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Interim Final

Feasibility Study
Centredale Manor Restoration Project
Superfund Site
North Providence, Rhode Island

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EXECUTIVE SUMMARY

The United States Environmental Protection Agency (EPA) Region I is conducting a Remedial Investigation and Feasibility Study (RI/FS) for the Centredale Manor Restoration Project (CMRP) Superfund site located in North Providence, Rhode Island (Figure ES-1). The main part of the CMRP site, which is referred to as the source area, is located at 2072 and 2074 Smith Street (Route 44). The CMRP site also includes free-flowing reaches and impoundments of the Woonasquatucket River adjacent to and downstream of the source area where contamination was historically released to the environment. The source area was used for chemical manufacturing and drum recycling operations, and is currently occupied by the Brook Village and Centredale Manor apartment complexes.



Figure ES-1. Site Map

The RI completed for the site evaluated the sources, nature, and extent of contamination at the site; characterized the fate and transport of contaminants; and evaluated potential human health and ecological risks resulting from exposure to contaminants at the site (Battelle, 2005a). The RI conclusions regarding source identification and control, nature and extent of contamination, fate and transport, exposure pathways, and human health and ecological risks were integrated into a conceptual site model (CSM), which was used in the FS to develop and evaluate suitable and appropriate remedial alternatives to address contamination at the site.

Areas evaluated in the FS include the source area and the reach of the Woonasquatucket River and its associated floodplain habitat, from Route 44 (Smith Street) downstream to the Lyman Mill Dam. This reach of the river includes two dammed impoundments, Allendale and Lyman Mill Ponds, which are connected by a free-flowing channel (Figure ES-1). This FS also includes an approach to assess site conditions at downstream areas to determine if additional action may be warranted following the implementation of a sediment remedy at Allendale and Lyman Mill. The results of the FS will be used by EPA, in consultation with the State of Rhode Island, to propose a preferred remedial action for the CMRP site. The preferred alternative will be presented in a Proposed Plan for Remedial Action that will be presented to the public. After the Proposed Plan is reviewed by the public, EPA will respond to public comments and select a remedy in a Record of Decision (ROD).

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REMEDIAL INVESTIGATION SUMMARY

Site History

The main part of the CMRP site, referred to as the source area, encompasses approximately 9 acres and is comprised of parking lots, roadways, and the Centredale Manor and Brook Village apartment complexes (Figure ES-2). Chemical manufacturing activities took place at the source area from approximately 1943 until the early 1970s. It is believed that the Metro Atlantic Chemical Company manufactured hexachlorophene at the source area around 1965 in a building on the eastern bank of the Woonasquatucket River, in what is now the Brook Village parking lot. 1,2,4,5,7,8-hexachloroxanthene and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) are associated with this process. Other chemical processes also occurred. The New England Container Company, Inc., operated an incinerator-based drum reconditioning facility at the source area from 1952 until the early 1970s. Chemical residues were dumped or burned prior to drum reconditioning. Residues associated with drum reconditioning operations are a source of dioxins, furans and other chemicals at the CMRP site. Evidence from historical photographs, state report files, and geophysical testing suggests that buried waste material may still be present in the source area.

In 1972, a fire destroyed most of the property structures. Brook Village was constructed in 1977 and Centredale Manor was constructed in 1982. Dioxin was first identified in the area in 1996 in fish collected from the Woonasquatucket River by EPA. Since that time, EPA has conducted numerous investigations to characterize the nature and extent of contamination at the CMRP site under current conditions. Elevated levels of contaminants including dioxin (primarily 2,3,7,8-TCDD), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals have been detected in various media including soil, groundwater, sediment, surface water, and biota. The CMRP site was listed on the National Priorities List in 2000.

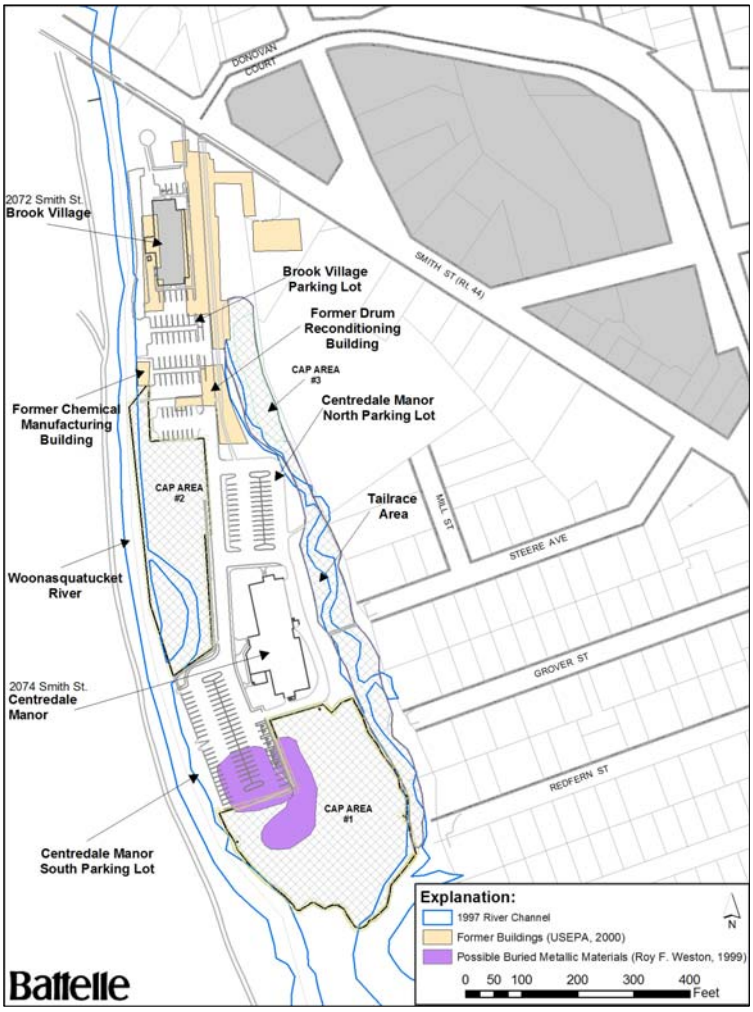


Figure ES-2. Historical Features of the Source Area

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Site Actions

Contamination at the CMRP site is being addressed in two stages: immediate (removal) actions and long-term (remedial) actions. A time critical removal action (TCRA) for the source area soils was conducted at the CMRP site in 1999-2000 to reduce the immediate threat to the health of residents on and near the site. The major activities conducted under the TCRA included construction of two interim soil caps and installation of fencing to restrict access to potentially contaminated areas. Repairs to the fence along Allendale Pond were performed in 2005; this also included relocating fencing in areas that were under water following the reconstruction of Allendale Dam in 2002. An Engineering Evaluation/Cost Analysis was performed in 2000 as the basis for a non-time critical removal action (NTCRA). The NTCRA included reconstruction of Allendale Dam and restoration of Allendale Pond (to its pre-1991 level), and excavation of contaminated floodplain soils in 11 residential-use properties and recreational access points along Allendale and Lyman Mill Ponds. Another TCRA was performed in 2003-2004 to cap contaminated soils and sediments in the former tailrace on the east side of the source area.

Conceptual Site Model

EPA conducted a series of investigations from 1999 to 2004 to characterize the nature and extent of contamination at the site, to better understand contaminant fate and transport processes, and to develop baseline risk assessments to assess current and potential future risk to human and ecological receptors from exposure to contamination at the CMRP site. Studies were also performed to address EPA's sediment management principles (EPA, 2002). EPA conducted additional investigations in 2004-2006 to address data gaps identified in the RI and address concerns of stakeholders. These studies focused on better understanding the 1) potential migration and flux of contaminants in groundwater at the source area to the surface water of the Woonasquatucket River; 2) vertical and spatial extent of contamination and rate of sediment accumulation at Lyman Mill Pond; 3) potential transport of dioxin downstream of Lyman Mill Dam under non-resuspending conditions; and 4) and potential current and future risks to human and ecological receptors from exposure to contaminated floodplain soil at the Oxbow, a forested wetland located immediately southwest of Allendale Dam. Results from the supplemental investigations, as well as results from a groundwater investigation conducted in 2008 by Loureiro Engineering Associates, were used to refine the CSM for the site (Figure ES-3).

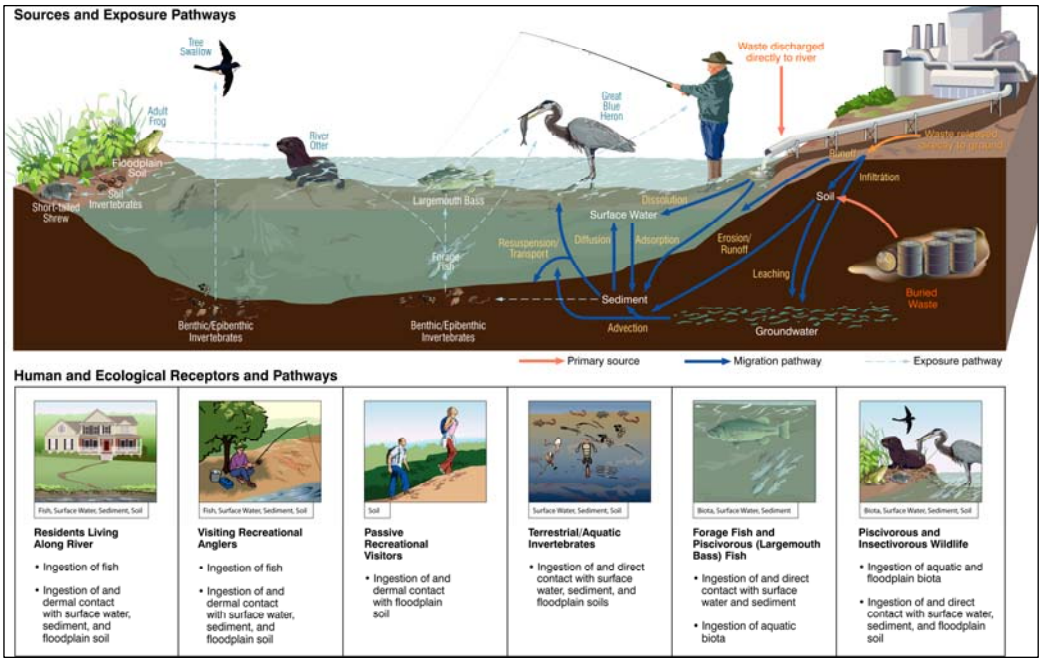


Figure ES-3. Illustration of the Generalized Conceptual Site Model

The risk assessments showed that the receptors at risk include residents living along the river, visiting recreational anglers, passive recreational visitors, benthic invertebrate communities, fish, and bird and mammal populations. Overall, the greatest risks at the CMRP site are associated with consumption of contaminated fish or prey, and direct contact with contaminated sediment and floodplain soil. Risk-based preliminary remediation goals (PRGs) were derived by medium (biota, sediment and floodplain soil) and exposure pathway (ingestion, direct contact) for contaminants that presents a risk to human and/or ecological receptors at the site. Contaminants in sediment and floodplain soil associated with human health and ecological risk include dioxin, dioxin-like PCBs, PCBs, and selected pesticides, SVOCs, and metals (summary statistics for selected contaminants are summarized in Table ES-1).

Table ES-1. Summary Statistics for Dioxin (ng/kg) and PCB (mg/kg) in Allendale and Lyman Mill Reach Sediment and Floodplain Soil

	Allendale		Lyman Mill	
	2,3,7,8-TCDD	Total PCB	2,3,7,8-TCDD	Total PCB
Sediment				
% Detection	97%	89%	97%	80%
Minimum	0.2	0.0006	0.035	0.0006
Maximum	110,000	28	49,421	3.26
Geometric Mean	879	0.27	433	0.135
Floodplain Soil				
% Detection	86%	80%	87%	39%
Minimum	0.24	0.037	0.095	0.030
Maximum	1,510	0.78	1,130	0.859
Geometric Mean	22.4	0.258	8.58	0.055 (median)

Contaminants in source area soil that presents a risk to human health and the environment through residential direct exposure and leaching of contaminants from soil to the underlying groundwater include: dioxin/furans, PCBs, selected pesticides, SVOCs, metals and VOCs. While groundwater at the site is not a source of drinking water, the groundwater discharge pathway into the Woonasquatucket River can be a contributor to risk identified for consumption of fish through bioaccumulation. Contaminants in groundwater include dioxin (2,3,7,8-TCDD), tetrachloroethylene (PCE), and trichloroethylene (TCE).

FEASIBILITY STUDY SUMMARY

Remedial Action Objectives, ARARs, and Cleanup Goals

The establishment of remedial action objectives (RAOs, also referred to as cleanup objectives) is the first step in the FS process of developing and evaluating remedial action alternatives. The RAOs were developed to protect human and ecological receptors against potential adverse effects associated with exposure to contamination at the CMRP site. RAOs focus on reduction or elimination of specific exposure-related risks associated with ingestion of contaminated fish or prey or direct contact with or ingestion of contaminants in sediment and soil. RAOs for ecological health also consider balancing remediation while minimizing the destruction of sensitive habitat. RAOs were also designed to minimize potential migration of contaminants to protect groundwater quality and the surface water of the Woonasquatucket River.

The next step in the FS process is to identify potential applicable or relevant and appropriate requirements (ARARs) and guidance and advisories (To Be Considered [TBC] criteria) pertinent to the remediation at the CMRP site. Potential ARARs and TBC criteria were identified based on federal and state regulations, requirements, and guidance applicable to the CMRP site. Those ARARs that are relevant for the remedial alternatives were analyzed in detail in the FS report. Notably, ARARs for the protection of floodplains and wetlands were considered because areas and media evaluated in this FS include floodplain and wetland areas that border parts of the Woonasquatucket River at Allendale and Lyman Mill.

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Next, cleanup goals for the site were developed based on an evaluation of potential ARARs, TBCs, risk-based PRGs (for the most sensitive receptor or exposure pathway), and site background data. Where a risk-based PRG and ARAR or TBC was available for the same contaminant, the lower, more protective value was used in the cleanup goal determination. In general, the cleanup goals are based on the risk-based PRG (and/or ARAR/TBC) or background, whichever is higher because it is not possible to clean up below background. Overall, cleanup goals are frequently based on background for sediment and floodplain soil and on ARARs for source area soil and groundwater. Proposed cleanup goals for selected contaminants in sediment, soil, and groundwater are summarized in Table ES-2.

Table ES-2. Proposed Cleanup Goals for Dioxin (ng/kg or pg/L), PCB (mg/kg) and PCE (µg/L)

Media	Contaminant	
	2,3,7,8-TCDD	Total PCB
Sediment	14.7	0.21
Floodplain Soil	17	1.7
Source Area Soil	Dioxin TEQ	Total PCB
	1,000	10
Source Area Groundwater	2,3,7,8-TCDD	PCE
	1,768	150

Areas and Volumes above Cleanup Goals

The proposed areas for cleanup developed in the FS were delineated by constructing a footprint to encompass all sampling locations with contaminant concentrations in excess of the cleanup goals developed for human and ecological protection. Based on the extent of contaminant concentrations exceeding cleanup goals at the CMRP site, proposed cleanup areas were developed for sediment and floodplain soil at the reaches of Allendale and Lyman Mill and soil and groundwater at the source area (Table ES-3). The proposed cleanup areas are conceptual; more precise cleanup areas will be developed during the remedial design.

An adaptive management approach is proposed to evaluate whether additional action is warranted for downstream reaches of the river following implementation of a sediment remedy upstream. EPA, in consultation with Rhode Island Department of Environmental Management and other stakeholders, will determine if additional action is warranted to address contaminated sediments in reaches downstream of Lyman Mill Dam.

Table ES-3. Proposed Cleanup Areas and Volumes for the CMRP Site

Action Area/ Media	Description	Cleanup Area		In-Situ Removal Volume (cubic yards)
		(square feet)	(acre)	
Allendale Reach/Sediment	River channel north of Allendale Pond[1] and Allendale Pond	673,600	15.5	48,200
Lyman Mill Reach/Sediment	Lyman Mill Pond	1,022,000	23.5	91,000
Allendale Reach/ Floodplain Soil	Floodplain areas abutting river channel north of Allendale Pond[1] and Allendale Pond	64,600	1.5	2,400
Lyman Mill Reach/Stream Sediment and Floodplain Soil	Stream channel and old mill raceway connecting Allendale and Lyman Mill Ponds, Oxbow (forested wetland southwest of Allendale Dam), and floodplain areas abutting Lyman Mill Pond	940,000	21.6	34,800
Source Area/Soil	Source area (2072 and 2074 Smith Street)	339,500	7.8	62,900
Source Area/ Groundwater	Impacted area at Brook Village parking lot (submerged contaminated soils that serve as contaminant source to groundwater)	5,500	0.13	1,300

[1] Upstream limit in vicinity of Brook Village.

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Screening of Remedial Alternatives

The FS evaluated a range of remedial alternatives suitable for achieving the cleanup objectives. The specific remedial technologies and process options evaluated included various natural recovery options, containment or removal options, forms of in-situ and ex-situ treatment, various transportation methods and disposal options, and types of monitoring. Remedial alternatives evaluated to address contaminated sediment and floodplain soil at the reaches of Allendale and Lyman Mill and contaminated soil and groundwater at the source area are summarized below.

- No Action – alternatives developed for sediment, soil, and groundwater include an option for No Action, which entails no active remediation. In accordance with the National Hazardous Substances and Pollution Contingency Plan (NCP) requirements, the No Action alternative is carried through the FS process for each action area and is used as a basis of comparison to the other alternatives.
- Natural Recovery – alternatives developed for sediment and floodplain soil include options for monitored natural recovery (MNR) or enhanced natural recovery (ENR). The MNR alternative would rely on natural recovery processes (e.g., burial of contaminated material by cleaner material) to reduce surface contamination over time. The ENR alternative would provide a thin-layer cover to enhance the natural recovery processes. MNR and ENR are best suited for use in stable, depositional environments where contaminant concentrations are low, contaminants are unlikely to bioaccumulate, and natural recovery processes are occurring within an acceptable time frame. Both the MNR and ENR alternatives would provide monitoring to assess the rate of recovery and risk reduction.
- Containment – alternatives developed for sediment, soil, and groundwater include options for an isolation cap or hydraulic barrier to isolate contamination from the environment. The isolation cap would be placed over contaminated sediment or soil to prevent exposure to the contaminated material beneath the cap and prevent migration or leaching of contaminants from the sediment or soil. The isolation cap would be designed to be stable in non-depositional areas and resist erosion during flood events. The hydraulic barrier would include options either to install a barrier around the groundwater impacted area to prevent the discharge of contaminated groundwater to the Woonasquatucket River or to provide hydraulic control through pump and treat. For source area soil, the containment alternatives include options for 1) long-term operation and maintenance of the existing surfaces (caps, parking lots, paved surfaces, rip rap, landscape areas) to prevent erosion and potential exposure of contaminated soils, 2) upgrading and extending the existing caps to cover landscape areas, or 3) converting the existing surfaces to Resource Conservation and Recovery Act (RCRA) caps.
- Full Removal – alternatives developed for sediment, soil, and groundwater include options utilizing dredging and/or excavation to remove all contaminated material with contaminant concentrations above the cleanup goals. Confirmation sampling would be performed to verify that the cleanup goals had been achieved.
- Partial Removal – hybrid alternatives developed for sediment and soil include options for targeted and/or partial excavation in conjunction with either isolation capping or ENR. Under these hybrid alternatives, contaminated material from targeted areas (e.g., areas of higher erosion potential in the ponds, areas where contaminant concentrations are in excess of ARARs, or areas where principal threat waste may be located at the source area) would be removed using excavation. An isolation cap or thin-layer cover (ENR) would then be placed wherever contaminated material above the cleanup goals remained in place.

- In-situ Treatment – alternatives developed for groundwater include options for in-situ biological or chemical treatment. For in-situ biological treatment, a permeable reactive barrier comprised of clean, organic rich material would be installed between the groundwater impacted area and the Woonasquatucket River. The barrier would allow the passive flow of water while resulting in either the degradation and/or retention of contaminants. VOCs would be removed through anerobic dechlorination and biogeochemical processes, and dioxin would be removed by sorption to the organic material and subsequent biodegradation. For in-situ chemical treatment, an oxidizing agent would be injected into the groundwater at the impacted area that would cause the rapid chemical destruction of the VOCs in the groundwater and oxidation of dioxins.
- Disposal and/or Treatment – contaminated material removed under the removal alternatives would be contained on site in an upland or nearshore confined disposal facility (CDF), treated on-site by thermal treatment, or shipped off site for disposal and/or treatment. An additional disposal option utilizing on-site consolidation and capping was also considered for the sediment partial removal alternative with the dams being replaced. Groundwater removed under the excavation alternative or extracted under the pump and treat options would be treated to remove contaminants and returned to the Woonasquatucket River.

Remedial alternatives developed for sediment also included options for leaving the dams in place, removing the dams, or replacing the dams with new weir structures designed to allow fish (including catadromous and anadromous species) to migrate upriver, allow water to flow freely between the ponds, and change the vertical profile of the river channel to provide ponded water surfaces at the locations of the existing ponds.

All of the remedial alternatives, except No Action, include long-term monitoring to assess recovery and risk reduction, and to assess the impact of the remedial action on the downstream areas. Long-term monitoring and maintenance would also be required to protect the integrity of the thin cover (ENR), isolation cap, or any CDFs constructed on site. Maintenance of the Allendale and Lyman Mill Dams (or weir structures) would also be required for those alternatives where contamination remained in the river or floodplain. Institutional controls (ICs) would also be required wherever contamination remained in place to prevent future releases and potential future human exposure. For the source area, the ICs would prohibit future excavation, restrict access for buried utilities, prevent the construction of buildings with pilings or basements, require maintenance of the caps, parking lots, paved surfaces, and rip rap areas, and prevent the use of groundwater. All of the alternatives include periodic reporting of remedy progress and efficacy, as well as five-year reviews.

The proposed remedial alternatives for sediment, soil, and groundwater were screened against the short- and long-term aspects of three broad criteria during this stage: effectiveness, implementability, and cost. The screening was performed with a level of detail sufficient to distinguish among the alternatives and ensure that the alternatives were being compared on an equivalent basis. The goal of alternative screening is to reduce the number of alternatives that will undergo a more thorough and extensive analysis (EPA, 1988). With the exception of No Action, alternatives that are not protective of human health and the environment or do not comply with ARARs (except where conditions for an ARAR waiver exist) were screened out. The alternatives with the most favorable evaluation of all three criteria were retained for a more detailed evaluation, along with the No Action alternative (Alternative 1). Based on the screening evaluation, the following remedial alternatives were retained and evaluated in greater detail.

Allendale and Lyman Mill Reach Sediment

- a full excavation alternative with the dams remaining in place (Alternative 7) or with the dams replaced with new weir structures (Alternative 10), and

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- a partial excavation and isolation capping alternative with the dams remaining in place (Alternative 8) or with the dams replaced (Alternative 11).

Allendale Reach Floodplain Soil

- a full excavation alternative (Alternative 5).

Lyman Mill Reach Stream Sediment and Floodplain Soil

- a targeted excavation and ENR alternative (Alternative 3), and
- a partial excavation and ENR alternative (Alternative 5).

Source Area Soil

- a targeted excavation and cap upgrade alternative (Alternative 3), and
- a targeted excavation and RCRA cap alternative (Alternative 4).

Source Area Groundwater

- an excavation and dewatering alternative (Alternative 2), and
- an in-situ treatment alternative using chemical oxidation (Alternative 5).

Detailed and Comparative Analysis of Remedial Alternatives

The remedial alternatives proposed in the FS would, at a minimum, address contamination that presents a risk to human health and the environment, and achieve the cleanup objectives at varying levels of effectiveness. Alternatives were individually evaluated in more detail against the NCP criteria, and the alternatives were then compared to identify the key tradeoffs among them. Key findings from the comparative analysis of alternatives for sediment, soil and groundwater are summarized below.

Allendale and Lyman Mill Sediment – Among the sediment alternatives evaluated, full removal using excavation (Alternatives 7 and 10) would provide the highest level of protection to human health and the environment. Under these alternatives, all sediment above the cleanup goals would be removed, which would quickly reduce human health and ecological risk to acceptable levels. Partial removal using excavation in conjunction with isolation capping (Alternatives 8 and 11) would also provide effective protection, although sediment above the cleanup goals would remain in place under the isolation cap and could be released in the future should catastrophic events occur or if monitoring, maintenance and/or ICs are not effective in the long term. Disposal options that used on-site thermal treatment (Alternatives 7d, 8d, 10d, and 11d) or off-site disposal and/or treatment (Alternatives 7e, 8e, 10e, and 11e) would provide the highest level of long-term effectiveness and permanence because the contaminated sediment would either be incinerated or shipped off site. Disposal options that used on-site containment in a CDF (Alternatives 7a, 7b, 8a, 8b, 10a, 10b, 11a and 11b) would provide effective long-term protection at costs that are substantially lower than the on-site treatment or off-site disposal and/or treatment options, although under Alternatives 7b, 8b, 10b and 11b, contaminants remain in the floodplain in CDFs.

All of the excavation alternatives constitute a discharge of dredged or fill material into the waters of the state/US, thereby triggering state and federal wetlands requirements that would have to be addressed. As a result, these actions must be evaluated to determine the least damaging practicable alternative. The nearshore CDF alternative (Alternatives 7b, 8b, and 10b), as well as Alternative 11, would result in the permanent occupancy and modification of the floodplain, and a determination would need to be made that

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there was no other practicable alternative before selecting one of these options as the preferred remedy. The upland CDF alternatives (Alternatives 7a, 8a, 10a, and 11a) could potentially result in the destruction of low-quality wetlands. In addition, these alternatives may require a treatability variance to reduce the amount of treatment required prior to disposal. Among the alternatives evaluated, the full excavation and on-site thermal treatment or off-site disposal and/or treatment alternatives (Alternatives 7d, 7e, 10d, and 10e) would result in the greatest reduction of toxicity, mobility, and volume of contamination through treatment. The No Action and excavation alternatives utilizing on-site containment in a nearshore CDF (7b, 8b, 10b, and 11b) or consolidation (Alternative 11f) do not require treatment of contaminated material, although all of these alternatives with the exception of No Action (Alternative 1) would reduce mobility. Potential short-term impacts to the community during construction and remedy implementation would be limited and of short duration, whereas short-term impacts to the environment would be more substantial. All of the excavation and capping alternatives would result in the complete loss of the benthic habitat in both ponds and the elimination of fish populations and other water-dependent species. This loss would have significant short-term impact on the overall ecological health of the ponds, and full recovery would likely require several (possibly up to five) years. The RAOs would be achieved at the completion of remedy implementation, which is expected to take approximately two years.

While the technology, equipment, and materials required for excavation and capping are readily available, these alternatives could be difficult to implement from an administrative perspective. The land in the immediate vicinity of the CMRP site is privately owned and already developed in many areas. Therefore, limited space is available on site, and upland land area would be required to provide staging areas for construction and sediment processing. The work would be done near residential areas, so that short-term impacts from construction would have to be controlled. Upland land area would also be required for the on-site disposal facilities (Alternatives 7a, 8a, 10a, and 11a) or on-site incinerator (Alternatives 7d, 8d, 10d, and 11d). The advantage of constructing CDFs within the pond footprints is that there is sufficient space on site for the disposal facilities, although the public may oppose the reduction of open water area. The nearshore CDF (Alternatives 7b, 8b, and 10b), as well as Alternative 11, would result in the permanent occupancy and modification of the floodplain, and a determination would need to be made that there was no other practicable alternative before selecting one of these options as the preferred remedy. Concerns regarding air quality may also make it difficult to implement the on-site thermal treatment disposal option (Alternatives 7d, 8d, 10d, and 11d). Under all alternatives other than No Action, impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable wetland impacts would be required.

Present worth costs for the No Action alternative is $450,000. Present worth costs for the excavation alternatives range from $35,000,000 for Alternative 11f (dam replacement, partial excavation, isolation capping and on-site consolidation) to $119,000,000 for Alternative 10d (dam replacement, excavation, and on-site thermal treatment). Costs for excavation with on-site containment are approximately half the cost for on-site thermal treatment or off-site disposal and/or treatment.

Allendale Reach Floodplain Soil – Two alternatives were evaluated in detail for Allendale reach floodplain soil, including No Action (Alternative 1) and excavation and disposal and/or treatment (Alternative 5). Excavation will provide a higher level of protection to human health and the environment and, used in conjunction with on-site thermal treatment or off-site disposal and/or treatment, will provide higher long-term effectiveness and permanence because the excavated material would be incinerated or removed from the site. This alternative would remove all floodplain soil above the cleanup goals and quickly reduce risk to acceptable levels.

The No Action alternative would not comply with ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil. The excavation alternative is expected to comply with ARARs and EPA's dioxin requirements, although this alternative would constitute a discharge of dredged

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or fill material into the waters of the state/US, thereby triggering state and federal wetlands requirements that would have to be addressed. As a result, these actions must be evaluated to determine the least damaging practicable alternative. In addition, a portion of the nearshore CDF (Alternative 5b) would require the permanent occupancy and modification of the floodplain, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. The upland CDF (Alternative 5a) could potentially result in the destruction of low-quality wetlands. Among the alternatives evaluated, the excavation and on-site thermal treatment alternative (Alternative 5d) would result in the greatest reduction of toxicity, mobility, and volume of contamination through treatment. The No Action and excavation alternative utilizing containment (Alternatives 5a, 5b and 5e) would not require treatment, although all of these alternatives, with the exception of No Action (Alternative 1), would reduce mobility. Potential short-term impacts to the community during construction and remedy implementation would be limited and of short duration. The excavation alternative (Alternative 5), however, would result in the elimination of floodplain soil infauna and riparian vegetation and collateral impacts to wildlife that rely on this habitat for shelter and food. At least several years would be required before the remediated areas recovered sufficiently to provide the environmental services that this habitat typically provides. The RAOs would be achieved at the completion of remedy implementation, which is expected to take approximately one month. The excavation alternative would result in unavoidable wetland loss and/or impacts requiring mitigative measures, and the disposal options would present some aspects that would have to be addressed (as described above for sediment).

Present worth costs for the No Action alternative is $0. Present worth costs for the excavation alternative ranges from $1,400,000 for on-site containment (Alternatives 5a and 5b) to $4,300,000 for on-site thermal treatment (Alternative 5d).

Lyman Mill Reach Stream Sediment and Floodplain Soil – Among the alternatives evaluated, the excavation alternatives (Alternatives 3 and 5) would provide effective protection of human health because floodplain soil with contaminant concentrations in excess of ARARs or EPA's recommended residential level for dioxin in soil would be removed, and either contained on site, destroyed, or shipped off site for disposal and/or treatment. With respect to ecological protection, remediation in this action area represents a balance between destruction of a portion of the forested wetland habitat in the removal and staging areas versus the long-term benefit of contaminated sediment/soil removal. Among the alternatives evaluated, targeted excavation (Alternative 3) would provide a somewhat lower level of ecological protection than Alternative 5 because a smaller volume of contaminated material would be removed from the system. However, it would preserve nearly nine additional acres of a regionally important forested wetland complex that is providing habitat to a variety of plants, invertebrates, and wildlife populations including possibly vernal pool species. The population level effects of eliminating this valuable hardwood forest habitat are considered to outweigh the potential benefits of reducing the risk in a quicker fashion. Both excavation alternatives (Alternatives 3 and 5) would provide effective protection in the long term, although a minimum of several decades may be required to attain the ecological cleanup objectives. This delay in achieving the remedial goals for ecological receptors is balanced by the need to preserve the habitat necessary to maintain the receptors to be protected.

