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2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies and screens technologies that may be assembled into remedial action alternatives for detailed evaluation. To develop a list of candidate technologies, the following activities need to be performed:

- Develop media-specific Remedial Action Objectives (RAOs) that are protective of human health and the environment and comply with Applicable or Relevant and Appropriate Requirements (ARARs). RAOs may specify:

  - contaminants of concern (COCs)
  - exposure pathways and receptors
  - preliminary remediation goals (PRGs) that identify potentially acceptable contaminant levels or ranges of levels for each exposure route

- Develop general response actions that define media-specific measures that will satisfy the site-specific RAOs.

- Develop initial estimates of areas or volumes of media to which the general response actions might be applied.

- Identify and screen the technologies applicable to each general response action.

- Consider future use of the study area, to the maximum extent practicable, when identifying and screening technologies.

Section 2.1 presents a preliminary listing of ARARs and other guidance to be considered in developing RAOs. Section 2.2 presents the COCs, PRGs, and RAOs and the rationale for how they were formulated, as well as volumes of contaminated media. Section 2.3 presents the general response actions that may be implemented at the study area, and Section 2.4 presents the identification and screening of representative technologies and process options.

2.1 ARARs and TBCs

ARARs and standards and guidance to be considered (TBCs) are the regulatory and non-regulatory environmental criteria that must be considered while evaluating remedial actions. In this section, the terms ARARs and TBCs are discussed in greater detail.

Section 121 of CERCLA, as amended, states that all remedial actions shall "attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment." With respect to hazardous substances, pollutants, and contaminants that will remain on site after the remedial action has been implemented, CERCLA Section 121 states, "if any standard, requirement, criteria, or limitation under any Federal environmental law, ... or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation... is legally applicable to the hazardous substance... or is relevant and appropriate under the circumstances of the release or threatened release... the remedial action selected... shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation." These requirements of CERCLA Section 121 are applicable to any cleanup action.

ARARs are promulgated federal and state environmental or facility siting requirements. There are two categories of requirements: "applicable" or "relevant and appropriate." CERCLA does not allow a regulation to be considered as both "applicable" and "relevant and appropriate." These categories are defined below:

> Applicable Requirements – Section 300.5 of the National Oil and Hazardous Substances Contingency Plan (NCP) defines applicable requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site."

Relevant and Appropriate Requirements – Section 300.5 of the NCP defines relevant and appropriate requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."

TBCs, as defined in Section 300.400(g)(3) of the NCP, consist of "advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies." Along with ARARs, TBCs may be used to develop the remedial action (cleanup) alternatives necessary to protect human health and the environment.

The NCP Section 300.430(f) states that remedial actions must meet ARARs unless there are grounds for invoking a waiver. A waiver is required if ARARs cannot be achieved. ARARs and TBCs are further divided into three categories: chemical-specific, action-specific, and location-specific. In Sections 2.1.1, 2.1.2, and 2.1.3, chemical-specific, action-specific, and location-specific categories are briefly described, and potential ARARs and TBCs for the study area are identified.

2.1.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the determination of numerical values that establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. In general, chemical-specific requirements are set for a single chemical or a closely-related group of chemicals. These requirements do not consider the mixture of chemicals (EPA/540/G-89/006, 1988). A set of potential chemical-specific ARARs and TBCs that may be applied to the study area is presented in Table 2-1A.

2.1.2 Action-Specific ARARs and TBCs

Action-specific ARARs and TBCs are usually technology- or activity-based requirements or limitations on actions taken with respect to the management of hazardous substances,

pollutants, or contaminants. These requirements are generally focused on actions taken to remediate, handle, treat, transport, or dispose of hazardous substances, pollutants, or contaminants. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved (EPA/540/G-89/006, 1988). A set of potential action-specific ARARs and TBCs that may be applied to the study area is presented in Table 2-1B.

2.1.3 Location-Specific ARARs and TBCs

Location-specific ARARs and TBCs are restrictions placed on the conduct of activities solely because they are in specific areas. Wetland and floodplain regulations are common location-specific ARARs for CERCLA cleanup actions. Additional potential location-specific ARARs include state and federal regulations that protect endangered species, fish and wildlife, and historical and archaeological resources. A set of potential location-specific ARARs and TBCs that may be applied to the study area is presented in Table 2-1C.

2.2 COCs, PRGs, and RAOs

Developing the preliminary list of technologies for source control at the study area depends on formulating RAOs that consist of medium-specific goals to protect human health and the environment. In addition, to the maximum extent practicable, the RAOs should consider other goals such as facilitating future use of the property.

RAOs for the protection of human health and the environment specify the contaminant medium of interest, exposure pathways, and acceptable contaminant level or range of levels for each exposure route. By specifying both an exposure pathway and a target contaminant level(s), protectiveness may be achieved by reducing exposure as well as by reducing contaminant concentrations.

Protection of human health and environment RAOs are formulated by identifying the COCs by medium and then developing PRGs for the COCs.

The human health COCs are site specific and are selected based on the results of the baseline risk assessment performed during the Final RI (TtNUS, 1999). The selection considers whether the media pose excess risk to human receptors outside the acceptable range specified in the NCP (10^{-4} to 10^{-6} for carcinogens) or a hazard quotient of 1.0 for non-carcinogens. The EPA target cancer risk range is 10^{-4} to 10^{-6}. Under EPA guidance, media with estimated risks greater than 10^{-4} are identified and selected for remediation. Those contaminants contributing most to the total risk are selected as COCs. PRGs are developed for each of these COCs, with the goal of bringing total site risk to less than 10^{-4}. Individual contaminant PRGs may be developed based on target risks of 10^{-4}, 10^{-5}, or 10^{-6} as needed to achieve the total site target risk. Since there are fewer than ten COCs at this site, PRGs were developed based on target risks of 10^{-5}. The CTDEP target risk level is 10^{-6} for any single contaminant and a total risk of 10^{-5}, if there are more than 10 contaminants. Individual chemicals posing risks greater than or equal to 1×10^{-5} or hazard quotients of 1.0 are selected as human health COCs based on EPA recommendations. Lead and asbestos also pose health risks and are retained as human health COCs. Environmental protection COCs are selected by identifying contaminants present in the study area soil-waste/fill materials and sediments at concentrations that result in unacceptable levels of contaminants leaching to groundwater or pose unacceptable risks to ecological species or habitats.

PRGs are developed for each of the identified COCs. PRGs are numerical values that are protective of human health and the environment if contaminant concentrations in the environmental media are reduced to these levels. Human health PRGs are established using readily available information including reference doses, risk-specific doses, chemical-specific ARARs, and site-specific risk-related factors. The potential re-use of the property is an additional factor to be considered in the development of RAOs for the study area. As such, the PRGs developed for the protection of human health would be relevant to facilitating future site re-use. Environmental PRGs are established based on contaminant leaching and risk related factors for ecological species.

An ecological risk assessment was performed as part of the Final RI; however, no numerical PRGs were developed for the protection of ecological species at the study area. Ecological impacts will be considered quantitatively during the selection of cleanup technologies.

Detailed discussions of the identification of COCs, development of PRGs, and formulation of RAOs for the study area are presented in the following sections.

2.2.1 Contaminants of Concern (COCs)

Tables 2-2A through 2-2E present summaries of risks to humans posed by direct contact with and incidental ingestion of contaminants that exceed acceptable risk levels in the soil-waste/fill materials and sediments, as detailed in the Final RI (TtNUS, 1999). Exposure to study area surface and subsurface soil-waste/fill materials and sediments, under the scenarios developed in the baseline risk assessment, results in total carcinogenic risks for the commercial worker that exceed the EPA target range of 10^{-4} to 10^{-6} and results in non-carcinogenic risks that exceed a hazard quotient of 1.0 for the commercial worker. In addition, lead exposures for recreational users exceed the EPA level of concern.

A review of Tables 2-2A through 2-2E indicates that several chemicals present at the study area individually pose carcinogenic risks in excess of the EPA target range and/or non-cancer hazard quotients in excess of 1.0. Table 2-3 identifies the COCs used to develop the PRGs. COCs are defined as those contaminants causing cancer risk in excess of 1×10^{-5} or having a hazard quotient of greater than 1.0. Lead is included as a COC based on the evaluation in the RI of modeled blood lead concentrations. Asbestos also poses non-carcinogenic health threats; however, sufficient risk data are not available to quantify these health threats. Therefore, asbestos is included as a COC.

2.2.2 Preliminary Remediation Goals (PRGs)

PRGs are developed to determine the degree of remediation necessary to protect human health. PRGs can be developed based on chemical-specific ARARs, when available, or risk-based factors. In addition, the protection of groundwater, the presence of COCs in background locations, and the analytical detection limits for contaminants are all considered in developing the PRGs. The methods used to develop candidate PRGs are discussed below.

Table 2-4 presents a set of candidate PRG numerical values for soil and sediment COCs derived to fulfill the following:

Protection of Human Health: Risk-based PRG values were developed for the COCs identified in Table 2-3. Based on future land use for the study area, the commercial scenario was used to develop a set of risk-based candidate PRG numerical values. The risks are based on a target cancer risk of 1×10^{-5} or a hazard quotient of 1.0.

Protection of Groundwater: Candidate PRGs for the protection of groundwater were developed based on theoretical contaminant leaching from soil-waste/fill or sediments to groundwater within the study area. The Connecticut Pollutant Mobility Criteria (PMC) are used as PRGs. These PRGs would be adequate to prevent further degradation of the Class GB aquifer (as designated by the State) beneath and surrounding the study area. For PCBs and metals, the Connecticut regulations specify acceptable concentrations resulting from Toxicity Characteristic Leaching Procedure (TCLP) or Synthetic Precipitation Leaching Procedure (SPLP) tests in lieu of acceptable soil or sediment concentrations.

Protection of Ecological Species: No numeric ecological PRGs were developed for the protection of ecological species at the study area; however, protection of ecological species as identified in the RI (TtNUS, 1999) will be considered qualitatively during the selection of cleanup technologies.

Background Concentrations: Some of the metals present in study area soils and sediments are naturally occurring substances that may be present in background areas not affected by past disposal activities at concentrations comparable to or higher than in the study area soil-waste/fill materials and sediment. Background soil and sediment concentrations may be used as PRGs since these values represent contaminant concentrations when no excess risk is anticipated. Using samples from representative background locations selected by EPA, the mean background soil or sediment concentration values for metals were calculated.

