the vapor-phase catalytic oxidation system.

Table C-9
Off-Gas Treatment with Catalytic Oxidation
Fischer and Porter Site

Parameter	Groundwater Extraction Alternatives	
	Source Control	**Sitewide Capture**
Number of Units	1	1
Air Flow (scfm)	1,200	2,600
Dimensions (ft)	13Lx6.5Wx9H	17Lx7Wx9H

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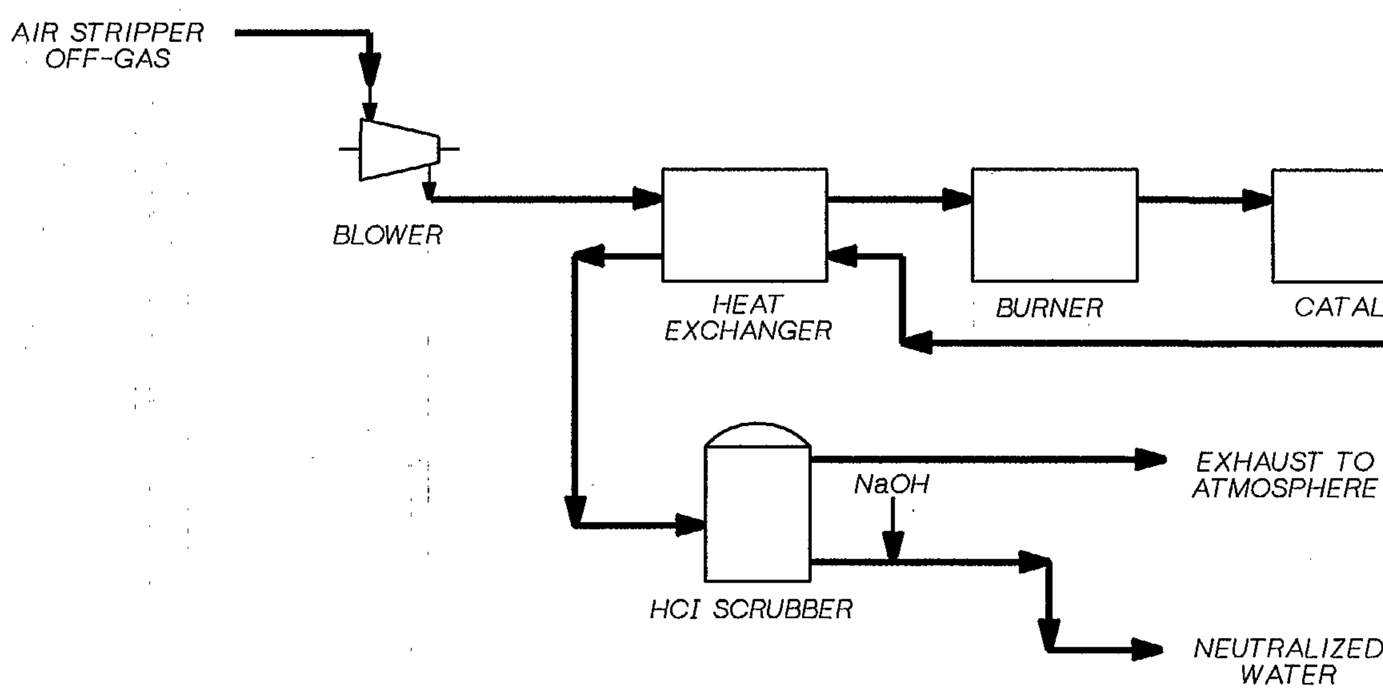

Figure C-6
VAPOR-PHASE TREATMENT ALTERNATIVE GT-6
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BUCKS COUNTY, PENNSYLVANIA

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6 Piping Route and Treatment System Building

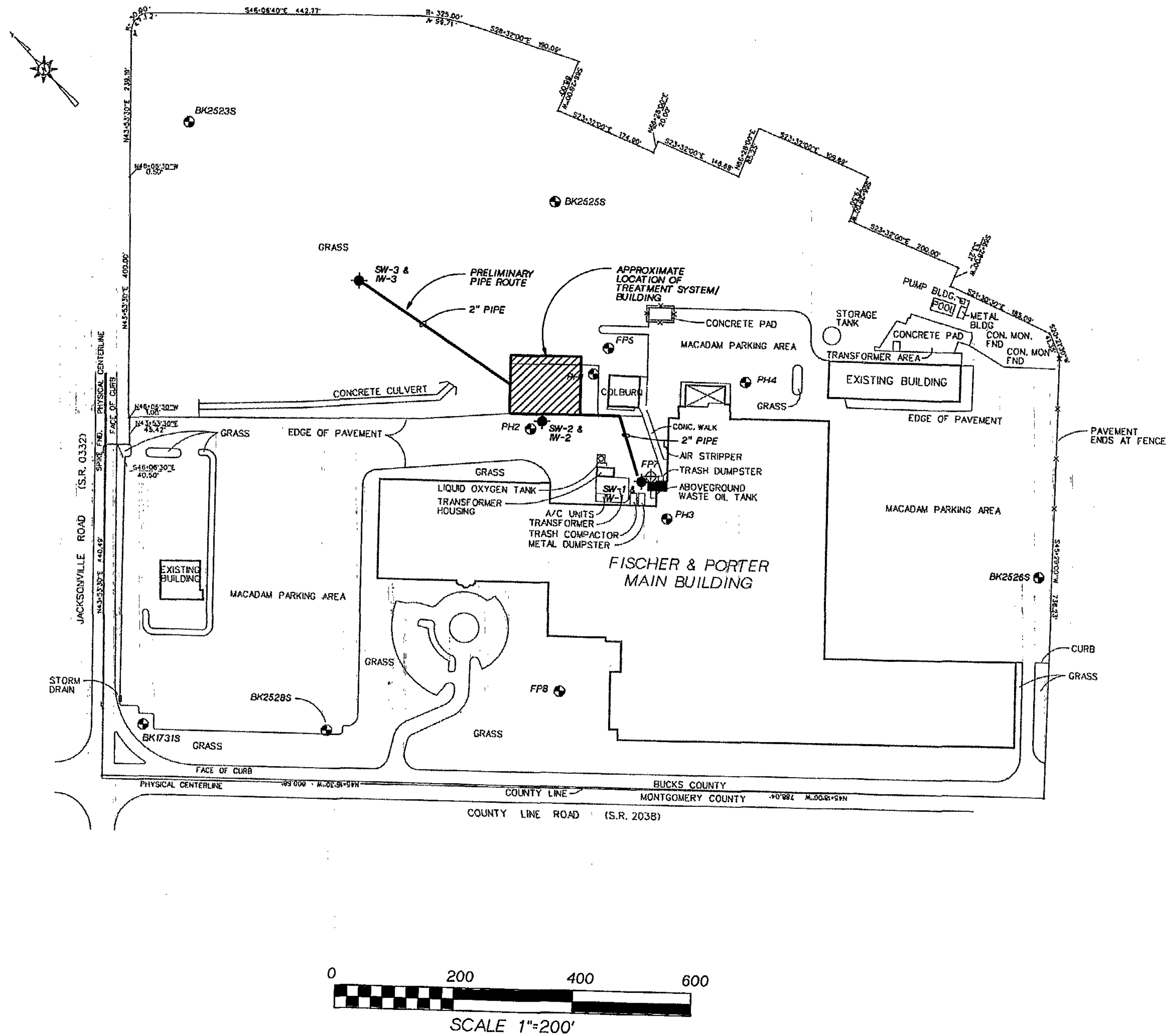
A small shed would be required for the following treatment options:

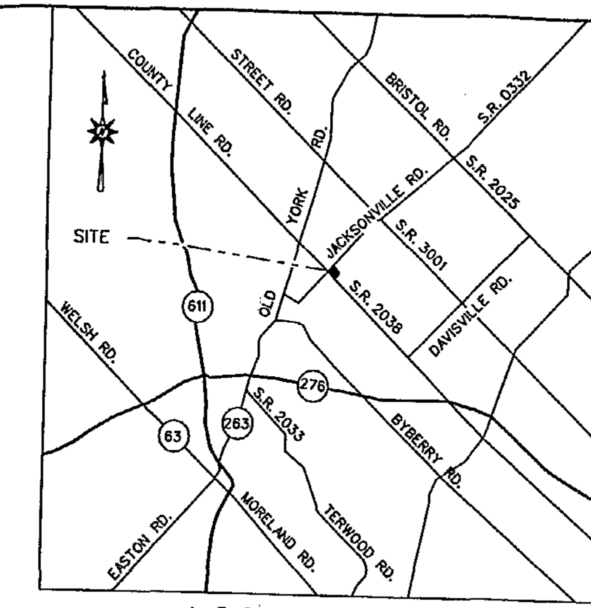
- Air stripper for blowers
- Chemical oxidation for chemical storage

No building would be required for the liquid-phase carbon. A building would be required for the metals treatment system because of the amount of processes and protection from freezing required. The preliminary square footage required for each extraction alternative are as follows:

- Source Control Alternative: 10,000 square feet
- Sitewide Capture Alternative: 15,000 square feet

The locations of the buildings and the piping required under the source control and sitewide capture alternatives are shown in Figures C-7 and C-8, respectively. The components of the treatment alternatives would be installed either in the building (metals precipitation) or next to the building (air stripper, carbon adsorption). If a building is determined not to be needed, the small shed can be installed at the locations for the buildings shown in the figures.





LOCATION MAP
(N.T.S.)

LEGEND

BK2525S — MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN SHALLOW WATER-BEARING ZONE.

SW-1 / IW-1 — EXTRACTION WELL WITH SCREENED INTERVAL IN SHALLOW AND INTERMEDIATE WATER-BEARING ZONE.