The No Action alternative would not comply with ARARs. The excavation alternatives (Alternatives 3 and 5) would comply with ARARs for residential direct exposure and EPA's recommended residential level for dioxin in soil; however, without a waiver the excavation alternatives would not comply with RCRA Subtitle C closure requirements. Excavation would result in the destruction of wetlands, and placing fill in a wetland and floodplain will trigger state and federal wetlands requirements that would have to be addressed. As a result, these actions must be evaluated to determine the least damaging practicable alternative. The excavation (Alternatives 3 and 5) and nearshore CDF (Alternative 3b and 5b) alternatives would also require the permanent occupancy and modification of the floodplain, and a determination would need to be made that there was no other practicable alternative before selecting one

of these options as the preferred remedy. The upland CDF alternatives (Alternatives 3a and 5a) could potentially result in the destruction of low-quality wetlands. In addition, these alternatives might require a treatability variance to reduce the amount of treatment required for sediment prior to disposal. Among the alternatives evaluated, the excavation and on-site thermal treatment and off-site disposal and/or treatment alternatives (Alternatives 5d and 3d, followed by 5e and 3e) would result in the greatest reduction of toxicity, mobility, and volume of contamination through treatment. The No Action and excavation alternatives utilizing on-site containment (Alternatives 3a, 3b, 5a, and 5b) would not require treatment, although all of these alternatives, with the exception of No Action (Alternative 1), would reduce mobility. The No Action alternative would have no short-term impacts to the community, the environment or workers, whereas the excavation alternatives (Alternatives 3 and 5) would result in the destruction of wetland and floodplain habitat that could take decades to recover.

The excavation alternatives (Alternatives 3 and 5) would result in unavoidable wetland loss and/or impacts requiring mitigative measures, and the disposal options would present some aspects that would have to be addressed (as described above for sediment). Although targeted excavation (Alternative 3) is expected to be less difficult to implement compared to the partial excavation alternative (Alternative 5), because the magnitude of wetlands destruction is reduced (i.e., 4.8 acres of wetlands destroyed under Alternative 3 compared to 13.5 acres destroyed under Alternative 5), both might present some implementability issues that would have to be addressed. If the presence of vernal pool habitat is confirmed within the current proposed cleanup area at the Oxbow, special care would have to be given during the design and construction aspects of any alternative other than No Action to mitigate concerns for animals that occur in vernal pools, which typically are very sensitive to environmental disturbances.

Present worth costs for the No Action alternative is $250,000. Present worth costs for the excavation alternatives range from $9,700,000 for targeted excavation, ENR, and on-site containment (Alternatives 3a and 3b) to $42,000,000 for partial excavation, ENR, and on-site thermal treatment (Alternative 5d). Costs for excavation with on-site containment are approximately half the cost for on-site thermal treatment or off-site disposal and/or treatment.

Source Area Soil – Among the alternatives evaluated for source area soil, the targeted excavation and RCRA cap alternative (Alternative 4) would provide the highest level of protection to human health and the environment and higher long-term effectiveness and permanence. Under this alternative, potential buried waste material that could be highly toxic or highly mobile would be removed using excavation and shipped off site for disposal and/or treatment. All existing surfaces (caps, parking lots, paved surfaces, rip rap, landscape areas) would be upgraded to RCRA caps that would provide stable and reliable long-term containment of contamination that remains in place. Moreover, the RCRA cap alternative is the only alternative that would comply with all ARARs, including requirements for RCRA and TSCA closure. The targeted excavation and cap upgrade alternative (Alternative 3) would also provide effective protection of human health and the environment, although the upgraded caps under this alternative would not comply with RCRA closure requirements or eliminate rainwater/snowmelt infiltration into the underlying soil and groundwater.

The No Action alternative would not include treatment, whereas the targeted excavation and capping alternatives (Alternatives 3 and 4) would include treatment to reduce the toxicity, mobility, or volume of contamination. The No Action alternative would not adversely impact the surrounding community and habitat because no construction activities would be required. The targeted excavation and capping alternatives, however, would result in the destruction of existing wetlands and placement of fill in wetland areas. As a result, these actions must be evaluated to determine the least damaging practicable alternative. The targeted excavation and capping alternatives would also require the permanent occupancy and modification of the floodplain, and a determination would need to be made that there was no other practicable alternative before selecting one of these options as the preferred remedy.

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Implementation of the No Action alternative would be routine, whereas the targeted excavation and capping alternatives would be more difficult because the remediation area is in close proximity to a sensitive population and there is limited space to conduct construction activities. All appropriate measures including engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring would be taken to mitigate risks to the residents, community and on-site workers. Additionally, all work would be performed in phases to minimize these impacts, and measures would be taken to provide residents continued access to the buildings and parking areas.

Present worth costs for the No Action alternative is $170,000. Present worth costs for the targeted excavation and capping alternatives range from $19,600,000 for the cap upgrade alternative (Alternative 3e) to $21,300,000 for the RCRA cap alternative (Alternative 4e).

Source Area Groundwater – Among all the alternatives evaluated for groundwater, the excavation/dewatering alternative (Alternative 2) would provide the highest level of both protection to human health and the environment and long-term effectiveness and permanence. Under this alternative, the contaminated soil would be removed and disposed off site, and the contaminated groundwater would be removed, treated, and returned to the Woonasquatucket River. The in-situ chemical oxidation alternative (Alternative 5) would provide some overall protection of human health and the environment, but the long-term effectiveness with respect to dioxin removal is unproven.

The excavation/dewatering alternative would comply with ARARs, whereas the in-situ chemical oxidation alternative might not comply with the ARARs for surface water quality and would require a non-CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) waiver if underground injections of chemical oxidants occur within 50 ft of a river. The excavation/dewatering and in-situ chemical oxidation alternatives would reduce the toxicity, mobility, and volume of contamination through treatment. Among the action alternatives, in-situ chemical oxidation would have fewest impacts to workers or residents compared to the excavation/dewatering alternative. All of the groundwater alternatives are implementable, although there might be some specialized aspects to each of the alternatives such as requiring mobilization from outside the region or requiring specialized experience or equipment.

Present worth costs for the No Action alternative is $270,000. Present worth costs for the action alternatives range from $1,200,000 for in-situ chemical oxidation (Alternative 5) to $3,000,000 for excavation/dewatering (Alternative 2).

Next Steps

The remedy considered most appropriate to achieve CERCLA requirements will be proposed by EPA in close coordination with the State of Rhode Island. Once proposed, the remedy for the site will be described in a Proposed Plan, which will be available for review and comment by the public. After consideration of public comments, the remedy selection decision will be documented in a ROD.

Following collection of additional baseline data and implementation of the selected remedy itself, the long-term monitoring plan will be executed to assess overall performance. Using an adaptive management approach, information from the monitoring plan and review process will be evaluated to determine whether potential down river contamination concerns might also need to be addressed.

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ABBREVIATIONS AND ACRONYMS

ARAR applicable or relevant and appropriate requirement
AET Atlantic Environmental Technologies, Inc.

BAF bioaccu mulation factor
BAZ biologically active zone
BERA baseline ecological risk assessment
bgs below ground surface
BHHRA baseline human health risk assessment
BSAF biota sediment accumulation factor

CAD confined aquatic disposal
CDF confined disposal facility
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cfs cubic feet per second
CMRP Centredale Manor Restoration Project
cm/yr centimeter per year
COC chemical of concern
CSM conceptual site model
cy cubic yards
cy/d cubic yards per day

DDD dichlorodi phenyldichloroethane
DDE dichlorodi phenyltrichloroethylene
DDT dichlorodi phenyltrichloroethane
DRE destruction and removal efficiency

EC engineering control
EE/CA Engineering Evaluation/Cost Analysis
ENR enhanced natural recovery
EPA United States Environmental Protection Agency
EPC exposure point concentration
ERDC Environmental Research and Development Center

FEMA Federal Emergency Management Agency
FISRWG Federal Interagency Stream Restoration Working Group
ft feet
FRTR Federal Remediation Technologies Roundtable
FS feasibility study

gpm gallon per minute

HCl h ydrochloric acid
HCX hexachloroxa nthene
HDPE high-densit y polyethylene
HI hazard index
HQ hazard quotient

IC institutional control
ISTD in situ thermal desorption

KPEG	potassium polyethylene glycol
LDR	land disposal restrictions
LEA	Loureiro Engineering Associates
LLDPE	low density polyethylene
LOAEL	lowest observed adverse effects level
LTMP	Long-term Monitoring Plan
MATC	maximum allowable toxicant concentration
mg/kg	milligrams per kilogram
mm milli	meter
MNA	monitored natural attenuation
MNR	monitored natural recovery
NAPL	non-aqueous phase liquid
NCDC	National Climatic Data Center
NCP	National Hazardous Substances and Pollution Contingency Plan
ng/kg	nanograms per kilogram
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effects level
NRC	National Research Council
NTCRA	non-time critical removal action
O&M	operation and maintenance
OSWER	(U.S. EPA's) Office of Solid Waste and Emergency Response
PAH	polycyclic aromatic hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PCB pol	ychlorinated biphenyl
PCE tetrachloroethy	lene (perchloroethylene)
pg/L	picograms per liter
ppb	parts per billion
PRB	permeable reactive barrier
PRG	preliminary remediation goal
QEA	Quantitative Environmental Analysis
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RG rem	ediation goal
RI rem	edial investigation
RIDEM Rhode	Island Department of Environmental Management
RIDOH Rhode	Island Department of Health
RIGIS	Rhode Island Geographical Information System
RME reasonable	maximum exposure
ROD	Record of Decision
sq ft	square feet
sq ft/d	square feet per day
SVOC sem	ivolatile organic compound

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TBC	to be considered
TCDD	tetrachlorodibenzo-*p*-dioxin
TCE	trichloroethylene (or trichloroethene)
TCLP	toxicity characteristic leaching procedure
TCRA	time critical removal action
TEF	toxic equivalency factor
TEQ	toxic equivalency
TMDL	total maximum daily load
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TTNUS	TetraTech NUS, Inc.
µg/L	micrograms per liter
UIC	underground injection control
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UTS	universal treatment standards
UV	ultraviolet
VOC	volatile organic compound
WTIC	Water Technology International Corporation
WQC	water quality criteria
WRWC	Woonasquatucket River Watershed Council

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1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) Region I is conducting a Remedial Investigation and Feasibility Study (RI/FS) for the Centredale Manor Restoration Project Superfund site (hereafter referred to as the CMRP site) located in North Providence, Rhode Island (Figure 1-1). The main part of the CMRP site, which is referred to as the source area, is located at 2072 and 2074 Smith Street (Route 44) (Figure 1-2). The CMRP site also includes free-flowing reaches and impoundments of the Woonasquatucket River adjacent to and downstream of the source area (Figure 1-1) where contamination has come to be located. Historically, the source area was used for chemical manufacturing and drum recycling operations, and is currently occupied by the Brook Village and Centerdale Manor apartment complexes. This report presents the results of the FS completed for the CMRP site; results from the RI are reported in the *Interim Final Remedial Investigation, Centredale Manor Restoration Project Superfund Site* (Battelle, 2005a). The FS was completed following *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), the final *RI/FS Work Plan* for the CMRP site (Battelle, 2003a), and *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (EPA, 2002). Areas evaluated in the FS include the source area and reaches of the river immediately downstream of the source area, i.e., Allendale and Lyman Mill. This report also includes an approach to assess site conditions at downstream areas to determine if additional action may be warranted following the implementation of a sediment remedy at Allendale and Lyman Mill.

1.1 Study Objectives and Approach

The purpose of this FS is to identify and evaluate a range of remedial alternatives to address soil, groundwater, and sediment contamination at the CMRP site that poses an unacceptable risk to human health or the environment. The areas and media that are evaluated in this FS are as follows:

- Source area soil
- Source area groundwater
- Allendale reach sediment
- Allendale reach floodplain soil
- Lyman Mill reach sediment
- Lyman Mill reach stream sediment and floodplain soil

In this FS, the term 'reach' is used to describe a segment of the river of specified length. The Allendale reach is an approximate 0.65 mile long segment of the Woonasquatucket River bounded to the north by Route 44 and to the south by Allendale Dam (Figure 1-1). The Allendale reach includes the stream adjacent to the source area and Allendale Pond. The Lyman Mill reach is approximately 0.85 miles long and is bounded to the north by Allendale Dam and to the south by Lyman Mill Dam (Figure 1-1). The Lyman Mill reach includes the stream and old race way beneath Allendale Dam, a forested wetland, and Lyman Mill Pond. Areas and media evaluated in this FS include floodplain and wetland areas that border parts of the river along the reaches of Allendale and Lyman Mill (Figure 1-3). Areas of wetland habitat shown in Figure 1-3 are identified according to the Rhode Island Geographical Information System (RIGIS) database. The most significant wetland area within this reach of the river is the Oxbow, a forested wetland (inset in Figure 1-3 shows United States Army Corps of Engineers [USACE] classified wetland types and delineated boundaries in the Oxbow). Additional wetland habitat (not shown in Figure 1-3) is present in adjoining floodplains in both Allendale and Lyman Mill Ponds.

This FS also evaluates the long-term effectiveness of time critical removal actions (TCRA) and non-time critical removal actions (NTCRA) previously performed at the CMRP site (Section 2.2.2) to determine whether additional action is needed to achieve a permanent remedy.

This FS provides a detailed analysis of a range of alternatives for remediation at the CMRP site. This was accomplished using the following steps:

- Remedial action objectives (RAOs) were formulated for the CMRP site based on protection of human health and the environment, and applicable or relevant and appropriate requirements (ARARs) of federal and state law;
- Preliminary remediation goals (PRGs) were identified, and proposed remediation goals (RGs, hereafter referred to as cleanup goals) capable of achieving the RAOs were established;
- Areas of the CMRP site and volumes of contaminated media requiring remediation to achieve the RAOs were identified; and
- A range of alternatives capable of achieving the cleanup goals were identified, developed, screened, and evaluated.

The results of the FS will be used by EPA and other stakeholders to propose a preferred remedial action for the CMRP site. The preferred alternative will be presented in a Proposed Plan for Remedial Action that will be presented to the public. After the Proposed Plan is reviewed by the public, EPA will respond to public comments and select a remedy in a Record of Decision (ROD).

1.2 Report Organization

This report was prepared in accordance with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) and EPA guidance under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA, 1988). The FS is organized in 8 sections and 14 appendices, as follows:

Section 1.0: Introduction. This section is an introduction and describes the objectives and technical approach of the FS.

Section 2.0: Remedial Investigation Summary. This section includes a description of the CMRP site and its physical setting, the conceptual site model (CSM), and a summary of the conclusions from the human health and ecological risk assessment.

Section 3.0: Development of Remedial Action Objectives and Action Areas. This section provides a summary of ARARs and To Be Considered (TBC) criteria, and presents RAOs based on risk and exposure pathways. Remedial goals for those areas of the site that pose an unacceptable risk are defined and the conceptual remedial footprints for source area soil and groundwater, sediment, and floodplain soil to which removal, containment, or treatment may be applied are developed.

Section 4.0: Identification and Screening of Remedial Technologies and Process Options. This section identifies and describes general response actions and associated remedial technologies that could be applied at the CMRP site. The response actions and technologies are screened against the NCP threshold criteria (i.e., effectiveness, implementability, and cost) to select those technologies that are most suitable and appropriate to be incorporated into remedial alternatives.

Section 5.0: Identification and Screening of Remedial Alternatives. Potential remedial alternatives that could be applied at the CMRP site are identified, described, and combined in Section 5.0; these alternatives are also screened on the basis of effectiveness, implementability, and cost.

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Section 6.0: Detailed Evaluation of Remedial Alternatives. The detailed evaluation of the remedial alternatives retained after the alternative screening process is presented in Section 6.0. The remedial alternatives are evaluated in detail using the seven NCP criteria; alternatives are also compared and contrasted to identify strengths and weaknesses.

Section 7.0: Summary and Conclusions. This section presents the summary and conclusions of the comparative analysis of the remedial alternatives.

Section 8.0: References. This section includes the references that have been cited and used to develop this report.

Appendix A: Supplemental Groundwater Investigations. This appendix provides the results of supplemental groundwater investigations conducted at the source area in 2004 and 2006.

Appendix B: Supplemental Sediment Investigations. This appendix provides the results of a supplemental sediment investigation conducted at Lyman Mill Pond in 2005.

Appendix C: Supplemental Surface Water Investigations. This appendix provides the results of supplemental surface water investigations conducted at the CMRP site in 2004.

Appendix D: Preliminary Remediation Goals for the Oxbow. This appendix provides the risk-based PRGs developed for the Oxbow, a forested wetland located southwest of Allendale Dam.

Appendix E: Quantitative Analysis of Sediment Capping Alternative. This appendix provides the quantitative analysis of the existing conditions and post-capping alternative conditions, and identifies areas and percent of pond bed with potential significant scour during periods of flood river flow.

Appendix F: Proposed Cleanup Goals for the CMRP Site. Data evaluations conducted to determine proposed cleanup goals for the CMRP site are summarized in this appendix.

Appendix G: Proposed Remedial Footprints for the CMRP Site. Data evaluations conducted to determine the proposed remediation footprints for the CMRP site are summarized in this appendix.

Appendix H: Conceptual Long-term Monitoring Approach. A conceptual approach for post-remedial monitoring is described in this appendix.

Appendix I: Remedial Technologies. Examples of possible containment, removal, transport, dewatering, disposal and treatment technologies that were considered during the alternative screening process are described in greater detail in this appendix.

Appendix J: Remedial Alternative Cost Estimates. This appendix includes FS-level cost estimates for the alternatives evaluated in Section 6.0.

Appendix K: Comparative Net Risk Analysis for Sediment Alternatives. This appendix provides the comparative net risk analysis which evaluates the risk of remedy implementation versus long-term risk reduction for the sediment alternatives evaluated in Section 6.0.

Appendix L: Confined Disposal Facility Equivalent Design Analysis. This appendix evaluates how a single liner and leachate collection system in an on-site upland confined disposal facility (CDF) would comply with either the State of Rhode Island solid or hazardous waste regulations.

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Appendix M: Comparative Net Risk Analysis for Floodplain Soil Alternatives. This appendix provides the comparative net risk analysis which evaluates the risk of remedy implementation versus long-term risk reduction for the floodplain soil alternatives evaluated in Section 6.0.

Appendix N: Evaluation of EPA's Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil Released December 30, 2009. Data evaluations conducted to assess impacts, if any, of EPA's draft recommended interim PRGs for dioxin in soil (EPA, 2009) on proposed cleanup goals, cleanup areas, and remedial alternatives for the CMRP site are summarized in this appendix.

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2.0 REMEDIAL INVESTIGATION SUMMARY

This section summarizes information presented in the *Interim Final Remedial Investigation, Centredale Manor Restoration Project Superfund Site, North Providence, Rhode Island* (Battelle, 2005a). Briefly, this section includes a description of the CMRP site location and history, investigations conducted to characterize the site, the physical setting, and the CSM which describes the sources, nature and extent of contamination, contaminant fate and transport mechanisms, and exposure pathways and potential receptors at risk. Key findings from the baseline human health risk assessment (BHHRA) and the baseline ecological risk assessment (BERA) are also summarized.

2.1 Site Location and History

The area evaluated in this FS includes a reach of the Woonasquatucket River and its associated floodplain habitat, approximately 1.5 miles long, from Route 44 (Smith Street) downstream to the Lyman Mill Dam (Figure 1-1). From north to south, this reach of the river has two dammed impoundments, Allendale and Lyman Mill Ponds, which are connected by a free-flowing channel. Greystone Mill Pond, upstream of the Route 44 Bridge, was used as a background area for the RI. The areas evaluated are located in North Providence, Providence, and Johnston, Rhode Island.

The source area encompasses approximately nine acres and is comprised of parking lots, roadways, and the Centredale Manor and Brook Village apartment complexes (Figure 1-2). The source area is bounded on the north by Route 44, on the south by Allendale Pond, on the west by the Woonasquatucket River, and on the east by commercial and residential properties along Route 44. Three interim soil caps have been constructed over contaminated soils in the source area: one to the south of the Centredale Manor south parking lot (Cap Area #1), one to the west of the Centredale Manor building (Cap Area #2), and one in the former tailrace (drainage channel) east of the Centredale Manor building (Cap Area #3).

Potential historical sources of contamination include but are not limited to chemical manufacturing process discharges, residues associated with drum reconditioning operations, and handling, storage and disposal of chemicals in drums, stockpiles and surface impoundments (EPA, 2000a).

Chemical manufacturing activities took place at the source area from approximately 1943 until the early 1970s. It is believed that the Metro Atlantic Chemical Company manufactured hexachlorophene at the CMRP site around 1965 (Cleary, 2003) in a building on the eastern bank of the Woonasquatucket River, in what is now the Brook Village parking lot (Figure 2-1). 1,2,4,5,7,8-hexachloroxanthene (HCX) and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) are associated with this process (Beliveau et al., 2003; Archer and Crone, 2000). Metro Atlantic also sent drums to New England Container Company, Inc. for reconditioning. Other chemical processes also occurred.

The New England Container Company, Inc. operated an incinerator-based drum reconditioning facility at the source area (Figure 2-1) from 1952 until the early 1970s. Chemical residues were dumped or burned prior to drum reconditioning (Emhart Industries v. Home Insurance Co., 2006a). Residues associated with drum reconditioning operations are a source of dioxins, furans and other chemicals at the CMRP site.

Evidence from historical photographs, state report files and geophysical testing suggest that buried waste material may still be present in the source area. Locations of the former chemical manufacturing and drum reconditioning buildings and areas of possible buried metallic materials are shown in Figure 2-1.

In 1972, a fire destroyed most property structures. Brook Village was constructed in 1977 and Centredale Manor was constructed in 1982. Dioxin was first identified in the area in 1996 in fish collected from the Woonasquatucket River by EPA (EPA, 1996a; EPA, 1998a). Since that time, EPA has conducted

numerous investigations to characterize the nature and extent of contamination at the CMRP site under current conditions. Elevated levels of contaminants including dioxin (primarily 2,3,7,8-TCDD), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals have been detected in various media including soil, groundwater, sediment, surface water, and biota. The CMRP site was listed on the National Priorities List in 2000.

A fish consumption advisory was issued by the Rhode Island Department of Health (RIDOH) and EPA in 1999 for dioxin, PCBs, and mercury. This advisory was updated in 2003, and reinforced that the public should not eat fish caught from the Woonasquatucket River below the Johnston and Smithfield town lines (EPA, 2003a). The reach of the river that includes the CMRP site is listed as an impaired water body under Section 303(d) of the Clean Water Act. Impairment has been attributed to pathogens, metals (copper, lead, zinc, and mercury), PCBs, dioxins, excess algal growth, and low dissolved oxygen (Rhode Island Department of Environmental Management [RIDEM], 2008a). RIDEM conducted a Total Maximum Daily Load (TMDL) study for the river, and identified dissolved metals and bacteria TMDLs for the watershed in April 2007 (RIDEM, 2007), which were made available for public comment in 2008 (RIDEM, 2008b).

EPA has used a variety of mechanisms to keep the public informed about activities at the CMRP site, and to solicit input from the public and stakeholders on critical issues. These mechanisms include public meetings, open houses, dissemination of numerous site updates and fact sheets, press releases, and individual contact with residents near the site on an as-needed basis. Updated site information is made available to the public on EPA's Superfund Web site (EPA, 2010). A Management Action Committee, which includes representatives from local, state, and federal agencies, community leaders, and community-based environmental groups, has also met periodically since 2000 to discuss project-specific issues and any progress being made. EPA has also convened a dialog process, a series of facilitated meetings with stakeholders, to discuss the RI/FS.

2.2 Site Characterization

A number of investigations have been conducted at the CMRP site since 1996 to establish and confirm the presence of contamination at the site, to support TCRA and NTCRA activities, and to support the development of long-term (remedial) actions. Results of the major investigations are summarized below.

2.2.1 Summary of Historical Site Investigations

EPA conducted a number of investigations from 1996 to 2002 to document the presence of contamination at the CMRP site, and support TCRA and NTCRA activities. Samples of soil, sediment, drinking water, and indoor air were collected, analyzed and evaluated. Contaminants detected in source area soils and Allendale and Lyman Mill reach sediments include dioxins, furans, pesticides, PCBs, VOCs, polycyclic aromatic hydrocarbons (PAHs), and various metals. Results from these studies indicated that short-term removal actions were needed to minimize exposure to contaminated soils in some areas, and prevent erosion and transport of contaminated soils into the Woonasquatucket River. Drinking water, indoor air samples, and soils in recreational use properties adjacent to the CMRP site were found to pose no risk to human health.

Geophysical surveys were conducted in the source area in 1999 to determine whether any buried waste material was present in the source area (Roy F. Weston, 1999). Thirteen significant undetermined electromagnetic anomalies were identified, some of which appeared to be buried anthropogenic features such as subsurface utilities and fill or construction-related debris, natural stratigraphic features such as paleochannels, and possibly alluvial deposits. Anomalies beneath the south end of the Centredale Manor

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parking lot were interpreted as having the highest potential for containing buried bulk metallic materials (Figure 2-1).

2.2.2 Summary of Site Actions

Contamination at the CMRP site is being addressed in two stages: immediate (removal) actions, and long-term (remedial) actions. Actions taken at the CMRP site are summarized in Table 2-1. Briefly, a TCRA for the source area soils was conducted at the CMRP site in 1999-2000 to reduce the immediate threat to the health of residents on and near the site. The major activities conducted under the TCRA included construction of two interim soil caps and installation of fencing to restrict access to potentially contaminated areas. Repairs to the fence along Allendale Pond were performed in 2005; this also included relocating fencing in areas that were under water following the reconstruction of Allendale Dam in 2002.

An Engineering Evaluation/Cost Analysis (EE/CA) was performed in 2000 as the basis for a NTCRA (Tetra Tech NUS Inc. [TTNUS], 2000a). The NTCRA included reconstruction of Allendale Dam and restoration of Allendale Pond, and excavation of contaminated floodplain soils in 11 residential-use properties and recreational access points along Allendale and Lyman Mill Ponds (sample data for contaminated material excavated under the NTCRAs were not used in the data evaluations to characterize nature and extent of contamination). Another TCRA was performed in 2003-2004 to cap contaminated soils and sediments in the former tailrace on the east side of the source area.

2.2.3 Summary of Remedial Investigation Activities

EPA conducted a series of investigations from 1999 to 2004 to characterize the nature and extent of contamination in source area soil and groundwater, sediment, floodplain soil, surface water, and biological tissue at the CMRP site. In addition, these investigations focused on gaining a better understanding of contaminant fate and transport processes and collecting data to support the baseline risk assessments. Investigations included: a vapor-to-water diffusion survey to characterize contaminated groundwater discharge from the source area to the Woonasquatucket River (U.S. Geological Survey [USGS], 2000); characterization of contaminants on residential use properties adjacent to the river and in river sediment and water (TTNUS, 2000b and 2001); characterization of soil and groundwater contamination and hydrogeology at the source area (TTNUS, 2002; Battelle, 2003b); and an investigation to characterize contamination in floodplain soil at a forested wetland (hereafter referred to as the Oxbow) located southwest of Allendale Dam in the Lyman Mill reach (Battelle, 2004a).

Several sediment-related studies were also conducted in the Allendale and Lyman Mill reaches as follows:

- a geomorphology investigation was conducted to identify morphological features and changes along the Woonasquatucket River (USACE/Engineer Research and Development Center [ERDC], 2004);
- a geophysical survey was conducted to map water depth and soft sediment thickness in Allendale and Lyman Mill Ponds (Lockheed Martin, 2003);
- sediment cores from Allendale and Lyman Mill Ponds were characterized to assess the vertical and spatial extent of contamination, estimate the rate of sediment accumulation, and identify relationships between depth, age, and dioxin contamination in the ponds, if any (USACE/ERDC, 2004; Battelle, 2005a); and
- a sediment stability evaluation was conducted to assess the impacts of sediment erosion, transport, and deposition processes on surficial sediment bed and water column concentrations of

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dioxin within Allendale and Lyman Mill Ponds (Quantitative Environmental Analysis [QEA], 2004).

Baseline risk assessments were conducted to assess current and potential future risk to human health and ecological receptors from exposure to contamination at the CMRP site (MACTEC, 2004 and 2005a). An environmental forensics review of soil and sediment chemistry data was also conducted to differentiate, if possible, chemical contamination signatures from the CMRP site from those in background and reference samples (NewFields, 2005).

2.2.4 Summary of Supplemental Site Investigations

EPA conducted additional investigations in 2004-2006 to address data gaps identified in the RI and address concerns of stakeholders. Briefly, these studies were conducted to gain a better understanding of potential 2,3,7,8-TCDD migration associated with the contaminated groundwater plume in the northwest region of the Brook Village parking lot, confirm the direction of groundwater flow in the source area, and estimate the potential flux of 2,3,7,8-TCDD from groundwater to surface water of the Woonasquatucket River (Battelle, 2005b and 2006).

A sediment coring study was conducted in 2005 (Battelle, 2005c) to assess the vertical and spatial extent of contamination at Lyman Mill Pond, estimate the rate of sediment accumulation, and identify relationships between depth, age, and dioxin contamination, if any. A surface water investigation was conducted in 2004 (Battelle, 2004b) to verify that no net transport of dioxin was occurring downstream of Lyman Mill Dam under non-resuspending conditions. Human health and ecological risks from exposure to contaminants at the Oxbow were characterized in 2006; supplemental evaluations of potential human health risk based on an alternative exposure scenario were evaluated in 2009 in response to concerns and comments raised during stakeholder meetings. Results from the supplemental groundwater, sediment, and surface water investigations are presented in Appendices A, B, and C, respectively. Results from the Oxbow risk assessment are reported in MACTEC and Battelle (2006). Risk-based PRGs for the Oxbow and results from the alternative exposure scenario are presented in Appendix D.

2.3 Physical Setting

The physical characteristics of the CMRP site and surrounding region are summarized below; additional detail is presented in the RI (Battelle, 2005a).

2.3.1 Demography and Land Use

Land use at the CMRP site is summarized in Table 2-2. The Brook Village and Centredale Manor apartment complexes occupy the northern portion of the site. This area is currently covered by buildings, pavement, landscaping, and interim protective caps, and is expected to remain a multi-family residential area. The locations of known underground utilities in the source area are shown in Figure 2-2. Institutional controls (ICs) are not currently in place to manage excavations on the CMRP site (e.g., to install or repair utilities).

Land use on the east side of the Woonasquatucket River in the vicinity of the CMRP site in North Providence, Rhode Island, is primarily residential, with some commercial and light industrial properties. The western side of the river in Johnston, Rhode Island, is characterized by mixed residential, commercial, and industrial use. The North Smithfield wastewater treatment plant is located upstream from the CMRP site, in the Greystone Mill Pond area. The Woonasquatucket River was recognized within the larger Blackstone River drainage as one of the 14 American Heritage Rivers in 1998, and is currently the focus of urban revitalization and watershed restoration efforts. The Woonasquatucket River

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Watershed Council (WRWC), formed shortly after the American Heritage River designation, is a community-based environmental group that works closely with RIDEM and other state and federal agencies to design and implement projects in the watershed. In 2008, with WRWC involvement, a fish ladder project at the Rising Sun Mills Dam was completed, which marks the beginning of the restoration of herring and alewife populations in the Woonasquatucket River. Future land use in the area is not expected to change significantly.

Groundwater in the vicinity of the CMRP site and surface water from the Woonasquatucket River are not used as drinking water sources. Groundwater at the site is federally classified as Class III: Not a Potential Source of Drinking Water and/or of Limited Beneficial Use. Under state groundwater regulations, this aquifer part is also classified as GB (defined as "may not be suitable for public or private drinking water use without treatment due to known or presumed degradation" [RIDEM, 2005a]). However, because the state has not obtained EPA approval of a Comprehensive State Ground Water Protection Program, it is necessary to default to the federal classification. A groundwater classification map is shown in Figure 2-3. RIDEM water quality regulations designate the reach of the river in the vicinity of the CMRP site as a Class B1 water body, which is defined as follows:

> "*Designated for primary and secondary contact recreational activities*[1] *and fish and wildlife habitat. They shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. These waters shall have good aesthetic value. Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges*" (RIDEM, 2005a).

The section of the Woonasquatucket River running through the CMRP site is an important recreational asset recognized by the Rhode Island Statewide Planning Program, Rivers Policy and Classification Plan, which states that "Rhode Island's rivers, lakes, ponds, and estuarine waterbodies are an important recreational asset and shall be managed as such, except in instances when they are drinking water supplies, or habitat for rare or endangered species, that would be harmed by recreational use." The plan also states that "The natural, cultural, and historic features of river systems and their adjacent lands shall be preserved and protected to the maximum extent possible" (Rhode Island Statewide Planning Program, 2004). As a specific goal, the policy for the lower segments of the Woonasquatucket River is "to complete the removal of dioxin contaminated sediment and restore the river for contact recreational uses by 2020." Currently, Greystone Mill, Allendale, Lyman Mill, and Manton Ponds are considered suitable for canoeing and other non-contact recreational activities.