Analytical Detection Limits: The analytical detection limits for the organic and inorganic COCs were also considered in developing the PRGs. Because the PRGs have to be detectable by current analytical means to ascertain attainment of these levels, analytical detection limits were designated as the lowest achievable PRGs. The detection limits for organics and inorganics are the EPA Contract Laboratory Program (CLP) Contract

Required Quantitation Limit (CRQL) and Contract Required Detection Limit (CRDL) values, respectively.

ARARs/TBCs: EPA recommends an acceptable value of 25 mg/kg PCBs for industrial or commercial sites (EPA, 1990). NESHAPs (40 CFR 61, Subsection M) identifies materials containing 1 percent or greater asbestos as needing to be addressed. EPA recommends an acceptable value of 1,000 mg/kg lead for industrial sites and 400 mg/kg for residential sites (EPA, 1994). EPA recommends a cleanup level of 0.001 mg/kg for dioxins (EPA, 1998).

Table 2-5 presents the recommended PRG used for each COC and the basis for selection. Recommended PRGs are the more conservative of the risk-based and groundwater protection values, unless superceded by the background value, CRQL/CRDL, or ARAR/TBC. PRGs for PCBs, asbestos, lead, and dioxins were selected based on ARARs/TBCs.

2.2.3 Remedial Action Objectives (RAOs)

RAOs are protective of human health and the environment. RAOs specify the environmental media receptors, exposure pathways, and acceptable contaminant cleanup levels for each medium used in the analysis of risk. The first column of Table 2-6 presents RAOs for the three environmental media, soils, wetland soils, and sediments. The following summarizes the RAOs:

- Based on the human health risk assessment and RI, the human health RAO is **"to prevent human exposure (incidental ingestion and/or dermal contact) to the contaminated soil-waste/fill, contaminated surface water, and contaminated sediments above acceptable risk levels."**

- Based on the ecological risk assessment and RI, the sediment RAO is **"to prevent further degradation or new degradation of ecological species from additional or new exposures to contaminated sediments."**

- The RAO for protection of the environment is to **"minimize leaching of contaminants to groundwater and surface water from the soil-waste/fill and sediments, to the extent practicable."**

Area A-1: Soils, Wetland Soils, and Sediment

RAOs for Area A-1 are protection of human health, protection of ecological receptors, sediments, and protection of groundwater. This will be achieved by reducing or eliminating the risk of human exposure to soils, wetland soils, and sediments containing contaminants, reducing or eliminating the risk of ecological receptor exposure to soils, wetland soils, and sediments containing contaminants, and reducing or eliminating the migration and/or erosion of contaminants to soils, wetland soils, sediments, and groundwater.

Area A-2: Soils

RAOs for Area A-2 are protection of human health, protection of ecological receptors, and protection of groundwater. This will be achieved by reducing or eliminating the risk of human exposure to soils containing contaminants, and reducing or eliminating the migration and/or erosion of soil contaminants to soils, wetland soils, sediments, and groundwater.

Area A-3: Soils, Wetland Soils, and Sediments

RAOs for Area A-3 are protection of human health, protection of ecological receptors, and protection of groundwater. This will be achieved by reducing or eliminating the risk of human exposure to soils, wetland soils, and sediments containing contaminants, reducing or eliminating the risk of ecological receptor exposure to sediments containing contaminants, and reducing or eliminating the migration and/or erosion of contaminants to soils, wetland soils, sediments, and groundwater.

2.2.4 Volume of Contaminated Media

The designated general media areas were described in Section 1.1.4 and shown on Figure 1-1. Soil volumes were calculated based on these areas, as measured by a planimeter,

and on fill thickness contour maps presented in the RI (TtNUS, 1999). Only non-saturated soils (extending down to approximately 8 feet below ground surface) were included in the total. Wetland and sediment COC concentration data for Areas A-1 and A-2 were reviewed, and a maximum contaminant depth was conservatively chosen to be 4 feet. Wetland soil and sediment volumes were therefore determined by multiplying their respective areas by 4 feet. The table below summarizes the estimated areas and volumes of contaminated media where a human health risk was identified.

Volume of Contaminated Media

	Approximate Area of Contamination (Square Feet)	Estimated Volume of Contaminated Media (Cubic Yards)
Area A-1		
Soils	462,660	58,376
Area A-2		
Soils	447,980	89,745
Area A-3		
Soils	143,129	16,527
Wetland Soils	112,430	16,656
Sediments	61,831	9,160
Total	1,228,030	190,464

2.3 General Response Actions (GRAs)

GRAs describe broad media-specific remedial actions that will satisfy RAOs. GRAs identified as applicable for addressing soils, wetland soils, and sediments within the study area are no action, limited action, removal, disposal, containment, treatment, and consolidation. The second column of Table 2-6 presents the GRAs for soils, wetland soils, and sediments. A description of each GRA is provided in the following subsections.

2.3.1 No Action

Under the no-action option, the site is left "as is," without implementing institutional controls, containment measures, removal, or treatment. This option does not provide for monitoring or placing access restrictions on contaminated media at the site. However, examination of this option is retained throughout the screening process, as required by the NCP. Although this

option proposes no remedial action, it provides a baseline against which the effectiveness of other GRAs can be evaluated.

2.3.2 Limited Action

The focus of the limited-action option is institutional controls and access restrictions which will limit the use of or access to the impacted areas in order to reduce or eliminate the risk of exposure to COCs. Examples of such controls and restrictions are deed restrictions, local ordinances, posting no trespassing signs, and installing fencing. This option also includes implementing a long-term monitoring program to assess changes in contaminant concentrations and distribution at the site. While institutional controls and access restrictions alone do not reduce the toxicity, mobility, or volume of contaminated media, naturally occurring attenuation processes may reduce contaminant concentrations over an extended period of time. Data generated from long-term monitoring activities would provide information to assist in determining natural attenuation kinetics. Monitoring would also provide information which could be used to determine if additional remedial actions are warranted, for instance if contaminant migration is observed.

2.3.3 Removal

Under this option, removal technologies would be used to collect contaminated media and prepare the material for disposal or treatment. Removal reduces the volume of contaminated media on site, thereby reducing the risk of human and environmental receptor exposure to COCs. For unsaturated soils, removal is typically performed by the use of mechanical excavation equipment. For wetland soils and sediment, removal typically involves mechanical excavation and/or the use of dredging equipment. Selection of the best means to proceed with this type of work must be done on a case by case basis, as site-specific variables must be considered. Removal of saturated wetland soils and sediments generally involves additional material-handling steps such as dewatering and stabilization. These steps are necessary to allow the material to be handled efficiently and in a controlled manner. Residual water may require disposal or treatment prior to discharge.

2.3.4 Disposal

Depending on the nature of the contaminated media, disposal sites may include building a secure landfill at a location(s) within the town of Stratford or moving the waste out of Stratford to a secure landfill. Disposal in a properly secured and maintained manner will effectively reduce the mobility of COCs.

2.3.5 Containment

Containment options reduce the potential for exposure to contaminated materials through the use of physical barriers. These barriers prevent direct contact with contaminated materials and reduce or prevent migration of contaminated media. Barriers may be permeable or impermeable and are comprised of natural and/or synthetic materials. Containment reduces the mobility of the contaminated media but does not reduce volume or toxicity.

Containment by capping of contaminated media in tidally influenced marine environments involves considerations of erosion forces such as tides, waves, channel maintenance and localized currents.

2.3.6 Treatment

Under this option, contaminated soils, wetland soils, and sediments would be treated following removal to reduce their toxicity, mobility, and/or volume. Treatment options can be divided into five categories: immobilization, thermal, physical, chemical, and biological technologies. Some types of treatment may have the option of being conducted on site, at another in-town location, or at an out-of-town facility, while others can only be done at an out-of-town facility. Treated material may be disposed of in town or out of town.

2.3.7 Consolidation

Consolidation is an option in which soils, wetland soils, and sediments from different Raymark OUs would be relocated and consolidated in one in-town location. Consolidation makes it

possible to address soils and sediments from various source areas in order to manage more effectively the larger volume of waste as a whole.

2.4 Identification and Screening of Representative Technologies and Process Options

A variety of technologies and specific process options exist for each GRA described in Section 2.3. A wide range of technology types and process options were identified and are presented along with the RAOs and GRAs in Table 2-6. The technology types and process options identified were screened to focus on technologies and specific process options appropriate for each area. Summaries of the identification and preliminary screening of technologies and specific process options for the study area are presented in Table 2-7 for Areas A-1, A-2, and A-3 in the study area. Technologies that were eliminated are shaded gray in the tables. Brief explanations for the elimination or retention of options is given in the "Screening Comment" column of the tables. In addition, the current status of each technology, showing its availability for use is presented.

Further information is provided in the text for all technologies that were retained in Table 2-7, as well as any well-established technology that was eliminated. No further discussion is provided for technologies that are not well established that were eliminated.

Technologies and process options were screened based on effectiveness, implementability, and cost, with a focus on effectiveness. Further screening of technologies will focus on implementability and cost. Brief descriptions of these criteria are as follows:

- **Effectiveness** – focuses on the potential ability of the technology and specific process option to remediate the estimated areas or volumes of media, and to meet the remediation goals identified in the RAOs, the potential impacts to human health and the environment during construction and implementation, and the technical reliability (effectiveness of innovative technologies versus proven technologies) with respect to the contaminants and conditions within the study area.

- **Implementability** – encompasses both the technical and institutional feasibility of implementing a process. The screening of technology types and specific process options was based on an evaluation of technical implementability issues in order to eliminate options that were clearly ineffective or unworkable. The subsequent, more detailed evaluation places greater emphasis on the institutional aspects of implementability (coordination with various regulatory agencies and contractors; the availability of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers to provide long-term operation and maintenance (O&M) services, etc.).

- **Cost** – plays a limited role in this initial screening of process options. Options are evaluated based on relative capital and O&M costs (whether the costs are high, medium, or low relative to the other options within the same remedial technology type). For this screening, the cost analysis is based on engineering judgment and not on detailed estimates. Cost of a remedial option is fully evaluated during the Feasibility Study process.

The following subsections present the evaluations of technologies for each GRA shown in Section 2.3.

2.4.1 No Action

The No Action scenario is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario, no removal or treatment of the contaminated soils or sediments would occur.

Effectiveness – The No Action option would not achieve any of the remedial objectives. Human health risks associated with exposure to carcinogenic and non-carcinogenic contaminants in the study area soils and sediments would become greater over time as a result of the continuing deterioration of the clean soil cover; long-term protection of groundwater would not be provided since the contaminants in the soils and sediments would potentially continue to migrate into the groundwater; and re-use of the property would be impeded. Because contaminated soils and sediments would remain on site, 5-year site

reviews would be conducted to evaluate the contamination status of the study area. Other effectiveness criteria are not applicable for the No Action scenario.