FP7 — OIL RECOVERY WELL

- - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH

—— ESTIMATED EXTENT OF GROUNDWATER CAPTURE

■ ASSUMED EXTENT OF LNAPL

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBURARY 12,1991.
3. HORIZONTAL DATUM ARE ASSUMED & ROTATED TO PLAN BOUNDARY MERIDIAN.
4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure C-7
CONCEPTUAL PIPING AND BUILDING LAYOUT OF SOURCE CONTROL EXTRACTION SYSTEM
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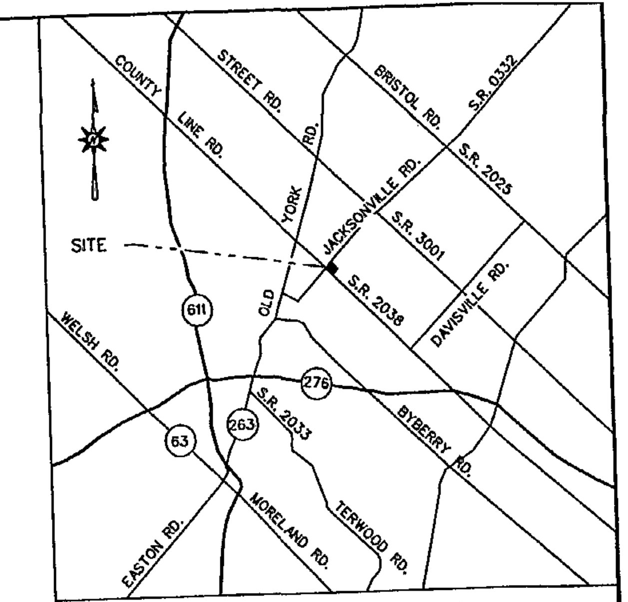
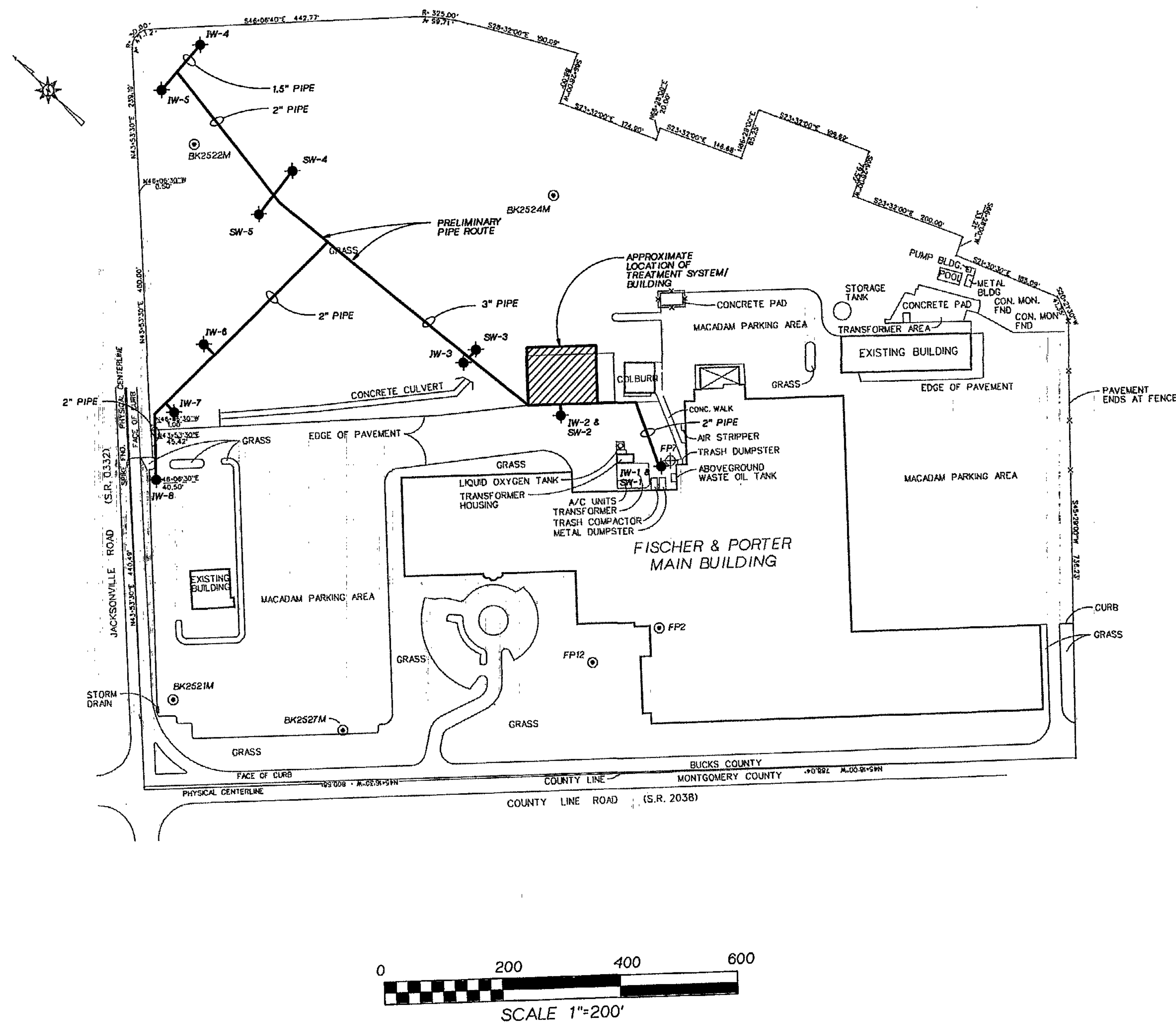


LOCATION MAP



LEGEND

- BK2525S — MONITORING WELL WITH SCREENED INTERVAL OR OPEN BOREHOLE IN INTERMEDIATE WATER-BEARING ZONE.
- SW-1 IW-1 — EXTRACTION WELL WITH SCREENED INTERVAL IN SHALLOW AND INTERMEDIATE WATER-BEARING ZONES.
- FP7 — OIL RECOVERY WELL
- - - - - ASSUMED DISSOLVED TCE CONCENTRATION ISOPLETH
- ——— ESTIMATED EXTENT OF GROUNDWATER CAPTURE

NOTES:

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5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. MONITORING WELL LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
7. ASSUMPTIONS USED TO DEVELOP THIS FIGURE ARE DESCRIBED IN APPENDICES A AND B.

Figure C-8
CONCEPTUAL PIPING AND BUILDING LAYOUT OF SITE WIDE EXTRACTION SYSTEM
FISCHER & PORTER
WARMINSTER TOWNSHIP
BUCKS COUNTY, PENNSYLVANIA

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Appendix D
Conceptual Design of Cap

1 Introduction

This appendix presents the conceptual design of the cap for the Fischer and Porter site.

During the Phase I RI, concentrations of PAHs and PCBs above RBCs (see Section 6 in the RI report) were detected in several borings in the source area. The human health risk assessment concluded that some of the concentrations at which these compounds were found, present a potential human health concern should the site be developed for residential use in the future. Although PAHs and PCBs were detected in onsite soil, they were either not found in groundwater (e.g., PCBs) or found in groundwater at concentrations below the RBCs (e.g., PAHs). Therefore, in contrast to the potential risk they present in soil, both classes of compounds do not present a potential human health risk in groundwater. Their limited presence in groundwater is consistent with the fact that both classes of compounds tend to adhere to soil rather than partition into infiltrating rainfall and leach to groundwater.

On the basis of the results of the risk assessment, the RA objective established in this FS was to prevent potential direct contact with PAHs and PCBs in onsite soil by future residents at the site. No RA objective was established for PAHs and PCBs in groundwater. Therefore, limiting infiltration through the contaminated soil is not a primary objective for the cap.

Although the site currently is an active manufacturing facility and there are no plans to develop it for residential use in the future, it should be noted that a cap over soil containing PAHs and PCBs concentrations above the RBCs would prevent exposures by site workers to these chemicals. This in turn, would provide additional protection of human health.

Therefore, the areal extent of the cap was estimated for the following two scenarios:

- **Scenario 1—Potential future residential site use:** Under this scenario, the entire area of soil containing PAHs and PCBs above RBCs would be covered with the cap. Portions of the area currently are under the existing pavement at the facility. This scenario, however, assumes that the existing pavement would be demolished under a potential future residential use of the site and a new cap would be constructed to cover this area.

- **Scenario 2—Current site use:** Under this scenario, only the area of soil containing PAHs and PCBs above RBCs, which is not currently paved, would be covered with the cap. The existing pavement at the facility would remain in place and used as the cap for the remainder of the area containing PAHs and PCBs above the RBCs.

These two scenarios for the area of the cap would provide EPA with an estimate of the range of costs for installing the selected type of cap at the Fischer and Porter site.

Several cap designs are available that can be easily implemented under current site use. The cap selected in this FS for detailed evaluation consists of either asphalt or concrete installed over a compacted base stone. For estimating cost, however, an asphalt cap is retained. A cap constructed from either of these materials would be compatible with a future residential use of the site under Scenario 1 and represent a natural extension of the pavement currently covering the majority of the source area under Scenario 2.

2 Areal Extent of Cap

Figure D-1 shows the areal extent, as determined in Appendix A, of PAH and PCB concentrations in soil above the PRGs in Section 2. The areal extent of cap under both scenarios 1 and 2 also is shaded in the figure and is estimated to be:

Scenario 1: Approximately 43,000 square feet

Scenario 2: Approximately 13,700 square feet

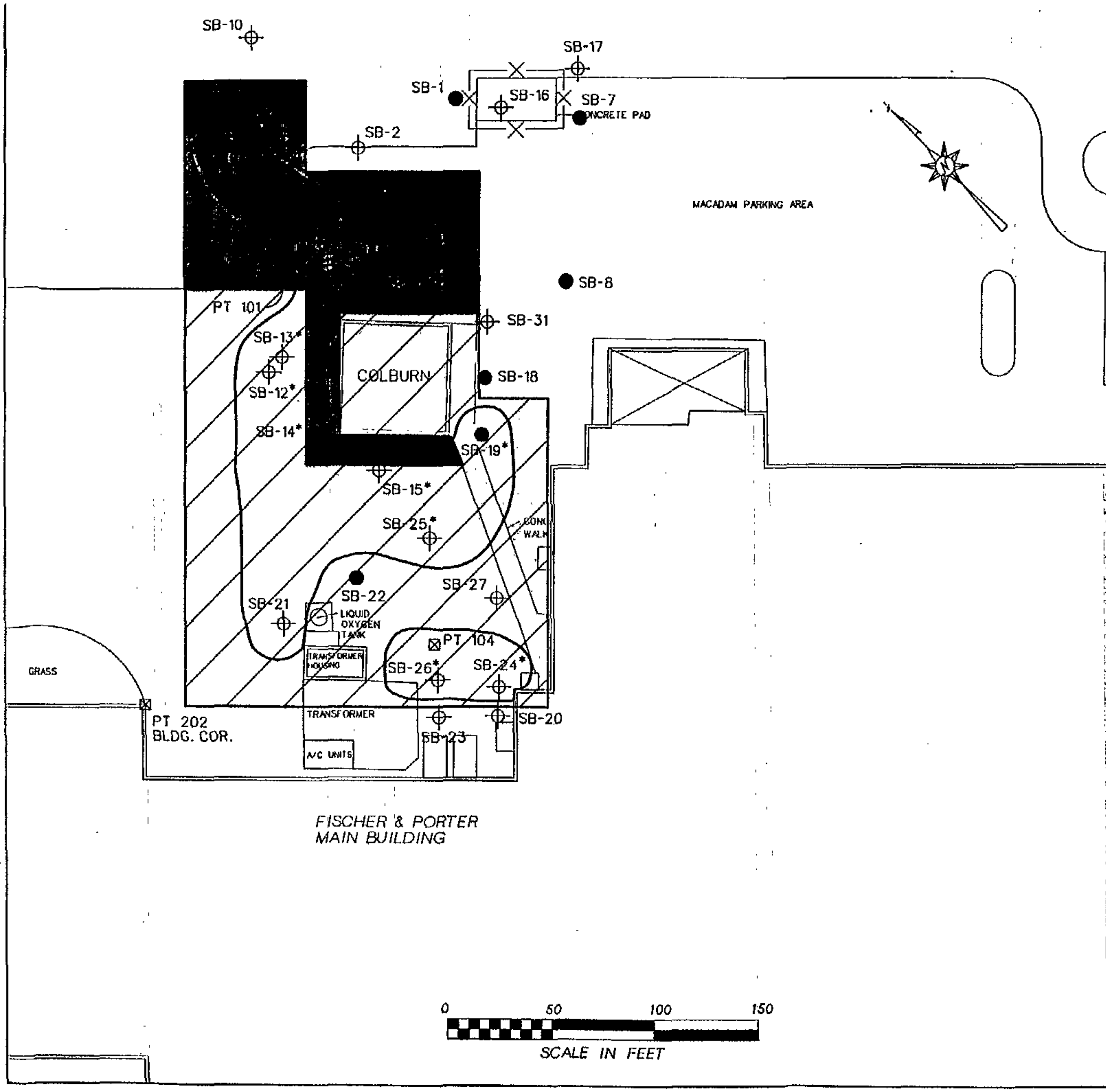
These cap areas extend beyond the limits of the area of PAH and PCB concentrations above RBCs and were developed to represent reasonable construction scenarios, i.e., straight lines versus curved lines.