2.3.2 Dam Ownership and Dam Conditions

The owner on record for Allendale Dam is The Mill at Allendale Condominium (Allendale Title Easement, 2002). Floodwaters breached the Allendale Dam in 1991, reducing the surface water level in Allendale Pond. The dam was breached again in 2001, exposing most of the Allendale Pond bottom adjacent to residential properties along the eastern bank of the pond. In early 2002, Allendale Dam was reconstructed and Allendale Pond was restored to its pre-1991 elevation as part of an NTCRA.

The owner on record for Lyman Mill Dam is Theta Properties, Inc. (RIDEM, 2005b). The dam was inspected in 1999 (USACE, 1999) in response to the discovery of dioxin in the pond sediments; an inspection report, which included recommendations for repair and further investigation, was forwarded to

[1] According to RIDEM (2005a), primary contact recreational activities "means any recreational activities in which there is prolonged and intimate contact by the human body with the water, involving considerable risk of ingesting water, such as swimming, diving, water skiing and surfing." Secondary contact physical activities include activities with minimal contact, such as boating and fishing.

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the registered owner (RIDEM, 1999). Overall, the inspection report indicated that the dam was in fair condition and did not show signs of immediate danger of failure. However, the report indicated that the dam was not properly maintained and the low level gates were inoperable, substantial vegetation was present and/or concrete surfaces were deteriorating. The report also stated that Lyman Mill Dam could be susceptible to rapid erosion during a 100-year flood, which could result in the washout of sediments behind the dam; however, the report indicated that sudden catastrophic failure appeared unlikely.

The Lyman Mill Dam was inspected again in 2005 and findings (USACE, 2005) were consistent with the 1999 inspection, although some minor changes in recommended remedial repairs were identified. Overall, recommendations for repair included 1) that a shallow toe drain system be constructed along the entire downstream edge of the embankment to control the observed seepage; 2) that gate structure 2 be rehabilitated to allow use of the gate during emergencies, inspections and construction activities; 3) that the gate closest to the spillway be repaired (significant amount of leakage was observed); 4) that gate structure 1 be sealed to prevent erosion of the embankment; and (5) that vegetation from embankments and gate structures be cleared.

2.3.3 Geomorphology

According to USACE/ERDC (2004), the Woonasquatucket River was once typical of most New England rivers: narrow, slightly sinuous, and fast flowing. The man-made alterations of the river channel from the construction of mill dams in the 1800s greatly influenced the river morphology and sedimentation. Surficial deposits in the area of the Woonasquatucket River watershed are predominantly glacial and can be classified broadly as glacial till or stratified drift (Krinsley, 1949; Smith, 1956). The bedrock underlying the surficial deposits consists of Pennsylvanian sandstone, shale, and conglomerates of the Narragansett Basin and older igneous and metamorphic rocks surrounding the basin (Smith, 1956).

The Woonasquatucket River is entrenched in a valley train, and geomorphic features along the river are typical of those found in riverine and glacial systems. The valley train limits the movement of Allendale Pond to the west; as a result, the position of the west bank of the Woonasquatucket River has changed very little over time. The east bank of the river in this area was developed as a residential area between 1888 and 1935. The river terrace along the east bank of the Woonasquatucket River is a former floodplain and is classified as a depositional feature; floodplain deposition occurs when sediment is transported over the riverbanks during high flows. The Centredale Manor and Brook Village Apartments are constructed on artificial fill on the floodplain of the river.

The Allendale reach has undergone significant changes due to the breaching of Allendale Dam in 1991 and 2001. The breach may have contributed to the transport of contaminated sediment downstream of the dam and also altered geomorphic features along the river. The reconstruction of Allendale Dam in early 2002 restored Allendale Pond to its pre-1991 elevation and minimized the potential for transport of contaminated sediments downstream of the dam.

Below Allendale Dam, the river channel had been historically sinuous as evidenced by an oxbow within approximately 27 acres of bordering wetland (Oxbow Area in Figures 1-1 and 1-3) where the active river flow once existed. Since that time, the channel has been straightened and dredged material from the channelization was used to build a levee covered with cobbles from the river channel. The Oxbow, a forested wetland, is located southwest of Allendale Dam (Figures 1-1 and 1-3). An abandoned channel located within the Oxbow is still in communication with the river during times of high water, and the presence of floodplain deposits along the western ridge of this area indicates that overbank river flow has occurred.

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Lyman Mill Pond is bordered by a valley train on the west bank and river terrace deposits on the east bank. Below the Lyman Mill Dam, the river was diverted almost due east to accommodate the Lymansville Mill.

2.3.4 Soils

USACE/ERDC (2004) reported that soils at and near the CMRP site reflect post-glacial development. Soil types on both sides of the Woonasquatucket River in the Allendale reach are primarily classified as Udorthents-Urban and Canton-Urban soil complexes. These soils are well drained and composed of fine sandy loam; urban areas are covered by pavement and buildings. Moderately to excessively drained soils are also located along the west bank of Allendale Pond and to the east of the source area.

A variety of soil types characterize the Lyman Mill reach of the river, consisting of poorly- to well-drained soils. Moderately well-drained, fine sandy loam soils are present in the Oxbow. Adrian muck, a very poorly drained soil composed of black muck at the surface and fine sand in the subsurface, was also found in the southern part of the Oxbow. The west side of the river is covered primarily by gravelly sand loam. Somewhat excessively drained sandy loam soils are located along the eastern side of Lyman Mill Pond.

2.3.5 Meteorology

According to the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC), the weather in the vicinity of Providence (including the CMRP site) is influenced by its proximity to Narragansett Bay and the Atlantic Ocean (NCDC, 2010). Coastal storms usually produce the most severe weather. Since 1900, Rhode Island has experienced five hurricanes, including three major hurricanes (i.e., greater than Category 3). Hurricanes affecting New England typically occur in late summer or early fall (NOAA Coastal Services Center, 2009). Thunderstorms are responsible for much of the rainfall from May through August, and usually produce heavy rainfall that, in turn, can result in the flooding of the Woonasquatucket River. The most recent documented flooding of the river occurred on October 15, 2005.

2.3.6 Geology

According to TTNUS (2002), characterization of subsurface geology in the source area showed that the overburden is largely comprised of silty sands and gravels underlain by bedrock. The majority of the source area is covered with loose to very dense fill, comprised of unsorted silt, sand, and gravel with trace amounts of anthropogenic debris (e.g., fragments of wood, metal, brick). Fill thickness appears to vary significantly across the source area, with a typical thickness of approximately 6 to 8 feet (ft). Fill material is underlain by fine-grained floodplain deposits, followed by sand and gravel, fine sand and silt, possible till, and bedrock. The most common soil type present at the source area is sand and gravel; thickness of this stratigraphic unit ranges from 12.5 to 43 ft, and appears to extend well beyond the boundaries of the site (Smith, 1956). Bedrock is located approximately 40 to 60 ft below ground surface (bgs) in the source area, and is situated above a north-south trending bedrock valley. A geologic cross-section of the source area showing site bedrock and overburden stratigraphy is provided in Figure 2-4.

2.3.7 Hydrogeology

The aquifer at the source area is divided into three major components: bedrock, deep overburden and shallow overburden (aquifer characteristics are summarized in Table 2-3). Bedrock beneath most of the source area is composed of foliated, gray to green schist or gneiss; granite has also been found in the northern part of the source area (TTNUS, 2002). The overburden at the source area is generally

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composed of sands and gravels, ranging from fine to coarse gravel and cobbles to poorly-graded, silty, fine to medium sands. Discontinuous lenses of silty fine sand and sandy silt are also present within the sands and gravels. Beneath the sands and gravel layer, a layer of dense to very dense, unsorted grain size mixture is present, possibly representing a basal till. Investigations conducted in the spring of 2001 showed that shallow subsurface soils in the source area appear to be highly permeable and high amounts of precipitation can locally alter the groundwater flow (TTNUS, 2002). During high-precipitation conditions, groundwater flow is apparently to the east-southeast and the river recharges the aquifer everywhere except in the immediate vicinity of the small groundwater mound beneath the Brook Village parking lot (TTNUS, 2002). Under low precipitation conditions, groundwater flow appears to the south and the aquifer recharges the river except at the south end of the source area where it appears that the river still loses water to the aquifer (TTNUS, 2002). The localized groundwater mound beneath the Brook Village parking lot was apparent under both low-flow and high-flow conditions in spring 2001, and may be due to groundwater perched above a low-permeability silt lens or man-made structure (TTNUS, 2002). No strong, sitewide vertical hydraulic gradient was evident.

Additional investigations conducted in the fall of 2001 (TTNUS, 2002), fall of 2002 (Battelle, 2003b), and winter of 2006 (Appendix A) also showed that groundwater flow was generally to the south under low-flow conditions. The groundwater mound beneath the Brook Village parking lot was less pronounced in fall 2001 and 2002; however, the groundwater mound was evident again in the winter of 2006 (Figure 2-5).

2.3.8 Sediment and Surface Water

The Woonasquatucket River is approximately 19 miles long, originating in North Smithfield, Rhode Island, and discharging to Providence Harbor approximately 8.5 miles downstream of the CMRP site. The river drains an area of approximately 50 square miles. The reaches or segments of the river evaluated in this FS include the Allendale and Lyman Mill reaches, an approximate 1.5 mile stretch of the river from Route 44 to Lyman Mill Dam that includes floodplain and wetland areas.

2.3.8.1 Allendale Reach

The Allendale reach of the Woonasquatucket River spans from Route 44 past the source area to the Allendale Dam and includes Allendale Pond (Figures 1-1 and 1-3). The river channel from the Route 44 Bridge to the head of Allendale Pond is straight and approximately 1,500 ft long. The channel bed is composed of gravel, cobbles, and sand. The eastern bank of the river along this reach is armored with rip rap installed in 1999 to prevent bank erosion. The 100-yr flood elevation follows a gradient of 101.2 ft at the Route 44 Bridge (Federal Emergency Management Agency [FEMA], 1999) to 97 ft at Allendale Dam (USACE, 2003a).[2]

The majority of data used to characterize Allendale Pond were collected after the disruptive events (i.e., dam breach in 1991 and 2001 and dam reconstruction in summer 2002), and include bathymetric and soft-sediment thickness data collected from the fall 2002 geophysical investigation and radiometric age dating and dioxin profile data from the 2003 and 2005 vibracoring investigations. Allendale Pond (restored to its pre-1991 level) has an area of approximately 14.7 acres. The hydrodynamic model, developed using bathymetric data from the fall 2002 geophysical investigation (Lockheed Martin, 2003), showed a minimal gradient in the water surface elevation during the 100-yr flood between the dam and the upstream extent of the pond. Inundation mapping conducted by USACE confirmed the low gradient

[2] For the purposes of this FS, it is assumed that the 100-yr flood elevation transition from 101.2 to 97 ft occurs along the stream channel between the Route 44 Bridge and the upstream extent of Allendale Pond, and that the 100-yr flood elevation at Allendale Pond is based on the stage height at the dam (97 ft according to USACE, 2003a).

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(USACE, 2000). Thus, assuming that the water surface elevation within the pond is equal to the stage height at the dam, the normal water and 100-yr flood elevations in Allendale Pond are 93.5 and 97 ft, respectively (USACE, 2003a).

Allendale Pond is a relatively shallow pond, with water depths ranging from less than 0.5 ft to a maximum of approximately 10 ft (Lockheed Martin, 2003) (Figure 2-6). Shallow areas of the pond are generally located in the north central and northeast regions of the pond. Deeper areas are generally located in the southern part of the pond. A deep flow channel is apparent along the western side of the pond, appears to cut across to the eastern side in the southern part of the pond, and then curves around towards the dam.

Soft sediment is underlain by hard sediment or possibly bedrock throughout the pond. The thickest soft sediments occur away from the present flow channel, in shallow water depths, although thick sediments also occur in deeper water in the southern portion of the pond (Figure 2-7). Apparent bedrock outcrops were observed on the east side of the pond, approximately halfway between the head of the pond and Allendale Dam.

The sediment bed in Allendale Pond is generally composed of cohesive sediment (i.e., muddy sediment with some sand and gravel). The surface layer (i.e., approximately top 6 to 12 inches) in Allendale Pond is primarily composed of fine-grained cohesive sediment with sandy sediment found in the deeper portions of the bed. Core logs presented in USACE/ERDC (2004) show that, generally, surficial sediment is classified as peat.

Sedimentation rates for Allendale Pond range on average from 0.5 centimeters per year (cm/yr) to 0.8 cm/yr (QEA, 2004), indicating that it will take approximately 40 to 60 years for 1 foot of sediment to accumulate on the pond bottom.

2.3.8.2 Lyman Mill Reach

The Lyman Mill reach includes the segment of the river between the Allendale and Lyman Mill Dams. This segment of the river includes the Oxbow and Lyman Mill Pond. The Woonasquatucket River is channelized below Allendale Dam (Figure 1-1). The Oxbow (Figure 2-8) has an area of approximately 27 acres. Lyman Mill Pond is located south of the Oxbow, and has an area of approximately 23.5 acres. The 100-yr flood elevation follows a gradient of 82.1 ft at the stream below the Allendale Dam to 80.6 ft at the Lyman Mill Dam (FEMA, 1993).[3] More recent studies are consistent with these flood elevation values. A wetland delineation study at the Oxbow (Section 2.3.10) showed that the wetland boundary to the north generally followed the 82-ft elevation contour (USACE, 2008). Further, among the floodplain soils collected at the Oxbow, only the sample collected above the 82-ft elevation contour had a dioxin signature similar to background,[4] indicating that this area had not been impacted by site contamination during flooding (MACTEC and Battelle, 2006). The normal water and 100-yr flood elevations at Lyman Mill Pond (77 and 80.6 ft, respectively) are based on the hydrodynamic model (QEA, 2004) developed using bathymetric data from the 2002 geophysical investigation at Lyman Mill Pond (Lockheed Martin, 2003). A recent survey at Lyman Mill Dam confirmed the normal water elevation of 77 ft (Loureiro Engineering Associates [LEA], 2005).

[3] For the purposes of this FS, it is assumed that the 100-yr flood elevation transition from 82.1 to 80.6 ft occurs along the stream channel just north of the Lee Romano ball field, where the surface water transitions from free-flowing to lacustrine (i.e., lake-like) conditions.

[4] The background dioxin signature is typically dominated by octachlorinated dibenzo-p-dioxin relative to the other congeners. The site dioxin signature is typically dominated by high levels of TCDD relative to the other congeners.

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The water level in Lyman Mill Pond has probably remained relatively constant for many years, and water depths range from less than 1 ft to a maximum of 9 ft (Lockheed Martin, 2003) (Figure 2-9). A deep flow channel is apparent along the eastern side of the pond. A prominent north-south trending ridge of sand and gravel divides the southernmost part of the pond.

Shallow water in the north end of the pond corresponds with thicker soft sediments (Figure 2-10). Soft sediments are underlain by a relatively hard sediment or possible bedrock; ground penetrating radar data suggest that bedrock is probably close to the surface in the central part of the pond (Lockheed Martin, 2003).

Sediment cores from Lyman Mill Pond consistently show a surface layer of gelatinous, highly organic silt ranging from less than 1 ft in the northern section of the pond to almost 4 ft in the southern portion (average thickness of about 2 ft). The organic silt layer is underlain by peat, clay, and sand in most locations. Gravel was found in some cores, especially those located in the flow channel.

Sedimentation rates for Lyman Mill Pond range on average from 0.5 cm/yr to 0.6 cm/yr (Appendix B), indicating that it will take approximately 50 to 60 years for 1 ft of sediment to accumulate on the pond bottom.

2.3.9 Surface Water Hydrology

The USGS has monitored streamflow for the Woonasquatucket River at Centerdale (USGS gauge station 01114500) since the early 1940s, and a wide range of streamflow statistical data is available on the Web (USGS, 2010). Streamflow is from north to south. Annual mean streamflow has ranged from 50 cubic feet per second (cfs) to 100 cfs in most years. The highest measured peak streamflow (1,530 cfs) was recorded in October 2005, which corresponds with the last documented flooding of the Woonasquatucket River.

Historical flowrate data from the USGS gauging station were used by USACE/ERDC to conduct a flood frequency analysis for determining flood flowrates with return periods ranging from 5 to 100 years. These flowrates were used in the sediment stability study to predict areas and depths of erosion resulting from flood events (QEA, 2004 and 2006). ERDC updated the flood frequency analysis in 2006 to include recent streamflow data from the USGS, and to calculate flowrates for a range of flood return periods ranging from 5 to 1,000 years. Table 2-4 summarizes the flowrates calculated in the updated flood frequency analysis (USACE/ERDC, 2006). For the 100-yr flood, the highest peak flow is 2,300 cfs (average regional skew, expected probability peak). This flowrate was used in the FS alternatives analysis (Section 6.0).

2.3.10 Ecology

The ecological habitats associated with the CMRP site are characteristic of fragmented, disturbed, and developed landscapes in the New England region and include riverine, lacustrine, and palustrine systems (MACTEC, 2004). Overall, a diverse mix of animals (invertebrates, fish, amphibians, birds, and mammals) and plants occur in (or adjacent to) the Woonasquatucket River. At the level of river from the site downstream into Providence, Rhode Island, fish and aquatic invertebrates associated with the Woonasquatucket River are typical of a warm-water fishery in New England; these organisms support a variety of wildlife species with diets that consist primarily of fish, invertebrates, or a variety of prey types (piscivores, insectivores/vermivores, and omnivores, respectively). However, upstream of Greystone Mill Pond, the aquatic habitat is more typical of a cool water fishery with habitat that can support rainbow trout (Libby, 2004).

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Floodplain and wetland areas that border parts of the river provide ecological habitat to animals and plants. For the purpose of this FS, floodplain areas are defined as the area above the normal water elevation and below the 100-yr flood elevation. Wetlands are generally recognized as habitats where the land is inundated and surface soils are wet for some period of time each year, but not necessarily permanently wet. Wetland definitions vary depending on the jurisdiction; federal jurisdictional wetlands are identified using positive field indicators for hydric soils, hydrology, and wetland plants (i.e., the 3-parameter method; Environmental Laboratory, 1987). Although RIDEM uses a similar procedure to delineate wetland boundaries, state regulations also recognize the presence of perimeter and submergent plant community wetlands (RIDEM, 2009). Pond, stream, and floodplain areas within the 1.5 mile reach of the river identified for the site are shown in Figure 1-3. In addition, wetland areas included in the RIGIS are depicted in this figure as well as federal jurisdictional wetlands in the Oxbow (inset to Figure 1-3) delineated by the USACE (2008).

The most significant wetland area addressed in this FS is the Oxbow located within the Lyman Mill reach. The Oxbow (inset in Figure 1-3) is characterized as a palustrine forested[5] wetland dominated by mature red maple trees (*Acer rubrum*) bordered to the south by fringing palustrine emergent and scrub shrub wetland habitats. Although approximate acreage for the palustrine forested and emergent wetland habitat types has not been measured, the USACE New England District has conducted a wetland delineation and functional assessment of the Oxbow (USACE, 2008), which provided acreage estimates that are summarized in Table 2-5. According to USACE (2008), "the Oxbow is among the largest areas of forested riparian habitat remaining along the Woonasquatucket River downstream of the Smithfield town line. The vegetated wetlands exhibit functions that are typical of freshwater palustrine systems. The most important function provided by the Oxbow wetlands is wildlife habitat. Other wetland functions and values provided by the wetlands to a notable degree include flood flow alteration, fish habitat, sediment/toxicant reduction, nutrient removal/transformation, production export, uniqueness/heritage value, and carbon sequestration." Some small potential vernal pools are also located within the Oxbow (inset in Figure 1-3); as described in the USACE (2008) report, although these pools lack some of the features characteristic of classic vernal pools they may be permanent fishless pools as defined by Colburn (2004). Because fish are excluded from these types of habitats (either because of their ephemeral nature or the lack of connectivity with larger aquatic habitat), they are important to regionally rare animals such as salamanders and certain invertebrates, whose aquatic stages are susceptible to fish predation.

Within the reaches comprising the Allendale and Lyman Mill Ponds, wetland vegetation (e.g., black willow [*Salix nigra*] and yellow birch [*Betula alleghaniensis*]) is found within the narrow riparian zone along the pond edges and it is likely that federal jurisdictional wetlands and floodplains are coincident throughout most of this zone. Scrub/shrub (including alders [*Alnus* spp.]) and herbaceous marsh (such as rushes and sedges) wetland vegetation is also present in the floodplain located immediately south of Cap Area #1 and similar vegetation may have (or may) become re-established along portions of Cap Area #3 (i.e., the former mill tailrace located just east of the Centredale Manor apartment building following the removal action in 2004). Finally, areas of the two ponds dominated by emergent vegetation such as cattail (*Typha latifolia*) and swamp loosestrife (*Decodon verticillatus*) are considered wetlands under federal jurisdiction. This emergent marsh wetland habitat is most extensively developed in the northern portion of Lyman Mill Pond, just south of the Oxbow Area, but sporadic occurrences have been noted elsewhere.

[5] Part of the palustrine forest above the 100-yr floodplain (inset in Figure 1-3) is influenced by a storm drain and by seepage from the adjacent steeply sloped upland; for the purposes of this FS this area above the 100-yr floodplain is not considered part of the floodplain.

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As mentioned above, federal jurisdictional wetlands are also recognized as wetland resource areas under the RI Fresh Water Wetlands Act (RIDEM, 2009); however, the state jurisdiction also extends to a number of additional wetland types. Under the state regulations, the free-flowing portion of the river immediately downgradient of the Allendale Dam is considered to be a "flowing water wetland" and the slow-flowing portions of the Woonasquatucket River behind the Allendale and Lyman Mill Dams may be either "flowing water" or "standing water" wetlands pending a specific determination by a state wetlands biologist (Kowal, 2010). State regulations also recognize a 50 foot "perimeter" wetland associated with swamps, marsh, and pond habitats and a 200 foot "riverbank" wetland associated with rivers that are 10 ft or greater in width. Finally, any "Area Subject to Flooding" or other areas defined by the 100 year flood boundary (i.e., Flood Plain) are considered freshwater wetlands, although these resource areas do not have associated perimeter or riverbank wetlands associated with them (RIDEM, 2009). In summary, floodplain areas are always considered wetlands from the state perspective, both Allendale and Lyman Mill Sediment Action Areas are wetlands (being either river or pond wetlands and also in many areas including Submergent Plant Community wetlands [open water habitat associated with some of Allendale Pond and a majority of Lyman Mill Pond] along with fringing Emergent Plant Community wetland along portions of both ponds). Finally, riverbank wetlands extend landward from the edge of the Allendale and Lyman Mill Sediment action area to a distance of either 50 or 200 ft depending on whether a given reach of the river is considered to be "pond" or "river" wetland.

2.4 Conceptual Site Model

This section summarizes the most significant findings of the RI (Battelle, 2005a), which are incorporated into an integrated CSM for the CMRP site. The CSM illustrates the sources of contamination, release mechanisms, transport pathways, migration routes, contaminated media, exposure pathways, and potential receptors (Figures 2-11a and 2-11b).

Findings from the supplemental investigations (Section 2.2.4) which were conducted to address data gaps identified in the RI have been incorporated into the CSM; complete details regarding the supplemental investigations are provided in Appendices A, B, and C.

2.4.1 Primary Sources of Contamination

The primary sources of contamination included handling, storage and disposal of chemicals associated with the chemical manufacturing and drum reconditioning operations that occurred at the source area from approximately 1943 to the early 1970s (EPA, 2000a). The facilities responsible for these activities are no longer in operation.

2.4.2 Primary Release and Transport Mechanisms

Chemicals were apparently released directly to the ground, buried, and possibly discharged directly to the Woonasquatucket River (Emhart Industries v. Home Insurance Co., 2006b). Direct infiltration of chemicals and leaching through the ground surface led to the contamination of surface and subsurface soils in the source area. Leaching has led to localized groundwater contamination. Discharge of chemicals directly into the river, overland flow of chemicals, and erosion and transport of contaminated soils at the source area by surface runoff resulted in contamination of surface water and sediment in the adjacent river and ponds and former tailrace on the east side of the source area site.

2.4.3 Nature and Extent of Contamination

Primary release and transport mechanisms led to the contamination of source area soil and groundwater, river and pond sediments, floodplain soils, surface water, and biota at the CMRP site (Figure 2-11a and

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Table 2-6a). Major findings regarding the nature and extent of contamination in these media are summarized below, with a focus on chemicals for which there are established PRGs (i.e., dioxin), potential ARARs for the site (i.e., RIDEM residential direct exposure and GB leachability criteria for soils, RIDEM GB groundwater objectives, and federal Water Quality Criteria [WQC]), or contaminants that were determined to be the primary contributors to unacceptable human health and ecological risks (statistical summaries of the site data are presented in Table 2-6b).

2.4.3.1 Source Area Soils

Concentrations of dioxin are above EPA's recommended residential level[6] (dioxin as toxic equivalency [TEQ]) in surface soils (0 to 1 ft bgs) throughout the source area (Figure 2-12). Contaminant concentrations in vadose zone soils (average thickness of the vadose zone in the source area is 5 ft) were also above RIDEM residential direct exposure and GB leachability criteria at numerous locations throughout the source area (representative contaminants including total PCBs and VOCs are shown in Figures 2-13 and 2-14, respectively). The contaminants most frequently detected at concentrations exceeding the residential direct exposure criteria are dioxin (Figure 2-12), medium to high molecular weight PAHs, PCBs (Figure 2-13), and several inorganics. Concentrations of total PCB exceed the Toxic Substances Control Act (TSCA) criteria of 50 milligrams per kilogram (mg/kg) at 15 locations at the source area, many of the exceedances occur at the central and southern portions of the source area under Cap Area #1 and the Centredale Manor parking lots (Figure 2-13). VOCs exceeded the direct exposure criteria in some samples, but at a lower frequency than the analytes noted above. Leachability criteria for VOCs were exceeded in samples from six locations (Figure 2-14). The majority of source area soils with contaminant concentrations above the exposure or leachability criteria are located in paved or capped areas. However, soils in several small areas that are not paved or capped have contaminant concentrations exceeding either RIDEM's direct exposure criteria or EPA's recommended residential level for dioxin.

Summary Statistics for Dioxin and PCB in Source Area Soil (see Table 2-6b and Battelle [2005a] for detail data)

	Dioxin TEQ (ng/kg)	**Total PCB (mg/kg)**
% Detection	100%	74%
Minimum	0.000079	0.0074
Maximum	140,000	1,300
Geometric Mean	118	0.29
Location Maximum	CMS-240 (Cap Area #1)	CMS-147 (Cap Area #1)

Dioxin is most widespread and present at the highest concentrations under Cap Area #1 (Figure 2-12). Soil sampled at numerous locations beneath Cap Area #2 also contained dioxin TEQ at concentrations above EPA's recommended residential level (Figure 2-12). PCB concentrations exceed RIDEM's residential direct exposure and GB leachability criteria at numerous locations in the central and southern portion of the source area (but not in the Brook Village parking lot) (Figure 2-13). Dioxin TEQ concentrations decrease with increasing depth, with only localized contamination found at depths greater than 5 ft bgs. PCB concentrations are highest at 2 to 3 ft bgs, and then decrease with increasing depth.

[6] EPA's recommended residential level for dioxin (as TEQ) of 1,000 nanograms per kilogram (ng/kg) (or 1 part per billion [ppb]) (EPA, 1998b). Dioxin TEQ (also referred to as dioxin/furans TEQ) concentrations reported in the FS are calculated using Toxic Equivalency Factors (TEFs – ranging from 0 to 1) to express the concentrations of individual dioxin and furan congeners in terms of their equivalent toxicity relative to 2,3,7,8-TCDD. The TEQ (or overall toxic equivalency to 2,3,7,8-TCDD) is the sum of the concentrations of the 17 dioxin-furan compounds with established TEFs that exceed zero, each multiplied by the corresponding TEF value.

Six VOCs exceeded the RIDEM direct exposure criteria for soils in more than one vadose zone sample: benzene, chlorobenzene, tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride, and xylenes (Battelle, 2005a). SVOC and metals concentrations were also above the RIDEM direct exposure criteria for residential soils at several locations.

2.4.3.2 Source Area Groundwater

Groundwater contamination at the CMRP site is not pervasive or widespread. Instead, leaching of contaminants from soil has led to localized groundwater contamination, particularly on the west side of the Brook Village parking lot, adjacent to the Woonasquatucket River. For example, in 2002, concentrations of VOCs were below RIDEM GB groundwater criteria except for PCE in samples from two wells (MW05S and MW14M) in the Brook Village parking lot and one well (MW13D) in the southern end of the source area (Figure 2-15; TCE was also in excess of RIDEM GB groundwater criteria at MW05S). PCE concentrations in the southern well were two orders of magnitude lower compared to levels measured at MW05S in the Brook Village parking lot. Elevated concentrations of VOCs (i.e., PCE, TCE, and cis-1,2-dichloroethylene) were also measured in groundwater sampled along the eastern bank of the river adjacent to the Brook Village parking lot (LEA, 2008). VOC concentrations generally decreased from 2001 to 2002. Groundwater data collected at Well MW-05S in 2005 suggest that VOC concentrations have continued to decline (Figure 2-16 and Appendix A). Trace levels of other contaminants (e.g., phenols and dioxin) have been detected in some groundwater samples.

High concentrations of dioxin (2,3,7,8-TCDD) were also measured in groundwater samples from Well MW-05S (Figure 2-16), whereas dioxin concentrations in groundwater from other monitoring wells in the source area were two or three orders of magnitude lower. A passive vapor diffusion survey identified a plume of VOC-contaminated groundwater discharging to the river near and immediately downstream of Well MW-05S (USGS, 2000). Sampling at one boring location near MW-05S noted a greenish non-aqueous phase liquid (NAPL), and Well MW-05S has PCE concentrations suggestive of the presence of NAPL. It appears that groundwater in the vicinity of Well MW-05S contains dissolved or suspended concentrations of dioxin, which is believed to be subsequently discharging to the river. Supplemental groundwater investigations conducted at the source area in 2005 demonstrated that the groundwater plume is likely an ongoing source or migration pathway of dioxin (2,3,7,8-TCDD) from the source area to the Woonasquatucket River (Appendix A). The 2008 groundwater investigation confirmed the presence of dioxin (2,3,7,8-TCDD) in groundwater (in dissolved phase and whole water) sampled along an 85-ft stretch of the eastern bank of the river in the area of the groundwater plume; the highest dioxin concentrations (2,740 picograms per liter [pg/L] and 6,150 pg/L) were measured in groundwater immediately west and downgradient of Well MW-05S (LEA, 2008). Estimates of the potential flux of 2,3,7,8-TCDD from groundwater to surface water of the river suggest that 2,3,7,8-TCDD loadings to the river could range from 140 to 4,200 micrograms of 2,3,7,8-TCDD per year (Appendix A, Table A-8). The wide range in loading values reflects uncertainty with key hydrogeologic and groundwater chemical factors used to estimate the flux (Appendix A).

Summary Statistics for Dioxin, PCE, and TCE in Source Area Groundwater (see Table 2-6b and Appendix G for detail data)

	2,3,7,8-TCDD (pg/L)	PCE (µg/L)	TCE (µg/L)
% Detection	49%	41%	34%
Minimum	0.95	0.1	0.0435
Maximum	6,154	61,000	2,500
Median	3.4	5.0	3.2
Location Maximum	MW-LEA-02 (river bank at Brook Village parking lot)	MW-05S (Brook Village parking lot)	

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2.4.3.3 Allendale and Lyman Mill Reach Sediments

The baseline risk assessments (Section 2.5) indicated that the greatest human health and ecological risks at the CMRP site are associated with exposure to contaminants that reside in sediments and pose a bioaccumulation hazard. The predominant contributors to human health and ecological risk are dioxin (2,3,7,8-TCDD and dioxin TEQ) and PCBs although other contaminants also contribute to ecological risks to specific receptors. For instance, a substantial number of PAHs, pesticides, and inorganic contaminants were detected in pond sediments at concentrations exceeding sediment benchmarks protective of exposures to benthic macroinvertebrates. This potential toxicity was confirmed by the results of laboratory toxicity tests, which demonstrated statistically significant adverse effects to laboratory test organisms relative to background conditions.