Implementability – No implementability considerations are associated with the No Action scenario.

Cost – Because no actions would be taken at the study area other than 5-year reviews of site status, capital and O&M costs would be negligible.

Conclusion – Retain the No Action scenario as a baseline, as required by the NCP.

2.4.2 Limited Action

The components of limited action that are evaluated in this screening are deed restrictions, local ordinances, fencing, posting of signs, and monitoring.

Deed Restrictions

Deed restrictions are institutional controls that are placed on property deeds. These restrictions are used to limit future activities or uses of a site to prevent human contact with contaminated soils, sediments, or groundwater. Deed restrictions commonly used to reduce exposure to contaminated media include prohibitions on installing water supply wells, restrictions on types of development allowed (e.g., no residential use), and limitations on certain types of construction (e.g., excavation, buildings with basements). Study area deed restrictions will consist of limiting excavation of soils and sediments and prohibition of residential home construction.

The State of Connecticut requires Environmental Land Use Restrictions (ELURs) in most cases where contaminants are left in place. An ELUR has four components: a declaration of the ELUR, a class A-2 survey of the parcel or portion of a parcel; a certificate of title demonstrating that all persons with an interest in the land have subordinated their interest to the ELUR, and a decision document signed by the Commissioner of Connecticut Department of Environmental Protection or a Licensed Environmental Professional. The decision

document describes the types of pollutants, location of pollutants, what activities and uses are prohibited, and a summary of the public comments received. An ELUR cannot be placed on a parcel unless the State has determined that the actions taken at the site are consistent with Connecticut Remediation Standard Regulations (RSRs). An ELUR must be placed on the deed by the property owner, and there are no legal actions that the state or locals can take, short of taking the property, if the property owner is unwilling to place an ELUR on the property.

Effectiveness – Deed restrictions could be applied to limit construction activities and future residential or commercial/industrial land use on the study area. However, historically these restrictions, by themselves, have not proven to be reliable because they are difficult to enforce and would not address the contaminant migration component of the remedial objectives. They are also not effective for ecological receptors. Deed restrictions, by themselves, are not effective in the long term to reduce risk and therefore, would not achieve the RAOs. No additional risks to human health and the environment would directly result from the imposition of deed restrictions.

Implementability – Deed restrictions may be implemented by the property owners or by state and local authorities. If property owners are not willing to place the desired restrictions on the property deeds, legal action by state or local authorities would be necessary to implement the deed restrictions. Deed restrictions are typically difficult to implement. Consideration of the availability of treatment, storage, or disposal (TSD) facilities and the need for permits are not applicable to deed restrictions.

Cost – Because only administrative actions would be taken at the study area, capital costs would be very low and no O&M costs would be incurred.

Conclusion – Although deed restrictions are not effective as a stand-alone action, this option can be used in conjunction with other technologies to restrict future exposure to surface or subsurface contaminants (including contaminants below the water table). As a result, deed restrictions will be retained for consideration only in combination with other process options.

Local Ordinances

Local ordinances are institutional controls enacted by municipalities to limit property use or activities. Local ordinances may be used to limit future uses or activities on a site to prevent human contact with contaminated soils, sediments, or groundwater. Local ordinances commonly used to reduce exposure to contaminated media include zoning regulations that prohibit particular land uses (such as residential development) in an area and regulations that restrict activities such as installation of potable water supply wells.

Effectiveness – Local ordinances could be applied to restrict land use and activities such as installation of water supply wells on the study area. These restrictions alone would not reduce human health risk and would not address the contaminant migration component of the remedial objectives or any ecological receptors. However, in combination with remedial actions such as capping that limit potential exposure to contaminants left in place, local ordinances may provide added assurance that contaminated media are not disturbed. No additional risks to human health and the environment would directly result from the imposition of local ordinances.

Implementability – The cooperation of local authorities is necessary to implement local ordinances. Consideration of the availability of TSD facilities and the need for permits are not applicable to local ordinances.

Cost – Because only administrative actions would be taken at the study area, capital costs would be very low and no O&M costs would be incurred.

Conclusion – Although local ordinances are not feasible as a stand-alone action at the study area, this option may be used in conjunction with other technologies to restrict future exposure to subsurface contaminants, if left in place. If future uses of the area include commercial/industrial development, local ordinances in the form of limitations on future land use or well installation may be required. This option is retained for further consideration only in combination with other process options.

Fencing

Fencing may be used as a barrier to restrict access to areas where contaminants are present at or near the surface, thereby limiting direct contact exposure. Access to the study area, where contaminated soils and sediments are present, is not currently restricted by fencing.
Effectiveness – Fencing would not meet RAOs because it does not reliably prevent access to contaminated soils and sediments and would not reduce leaching of contamination to groundwater and surface water. Fencing provides limited protection of human health by discouraging trespasser access to areas where subsurface contamination is present. The effectiveness of fencing in reducing access and thereby reducing exposure to contaminants is highly dependent on fence maintenance and on the determination of the would-be trespasser. Even well maintained fencing is not likely to be completely effective in restricting access, particularly by a determined trespasser. Fencing would not be effective in the long term to eliminate risk. Fencing would not protect ecological receptors or groundwater nor limit the migration of contaminants from source areas and may impede re-use of the property. No additional risks to human health and the environment would result from the installation of fencing.

Implementability – Installation of new fencing is readily implementable. Contractors and equipment are readily available for fence installation and maintenance.

Cost – The capital and O&M costs for fencing would be low.

Conclusions – Although fencing alone is not effective for achieving RAOs, it may be used in conjunction with other technologies to limit exposure to soil and sediment contaminants. Fence installation is retained for further consideration only in combination with other process options.

Post Signs

The posting of signs may be used as a means of indicating areas where contaminants are present at or near the surface, thereby preventing direct contact exposure. The study area,

where contaminated soil and sediment is present beneath the surface, is not currently posted with warning signs.

Effectiveness – Sign posting would not meet RAOs because it does not reliably prevent access to contaminated soils and sediments and would not reduce leaching of contamination to groundwater and surface water. Signs provide only limited protection of human health by discouraging trespasser access to areas where subsurface contamination is present. Signs would not be effective in the long term to eliminate risk, nor would they protect ecological receptors or groundwater nor limit the migration of contaminants from source areas. No additional risks to human health and the environment would result from the installation of signs.

Implementability – Installation of new signs is readily implementable. Contractors and equipment are readily available for sign installation and maintenance.

Cost – The capital and O&M costs for posting signs would be low.

Conclusions – Although signs alone are not effective for achieving RAOs, they may be used in conjunction with other technologies to limit exposure to soil and sediment contaminants. Sign installation is retained for further consideration only in combination with other process options.

Monitoring

Sampling and analysis of groundwater, surface water, soils, wetland soils, and sediments at the study area could be used to evaluate potential leaching and migration of contaminants from contaminant source areas. Monitoring will be required for any technologies and process options where soil-waste/fill or contaminated sediment remains in the study area.

Effectiveness – Monitoring would not reduce the toxicity, mobility, or volume of contaminants in the soils, sediments, or groundwater. Monitoring would not provide any additional protection to the environment since contaminants would continue to spread into uncontaminated or less contaminated areas. However, by serving as a warning mechanism, periodic monitoring would allow the responsible agency to gauge contaminant migration and determine whether future

actions are necessary to mitigate risk. Monitoring will facilitate evaluating the effectiveness of source control measures in preventing contaminant leaching.

Implementability – A monitoring program could be readily implemented at the study area. Access agreements may be required for sampling or installation of new monitoring wells and borings on town, state, or private properties.

Cost – The capital and O&M costs for periodic monitoring would be moderate.

Conclusion – Monitoring would be an effective and easily implementable method of observing contaminant migration and the progress of remediation. Alone, it would provide no additional protection of human health or the environment. Monitoring will be required for any technologies and process options where soil-waste/fill or contaminated sediment remains in the study area. As a result, monitoring will be retained for consideration only in combination with other process options.

2.4.3 Removal

The components of removal that are evaluated in this screening are bulk excavation and dredging.

Bulk Excavation

Bulk excavation involves the large-scale removal of soil and waste materials. Traditional excavation equipment such as hydraulic excavators, scrapers, bulldozers, wheel loaders, and off-road dump trucks are typically used. The excavated material could be loaded onto trucks and hauled to an approved treatment or disposal facility, or could be treated and/or relocated at the study area or another in-town location. Backfilling open excavations would require the use of clean fill or decontaminated, solidified/stabilized soils.

Effectiveness – Bulk excavation would be effective for handling the volume of contaminated soil at the study area. Control of airborne asbestos and fugitive dust would be required during excavation to protect on-site workers and the surrounding community. Standard engineering

controls such as dust suppressants and negative pressure enclosures would adequately and safely collect and control airborne contaminants. This technology, combined with subsequent treatment and/or disposal, would be a permanent solution and attain the goals outlined in the RAOs. The quantities of material involved and the types of soils at the study area can be excavated.

Implementability – Excavation is readily implementable for shallow, easily accessible soils. Deeper soils and saturated soils at or near the water table are somewhat more difficult to excavate. Excavation would most likely be accomplished in a staged approach to minimize adverse conditions. Contractors for this type of excavation are readily available in this area. The need for TSD facilities should not be required for excavation if waste materials are disposed of at an in-town location. If excavated materials are disposed of out of town, transportation and TSD facility requirements must be met.

Cost – The costs range from moderate for shallow soils to high for deeper, saturated soils.

Conclusion – Removal of contaminated soils by bulk excavation is retained for further evaluation in conjunction with other process options.

Dredging

Clamshell dredges are mechanical excavators commonly used to excavate sediments from water bodies and soils from below the water table. Clamshell buckets range in capacity from 1 to 12 cubic yards. The dredge excavates a heaped bucket of saturated material; water rapidly drains from the soils as the bucket is hoisted, typically resulting in the loss of a portion of the dredged sediments. The dredged materials can be further dewatered by natural drainage in a specially designed staging area or an area within the overall excavation. The dewatered dredged material can be loaded onto trucks and hauled to an out-of-town TSD facility or treated or disposed of on site or at another in-town location. Removal of contaminated soil beneath buildings, if necessary, would require demolition and removal of the buildings. Backfilling would require the use of clean fill or the use of decontaminated soils to restore the study area to its original grade.