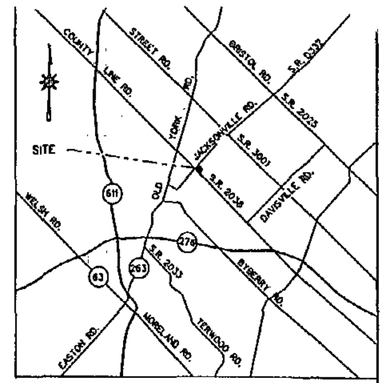
3 Conceptual Design of Cap

An asphalt cap was retained for detailed evaluation to meet the RA objectives. Figure D-2 shows the conceptual design of the cap. The components of constructing and maintaining this cap at the site are as follows:

- Remove top layer of soil and regrade the existing native soil to promote surface runoff away from the area of the cap and limit infiltration
- Place and compact base stone to a minimum thickness of 6 inches on top of the regraded native soil
- Place and compact asphalt to a minimum thickness of 4 inches on top of the base stone
- Maintain the cap by inspecting annually and resurfacing every 5 years

Although the minimum thickness of the cap was selected to accommodate vehicular traffic, The assumption is that only cars or an unloaded truck would drive and park over the new cap. If it is determined that this area will be used by loaded trucks, then the thickness of the cap would need to be increased or reinforcement would need to be included.





LOCATION MAP
(N.T.S.)

LEGEND

- SURVEYED SOIL BORING LOCATION
- APPROXIMATE SOIL BORING LOCATION
- SURVEY REFERENCE POINTS
- SCENARIO 1: EXTENT OF CAP REQUIRED IF EXISTING PAVEMENT IS REMOVED
- SCENARIO 2: EXTENT OF CAP REQUIRED IF EXISTING PAVEMENT IS LEFT IN PLACE
- AREA OF SOIL REQUIRING REMEDIAL ACTION

NOTES:

1. ADAPTED FROM SOIL GAS PROBE LOCATION PLAN PREPARED BY GILLMORE & ASSOCIATES INC. DATED FEBRUARY 28, 1993.
2. OUTBOUND INFORMATION ARE TAKEN FROM A PLAN PREPARED FOR FISCHER & PORTER DATED FEBRUARY 12, 1991.
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4. APPROXIMATE FEATURE LOCATION IS DIGITIZED FROM A PLAN PREPARED FOR FISCHER & PORTER DATED 2/12/91.
5. EXTENT OF PAVED AND GRASS AREAS IS APPROXIMATE BASED ON FIELD OBSERVATIONS.
6. ALL BORING LOCATIONS WERE SURVEYED EXCEPT FOR THE FOLLOWING: SB-1, SB-7, SB-8, SB-14, SB-18, SB-19, SB-22, SB-29 AND SB-30.
7. * INDICATES BORING IN WHICH CONCENTRATIONS OF PAHs OR PCBs EXCEED THE PRGs.

SB-29

SB-30

Figure D-1
AREAL EXTENT OF CAPPING
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BUCKS COUNTY, PENNSYLVANIA

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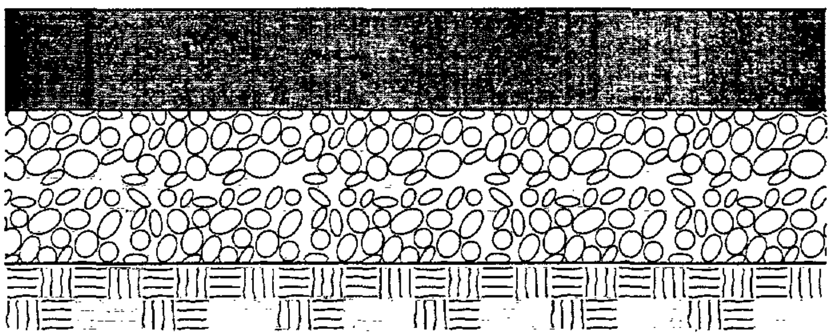

Figure D-2
ASPHALT CAP SCHEMATIC
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BUCKS COUNTY, PENNSYLVANIA

CH2M HILL

14-APR-1997 5600f033.dgn

Appendix E
Detailed Cost Analysis

This appendix presents the assumptions used to estimate the capital and operation and maintenance (O&M) costs of each alternative developed in Section 3. This information supplements the descriptions if alternatives and conceptual designs presented in Section 3 and Appendices B through D. Costs are summarized in Table E-1, and detailed cost estimates are presented in Tables E-2 through E-21.

Cost estimates were prepared to aid in evaluating alternatives using information available at the time of preparation of this FS. Final project costs will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule, the firm selected for final engineering design, treatability testing, and other factors. As a result, final project costs will vary from these estimates. Because of these factors, funding needs must be carefully reviewed before specific financial decisions are made or final remedial action (RA) budgets are established.

The cost estimates presented in this appendix are order-of-magnitude estimates with an intended accuracy of +50 percent to -30 percent. This range applies only to the alternatives described in Section 3 and does not account for changes in scope of the alternatives. Each selected technology or process is intended not to limit flexibility during remedial design but to provide a basis for making feasibility study cost estimates. The cost estimates will be refined during final design.

Unit prices are based on construction cost data, engineers' cost estimates for similar work, quotes from vendors and contractors, and engineering judgment.

1 Overview of Cost Estimates

The cost estimates are intended to provide a measure of total resource costs. They include total capital costs and annual O&M costs. Capital costs are represented as the total present worth of each alternative.

1.1 Total Capital Costs

Capital costs are direct and indirect costs required to initiate and install a remedial action. They include only expenditures incurred to design and implement a remedial action and exclude costs required to maintain the action throughout its lifetime.

Direct costs are expenditures necessary for installation of remedial actions, such as costs for construction, site development, and buildings and services. Construction costs include costs necessary to construct or implement the action, such as those for materials, labor, and equipment. Items such as site preparation for remedial action, equipment and installation of monitoring wells also are construction cost. Standard engineering cost factors were used to estimate direct capital costs for miscellaneous piping, electrical, instrumentation and control, structural, and site work.

Table E-1
Cost Summary
Fischer and Porter Site

Alternative	Description	Capital Costs	Present Worth for O&M Costs	Total Present Worth
Remedial Action Alternatives for Soil				
S-1	No Action	$0	$14,000	$14,000
S-2	Institutional Controls	$0	$14,000	$14,000
S-3	Cap (Future residential site use)	$468,000	$75,000	$543,000
	Cap (Current site use)	$178,000	$58,000	$236,000
Remedial Action Alternatives for Groundwater				
G-1	No Action	$0	$14,000	$14,000
G-2	Institutional Controls	$0	$450,000	$450,000
GC-1	Source Control by Extraction Wells	$859,900	$619,100	$1,479,000
GC-2	Sitewide Capture by ExtractionWells	$1,821,600	$759,400	$2,581,000
GT-1	Carbon Adsorption (Liquid Phase) - 90 gpm	$454,300	$9,183,700	$9,638,000
	Carbon Adsorption (Liquid Phase) - 195 gpm	$454,300	$12,987,700	$13,442,000
GT-2	Air Stripping - 90 gpm	$140,800	$533,200	$674,000
	Air Stripping - 195 gpm	$171,600	$747,400	$919,000
GT-3	Metals Precipitation - 90 gpm	$3,332,300	$5,031,700	$8,364,000
	Metals Precipitation - 195 gpm	$5,103,700	$7,145,300	$12,249,000
GT-4	Chemical Oxidation - 90 gpm	$44,200	$1,536,800	$1,581,000
	Chemical Oxidation - 195 gpm	$53,200	$2,491,800	$2,545,000
GT-5	Carbon Adsorption (Vapor Phase) - 90 gpm	$207,200	$21,019,800	$21,227,000
	Carbon Adsorption (Vapor Phase) - 195 gpm	$207,200	$25,753,800	$25,961,000
GT-6	Catalytic Oxidation - 90 gpm	$508,500	$447,500	$956,000
	Catalytic Oxidation - 195 gpm	$689,500	$470,500	$1,160,000
GD-1	Discharge to Surface Water	$0	$0	$0

Fp_gw$/Summary

Table E-2

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: S-1
DESCRIPTION: No Action

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
TOTAL CAPITAL								$0
Labor for 5 year site review	*40*	*HR*	*$91.00*	*$3,640*	*$728*	*$0*	*$655*	*$5,023*
Annualized cost for 5-year site review (1)								$909
TOTAL ANNUALIZED EXPENSES								$900

PRESENT WORTH =	$14,000

(1) Annualized cost of site review = present value of expenditures every 5 years for 30 years, annualized over 30 years.

Table E-3

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: S-2
DESCRIPTION: Institutional Controls

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
TOTAL CAPITAL								$0
Labor for 5 year site review	*40*	*HR*	*$91.00*	*$3,640*	*$728*	*$0*	*$655*	*$5,023*
Annualized cost for 5-year site review (1)								$909
TOTAL ANNUALIZED EXPENSES								$900

PRESENT WORTH =	$14,000

(1) Annualized cost of site review = present value of expenditures every 5 years for 30 years, annualized over 30 years.