Dioxin contamination in the Allendale and Lyman Mill sediments is characterized by 2,3,7,8-TCDD, which was typically detected at high concentrations relative to the other congeners. Widespread dioxin contamination is evident in the surface (uppermost 1 ft) sediments at Allendale (Figure 2-17) and Lyman Mill (Figure 2-18) Ponds. The vertical extent of dioxin contamination typically showed higher contamination in the uppermost 1 ft of sediment in Allendale Pond (Figure 2-19), and in the uppermost 1 to 2 ft in Lyman Mill Pond (Figure 2-20). Dioxin concentrations are highest in Allendale Pond (mean concentration of 972 ng/kg dioxin TEQ and 879 ng/kg 2,3,7,8-TCDD), and decrease in a downstream direction. Moreover, surface dioxin concentrations at Allendale Pond are generally highest where soft sediments have accumulated and are thickest, i.e., outside the deeper flow channel, in the shallow portions of the pond (compare Figures 2-6, 2-7 and 2-17). Dioxin (TEQ and 2,3,7,8-TCDD) concentrations in the Allendale and Lyman Mill reaches of the river are significantly[7] higher than upstream (background) concentrations (Appendix B, Table B-4). Similar to dioxin, the mean concentrations of a majority of other contaminants are typically highest in Allendale Pond sediments; however, average concentrations of technical chlordane, arsenic, and vanadium are greatest in Lyman Mill Pond followed by Allendale Pond (Appendix B, Table B-4).

Summary Statistics for Dioxin and PCB in Allendale and Lyman Mill Reach Sediment (see Table 2-6b, Battelle [2005a], and Appendix B of this FS for detail data)

	Allendale		Lyman Mill	
	2,3,7,8-TCDD (ng/kg)	**Total PCB (mg/kg)**	**2,3,7,8-TCDD (ng/kg)**	**Total PCB (mg/kg)**
% Detection	97%	89%	97%	80%
Minimum	0.2	0.0006	0.035	0.0006
Maximum	110,000	28	49,421	3.26
Geometric Mean	879	0.27	433	0.135
Location Maximum	CMS-208	CMS-607	LPX-SD-4205	

Radiometric age dating results indicate that no significant dioxin contamination was found in sediments deposited prior to 1940. Maximum dioxin concentrations generally correspond to sediments deposited between about 1950 and 1970 at Allendale Pond; this period corresponds with the years when the chemical manufacturing and barrel refurbishing operations took place. Maximum dioxin concentrations in Lyman Mill Pond generally correspond to sediment deposited between 1960 and 2000 (Appendix B), which corresponds with the time that chemical manufacturing and drum reconditioning activities occurred at the CMRP site and possibly also reflects downstream transport of contaminated sediments following

[7] Statistical comparisons were conducted using a modified Kaplan-Meier test at the 0.05 significance level; statistical methods are summarized in Appendix B and described in detail in Appendix A of the site RI (Battelle, 2005a).

the breach of the Allendale Dam in 1991 and again in 2001. The most recently deposited sediments at Allendale and Lyman Mill Ponds still show evidence of dioxin contamination, which may reflect that upland sources were not completely controlled (i.e., most of the contaminated soils in the source area were not capped) until approximately 2004. Additionally, post-depositional processes (such as bioturbation and sediment resuspension) may have mixed surface sediment with more highly-contaminated subsurface sediment.

While dioxin and other hydrophobic organic compounds tend to adsorb to fine-grained sediment particles and organic material, dioxin (TEQ) concentration and total organic carbon (TOC) content are not well correlated;[8] therefore, organic content cannot be used as a reliable predictor of dioxin contamination. Although dioxin (TEQ) concentration and grain size are not well correlated, dioxin concentrations are lowest in samples with less than 20% silt+clay and less than 3% TOC content.

An environmental forensics review of sediment chemistry data for chlorinated organic compounds suggests that different contaminants could have had different release histories and transport mechanisms. For example, dioxin (primarily 2,3,7,8-TCDD) contamination in sediment extended further downstream from the source area compared to PCB and pesticide contamination. Further, 2,3,7,8-TCDD concentrations in sediment are significantly higher in the reaches of the river adjacent to and downstream of the CMRP site relative to upstream background concentrations; whereas, PCB and pesticide concentrations in sediment generally were not significantly higher than upstream background concentrations below Allendale Dam (Battelle, 2005a). These differences could arise from differences in timing, location, and magnitude of the original releases, and in subsequent transport mechanisms.

2.4.3.4 Allendale and Lyman Mill Reach Floodplain Soils

Floodplain soils are located in floodplain and wetland areas that border parts of the river (Figure 1-3). Throughout the reaches associated with Allendale and Lyman Mill Ponds (with the exception of the Oxbow Area), it is likely that the majority of the bordering floodplain area includes federal jurisdictional wetlands. This conclusion is based on the presence of positive wetland indicators (i.e., hydric soils, vegetation, and hydrology) that have been observed during various site visits by wetland scientists. The predominant contributor to human health and ecological risk is dioxin (2,3,7,8-TCDD and dioxin TEQ) although other contaminants (e.g., PCBs and selected pesticides and metals) also contribute to risks to specific receptors. Dioxin concentrations are higher in the Allendale and Lyman Mill floodplain soils compared to the upstream background area (MACTEC, 2004), but are only present at concentrations above EPA's recommended residential level (EPA, 1998b) at less than 3% of the locations sampled.[9] The highest dioxin concentration was detected in the Oxbow wetland, within approximately 75 ft of the Woonasquatucket River in an area where floodwaters appear to routinely overflow the banks of the river (MACTEC and Battelle, 2006). Dioxin TEQ concentrations in floodplain soils from the Oxbow wetland are within the range measured in sediment samples from Allendale and Lyman Mill Ponds (Battelle, 2005a), suggesting that low-lying areas in this forested wetland have been impacted by contamination from the CMRP site. This is consistent with the geomorphology investigation which showed that this area is impacted during flooding and times of high water. Further, all but one of the Oxbow floodplain soils had a dioxin signature dominated by 2,3,7,8-TCDD, which is consistent with the CMRP site dioxin signature (MACTEC and Battelle, 2006). The sample collected above the 100-yr flood elevation had a dioxin signature similar to background concentrations (MACTEC and Battelle, 2006).

[8] Correlation coefficients <0.3 (Battelle, 2005a).

[9] Sample data for contaminated material excavated under the NTCRAs were not used to characterize the nature and extent of contamination. Dioxin TEQ concentrations are in excess of EPA's recommended residential level at one location along the western shore of Allendale Pond; three locations in the Oxbow (sampled after the NTCRA); and two locations along the eastern shore of Lyman Mill Pond.

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Contaminant concentrations were below the available RIDEM GB leachability criteria in floodplain soils associated with Allendale and Lyman Mill reaches (including Oxbow wetland).[10] Detected concentrations of many contaminants (e.g., SVOCs, VOCs, metals) in floodplain soils were also below the available RIDEM residential direct exposure criteria. Contaminants infrequently (<10% of the samples) measured at concentrations in excess of the residential direct exposure criteria include pyrene, fluoranthene, phenanthrene, anthracene, dieldrin, antimony, copper and chromium. The most common contaminant detected at concentrations in excess of the residential direct exposure criteria was lead (61% of samples), followed by chrysene, beryllium, benzo(a)pyrene, arsenic, manganese, benzo(k)fluoranthene, benzo(b)fluoranthene, benzo(a)anthracene, technical chlordane, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene.

Summary Statistics for Dioxin and PCB in Allendale and Lyman Mill Reach Floodplain Soil (see Table 2-6b and Battelle [2005a] for detail data)

	Allendale		Lyman Mill	
	2,3,7,8-TCDD (ng/kg)	**Total PCB (mg/kg)**	**2,3,7,8-TCDD (ng/kg)**	**Total PCB (mg/kg)**
% Detection	86%	80%	87%	39%
Minimum	0.24	0.037	0.095	0.030
Maximum	1,510	0.78	1,130	0.859
Geometric Mean	22.4	0.258	8.58	0.055 (median)
Location Maximum	CMS-019	SS-05 (near Cap Area #1)	LPX-FP-4004 (Oxbow)	

2.4.3.5 Allendale and Lyman Mill Reach Surface Water

Dioxin (2,3,7,8-TCDD) concentrations in surface water at the Allendale and Lyman Mill reaches of the river are higher than background concentrations (dioxin was undetected in surface water at the upstream background; Appendix C). Even so, the BHHRA found that potential risks from direct exposure (dermal contact and incidental ingestion) to dioxin in surface water were not above the management range for Superfund (MACTEC, 2005a). The BERA found that the consumption of site surface water did not pose a risk to wildlife receptors; however, this was not necessarily the case for aquatic organisms that could be exposed to contamination through direct contact or ingestion pathways (MACTEC, 2004).

Summary Statistics for Dioxin in Allendale and Lyman Mill Reach Surface Water (see Table 2-6b and Appendix C of this FS for detail data)

	Allendale	Lyman Mill
	2,3,7,8-TCDD (pg/L)	
% Detection	42%	60%
Minimum	0.145	1.75
Maximum	4,000	853
Median	1.9	3.65
Location Maximum	APB-SW-2029	WRL-SD-2042 (stream channel at Oxbow)

Detected concentrations of many contaminants (e.g., SVOCs, VOCs, and PCBs) were below the State of Rhode Island standards or federal WQC[11] (RIDEM, 2006 and EPA, 2006) in

[10] Results from the comparison of floodplain soil data to the RIDEM residential direct exposure and GB leachability criteria are provided in Appendix F, Table F-2b.

[11] Chronic ambient freshwater and human health for consumption of water + organism criteria (RIDEM, 2006 and EPA, 2006).

surface water at the CMRP site.[12] Contaminants infrequently (<5% of the samples) detected at concentrations in excess of the standards/WQC include: chrysene, bis(2-ethylhexyl)phthalate, 4,4'-dichlorodiphenyltrichloroethylene (4,4'-DDE), 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT), endrin, alpha-BHC, alpha-chlordane, gamma-chlordane, total PCB, beryllium, cadmium, chromium, nickel, and selenium. The most common contaminant detected at concentrations in excess of the standards/WQC was copper (54% of samples), followed by arsenic, dioxin (2,3,7,8-TCDD), zinc, lead, and thallium. Among these contaminants, copper, arsenic, zinc, and lead were also measured in upstream locations at concentrations in excess of the standards/WQC, albeit generally at lower concentrations on average compared to concentrations at the source area. The presence of copper, arsenic, zinc, and lead in surface water at upstream locations suggests that the site contributes some of this contamination but that there are other upstream sources. Dioxin (2,3,7,8-TCDD) was not detected in upstream locations and thallium was only detected in upstream locations at concentrations below the WQC.

2.4.3.6 Allendale and Lyman Mill Reach Biota

Contaminant concentrations in biota and their significance are evaluated in the BERA and BHHRA (MACTEC, 2004 and 2005a). Although a fish consumption advisory has been issued by the State of Rhode Island, it is not believed to provide a sufficient barrier for human exposure to contaminated biota from the Woonasquatucket River in the short term. However, the advisory may be effective in reducing fish consumption rates in the reach of the river at the site. The BHHRA (MACTEC, 2005a) indicated that the consumption of contaminated fish was the predominant exposure pathway to non-cancer risk at the site, with Aroclor 1254 contributing the greatest portion of non-cancer risk. Fish consumption (and exposure to sediment) is also the predominant contributor to cancer risk, with dioxins and furans (primarily 2,3,7,8-TCDD) representing the largest chemical contributor to cancer risk. In general, the concentrations in fish tissue of the predominant risk contributors appear to be correlated with the corresponding sediment concentrations. Summary statistics and exposure point concentrations (EPCs) for contaminants in biota that contribute to carcinogenic and non-carcinogenic risks at Allendale and Lyman Mill Ponds are presented in Section 2.5.1 (Tables 2-7a and 2-7c). EPCs for the predominant contributors to risk (dioxin TEQ and Aroclor 1254) were slightly higher at Lyman Mill Pond compared to Allendale Pond.

The BERA (MACTEC, 2004) demonstrated that fish tissue residues of 4,4'-dichlorodiphenyldichloroethane (4,4'-DDD), 4,4'- -DDE, technical chlordane, Aroclor 1254, total Aroclors, dioxin TEQ, PCB TEQ, aluminum, barium, selenium, vanadium, and zinc pose an unacceptable risk to fish receptors. Moreover, the concentrations of 4,4-DDD, 4,4'-DDE, technical chlordane, Aroclor 1254, total Aroclors, dioxin TEQ, PCB TEQ, and zinc in fish tissue were shown to pose an unacceptable risk to piscivorous wildlife receptors that feed on fish from Allendale and Lyman Mill Ponds. These contaminants were detected in Allendale Pond and Lyman Mill Pond at concentrations that are elevated above background conditions; in general, average concentrations in biological tissue are greatest in Allendale Pond followed by Lyman Mill Pond although in some cases the reverse is true (e.g., coplanar PCBs [white sucker, tree swallow nestlings], chlordane [white sucker]). In general, the analytical data for contaminants in biological tissue appear to correlate well with the sediment chemistry data with respect to the relative magnitude (among different contaminants) and location (among different exposure areas).

2.4.3.7 Downstream Areas (Manton Pond and Former Dyerville Pond)

The greatest human health and ecological risks at downstream areas of the site (i.e., Manton Pond and the former Dyerville Pond [only pilings remain of the former Dyerville Dam, which apparently failed in the

[12] Results from the comparison of surface water data to the State of Rhode Island standards and federal WQC are provided in Appendix F, Table F-3b.

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1990s]) appear to be associated with the sediments that pose a bioaccumulation hazard (MACTEC, 2004 and 2005a). The predominant contributors to risk are dioxin (2,3,7,8-TCDD and dioxin TEQ) and PCBs although other contaminants such as selected pesticides (i.e., 4,4'- DDE, 4,4'- DDD, dieldrin, technical chlordane), metals (i.e., aluminum, barium, methyl mercury, vanadium, and zinc), and SVOCs (i.e., benzo(a)pyrene) also contribute as risks to specific receptors.

Concentrations of dioxin in sediment from reaches of the river downstream of Lyman Mill Dam were significantly higher relative to upstream background concentrations (Battelle, 2005a). However, concentrations of all other contaminants were not significantly different from upstream background concentrations (Battelle, 2005a), which is not unexpected in an urban setting such as the Lower Woonasquatucket River Watershed.

Results from investigations conducted since actions were taken to control the primary sources of contamination at the source area (Section 2.2.2) suggest that dioxin (2,3,7,8-TCDD) concentrations in surface sediment at downstream locations have decreased in recent years and are approaching upstream background concentrations (i.e., 14.7 ng/kg based on arithmetic mean of background data). For example, the median dioxin (2,3,7,8-TCDD) concentration in surface sediment at Manton Pond in April 2005 was 48.7 ng/kg (Battelle, 2005d), which represents a four-fold reduction compared to median concentrations in sediment collected in 1998–2000 (median concentration 190 ng/kg). Similarly, dioxin (2,3,7,8-TCDD) concentrations in three of four surface sediments collected in November 2006 at locations downstream of Manton Pond (EA Engineering, Science, and Technology, Inc., 2007) were below upstream background concentrations.

While the data are limited, results from these recent investigations suggest that dioxin concentrations may be decreasing over time, possibly due to natural recovery and control of primary sources of contamination at the source area. Downstream areas would continue to be assessed as part of the monitoring program (see Section 3.6).

2.4.4 Secondary Release and Transport Mechanisms

The most important potential transport mechanisms currently affecting the source area include erosion and runoff of contaminated soils, volatilization of contaminants from soils, leaching of contaminants from soil to groundwater, and advection of contaminants from groundwater to surface water and river sediment (Figures 2-11a and 2-11b). Erosion and runoff of contaminated soils, however, does not appear to be a major pathway of concern since implementation of TCRAs because the soil caps and paved surfaces currently prevent erosion and runoff. Volatilization of VOCs from vadose zone soils is not likely to be a significant pathway given the localized nature of VOC contamination, apparent lack of VOC migration into the Centredale Manor and Brook Village buildings, and presence of soil caps or pavement over the majority of the site. A leachability evaluation indicated that, with the exception of the vicinity of the Brook Village parking lot, leaching does not appear to be a major pathway of concern (Battelle, 2004c). Contaminated groundwater discharging to the Woonasquatucket River in the vicinity of the Brook Village parking lot is likely an ongoing source or migration pathway for 2,3,7,8-TCDD from the source area to the Woonasquatucket River (Appendix A and Section 2.4.3.2). While the magnitude of the ongoing groundwater source is not clear, concentrations of 2,3,7,8-TCDD in surface river sediments adjacent to this area were detected at elevated levels (Section 3.4), indicating risk. The elevated concentrations of 2,3,7,8-TCDD in adjacent river sediment may reflect legacy contamination from historic site activities, continuing contributions from contaminated groundwater, or a combination of the two.

Because of the hydrophobic and persistent nature of the primary contaminants (i.e., dioxin and PCBs), sediment resuspension and downstream transport are likely to be the most important potential transport pathways in the Woonasquatucket River (Figure 2-11a). A sediment stability evaluation of Allendale and

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Lyman Mill Ponds indicated that during a rare flood (i.e., 100-yr return period), significant scour (i.e., more than approximately 1 cm of erosion) will occur over 3% or less of the bed area in Allendale Pond, and over a larger area (up to 8%) in Lyman Mill Pond (Appendix E). Scour would generally occur in the northern portion of both ponds, with maximum erosion near the upstream inlets. Sediment eroded in the upstream portion of each pond during a flood would be transported downstream by river currents. A portion of the eroded sediment is likely to be redeposited within each pond where current velocities tend to decrease.

Analysis of surface water data from 1999 and 2004 (QEA, 2004 and 2006) suggests that minimal net export of dioxin from the two ponds occurs during low-flow, non-resuspending conditions. The water column load of dioxin entering the study area (i.e., the background load) is approximately equal to the load over Lyman Mill Dam during low-flow periods.

Evaluation of the biota data revealed the presence of contamination in biological tissue of various trophic level organisms (MACTEC, 2004 and 2005a), indicating that bioaccumulation is a significant transport pathway at the CMRP site for transfer of contaminants from lower trophic level organisms into upper trophic level organisms (Figure 2-11b). Compounds with a tendency to bioaccumulate are taken up by biota and are transferred through aquatic food webs. As a consequence, wildlife species that consume these lower trophic level organisms are also exposed to contaminants. Humans also are exposed to the contaminants through ingestion of fish and possibly other aquatic organisms.

Vertical dioxin profiles in sediment cores at Allendale and Lyman Mill Ponds (Figures 2-19 and 2-20) indicate that natural recovery (i.e., burial of contaminated sediment by cleaner sediment) may be occurring in some areas of the ponds, but not in others. A natural recovery trend is not expected to be apparent in the ponds at this point because contaminated soils in the source area were not completely capped until 2004, and post-depositional processes will continue to mix surface and subsurface sediments. Based on the average sedimentation rate for Allendale and Lyman Mill Ponds (Section 2.3.8), it will take approximately 40 to 60 years for 1 ft of clean sediment to deposit on the pond bottoms.

2.4.5 Principal Threat and Low-level Threat Wastes

The identification of principal threat and low-level threat wastes is applied on a site-specific basis with respect to characterizing the source(s) of contamination, i.e., source material. Examples of source materials generally include drummed wastes, contaminated soil and debris, pools of dense NAPLs submerged beneath groundwater or in fractured bedrock, and contaminated sediments and sludges. Non-source materials include groundwater, surface water, and residuals resulting from treatment of site materials. Consideration of site-specific factors can influence the determination as to whether a source material is a principal or low-level threat waste (EPA, 1991a).

Potential principal threat and low-level threat wastes for the CMRP site are summarized in Table 2-8. Principal threat wastes are those source materials considered to be highly toxic or highly mobile, that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. Wastes generally considered to be principal threats are liquid, mobile and/or highly-toxic source material. Low-level threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of a release. They include source materials that exhibit low toxicity, low mobility in the environment, or are near health-based levels. Wastes generally considered to be low-level threat wastes include non-mobile contaminated source material of low to moderate toxicity, surface soil containing contaminants that are relatively immobile in air or groundwater, low leachability contaminants or low toxicity source material.

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Principal threat wastes for the CMRP site include buried waste material that still may be present in the source area, particularly near the southern area of Cap Area #1 (buried waste materials are shown as possible buried metallic materials in Figure 2-1). This material under Cap Area #1 could be highly toxic and highly mobile and could present a significant risk to human health or the environment should exposure occur. Principal threat wastes for the CMRP site also include highly-toxic soils on the west side of the Brook Village parking lot and potentially NAPL. Leaching of contaminants from these soils has led to localized groundwater contamination in this area (maximum dioxin concentration in soil and groundwater is 140,000 ng/kg in soil at CMS-451 and 6,150 pg/L in groundwater at MW-LEA-02), and the enhanced transport of dioxin (2,3,7,8-TCDD) from the source area to the Woonasquatucket River (see Section 2.4.4).

Dioxin-contaminated soil and sediment at the CMRP site are highly toxic materials that could meet the definition of principal threat waste. However, site specific factors indicate it may be appropriate to address this material as low-level threat waste. While the dioxin-contaminated source area soil and Allendale and Lyman Mill reach sediment are toxic, these source materials exhibit low mobility in the environment. Hydrodynamic modeling performed for the site also showed that the risk of significant erosion is low in the majority of the pond areas, even during a rare flood event. The contamination is widely distributed with no identifiable 'hot spot' areas. Moreover, the contaminants in the sediment are hydrophobic and insoluble in nature, which makes them likely to remain sorbed to organic carbon in the sediment and relatively immobile (i.e., low volatility, low leachability). Finally, Allendale and Lyman Mill Ponds are relatively stable depositional settings. A similar conclusion can be reached for the floodplain soils because the contaminant levels are low and contamination is generally not mobile.

2.5 Summary of Human Health and Ecological Risks

This section summarizes the most significant findings of the baseline risk assessments that evaluated human health and ecological risk from exposure to contamination at the CMRP site (MACTEC, 2005a and 2004; MACTEC and Battelle, 2006). Overall, the risk assessments showed that the receptors at risk include residents living along the river, visiting recreational anglers, passive recreational visitors, benthic invertebrate communities, fish, and bird and mammal populations. Visiting subsistence anglers were also found to be at risk, however, it is uncertain whether there is currently a significant population of subsistence anglers at the CMRP site (MACTEC, 2005a). Moreover, large uncertainties are also associated with the actual fish consumption patterns and rates for this exposure scenario. As a result, the summary of human health risks described below does not include a discussion of the visiting subsistence anglers. Further details regarding the potential risks to this receptor subpopulation are provided in an appendix to the BHHRA (MACTEC, 2005a).

Overall, the greatest risks at the CMRP site are associated with consumption of contaminated fish or prey, and direct contact with contaminated sediment and floodplain soil. The primary risk drivers are dioxin (2,3,7,8-TCDD and dioxin TEQ[13]) and PCBs but other contaminants contribute to risk as well.

2.5.1 Human Health Risks

The BHHRA evaluated potential risks to human health associated with the consumption of fish and human contact with sediment, soil (bank, surface soils, and floodplain), and surface water at the CMRP site. Exposure to source area soils was not evaluated because TCRAs have been taken to prevent human contact with source area soils (Section 2.2.2) and additional actions will be taken in accordance with

[13] TEFs used to calculate dioxin TEQ were revised in 2005 (Van den Berg et al., 2006) from the 1998 values (Van den Berg et al., 1998) used in the baseline risk assessments. The revised TEF values are not expected to impact the risk assessment conclusions because in general, the great majority of the overall TEQ concentrations are contributed by 2,3,7,8-TCDD (which has a TEF equal to one in both the 1998 and 2005 lists).

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ARARs and the EPA guidance dioxin level to ensure the remedy remains protective. Exposure to residential-use groundwater was not evaluated because groundwater is not a source of drinking water at the site. However, the groundwater discharge pathway into the river can be a contributor to risk identified for consumption of fish through bioaccumulation. Overall, findings from the BHHRA (MACTEC, 2005a) showed that the greatest human health risks at the CMRP site are associated with potential exposure to dioxins and furans (primarily 2,3,7,8-TCDD) from consumption of fish.

Action is generally warranted at a site where the incremental risks (i.e., those related to exposures in excess of background conditions) from exposure to contamination are above EPA's guidelines, i.e., reasonable maximum exposure (RME) cancer risk of one in ten thousand (10^{-4}) and non-cancer hazard index (HI) value of 1. Key findings from the BHHRA summarized in this section focus on site contamination that presents cumulative cancer and non-cancer risks above EPA's guidelines. Key findings are discussed in terms of who is at risk and what exposure routes, areas, media, and contaminants present risk above EPA's guidelines. Supporting information from the risk assessment is summarized in Table 2-7 and Tables 2-9 through 2-12. Summary statistics and EPCs for the contaminants that contribute to carcinogenic and non-carcinogenic risk are summarized in Table 2-7. Cancer and non-carcinogenic toxicity data for all contaminants and exposure pathways with actionable risk are summarized in Tables 2-9 and 2-10, respectively. The carcinogenic and non-carcinogenic risk results are summarized in Tables 2-11 and 2-12, respectively.

2.5.1.1 Human Receptors at Risk

The BHHRA (MACTEC, 2005a; MACTEC and Battelle, 2006) indicated that residents living along the river, visiting recreational anglers, and passive recreational visitors[14] are at risk from exposure to contamination at the CMRP site. Exposure to biota by consumption of fish and exposure to sediment and floodplain soil by dermal contact and incidental ingestion present cumulative incremental risks above EPA's guidelines, as follows:

Biota – Residents living along the river and visiting recreational anglers that consume contaminated fish from Allendale and Lyman Mill reaches are at risk. The contaminants in Allendale reach biota that present cumulative incremental cancer risk above EPA's guidelines include: Aroclor 1254, Aroclor 1268, dieldrin, technical chlordane, dioxin-like PCBs (reported as PCB TEQ), and dioxins and furans (primarily 2,3,7,8-TCDD) (Tables 2-11a and 2-11c). The contaminants in Lyman Mill reach biota that present cumulative incremental cancer risk above EPA's guidelines include: benzo(a)pyrene, 4,4'-DDE, Aroclor 1254, Aroclor 1268, dieldrin, technical chlordane, dioxin-like PCBs (reported as PCB TEQ), and dioxins and furans (primarily 2,3,7,8-TCDD) (Tables 2-11b and 2-11d). The contaminant in the biota at Allendale and Lyman Mill reaches that present cumulative incremental non-cancer risk above EPA's guidelines is Aroclor 1254 (Tables 2-12a through 2-12d).

Sediment – Residents living along the river that are exposed to Allendale and Lyman Mill sediment through dermal contact and incidental ingestion are at risk. The contaminants in Allendale sediment that present cumulative incremental cancer risk above EPA's guidelines to residents include: benzo(a)pyrene, dibenzo(a,h)anthracene, arsenic, and dioxins and furans (primarily 2,3,7,8-TCDD) (Table 2-11a). The contaminants in Lyman Mill sediment that present cumulative incremental cancer risks above EPA's guidelines to residents include: n-nitroso-di-n-propylamine, benzo(a)pyrene, dibenzo(a,h)anthracene, arsenic, and dioxins and furans (primarily 2,3,7,8-TCDD) (Table 2-11b). Exposure to Allendale and Lyman Mill sediment do not present cumulative non-cancer risk above EPA's guidelines.

[14] The calculated risks associated with floodplain soil exposure at the Oxbow Area for the passive recreational visitor are within the EPA acceptable risk range based on the alternative exposure scenario (Appendix D, Part III).

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Floodplain Soil – Passive recreational persons that visit the Oxbow wetland and are exposed to floodplain soil through dermal contact and incidental ingestion are at risk. The contaminants in Oxbow floodplain soil that present cumulative incremental cancer risks above EPA's guidelines include: Aroclor 1254, arsenic, and dioxins and furans (reported as dioxin TEQ) (Table 2-11e). Dioxin TEQ is the largest single contributor to the incremental cancer risk. Exposure to floodplain soils at the Oxbow wetland does not present cumulative non-cancer risk above EPA's guidelines.

Exposure to surface water and bank soil at Allendale and Lyman Mill reaches does not present an unacceptable risk to residents living along the river or visiting recreational anglers. Contaminants in surface water and sediment,[15] however, can indirectly lead to risk as a consequence of anglers consuming fish tissue that has bioaccumulated contaminants from these media.

In summary, the human health risks are summarized below.

Allendale Reach

- Fish Consumption – Cancer risk to residents and visiting recreational anglers through ingestion (biota consumption) of Aroclor 1254, Aroclor 1268, dieldrin, technical chlordane, dioxin-like PCBs (PCB TEQ), and dioxins and furans (primarily 2,3,7,8-TCDD). Non-cancer risk to residents and visiting recreational anglers through ingestion (biota consumption) of Aroclor 1254.
- Sediment – Cancer risk to residents through dermal contact/incidental ingestion of benzo(a)pyrene, dibenzo(a,h)anthracene, arsenic, and dioxins and furans (primarily 2,3,7,8-TCDD).

Lyman Mill Reach

- Fish Consumption – Cancer risk to residents and visiting recreational anglers through ingestion (biota consumption) of benzo(a)pyrene, 4,4'-DDE, Aroclor 1254, Aroclor 1268, dieldrin, technical chlordane, dioxin-like PCBs (PCB TEQ), and dioxins and furans (primarily 2,3,7,8-TCDD). Non-cancer risk to residents and visiting recreational anglers through ingestion (biota consumption) of Aroclor 1254.
- Sediment – Cancer risk to residents through dermal contact/incidental ingestion of n-nitroso-di-n-propylamine, benzo(a)pyrene, dibenzo(a,h)anthracene, arsenic, and dioxins and furans (primarily 2,3,7,8-TCDD).
- Floodplain Soil – Cancer risk to passive recreational visitors to the Oxbow through dermal contact/incidental ingestion of Aroclor 1254, arsenic, and dioxins and furans (dioxin TEQ).

2.5.2 Ecological Risks

The BERA evaluated potential adverse ecological effects to wildlife associated with the consumption of contaminated prey, drinking water, and the incidental ingestion of surface soil and sediment during foraging or preening activities. In addition, the BERA evaluated potential ecological effects to other ecological receptors (including macroinvertebrates and fish) associated with direct contact and ingestion of surface water, sediment, and/or floodplain soil.

Ecological receptor species considered in the BERA include aquatic and floodplain invertebrates, amphibians, fish, birds, and mammals that depend on aquatic resources of the Woonasquatucket River.

[15] The relative significance of the surface water and sediment media on the potential bioaccumulation of contaminants in aquatic food webs associated with Allendale Pond and Lyman Mill Pond was not determined in the BHHRA.

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Overall, findings from the BERA (MACTEC, 2004) indicate that the primary exposure pathway of concern to wildlife receptors is ingestion of contaminated prey, and that concentrations of the predominant risk contributors (e.g., dioxin) in prey (biota) are directly related to corresponding sediment and floodplain soil concentrations for aquatic and floodplain exposures, respectively. As a result, the greatest ecological risks at the CMRP site are associated with potential exposure to sediments and floodplain soils, which pose a bioaccumulation hazard through indirect trophic transfer.

Aquatic and floodplain invertebrates that are exposed to sediment and floodplain soils via the direct consumption and ingestion exposure pathways are also at risk.

Key findings from the BERA summarized in this section are discussed in terms of which receptors appear to be at substantial risk of harm, and what areas, media, and contaminants present risk above EPA's guidelines (i.e., Hazard Quotient [HQ] value of 1 or higher[16]). Supporting information from the risk assessment is summarized in Tables 2-13 through 2-15. Summary statistics and screening toxicity data for the contaminants contributing to ecological risk are summarized in Table 2-13. Ecological exposure pathways of concern evaluated in the BERA are summarized in Table 2-14. Toxicity tests and field studies conducted to evaluate ecological effects and assessment and measurement endpoints used for the assessment are summarized in Table 2-15. Threshold contaminant concentrations in sediment and floodplain soil media below which ecological receptors are believed to be adequately protected are summarized in Table 2-16.