Effectiveness – Removal of the saturated contaminated soil and/or sediments by mechanical dredging equipment such as clamshell buckets would be effective in handling the volume of saturated media at the study area. Control of volatile organics may be necessary during dredging to protect on-site workers and the surrounding community. Standard engineering controls such as negative pressure enclosures would adequately and safely collect any VOC emissions. This technology, combined with subsequent treatment and/or disposal, would be a permanent solution and attain the goals outlined in the RAOs.

Implementability – Mechanical dredging of saturated soils and/or sediments is readily implementable for shallow, easily accessible saturated soils and sediments. Contractors for this type of removal are readily available in this area. The need for permits or TSD facilities should not be required for mechanical dredging.

Cost – The costs range from moderate for shallow soils and sediments to high for deeper soils and sediments.

Conclusion – Removal of saturated (at or below the water table) contaminated soils or sediments via mechanical dredging may be considered for shallow soils and/or sediments.

2.4.4 Disposal

Landfills

Contaminated soil-waste materials and/or sediments may ultimately be disposed of at a regulated landfill. Depending on the contaminants and their concentrations, the material may or may not require treatment prior to landfilling. The treatment, if necessary, can be part of a process option chosen in the selected remedy or can be provided by the operator of the landfill as part of the disposal service.

The types of landfills considered are hazardous waste landfills and non-hazardous waste landfills. The principal differences between these landfills are the administrative requirements and the design of the cap and base to prevent infiltration and leaching. These two types of landfills are described as follows:

- **Hazardous Waste Landfill**

  Hazardous waste landfills are regulated by the landfill and post-closure requirements of RCRA (40 CFR 264 and 265, Subparts G and N), the Toxic Substances Control Act (TSCA) for PCBs, and state and local laws. Among the requirements are foundations, double liner systems, leak detection systems, leachate collection and treatment systems, capping, post-closure inspections and maintenance of the landfill (30-year period), and post-closure groundwater monitoring (30-year period).

- **Non-hazardous Landfill**

  Non-hazardous landfills include municipal waste landfills and construction/demolition waste landfills. Design and operating practices are somewhat similar to hazardous waste landfills; however, the permitting requirements are not as stringent. These landfills may be used for wastes that are not classified as hazardous but may still significantly contaminate groundwater. Among the design and operating requirements are foundations, liner systems, leak detection systems, leachate collection and treatment systems, capping, post-closure inspection and maintenance of the landfill, and post-closure groundwater monitoring.

Hazardous and non-hazardous landfills are currently available out of town to accept wastes. A new hazardous or non-hazardous landfill could also be constructed in a location within the study area or elsewhere in the Town of Stratford.

Effectiveness – Disposal of soil-waste/fill at a landfill would achieve the RAOs by preventing direct exposure to and the leaching of contaminated soils and sediments. Since a significant portion of the soils and sediments is contaminated with metals and asbestos, which are not easily treated, a landfill may be required for ultimate disposal. The options available include a secure hazardous waste landfill and a non-hazardous landfill. The selection of one landfill over another depends on the relative toxicity of the soils and debris, the risks associated with their disposal, and the regulatory requirements. The contaminated soils and sediments contain elevated levels of metals, asbestos, and organics.

Soils and sediments containing contaminants restricted under RCRA land disposal restrictions (LDRs) regulations would have to be treated to acceptable levels prior to landfilling. In addition to these RCRA-mandated LDRs, pre-treatment requirements are typically established by individual landfill operators to comply with their respective permit conditions. The treatment can usually be provided by the operator of the landfill as part of a turnkey package of the disposal service of an out-of-town landfill.

Disposal of hazardous substances from the study area would have to comply with the CERCLA Off-site Rule (EPA, 1993), which establishes criteria for selecting an appropriate TSD facility and prohibits the use of a RCRA facility for off-site management of Superfund hazardous substances if the facility has significant RCRA violations.

A hazardous waste landfill is appropriate for disposal of most contaminated soils and sediments, and a non-hazardous landfill may be appropriate for slightly contaminated soils and sediments or those that have been treated by a process option.

Landfills should be capable of handling the volumes of contaminated soil-waste materials and contaminated sediments. Landfilling alone would achieve some of the remediation objectives. Because concentrations of leachable metals are present in the study area soils and sediments, some treatment (either as part of the selected remedy or by the landfill operator) would likely be required prior to landfilling most of the contaminated soils and sediments. Risks to human health and the environment associated with implementing landfilling are considered minor.

Implementability – Landfills are implementable, although availability of out-of-town landfill capacity may be limited. For an out-of-town landfill, transportation requirements must be met to transport the various types of wastes from the study area. Treatment of the wastes in compliance with RCRA LDRs prior to landfilling may be required for some of the soils and sediments. Out-of-town TSD facilities are available to receive this waste, although the high volume of soil-waste/fill materials and contaminated sediments from the study area may limit the number of facilities willing to accept the material. Also, no hazardous waste landfills are located in Connecticut (the closest is Model City, New York). Equipment and resources needed to transport the soil-waste/fill and sediments are readily available.

In-town landfill options would consist of constructing a new facility for either hazardous or non-hazardous waste, either in the study area or elsewhere in the Town of Stratford. Siting, construction, and permitting requirements of the State of Connecticut would have to be met and will be difficult and lengthy. The scale of construction and certification of a new landfill makes the option of the in-town landfill undesirable as compared to existing, currently-operating landfills out of town.

Cost – For out-of-town landfills, the relative capital costs are moderate to high (depending on the distance of transportation of wastes). Out-of-town disposal in hazardous waste landfills is the most expensive of the landfill options, while disposal in a non-hazardous landfill is less expensive. The cost for an in-town landfill would be high because of the cost of new construction.

Conclusion – Landfilling is an effective containment option for the contaminated soils and sediments. It is implementable when using existing out-of-town facilities although very difficult to implement in town, as new construction would be required. As a result, out-of-town landfills are retained for further consideration, and in-town landfills are eliminated.

2.4.5 Containment

The following containment technologies and process options for contaminated soils and sediments are evaluated in this section.

- Horizontal Barriers
  - Impermeable Cap
  - Permeable Cover
  - Subaqueous Permeable Cover
  - Subaqueous Impermeable Cap
  - Rip Rap
  - Culvert
- Vertical Barriers
  - Sheet Pile
  - Slurry Wall

Impermeable Cap

Capping involves installing an impermeable barrier over the contaminated soils or sediments to restrict access and reduce infiltration of precipitation into the subsurface. Impermeable and low-permeability barriers are appropriate where soil or sediment contamination threatens groundwater or surface water. Regrading of soils prior to capping may be required. Cap materials can either be natural or synthetic. Frequently used materials include low-permeability clays such as bentonite and synthetic membranes such as high-density polyethylene (HDPE), polyvinyl chloride (PVC), and Hypalon. These materials are typically covered with a clean fill and vegetation (grass) or asphalt to protect them against damage caused by puncturing and weathering. Capping will involve regrading to provide for erosion and drainage control.

Effectiveness – Capping can achieve RAOs associated with preventing exposure to contaminated soils, sediments, and waste materials and minimizing the migration of contaminants from the study area. Capping is a reliable technology that would reduce risk to human health by providing a barrier between contaminated soils and potential receptors, thus significantly limiting fugitive dust emissions and direct contact with contaminated soils and sediments. Capping would be effective in limiting the infiltration of precipitation and consequently the potential leaching of contaminants from unsaturated soils, sediments, and waste materials to groundwater. Capping alone would not prevent potential contaminant leaching to groundwater from saturated soils. Because capping does not alter the natural flow of groundwater through the subsurface, contaminated saturated zone soils would remain a continuing source of contamination to groundwater. Capping only isolates existing contamination, offering no decrease in contaminant levels. Since contaminants remain in place, the long-term effectiveness of capping depends on adequate long-term cap maintenance. During remedial activities, fugitive dust emissions would have to be controlled to minimize effects on human health and the environment. Emissions can be safely and adequately controlled using standard engineering controls such as dust suppressants and enclosures.

Implementability – The construction of an impermeable cap is readily implementable at the study area. A variety of proven capping materials can be used, including soils, clay soils,

geosynthetic membranes, and combinations of these materials. Due to the grade differential across the study area and the close proximity of contaminated soils and sediments to the study area boundaries, significant earthwork may be required to achieve proper slopes for cap stability and surface water runoff control. Remedial activities involving capping are relatively common and can be conducted by many contractors. No permits or other administrative requirements would be necessary for on-site activities. Because the contaminated soil-waste/fill and contaminated sediments would remain in the study area, the need for TSD facilities is not a concern. However, deed restrictions and ELURs would be required in conjunction with capping to limit the future use of the capped areas or actions that may damage the cap. Long-term groundwater monitoring would also be implemented.

Cost – The capital costs for conventional cap construction are expected to be moderate. O&M costs are low for an impermeable cap.

Conclusion – Capping would prevent exposure to contaminated soils and sediments and minimize migration of source contaminants. Because capping alone does not prevent saturated soil contaminants from migrating in the groundwater, other technologies, such as vertical barriers, may be considered and used in conjunction with capping when groundwater issues are addressed under OU2. Capping with an impermeable barrier will be retained for further consideration.

Permeable Cover

Permeable covers and soil caps are lower cost alternatives to conventional caps. Permeable covers and soil caps are placed over contaminated soils and sediments to prevent access to surficial and near-surface contaminants. Because they provide little or no reduction in infiltration, they are appropriate for use where direct exposure to contaminated material is to be prevented and contaminant leaching to groundwater is not a concern.

Effectiveness – Installation of a permeable cover or soil cap would achieve the RAO for preventing direct exposure to contaminated soils and sediments but would not achieve the RAO for protection of the environment, which is to minimize leaching of contaminants to groundwater. A permeable cover or soil cap would not be effective in preventing infiltration or

potential leaching of soil and sediment contaminants to groundwater. Because contaminated soils and sediments remain in place, the effectiveness of a permeable cover or soil cap in preventing direct exposure to contaminants depends on adequate cover maintenance.

Implementability – Construction of a permeable cover or soil cap is readily implementable at the study area. Specialized construction techniques are not required, and qualified contractors and necessary cover materials are readily available. Earthwork requirements would be similar to those described for an impermeable cap. No permits or other administrative requirements would be necessary. Because no off-site activities would be occurring, the need for TSD facilities is not a concern. Deed restrictions and ELURs would be required in conjunction with the cover to limit the future use of or intrusion into the covered areas.

Cost – The capital and O&M costs for a permeable cover are low.