Fp_soil$
S-1 & S-2
5/14/97

Table E-4

[illegible] Summary

PROJECT: Fischer & Porter
ALTERNATIVE: S-3
DESCRIPTION: Cap - Scenario 1 (Future Residential Use)

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Excavation of Top 6-Inches of Soil	796	CY	$4.50	$3,583	$717	$215	$677	$5,192
Transportation and Disposal of Nonhaz Soil	796	CY	$40.00	$31,852	$6,370	$1,911	$6,020	$46,153
Rough Grading	14,333	CY	$2.29	$32,823	$6,565	$1,969	$6,204	$47,561
Place and Compact 6" Stone Base	4,778	SY	$5.53	$26,427	$5,285	$1,586	$4,995	$38,292
Place and Compact 4" Asphalt	4,778	SY	$6.52	$31,171	$6,234	$1,870	$5,891	$45,167
Subtotal				$125,856	$25,171	$7,551	$23,787	$182,366
Level of Protection								
Level D	18%	LS						$32,182
SUBTOTAL - CAPITAL								$215,000
Engineering @ 10% Construction	1	LS						$21,500
TOTAL CAPITAL								$237,000
Reseal Asphalt Cap (Cost Incurred Every 5 Years)	*4,778*	*SY*	*$1.58*	*$7,566*	*$1,513*	*$0*	*$1,362*	*$10,442*
Annualized Cost to Reseal Every 5 Years (1)								$1,890
Annual Inspection and Report	24	HR	$91.00	$2,184	$437	$0	$393	$3,014
TOTAL ANNUALIZED COSTS (2)								$4,900

PRESENT WORTH	$312,000

(1) Annualized cost of reseal = present value of expenditures every 5 years for 30 years, annualized over 30 years.
(2) Total annualized costs = Annual inspection + Annualized cost for reseal of cap.

Fp_soilS
S-3 (1)
6/9/97

AR301441

Table E-5

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: S-3
DESCRIPTION: Cap - Scenario 2 (Current Site Use)

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Excavation of Top 6-Inches of Soil	254	CY	$4.50	$1,142	$228	$69	$216	$1,654
Transportation and Disposal of Nonhaz Soil	254	CY	$40.00	$10,148	$2,030	$609	$1,918	$14,705
Rough Grading	4,567	CY	$2.29	$10,458	$2,092	$627	$1,976	$15,153
Place and Compact 6" Stone Base	1,522	SY	$5.53	$8,420	$1,684	$505	$1,591	$12,200
Place and Compact 4" Asphalt	1,522	SY	$6.52	$9,931	$1,986	$596	$1,877	$14,390
Subtotal				$40,098	$8,020	$2,406	$7,579	$58,103
Level of Protection								
Level D	18%	LS						$10,253
SUBTOTAL - CAPITAL								$68,000
Engineering (equivalent to Scenario 1)	1	LS						$21,500
TOTAL CAPITAL								$90,000
Reseal Asphalt Cap (Cost Incurred Every 5 Years)	*1,522*	*SY*	*$1.58*	*$2,411*	*$482*	*$145*	*$456*	*$3,493*
Annualized Cost to Reseal Every 5 Years (1)								$632
Annual Inspection and Report	24	HR	$91.00	$2,184	$437	$131	$413	$3,165
TOTAL ANNUALIZED COSTS (2)								$3,800

PRESENT WORTH	$148,000

(1) Annualized cost of reseal = present value of expenditures every 5 years for 30 years, annualized over 30 years.
(2) Total annualized costs = Annual inspection + Annualized cost for reseal of cap.

Fp_soil$
S-3 (2)
6/9/97

AR301442

Table E-6

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: G-1
DESCRIPTION: No Action

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
TOTAL CAPITAL COST								$0
Labor for 5 year site review	*40*	*HR*	*$91.00*	*$3,640*	*$728*	*$0*	*$655*	*$5,023*
Annualized Labor for site review (1)								$909
TOTAL ANNUALIZED COST								$900

PRESENT WORTH = $14,000

(1) Annualized cost of site review = present worth of expenditures every 5 years for 30 years, annualized over 30 years.

Table E-7

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: G-2
DESCRIPTION: Institutional Controls

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
TOTAL CAPITAL								$0
Labor for 5 year site review	*200*	*HR*	*$91.00*	*$18,200*	*$3,640*	*$0*	*$3,276*	*$25,116*
Annualized Labor for site review (1)								$2,543
Labor (16 wells)	256	HR	$61.00	$15,616	$3,123	$0	$2,811	$21,550
Analysis (VOCs all wells)	12	each	$150.00	$1,800	$360	$0	$324	$2,484
Analysis (PAHs & PCBs source wells)	4	each	$500.00	$2,000	$400	$0	$360	$2,760
TOTAL ANNUALIZED COSTS								$29,300

PRESENT WORTH = $450,000

(1) Annualized cost of site review = present worth of expenditures every 5 years for 30 years, annualized over 30 years.

Fp_gw$
G-1 & G-2
5/16/97

Table E-8

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GC-1
DESCRIPTION: *Source Control Extraction System*

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Backpressure Valve, Various Fittings	1	LS	$1,000.0	$1,000	$200	$60	$189	$1,449
Pipe Trenching/Bedding	800	LF	$4.50	$3,600	$720	$216	$680	$5,216
Pipe (1.5" PVC)	250	LF	$7.83	$1,958	$392	$117	$370	$2,836
Pipe (2" PVC)	500	LF	$8.86	$4,430	$886	$266	$837	$6,419
Pipe (3" PVC)	20	LF	$11.23	$225	$45	$13	$42	$325
Removal of FP1, FP2, and FP7	1	LS	$5,500	$5,500	$1,100	$330	$1,040	$7,970
Sealing FP1 & FP7	1	LS	$5,546	$5,546	$1,109	$333	$1,048	$8,036
Installation of Shallow Aquifer Extraction Wells	3	EA	$23,538	$70,614	$14,123	$4,237	$13,346	$102,320
Shallow Aquifer Pumps	3	EA	$2,440	$7,320	$1,464	$439	$1,383	$10,607
Management of IDW for Shallow Wells	3	EA	$7,650	$22,950	$4,590	$1,377	$4,338	$33,255
Installation of Intermediate Aquifer Ext. Wells	3	EA	$36,138	$108,414	$21,683	$6,505	$20,490	$157,092
Intermediate Aquifer Pumps	3	EA	$4,140	$12,420	$2,484	$745	$2,347	$17,997
Management of IDW for Intermediate Wells	3	EA	$15,300	$45,900	$9,180	$2,754	$8,675	$66,509
Installation of 4 MWs at FP1 & FP2	1	LS	$26,322	$26,322	$5,264	$1,579	$4,975	$38,141
Management of IDW for MWs	1	LS	$7,500	$7,500	$1,500	$450	$1,418	$10,868
Subtotal				$323,698	$64,740	$19,422	$61,179	$469,039
Miscellaneous Structural			5%	$26,975	$5,395	$1,618	$5,098	$39,087
Miscellaneous Site Work			5%	$26,975	$5,395	$1,618	$5,098	$39,087
Miscellaneous Mechanical/Piping			15%	$80,925	$16,185	$4,855	$15,295	$117,260
Electrical/I&C			15%	$80,925	$16,185	$4,855	$15,295	$117,260
Subtotal				$539,497	$107,899	$32,370	$101,965	$781,731
Engineering @ 10% Construction	1	LS						$78,200
TOTAL CAPITAL								$859,900
Labor to Maintain Extraction System	240	hr	$61.00	$14,640	$2,928	$0	$2,635	$20,203
Water Level Measurements	40	hr	$61.00	$2,440	$488	$0	$439	$3,367
Remove LNAPL	96	hr	$61.00	$5,856	$1,171	$0	$1,054	$8,081
LNAPL Waste Management	2	drm	$500.00	$1,000	$200	$0	$180	$1,380
Electricity for Extraction Pumps	58,800	Kwh	$0.09	$5,292	$1,058	$0	$953	$7,303
TOTAL ANNUALIZED COSTS								$40,300

PRESENT WORTH = $1,479,000

Fp_gw$
GC-1
5/16/97

AR301444

Table E-9

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GC-2
DESCRIPTION: Site-Wide Capture Extraction System

DESCRIPTION	QTY	UNITS	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Backpressure Valve, Various Fittings	2	LS	$1,000.0	$2,000	$400	$120	$378	$2,898
Pipe Trenching/Bedding	1,900	LF	$4.50	$8,550	$1,710	$513	$1,616	$12,389
Pipe (1.5" PVC)	290	LF	$7.83	$2,271	$454	$136	$429	$3,290
Pipe (2" PVC)	960	LF	$8.86	$8,506	$1,701	$510	$1,608	$12,325
Pipe (3" PVC)	580	LF	$11.23	$6,513	$1,303	$391	$1,231	$9,438
Pipe (4" PVC)	20	LF	$12.23	$245	$49	$15	$46	$354
Removal of FP1, FP2, and FP7	1	LS	$5,500	$5,500	$1,100	$330	$1,040	$7,970
Sealing FP1 & FP7	1	LS	$5,546	$5,546	$1,109	$333	$1,048	$8,036
Installation of Shallow Aquifer Extraction Wells	5	EA	$23,538	$117,690	$23,538	$7,061	$22,243	$170,533
Shallow Aquifer Pumps	5	EA	$2,440	$12,200	$2,440	$732	$2,306	$17,678
Management of IDW for Shallow Wells	5	EA	$7,650	$38,250	$7,650	$2,295	$7,229	$55,424
Installation of Intermediate Aquifer Ext. Wells	8	EA	$36,138	$289,104	$57,821	$17,346	$54,641	$418,912
Intermediate Aquifer Pumps	8	EA	$4,140	$33,120	$6,624	$1,987	$6,260	$47,991
Management of IDW for Intermediate Wells	8	EA	$15,300	$122,400	$24,480	$7,344	$23,134	$177,358
Installation of 4 MWs at FP1 & FP2	1	LS	$26,322	$26,322	$5,264	$1,579	$4,975	$38,141
Management of IDW for MWs	1	LS	$7,500	$7,500	$1,500	$450	$1,418	$10,868
Subtotal				$685,716	$137,143	$41,143	$129,600	$993,603
Miscellaneous Structural			5%	$57,143	$11,429	$3,429	$10,800	$82,800
Miscellaneous Site Work			5%	$57,143	$11,429	$3,429	$10,800	$82,800
Miscellaneous Mechanical/Piping			15%	$171,429	$34,286	$10,286	$32,400	$248,401
Electrical/I&C			15%	$171,429	$34,286	$10,286	$32,400	$248,401
Subtotal				$1,142,861	$228,572	$68,572	$216,001	$1,656,005
Engineering @ 10% Construction	1	LS						$165,600
TOTAL CAPITAL								$1,821,600
Labor to Maintain Extraction System	240	hr	$61.00	$14,640	$2,928	$0	$2,635	$20,203
Water Level Measurements	40	hr	$61.00	$2,440	$488	$0	$439	$3,367
Remove LNAPL	96	hr	$61.00	$5,856	$1,171	$0	$1,054	$8,081
LNAPL Waste Management	2	drm	$500.00	$1,000	$200	$0	$180	$1,380
Electricity for Extraction Pumps	131,400	Kwh	$0.09	$11,826	$2,365	$0	$2,129	$16,320
TOTAL ANNUALIZED COSTS								$49,400