2.5.2.1 Ecological Receptors at Risk of Harm

The BERA (MACTEC, 2004; MACTEC and Battelle, 2006) determined that wildlife and other ecological receptors (including fish and invertebrates) appear to be at substantial risk of harm from exposure to contamination at the CMRP site. For wildlife receptors, potential exposure to sediment and floodplain soil contaminants that have bioaccumulated in prey tissue was identified as the most significant pathway, with the incidental ingestion of sediment or floodplain soil (during foraging and preening activities) of secondary importance. Potential wildlife exposures to contaminants associated with the drinking water pathway were found to be inconsequential. The bioaccumulation of contaminants in fish tissue was determined to pose a substantial risk of harm to this receptor group; however, it was not possible to evaluate the relative significance of the various exposure pathways (primarily dermal exposure and ingestion). Macroinvertebrates could be potentially exposed to contaminants in sediment and floodplain soils via the direct contact and ingestion exposure pathways and as with fish, the relative importance of the different exposure pathways could not be assessed.

Biota – Piscivorous and insectivorous mammal and bird populations that forage in Allendale Pond and Lyman Mill Pond are at substantial risk of harm due to the consumption of fish and insect prey that have bioaccumulated contaminants in sediment (and potentially surface water). In addition, the incidental ingestion of sediment (associated with foraging and preening activities) was identified as an exposure pathway of secondary concern while the consumption of drinking water was found to pose only a *deminimis* level of risks to these receptors.

Consumption of contaminated fish from Allendale Pond containing total Aroclors, dioxin TEQ, and Aroclor 1254 by heron and kingfisher receptors present incremental risk in excess of EPA's guidelines. In Lyman Mill Pond, consumption of contaminated fish that have bioaccumulated total Aroclors, dioxin TEQ, 4,4'-DDE, PCB TEQ, Aroclor 1254, 4,4'-DDD and technical chlordane (kingfisher only) present an

[16] Here and throughout this section, HQs are reported as unitless values derived as the ratio of an exposure estimate (in units of either a medium concentration or dose) divided by a toxicological benchmark estimate (in the same units of medium concentration or dose).

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incremental risk to the heron and kingfisher in excess of EPA's guidelines. The incremental risks associated with the two ponds are of the same order of magnitude although generally slightly higher in Lyman Mill Pond compared to Allendale Pond. For instance, in the case of the heron, incremental risks for Allendale Pond (based on no observed adverse effects level [NOAELs]) range from 1.4 (Aroclor 1254) to 7.6 (dioxin TEQ), whereas the incremental risks for Lyman Mill Pond range from 1.3 (4,4'-DDD) to 7.8 (dioxin TEQ). In the case of the otter, only exposure to dioxin TEQ in its fish diet from Allendale Pond poses an incremental risk of harm in excess of EPA's guidelines; in Lyman Mill Pond, the incremental risks associated with dietary exposures to dioxin TEQ, Aroclor 1254, and PCB TEQ all exceed EPA's guidelines. As in the case of the heron, risks are slightly greater in Lyman Mill Pond compared to Allendale Pond (NOAEL-based incremental risks for dioxin TEQ are 7.0 and 5.6, respectively).

For aquatic-dependent wildlife that forage primarily on emerging insects (including adult tree swallows and little brown bats), only dioxin TEQ contributed to the incremental risk in excess of EPA's guidelines. Incremental risks to both receptors are higher in Allendale Pond compared to Lyman Mill Pond: for the swallow, the incremental risks (based on the NOAEL) are 29 and 7.6, respectively, whereas for the bat, the corresponding risks are 220 and 58.

Vermivorus mammal and bird populations that forage in the Oxbow Area and other floodplain habitat associated with Allendale Pond and Lyman Mill Ponds are also at substantial risk of harm due to the consumption of earthworm prey that have bioaccumulated contaminants (in particular dioxin TEQ) in floodplain soil. In addition, the incidental ingestion of floodplain soil (associated with foraging and preening activities) was identified as an exposure pathway of primary concern. The incremental risk (based on NOAELs) in excess of EPA's guidelines for Allendale Pond are 6.6 and 130 for the woodcock and shrew receptors, respectively. For the shrew, Aroclor 1254 also contributes to the incremental risk with a NOAEL-based value of 1.3. In the Oxbow, consumption of contaminated earthworms and incidental ingestion of floodplain soil that contain dioxin TEQ, total Aroclors, Aroclor 1254 (shrew only), antimony (shrew only), cadmium (shrew only), lead (woodcock only) and zinc (woodcock only) present an incremental risk to the woodcock and shrew receptors in excess of EPA's guidelines. Incremental risks are somewhat higher than those associated with Allendale Pond. For instance, the incremental risks associated with dioxin TEQ (NOAEL-based) for the shrew are 180 (Oxbow) and 130 (Allendale Pond).

Both pelagic and demersal fish populations that reside in Allendale and Lyman Mill Ponds may be at substantial risk of harm due to exposure to contaminants that have bioaccumulated in their tissue as a result of direct exposure to sediment and surface water and indirectly through consumption of contaminated prey items. Although tissue residues in adult fish generally appear to be lower than concentrations associated with early life stage effects in their offspring, these residues are predicted to adversely effect the adult fish. White sucker (representative of demersal, omnivorous fish populations) tissue residues of Aroclor 1254, technical chlordane, dioxin TEQ, selenium, and zinc present an incremental risk in both Allendale and Lyman Mill Ponds that are in excess of EPA's guidelines. In addition, 4,4'-DDD, 4,4'-DDE, aluminum, and vanadium contribute to the incremental risks in Lyman Mill Pond. Incremental risks (based on NOAEL values) for the individual contaminants range from 1.2 (zinc) to 6.4 (technical chlordane) in Allendale Pond and from 1.1 (zinc) to 110 (technical chlordane) in Lyman Mill Pond. Largemouth bass (representative of pelagic, piscivorous fish populations) tissue residues of technical chlordane, dioxin TEQ, aluminum, barium, vanadium, and zinc present an incremental risk in Lyman Mill Pond (no bass were collected in Allendale Pond) that are in excess of EPA's guidelines. One source of uncertainty in the BERA was the failure of two site-specific fish community studies to corroborate effects predicted by the residue based analysis.

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Surface Water – As discussed above, exposure to contaminants in drinking water was determined to pose no substantive risk to wildlife receptors. However, the relative significance of the surface water and sediment media on the potential bioaccumulation of contaminants in aquatic food webs associated with Allendale Pond and Lyman Mill Pond has not been determined. Surface water concentrations for gamma-chlordane, endosulfan sulfate, dioxin TEQ, , silver, thallium, and zinc in Allendale Pond and alpha- and gamma-chlordane, dioxin TEQ, lead, silver, and thallium in Lyman Mill Pond present an incremental risk (based on comparison to WQC) in excess of EPA guidelines. Incremental risks (based on NOAELs) range from 1.2 (endosulfan sulfate) to 110 (dioxin TEQ) in Allendale Pond and from 1.2 (lead) to 85 (dioxin TEQ) in Lyman Mill Pond.

Sediment – The BERA (MACTEC, 2004) concluded that macroinvertebrate communities found in Allendale and Lyman Mill Ponds are at substantial risk of harm from direct exposure to contaminants in sediment located in depositional areas (lentic) but not in the free-running reach of the river between Allendale and Lyman Mill Ponds. These conclusions were drawn primarily from site-specific studies that identified statistically significant toxicological effects in laboratory sediment bioassays as compared to background control sediments and an absence of observable effects in a macroinvertebrate community study conducted in lotic portions of the study area.

Average concentrations for a variety of sediment contaminants in Allendale Pond including PAHs (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene), di-n-butylphthalate, PCBs (Aroclors 1248, 1254, 1260, and total), dioxin TEQ, and metals (chromium, copper, cyanide, lead, mercury, and zinc) present an incremental risk (based on comparison to sediment benchmarks) in excess of EPA guidelines. In Lyman Mill Pond, the average sediment concentrations of contaminants including PAHs (acenaphthene, acenaphthylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, and pyrene), di-n-butylphthalate, pesticides (alpha- and gamma-chlordane, technical chlordane, 4,4'-DDD, 4,4'-DDE, dieldrin, and endrin), PCBs (Aroclors 1254, 1268, and total), dioxin TEQ, and metals (cadmium, copper, lead, and zinc) present an incremental risk (based on comparison to sediment benchmarks) in excess of EPA guidelines. Incremental risks (based on average concentrations) range from 1.1 (zinc) to 800 (dioxin TEQ) in Allendale Pond and from 1.0 (4,4'-DDE) to 3,200 (technical chlordane) in Lyman Mill Pond.

As the concentrations of most contaminants detected in the prey (e.g., fish and insects) of aquatic-dependent wildlife are correlated with sediment levels, the results described above for biota are indirectly attributable to contaminants in sediment, as well.

Floodplain Soil – The BERA concluded that the macroinvertebrate communities residing in the floodplain habitat associated with the reaches of Allendale and Lyman Mill (including the Oxbow Area) are unlikely to be at substantial risk of harm from contaminants in floodplain soils as a result of direct contact and ingestion exposure pathways. Although contaminant concentrations in floodplain soil do exceed floodplain soil benchmarks, the site-specific soil invertebrate study concluded that there were no discernable differences in community-level endpoints between those associated with Allendale Pond and Lyman Mill Pond and background locations. Nonetheless, because the concentrations of most contaminants detected in the prey (e.g., earthworms) of wildlife that forage in these floodplains are correlated with soil concentrations, the results described above for biota are indirectly attributable to contaminants in floodplain soil.

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In summary, the ecological risks by area are summarized below.

Allendale Reach

- Biota Tissue – Hazards to fish-feeding avian wildlife through ingestion of fish prey containing total Aroclors, dioxin TEQ (primarily 2,3,7,8-TCDD), Aroclor 1254, and PCB TEQ. Hazards to fish-feeding mammalian wildlife through ingestion of fish prey containing dioxin TEQ. Hazards to invertebrate-feeding wildlife through ingestion of aquatic prey containing dioxin TEQ, and PCB TEQ and through ingestion of floodplain prey containing dioxin TEQ and Aroclor 1254. Hazards to fish exposed through multiple exposure pathways that result in elevated body burdens of Aroclor 1254, technical chlordane, dioxin TEQ, selenium, and zinc.
- Surface Water – Hazards to aquatic animals (including invertebrates and fish) through direct contact with and ingestion of water containing gamma-chlordane, endosulfan sulfate, dioxin TEQ, silver, thallium, and zinc.
- Sediment – Hazards to aquatic invertebrates through direct contact with and ingestion of sediments containing PAHs (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene), di-n-butylphthalate, PCBs (Aroclors 1248, 1254, 1260, and total), dioxin TEQ, and metals (chromium, copper, cyanide, lead, mercury, and zinc).
- Floodplain Soil – The risks associated with ecological exposure to floodplain soil are related to the bioaccumulation hazards posed by dioxin TEQ and Aroclor 1254 in soil invertebrate tissue (see above).

Lyman Mill Reach

- Biota Tissue – Hazards to fish-feeding avian wildlife through ingestion of fish prey containing total Aroclors, dioxin TEQ, 4,4'-DDE, PCB TEQ, Aroclor 1254, 4,4'-DDD and technical chlordane. Hazards to fish-feeding mammalian wildlife through ingestion of fish prey containing dioxin TEQ, Aroclor 1254, and PCB TEQ. Hazards to invertebrate-feeding wildlife through ingestion of aquatic prey containing dioxin TEQ and PCB TEQ or through ingestion of floodplain prey containing 2,3,7,8-TCDD (dioxin TEQ), 4,4'-DDE, dieldrin, antimony, arsenic, cadmium, lead, selenium, and zinc. Hazards to fish exposed through multiple exposure pathways that result in elevated body burdens of Aroclor 1254, technical chlordane, 4,4'-DDD, 4,4'-DDE, dioxin TEQ, aluminum, barium, selenium, vanadium and zinc.
- Surface Water – Hazards to aquatic animals (including invertebrates and fish) through direct contact with and ingestion of water containing alpha- and gamma-chlordane, dioxin TEQ, lead, silver, and thallium.
- Sediment – Hazards to aquatic invertebrates through direct contact with and ingestion of sediments containing PAHs (acenaphthene, acenaphthylene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, and pyrene), di-n-butylphthalate, pesticides (alpha- and gamma-chlordane, technical chlordane, 4,4'-DDD, 4,4'-DDE, dieldrin, and endrin), PCBs (Aroclors 1254, 1268, and total), dioxin TEQ, and metals (cadmium, copper, lead, and zinc).
- Floodplain Soil – The risks associated with ecological exposure to floodplain soil are related to the bioaccumulation hazards posed by dioxin TEQ cadmium, lead, selenium, and zinc in soil invertebrate tissue (see above).

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3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND ACTION AREAS

The RI (Battelle, 2005a) and baseline risk assessments (MACTEC, 2004 and 2005a; MACTEC and Battelle, 2006) for the CMRP site identified a number of exposure scenarios associated with unacceptable risks to human and ecological receptors. This section identifies the RAOs necessary to address potentially unacceptable human health and ecological risks, presents potential ARARs and TBC criteria, PRGs and cleanup goals for the contaminants that drive risk at the site, and identifies the areas of the site where contaminant concentrations exceed cleanup goals. In addition, this section describes an adaptive management approach to address areas downstream of Lyman Mill Dam following implementation of the sediment remedy at the reaches of Allendale and Lyman Mill.

3.1 Remedial Action Objectives

The establishment of RAOs or cleanup objectives is the first step in the process of developing and evaluating remedial action alternatives. RAOs provide a general description of what the CERCLA remedy at the site will be designed to accomplish (EPA, 1988). Each RAO specifies the contaminants, the relevant exposure routes and receptors, and an acceptable contaminant concentration or range of concentrations for each exposure pathway. RAOs were developed following EPA guidance (EPA, 1988 and 2005). Medium-specific RAOs that are based on protection of human health and ecological receptors are described below.

3.1.1 Human Health RAOs

The RAOs specified for protecting human health focus on reduction or elimination of specific exposure-related risks. Residents living along the river, visiting recreational anglers, and passive recreational visitors were considered in developing the RAOs related to human health risks. RAOs for the residential and visiting angler scenarios considered the consumption of contaminated fish and other biota. RAOs for the residential scenarios also considered the incidental ingestion of and direct contact with sediment from the reaches of Allendale and Lyman Mill. RAOs for the passive recreational visitor considered incidental ingestion and direct contact with floodplain soil from the Oxbow. Medium-specific RAOs for the protection of human health include:

Allendale and Lyman Mill reach sediment. Prevent direct human exposure by incidental ingestion of and dermal contact with sediments containing contaminants at concentrations that would result in:

- A total excess lifetime cancer risk greater than the target risk range of one in one million (10^{-6}) to one in ten thousand (10^{-4}); or
- An HI greater than 1.

Prevent human ingestion of fish and other aquatic organisms containing contaminants at concentrations that would result in:

- A total excess lifetime cancer risk greater than the target risk range of 10^{-6} to 10^{-4} ; or
- An HI greater than 1.

Allendale and Lyman Mill reach floodplain soil. Prevent direct human exposure by incidental ingestion of and dermal contact with floodplain soil that contain contaminants at concentrations that would result:

- In excess of ARARs (e.g., RIDEM residential direct exposure and GB leachability criteria) and/or a total excess lifetime cancer risk[17] greater than the target risk range of 10^{-6} to 10^{-5};
- In excess of ARARs (e.g., RIDEM residential direct exposure and GB leachability criteria) and/or an HI greater than 1; or
- In excess of EPA's recommended residential level for dioxin (as TEQ) of 1,000 ng/kg (EPA, 1998b).[18]

Allendale and Lyman Mill reach surface water. The baseline risk assessment (MACTEC, 2005a) indicated that exposure to surface water at the site does not present human health risk. However, contaminants in surface water can indirectly lead to human health risks following consumption of biota tissue that have accumulated contaminants in their tissues. As a result, action should be taken to minimize migration of contaminants to surface water to the extent possible.

Source Area soils. Prevent direct human exposure by incidental ingestion of and dermal contact with source area soils that contain contamination in excess of ARARs (e.g.., RIDEM residential direct exposure criteria and TSCA requirements for PCBs) and EPA's recommended residential level for dioxin (EPA, 1998b).

In addition, prevent leaching or migration of contaminants from vadose zone soils that would result in groundwater contamination in excess of ARARs (e.g., RIDEM GB leachability criteria).

Source Area groundwater. Prevent migration of contaminants from groundwater at the source area that would result in surface water contamination in excess of ARARs (e.g., State of Rhode Island standards and federal WQC: chronic ambient freshwater and human health criteria for consumption of water and aquatic organisms) or that could indirectly lead to unacceptable human health risks. In addition, improve groundwater quality so that ARARs (i.e., State of Rhode Island GB groundwater objectives) are met.

3.1.2 Ecological RAOs

The RAOs for protecting the environment were developed to be consistent with the assessment endpoints (i.e., "protect and maintain") established in the BERA (MACTEC, 2004; MACTEC and Battelle, 2006). Macroinvertebrates, fish and wildlife that consume fish and/or other aquatic prey items, and wildlife that consume terrestrial prey items within the floodplain of the Woonasquatucket River were considered in the development of the RAOs. The following exposure pathways and effects were the basis of the RAOs developed for ecological receptors:

- Direct contact with surface water and sediment containing contaminants that result in community-level effects in benthic macroinvertebrates occurring in lentic (i.e., slow moving) habitats within the river;

[17] The Rhode Island Site Remediation Regulations define acceptable carcinogenic risk as within the range of 10^{-6} to 10^{-5}.

[18] EPA released Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites on December 30, 2009 (EPA, 2009). An evaluation of potential impacts of the recommended interim PRGs on cleanup goals, cleanup areas, and remedial alternatives developed in this FS is provided in Appendix N of the FS report.

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- Direct contact with abiotic media and consumption of aquatic prey items containing contaminants by predatory fish that result in maternal transfer of contaminants to eggs and early life-stage effects and other bioaccumulation-related effects in fish;
- Consumption of contaminated fish by piscivorous bird receptors which results in adverse survival, growth, and/or reproductive effects in piscivorous bird receptors;
- Consumption of contaminated emerging insects which results in reduced egg hatchability and other bioaccumulation-related effects in insectivorous bird receptors; and,
- Incidental soil ingestion and consumption of contaminated soil invertebrates (e.g., earthworms) by insectivorous/vermivorous mammals which result in adverse survival, growth, and/or reproductive effects in insectivorous/vermivorous mammals.

Ecologically-based RAOs also considered several goals of the River's Policy and Classification Plan established by the Rhode Island Statewide Planning Program (2004). Policy R-5 states that "Rhode Island's rivers, lakes, ponds, and estuarine waterbodies are an important recreational asset and shall be managed as such, except in instances when they are drinking water supplies, or habitat for rare or endangered species, that would be harmed by recreational use." In Policy R-6, "suburban and urban areas priority shall be given to the preservation and restoration of habitat and the establishment of greenways that link natural, historic, and cultural communities and/or provide recreational opportunity." Finally, Policy R-7 sets forth that "The natural, cultural, and historic features of river systems and their adjacent lands shall be preserved and protected to the maximum extent possible."

Ecologically-based RAOs for sediment, floodplain soil, surface water, and groundwater are designed to minimize potential downstream migration of contamination that would result in surface water concentrations above the State of Rhode Island standards and federal WQC or concentrations in the Woonasquatucket River above the sediment cleanup goals. In addition, sediment and floodplain soil RAOs for the protection of the ecological receptors include:

Allendale and Lyman Mill reach sediment. Prevent dermal contact, ingestion, and uptake by aquatic invertebrates, fish, amphibians, birds, and mammals to sediments containing contaminants at levels that would result in unacceptable impacts.

Allendale and Lyman Mill reach floodplain soil. Prevent dermal contact, ingestion, and uptake by floodplain plants, soil invertebrates, birds, and mammals to floodplain soils containing contaminants at levels that would result in unacceptable impacts. For ecological receptors, the RAO is to maximize hazard reduction and minimize remediation-related habitat loss.

Allendale and Lyman Mill reach surface water.[19] Prevent migration of contaminants from sediment, groundwater, or soils that would result in surface water concentrations in the Woonasquatucket River in excess of ARARs (e.g., State of Rhode Island standards and federal WQC: chronic ambient freshwater).

The reach of the Woonasquatucket River (including Allendale and Lyman Mill Ponds) is classified as Class B1 water in the State of Rhode Island, and all Class B criteria must be met (RIDEM, 2000). Further, the Governor's Narragansett Bay and Watershed Planning Commission (established by an Executive Order issued on October 22, 2003) initial charge to make the Blackstone, Woonasquatucket and Wood-Pawcatuck Rivers, and Greenwich Bay fishable and swimmable by 2015 is identified as a long-term goal for this portion of the river.

[19] The BERA (MACTEC, 2004) concluded that aquatic macroinvertebrate communities found in slow-moving (but not fast-moving) reaches of the river were at substantial risk of harm based on consideration of contaminant concentrations in sediment, surface water, biological tissue, and toxicity tests.

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Source Area groundwater. Prevent migration of contaminants from groundwater at the source area that would result in surface water concentrations in excess of the ARARs (e.g., State of Rhode Island standards and federal WQC: chronic ambient freshwater).

3.2 Applicable or Relevant and Appropriate Requirements

The next step in the process of developing and evaluating remedial action alternatives is to identify potential ARARs, guidance and advisories (TBC criteria).

3.2.1 Introduction to Potential ARARs and To Be Considered Criteria

This section identifies potential ARARs and TBC criteria based on federal and State of Rhode Island regulations, requirements, and guidance applicable to the CMRP site, and sets forth those ARARs that are relevant for the remedial alternatives analyzed in detail in this FS report. Only substantive portions of laws and regulations are ARARs (ARARs do not include administrative or procedural requirements). In addition, under CERCLA, permits are not required to be obtained for actions taken on site; only the substantive requirements thereof must be met. Key requirements and the reasons for their applicability or relevance and appropriateness have been integrated into the detailed evaluation of alternatives presented in Section 6.0. Potential ARARs are summarized in Table 3-1.

The identification of ARARs is an iterative process. The final determination of ARARs will be made in the ROD as part of the response action selection process.

3.2.1.1 Summary of CERCLA and NCP Requirements

Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or surpass ARARs. ARARs consist of:

- any standard, requirement, criterion, or limitation promulgated under federal environmental law; and
- any promulgated standard, requirement, criterion, or limitation under a state environmental or facility citing law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

Applicable requirements are defined as any cleanup standards, standards of control, or other environmental protection requirements, criteria, or limitations promulgated under state or federal law that directly address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.

Relevant and appropriate requirements are defined as cleanup standards, standards of control, or other environmental protection requirements, criteria, or limitations promulgated under state or federal law, that although not "applicable" (as defined above), address problems or situations sufficiently similar (i.e., relevant) to those encountered at the CERCLA site with a well suited (appropriate) use. TBC criteria are non-promulgated, non-enforceable guidelines or criteria that may be useful in developing remedial action alternatives and for determining cleanup levels protective of human health and the environment.

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Alternatives that do not attain all ARARs may be selected if any of the following six conditions for the waiver of an ARAR exist:

- the action is an interim measure, and the final remedy will achieve the ARAR upon completion;
- compliance with the ARAR will result in greater risk to human health and the environment;
- compliance with the ARAR is technically infeasible;
- an alternative remedial action will attain the equivalent of the ARAR;
- the state has not consistently applied the requirement in similar circumstances (applies to state ARARs only); and,
- compliance with the ARAR will not provide a balance between protecting public welfare and the environment with the availability of funds (applies only to Superfund financed actions).

ARARs fall into three general categories, as follows:

- ***chemical-specific ARARs*** are health- or risk-based numerical values or methodologies that establish concentration limits for specific chemical constituents;
- ***location-specific ARARs*** are restrictions based upon concentrations of chemical constituents or conduct of activities in particular locations (e.g., wetlands, floodplains, historic sites, sensitive habitats). Location-specific ARARs may restrict or preclude certain remedial actions in an area; and,
- ***action-specific ARARs*** are technology or activity-based controls or restrictions pertaining to implementing a given remedy.

EPA (1988) guidance recommends that the lead federal agency consult with the state when identifying state ARARs for remedial actions. EPA formally requested state chemical-, location-, and action-specific ARARs for the CMRP site from RIDEM in a letter dated September 28, 2004. RIDEM provided potential ARARs in a letter dated October 4, 2004, as modified on September 26, 2007. Potential ARARs identified by RIDEM have been incorporated into the FS (Table 3-1).

3.2.1.2 Waste Characterization

The selection of ARARs involves the characterization of wastes according to Federal Resource Conservation and Recovery Act (RCRA) and state hazardous waste requirements. As previously noted, the final determination of ARARs will be made in the ROD. Waste disposals will be conducted in accordance with applicable federal and state regulations.

Waste disposal options evaluated in the FS include options for "F" listed, TSCA, and unregulated wastes. F-listed wastes are known as wastes from non-specific sources (40 CFR §261.31) such as common manufacturing and industrial processes and include wastes generated from the production or manufacturing use of trichlorophenol (F020). Currently, F-listed wastes can be shipped and disposed of within the U.S. and Canada, and both incineration and landfill options are available depending on the concentrations. TSCA waste is known as PCB-remediation waste, and consists of contaminated soils present at the source area with total PCB concentrations in excess of 50 mg/kg.

For off-site disposal options within the U.S., F-listed waste or characteristic waste (i.e., exceeds Toxicity Characteristic Leaching Procedure [TCLP] concentration) with contaminant concentrations in excess of the treatment standards listed in 40 CFR §268.40 of the Land Disposal Restrictions (LDR) or the

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alternative treatment standards for contaminated soil in 40 CFR §268.49 (applicable to soil only) would require disposal by incineration. The LDR alternative treatment standards in 40 CFR §268.49 apply to land disposal of contaminated soils where contaminant concentrations for each underlying hazardous constituent in the waste is below 10 times the universal treatment standard (UTS) criteria. For example, if an F-listed waste contains arsenic, and the UTS for arsenic is 500 mg/kg, then soil with arsenic concentrations above 5,000 mg/kg may require incineration. To incinerate dioxin-listed hazardous wastes, a destruction and removal efficiency (DRE) of 99.9999% must be achieved (40 CFR §264.343(a)(2)). F-listed waste or characteristic waste with contaminant concentrations below the applicable treatment standards in 40 CFR §268.40 or the alternative treatment standards for contaminated soil in 40 CFR §268.49 (applicable to soil only) could be disposed of in a hazardous waste landfill. Certain facilities in Canada may allow land disposal of F-listed waste or characteristic waste above the U.S. treatment standards. Waste that is neither F-listed nor characteristic (i.e., below TCLP concentration) may be disposed of as non-hazardous at a local, permitted landfill.

For on-site disposal options, all waste can be addressed without treatment, regardless of its characterization or contaminant concentrations, if such waste is consolidated or treated in-situ within an "area of contamination." The consolidation or in-situ treatment of waste within an "area of contamination" is not considered disposal and, thus, does not trigger the LDRs or minimum technology requirements. However, if waste is managed ex-situ (such as through dewatering in a separate container) or transferred from one "area of contamination" to another, then the LDRs must be met (i.e., F-listed or characteristic soil waste with an underlying hazardous constituent that exceeds 10 times the UTS in 40 CFR §268.48 and F-listed or characteristic sediment waste with an underlying hazardous constituent that exceeds the treatment standards in 40 CFR §268.40 will need to be treated prior to disposal).

It may be possible to reduce the amount of treatment required before disposal of sediment by seeking a treatability variance pursuant to 40 CFR §268.44(a)(2). Under this scenario, the variance would allow for the disposal of un-treated sediment if the sediment meets the alternative soil treatment standards in 40 CFR §268.49 (i.e., each underlying hazardous constituent in the waste is below 10 times the UTS criteria). A treatability variance would be appropriate here because it would encourage removal of the contaminated sediment and soil.

For purposes of developing cost estimates for the remedial alternatives identified in the FS, sediment and floodplain soil data for the Allendale and Lyman Mill reaches of the river and soil data for the source area were compared to the treatment standards and UTS criteria. For sediment, approximately 50% of data exceeded the UTS criteria.[20] (For purposes of the treatability variance approach discussed above, approximately 10% of the sediment data exceeded the 10 times UTS criteria.) For floodplain soil, less than 5% of the data exceeded the UTS criteria, except at the Oxbow where approximately 40% of the data exceeded the UTS criteria. All floodplain soils meet the 10 times UTS criteria. For source area groundwater, approximately 30% of the data (contaminated soils within the groundwater cleanup area) exceeded the UTS criteria and approximately 20% exceeded the 10 times UTS criteria. As mentioned above, all F-listed and/or characteristic waste with underlying hazardous constituents in excess of the treatment standards (40 CFR §268.40 or the alternative treatment standards for soil in 40 CFR §268.49) must either be managed within an "area of contamination" or treated prior to disposal.

Potential waste scenarios and disposal options are summarized in Table 3-2. The application of the LDRs and their effect on disposal options will be discussed in more detail in Section 6.0.

[20] Land disposal of soils containing dioxin at concentrations 5 times the UTS, or 5 µg/kg, is currently allowed in Quebec, Canada. Approximately 20% of the sediment data exceed the 5 times UTS criteria.

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3.3 Preliminary Remediation Goals

The next step in the process of developing and evaluating remedial action alternatives is to develop PRGs, which are risk-based concentrations of chemicals in environmental media that have been brought forward from the human health and ecological risk assessments conducted for the site. Risk-based PRGs were developed for contaminants in biota, sediment and floodplain soil. Risk-based PRGs were not developed for surface water. Cleanup goals for contaminants in surface water, soil, and groundwater are based on an evaluation of ARARs as described in Section 3.4.

PRGs were developed at various risk levels (excess lifetime cancer risk of 10^{-6}, 10^{-5}, and 10^{-4} and non-cancer HQs of 0.1, 1.0, and 10) for exposure scenarios and contaminants that pose a risk to human and/or ecological receptors at the CMRP site. PRGs for specific environmental media (e.g., sediment, floodplain soil, biota tissue) were calculated using these target risk levels, toxicological benchmarks, and receptor-specific exposure parameters as necessary (e.g., body weight and ingestion rates for dose-dependent exposure). In addition, contaminant transfer factors (biota sediment accumulation factors [BSAFs] and bioaccumulation factors [BAFs]) were used to estimate protective abiotic media concentrations based on tissue concentrations established for the various target risk levels. As mentioned in Section 2.4.3.3, dioxin TEQs and sediment TOC are not well correlated, limiting the predictive ability of site-specific media transfer factors such as BSAFs for this contaminant. However, sediment PRGs were calculated using average TOC and fish lipid concentrations for Allendale and Lyman Mill and the use of BSAFs is justified as long as it can be reasonably assumed that the ratio of these two parameters will not differ substantively in the future. Details regarding the derivation of PRGs and PRG summary tables are presented in MACTEC (2005b). PRGs derived for the Oxbow are presented in Appendix D.

PRGs were developed consistent with EPA guidelines (EPA, 1991b, 2001a, and 2002), and are based on the baseline risk assessments conducted for the CMRP site and the physical and chemical conditions of the site. As a result, the PRGs are site-specific and appropriate for use in the remedial decision-making process.

3.3.1 Site-Specific Human Health PRGs

Human health PRGs were derived, by medium and exposure pathway, for all contaminants contributing to an excess lifetime cancer risk greater than 10^{-6} and/or a non-cancer HQ greater than 1.0.[21] Overall, human health PRGs were derived for biota (fish tissue) and sediment for the fish consumption pathway and for sediment and floodplain soil for the direct contact and incidental ingestion pathways. Biota PRGs were calculated as an interim step in the derivation of biota consumption-based sediment PRGs. Sediment PRGs were derived for the fish consumption pathway because the persistent, bioaccumulating substances in fish tissue that are the major contributors to human health risk (primarily dioxins and PCBs) are typically present in fish as the result of bioaccumulation from sediments (MACTEC, 2005b). Biota PRGs are not presented in this FS because the sediment PRGs (based on fish consumption and direct contact/incidental ingestion) were used to determine proposed cleanup areas; complete details regarding the biota PRGs, calculated as an interim step, are available in MACTEC (2005b). The remedial requirements for sediments were developed primarily to identify actions necessary to ultimately achieve the biota tissue PRGs.