Conclusion – Although a permeable cover or soil cap would not achieve all RAOs, use of a permeable cover or soil cap will be retained for further consideration for use in areas where direct contact exposure to contaminated media is the primary concern.

Subaqueous Permeable Cover

Subaqueous permeable capping or covering is a means of containing contaminated sediments. The principal concept for reducing long-term environmental effects is to cover the contaminated material with clean dredged material. By keeping contaminated sediment in the waterway, stable geochemical and geohydrologic conditions are maintained in place within the sediment, minimizing release of contaminants to surface water, groundwater, and air.

Permeable cover options include placing natural silts, fill, sand, gravel, and/or crushed stone directly over the contaminated area. The selection of materials and associated thickness are chosen based on their ability to physically isolate contaminated sediment from the aquatic environment as well as maintain surface water flow. A cover comprised of materials similar to the existing substrate, but with more coarse materials to provide erosion resistance, is recommended for use in underwater containment. The larger particle sizes, typical of sand and crushed stone, would also allow for more uniform placement within areas of strong tidal

action or underwater currents. The coarse fraction within the cover would protect the cap itself and limit erosion due to wave action and underwater currents.

Effectiveness – Since a subaqueous permeable cover offers no removal or treatment, it would not reduce the toxicity or volume of contaminated sediment. However, the cover would be effective in minimizing human and environmental exposures due to direct contact with contaminated sediment. The effectiveness of a subaqueous cover in preventing potential migration of contaminants depends on its ability to resist erosion and prevent exposure and migration of the contaminated media. Use of appropriately sized and graded capping materials would limit upward migration of contaminated sediments. Migration of dissolved contaminants through the cover could occur under the force of an upward groundwater gradient, potentially contaminating the cover materials over time. Wave action and local currents may limit the long-term integrity of a subaqueous cover in the marine environment, especially in the high-energy areas near the shore. Short-term risks to human health and the environment may be associated with cover installation, as sediments would be stirred up. However, the use of proper equipment and turbidity control measures would reduce these risks.

The long-term effectiveness of the subaqueous permeable cover could be monitored by periodically inspecting the cover to ensure that its thickness has not decreased and collecting sediment samples to determine whether contaminants have been released from under the cover. Periodic maintenance would be required to replace any cover materials that had eroded.

Implementability – Placement of a subaqueous permeable cover is implementable by companies with trained personnel qualified to handle contaminated sediment dredging, grading, and erosion control operations in an aqueous environment. All on-site personnel must be trained in hazardous waste site operations. Proper placement would require considerations of wave action, local currents, and tidal fluctuations. Turbidity control measures would be required to minimize resuspension of contaminated sediment and to limit its migration during capping operations. Installation could be conducted by land-based and barge-mounted equipment. Proper anchoring of the cover and maintenance to ensure its long-term integrity may be difficult.

In addition, the applicability of ARARs must be evaluated on a location-specific basis.

Cost – The capital and O&M costs are low for a subaqueous permeable cover comprised of sand and crushed stone layers.

Conclusion – A subaqueous permeable cover can be an effective and implementable containment technology for contaminated sediments. Subaqueous permeable covers will be retained for further consideration for isolating study area sediments.

Subaqueous Impermeable Cap

Subaqueous impermeable capping is similar to subaqueous permeable covering, except that water and contaminants are not able to pass through the cap. The principal concept for reducing long-term environmental effects is to physically isolate the contaminated material with an impermeable barrier of natural and/or geosynthetic material.

As with the permeable cover, the selection of materials and associated thickness for the impermeable cap are chosen based on their ability to physically isolate contaminated sediment from the aquatic environment. Anchoring of the cap is necessary to prevent movement resulting from tidal action or underwater currents.

Effectiveness – Since a subaqueous impermeable cap offers no removal or treatment, it would not reduce the toxicity or volume of contaminated sediment. However, the cap would be effective in minimizing human and environmental exposures due to direct contact with contaminated sediment. Migration of dissolved contaminants through the cap would be minimal due to the impermeable layers. Short-term risks to human health and the environment may be associated with cap installation, as sediments would be stirred up. However, the use of proper equipment and turbidity control measures would reduce these risks.

A major concern for the effectiveness of an impermeable cap in underwater applications is maintaining its integrity because of potential forces acting on it. Any water movement or gas formation under the cap could become trapped and stress the integrity of the cap. The discharge of groundwater to the sediment area could also cause upward forces on the cap.

The long-term effectiveness of the subaqueous impermeable cap could be monitored by periodically inspecting the cap to ensure its integrity. Periodic maintenance would be required to repair the cap and replace any top-layer cover materials that had eroded.

Implementability – Placement of a subaqueous impermeable cap is implementable by companies with trained personnel qualified to handle contaminated sediment dredging, grading, and erosion control operations in an aqueous environment. Placement of a geomembrane liner may be difficult, as it would tend to float on the water surface during installation. All on-site personnel must be trained in hazardous waste site operations. Proper cap placement would require considerations of wave action, local currents, and tidal fluctuations. Turbidity control measures would be required to minimize resuspension of contaminated sediment and to limit its migration during capping operations. Installation could be conducted by land-based and barge-mounted equipment. Proper anchoring of the cap and maintenance to ensure its long-term integrity is needed.

Cost – The capital and O&M costs are moderate for a subaqueous impermeable cap comprised of natural and geosynthetic layers.

Conclusion – The subaqueous impermeable cap is eliminated from further consideration due primarily to groundwater discharge into the sediment area, which could cause upward forces to act on the cap.

Rip Rap

Rip rap material, consisting of 6- to 8-inch average diameter rock, is used to line banks and channels to prevent erosion and migration of sediments. It also serves to prevent direct exposure to contaminated sediments. A geosynthetic fabric would likely be placed beneath the rip rap to further stabilize the bank and contain the contaminated sediments.

Effectiveness – Rip rap would be effective for limiting exposure to and preventing migration of contaminated sediments. However, it is not an impermeable layer and would not prevent infiltration or potential leaching of sediment contaminants to groundwater. Because

contaminated sediments remain in place, the effectiveness of a rip rap lining depends on its adequate maintenance.

Implementability – Placing rip rap and geosynthetic fabric in Ferry Creek or along the shore is readily implementable at the study area. Some excavation or dredging of sediments and soils in the creek (up to approximately 18 inches) may be necessary to maintain the hydraulic grade of the creek bed to allow proper creek flow. Qualified contractors and materials are readily available.

Cost – The cost for rip rap would be low.

Conclusion – Containment of contaminated sediments by rip rap is retained for further evaluation.

Culvert

Culverting Ferry Creek would involve installing piping in the existing creek bed and then backfilling to the surrounding grade. Culverting and backfilling would prevent direct contact with sediments and also minimize erosion and migration of contaminated sediment within the creek bed. The culvert would consist of reinforced concrete pipe, sized adequately to maintain the discharge from Ferry Creek. Some contaminated sediment would likely be dredged for the placement of the culvert in order to maintain the current hydraulic elevations. The concrete pipe would then be covered with geotextile, gravel, and clean soil and the area above the finished culvert vegetated.

Effectiveness – Installation of a culvert would be effective for limiting exposure to and preventing migration of contaminated sediments. Backfilling to the surrounding grade would also help to prevent infiltration and potential leaching of sediment contaminants to groundwater. Because the creek flow would be contained inside the concrete pipe, scouring of sediments in the creek bed by turbulent flow and tidal influence would be eliminated.

Implementability – Culverting Ferry Creek is implementable at the study area. Some excavation or dredging of sediments and soils in the creek may be necessary to maintain the

hydraulic grade of the culvert to allow proper flow. Qualified contractors and materials are readily available.

Cost – The cost for the installation of a culvert along Ferry Creek would be moderate.

Conclusion – Containment of contaminated sediments by the installation of a culvert is retained for further evaluation.

Sheet Pile

Steel sheet piles, aligned and interlocked at the surface, are driven into the ground to create vertical barrier systems. Typically, sheet pile barriers are used in construction to provide structural stability to walls in excavations or open cuts but can also be used as vertical barriers to prevent the migration of contaminants, which is the application for this study area. Steel sheet piles come in various shapes and interlocks, e.g., straight web type, arch web type, and deep arch web type, and are installed using heavy equipment such as a drop hammer or a vibratory hammer. Often a cap block or driving head is placed on the top edge to prevent the driving equipment from damaging the piles. The piles are driven a few feet at a time over the entire length of the wall. This process is repeated until the piles are all driven to the desired depth (usually until a low permeable layer is reached).

Effectiveness – When first placed in the ground, sheet piling cut-off barriers are quite permeable at the interlocks. The edge interlocks, which are loose to facilitate placement, allow easy passage of groundwater. With time, however, fine soil particles are washed into the seams and water cut-off is effected. Considering the texture of soils at the study area (silty sand), the sealing process would be quite slow and might never seal. In some cases, the seams could be grouted but this procedure is costly. The performance life of a sheet-piling wall can vary between 7 and 40 years, depending on the condition of the soil in which the wall is installed (EPA, 1985).

Implementability – Sheet pile installation is readily implementable. The equipment and resources necessary to construct the barrier are available from a number of contractors. Given the soil conditions at the study area, sheet piles could easily be driven into the ground;

however, the fractured bedrock surface would not produce a suitable low permeability stratum in which to key the vertical barrier.

Cost – The capital cost of sheet piling is moderate and the O&M costs are low.

Conclusion – Concerns about groundwater leakage through the sheet piling seams eliminate this technology from consideration for a permanent vertical barrier.

Slurry Walls

Slurry walls are subsurface barriers used to reduce lateral groundwater flow in unconsolidated materials. The term slurry wall is used to describe barriers constructed in a vertical trench that is excavated under a slurry. The slurry, usually a mixture of bentonite and water, acts essentially like a drilling fluid, shoring the walls of the trench to prevent collapse and to reduce infiltration of groundwater during excavation. The excavated trench is backfilled with low-permeability material such as a soil-bentonite-water mixture or a slurry of cement, bentonite, and water.

Slurry walls can be placed hydraulically upgradient of a contaminant source area to divert clean groundwater and reduce the generation of leachate. They are often installed circumferentially around the source area to reduce the flow of clean groundwater entering and contaminated groundwater leaving the site. For maximum effectiveness, slurry walls must be "keyed-in" to a low permeability layer such as clay or competent bedrock.

Effectiveness – Slurry walls are an effective means of reducing lateral groundwater flow through unconsolidated materials. The wall permeability depends primarily on the backfill material. The most common material used to construct a slurry wall is a soil-bentonite slurry mixture. These materials have the lowest permeabilities (approximately 1×10^{-8} cm/sec) and the widest range of chemical compatibilities (EPA, 1985).