PRESENT WORTH = $2,581,000

Fp_gw$
GC-2
5/16/97

Table E-10

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-1 (90 gpm)
DESCRIPTION: Liquid Phase Carbon

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Carbon unit skid (2 10-ft. diam. columns)	1	EA	$165,000	$165,000	$33,000	$9,900	$31,185	$239,085
Feed pump (2 hp)	2	EA	$3,000	$6,000	$1,200	$360	$1,134	$8,694
Subtotal				$171,000	$34,200	$10,260	$32,319	$247,779
Miscellaneous Structural			5%	$14,250	$2,850	$855	$2,693	$20,648
Miscellaneous Site Work			5%	$14,250	$2,850	$855	$2,693	$20,648
Miscellaneous Mechanical/Piping			15%	$42,750	$8,550	$2,565	$8,080	$61,945
Electrical/I&C			15%	$42,750	$8,550	$2,565	$8,080	$61,945
Subtotal				$285,000	$57,000	$17,100	$53,865	$412,965
Engineering @ 10% Construction	1	LS						$41,300
TOTAL CAPITAL								$454,300
Miscellaneous electrical	13,100	Kwh	$0.09	$1,179	$236	$0	$212	$1,627
Quarterly Effluent Sampling and Report	100	HR	$61.00	$6,100	$1,220	$0	$1,098	$8,418
Effluent Analysis (VOCs)	4	EA	$150.00	$600	$120	$0	$108	$828
Carbon Replacement	419,750	lbs	$1.00	$419,750	$83,950	$0	$75,555	$579,255
Labor for Carbon Replacement	86	HR	$61.00	$5,239	$1,048	$0	$943	$7,230
TOTAL ANNUALIZED COST								$597,400

PRESENT WORTH = $9,638,000

Fp_gw$
GT-1 (90 gpm)
5/16/97

Table E-11

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-1 (195 gpm)
DESCRIPTION: Liquid Phase Carbon

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/ANS 5.00%	OH&P 15.00%	TOTAL
Carbon unit skid (2 10-ft. diam. columns)	1	EA	$165,000	$165,000	$33,000	$9,900	$31,185	$239,085
Feed pump (2 hp)	2	EA	$3,000	$6,000	$1,200	$360	$1,134	$8,694
Subtotal				$171,000	$34,200	$10,260	$32,319	$247,779
Miscellaneous Structural			5%	$14,250	$2,850	$855	$2,693	$20,648
Miscellaneous Site Work			5%	$14,250	$2,850	$855	$2,693	$20,648
Miscellaneous Mechanical/Piping			15%	$42,750	$8,550	$2,565	$8,080	$61,945
Electrical/I&C			15%	$42,750	$8,550	$2,565	$8,080	$61,945
Subtotal				$285,000	$57,000	$17,100	$53,865	$412,965
Engineering @ 10% Construction	1	LS						$41,300
TOTAL CAPITAL								$454,300
Miscellaneous electrical	35,000	Kwh	$0.09	$3,150	$630	$0	$567	$4,347
Quarterly Effluent Sampling and Report	100	HR	$61.00	$6,100	$1,220	$0	$1,098	$8,418
Effluent Analysis (VOCs)	4	EA	$150.00	$600	$120	$0	$108	$828
Carbon Replacement	594,950	lbs	$1.00	$594,950	$118,990	$0	$107,091	$821,031
Labor for Carbon Replacement	122	HR	$61.00	$7,442	$1,488	$0	$1,340	$10,270
TOTAL ANNUALIZED COST								$844,900

PRESENT WORTH = $13,442,000

Fp_gw$
GT-1 (195 gpm)
5/16/97

Table E-12

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-2 (90 gpm)
DESCRIPTION: Air Stripping

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Air stripper system (30 feet packing, 4-ft diam., 2 1200 scfm blowers, etc.)	1	EA	$42,000	$42,000	$8,400	$2,520	$7,938	$60,858
Prefab Blower Shed	100	SF	$50	$5,000	$1,000	$300	$945	$7,245
Feed pumps (2 hp)	2	EA	$3,000	$6,000	$1,200	$360	$1,134	$8,694
Subtotal				$53,000	$10,600	$3,180	$10,017	$76,797
Miscellaneous Structural			5%	$4,417	$883	$265	$835	$6,400
Miscellaneous Site Work			5%	$4,417	$883	$265	$835	$6,400
Miscellaneous Mechanical/Piping			15%	$13,250	$2,650	$795	$2,504	$19,199
Electrical/I&C			15%	$13,250	$2,650	$795	$2,504	$19,199
Subtotal				$88,333	$17,667	$5,300	$16,695	$127,995
Engineering @ 10% Construction	1	LS						$12,800
TOTAL CAPITAL								$140,800
Miscellaneous electrical	43,800	Kwh	$0.09	$3,942	$788	$0	$710	$5,440
Quarterly Effluent Sampling and Report	100	HR	$61.00	$6,100	$1,220	$0	$1,098	$8,418
Effluent Analysis (VOCs)	4	EA	$150.00	$600	$120	$0	$108	$828
Quarterly AST acid wash: Labor	32	HR	$61.00	$1,952	$390	$0	$351	$2,694
Quarterly AST acid wash: Acid/Lime	3,200	lbs	$0.80	$2,560	$512	$0	$461	$3,533
Quarterly AST acid wash: Waste Mangmt	20	drums	$500.00	$10,000	$2,000	$0	$1,800	$13,800
TOTAL ANNUALIZED COSTS								$34,700

PRESENT WORTH = $674,000

Fp_gw$
GT-2 (90 gpm)
5/16/97

Table E-13

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-2 (195 gpm)
DESCRIPTION: Air Stripping

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Air stripper system (30 feet packing; 5-ft diam.; 2 1200 scfm blowers, etc.)	1	EA	$51,000	$51,000	$10,200	$3,060	$9,639	$73,899
Prefab Blower Shed	100	SF	$50	$5,000	$1,000	$300	$945	$7,245
Feed pumps (5 hp)	2	EA	$4,300	$8,600	$1,720	$516	$1,625	$12,461
Subtotal				$64,600	$12,920	$3,876	$12,209	$93,605
Miscellaneous Structural			5%	$5,383	$1,077	$323	$1,017	$7,800
Miscellaneous Site Work			5%	$5,383	$1,077	$323	$1,017	$7,800
Miscellaneous Mechanical/Piping			15%	$16,150	$3,230	$969	$3,052	$23,401
Electrical/I&C			15%	$16,150	$3,230	$969	$3,052	$23,401
Subtotal				$107,667	$21,533	$6,460	$20,349	$156,009
Engineering @ 10% Construction	1	LS						$15,600
TOTAL CAPITAL								$171,600
Miscellaneous electrical	70,100	Kwh	$0.09	$6,309	$1,262	$0	$1,136	$8,706
Quarterly Effluent Sampling and Report	100	HR	$61.00	$6,100	$1,220	$0	$1,098	$8,418
Effluent Analysis (VOCs)	4	EA	$150.00	$600	$120	$0	$108	$828
Quarterly AST acid wash: Labor	32	HR	$61.00	$1,952	$390	$0	$351	$2,694
Quarterly AST acid wash: Acid/Lime	5,333	lbs	$0.80	$4,267	$853	$0	$768	$5,888
Quarterly AST acid wash: Waste Mangmt.	32	drums	$500.00	$16,000	$3,200	$0	$2,880	$22,080
TOTAL ANNUALIZED COSTS								$48,600

PRESENT WORTH = $919,000

Fp_gw$
GT-2 (195 gpm)
5/16/97

AR301449

Table E-14

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-3 (90 gpm)
DESCRIPTION: Metals Precipitation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Transfer Pumps								
Pump and motor (2 hp)	4	EA	$3,000	$12,000	$2,400	$720	$2,268	$17,388
pressure release valves	1	EA	$2,500	$2,500	$500	$150	$473	$3,623
Equalization								
Tank (14,000 Gal)	1	EA	$30,000	$30,000	$6,000	$1,800	$5,670	$43,470
Mixer	1	EA	$8,500	$8,500	$1,700	$510	$1,607	$12,317
Chemical Feed/Flocculation								
Reaction Tank	1	EA	$13,000	$13,000	$2,600	$780	$2,457	$18,837
Reaction Tank Mixer	1	EA	$7,000	$7,000	$1,400	$420	$1,323	$10,143
Flocculation Tank	1	EA	$9,000	$9,000	$1,800	$540	$1,701	$13,041
Flocculation Tank Mixer	1	EA	$7,000	$7,000	$1,400	$420	$1,323	$10,143
Clarifer System								
Clarifier	1	EA	$70,000	$70,000	$14,000	$4,200	$13,230	$101,430
Sludge Wasting Pumps (air dpgm)	2	EA	$2,500	$5,000	$1,000	$300	$945	$7,245
Gravity Sand Filter								
Filter w/2 bays	1	EA	$80,000	$80,000	$16,000	$4,800	$15,120	$115,920
Quarterly AST acid wash: Labor	1	EA	$9,600	$9,600	$1,920	$576	$1,814	$13,910
Quarterly AST acid wash: Acid/Lime	2	EA	$7,700	$15,400	$3,080	$924	$2,911	$22,315
Quarterly AST acid wash: Waste Mangmt								
Final pH adjustment tank								
Tank	1	EA	$13,000	$13,000	$2,600	$780	$2,457	$18,837
Mixer	1	EA	$8,400	$8,400	$1,680	$504	$1,588	$12,172
Sludge Dewatering								
Sludge storage tank	1	EA	$18,000	$18,000	$3,600	$1,080	$3,402	$26,082
Plate and frame filter press	1	EA	$110,000	$110,000	$22,000	$6,600	$20,790	$159,390
Platform	1	EA	$7,000	$7,000	$1,400	$420	$1,323	$10,143
Chemical Feed Systems								
Sodium hydroxide storage tank	1	EA	$21,000	$21,000	$4,200	$1,260	$3,969	$30,429
Sodium hydroxide feed pumps	2	EA	$3,500	$7,000	$1,400	$420	$1,323	$10,143
Sulfuric acid storage tank	1	EA	$2,000	$2,000	$400	$120	$378	$2,898
Sulfuric acid feed pumps	2	EA	$3,500	$7,000	$1,400	$420	$1,323	$10,143
Soda Ash Storage Tank	1	EA	$17,000	$17,000	$3,400	$1,020	$3,213	$24,633
Soda Ash Feed Pumps	2	EA	$3,500	$7,000	$1,400	$420	$1,323	$10,143
Polymer/Blender Feeders	2	EA	$6,500	$13,000	$2,600	$780	$2,457	$18,837
Air Compressor	1	EA	$35,000	$35,000	$7,000	$2,100	$6,615	$50,715