Allendale and Lyman Mill reach sediment, Combined Fish Diet. PRGs were developed for residents and visiting recreational anglers. Contaminants identified based on cancer risk are: dioxins and furans (reported as 2,3,7,8-TCDD), dioxin-like PCBs (TEQ), Aroclor 1254, technical chlordane, dieldrin,

[21] Human health PRGs were also derived for other chemicals with HQ greater than 0.1 to provide additional perspective concerning cumulative risks from multiple compounds.

4,4'-DDE (Lyman Mill only), benzo(a)pyrene (Lyman Mill only), and Aroclor 1268. The contaminant identified based on non-cancer risk[22] is Aroclor 1254; only Aroclor 1254 was associated with an HQ greater than 1.0.

The PRGs for dioxins and dioxin-like PCBs are based on cancer risk only because a non-cancer reference dose is not available for dioxins, and the non-cancer effects associated with the dioxin-like PCBs have been evaluated as a component of the assessment of the reported Aroclors. The PRGs for Aroclor 1254 are based on both cancer risk and non-cancer risk.

Allendale and Lyman Mill reach sediment, Direct Contact and Incidental Ingestion. PRGs were developed for residents. Contaminants identified based on a cancer risk are: dioxins and furans (reported as 2,3,7,8-TCDD), arsenic, benzo(a)pyrene, dibenzo(a,h)anthracene, and N-nitrosodi-n-propylamine (Lyman Mill only). No contaminants were identified based on non-cancer risk (no chemicals had an HQ greater than 1.0).

Lyman Mill reach floodplain Soil, Direct Contact and Incidental Ingestion. PRGs were developed for the passive recreational visitor exposed to floodplain soil at the Oxbow area of Lyman Mill reach. The contaminants identified based on a cancer risk are dioxins and furans (reported as dioxin TEQ), Aroclor 1254, and arsenic. No contaminants were identified based on non-cancer risk (HQ greater than 1.0).

3.3.2 Site-Specific Ecological PRGs

Ecological PRGs were derived for Allendale and Lyman Mill sediments[23] and floodplain soils based on risks to the most sensitive receptors identified for each pathway and/or endpoint evaluated in the BERA (MACTEC, 2004 and Appendix D). PRGs developed for Oxbow floodplain soils (Appendix D) differ from the PRGs developed in MACTEC (2005b) for Allendale and Lyman Mill floodplain soils because the Oxbow is where the most significant ecological exposures will occur. PRGs were developed for sediments and floodplain soils because ecological receptors exposed to contaminants in these media, either directly or through biological uptake, were determined to be at substantial risk of harm. In general, PRGs were developed based on measurement endpoints used in the BERA, and were calculated for NOAEL, Lowest Observed Adverse Effect Level (LOAEL), and Maximum Allowable Toxicant Concentration (MATC) endpoints where available. For each of these endpoints (NOAEL, LOAEL, and MATC), PRGs were calculated based on target HQ values of 0.1, 1.0, and 10.

Allendale and Lyman Mill reach sediment. PRGs were developed for demersal fish (white sucker and American eel), pelagic fish (largemouth bass), piscivorous wildlife (belted kingfisher), and insectivorous wildlife (tree swallow embryos). PRGs were developed for the following contaminants: dioxin TEQ, dioxin-like PCBs (TEQ), Aroclor 1254, total Aroclors, technical chlordane, 4,4'-DDD (Lyman Mill only), 4,4'-DDE (Lyman Mill only), aluminum (Lyman Mill only), barium (Lyman Mill only), selenium, vanadium (Lyman Mill only), and zinc.

[22] Several chemicals contributed to non-cancer risk as described in MACTEC (2005b), but Aroclor 1254 is identified on the basis of an HQ greater than 1.0.

[23] Although the BERA (MACTEC, 2004) identified actionable risk to the macroinvertebrate community associated with exposure to sediment and floodplain soil containing elevated contaminant concentrations, it was not possible to derive PRGs using the available site-specific effects information. Moreover, it is not appropriate to develop PRGs based on generic benchmarks, which are conservative in nature and intended for screening purposes only. Ecological PRGs were derived to be protective of the bioaccumulation hazards posed to aquatic organisms and wildlife. Consideration of the spatial distribution and magnitude of the risk estimates for vertebrate receptors supports the use of fish- and wildlife-based PRGs as protective surrogates for invertebrate receptors as well.

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Allendale and Lyman Mill reach floodplain soil. PRGs were developed for soil invertebrates (earthworm) and vermivorous wildlife (American woodcock, short-tailed shrew) for the following contaminants: dioxin (2,3,7,8-TCDD and TEQ), Aroclor 1254, total Aroclors, 4,4'-DDE, dieldrin, antimony, arsenic, cadmium, lead, selenium, and zinc. (PRGs for all contaminants except dioxin are applicable to Lyman Mill floodplain soil only; PRGs for dioxin are applicable to Allendale and Lyman Mill floodplain soil.)

3.4 Cleanup Goals

This section describes the general approach and rationale used to develop remediation or cleanup goals for sediment, floodplain soil, surface water, and source area soil and groundwater at the CMRP site (additional details are provided in Attachment F). Cleanup goals are used to determine the proposed cleanup areas and are based on an evaluation of potential ARARs, TBCs, PRGs and site background data. There are no applicable chemical-specific ARARs for sediment or site-specific PRGs for surface water, source area soil, or source area groundwater. In general, the cleanup goal is based on the PRG (and/or ARAR) or background, whichever is higher.

Remediation and cleanup goals are often interchangeable, although 'cleanup goals' are typically developed during the Record of Decision and are based on a consideration of 'remediation goals' developed during the Feasibility Study. The term 'cleanup goal' is used here for simplicity.

Allendale and Lyman Mill reach sediment. Cleanup goals for sediment are summarized in Table 3-3. Cleanup goals are selected based on the PRG or background concentration, whichever is higher (see Appendix F for comparison of PRGs to site background data). For carcinogenic effects, the lowest risk level value (PRG associated with 10^{-6} or one-in-one million risk) was compared to the background concentration. For non-carcinogenic effects and all ecologically-protective PRGs, the middle risk level value (PRG associated with target HQ of 1) was compared to the background concentration. For a given contaminant, the PRG compared to background was based on the most sensitive receptor or exposure pathway. For example, PRGs were developed for 2,3,7,8-TCDD based on the direct contact with sediment (26.2 ng/kg) and combined fish diet (0.5 ng/kg) exposure pathways for residents living along the river and visiting recreational anglers. The more protective of these PRGs for the most sensitive receptor (i.e., residents living along the river consuming fish with a combined fish diet, 0.5 ng/kg) was compared to background concentrations to develop cleanup goals for the CMRP site (Appendix F, Table F-1). In general, cleanup goals for sediment are based on background concentrations (Table 3-3).

Proposed Cleanup Goals for Selected Contaminants in Allendale and Lyman Mill Sediment (see Table 3-3 for complete list)

Proposed Cleanup Goals	
2,3,7,8-TCDD (ng/kg)	Total PCB (mg/kg)
14.7	0.21

Fish tissue concentrations (i.e., biota tissue targets) in Allendale Pond and Lyman Mill Pond that correspond to the sediment cleanup goals are also presented in Appendix F (Attachment F-1). These concentrations are distinct from the fish tissue PRGs provided in the MACTEC (2005b) because they were derived using sediment cleanup goals rather than sediment PRGs and, in the majority of cases, are based on background conditions rather than the (lower) risk protective levels. Biota tissue targets were not used in the determination of remedial footprints, but rather to better understand the anticipated residual risks following remedy implementation for pond sediment. In addition, these concentrations will be an important tool in evaluating monitoring data and assessing compliance with RAOs.

Allendale and Lyman Mill reach floodplain soil. Cleanup goals for floodplain soil are summarized in Table 3-4. Cleanup goals are based on an evaluation of potential ARARs, TBCs, PRGs and site data. Potential ARARs include the RIDEM residential direct exposure and GB leachability criteria (RIDEM,

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2004). TBCs include EPA's recommended residential level for dioxin (EPA, 1998b).[24] PRGs include risk-based concentrations and are based on the most sensitive receptor or exposure pathway. For carcinogenic effects, the lowest risk level value (PRG associated with 10^{-6} or one-in-one million risk) was used. For non-carcinogenic effects and all ecologically-protective PRGs, the middle risk level value (PRG associated with target HQ of 1) was used.

Cleanup goals for floodplain soil were determined in an iterative approach. First, the site data were evaluated to identify contaminants detected at concentrations in excess of the ARARs or TBCs (see Appendix F, Table F-2b for comparison of site data to ARARs and TBCs). Next, the site data were statistically evaluated using methods established for the RI (Battelle, 2005a) to determine if the contaminants detected at concentrations in excess of ARARs were consistent with background conditions. Contaminants that were detected in excess of ARARs or TBCs and were determined to be significantly higher than background conditions were retained for cleanup goal determination; these contaminants represent a subset of the contaminants for which risk-based PRGs are available. Contaminants detected in excess of ARARs or TBCs but found to be consistent with, or less than background conditions were not included in the determination of cleanup goals unless a risk-based PRG was available for the contaminant.

Next, for contaminants with an ARAR, TBC and PRG, the lower of the values was compared to the site background concentration to determine the cleanup goal (Appendix F, Table F-2a). (Where multiple PRGs were available, the more protective PRG value based on the most sensitive receptor and exposure pathway was used in the comparison as described above for sediment.) For example, the ARAR and PRG values for total PCB are 10 mg/kg and 1.7 mg/kg (based on ecological health American woodcock diet), respectively. The lower of the two values (ecological health PRG of 1.7 mg/kg) was then compared to the background concentration (0.06 mg/kg), and the higher of the values was identified as the proposed cleanup goal. Cleanup goals for floodplain soil are based on background concentrations for some contaminants and on risk-based PRGs for other contaminants (Table 3-4).

Proposed Cleanup Goals for Selected Contaminants in Allendale and Lyman Mill Floodplain Soil (See Table 3-4 for complete list)

Proposed Cleanup Goals	
2,3,7,8-TCDD (ng/kg)	Total PCB (mg/kg)
17	1.7

Allendale and Lyman Mill reach surface water. Cleanup goals for surface water are summarized in Table 3-5. Cleanup goals are based on an evaluation of potential ARARs and site data. Potential ARARs include the State of Rhode Island standards and federal WQC: chronic ambient freshwater and human health criteria for consumption of water and aquatic organisms (RIDEM, 2006 and EPA, 2006 and 1990a). State standards and federal WQC have been promulgated for approximately 150 pollutants, and provide for the protection of aquatic life and human health in surface water. The WQC criteria for dioxin (2,3,7,8-TCDD) was modified based on site-specific bioaccumulation factors as described in Appendix F (Attachment F-2).

Cleanup goals for surface water were determined in an iterative approach. First, the site data were evaluated to identify contaminants detected at concentrations in excess of the ARARs (Appendix F, Table F-3b). For contaminants with multiple ARAR values, the lower (more protective) value was used in the data comparison. For example, the federal WQC and State of Rhode Island standards for arsenic are 150 micrograms per liter (µg/L) (federal and state freshwater chronic criteria/standards), 0.018 µg/L (federal human health consumption of water + organism), and 0.18 µg/L (state human health consumption of water + organism). The lower of these values (0.018 µg/L) was compared to the site data (Appendix F,

[24] EPA's new proposed residential level for dioxin (EPA, 2009) is used in the cleanup goal determination provided in Appendix N.

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Table F-3b). Next, the site data were statistically evaluated using methods established for the RI (Battelle, 2005a) to determine if the contaminants detected at concentrations in excess of ARARs were consistent with background conditions. Among the contaminants that were detected in excess of ARARs, only dioxin (2,3,7,8-TCDD) was retained for cleanup goal determination because it was the only contaminant determined to be significantly higher than background conditions. The cleanup goal for dioxin (2,3,7,8-TCDD) is based on the ARAR as modified based on site-specific bioaccumulation factors.

Source Area soil. Cleanup goals for soils at the source area are summarized in Table 3-6. Cleanup goals are based on an evaluation of potential ARARs, TBCs, and site data. Potential ARARs include Rule 8.02B of the Rhode Island Remediation Regulations (RIDEM, 2004), which states that soil contaminated as a result of a release of hazardous materials must be remediated in a manner that meets the direct exposure *and* leachability criteria for each hazardous substance present. Because the CMRP site is used for residential purposes, the residential direct exposure and leachability criteria are potential ARARs for the site and these criteria must be applied to soils throughout the vadose zone. The leachability criteria are intended to ensure protection of the designated groundwater classification; therefore, the GB leachability criteria apply to site soils as long as application of these criteria does not contribute to actual or potential adverse impacts to surface water and/or sediment. GB leachability criteria have been promulgated for VOCs and PCBs only. Potential TBCs include EPA's recommended residential level for dioxin (EPA, 1998b),[25] which was recommended as the cleanup level for residential properties, and was used as the basis for the first TCRA and the NTCRA.

Contaminants detected in source area soils at concentrations in excess of the ARARs (applicable to vadose zone soils) or TBCs (applicable to surface soils) were used in the determination of cleanup goals (see Appendix F, Table F-4b for comparison of site data to ARARs and TBCs). For contaminants with multiple ARAR values, the lower (more protective) value was identified as the proposed cleanup goal (Appendix F, Table F-4a). For example, potential ARARs for benzene are 2.5 mg/kg (RIDEM residential direct exposure criteria) and 4.3 mg/kg (RIDEM GB soil leachability criteria). The lower of these values (2.5 mg/kg) was identified as the proposed cleanup goal.

Proposed Cleanup Goals for Selected Contaminants in Source Area Soil (See Table 3-6 for complete list)

Proposed Cleanup Goals		
Dioxin TEQ (ng/kg)	Total PCB (mg/kg)	PCE (mg/kg)
1,000	10	4.2

Source Area groundwater. Cleanup goals for source area groundwater are summarized in Table 3-7. Cleanup goals are based on an evaluation of potential ARARs and site data. Potential ARARs include Rules 8.03 and 8.02.B of the Rhode Island Remediation Regulations (RIDEM, 2004). Rule 8.03 states that groundwater contaminated as a result of a release of hazardous materials located in a GB area shall be remediated to a concentration that meets the GB groundwater objectives. Rule 8.02.B provides GB soil leachability criteria that are intended to ensure protection of the designated groundwater classification. Rules 8.03 and 8.02B are promulgated for VOCs (groundwater and soil leachability) and PCBs (soil leachability). Contaminants detected in source area groundwater and soil at concentrations in excess of the ARARs (see Appendix F, Tables F-4b and F-5b for comparison of source area soil and groundwater data to ARARs, respectively) were used in the determination of cleanup goals.

Proposed Cleanup Goals for Selected Contaminants in Source Area Groundwater (See Table 3-7 for complete list)

Proposed Cleanup Goals		
2,3,7,8-TCDD (pg/L)	PCE (µg/L)	TCE (µg/L)
1,768	150	540

[25] EPA's new proposed residential level for dioxin (EPA, 2009) is used in the cleanup goal determination provide in Appendix N

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One of the RAOs for groundwater is based on preventing the migration of contaminants (i.e., dioxins) from groundwater at the source area to the river that would result in surface water concentrations in excess of the ARARs for those media. The RIDEM GB criteria (soil leachability and groundwater objectives), however, have not been promulgated for dioxin. Therefore, cleanup goals were developed for this exposure pathway using a simplified mass balance analysis (based on the relative mixing of groundwater with surface water and the partitioning of dioxin between soil and groundwater) to determine the concentrations of dioxin (2,3,7,8-TCDD) in soil and groundwater that would result in surface water concentrations that meet ARARs. These ARARs are based on the State of Rhode Island standards and federal WQC (human health scenario including drinking water and fish consumption), as modified based on site-specific bioaccumulation factors. Complete details of the approach used to develop the cleanup goals for 2,3,7,8-TCDD in source area soil and groundwater are presented in Appendix F (Attachments F-2 and F-3).

3.5 Areas and Volumes above Cleanup Goals

This section describes how proposed areas for cleanup at the CMRP site were identified, including sediment, floodplain soil, and source area soil and groundwater. The implementation of the selected sediment remedy will result in the surface water cleanup goals ultimately being attained.[26] Overall, the proposed areas for cleanup were delineated by constructing a footprint to encompass all sampling locations with cleanup goal exceedances (see Appendix G for comparisons of site data to the cleanup goals). Areas and theoretical volumes for cleanup are summarized in Table 3-8, by action area and media. The theoretical volumes are based on the removal depth needed to reach the cleanup goals, but do not include any allowance for over-excavation or over-dredging which is needed to perform the remediation. The volumes described in the alternative descriptions and cost estimates in subsequent sections in this FS are higher because they include an over-dredge or over-excavation allowance.

Areas and Volumes above Cleanup Goals at the CMRP Site (See Table 3-8 for detail)

Action Area	Media	Cleanup Area and Volumes		
		Square Feet	Acres	Cubic Yards[1]
Allendale	Sediment	673,600	15.5	48,200
	Floodplain Soil	64,600	1.5	2,400
Lyman Mill	Sediment (pond)	1,022,000	23.5	91,000
	Stream Sediment/ Floodplain Soil	940,000	21.6	34,800
Source Area	Soil	339,500	7.8	62,900
	Groundwater	5,500	0.13	1,300

[1] In-situ removal volumes do not include any allowance for over-excavation or over-dredging.

The proposed cleanup areas or remedial footprints as conveyed in this FS are conceptual. More precise cleanup footprints will be developed during the remedial design, and the removal of contaminated media will be confirmed through appropriate sampling and monitoring (see monitoring details for each remedial alternative in Section 6.0). Proposed cleanup footprints evaluated in this FS are discussed below, by action area and media.

3.5.1 Allendale Reach Sediment

The proposed cleanup area for Allendale sediments is shown in Figures 3-1 and 3-5. The spatial extent of the proposed footprint encompasses the river channel bounded to the north by Route 44 (Figure 3-5) and the entire Allendale Pond (Figure 3-1) bounded by the normal water elevation (93.5 ft at the Allendale

[26] The surface water cleanup goals serve as useful benchmarks that will be monitored during remedy implementation to assess short-term impacts and post-construction to assess system recovery.

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Dam). The proposed area is approximately 15.5 acres, with a removal volume of approximately 48,200 cubic yards (cy). Concentrations of dioxin are above the cleanup goal of 14.7 ng/kg in nearly all surface (top 1 foot) sediment samples; concentrations of the other contaminants are also above the cleanup goals at numerous locations throughout Allendale Pond (sediment cleanup goals are summarized in Table 3-3; the comparison of site data to sediment cleanup goals is provided in Appendix G, Table G-1). The vertical extent of the footprint is determined by comparing sub-surface data for all contaminants to the cleanup goals at each sampling location. The depth for cleanup corresponds to that depth at which concentrations of the contaminants do not exceed the cleanup goals. For the river channel, the vertical extent is assumed to be 1 foot in the absence of sub-surface data, but will be confirmed during the remedial design. For Allendale Pond, the vertical extent varies by location in the pond (Appendix G, Table G-3), with an average vertical extent of 1.9 ft.

Overall, the spatial and vertical extent of the proposed cleanup area at Allendale Pond is driven by the cleanup goal for 2,3,7,8-TCDD. Areas with concentrations of other contaminants at levels above the cleanup goals generally represent a smaller area within the 2,3,7,8-TCDD footprint, suggesting that cleanup for 2,3,7,8-TCDD will address the other contaminants as well. Further, due to the widespread extent of the dioxin contamination and because the cleanup goals are generally based on background, limiting cleanup to 'hot spot' areas only would not be sufficient to reduce the surface weighted average concentration to a level below the cleanup goals, as illustrated in the cleanup curve shown in Appendix G (Figure G-1 and Table G-5).

3.5.2 Lyman Mill Reach Sediment

The proposed cleanup area for Lyman Mill sediments is shown in Figure 3-2. The spatial extent of the proposed footprint encompasses all of Lyman Mill Pond bounded by the normal water elevation (77 ft at the Lyman Mill Dam) (sediment from the stream channel and old mill raceway connecting Allendale and Lyman Mill Ponds is included under the action area described in Section 3.5.4). The proposed area is approximately 23.5 acres with a volume of approximately 91,000 cy. Concentrations of dioxin are above the cleanup goal of 14.7 ng/kg in all but two surface (top 1 foot) sediment samples (sediment cleanup goals are summarized in Table 3-3; the comparison of site data to sediment cleanup goals is provided in Appendix G, Table G-2). The vertical extent of the footprint is determined using the same approach utilized for Allendale Pond. The vertical extent of contamination in Lyman Mill Pond varies by location in the pond (Appendix G, Table G-4), but has an average depth of 2.4 ft.

Similar to the situation in Allendale Pond, cleanup for 2,3,7,8-TCDD at Lyman Mill Pond will address other contaminants as well, and remediation of the entire pond (as opposed to remediation of 'hot spot' areas only) is required to meet both the cleanup goals and RAOs (Appendix G, Figure G-2 and Table G-6).

3.5.3 Allendale Reach Floodplain Soil

The proposed cleanup area for Allendale floodplain soils is shown in Figures 3-3a and 3-3b; this proposed area is approximately 1.5 acres with a volume of approximately 2,400 cy.[27] The spatial extent of the proposed footprint encompasses floodplain areas[28] along the river channel north of Allendale Pond and the shore of Allendale Pond. Floodplain soils at Allendale reach pose an exposure hazard to ecological receptors (see Section 2.5) but these receptors are only exposed in that portion of the floodplain that

[27] Appendix N describes how the proposed area and volume for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

[28] Area between the normal water and 100-yr flood elevations; 100-yr flood gradient of 101.2 ft downstream of Route 44 to 97 ft at the Allendale Dam (see Section 2.3.8.1).

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provides suitable habitat (i.e., a vertically stratified riparian vegetation). Therefore, the spatial extent of the proposed footprint was delineated to include:

- Areas of high value ecological floodplain habitat with contaminant concentrations above the cleanup goals;
- Areas that have potential for erosion; and,
- Areas with contaminant concentrations in excess of ARARs (RIDEM residential direct exposure and GB leachability criteria [RIDEM, 2004]) or EPA's recommended residential level for dioxin (EPA, 1998b).

Selected floodplain soil locations with contaminant concentrations above the ecological cleanup goals are not included in the cleanup area either because these specific concentrations are unlikely to contribute to overall area wide exposures exceeding acceptable risk thresholds or ecological exposures are not anticipated due to the nature of the specific habitat conditions present at the sampling locations. With regard to overall contaminant exposures, some locations were not included in the cleanup area because contamination in the surrounding area (and at depth) is below the cleanup goals or the cleanup goals are only slightly exceeded and the concentrations are comparable to results for upstream background. Considering habitat conditions and the likelihood of future exposures by ecological receptors, some of these locations abut residential properties and lack natural vegetation, elsewhere particularly along steep portions of the western bank of the Allendale reach, the floodplain zone is too narrow to provide significant habitat (see Appendix G, Table G-7 and Figure G-3). Additional sampling will be performed during the design phase to verify the spatial extent of the footprint.

Overall, the proposed cleanup area encompasses nearly all floodplain locations with contaminant concentrations above the ecological cleanup goals and all locations with contamination in excess of ARARs and/or EPA's recommended residential level for dioxin (EPA, 1998b) (see Appendix G, Table G-7).

The vertical extent of the footprint is based on a removal depth of 1 foot, which would be subsequently backfilled by 1 foot of clean material. This 1 foot vertical zone encompasses the area where the most significant ecological exposures occur. The actual depth of removal would extend deeper within the vadose zone to meet ARARs or EPA's dioxin requirements as necessary, and would be determined during design based on sampling and analysis of deeper soil samples.

3.5.4 Lyman Mill Reach Stream Sediment and Floodplain Soil

The proposed cleanup area for Lyman Mill reach stream sediments and floodplain soils is shown in Figures 3-4a and 3-4b. The proposed area is approximately 21.6 acres, with a volume of approximately 34,800 cy.[29] The spatial extent of the proposed footprint is determined separately for the stream sediment and floodplain soil as described below. The vertical extent of the footprint is assumed to be 1 foot, which encompasses the area where the most significant ecological exposures occur. The actual depth of removal would extend deeper within the vadose zone to meet ARARs or EPA's dioxin requirements as necessary, and would be determined during design based on sampling and analysis of deeper soil samples.

[29] Appendix N describes how the proposed area and volume for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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3.5.4.1 Lyman Mill Reach Stream Sediment

The spatial extent of the proposed footprint encompasses submerged sediments located within the stream and old mill raceway connecting Allendale and Lyman Mill Ponds (Figure 3-4a). Concentrations of dioxin are above the cleanup goal of 14.7 ng/kg in nearly all surface (top 1 foot) sediment samples; concentrations of other contaminants are also above the cleanup goals, but to a lesser extent (sediment cleanup goals are summarized in Table 3-3; the comparison of site data to sediment cleanup goals is provided in Appendix G, Table G-8).

3.5.4.2 Lyman Mill Reach Floodplain Soil

The spatial extent of the proposed footprint encompasses floodplain areas[30] at the Oxbow (Figure 3-4a) and along the shore of Lyman Mill Pond (Figure 3-4b). Given that the Oxbow represents a significant wildlife habitat and unique area along the lower Woonasquatucket River, the proposed footprint in this area was further delineated to ensure that the net environmental benefit that was derived from the proposed action was maximized.

Oxbow – Local topography, vegetation, and land use were reviewed to delineate the proposed footprint to remediate areas to protect human health and to maximize hazard reduction to ecological receptors at risk subject to the constraints of minimizing remediation related habitat loss. Areas within the 100-yr floodplain but above the 78-ft topographic contour were generally excluded from the proposed footprint because: 1) the available chemical data indicate that the highest contaminant concentrations are primarily within 1-ft of the normal water elevation and 2) the shift in vegetation from scrub/shrub wetland to forest also tends to occur along this boundary. Unlike the forested portions of the Oxbow (which could take many decades to recover), the scrub/shrub wetland habitat would likely recover within a decade or so of a remedial action. Further discussion of the characteristic vegetative communities found within the Oxbow is provided in USACE (2008).

The area immediately southwest of the stream channel and old mill raceway in the northern section of the Oxbow (Figure 3-4a) is included in the proposed footprint even though it is higher than 78-ft in elevation. Elevated dioxin concentrations were found near this area, suggesting that this area receives overbank deposits during flooding.

Overall, the proposed areas for cleanup at the Oxbow encompass all floodplain soil locations with contamination above the cleanup goals and all locations with contamination in excess of ARARs (RIDEM residential direct exposure criteria [RIDEM, 2004]; there were no exceedances of RIDEM's GB leachability criteria), and/or EPA's recommended residential level for dioxin (EPA, 1998b) (see Appendix G, Table G-9).

Lyman Mill Shore – Floodplain soils along the shore of Lyman Mill Pond pose an exposure hazard to ecological receptors only. Therefore, the spatial extent of the proposed footprint was delineated to include only areas with contaminant concentrations above the cleanup goals (see Appendix G, Table G-9 and Figure G-4) that represent high value ecological floodplain habitat or have potential for erosion, and areas with contaminant concentrations in excess of ARARs (RIDEM residential direct exposure and GB leachability criteria [RIDEM, 2004]) or EPA's recommended residential level for dioxin (EPA, 1998b) as follows:

[30] Area between the normal and 100-yr flood elevations; 100-yr flood gradient of 82.1 ft at the stream below Allendale Dam to 80.6 ft at the Lyman Mill Dam (see Section 2.3.8.2).

- The small area along the eastern shore south of Falco Street (contaminant concentrations at one location in this area are in excess of ARARs and EPA's recommended residential level for dioxin);
- The forested area occurring along the eastern shore, between Jefferson and Earl Streets (contaminant concentrations are above cleanup goals at multiple locations at this area); and,
- The small peninsula north of the confluence of Assapumpset Brook and Lyman Mill Pond (there are no available contaminant data for this area, but the area has potential for erosion).

Floodplain areas that do not represent high value ecological habitat (i.e., areas are developed, in close proximity to residential structures and lacking native vegetation or where the grade is steep and the riparian zone only narrowly defined) and have low potential for erosion were excluded from the proposed footprint (Appendix G, Figure G-4), as follows:

- The small isolated patches of floodplain vegetation occurring along the eastern shore, between Warren Avenue and Lyman Mill Dam (concentrations of arsenic and lead are in excess of RIDEM's residential direct exposure criteria at these areas [see Appendix G, Table G-9]; however, these contaminants appear to be comparable to background conditions and additional sampling will be performed during design to confirm background conditions as described in Section 3.4 and Appendix F); and
- The western shore of Lyman Mill Pond, except the small peninsula north of the confluence of Assapumpset Brook and Lyman Mill Pond which is included in the footprint because it is a large depositional area that has likely been impacted by riverborne contaminants and could represent a substantial recontamination hazard.[31]

3.5.5 Source Area Soil

The proposed cleanup area for source area soils is shown in Figure 3-5. The proposed area is approximately 7.8 acres, with a volume of approximately 62,900 cy. The spatial extent of the proposed footprint encompasses the entire source area except for a small area located to the north near Brook Village, where contaminant concentrations are below the cleanup goals (cleanup goals are based on ARARs and EPA's recommended residential level for dioxin).[32] Overall, areas included in the proposed footprint encompass the three capped areas, parking lots, paved surfaces, rip rap and landscaped areas in the source area. The vertical extent of the footprint extends to 5 ft bgs, and is based on the average thickness of the vadose zone. Concentrations of dioxin TEQ, PCBs, pesticides, VOCs, SVOCs, and metals are above the cleanup goals at multiple locations and depths within the proposed footprint (see Appendix F, Table F-4b).

3.5.6 Source Area Groundwater

The proposed cleanup area for groundwater is shown in Figure 3-6. The proposed area is approximately 0.13 acres, with a volume of approximately 1,300 cy. The proposed cleanup area was determined based on the comparison of site data to cleanup goals and an evaluation of key findings from supporting investigations (Appendix G), including the USGS vapor diffusion study (USGS, 2000), the SPMD study (Appendix A), and the 2008 groundwater investigation (LEA, 2008).

[31] However, there are no available contaminant data for this area.
[32] Appendix N describes how the proposed area and volume for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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The proposed cleanup area for groundwater encompasses the VOC and dioxin-impacted area on the west side of the Brook Village parking lot, where contaminant concentrations are in excess of the cleanup goals and contaminated groundwater is discharging to the river (see Appendix G, Table G-10 and G-11). The western boundary of the proposed remedial footprint encompasses the area where the maximum potential dioxin load to the river from contaminated groundwater discharge could occur as identified based on the SPMD study (Appendix A) and corroborated based on groundwater samples collected from three wells located along the eastern bank of the river (LEA, 2008). The eastern boundary of the proposed remedial footprint encompasses borings CMS-451, CMS-453, and MW-05S, locations with the highest dioxin-contaminated soils at depths near the water table. The vertical extent of the footprint is based on an average depth of 8 ft bgs, which encompasses the expected depth of contaminated soils that appear to be serving as contaminant sources to groundwater (Appendix G). Dioxin concentrations at deeper depths are generally below the cleanup goals, and there is no evidence of NAPLs below 6 ft bgs.

The proposed cleanup area excludes locations where contamination has been variable (MW-14M[33]) or was generally low and decreased to acceptable levels in 2002 (GEC6, MW07S, MW02D, MW13B) and locations where the existing surfaces appear to be protective of the underlying groundwater (Appendix G). The proposed cleanup area also does not include one location at the southern end of the source area where concentrations of PCE were slightly above the cleanup goal in 2002 (220 µg/L compared to cleanup goal of 150 µg/L).

3.6 Contingency Monitoring and Evaluations for Downstream Areas

Results from recent investigations suggest that dioxin concentrations in surface sediment from reaches of the river downstream of Lyman Mill Dam have decreased in recent years and are approaching background concentrations (see Section 2.4.3.7), possibly due to natural recovery and control of primary sources of contamination upstream at the source area. Since 2005, dioxin concentrations in surface sediment at downstream areas (2,3,7,8-TCDD concentrations in surface sediment range from 9.1 to 130 ng/kg, with an average concentration of 52.6 ng/kg) are within an order of magnitude of the cleanup goal established for Allendale and Lyman Mill sediment (14.7 ng/kg). Even so, contaminated sediments at Allendale and Lyman Mill Pond are currently secondary sources of contamination to downstream areas.