The complex geology and hydrogeology of the study area will likely limit the effectiveness of slurry walls for complete containment. The absence of a low permeability clay layer and the presence of fractured bedrock will not provide an adequate layer to key in the slurry wall.

Implementability – Slurry walls are readily implementable. Common trenching techniques and equipment such as excavators and clam shell dredges are employed in their construction. The equipment and resources necessary for slurry wall installation are readily available. Consideration of the need for TSD facilities is not applicable to this technology.

Cost – The capital and O&M costs of slurry walls are low.

Conclusion – Due to concerns about the effectiveness of this technology for reducing the flow of groundwater through source area soils and sediments, slurry walls are eliminated from further consideration.

2.4.6 Treatment

The following treatment technologies and process options for contaminated soils, wetland soils, and sediments are evaluated in this section.

- Immobilization
  - Solidification/Stabilization
- Thermal Treatment
  - Incineration
  - Thermal Desorption
  - Vitrification
- Physical Treatment
  - Soil Flushing
  - Soil Washing
  - Soil Vapor Extraction
- Chemical Treatment
  - Chemical Oxidation
  - Solvent Extraction
- Biological Treatment
  - Aerobic Biodegradation

Discussion of in situ treatment indicates that treatment takes place in the ground without excavation. Ex situ treatment implies the removal of waste from the ground and transport to a treatment unit either on the site, in town, or out of town. A high, moderate, or low cost option is compared to the other process options within the treatment GRA.

Solidification/Stabilization

Solidification/stabilization processes involve mixing excavated contaminated materials with proportional amounts of treatment reagents to physically or chemically decrease the mobility of contaminants in the waste and convert the contaminants to a less soluble, less mobile, or less toxic form. The end product may be a standing monolithic solid or may have a crumbly, soil-like consistency, depending on the amount and type of reagent added. A typical treatment system consists of a materials feed system, a reaction tank equipped with mixing equipment, and an area for curing. The effectiveness of the immobilization process is evaluated by running leaching tests such as TCLP or SPLP on the treated materials.

Portland cement and pozzolanic (silica-bearing substances) materials such as fly ash are widely used as immobilization reagents because of their ready availability and effectiveness in binding contaminants to minimize leaching. A number of additives have been developed for use with cement and pozzolanic materials to improve the physical characteristics and decrease the leaching losses from the resulting solidified material. In addition to cement and pozzolanic materials, other reagents such as organic polymers, thermoplastic materials, and sorbents are also utilized; however, these materials are less effective in binding the contaminants, and the resultant products are more susceptible to degradation and leaching than materials stabilized with cement or pozzolanic materials.

Solidification/stabilization has reportedly been capable of immobilizing up to 99 percent of inorganic contaminants at some sites, but was not successful at significantly immobilizing organic contaminants (EPA/540/5-89/001a, 1989). One study indicated that volatile organic contaminants did not leach from the solidified matrix; however, the study attributed the removal of VOCs in part to volatilization during extraction and mixing (Longest, 1989). Another study found that PCBs were 100 percent immobilized, but also suggested that TCLP results from samples of the soil before treatment indicated no PCB leaching (EPA/540/5-89/005a, 1990).

Effectiveness – Solidification/stabilization processes have been widely demonstrated in full-scale remediation projects to immobilize metals in soils. Cement- and pozzolan-based methods have been effective for immobilizing heavy metals including lead. Treatability testing conducted on the Raymark Facility soils indicates that mixing soils with 20 percent cement provides effective stabilization of lead and asbestos with a waste volume increase of approximately 25 percent (HNUS, 1994a). Additionally, the cured mix can be solidified as a soil-like product that could be more easily placed as fill.

Immobilizing of organic compounds may be effective in some cases. Data from several bench-scale studies indicate that immobilization of semi-volatile organic compounds, particularly polynuclear aromatic hydrocarbons (PAHs), is possible. PCBs immobilization may be effective, particularly where initial concentrations are low. However, limited test data are available to support this conclusion (EPA, 1990). Solidification/stabilization would likely be effective in immobilizing lead and other metals, even at high concentrations, to prevent their leaching into the groundwater; however, immobilization of all organic contaminants is unlikely, although some reduction in leachability for select organics may occur.

Solidification should be capable of handling the volume of contaminated soils, wetland soils, and sediments at the study area. The process should be effective in significantly reducing the mobility of the COC metals and asbestos present in the soil-waste/fill and sediments. The treated residual must be tested prior to disposal to ensure that disposal requirements are met. Implementation should not cause any adverse effects on human health and the environment.

Implementability – Solidification/stabilization is an implementable technology for soils, wetland soils, and sediments in the study area but would require significant staging. The equipment and resources necessary to treat the soils, wetland soils, and sediments are available, with several vendors capable of performing this work. If treatment is conducted either in situ or ex situ, space is necessary to build or stage treatment equipment; constraints such as meeting TSD facility requirements and facility monitoring are also concerns. If the treatment is conducted out of town, some facilities are available that would be able to treat this waste. Transportation and TSD facility requirements must be met for out-of-town treatment. If solidification is chosen as a treatment option, it would probably be better implemented in situ at the study area due to the large extent of

waste. Also, less effort would be required to stage equipment for in situ treatment than for ex situ treatment.

Cost – The relative capital and O&M costs are moderate for cement-based solidification/ stabilization methods.

Conclusion – In situ solidification/stabilization is an effective and implementable technology for immobilizing metals and asbestos in contaminated soils and sediments and can provide stabilization for some organics. Ex situ cement-based solidification of the contaminated soils and sediments should be effective to immobilize COC metals and asbestos in soils and sediments but may be difficult to implement; in situ solidification would be more easily implemented. Both in situ and ex situ cement-based solidification are retained for further consideration.

Incineration

Incineration is a thermal oxidation process that uses high-temperature, controlled flame combustion in an enclosed reactor to decompose organics in solids, liquids, and gases. Carbon and hydrogen waste components are converted to carbon dioxide and water, respectively. Chlorine, if present, is mostly converted to hydrochloric acid. Other combustion products are also formed in smaller quantities and may include carbon monoxide, nitrogen oxides, and free chlorine and fluorine. Inorganics are not treated in incineration and may, in some situations, become more toxic due to a concentration effect. Incineration produces a solid stream from the incombustible portion of the original material, which is removed as bottom and fly ash, detoxified soil, and possibly other solid treatment residuals. If a wet scrubber air pollution control system is used, a liquid waste stream could also be generated. Depending on the original waste stream, process residuals may require further treatment and/or disposal. The rotary kiln incinerator, which is capable of burning a broad range of hazardous solids, slurries, liquids, and gases, is the most common and versatile type of incinerator. Other types of incinerators capable of treating contaminated soils and sediments include the circulating bed, multiple hearth, and infrared incinerators.

Effectiveness – Incineration is a highly proven technology to treat wastes containing high concentrations of organics. Incinerators have successfully been demonstrated to destroy

refractory compounds such as PCBs as well as other organic contaminants present in study area soils, sediments, and waste materials at efficiencies in excess of 99.99 percent. Incineration should be capable of achieving the remediation goals for organics. Incineration does not destroy asbestos or metals. Metals in the waste matrix will form metal oxides that enter the gas stream or will be concentrated in the treated soil or sediment. Asbestos will either enter the gas stream and be captured in the pollution control equipment (scrubber, filters) or will become concentrated in the treated soil or sediment. Treated soils or sediments may require additional treatment to remove or immobilize metals and asbestos prior to disposal. Conventional air pollution control equipment such as scrubbers and baghouse dust filters will be required to remove acid gas and particulates. Air emissions from the incinerator will be monitored closely to ensure that human health and the environment are not adversely affected.

Implementability – Incineration, whether conducted at an in-town or out-of-town locations, is implementable. The equipment and resources necessary to incinerate soils and sediments are available, and several vendors are capable of performing this work. The large volume of contaminated soils and sediments at the study area may pose logistical problems for incineration; several facilities would likely be needed to treat the large volume. Out-of-town TSD facilities are available that could treat study area soils, sediments, and waste materials. If incineration is conducted out of town, transportation requirements would be applicable and the off-site facility would have to meet RCRA permit requirements. Incineration would have to meet the substantive requirements of the RCRA incineration regulations; therefore, incineration conducted in town would not be considered a viable option. These regulations would require a trial burn for incineration to demonstrate destruction and removal efficiency; regulate emissions of hydrogen chloride, nitric and sulfuric oxides, and particulates; and require monitoring for carbon monoxide. In-town incineration would also have to meet Connecticut Air Quality Standards and Connecticut Hazardous Waste Site Management regulations, which include restrictions on facility siting, construction, and operation.

Costs – The relative capital and O&M costs are high for incineration.

Conclusion – Incineration is an effective option for destroying the organics present in the study area contaminated soils and sediments; however, inorganics would be left unaffected.

Incineration would require substantial logistics and restrictions due to the large volumes to be treated. Due to the lack of treatment of inorganic contaminants and its high cost, incineration is eliminated from further consideration.

Thermal Desorption

Thermal desorption is a treatment process that uses heat and physical agitation to volatilize organic contaminants from soils, wetland soils, and sediments; the resulting vapor stream is subsequently treated to collect or destroy the contaminants. A typical thermal desorption system consists of a rotary drum thermal processor equipped with heat transfer surfaces, and a vapor treatment system. Direct-fired and indirectly heated systems (generally heated by circulating hot oil) are available. Temperatures used in the thermal processor are contaminant- and matrix-specific, with a range of approximately 150 degrees Fahrenheit (F) to 800 degrees F. Most units incorporate mechanical agitation during treatment to facilitate complete desorption of organics. An induced air flow conveys the volatilized organics through a gas treatment system, such as a carbon adsorption unit, a thermal oxidizer, or a condenser unit. The air stream is then discharged through a stack. Thermal desorption is a well-demonstrated technology for industrial sludge and product drying applications, but its use for remediation of soils and sediments is less demonstrated. The process is most effective on volatile organic compounds, but units operating at higher temperatures are also capable of treating semi-volatile organics and PCBs.