Fp_gw$
GT-3 (90 gpm)
5/16/97

AR301450

Table E-14

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-3 (90 gpm)
DESCRIPTION: Metals Precipitation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Subtotal				$534,400	$106,880	$32,064	$101,002	$774,346
Miscellaneous Metals			1%	$9,375	$1,875	$563	$1,772	$13,585
Finishes			2%	$18,751	$3,750	$1,125	$3,544	$27,170
Miscellaneous Structural			5%	$46,877	$9,375	$2,813	$8,860	$67,925
Miscellaneous Site Work			5%	$46,877	$9,375	$2,813	$8,860	$67,925
Miscellaneous Mechanical			15%	$140,632	$28,126	$8,438	$26,579	$203,775
Electrical/I&C			15%	$140,632	$28,126	$8,438	$26,579	$203,775
Subtotal				$937,544	$187,509	$56,253	$177,196	$1,358,501
Metal Building	10,000	EA	$75	$750,000	$150,000	$45,000	$141,750	$1,086,750
Subtotal				$1,687,544	$337,509	$101,253	$318,946	$3,029,407
Engineering @ 10% Construction	1	LS						$302,900
TOTAL CAPITAL								$3,332,300
Sludge trans. & disposal (haz.)	300	TON	$250.00	$75,000	$15,000	$0	$13,500	$103,500
Miscellaneous electrical	297,800	Kwh	$0.09	$26,802	$5,360	$0	$4,824	$36,987
Quarterly Effluent Sampling (1)	8	HR	$61.00	$488	$98	$1	$88	$675
Quarterly Analysis (Al, Be, Fe, Mn)	4	EA	$40.00	$160	$32	$2	$29	$223
Weekly Analysis of 2 Process Pts (Fe, TSS)	104	EA	$25.00	$2,600	$520	$3	$468	$3,591
Chemical Costs								
NaOH (25%)	14,600	Gal	$0.56	$8,176	$1,635	$0	$1,472	$11,283
H2SO4 (93%)	3,650	Gal	$0.53	$1,935	$387	$0	$348	$2,670
Soda Ash (30%)	87,500	lb	$0.11	$9,636	$1,927	$0	$1,734	$13,298
Less Air Stripper Acid Wash	1	LS		($14,512)	($2,902)	$0	($2,612)	($20,027)
Treatment Plant Labor	2,080	HR	$61.00	$126,880	$25,376	$0	$22,838	$175,094
TOTAL ANNUALIZED COSTS								$327,300

PRESENT WORTH = $8,364,000

Fp_gw$
GT-3 (90 gpm)
5/16/97

AR301451

Table E-15

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-3 (195 gpm)
DESCRIPTION: Metals Precipitation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Transfer Pumps								
Pump and motor (2 hp)	4	EA	$3,000	$12,000	$2,400	$720	$2,268	$17,388
pressure release valves	1	EA	$3,200	$3,200	$640	$192	$605	$4,637
Equalization								
Tank (14,000 Gal)	2	EA	$30,000	$60,000	$12,000	$3,600	$11,340	$86,940
Mixer	2	EA	$8,500	$17,000	$3,400	$1,020	$3,213	$24,633
Chemical Feed/Flocculation								
Reaction Tank	1	EA	$19,700	$19,700	$3,940	$1,182	$3,723	$28,545
Reaction Tank Mixer	1	EA	$7,800	$7,800	$1,560	$468	$1,474	$11,302
Flocculation Tank	1	EA	$13,600	$13,600	$2,720	$816	$2,570	$19,706
Flocculation Tank Mixer	1	EA	$7,800	$7,800	$1,560	$468	$1,474	$11,302
Clarifer System								
Clarifier	2	EA	$70,000	$140,000	$28,000	$8,400	$26,460	$202,860
Sludge Wasting Pumps (air dpgm)	2	EA	$11,400	$22,800	$4,560	$1,368	$4,309	$33,037
Gravity Sand Filter								
Filter w/2 bays	1	EA	$121,000	$121,000	$24,200	$7,260	$22,869	$175,329
Backwash Storage Tank	1	EA	$15,000	$15,000	$3,000	$900	$2,835	$21,735
Backwash Pumps	2	EA	$11,000	$22,000	$4,400	$1,320	$4,158	$31,878
Final pH adjustment tank								
Tank	1	EA	$20,000	$20,000	$4,000	$1,200	$3,780	$28,980
Mixer	1	EA	$13,000	$13,000	$2,600	$780	$2,457	$18,837
Sludge Dewatering								
Sludge storage tank	1	EA	$28,000	$28,000	$5,600	$1,680	$5,292	$40,572
Plate and frame filter press	1	EA	$170,000	$170,000	$34,000	$10,200	$32,130	$246,330
Platform	1	EA	$10,000	$10,000	$2,000	$600	$1,890	$14,490
Chemical Feed Systems								
Sodium hydroxide storage tank	1	EA	$21,000	$21,000	$4,200	$1,260	$3,969	$30,429
Sodium hydroxide feed pumps	2	EA	$5,000	$10,000	$2,000	$600	$1,890	$14,490
Sulfuric acid storage tank	1	EA	$2,000	$2,000	$400	$120	$378	$2,898
Sulfuric acid feed pumps	2	EA	$5,000	$10,000	$2,000	$600	$1,890	$14,490
Soda Ash Storage Tank	1	EA	$17,000	$17,000	$3,400	$1,020	$3,213	$24,633
Soda Ash Feed Pumps	2	EA	$5,000	$10,000	$2,000	$600	$1,890	$14,490
Polymer/Blender Feeders	2	EA	$10,000	$20,000	$4,000	$1,200	$3,780	$28,980
Air Compressor	1	EA	$35,000	$35,000	$7,000	$2,100	$6,615	$50,715

Fp_gw$
GT-3 (195 gpm)
5/16/97

Table E-15

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-3 (195 gpm)
DESCRIPTION: Metals Precipitation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	AMOUNT	CONTINGENCY 20.00%	MOB/DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Subtotal				$827,900	$165,580	$49,674	$156,473	$1,199,627
Miscellaneous Metals			1%	$14,525	$2,905	$871	$2,745	$21,046
Finishes			2%	$29,049	$5,810	$1,743	$5,490	$42,092
Miscellaneous Structural			5%	$72,623	$14,525	$4,357	$13,726	$105,230
Miscellaneous Site Work			5%	$72,623	$14,525	$4,357	$13,726	$105,230
Miscellaneous Mechanical			15%	$217,868	$43,574	$13,072	$41,177	$315,691
Electrical/I&C			15%	$217,868	$43,574	$13,072	$41,177	$315,691
Subtotal				$1,452,456	$290,491	$87,147	$274,514	$2,104,609
Metal Building	15,000	EA	$75	$1,125,000	$225,000	$67,500	$212,625	$1,630,125
Subtotal				$2,577,456	$515,491	$154,647	$487,139	$4,639,716
Engineering @ 10% Construction	1	LS						$464,000
TOTAL CAPITAL								$5,103,700
Sludge trans. & disposal (haz.)	600	TON	$250.00	$150,000	$30,000	$0	$27,000	$207,000
Miscellaneous electrical	438,000	Kwh	$0.09	$39,420	$7,884	$0	$7,096	$54,400
Quarterly Effluent Sampling (1)	8	HR	$61.00	$488	$98	$1	$88	$675
Quarterly Analysis (Al, Ba, Fe, Mn)	4	EA	$40.00	$160	$32	$2	$29	$223
Weekly Analysis of 2 Process Pts (Fe, TSS)	104	EA	$25.00	$2,600	$520	$3	$468	$3,591
Chemical Costs								
NaOH (25%)	29,200	Gal	$0.56	$16,352	$3,270	$0	$2,943	$22,566
H2SO4 (93%)	7,300	Gal	$0.53	$3,869	$774	$0	$696	$5,339
Soda Ash (30%)	175,200	lb	$0.11	$19,272	$3,854	$0	$3,469	$26,595
Less Air Stripper Acid Wash	1	LS		($22,219)	($4,444)	$0	($3,999)	($30,662)
Treatment Plant Labor	2,080	HR	$61.00	$126,880	$25,376	$0	$22,838	$175,094
TOTAL ANNUALIZED COSTS								$464,800

PRESENT WORTH = $12,249,000

Fp_gw$
GT-3 (195 gpm)
5/16/97

Table E-16

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-4 (90 gpm)
DESCRIPTION: Chemical Oxidation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Influent pumps	2	EA	$3,000	$6,000	$1,200	$360	$1,134	$8,694
450 gallon reactor	1	EA	$1,620	$1,620	$324	$97	$306	$2,347
Hydrogen peroxide injection system	1	EA	$2,000	$2,000	$400	$120	$378	$2,898
Prefabricated Shed	165	SF	$50	$8,250	$1,650	$495	$1,559	$11,954
Subtotal				$17,870	$3,574	$1,072	$3,377	$25,894
Miscellaneous Structural			5%	$1,489	$298	$89	$281	$2,158
Miscellaneous Site Work			5%	$1,375	$275	$82	$260	$1,992
Miscellaneous Mechanical/Piping			15%	$3,829	$766	$230	$724	$5,549
Electrical/I&C			15%	$3,154	$631	$189	$596	$4,569
Subtotal				$27,717	$5,543	$1,663	$5,238	$40,161
Engineering @ 10% Construction	1	LS						$4,016
TOTAL CAPITAL								$44,200
Miscellaneous electrical	35,000	Kwh	$0.09	$3,150	$630	$0	$567	$4,347
Hydrogen peroxide usage	438	gal	$85.00	$37,230	$7,446	$0	$6,701	$51,377
Quarterly Effluent Sampling & Report	100	HR	$61.00	$6,100	$1,220	$0	$1,098	$8,418
Effluent Analysis (VOCs)	4	EA	$150.00	$600	$120	$0	$108	$828
Treatment Facility Operation	416	HR	$61.00	$25,376	$5,075	$0	$4,568	$35,019
TOTAL ANNUALIZED COSTS								$100,000