This section describes an adaptive management approach that would be used to evaluate whether additional action is warranted for downstream reaches of the river following implementation of a sediment remedy upstream. Adaptive management is the use of a structured process of selecting a management action, monitoring the effects of the action, and applying those lessons to optimize management action and guide future decisions. Adaptive management is not a means to sanction less rigorous cleanups or to avoid public scrutiny of the decision-making process. Overall, an adaptive management process such as a decision tree (Figure 3-7) would be used to address contaminated sediments in reaches of the river downstream of Lyman Mill Dam to:

1) describe specific monitoring activities that would be performed to assess the rate of recovery at downstream areas, and
2) identify triggers for future potential actions (e.g., cleanup goal exceedances).

Environmental monitoring at the site is an important component of the remedial action. The sediment alternatives evaluated in this FS (see Section 6.0) include monitoring before, during and after construction. Overall, monitoring data will be used to assess site conditions, evaluate recovery, determine

[33] PCE concentrations in groundwater at MW14M were below RIDEM GB objectives in 2001, but in excess of criteria (13x criteria) in 2002.

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impacts the remedy may have on downstream areas, and support five-year reviews. Data from pre-construction monitoring will become the new baseline and would be used in conjunction with post-construction monitoring data to evaluate impacts of remedy implementation and recovery or improvement over time (Figure 3-7). Post-construction monitoring data would include confirmation sampling conducted immediately following construction and long-term monitoring conducted once the system has equilibrated approximately one year after construction is complete. Monitoring data would support the general decision-making process and specific risk evaluations (i.e., confirming that the remedy remained effective and that the cleanup goals were still protective) and would assess whether monitoring opt-out provisions could be considered.

An overview of the components of the long-term monitoring plan (LTMP) for the site is provided in Appendix H; a more detailed and comprehensive LTMP would be developed during remedial design. As part of the long-term monitoring in the downstream areas, data quality objectives will be established detailing such items as purpose and objectives, sample design, and number and location of samples. Objectives of the long-term monitoring will include determining whether contaminant concentrations in downstream areas have decreased over time with upstream source control and/or if natural recovery is occurring. Specific media to be collected for long-term monitoring will be determined during development of the LTMP. Sampling as part of long-term monitoring may consist of any or all of the following: sediment surface grab sampling (to measure surficial contaminant concentrations), sediment core sampling (to determine whether deposition is occurring using such methods as radioisotope dating), and/or biota sampling (to assess bioavailability and bioaccumulation potential). In addition, toxicity testing and/or other measures of ecological effects might be necessary to determine whether contaminant exposures were still resulting in unacceptable ecological risks. Samples will be collected at downstream areas using a statistically-based sampling design that will be described in the monitoring plan. The geographic extent of the downstream area for monitoring will also be identified in the monitoring plan.

Allendale and Lyman Mill Dams are privately owned. Allendale Dam was reconstructed in 2002, whereas Lyman Mill Dam is currently in need of repair and maintenance. In tandem with the remedial actions occurring in the two ponds and the source area, dam maintenance needs to be performed (unless an alternative involving dam removal is selected) and enforced to minimize the potential for future dam breaches which could result in sediment transport downstream. The long-term monitoring effort for the remedy will include dam maintenance (unless an alternative involving dam removal is selected).

Long-term monitoring at the site would commence following completion of the construction to ensure the RAOs have been met. It is anticipated that monitoring for the source area and downstream areas would start one year after the end of construction and continue on a regular basis. Study area conditions would be reassessed after a proposed timeframe of five years. If, after five years, downstream risks remained the same or decreased, then a determination of whether to re-evaluate monitoring frequency would be made (Figure 3-7). If, after five years, downriver risks increased or site conditions changed, then additional remedial action in these areas might be warranted. As part of the long-term monitoring in the downstream areas, specific triggers will be proposed to specify when monitoring could cease or when site conditions warranted additional remedial action in the downstream areas. Cleanup goal exceedances are one such trigger that might require further evaluation of the data to determine whether a remedial action was necessary. The results of the adaptive management approach will be used by EPA in consultation with RIDEM and other stakeholders to determine if additional action to address contaminated sediments in reaches downstream of Lyman Mill Dam was warranted. Results from the adaptive management approach could be the basis of an Explanation of Significant Difference or ROD if downstream action was deemed warranted.

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4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

The purpose of this section is to identify and screen a range of general response actions, remedial technologies, and process options that may be suitable for achieving the RAOs for sediment, soil, and groundwater at the CMRP site. General response actions are various approaches that could be used to satisfy the RAOs (Section 3.1). The term "technology" refers to general categories of remediation mechanisms or tools, such as isolation caps or dredging. The term "process option" refers to specific processes within each technology family, such as using sand for an isolation cap or mechanical equipment for dredging. A general response action may be accomplished by several types of remedial technologies, and process options are specific methodologies within each technology type.

The initial screening process is intended to eliminate technologies and process options that are inappropriate or infeasible for the CMRP site. The initial screening analysis of technologies and process options is based on a subset of the NCP screening criteria described below, including effectiveness, implementability, and cost. The criterion of effectiveness was given the most weight, followed by implementability, and then cost.

Effectiveness

The potential effectiveness of each remedial technology and process option is evaluated by considering the degree to which it meets the following criteria:

- The ability of the options to meet the RAOs;
- Potential impacts to human health and the environment during the construction and implementation phase; and
- Reliability with respect to the contaminants and conditions at the site. A summary of the areas of contamination and contaminant concentrations is provided in Section 2.4 and specific contaminants at the CMRP site are discussed in Section 2.5.

Technologies providing significantly less effectiveness than other, more promising technologies may be eliminated, and alternatives that do not adequately protect human health and the environment must be eliminated from further consideration. Effectiveness is evaluated using terms such as: not effective; or low, moderate, and high effectiveness.

Implementability

Implementability focuses on the technical feasibility and availability of the technologies that each alternative would employ, and the administrative feasibility of implementing the alternative. Technologies that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time, may be eliminated from further consideration. Implementability is generally evaluated using terms such as: infeasible or not possible, or complex/difficult, moderate, and easily (i.e., high) implementable.

Cost

Cost plays a limited role in screening of technologies and process options. The costs of construction and any long-term costs to operate and maintain the technologies are considered. The costs are based on engineering judgment and available historical information rather than detailed estimates. Cost is qualitatively assessed as being low, moderate, high, and very high.

General response actions, technologies and process options for sediment, soil, and groundwater at the CMRP site are described and evaluated in Sections 4.1 through 4.4 as outlined below. Broad categories of response actions include no action, institutional actions, containment actions, such as capping, removal actions such as excavation, and treatment. The most suitable technologies and process options retained after screening are used in the development of remedial alternatives for the CMRP site (see Section 5.0).

General Response Action	Section Description by Media		
	Sediment	Soil	Groundwater
No Action	4.1	4.1	4.1
Institutional Controls	4.2.1	4.3.1	4.4.1
Engineering Controls	4.2.2	4.3.2	—
Monitored Natural Recovery	4.2.3	4.3.3	—
Monitored Natural Attenuation	—	—	4.4.2
Containment (In-Situ Capping)	4.2.4	4.3.4	4.4.3
Removal	4.2.5	4.3.5	—
Transportation	4.2.6	4.3.6	—
Dewatering	4.2.7	4.3.7	4.4.4
Disposal	4.2.8	4.3.8	—
Treatment	4.2.9	4.3.9, 4.3.10	4.4.5, 4.4.6

4.1 No Action

In accordance with NCP requirements (EPA, 1988), the No Action response must be carried through the entire FS process to serve as the baseline condition to which all other response actions are compared. As a result, No Action is a general response common to sediment, soil, and groundwater at the CMRP site. The No Action response does not include technologies such as ICs or treatment; however, this response could include monitoring. For example, if the risk at a site was low but more contaminated material was present at depth, monitoring could be implemented to track the changes in contaminant levels over time. No Action may be appropriate if a site does not currently pose a potential threat to human health or the environment, if a site is not expected to present a threat in the future, or if previous remedial actions have eliminated the need for further actions.

Effectiveness

The No Action response would not reduce potential exposure to contaminated media at the CMRP site and would not be effective in reducing the potential risk to human health or the environment.

Implementability

No Action is both technically and administratively easily implementable.

Cost

Because no action would be taken, no costs would apply to this option other than monitoring costs which would be low.

Screening Result

No Action is retained as a baseline in the evaluation of sediment, soil, and groundwater alternatives.

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4.2 General Response Actions and Technologies for Sediment

General response actions, technologies, and process options for sediments located in the Allendale and Lyman Mill reaches of the river are described and evaluated in this section, and summarized in Table 4-1. Additional details regarding sediment response actions are also provided in Appendix I.

4.2.1 Institutional Controls

4.2.1.1 Description of Institutional Controls

ICs are measures used to protect human health and the environment where residual contamination remains on site above safe levels. ICs are defined by EPA (2003b) as "non-engineering instruments, such as administrative and legal controls that help to minimize the potential for human exposure to contamination and/or protect the integrity of a remedy." ICs are often used in conjunction with engineering controls (ECs), which are engineering measures designed to minimize the potential for human exposure to contamination and measures to contain or reduce contamination. ICs are described in detail below. Specific measures identified for the CMRP site are identified and evaluated as well.

ICs are non-engineering instruments designed to limit land or resource use and/or make information available to modify or guide human behavior at the site. EPA (2003b) defines four general categories of ICs, as follows:

1) Proprietary Controls – these controls are based on state law and use a variety of tools to prohibit activities that may compromise the effectiveness of the remedy or restrict activities or future uses of resources that may result in unacceptable risk to human health or the environment. They may also be used to provide site access for operation and maintenance (O&M) activities. The most common examples of proprietary controls are easements and covenants;
2) Government Controls – these controls impose land or resource restrictions using the authority of an existing unit of government. Typical examples of governmental controls include zoning, building codes, local ordinances, drilling permit requirements and state or local groundwater use regulations;
3) Enforcement and Permit Tools with IC Components – these types of legal tools include orders, permits, and consent decrees. These instruments may be issued unilaterally or negotiated to compel a party to limit certain site activities as well as ensure the performance of affirmative obligations (e.g., to monitor and report on an IC's effectiveness); and
4) Informational Devices – these tools provide information or notification about whether a remedy is operating as designed and/or that residual or contained contamination may remain on site. Typical information devices include state registries, deed notices, and advisories.

Proprietary controls identified for the CMRP site include covenants and easements. Covenants could be used to prohibit future activities that could lead to the release of contaminated sediment (e.g., excavation or unauthorized dam alterations) and restrict uses such as anchoring and swimming. Easements could be used to provide site access where access is needed in the future.

Government controls identified for the CMRP site include local ordinances or zoning. Local ordinances or zoning could be used to prohibit activities that could lead to contact with contaminated sediments or new releases to the environment (e.g., excavation).

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Informational devices identified for the CMRP site include legal notices, advisories, dissemination of information or notices to the public using outreach documents and/or signs. Legal notices and advisories could be used to inform the public of existing contamination on a site, and are often implemented with signs or ECs such as fences. Consumption and health advisories could be used to restrict fish consumption (a fish consumption advisory is currently in place for the lower Woonasquatucket River, see Section 2.1). These advisories could protect human health by limiting potential exposure to contaminated fish, although no enforcement mechanism for such advisories is available. Public outreach documents could be used to inform the public of site contamination, and identify measures that should be taken to prevent exposure to site contamination. Public outreach documents are currently in place for the site, and include the *Do's and Don'ts for the Woonasquatucket River*. Signs could be used to inform the public of fishing advisories. Signs are currently in place at the site to warn the public against eating fish caught from the lower Woonasquatucket River.

4.2.1.2 Screening of Institutional Controls

Effectiveness

The use of ICs is somewhat effective in reducing exposure to contamination by limiting the amount of direct contact with contaminated media. However, the effectiveness of ICs alone would be uncertain because of the inherent difficulty in enforcing such restrictions. ICs would not achieve the long-term goal that this portion of the Woonasquatucket River be fishable and swimmable. Nor would ICs effectively address risk to ecological receptors. Overall, ICs are considered to have low to moderate effectiveness.

Implementability

ICs are easily implemented at sites where contamination above risk based levels remains in place.

Cost

The cost is low because no construction work would be required.

Screening Result

ICs are retained for alternative development. These controls would not be used as the sole element of any alternative, but would be used in combination with other response actions as part of several alternatives.

4.2.2 Engineering Controls

4.2.2.1 Description of Engineering Controls

Like ICs, ECs are measures used to protect human health and the environment where residual contamination remains on site above safe levels. ECs are engineering measures designed to minimize the potential for human exposure to contamination and measures to contain or reduce contamination. ECs identified for the CMRP site include perimeter fences, warning buoys, and maintenance of the Allendale and Lyman Mill Dams (for alternatives that assume the dams remain in place) or removal of these dams altogether. A perimeter fence could be used to limit exposure by restricting public access to areas of the site. A perimeter fence is currently in place at the source area and Allendale Pond. Warning buoys could be placed in the water to warn boaters to stay out of the area and not to fish in the area. The Allendale

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and Lyman Mill Dams can be maintained to minimize the risk of structural breaches that could potentially transport contaminated sediments downstream.

A dam is a barrier that impounds water in a river or stream. Dams generally serve the primary purpose of retaining water for intended purposes such as providing water for irrigation to town or city water supplies, improving navigation, creating a reservoir of water to supply industrial uses, generating hydroelectric power, creating recreation areas or habitat for fish and wildlife, or retaining wet season flow to minimize downstream flood risk. The Allendale and Lyman Mill Dams no longer serve their original intended industrial purpose. However, the dams now act to reduce the risk of transport of contaminated sediments downstream. Remedial alternatives developed in Section 5 include a range of alternatives, some that include maintaining the current dams, some that include replacement of the dams with a smaller weir-type structure, and some that include removal of the dams altogether. The recreational and ecological habitat the dams created in the Allendale and Lyman Mill Ponds will be altered and abutting properties could be impacted if the dams are replaced with smaller weir structures or removed. The advantages and disadvantages of each approach will be discussed in Section 6.0.

4.2.2.2 Screening of Engineering Controls

Effectiveness

Most ECs have limited effectiveness in reducing exposure to contamination in the long term because of the inherent difficulty in enforcing such restrictions. ECs would not achieve the long-term goal that this portion of the Woonasquatucket River be fishable and swimmable. Nor would ECs effectively address risk to ecological receptors.

Maintenance of the Allendale and Lyman Mill Dams would have high effectiveness in preventing structural breaches that could potentially transport contaminated sediments downstream provided the dams are reliably maintained.

Overall, ECs are considered to have low to moderate effectiveness.

Implementability

ECs are easily implemented at sites where contamination above risk based levels remains in place. Long-term maintenance of the Allendale and Lyman Mill Dams may be more difficult from an administrative perspective because the dams are privately owned.

Cost

The cost is low because no substantive construction work would be required.

Screening Result

ECs are retained for alternative development. These controls would not be used as the sole element of any alternative, but would be used in combination with other response actions as part of several alternatives.

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4.2.3 Monitored Natural Recovery

4.2.3.1 Description of Monitored Natural Recovery

Monitored natural recovery (MNR) relies on ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in surface sediments over time, thereby reducing risk to human and/or ecological receptors (EPA, 2005). These natural processes include physical, biological and chemical mechanisms. Figure 4-1 presents a generalized summary of the different processes that contribute to natural recovery; the processes expected to be the most relevant to the CMRP site are the natural deposition of clean sediment (i.e., burial of contaminated sediment by cleaner sediment) and biological degradation. In stable depositional areas, clean sediments tend to naturally cover contaminated sediments after sources of contamination are reduced or eliminated.

A number of physical processes can result in a change of chemical concentrations in the surface sediment over time. Deposition of clean sediment over contaminated sediment reduces risk by containing sediment in place and covering surface contaminant concentrations. Other processes such as erosion, dispersion, bioturbation, advection and volatilization may reduce chemical concentrations and bioavailability on a specific site, but may result in moving contaminants to another medium or area. Therefore, it is important that monitoring methods used are designed to verify which processes are occurring at the site.

In order for MNR to be effective, significant sources of contamination to sediments must be eliminated, exposure to unacceptable levels of contamination during the recovery period must be addressed, and monitoring of the recovery process and comparison of the actual rate of recovery to the predicted rate would be required.

MNR would generally be used with ICs and/or ECs because contamination above cleanup goals would remain in the sediment. After cleanup goals are reached, ICs and/or ECs would be needed in the long term to reduce the risk of re-exposing buried contamination.

4.2.3.2 Screening of Monitored Natural Recovery

Effectiveness

MNR could potentially provide some degree of effectiveness for contaminated sediment at depositional areas of Allendale and Lyman Mill Ponds. MNR would not be effective, however, for areas where erosion is expected to occur during flood flows, or in the river channel areas. The CSM for the CMRP river and pond sediment shows that the primary mechanism for ongoing release of contaminants from the sediment to the environment is through sediment resuspension to the surface water. Deposition of clean sediments during MNR would reduce this exposure and minimize downstream transport of the contamination by burying contaminated sediments to a depth below the biologically active zone (BAZ).

Some of the physical conditions in the Allendale and Lyman Mill Ponds appear to be appropriate for MNR. The two ponds are generally shallow with slow-moving waters behind the dams; further, clay and silt sized particles, which are characteristic of depositional areas, have accumulated behind each of the dams. Further, the hydrophobic and insoluble nature of the contaminants, such as dioxin and PCBs, makes it likely to remain sorbed to organic carbon in the sediment. The sedimentation rates in the two ponds range from 0.5 to 0.8 cm/yr in Allendale Pond and from 0.5 to 0.6 cm/yr in Lyman Mill Pond (Section 2.3.8). It is thought that the BAZ is 1 ft (30.5 cm) thick in the ponds; this is a conservative assumption and the actual thickness of the BAZ could be less depending upon the thickness of the oxic sediment layer in the ponds. The sedimentation rates in the ponds are not expected to change

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dramatically because land use in the watershed is not likely to be altered substantially. With the current sedimentation rates it would take approximately 40 to 60 years to accumulate 1 ft of material in the deeper, quiescent areas of the ponds (Section 2.3.8). Material would not likely accumulate in the northern inlets in either pond due to the higher current velocities and scour potential in these areas.

Although natural biological degradation can theoretically occur, the rate would be very slow at the CMRP site based on the recalcitrant characteristics of contaminants. Natural degradation of dioxins and PCBs has been documented in laboratory-based studies; however, the effectiveness of natural degradation at large-scale field sites is less certain and the implementation period is expected to be prohibitively long. The specific conditions, such as having the appropriate bacterial populations and environmental conditions to support them, may also be absent at the CMRP site.

The MNR response action would eventually meet the sediment RAOs in depositional areas of the river in that the residual risk would decrease with time and physical deposition of clean sediments would minimize downstream transport of contamination in these areas of the site. However, there might be little reduction in risk to human health or the environment for a very long time until safe levels are reached and not all areas can be effectively addressed.

Overall, MNR utilizing natural physical deposition is considered to be low to moderately effective, whereas natural biological degradation is considered not effective.

Implementability

MNR is easily implemented at sites where contamination above risk based levels remains in place. It is technically feasible to address some areas of the CMRP site using MNR (assuming natural physical deposition). This option is administratively feasible in that only monitoring would be required and these services are readily available. No in-water construction is required thereby eliminating any administrative implementability issues.

Cost

The costs for MNR are low, and would be limited to costs for collection and evaluation of monitoring data.

Screening Result

MNR utilizing natural physical deposition is retained for alternative development. MNR utilizing natural biological degradation is screened out.

4.2.4 Containment (In-Situ Capping)

4.2.4.1 Description of Containment (In-Situ Capping)

Capping of contaminated sediment in place can be a reliable response action depending upon site conditions. According to Palermo et al. (1998):

> *Capping of contaminated material in open-water sites began in the late 1970s, and a number of capping operations under a variety of disposal conditions have been accomplished. Field experience with these projects has shown that the capping concept is technically and operationally feasible.*

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> *The cost of capping is generally lower than alternatives involving confined (diked) disposal facilities. The geochemical environment for subaqueous capping favors long-term stability of contaminants as compared with the upland environment where geochemical changes may favor increased mobility of contaminants. Capping is therefore an attractive alternative for disposal of contaminated sediments from both economic and environmental standpoints.*

Capping would reduce exposure of human or ecological receptors by preventing direct contact and the migration of contamination from the sediment to the water column. The most common technology is an isolation cap, where clean material is placed over contaminated sediment to prevent direct contact and sediment erosion, and retard migration into surface water. Another technology, a reactive cap, involves addition of reactive materials to the cap to increase adsorption, react with contaminants, or accelerate biological degradation. In some locations, placement of cap materials will raise the existing ground surface or mudline elevation which may change habitat types and/or reduce flood storage capacity. In this situation, the top layer of the cap can be modified to support habitats such as wetland plantings (referred to as a wetland cap). In depositional areas, a thin-layer cap may be used to improve habitat substrate and to accelerate natural recovery (referred to as a habitat cap). Where contamination exists along a shoreline, caps can be placed in the zone between subaqueous areas and upland areas. These shoreline stabilization caps may be placed on relatively steep slopes and can be designed to resist erosion by waves, wind and river flows. These capping technologies are discussed in further detail below. Additional details about cap design and placement are discussed in Appendix I.

Isolation Capping Technology

The primary objectives of isolation caps according to Palermo et al. (1998) are:

- Physical isolation of the contaminated sediment from the benthic environment.
- Stabilization of contaminated material, preventing resuspension and transport to other areas.
- Reduction of the flux of dissolved contaminants into the cap and overlying water column.

Isolation caps are commonly constructed of granular material (e.g., sand), geosynthetic membranes, bentonite, or clean dredged material, and range from one to several feet thick. The isolation layer may be supplemented by additional layers for various purposes such as providing habitat or erosion control.

Isolation caps are an effective remedy under the right conditions. The effectiveness and implementability of isolation capping depends on the following factors:

- **Potential water column impacts during placement**. Cap material must be placed through the water column to cover contaminated sediment. During placement, there is the potential for some of the cap material to be released into the water column and transported with the current; because the cap material would be composed of clean material, this would not result in any chemical contamination of the river. However, cap placement could result in localized, temporary increases in turbidity levels. There is also the potential for contaminated sediments to be resuspended into the water column as the cap material is placed onto the sediment bed.
- **Ability to obtain and place the cap materials**. The implementability of capping depends on the availability of cap materials, the ability to transport the materials to the site, and the ability to place the materials.
- **Long-term cap stability**. The cap must be stable in the long term to provide an effective remedy. The evaluation must consider the potential for long-term erosion by currents, waves, or

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other forces such as anchors and boat traffic, potential bioturbation, and long-term contaminant migration due to advection or diffusion.

- **Site stability.** The site must provide stable, reliable, long-term support for the cap. The site should be in areas where sediment naturally deposits and where areas are relatively level.

The factors affecting isolation cap effectiveness depend on the specific site conditions. These are described in the guidance documents prepared by EPA and USACE for capping contaminated sediments (Palermo et al., 1998; Herbich, 2000). Isolation caps have been shown to be effective under the conditions described below.

In general, the candidate site for isolation capping should be classified as non-dispersive, where sediment is in a stable depositional area. Ideally, the capping site should be in a low-energy location with little potential for cap erosion. However, capping can be successful in higher energy sites provided that the cap design accounts for erosion potential.

Capping is most effective where the bottom slope is close to horizontal. As the slope angle increases, there is an increase in potential lateral movement of either soft, contaminated sediment or cap material. Isolation caps have been placed on slopes as steep as 2 ft horizontal to 1 ft vertical (which is a slope of 50% or approximately 26 degrees) along shorelines using special construction methods and erosion control layers added to the cap (Tetra Tech Foster Wheeler Inc., 2003). The cap design must consider the potential for erosion due to waves and water currents including storm induced flows. In areas of potential erosion, the upper cap layers should be constructed with coarse-grained material and/or armor stone to resist storm induced waves and currents. The design should be based on storms with a return interval of 50 to 100 years (Palermo et al., 1998).

Caps have been placed in water depths of up to 100 ft. In general, deeper water depths provide a more stable bottom because there are no wave effects, low erosion due to propeller forces, and low current velocities. However, caps have been used in shallow water areas and can be effective when erosion control is considered in the design process.

A procedure for designing the thickness and types of materials in caps is provided in the USACE guidance on capping (Palermo et al., 1998). The total cap thickness is the sum of four components: (1) thickness required to provide chemical isolation; (2) thickness equal to the depth in which the deepest burrowing organism at the site can reach (called the bioturbation depth); (3) thickness that could be eroded during storms or floods; and (4) thickness equal to the self-weight consolidation of the cap material. For caps made with sand or gravel, the consolidation thickness is essentially zero. Figure 4-2 shows a typical cross-section for capping along a shoreline area.

Reactive Cap Technology

Reactive capping is an innovative technology for improving cap performance. A demonstration project was conducted in the Anacostia River in Washington, DC, to develop methods for designing, constructing, and monitoring reactive or active caps (Reible et al., 2003). As a new and emerging technology, reactive caps are not identified in the EPA guidance on capping (Palermo et al., 1998); however, the *Contaminated Sediment Guidance for Hazardous Waste Sites* (EPA, 2005) indicates that "reactive or adsorptive materials may be used to enhance chemical isolation capacity."

Capping with clean sediment is an effective technology. However, there could be situations when such conventional capping techniques may not be protective of human health and the environment. These

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include areas where the chemical concentrations are relatively high, where groundwater gradients could lead to advection of contaminants through the cap, or where NAPL could migrate through the cap (Reible et al., 2003). In these instances, it may be appropriate to design a cap that incorporates some form of treatment such as activated carbon, zero-valent iron, or an organic soil or sediment.

Wetland Cap Technology

The difference between wetland caps and isolation caps is that the top layer of cap material in a wetland cap is designed to support wetland vegetation, and the cap must be at the appropriate elevation relative to the surface water elevations to promote vegetative growth. In order to provide environmental protection, a wetland cap should be made from two layers. The lower layer should be designed as the chemical isolation layer. The upper layer should be designed with the soil types best suited to support the target vegetation types. The thickness of the upper layer should be based on plant root depths and potential bioturbation depth.

Habitat Enhancement Cap Technology (Thin-Layer Cover)

Habitat enhancement capping is a method of enhancing or accelerating natural recovery. These caps have also been called thin-layer covers. Habitat enhancement caps are not designed to provide chemical isolation; therefore, they do not need to be designed to prevent chemical migration by diffusion or advection. The cap would be designed to provide a degree of physical separation of the contaminated sediment from the benthic environment and to reduce resuspension or transport of contaminated sediment particles.

The material type selected for a thin-layer habitat cap depends on the type of habitat needed. For example, at the Ketchikan Pulp Company site in Alaska, natural sediments were covered with excessive amounts of man-made organic material from historic wastewater treatment plant discharges from the Mill wastewater treatment plant (EPA, 1999). The habitat was degraded by the physical presence of the man-made material; therefore, one of the criteria for the thin-layer cap was to reduce the organic content at the surface. Therefore, the cap was made from inorganic sand with almost no organic matter or clay particles.

Shoreline Stabilization Cap Technology

In areas of potential erosion, such as shorelines, caps must be designed to prevent erosion. In this situation, the upper layer of the cap can be made from armor stone designed to be stable in a storm or flood (Palermo et al., 1998).

The armor layer would be designed using established methods for shoreline protection, such as those described in Appendix A of the USACE guidance (Palermo et al., 1998). The armor layer would be placed over the isolation layer or over an intermediate layer of coarse sand. The intermediate layer may be necessary to provide a stable base for the armor to prevent fine-grained particles in the isolation layer from migrating into the void spaces in the armor layer. A separate bioturbation layer is generally not needed because the armor would prevent burrowing organisms from reaching the isolation layer. In some instances, biodegradable fabric can also be used to temporarily stabilize materials while re-establishing vegetation.

The installation of a shoreline cap uses similar methods to sediment removal (Section 4.2.5) and dredged material transport (Section 4.2.6).

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4.2.4.2 Screening of Containment (In-Situ Capping)

Effectiveness

Capping contaminated sediment would be a somewhat effective response action, especially in the depositional areas of the ponds. However, in shallow, erosional areas such as the upstream inlets and the river channel areas (i.e., channel area between the Route 44 Bridge and Allendale Pond and the stream channel connecting the two ponds) placement of a cap that will be resistant to the current velocities may require some excavation of underlying material in order for the new cap surface to remain below the present water line. As described above in the MNR response action (Section 4.2.3), the most important potential mechanism for ongoing release of contamination from the sediment to the environment is through sediment resuspension and downstream transport of sediment particles. Capping would be a fairly effective response action for minimizing transport via this pathway.

Allendale and Lyman Mill Ponds are shallow ponds behind dams, with slow-moving waters and fine-grained silt and clay sediment, which is characteristic of depositional areas. This makes the Allendale and Lyman Mill Ponds more appropriate sites for capping. The insoluble nature of the primary contaminants makes them likely to remain sorbed to the organic matter and fine-grained materials in the pond sediments.

Isolation capping, wetland capping, and shoreline stabilization could all potentially be used in the Allendale and Lyman Mill reaches. These capping technologies could achieve the sediment RAOs and could be effective in protecting human health and the environment by preventing direct contact and essentially eliminating contaminant migration to the overlying surface water providing the caps are not disturbed. The thin-layer habitat enhancement capping technology would have lower overall effectiveness as a stand-alone alternative. The thin layer of material would be more readily mixed with surface sediment via bioturbation and would provide less protection from direct exposure to contamination than an isolation cap. In some situations, reactive caps with additives for improving sorption of contamination can be more protective than an isolation cap. However, given the low solubility of the chemicals and low advection due to groundwater flow, a reactive cap would not provide a substantial improvement compared to a conventional isolation cap. Overall, the capping response action could provide reliable long-term protection, as long as the cap remained intact and was not disturbed. This would require ICs and long-term O&M to ensure the integrity of the cap.

There could be some short-term impacts to water quality, for resuspension of contaminated sediment, and migration of contaminants to the porewater during capping. However, these could be controlled using standard construction techniques. In addition, placement of the cap would result in the loss of benthic organisms, although decisions regarding the type of cap could be used to enhance recovery of the benthic habitat.

Overall, the capping technologies have moderate effectiveness, with the exception of habitat enhancement and reactive caps, which would have lower overall effectiveness.

Implementability

Isolation capping, wetland capping, shoreline stabilization, and habitat enhancement capping are all technically implementable. These caps can be designed and implemented in the Allendale and Lyman Mill reaches with special construction techniques for working in shallow water. However, cap placement in the vegetated areas near some sections of the shoreline may require removal of the existing vegetation; this will likely be difficult due to the very soft sediment and shallow water. In some cases, the vegetation

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may be removed from shore by using long-reach equipment; however, other areas may require the use of specialized low ground pressure or amphibious equipment to work in the shallow areas along the shoreline. Placement of caps in shallow water and along shorelines has been successfully implemented at similar sites (Palermo et al., 1998), and the implementability and acceptability can be increased with the use of wetland caps or other habitat enhancement layers that improve the existing habitat.

The capping response action is administratively implementable and the capping materials and construction and monitoring equipment and personnel are readily available from several commercial companies. Capping may result in impacts to wetland and floodplain areas that would have to be assessed (see Section 4.5.2.4).

Overall, all of the capping technologies are considered to be moderately implementable.

Cost

The costs for all capping technologies would be moderate.

Screening Result

Isolation capping, wetland capping, shoreline stabilization, and habitat enhancement capping are all retained for alternative development. Reactive capping is retained for consideration in the final design as part of an isolation cap alternative.

4.2.5 Sediment Removal

4.2.5.1 Description of Sediment Removal

Sediment removal is a response action that involves moving sediment from its current location to a new location that reduces potential mobility and exposure of human or ecological receptors to the sediment. Dredging is defined as the technology where sediment under water is removed. Excavation is defined as the technology where the overlying water is drained and then the sediment is removed using conventional earthmoving equipment.

Dredging would apply to those alternatives where the existing dams would remain in operation during and after sediment remediation. For those response actions where the dams would be removed, dredging would not be needed because most of the sediment would be exposed after dam removal. Excavation would apply to all alternatives.