Effectiveness – Thermal desorption should be capable of accommodating the volumes of contaminated soils, wetland soils, and sediments at the study area. Thermal desorption at a relatively high temperature would be expected to achieve the remediation goals for the PCBs, VOCs, and most SVOCs. Treatability testing, under static conditions, of Raymark soil-waste/fill demonstrated removal of PCBs (Aroclors 1262 and 1268) to below 2 µg/kg at an operating temperature of 1000 degrees F and a 60 minute residence time (HNUS, 1994b). Metals and asbestos would not be addressed by this technology. The effectiveness of thermal desorption is dependent primarily on the boiling point of the contaminant. For volatile organics such as trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA), with relatively low boiling points, nearly complete removal from the soils and sediments would be expected at relatively low operating temperatures. Many of the organics present in the study area contaminated soils

and sediments have much higher boiling points; for example, PCBs have boiling points in excess of 600 degrees F. The upper temperature range for thermal desorption approaches the lower temperature range for incineration, and some thermal desorption systems are permitted as incinerators.

Implementability – Thermal desorption is implementable. The equipment and resources necessary to treat the soils and sediments are available, with several vendors capable of performing this work. Connecticut Air Quality Standards would have to be met. Few, if any, out-of-town thermal desorption facilities would be able to accept these soils and sediments; therefore, consideration of thermal desorption is effectively limited to an in-town location.

Thermal desorption, if selected, would likely be included as part of a treatment train of multiple process options due to its ineffectiveness for inorganic contaminants.

Cost – The relative capital and O&M costs for thermal desorption are moderate.

Conclusion – Thermal desorption is an effective and implementable technology to remove organics from contaminated soils and sediments. Thermal desorption will be retained for further consideration for treating study area soils, sediments, and waste materials.

Vitrification

Vitrification is a thermal destruction process that immobilizes soil contaminants by converting the contaminated soils or sediments to a chemically inert, stable, glass product. Vitrification is conducted by applying energy through electrodes inserted around the area to be melted. Wastes are heated to temperatures of 1,350 degrees F to 3,000 degrees F inside a refractory vessel, forming a molten glass and thereby destroying organics and immobilizing metals and asbestos. Organics in the waste matrix are volatilized, and the resulting gases are oxidized in the turbulent zone above the glass. Metals and asbestos are retained in the glass which, when cooled, is a stable, non-leachable, vitreous solid. This glassy residual may then be landfilled or used as backfill.

Effectiveness – Vitrification is an effective technology to destroy organics and immobilize metals and asbestos. The vitrification process should be capable of achieving the remediation goals for

organics, metals, and asbestos. Using this process, inorganic contaminants would be immobilized while organic contaminants would be destroyed to below clean-up levels. Human health and environmental concerns are similar to those for incineration. Air pollution control equipment would be necessary to remove particulates and acid gases. Vitrification should be reliable with respect to the study area contaminants and conditions. Short-term concerns associated with vitrification are the potential risks resulting from volatilization; however, study area soils and sediments contain few VOCs.

Implementability – Vitrification is implementable for study area soils, wetland soils, and sediments. For vitrification conducted in town, the close proximity of the contaminated soils and sediments to the homes and public roadways may pose problems for set-up and control of the process. For out-of-town vitrification, few facilities would be able to treat these soils and sediments. Thus, treatment is effectively limited to in-town processes. The equipment and resources necessary to vitrify the soils and sediments are commercially available from a few vendors. However, the overall capacities of the vitrification units are typically low and may be inadequate for the large volume of soil and sediment requiring treatment. The vitrification process is extremely energy intensive and requires sophisticated machinery and highly trained personnel for operation. Application of this technology has been primarily limited to treating radioactive or highly toxic wastes.

Cost – The relative capital costs are high. Operation costs are also high because of intensive energy usage, although maintenance costs are low.

Conclusion – Vitrification is a potentially effective technology for treatment of study area soils, wetland soils, and sediments. Although the costs are high, vitrification provides a high level of immobilization of all contaminants and is therefore retained for further consideration.

Soil Flushing

Soil flushing is a process that uses a closed loop recirculation system of injection and extraction wells to remove contaminants from the saturated and unsaturated soils and sediments. Under soil flushing, water, with or without other additives, is sprayed onto or injected into the soils or sediments. Additives are used to increase the mobility of the contaminants. To remove organics, surfactants or alkalis are commonly used. Acids, alkalis, oxidizers, reducing agents, and/or

complexing agents are commonly used to remove inorganics. Collection of the flushing agent solvent is an important step. At the collection point, treatment systems such as air stripping or carbon adsorption are then utilized to separate the contaminants from the extracted water. The treated water is recirculated through the system by reinjection into the contaminated soil.

Effectiveness – Soil flushing may be effective in treating some of the organic and inorganic contaminants at the study area; however, several factors can limit its effectiveness. Of primary concern is the difficulty of treating organics and inorganics simultaneously and the ability to capture mobilized contaminants. Additionally, because of their low water solubility, PCBs may not be readily flushed from soils, and asbestos, which is insoluble in water, would not be removed. Some other effectiveness concerns are the ability to contact all the soils or sediments, the ability to separate the contaminants from the flushing agent, and the ability to monitor compliance. For the study area, the heterogeneity and stratification of the soils make contact with soils and capture of mobilized contaminants uncertain. Additionally, the burdened flushing fluids would likely contain significant concentrations of contaminants in highly mobile forms; a significant threat to human health and the environment might result if the contaminated fluids are not completely captured.

Implementability – Soil flushing would be difficult to implement at the study area. A primary concern is the difficulty of ensuring complete capture of mobilized contaminants and restrictions on underground injection of wastes mandated by state and federal regulations. If treatment is conducted at the study area, space is necessary to build or stage treatment equipment. TSD facility requirements must be met, and facility monitoring would be required. If soil flushing is chosen, then consideration of capturing the groundwater and recovering the flushed contaminants is critical. TSD facilities may be necessary if residuals such as spent carbon or biomass are generated during treatment of the captured water. The equipment and resources necessary to implement soil flushing are available, and a few vendors are capable of performing this work.

Cost – The capital and O&M costs of soil flushing are highly dependent on the cost of treating the extracted water. Because of the complex mixture of contaminants in the soils, sediments, and groundwater, the cost of implementing soil flushing at the study area is likely to be moderate.

Conclusion – Due to several effectiveness and implementability concerns, including a potential risk to human health and the environment, soil flushing will be eliminated from further consideration as a process option.

Soil Washing

Soil washing is a treatment process that removes contaminants from soils, wetland soils, and sediments by either dissolving or suspending them in the wash solution (which is later treated by conventional water treatment methods) or by concentrating them into a smaller volume of soil through standard particle size separation techniques. The concept of reducing soil contamination by particle size separation is based on the finding that most organic and inorganic contaminants in soil and sediments tend to bind to fine-sized clay and silt particles through surface adsorption. Soil washing relies heavily on this principle of separating highly contaminated fine materials from washed coarse materials to decrease the volume of particles that require treatment.

Soil washing is generally a water-based process; however, chemicals such as surfactants are sometimes added to the wash fluid to enhance removal of specific contaminants. Organic or inorganic compounds can be removed using this process. In the washing process, soils and sediments are screened and then scrubbed to break up soil aggregates and liberate fines. The surfaces of the coarse particles are "washed" by abrasive action and by desorption of contaminants upon contact with the washing solution. The contaminated fine particles typically require further treatment. Applicable processes to treat fine particles may include chemical extraction, biodegradation, immobilization, or destruction processes.

Effectiveness – Depending on the proportion of coarse and fine materials in the contaminated soils and sediments, soil washing can be effective in reducing the volume of material that requires intensive treatment. Soil washing would be effective for removal of both organic and inorganic contaminants from coarse material within the study area, minimizing the volume of materials requiring intensive treatment. Contaminants would be concentrated in the relatively smaller fine soil fraction or the wash solution; contaminant extraction from the fine fraction by the soil washing process would likely be incomplete. The fine fraction and wash solution would likely require additional treatment. Effective removal of the contaminants in the soil-waste/fill may require

multiple cycles of treatment and could require additional, specialized treatment to immobilize the asbestos.

Implementability – Soil washing is a proven and reliable technology to remove organic and inorganic contaminants from soils and sediments with a relatively small fines fraction. The equipment and resources necessary to treat the soils and sediments are available, and several vendors are capable of performing this work. If treatment is conducted at the study area, space is necessary to build or stage treatment equipment; constraints such as meeting TSD facility requirements and facility monitoring are also concerns. Few, if any, off-site TSD facilities would be able to accept and treat the large volume of contaminated soils and sediments from the study area. This shortage effectively limits consideration of soil washing technologies to in-town processes.

Cost – The relative capital and O&M costs are moderate to high.

Conclusion – Soil washing is an effective and implementable technology to remove organics and inorganics from contaminated soils and sediments. Soil washing will be retained for further consideration for treating study area soils and sediments.

Soil Vapor Extraction

In situ vapor extraction is a well-demonstrated technology to remove VOCs from unsaturated or vadose zone soils. Vapor extraction uses an induced vacuum to pull air through the soil. The induced airflow desorbs VOCs from soil particles and transports the volatilized organic contaminants to a collection system at the ground surface. Upon withdrawal, the VOC-laden air stream is treated with a technique appropriate for the specific contaminants. The recovery rate increases as the vapor pressure of the VOC increases. Vapor treatment technologies may include carbon adsorption, condensation, and thermal or catalytic destruction.

A typical soil vapor extraction system is comprised of a vacuum pump connected to a network of vapor extraction wells situated within the contaminated area. The wells are typically constructed of PVC pipe set in permeable packing and screened within the unsaturated zone. Vapor extraction technology can potentially treat soils beneath structures and around utility lines, and to soil depths beyond the practical limits of excavation.

Variations on the standard vapor extraction process include thermally-enhanced systems, which use heat to accelerate VOC removal and potentially expand the array of treatable compounds, and air sparging systems, which use injected air to enhance VOC removal from unsaturated soils as well as from saturated soils and groundwater.

Effectiveness – The standard and thermally enhanced vapor extraction processes may be capable of effectively removing VOCs from unsaturated study area soils. The thermally-enhanced process is also potentially capable of removing some heavier organics. Both systems would achieve limited removal of contaminants from the groundwater due to interactions between contaminants in the groundwater and soils. Concurrent groundwater remediation is necessary to prevent groundwater contaminants from migrating back into the soils near the groundwater table fringe area when the vapor extraction system is shut off.

Vapor extraction with air sparging may be capable of treating VOC contamination in unsaturated and saturated soils at the study area. Due to increased air flow, air sparging would likely achieve RAOs faster than standard vapor extraction. The biodegradation aspect of the process may increase its potential effectiveness in treating a wider array of contaminants including some heavier organics.