PRESENT WORTH = $1,581,000

Fp_gw$
GT-4 (90 gpm)
5/16/97

Table E-17

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-4 (195 gpm)
DESCRIPTION: Chemical Oxidation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Influent pumps	2	EA	$3,000	$6,000	$1,200	$360	$1,134	$8,694
975 gallon reactor	1	EA	$3,510	$3,510	$702	$211	$663	$5,086
Hydrogen peroxide injection system	1	EA	$2,000	$2,000	$400	$120	$378	$2,898
Prefabricated Shed	200	SF	$50	$10,000	$2,000	$600	$1,890	$14,490
Subtotal				$21,510	$4,302	$1,291	$4,065	$31,168
Miscellaneous Structural			5%	$1,793	$359	$108	$339	$2,597
Miscellaneous Site Work			5%	$1,655	$331	$99	$313	$2,398
Miscellaneous Mechanical/Piping			15%	$4,609	$922	$277	$871	$6,679
Electrical/I&C			15%	$3,796	$759	$228	$717	$5,500
Subtotal				$33,362	$6,672	$2,002	$6,305	$48,342
Engineering @ 10% Construction	1	LS						$4,834
TOTAL CAPITAL								$53,200
Miscellaneous electrical	52,600	Kwh	$0.09	$4,734	$947	$0	$852	$6,533
Hydrogen peroxide usage	949	gal	$85.00	$80,665	$16,133	$0	$14,520	$111,318
Quarterly Effluent Sampling & Report	100	HR	$61.00	$6,100	$1,220	$0	$1,098	$8,418
Effluent Analysis (VOCs)	4	EA	$150.00	$600	$120	$0	$108	$828
Treatment Facility Operation	416	HR	$61.00	$25,376	$5,075	$0	$4,568	$35,019
TOTAL ANNUALIZED COSTS								$162,100

PRESENT WORTH = $2,545,000

Fp_gw$
GT-4 (195 gpm)
5/16/97

Table E-18

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-5 (90 gpm)
DESCRIPTION: Off-Gas Treatment with Vapor Phase Carbon

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Vapor Phase Carbon Units (2 in series, 8-ft. diam.; heat exchanger, booster blowers)	1	EA	$78,000.00	$78,000	$15,600	$4,680	$14,742	$113,022
Subtotal				$78,000	$15,600	$4,680	$14,742	$113,022
Miscellaneous Structural			5%	$6,500	$1,300	$390	$1,229	$9,419
Miscellaneous Site Work			5%	$6,500	$1,300	$390	$1,229	$9,419
Miscellaneous Mechanical/Piping			15%	$19,500	$3,900	$1,170	$3,686	$28,256
Electrical/I&C			15%	$19,500	$3,900	$1,170	$3,686	$28,256
Subtotal				$130,000	$26,000	$7,800	$24,570	$188,370
Engineering @ 10% Construction	1	LS						$18,837
TOTAL CAPITAL								$207,200
Miscellaneous electrical	8,800	Kwh	$0.09	$792	$158	$48	$150	$1,148
Quarterly Air Emissions Sampling & Report	80	HR	$61.00	$4,880	$976	$293	$922	$7,071
Quarterly Air Emissions Analysis (VOCs)	4	EA	$500.00	$2,000	$400	$120	$378	$2,898
Carbon changeout labor	122	HR	$61.00	$7,442	$1,488	$447	$1,407	$10,783
Carbon Changeout	386,900	lbs	$2.40	$928,560	$185,712	$55,714	$175,498	$1,345,483
TOTAL ANNUALIZED COSTS								$1,367,400

PRESENT WORTH = $21,227,000

Fp_gw$
GT-5 (90 gpm)
5/16/97

AR301456

Table E-19

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-5 (195 gpm)
DESCRIPTION: Off-Gas Treatment with Vapor Phase Carbon

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 5.00%	OH&P 15.00%	TOTAL
Vapor Phase Carbon Units (2 in series, 8-ft. diam.; heat exchanger, booster blowers)	1	EA	$78,000.00	$78,000	$15,600	$4,680	$14,742	$113,022
Subtotal				$78,000	$15,600	$4,680	$14,742	$113,022
Miscellaneous Structural			5%	$6,500	$1,300	$390	$1,229	$9,419
Miscellaneous Site Work			5%	$6,500	$1,300	$390	$1,229	$9,419
Miscellaneous Mechanical/Piping			15%	$19,500	$3,900	$1,170	$3,686	$28,256
Electrical/I&C			15%	$19,500	$3,900	$1,170	$3,686	$28,256
Subtotal				$130,000	$26,000	$7,800	$24,570	$188,370
Engineering @ 10% Construction	1	LS						$18,837
TOTAL CAPITAL								$207,200
Miscellaneous electrical	17,500	Kwh	$0.09	$1,575	$315	$95	$298	$2,282
Quarterly Air Emissions Sampling & Report	80	HR	$61.00	$4,880	$976	$293	$922	$7,071
Quarterly Air Emissions Analysis (VOCs)	4	EA	$500.00	$2,000	$400	$120	$378	$2,898
Carbon changeout labor	146	HR	$61.00	$8,906	$1,781	$534	$1,683	$12,905
Carbon Changeout	474,500	lbs	$2.40	$1,138,800	$227,760	$68,328	$215,233	$1,650,121
TOTAL ANNUALIZED COSTS								$1,675,300

PRESENT WORTH =	$25,961,000

Fp_gw$
GT-5 (195 gpm)
5/16/97

Table E-20

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-6 (90 gpm)
DESCRIPTION: Off-Gas Treatment with Catalytic Oxidation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Catalytic Oxidizer w/standard options (1200 scfm)	1	EA	$194,148	$194,148	$38,830	$11,649	$36,694	$281,320
HCl Scrubber	1	EA	$113,760	$113,760	$22,752	$6,826	$21,501	$164,838
Prefabricated Shed	400	SF	$50	$20,000	$4,000	$1,200	$3,780	$28,980
Subtotal				$307,908	$22,752	$6,826	$21,501	$164,838
Miscellaneous Structural			5%	$25,659	$5,132	$1,540	$4,850	$37,180
Miscellaneous Site Work			5%	$25,659	$5,132	$1,540	$4,850	$37,180
Miscellaneous Mechanical/Piping			15%	$76,977	$15,395	$4,619	$14,549	$111,540
Electrical/I&C			15%	$76,977	$15,395	$4,619	$14,549	$111,540
Subtotal				$513,180	$63,806	$19,142	$60,297	$462,277
Engineering @ 10% Construction	1	LS						$46,200
TOTAL CAPITAL								$508,500
Miscellaneous electrical	8,800	Kwh	$0.09	$792	$158	$0	$143	$1,093
Natural Gas	675	THM	$0.60	$405	$81	$0	$73	$559
Quarterly Air Emissions Sampling & Report	80	HR	$61	$4,880	$976	$293	$922	$7,071
Quarterly Air Emissions Analysis (VOCs)	4	EA	$500	$2,000	$400	$120	$378	$2,898
Treatment Facility Operation	208	HR	$61.00	$12,688	$2,538	$0	$2,284	$17,509
TOTAL ANNUALIZED COSTS								$29,100

PRESENT WORTH = $956,000

Fp_gw$
GT-6 (90 gpm)
5/16/97

Table E-21

Estimate Summary

PROJECT: Fischer & Porter
ALTERNATIVE: GT-6 (195 gpm)
DESCRIPTION: Off-Gas Treatment with Catalytic Oxidation

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 20.00%	MOB DEMOB/INS 6.00%	OH&P 15.00%	TOTAL
Catalytic Oxidizer w/standard options (1200 scfm)	1	EA	$297,828	$297,828	$59,566	$17,870	$56,289	$431,553
HCl Scrubber	1	EA	$140,400	$140,400	$28,080	$8,424	$26,536	$203,440
Prefabricated Shed	500	SF	$50	$25,000	$5,000	$1,500	$4,725	$36,225
Subtotal				$438,228	$28,080	$8,424	$26,536	$203,440
Miscellaneous Structural			5%	$36,519	$7,304	$2,191	$6,902	$52,916
Miscellaneous Site Work			5%	$36,519	$7,304	$2,191	$6,902	$52,916
Miscellaneous Mechanical/Piping			15%	$109,557	$21,911	$6,573	$20,706	$158,748
Electrical/I&C			15%	$109,557	$21,911	$6,573	$20,706	$158,748
Subtotal				$730,380	$86,510	$25,953	$81,752	$626,768
Engineering @ 10% Construction	1	LS						$62,700
TOTAL CAPITAL								$689,500
Miscellaneous electrical	17,500	Kwh	$0.09	$1,575	$315	$0	$284	$2,174
Natural Gas	1184	THM	$0.60	$711	$142	$0	$128	$981
Quarterly Air Emissions Sampling & Report	80	HR	$61	$4,880	$976	$293	$922	$7,071
Quarterly Air Emissions Analysis (VOCs)	4	EA	$500	$2,000	$400	$120	$378	$2,898
Treatment Facility Operation	208	HR	$61.00	$12,688	$2,538	$0	$2,284	$17,509
TOTAL ANNUALIZED COSTS								$30,600

PRESENT WORTH =	$1,160,000

Fp_gw$
GT-6 (195 gpm)
5/16/97

AR301459

Indirect capital costs consist of engineering, supervision during construction, licenses and permits, and other services necessary to carry out a remedial action. They are not incurred as part of the actual remedial action but are ancillary to direct or construction costs. Indirect capital costs include bid and scope contingencies that attempt to reduce the possibility of a cost overrun. Bid contingencies account for costs associated with construction of a given project, such as general economic conditions at the time of bidding, adverse weather conditions, and strikes by material suppliers. Scope contingencies cover changes that invariably occur during final design and implementation. Scope contingencies include provisions for such items as inherent uncertainties in defining waste volumes and regulatory or policy changes that may affect FS assumptions. A bid contingency of 10 percent and a scope contingency of 10 percent have been assumed in this FS. Therefore, a combined contingency of 20 percent was used to calculate indirect capital costs. EPA and the State of Pennsylvania administrative costs also are indirect costs, but they are not included in this cost estimate.

Additional indirect costs incurred include contractor mobilization, demobilization, and insurance costs, and contractor overhead and profit (OH&P). Standard cost estimate value of 5 percent was used for mobilization, demobilization, and insurance costs. An OH&P factor of 15 percent was used to calculate indirect capital costs.

Engineering costs (final design) were calculated for each alternative assuming 10 percent of the subtotal of direct and indirect capital costs for each alternative. Actual engineering costs may vary based on additional investigation results and preliminary design information.

Finally, additional data are recommended to be obtained before design of the selected remedial alternative. These data can be obtained as part of the remedial design phase of the project. The estimated costs for these additional investigation efforts are not included in this appendix but at the end of Appendix B where the scope of these efforts is described.

Annual Operating Costs

Annual O&M costs for a remedial action include the costs incurred each year following construction or installation of a project. For economic analysis, O&M costs are assumed to be paid at the end of the year in which they occur.

Economic Analysis

The present-worth analysis provides a method for comparing costs that occur over different periods by discounting future expenditures to the present year. Present-worth calculations are based on a 30-year period and 5 percent discount rates. O&M costs are based on 30 years for all alternatives. O&M costs may be incurred beyond this period but 30 years was used for comparison. Future costs were not escalated to account for inflation.