Vapor extraction may be effective for removing VOCs from study area soils. However, vapor extraction technology is best suited to homogeneous, permeable soils; the heterogeneous nature of the soils at the study area may result in air channeling and inadequate treatment of portions of the soil. Additionally, vapor extraction would not be effective for treating metals, asbestos, and PCBs. Pre-design testing would have to be conducted to determine whether the soils are sufficiently permeable and homogeneous to allow effective treatment. Off-gas treatment would be required to protect human health and the environment during operation. Standard engineering controls and vapor treatment systems are capable of adequately collecting and treating VOC emissions.

Implementability – Vapor extraction technology is implementable at the Raymark Facility. Numerous vendors are capable of implementing most variations of this technology. The equipment and resources are also readily available. However, because of the shallow depth to groundwater, extensive dewatering would be required for effective treatment of the entire fill

layer. Depending on the type of air treatment employed, residuals such as spent carbon, condensed VOCs, or acid scrubber sludge may require disposal.

Cost – Capital and O&M costs of standard vapor extraction and air sparging systems are low to moderate. Capital and O&M costs of thermally-enhanced vapor extraction systems are moderate.

Conclusion – Due to concerns about the effectiveness of vapor extraction for treating study area soils and its effectiveness primarily for VOCs, vapor extraction will be eliminated from further consideration.

Chemical Oxidation

Chemical oxidation is the process by which the oxidation state of a compound is raised in order to change the chemical form of the compound to render it less toxic or change its solubility or stability. This process has been used traditionally in ex situ applications to treat water, municipal wastewater, or industrial wastewater to destroy organic compounds, to remove soluble iron and manganese, or to control odors. In more recent times, chemical oxidants have been used in a variety of in situ pilot tests and full-scale applications to destroy residual organic compound contamination in soils and in aquifers.

Chemical oxidation has been used to reduce organic compound levels in saturated soils much faster than would occur through the gradual desorption and diffusion of groundwater contaminants for the aquifer materials. Typically, injection wells are installed to deliver the chemical oxidants to subsurface soils or into aquifers. The effectiveness of chemical oxidation is highly dependent on the ability for the oxidizing agents to come into contact with the contaminants. Therefore, the successful implementation in situ chemical oxidation is highly dependent on accurate characterization of site-specific geology, hydrogeology, and contaminant distribution to determine the proper siting of injection wells and the ability to deliver oxidizers into the contaminated aquifers. Soils and overburden aquifers can be characterized through hydrogeologic investigations, and injection wells can be designed to deliver the oxidizers where they can be most effective.

Effectiveness – Enhanced oxidation technology has been demonstrated to effectively oxidize a wide variety of organic compounds. The ease of treatment varies greatly depending on the particular contaminants. Effective destruction of some compounds requires much longer contact time than is required for oxidation of other organic compounds. The process is ineffective for inorganic constituents.

Implementability – Enhanced oxidation technology should be implementable at the study area. Currently, only a few vendors offer this technology, and most of the commercially available systems utilize hydrogen peroxide. This system would require storage and handling of hydrogen peroxide. Most oxidation systems require high maintenance because of manganese of iron fouling.

Cost – Capital and O&M costs are moderate; however operating costs can vary significantly depending on loading rate, contaminant types, and concentrations. Enhanced oxidation requires high energy usage, which can result in prohibitive costs, particularly if contaminants are difficult to destroy.

Conclusion – Due to concerns about the effectiveness of the oxidation of PCBs and the lack of effectiveness for inorganics, chemical oxidation will be eliminated from further consideration at this time.

Solvent Extraction

Solvent extraction is a treatment technology that employs a solvent to extract contaminants from soils, sediments, sludges, or wastewater. Extraction of organics is accomplished by various mechanisms including dissolution, formation of an emulsion or soluble chelation product, and chemical reaction. For metal extraction, acidification and chelation are the predominant mechanisms. The selection of the appropriate solvent depends on the chemical and physical properties of the contaminants present. Aqueous solutions including surfactants can be used to enhance removal or emulsification of a wide range of hydrophobic organic compounds. Dilute solutions of acids and bases can remove a wide range of metal ions.

Typical solvent extraction units include countercurrent extraction equipment, a pug mill, or a truck-loaded cement mixer. After contact and mixing, the solvent laden with contaminants is removed from soil or sediment by methods such as centrifugation or filtration. The extraction process results in a cleaned soil and a liquid waste stream that concentrates the extracted contaminants within the recovered solvent.

Contaminants within the waste stream are not destroyed, and the waste stream requires additional treatment or disposal. In many cases, contaminants retained in the solvent can be separated out, and the solvent can be re-used in the extraction process. Depending on the solvents used and the contaminants to be removed, soils or sediments may require supplemental treatment by soil washing or by extraction using additional solvents to target different contaminants.

Effectiveness – Solvent extraction is an effective technology to remove a wide range of inorganic and organic contaminants from medium to coarse soils and sediments. Commercial processes using secondary and tertiary amines have effectively removed PCBs, VOCs, and SVOCs from contaminated soil. Acid and alkaline solutions have been used to remove a wide range of metals. The process may have limited effectiveness for the study area soils due to the difficulty in formulating a suitable extraction fluid to treat a complex mixture of contaminants. Additionally, the variations in contaminant concentrations and contaminant distribution in the soil-waste/fill and contaminated sediments may require frequent adjustment or reformulation of the extraction fluid. The removal of metals and organics would likely have to be conducted in stages, using different solvents. Also, solvent extraction is ineffective for asbestos. A treatability study would be required to select the appropriate extraction solutions and determine operating parameters to ascertain whether effective treatment is possible.

Implementability – Solvent extraction is a widely demonstrated and reliable technology for the treatment of simple waste streams. Several commercial vendors are available that provide solvents to treat a variety of organic and inorganic contaminants. If treatment is conducted at an in-town location, space is necessary to build or stage treatment equipment. Few, if any, out-of-town TSD facilities using solvent extraction would be able to accept and treat the large volume of contaminated soils, sediments, and waste materials from the study area. This shortage effectively limits consideration of extraction technologies to in-town processes.

Cost – The relative capital and O&M costs of solvent extraction are moderate.

Conclusion – Because of concerns regarding the effectiveness of solvent extraction for treating study area soils and sediments, this technology will be eliminated from further consideration.

Aerobic Biodegradation

Ex situ aerobic biodegradation is a destruction process that uses microorganisms to chemically break down and detoxify organic compounds in the presence of oxygen. The organic compounds are used as energy sources and are metabolized by microorganisms such as bacteria, actinomycetes, and fungi. Biodegradation process residuals are carbon dioxide, water, and biomass. The biomass, which consists mainly of cell protein but also contains partially degraded constituents and intermediate biodegradation products, must be tested and may require additional treatment prior to disposal.

Several types of aerobic biodegradation have been used to treat contaminated soils. The primary ex situ methods are 1) slurrying the waste and treating it in a bioreactor and 2) using standard irrigation and soil mixing techniques to treat the soil directly on land (landfarming) or in an above-ground cell (composting). Landfarming is generally less effective than other ex situ techniques because operating parameters are difficult to control.

Effectiveness – The effectiveness of biodegradation is highly dependent on the nature and concentration of the contaminants. In general, aerobic degradation of organics is applicable to petroleum hydrocarbons, halogenated and non-halogenated aromatics, phenols, biphenyls, and pesticides (EPA/625/6-85/006, 1985). Biodegradation processes are not suitable for treating wastes with high levels of metals. The metals are not destroyed in the process and high metals concentrations may be toxic to the microorganisms.

Aerobic biodegradation may be effective for treating many of the organics in study area soils, although, heavy metals present in soils may decrease the effectiveness of the process. Biodegradation would likely have difficulty achieving PRGs for many of the organic COCs. The effectiveness of biodegradation for PCBs (Aroclor 1262 and 1268) is relatively unproven and data are limited.

Implementability – The equipment and resources necessary to conduct ex situ biodegradation are readily available, and several vendors are capable of performing this work. Aerobic biodegradation is an implementable technology for study area soils. However, due to the concentrations of difficult-to-degrade contaminants, the throughput capacity of the units is expected to be relatively low for treating the soil, sediments, and waste materials. If treatment is conducted at an in-town location, space is necessary to build or stage treatment equipment; constraints such as meeting TSD facility requirements and facility monitoring are also concerns. If the treatment is conducted at an out-of-town location, few, if any, facilities would be able to treat this waste. Lack of out-of-town treatment capacity effectively limits consideration of bioremediation to in-town processes.

Cost – The relative capital and O&M costs are low for in situ and ex situ aerobic biodegradation.

Conclusions – Because of concerns about the effectiveness of this process for several study area contaminants and the anticipated low throughput capacity for treating the soils, sediments, and waste materials, aerobic bioremediation is eliminated from further consideration.

2.4.7 Consolidation

Consolidation is an option in which soils, wetland soils, and sediments from different Raymark OUs would be relocated and consolidated in one in-town location. Consolidation makes it possible to address soils and sediments from various source areas in order to manage more effectively the larger volume of waste as a whole.

Effectiveness – Consolidation of soils and sediments optimizes "Raymark-wide" options by allowing one location to be used for treatment or containment. Since the materials would only be transported a short distance within the Town of Stratford and the exposure pathways are addressed by other actions, minimal health concerns would be associated with consolidating the soils. Consolidation alone would not achieve RAOs, but combined with other remedial actions, could facilitate meeting RAOs.

Implementability – No permits are required for consolidation, and issues such as availability of TSD facilities are not applicable. The consolidation would be conducted using readily available construction equipment, and would only be considered for an in-town location.

Cost – Consolidation of wastes at an in-town location will require, at a minimum, a containment or treatment option. However, by consolidating the material and having one location for containment or treatment instead of multiple locations, significant cost savings can be realized. The cost for consolidation itself, not including the containment or treatment option, would only include transportation and would be low.

Conclusion – Consolidation of soils, wetland soils, and sediments would be effective and implementable, provided the materials are contained or treated by other actions. As a result, in-town consolidation will be retained for further consideration.

2.4.8 Other

Other technologies and process options may be identified for additional screening prior to remediation. These technologies, if appropriate, can be incorporated into future evaluations of study area technologies.

2.5 Retained Technologies and Process Options

Following the initial screening presented in Table 2-7, the retained technologies are presented in Table 2-8 along with unit costs. The cost information presented includes only the unit rates for the specific technologies without considering other components, including costs for site preparation, mobilization, analytical results, administration, etc. This allows broad-scale costs comparison between technologies that can be used when assembling alternatives during the Feasibility Study.