The FS cost estimates were developed based on numerous assumptions involving the physical characteristics of the site and the nature and extent of the contamination. The majority of these assumptions are presented in Section 3 and in the conceptual designs of the extraction and treatment systems as described in Appendices B, C, and D. Assumptions for individual items also are stated within the tables presenting the estimated costs in this appendix. Major assumptions are discussed below.

Cost Assumptions for Soil Alternatives

Alternative S-1—No Action

Costs are summarized for Alternative S-1 in Table E-2. The following assumptions were made to estimate the costs for Alternative S-1:

Capital Costs:

- There are no capital costs associated with this alternative.

O&M Costs:

- Five-year review includes development of report. Assume 40 hours to write report every 5 years. The report will be based on groundwater sampling results collected as part of the groundwater RA alternatives.

Alternative S-2—Institutional Controls

Costs are summarized for Alternative S-2 in Table E-3. The following assumptions were made to estimate the costs for Alternative S-2:

Capital Costs:

- There are no capital costs associated with this alternative.

O&M Costs:

- Five-year review includes development of report. Assume 40 hours to write report every 5 years. The report will be based on groundwater sampling results collected as part of the groundwater RA alternatives.

Alternative S-3—Cap

There are two scenarios for Alternative S-3: (1) future residential site use, and (2) current site use. Costs for Scenarios 1 and 2 of Alternative S-3 are summarized in Tables E-4 and E-5, respectively. Major assumptions are summarized below.

Capital Costs:

- Remove the top layer of soil and regrade the existing native soil to promote surface runoff away from the area of the cap and limit infiltration.
- Dispose of the top 6 inches of soil as nonhazardous waste.
- Place and compact base stone to a minimum thickness of 6 inches on top of the regraded native soil.
- Place and compact asphalt to a minimum thickness of 4 inches on top of the base stone.
- Engineering costs assumed to be the same for both scenarios, since similar level of effort would be required to design the cap.

O&M Costs:

- Maintain the cap by inspecting annually and resurfacing every 5 years.

Cost Assumptions for Groundwater Alternatives

Alternative G-1—No Action

Costs for Alternative G-1 are summarized in Table E-6. The following assumptions were made to estimate the costs for Alternative G-1:

Capital Costs:

- There are no capital costs associated with this alternative.

O&M Costs:

- O&M costs for current system are paid for by Fischer and Porter.
- O&M costs for wellhead treatment are paid for by the Hatboro and Warminster Water Authorities.
- Five-year review includes development of report. Assume 40 hours to write report every 5 years. The report will be based on data collected by Fischer and Porter as part of the operation of the existing extraction and treatment system.

Alternative G-2—Institutional Controls

Costs for Alternative G-2 are summarized in Table E-7. The following assumptions were made to estimate the costs for Alternative G-2:

Capital Costs:

- There are no capital costs associated with this alternative.

O&M Costs:

- O&M costs for current system are paid for by Fischer and Porter.
- O&M costs for wellhead treatment are paid for by the Hatboro and Warminster Water Authorities.
- Annual sampling of four monitoring wells in source area for VOCs, PAHs, and PCBs.
- Annual sampling of 12 monitoring wells outside of source area for VOCs only.
- Collect water levels from existing and new monitoring wells at the site.
- Five-year review includes development of report. Assume 200 hours to write report every 5 years. The report will be based on the data collected annually from onsite wells and includes data entry, tabulation, mapping, and analysis.

Alternative GC-1—Source Control by Extraction Wells

Costs for Alternative GC-1 are summarized in Table E-8. The following assumptions were made to estimate the costs for Alternative GC-1:

Capital Costs:

- Install and develop three extraction well couplets (one shallow well and one intermediate well at each location to anticipated depths of 120 feet and 220 feet bgs, respectively).
- Extract 15 gallons per minute (gpm) from each of the six extraction wells for a total flow rate of 90 gpm.
- Pipe the extracted groundwater from the extraction wells to the treatment location.
- Partially seal using grout current extraction well FP1 to a depth of 220 feet bgs.
- Install two monitoring wells in each of the existing holes of wells FP1 and FP2.
- Partially seal using grout well FP7 to a depth of 220 feet bgs.

O&M Costs:

- Remove any accumulated LNAPL from well FP7 on a quarterly basis and dispose of as hazardous waste. Assumed one-half drum will be collected quarterly (i.e., two drums annually).
- Collect water level measurements from existing and new monitoring wells at the site. Assume a total of 20 wells.

Alternative GC-2—Sitewide Capture by Extraction Wells

The costs presented in Table E-9 are the costs associated with installation of the entire sitewide capture extraction system. The following assumptions were made to estimate the costs for this alternative in addition to the assumptions listed above for Alternative GC-2:

Capital Costs:

- The location of the source control extraction wells SW-3 and IW-3 (shallow and intermediate, respectively) would be moved closer to the source area.
- Two additional extraction wells (SW-4 and SW-5) would be installed to an anticipated depth of 120 feet bgs on the downgradient edge of the TCE plume.
- Five additional extraction wells (IW-4 through IW-8) would be installed to an anticipated depth of 220 feet bgs at the site boundary.
- Extract 15 gpm from each of the additional 7 extraction well for a total flow rate from all extraction wells of 195 gpm.

Alternative GT-1—Carbon Adsorption (Liquid Phase)

The costs for Alternative GT-1 are summarized in Tables E-10 and E-11 for the 90 gpm and 195 gpm flow rates, respectively. The following assumptions were made to estimate the costs for Alternative GT-1:

Capital Costs:

- Two carbon vessels, 10 feet in diameter with 20,000 pounds of GAC per vessel. The same size carbon vessel will be used for the 90 gpm and 195 gpm systems, per Appendix C.
- Heat-trace and insulate of aboveground piping.

O&M Costs:

- Annual carbon usage rate: 1,150 lb/day for 90 gpm system; 1,630 lb/day for 195 gpm system.
- Carbon replacement will require 4 hours per changeout. Changeout frequency: once every 17 days for the 90 gpm system; once every 12 days for the 195 gpm system.
- Sample quarterly the effluent for VOCs and prepare annual of report to document compliance with discharge limits.

Alternative GT-2—Air Stripping

The costs associated with Alternative GT-2 are summarized in Tables E-12 and E-13 for the 90 gpm and 195 gpm flow rates, respectively. The following assumptions were made to estimate the costs for Alternative GT-2:

Capital Costs:

- The estimated costs reflect a packed-column air stripper. A 4-foot-diameter packed-column air stripper will be used for the 90 gpm system; a 5-foot-diameter packed-column will be used for the 195 gpm system.
- The packing height will be 30-feet for both flow rates.
- A prefabricated shed will be provided to house the blowers.
- Heat-trace and insulate of aboveground piping.

O&M Costs:

- Acid wash of the column will be performed four times per year to reduce fouling of packing. Assume 8 hours of labor, 800 lbs of acid; and 5 drums of waste wash water generated per acid wash for the 90 gpm system. For the 195 gpm, 1,250 lbs of acid will be used and 8 drums of waste wash water will be generated per acid wash. Labor is assumed to be the same.
- Sample quarterly the effluent for VOCs and prepare annual of report to document compliance with discharge limits.

Alternative GT-3—Chemical Precipitation of Metals

Metals precipitation would be associated with Alternative GT-2, only. Costs for Alternative GT-3 are incremental to the estimated costs for Alternative GT-2. In addition to the assumptions shown in Tables E-14 and E-15 (90 gpm and 195 gpm flow rates, respectively), the following assumptions were made to estimate the costs for Alternative GT-3:

Capital Costs:

- A building will be required to house the wastewater treatment system. To reduce overall profile of the building, the assumption is that the air stripper would be located outside of the building. Building footprint: 10,000 ft^2 for the 90 gpm system; 15,000 ft^2 for the 195 gpm system.

O&M Costs:

- O&M costs include elimination of acid wash of the air stripper since treatment for metal removal is provided. The cost for the acid wash is included in the O&M costs for the air stripper and subtracted from the O&M costs for this alternative.
- Sodium hydroxide usage rate: 40 gpd for 90 gpm system; 80 gpd for the 195 gpm system.
- Sulfuric acid usage rate: 10 gpd for the 90 gpm system; 20 gpm for the 195 gpm system.
- Soda ash (30 percent) usage rate: 240 gpd for the 90 gpm system; 480 gpd for the 195 gpm system.
- Sample quarterly the effluent for aluminum, barium, iron, and manganese. Report preparation is included under Alternative GT-2.
- Sample weekly two process points for TSS and iron.

Alternative GT-4—Chemical Oxidation

The costs associated with Alternative GT-4 are summarized in Tables E-16 and E-17 for the 90 gpm and 195 gpm flow rates, respectively. The following assumptions were made to estimate the costs for Alternative GT-4:

Capital Costs:

- A prefabricated shed will be provided to house the chemical oxidation reactor and chemical oxidizer feed system.
- Heat-trace and insulate aboveground piping.

O&M Costs:

- Maintenance of the treatment system will require 8 hours per week.
- Hydrogen peroxide dosage of 10 mg/L (usage rate: 11 lb/day for 90 gpm system; 24 lb/day for 195 gpm system).
- Sample quarterly the effluent for VOCs and prepare annual report to document compliance with discharge limits.

Alternative GT-5—Carbon Adsorption (Vapor Phase)

The costs associated with Alternative GT-5 are summarized in Tables E-18 and E-19 for the 90 gpm and 195 gpm flow rates, respectively. The following assumptions were made to estimate the costs for Alternative GT-5:

Capital Costs:

- Two carbon vessels, 8 feet in diameter with 12,500 lbs of carbon.
- The same size carbon vessel will be used for the 90 gpm and 195 gpm systems, per Appendix C.

O&M Costs:

- Annual carbon usage rate: 1,060 lb/day for 90 gpm system; 1,300 lb/day for 195 gpm system.
- Carbon replacement will require 4 hours per changeout. Changeout frequency: once every 12 days for the 90 gpm system (i.e., 31 times per year); once every 10 days for the 195 gpm system (i.e., 37 times per year).
- Quarterly sample the effluent for VOCs and prepare annual report to document compliance with discharge limits.

Alternative GT-6—Catalytic Oxidation

The costs associated with Alternative GT-6 are summarized in Tables E-20 and E-21 for the 90 gpm and 195 gpm flow rates, respectively. The following assumptions were made to estimate the costs for Alternative GT-6:

Capital Costs:

- A prefabricated shed will be provided to house the catalytic oxidizer and scrubber system.
- Heat-trace and insulate aboveground piping.

O&M Costs:

- Natural gas usage rate: 77 THMs/hr for 90 gpm system; 135.2 THMs/hr for the 195 gpm system.
- Maintenance of the unit will require 4 hours per week.
- Quarterly sample the effluent for VOCs and prepare annual report to document compliance with discharge limits.

Alternative GD-1—Discharge to Surface Water

Capital and O&M Costs:

- There are no capital and O&M costs associated with this alternative.