Dredging Technology

Dredges are commonly classified as mechanical, hydraulic, hybrid, or pneumatic (USACE, 1983; Herbich, 2000). Mechanical dredges use digging buckets (such as a clamshell) that are suspended by a cable from a crane, an excavator on a fixed arm, or dragline buckets that are suspended by a cable from a crane. Hydraulic dredges add water to sediment to create a slurry that can be pumped in a pipeline to the sediment processing site or to a hopper dredge. Hybrid dredges use mechanical devices to first remove sediment and then mix sediment with water to create a slurry which is pumped to a sediment processing site. The hybrid process option includes various pumps that can move slurries with higher solids content than traditional hydraulic dredges, so that less water is added to produce the slurry. Pneumatic dredges are similar to hydraulic dredges, except that they use pneumatic systems to move the dredged material.

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Mechanical Dredging Process Option

Mechanical dredging buckets are similar to land-based crane and bucket excavators. The bucket is dropped through the water column and penetrates into the sediment by gravity. The bucket is closed and then lifted from the sediment through the water column. When the bucket is above the water surface, it is moved to deposit the dredged material into a transport container or onto a suitable staging area. The container is typically a barge, hopper, and conveyor system, or land-based truck, and the staging area is commonly a dedicated shoreline area (e.g., a levee or dewatering area).

Mechanical dredges remove sediment at nearly the in-place density and water content. However, some water is added to the collected sediment because every grab cannot be filled completely with sediment. Mechanical dredges typically include water at a volume of 20% to 50% of the bucket capacity.

Enclosed environmental buckets (Figure 4-3) have been designed to remove sediment in relatively thin layers and to create a seal to reduce sediment loss, which minimizes sediment resuspension during dredging. These types of buckets have been used in several projects in the Great Lakes (EPA, 1994a), in the Pacific Northwest, and in New Bedford, Massachusetts (Palermo et al., 2004). Some environmental buckets use hydraulic cylinders to close the clamshell, which provides a tighter seal and further reduces sediment loss.

Other types of mechanical dredging systems include backhoes and dragline dredges. Backhoes are similar to land-based excavators but can be placed either on barges or the shoreline and used to remove sediment. Backhoes have not been used extensively for contaminated sediment removal projects due to the difficulty of excavating continuous, level areas, and the potential loss of sediment from the open excavator bucket; additionally, unless modified specifically for work in soft sediments, a backhoe is likely to become stuck. Backhoes can be more effective than clamshells for removing dense or hard material, and are effective for dredging slopes along shorelines. Backhoes are most effective in shoreline or shallow-water work where they can be placed either on land or on shallow-draft pontoon barges.

Dragline dredges use a barge-mounted crane which is similar to a clamshell dredge. However, dragline buckets are open on one side and are lowered into the sediment with a lifting cable, then pulled back towards the crane with a second cable. Draglines have been used in navigational dredging and are used in mining operations because they are efficient at removing large quantities of sediment. They have been used rarely for contaminated sediment projects because the open side of the bucket does not effectively contain the dredged sediments, which can increase resuspension rates.

Hydraulic Dredge Process Option

There are several types of hydraulic dredges that use different methods to loosen sediment and guide the material into a suction pipe. A cutter head dredge has a rotating head that cuts into the sediment. An auger dredge has a horizontal auger that loosens the sediment and pulls it to the center of the dredge where the suction inlet pipe is located. Some hydraulic dredges do not use any cutting device and rely only on suction to remove the sediment. A large amount of water must be added to create a slurry and remove sediment. In general, the volume of water added is five to 10 times the in-place volume of sediment removed.

The cutter head system is the most common technology used to remove sediment. Cutter head dredges can remove a wide variety of sediment types, including dense sand and hard clay. Because suction dredges do not use a cutting device to loosen the sediment, they can generally only remove soft sediments with little debris. Suction dredges often include water jets to help loosen the sediment. Figure 4-4 shows a schematic of a typical hydraulic cutter head dredge and discharge pipeline system.

Pneumatic Dredge Process Options

Pneumatic dredges are similar to hydraulic dredges, except that a pressure gradient created with compressed air is used to lift and move dredged material instead of a pump. Pneumatic dredges are not common, and are used primarily for small-scale cleanup of spilled contaminants and marine archaeology.

Excavation Technology

To perform excavation of sediment, the overlying water must be temporarily removed and a temporary water containment barrier (cofferdam) is often needed. Once the water is removed, the exposed sediment can be removed using conventional upland excavation equipment.

At many sites, the exposed sediment will still have high water content and very low strength. In these cases, it may be necessary to install temporary access roads so that excavators and haul trucks can access the excavation area. Once roads are installed, excavators with long arms can reach distances of up to 50 ft from the edge of the road to remove sediment and place it into trucks for hauling. If the sediment is dense enough, temporary roads may not be necessary.

Cofferdams

There are several types of cofferdams. One common type of cofferdam is a berm, or dam, made from natural earth materials. These are similar to earth dams or flood control levees along rivers. Earth berms have to be wider at the bottom than at the top to be stable. Typical earth berms have side slopes of 3 ft horizontal to 1 ft vertical (which is a slope of 33% or approximately 18 degrees) and are about 10 ft wide at the top. For a water depth of 8 ft, a typical berm would be built 10 ft high, 10 ft wide at the top and 70 ft wide at the base (two sides that are 30 ft wide plus a 10 foot wide center section). Earth dams generally have clay in the interior to reduce water seepage through the dam. It is not feasible to build berms underwater with clay, so temporary cofferdams are usually built with fine sand covered with gravel-sized rock for erosion protection. Pumps are placed inside the cofferdam to remove any water that seeps through the berm.

Cofferdams are often built with steel sheet piles (Figure 4-5). For sites with shallow water (less than 10 to 15 ft) and the proper soil conditions, a single row of vertical sheet piles can be used. For deeper water depths (10 to 30 ft), a single sheet pile does not have adequate strength to resist the water pressure. In this situation, cofferdams can be made by installing two parallel rows of sheet piling and placing sand between the sheets, or by installing the sheet piles in an inter-locking circular shape and filling the inside with sand.

Fabric Dams

Fabric dams could also be used if site conditions are appropriate. These types of dams are constructed by placing an impervious membrane over a free-standing steel support structure. Portadam® is one example of this type of dam. Fabric dams are designed for use in open water up to 12 ft deep; these dams can be constructed without extensive excavation or fill and without constructing temporary dikes or berms. The waterproof membrane is also flexible, allowing for relatively easy installation in any configuration and over uneven sediment bed contours. The installation process for a fabric dam is illustrated in Figure 4-6.

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4.2.5.2 Screening of Sediment Removal

Effectiveness

Sediment removal by dredging or excavation is a very effective response action because it would achieve the sediment RAOs at the end of construction. Dredging or excavation provide very effective protection by removing the contaminated sediment from the environment that presents an unacceptable risk, thereby greatly reducing the risk of exposure to chemical contaminants or migration of contaminants that may present an unacceptable risk in the future. Once the sediment is removed, confirmation sampling would be performed to confirm that the cleanup goals were met. Additionally, because nearly all of the contamination that presents an unacceptable risk is removed, the need for monitoring as a way to ensure protectiveness in the long term is greatly diminished.

For dredging, there is the potential for short-term impacts to water quality and potential for residual contamination (National Academies Press, 2007; EPA, 1994a). During any dredge operation, some sediment becomes resuspended into the water column. This sediment can be carried by water currents until it settles back to the bottom. This potential impact would be monitored by taking water quality samples in the surrounding areas. The environment would be protected by compliance with appropriate short-term water quality criteria; however, it is not possible to remove all contaminated sediment because the work is performed underwater and every dredge leaves some residual material on the bottom. Confirmation sampling would be performed after the completion of dredging to demonstrate that contaminant concentrations in the remaining sediments are below the cleanup goals. For excavation, the water level would be lowered to expose the sediment, which could result in unpleasant odors and short-term loss of shallow-water habitat. However, removal using excavation is much more precise and there are fewer problems associated with residual contamination and downstream transport of suspended materials.

Overall, dredging is considered moderately effective and excavation is considered highly effective because the excavation methods allow for more precise removal of contaminated material, minimizing the amount of excess material, or overdredge, removed from a site.

Implementability

Sediment removal by dredging or excavation are proven technologies that have been successfully implemented at other sites (USACE, 1990; Scenic Hudson, 2000), and would be technically and administratively implementable at the CMRP site. Sediment removal at Allendale and Lyman Mill reaches using dredging or excavation would present some technical implementability issues that could be addressed using standard construction techniques. For example, dredging in the vegetated areas along the shorelines would require removal of the existing vegetation and would require low-ground pressure or amphibious equipment. For excavation, the gate structures at Lyman Mill Dam would require repairs to be returned to operable condition. Large pumps could be used to pump water around Lyman Mill Dam and either repairs to the gates could be made after the pond elevation is lowered (for alternatives where the dams remain), or the dam would be removed (for alternatives without the dams). Once the pond levels were lowered, most of the sediment in the ponds would be removed using excavation equipment. The sediment would still likely have a relatively high water content and low ground-pressure vehicles or other equipment designed to work on soft mud would be required. The river channel remaining after the water level is lowered would be fairly narrow, and excavation equipment would have booms or arms long enough to remove sediment from the channel sides and bottom. The presence of substantial amounts of debris can present technical implementability issues with respect to sediment removal using dredging. Debris can become entangled in the cutterheads and plug in slurry pipelines when using hydraulic

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dredges. Debris can prevent clamshell buckets from closing when using mechanical dredging, which can lead to greater impacts to water quality. Debris would not present substantive implementability issues using excavation.

The technical implementability of the sediment removal response action is considered moderate and the construction and monitoring equipment and personnel are readily available from several commercial companies. Dredging or excavation may result in impacts to wetland and floodplain areas that would have to be assessed (see Section 4.5.2.5).

Cost

Both dredging and excavating contaminated sediment would have moderate costs.

Screening Result

Dredging and excavation are retained for alternative development.

4.2.6 Transportation

4.2.6.1 Description of Transportation

Like sediment removal, dredged or excavated material can be transported using either mechanical or hydraulic methods. Mechanical methods include floating barges, amphibious vehicles, wheeled vehicles, railroads, or conveyors. With all mechanical methods, the dredged/excavated material is moved with essentially no change in water content. Mechanical methods are similar to conventional methods used for upland soil transport. Hydraulic methods use a pump and pipeline to transport sediment in a slurry form.

When a conventional hydraulic dredge is used, the slurry that leaves the dredge can be pumped without adding any more water. When dredged material removed by mechanical dredging is transported by pipeline, water must be added to produce a slurry.

In the majority of projects, sediment that is dredged with mechanical equipment is transported with mechanical methods and likewise, sediment that is dredged with hydraulic equipment is transported by hydraulic methods. Sediment that has been dredged or excavated with mechanical equipment is almost always too thick to move with pumps. Unless water is added to make a slurry (as in some hybrid systems), hydraulic transport is not possible. Sediment that has been dredged with hydraulic equipment is in a slurry form that behaves more like a liquid than solid material. It is typically not practical to transport slurries with most mechanical equipment, although there are exceptions. Therefore, sediment transport technologies are screened separately from sediment removal technologies.

Mechanical Transport Technology

Barge Process Option
Barges are the most common method of transport for mechanically dredged sediment (EPA, 1994a). Hopper barges hold the dredged material in compartments during transport, then release the material through doors in the bottom of the compartment. Split-hull barges are a special type of hopper barge that are constructed in two halves which are connected by hinges at the top. They have one compartment that runs the entire length of the barge. At the disposal site, hydraulic cylinders or cables split the two halves apart at the bottom and the material falls out. Deck barges simply have flat surfaces to hold equipment or materials. Some deck barges have sideboards to prevent materials from falling into the water.

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Barges are used to transport dredged sediment over water. Sediments can be loaded directly onto barges during dredging operations, after which the barge would transport sediments to a pier or shoreline where the sediment could be offloaded mechanically or hydraulically. Barges also can be used to transport dewatered sediments, in which case the sediment would be loaded from land and onto the barge for transport over water. Barges frequently require liners and a retaining system to protect against spillage.

Truck Process Option
After dewatering, trucks can be used for land transport of dredged material to an appropriate disposal site. Truck containers frequently require liners and lids/covers to protect against spillage.

Rail Process Option
Rail transport can be available for movement of dredged material to an appropriate disposal site. Rail transport requires the presence of an existing rail system that can connect a site with a selected disposal location. Similar to trucks, rail containers frequently require liners and lids to protect against spillage.

Conveyor Process Option
Conveyors have also been used for transporting bulk materials such as coal and mine ore. For sediment projects, conveyors have been used to move sediment from barges onto shore, between dewatering or other processing equipment, and to spread material at the disposal site.

Hydraulic Transport Technology

Hydraulic transport is defined as the process of pumping sediment slurry through a solid pipeline. Hydraulic transport can be an economical method of transporting large volumes of sediment over relatively short distances, especially when connected directly to the discharge from hydraulic dredges. For water transport, pipelines can either float on the water or be submerged to rest on the sediment surface. Steel and high-density polyethylene (HDPE) are the most commonly used pipe materials to support hydraulic transport.

When a conventional hydraulic dredge is used, the slurry that leaves the dredge typically can be pumped without adding additional water. When dredged material removed by mechanical dredging is transported by pipeline, water must be added to the sediment to create a slurry. For long transport distances, booster pumps can be installed along the pipe route. These pumps boost the pressure to increase the total achievable transport distance. The maximum distance of dredged material transport by pipeline is generally in the range of 2 to 10 miles.

Multiple transport methods, including truck and rail transport, can be combined. All transport methods generally require water- and spill-control systems (e.g., liners and adequate freeboard) to prevent uncontrolled sediment and water spills during transport.

4.2.6.2 Screening of Transportation

Effectiveness

Mechanical and hydraulic transport are highly effective and proven technologies for moving contaminated sediment from the dredge site to the treatment or disposal site. With any method, the contaminated material would be safely contained and would be moved with low risk of spillage. Equipment reliability and safety are equivalent to conventional earthwork construction.

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Implementability

Mechanical and hydraulic transport technologies are proven technologies that have been successfully implemented on dredging and upland soil transportation projects, and would be technically and administratively implementable at the CMRP site. The shallow water depths in the Allendale and Lyman Mill Ponds would limit the size of the barges and dredges that can be used. While this equipment is specialized, it is available from commercial contractors and equipment leasing companies.

Cost

The cost of transportation depends primarily on the distance traveled. Both technologies are expected to have moderate costs.

Screening Result

Mechanical transport and hydraulic transport are retained for alternative development.

4.2.7 Dewatering

4.2.7.1 Description of Dewatering

After sediment is dredged or excavated, the material is generally too wet to be transported directly to a disposal facility. As indicated in Section 4.2.5.1, mechanical dredging can increase the in-place sediment volume by 20% to 50%, and hydraulic dredging can add up to five to 10 times the in-place sediment volume as water. Excavation in the dry would not include the volume of water typical of mechanical dredges and, as a result, would not significantly reduce the in-situ solids content of the sediment. Dewatering is performed routinely for the management of contaminated dredge sediments and can reduce the weight and volume of sediment designated for off-site disposal, which can reduce controls and restrictions on transportation. Accordingly, dewatering can reduce transportation and disposal costs. Figure 4-7 shows a schematic example of a dredging, transport, dewatering, and water treatment system.

The management of water removal from wet sediments is an integral component of the dewatering approach. The magnitude and extent of water management requirements typically depend on the dredging method (mechanical dredging typically requires much less water management than hydraulic dredging) and the dewatering method (passive dewatering typically requires less water management than mechanical dewatering). The two types of dewatering are discussed below.

Passive Dewatering Technology

Passive dewatering refers to methods that use drainage or evaporation to remove water from the dredged material. The most common and lowest cost method is to place dredged material into a detention basin, composed of perimeter berms and a sand bottom overlain by a geomembrane liner, or tank and let the sediment particles settle out by gravity. Dewatering in a basin or tank may result from particle settling, surface drainage, or self-weight consolidation. Water on the surface may evaporate, reducing the amount of water in the sediment. After settling, the overlying water (called supernatant) can be removed by slowly draining over an outlet weir. After most of the water is removed, air drying can be used to remove more water from the dredged material.

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Passive dewatering is most effective when the dredged material can be spread into thin layers (2 to 4 ft thick) and left in the basin or tanks for several weeks or months. The rate of dewatering is not constant and generally proceeds more slowly with time. When hydraulic transport is used, the majority of sediment particles settle relatively quickly (one or two days) and an interface forms between the supernatant on the top and the sediment solids on the bottom. This generally does not occur when mechanical dredging and transport are used because the material remains in a solid phase.

Additional time is required for passive dewatering after the initial particle settling phase. The supernatant will contain some clay and colloid particles that will remain in suspension for a long period of time. It is generally best to remove the supernatant to facilitate evaporation. The supernatant may require treatment, such as filtering, before being disposed or discharged back to the river. In its natural setting, sediment density increases with increasing depth below the mudline due to the process of consolidation. As sediment is deposited, the weight of the material increases the vertical stress on the underlying sediment, resulting in some of the porewater being squeezed out. This process is called self-weight consolidation and also occurs in detention basins.

Passive dewatering has substantial space requirements. For example, a detention area of 25 acres with sediment 2 ft thick would have the capacity to dewater 80,000 cy of dredged sediment.

Solidification Technology

Solidification is the technology of mixing additives with the sediment to form a solid mass with high shear strength. The most common additives are cement, lime, and fly ash. Solidification has been used on several sediment sites and recent experience in the northeast is summarized in a guidance document prepared for the Port Authority of New York and New Jersey (PANYNJ, 1999). Solidification was used on two projects in New Bedford: the State Pier Dredging performed by the City of New Bedford and for dredging performed as part of bulkhead construction by the USACE (1990).

Mechanical Dewatering Technology

In some situations, gravity settling and passive dewatering are insufficient and mechanical systems are used to enhance and accelerate the dewatering process. Mechanical dewatering technologies include belt presses, filtration (e.g., plate and frame and geotextile filter), and heat/forced air systems. The equipment cannot handle debris or gravel-sized material, so pre-treatment is required prior to dewatering. Water may need to be added to slurry and process excavated sediment which contain higher in-situ solids content compared to dredged sediment. A typical dewatering system includes the following:

- Separation of coarse-grained material (sand and gravel) from fine-grained material (silt and clay),
- Polymer storage and mixing tanks,
- Slurry mixing tanks to add polymer and make consistent slurry density for treatment,
- Pumping and piping to feed dewatering equipment,
- Dewatering equipment,
- Water pumping system to transport water to treatment system,
- Conveyor systems to move dewatered material to loading area,
- Material loading area,
- Water treatment system.

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Figure 4-8 shows a schematic of a typical belt-type dewatering press. Belt presses have continuous belts similar to conveyor belts. In a belt press, the dredge slurry is compressed between a pair of belts to squeeze out water. Plate and frame systems pump slurry into a void space between two plates lined with a permeable fabric. The plates are pushed together under high pressure to squeeze out water. Geotextile filtration methods involve placing dredge sediment on top of a membrane or into a tube shaped membrane. Water is then forced through pores in the geotextile membrane via gravity or hydraulic pressure. The dewatered sediment from these filtration systems (generally called filter cake) can be handled with conventional earthmoving equipment after dewatering. The advantages of the plate and frame press option is that it is capable of producing filter cake at much higher percent solids (60%) compared to the belt press option (50%), thereby reducing the volume/mass of material for disposal. The somewhat higher cost of the plate and frame press method may be overcome by the cost savings due to reduction in disposal volume/mass. Bench-scale testing would be performed during design to evaluate the mechanical dewatering options provided mechanical dewatering is a component of the remedy selected.

Large centrifuges or cyclonic separators may also be used to separate water and solids. These machines separate the solid and liquid phase using rotational force. Large-scale centrifuges developed for the oil industry are capable of processing 6 to 12 tons of material per hour.

Belt presses and other filtration technologies are used primarily with hydraulic dredge operations. Excess water usually must be treated and discharged to a sanitary sewer, storm drain system, or returned to the dredge site.

In order to implement an active dewatering system, a minimum of two acres is required to accommodate stockpiles and allow for equipment staging. Ideally, a minimum of five acres would be used; the larger area would more easily accommodate the construction of temporary buildings and temporary stockpiles for sediment transfer activities. Temporary buildings, constructed of canvas or a similar material stretched over steel framing, are used to minimize and contain any dust generated by sediment handling.

4.2.7.2 Screening of Dewatering

Effectiveness

Passive dewatering is a highly effective method to reduce the volume of material for disposal when there is space to construct a detention basin and time to let the dredged material dry for several weeks or months. The rate of passive dewatering can be increased by removing the surface water that accumulates, or by installing a drainage system on the bottom of the basin. Passive dewatering is more effective in warm, dry weather because evaporation occurs faster in warm temperatures and precipitation adds to the water in a detention basin.

Solidification would be highly effective in creating material with higher strength and lower water content. Amendments such as lime or portland cement could be added in lieu of dewatering to prepare the material for mechanical transport. This alternative may be necessary if passive or mechanical dewatering on site is not feasible.

Mechanical dewatering would also be a highly effective method to reduce the volume of material for disposal. All types of sediment can be dewatered with these systems, although it is easier to dewater sand than silt or clay, which comprises much of the sediment at the CMRP site. The silt and clay in Allendale and Lyman Mill Ponds has high in-situ water content (i.e., greater than 50% water by weight) and these types of fine-grained sediment can be dewatered effectively with mechanical dewatering equipment.

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All of the dewatering technologies could have short-term impacts on surface water quality that would be addressed using standard engineering controls. Passive dewatering also includes the potential for odors that could impact nearby residents.

Overall, passive dewatering, solidification, and mechanical dewatering would all be highly effective at the CMRP site.

Implementability

The technical implementability of passive dewatering is contingent upon the availability of adequate upland areas adjacent to the ponds. The southern section of the source area (Cap Area #1) is a potential location for passive dewatering; however, this area encompasses only approximately 1.5 acres. There are some privately owned commercial and industrial parcels on the west side of the Lyman Mill and Allendale Ponds that have areas ranging from about 0.5 to about 2 acres; however, the availability of these properties for dewatering purposes is not certain. Ideally, each pond would have a dewatering area; this would minimize the amount of transport of wet sediment.

Solidification could be implemented using conventional construction methods. Dredged material has been successfully treated with cement or lime type material for solidification or stabilization at several sites (PANYNJ, 1999).

Mechanical dewatering is routinely used on dredging projects and could be implemented at the CMRP site. Potential technical implementability issues include the presence of debris and vegetated material mixed in with the dredged/excavated sediment, which is expected in the pond sediment. Debris and vegetation would have to be removed prior to mechanical dewatering, which would make the overall dewatering process moderately complex. Mechanical dewatering is administratively implementable and the construction equipment is readily available from numerous contactors and equipment leasing companies.

All of the dewatering technologies might have potential impacts to wetland and/or floodplain areas that would have to be assessed if an upland processing area is not available (see Section 4.5.2.7).

Overall, passive dewatering is considered technically infeasible to implement because of the limited space in the vicinity of both Allendale and Lyman Mill Ponds and the close proximity of residential areas. The implementability of solidification and mechanical dewatering technologies is considered moderate.

Cost

Passive dewatering is a low cost technology for dewatering dredged/excavated material if space is available. The costs for solidification are moderate. Mechanical dewatering costs are also moderate, but are generally higher compared to passive dewatering and solidification because of additional costs associated with pre-treatment.

Screening Result

Mechanical dewatering and solidification are retained for alternative development. Passive dewatering is screened out due to the lack of available space leading to significant implementability concerns.

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4.2.8 Sediment Disposal

4.2.8.1 Description of Sediment Disposal

Sediment disposal involves moving sediment and debris into a containment facility to reduce exposure to the material. This can occur without treatment of the sediment, after treatment, which is a separate response action, or after dewatering of sediment depending upon the regulatory nature of the material and the method of disposal. Disposal technologies described and evaluated below include options for on- and off-site disposal using either confined aquatic disposal (CAD) cells or a confined disposal facility (CDF). The distinction between these technologies is that CAD cells contain dredged material in an area constructed beneath the water, whereas CDFs contain dredged material in areas constructed in subaqueous, intertidal, or upland land areas and the top of the CDFs would be above the normal water surface elevation. Disposal using on-site consolidation is also considered.

On-Site Confined Aquatic Disposal Technology

In the CAD technology, the untreated dredged material is moved directly into an area beneath the water on the site, and covered with clean cap material. The area where the sediment would be deposited can be made by dredging a pit or by using a natural depression in the mudline. With this technology, it is not feasible to place impermeable liners beneath the sediment before it is moved into the CAD cell or to attempt collection and treatment of porewater.

CAD is only practical with mechanical dredging and transport because contaminated dredged material must drop through the water column and land in a predetermined area. The slurry that would be discharged from hydraulic dredging would be dispersed in the water column, which has the potential to spread contamination into the surrounding areas of the site.

CAD cells are only effective in relatively stable depositional areas beneath the water with low potential for erosion. A CAD site must have the same characteristics as described in Section 4.2.4 for capping because contaminated sediment would remain under a cap. In addition, a deep natural depression is needed to serve as the disposal area or a pit must be dredged.

CAD cells require extensive long-term monitoring and maintenance to ensure cap integrity and stability of buried sediments and contaminants. Figure 4-9 shows typical CAD cell designs. Key advantages of utilizing a CAD cell are that sediment does not require dewatering or treatment, the disposal area is unobtrusive, contaminants are isolated from contact with the environment as long as the CAD cell remains intact, and costs are likely to be relatively low. Disadvantages are that long-term integrity must be maintained, the use of waterway may be restricted, and locating an appropriate CAD site may be difficult. Site use restrictions would have to be imposed to help with long-term reliability. Restrictions would include items such as not allowing future dredging for deeper navigation, not allowing anchors which may penetrate the cap and not allowing any other construction dredging in the CAD site.

Off-site Confined Aquatic Disposal Facility Technology

The general description of the CAD cell provided above is also relevant to an off-site CAD facility and the design and monitoring requirements would be similar. Dredged material from the CMRP site could potentially be disposed of at an off-site CAD location, such as Providence Harbor CAD cells, which are used to isolate material dredged from navigation channels and harbors that did not meet the criteria for disposal at an off-shore disposal site. In order to use this disposal option, sediment removed from

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Allendale and Lyman Mill Ponds would be removed, dewatered, transported, and then shipped to the off-site CAD cell.

On-site Nearshore Confined Disposal Facility Technology

The Nearshore CDF is a technology where dredged/excavated material is moved to a subaqueous or intertidal land area inside perimeter dikes or berms that are built up above the water surface level. The principal difference between nearshore and aquatic disposal is that in the nearshore technology, the disposal area is separated from the surface water by perimeter berms and the final cover over a CDF is above the normal water level. There may be a pond inside the CDF to facilitate placement of the floating hydraulic pipeline, or the area may be above the water level and conventional earthmoving equipment would be used to move the material.

Nearshore disposal can be used with either mechanical or hydraulic dredging and mechanical or hydraulic transport. With hydraulic transport, the area inside the perimeter dikes is usually filled with water and floating pipelines distribute dredged material throughout the site. The ponded area also serves as a detention basin for dewatering the dredged material and for initial gravity settling of the supernatant water that separates from the dredged slurry.

With mechanical transport, the water inside the CDF may be left in place or may be removed. If the site is deep enough, it may be possible to leave a small opening in the dike and bring haul barges into the disposal area. As the depth decreases, it is usually necessary to close the dike, remove surface water and completely fill in the "dry" area.

Once filled, CDFs can be capped with clean material; these caps may be permeable or impermeable, depending upon the nature of the contaminants and porewater, as well as the intended use after closure. An additional process that may be associated with a CDF would be the installation of a base liner and collection system. A soil gas collection system may also be utilized if necessary. Long-term monitoring would be required to ensure that contaminants within the CDF were not leaking from the CDF and adversely impacting the surrounding environment. The CDF structure and cap also would require periodic inspection and maintenance. ICs (i.e., deed restrictions) would be required to prohibit future uses that could potentially disrupt the integrity of the CDF.

Advantages of CDFs are that they can be easy to implement provided that appropriate site conditions exist. In addition, CDFs built and monitored over the last 20 years have been shown to be effective and reliable (Herbich, 2000; Palermo and Averett, 2000). The disadvantages of CDFs are long-term risks of leaving highly contaminated material on site in a floodplain, potential loss of shoreline and/or surface water depending on where the CDF is sited, and long-term obligations to ensure integrity must be maintained. The long-term O&M of these facilities is crucial and needs to be properly addressed and administered in order for them to function and protect human health and the environment. Guidance regarding O&M requirements and landscape planting and vegetation management on any flood damage mitigation structure is provided in USACE (2006 and 2009).

On-site Consolidation

For the purposes of this FS, on-site consolidation is a technology where dredged/excavated material is moved to a intertidal land area that is built up above the water surface level and is contained under a final cover system protected by an armored slope. On-site consolidation is conceptually similar to the nearshore CDF technology in some respects and different in others. Like the nearshore CDF, the disposal

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area is separated from the surface water and the final cover is above the normal water elevation. However, on-site consolidation is structurally different from the nearshore CDF technology in that the contaminated sediment is consolidated under a cover system and an armored slope rather than inside perimeter berms and dikes.

The contaminated sediment is moved into the consolidation area by mechanical transport following mechanical excavation. Once placed in the consolidation area, the contaminated sediment is capped with clean material as described above for the nearshore CDF except that on-site consolidation would not include a base liner or collection system. Long-term monitoring would be required to ensure that contaminants within the consolidation area were not migrating outside the consolidation area and adversely impacting the surrounding environment. The armored slope (e.g., concrete wall) and cap also would require periodic inspection and maintenance. ICs (i.e., deed restrictions) would be required to prohibit future uses that could potentially disrupt the integrity of the consolidation area.

The advantages and disadvantages of on-site consolidation are similar to that described for nearshore CDF, except that there are additional reliability concerns because on-site consolidation does not include key structural components of a CDF (i.e., perimeter berms and dikes).

On-site Upland Confined Disposal Facility Technology

For purposes of this FS, an on-site upland CDF is a monofill, similar to a solid waste or hazardous waste landfill, that is designed and built solely for dredged/excavated material from the CMRP site. A multi-user facility that accepts dredged material from several dredge projects, and a permitted solid waste or hazardous waste landfill that can accept dredged material as well as municipal waste, are considered off-site disposal options and are discussed below.

The on-site upland CDF or monofill may be able to accept material by hydraulic transport in a manner similar to a nearshore CDF. The first step for a monofill is to construct the disposal facility. This consists of perimeter dikes and possibly a bottom liner, leachate collection system and water treatment system, if needed. After construction of the disposal site, dredged slurry can be discharged directly into the containment area. For a monofill, slurry can be pumped into the site for the duration of the dredging work, then passive dewatering can be performed after the completion of dredging. Once the dredged material has been dewatered, a cover similar to a conventional landfill could be placed.

Off-site Disposal Facility Technology

For off-site disposal options, including a multi-user facility or permitted landfill, the dredged material must be dewatered prior to disposal. These facilities are designed and operated to transport and place waste material with conventional upland earthmoving equipment and cannot handle slurry material.

Major advantages of on-site upland and off-site landfill disposal are that these are proven and reliable technologies, contaminants are isolated from the environment in a secure and regulated environment, on-site upland disposal sites exist (although are owned by private parties), off-site disposal facilities exist, and disposal costs can be competitive with treatment costs. Disadvantages are that dewatering generally is required, disposal costs can change with time and may increase, transportation to disposal facilities is required, and contaminants are relocated but are not necessarily destroyed.

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4.2.8.2 Screening of Sediment Disposal

Effectiveness

On-site CAD. If properly implemented, operated and maintained in the long term, a CAD cell would be moderately effective in preventing the resuspension of contaminated sediment and the migration of contaminants into the surface water. However, because contamination remains in place beneath the water there is the chance that contamination could be released in the future despite efforts to properly monitor and maintain this option. There is a potential for short-term impacts to the water quality at the disposal area because contaminated sediment would be falling through the water column. The risk would be relatively low at Allendale and Lyman Mill Ponds because the contaminants are sorbed onto the sediment particles and have low solubility, and the current speeds in the ponds are low. However, it is not possible to ensure that all of the contaminated material would reach the disposal area and there could be some migration of contaminated particles in the surface water as a result.

Off-site CAD. Shipping the dredged/excavated sediment off site for disposal at a federally maintained CAD cell is a highly effective option provided the CAD location would accept dioxin-contaminated material from an inland site (see Implementability, below). Whether or not treatment would be required would also need to be evaluated.

On-site Nearshore or Upland CDF. Moving the dredged material into a nearshore CDF could also be effective for the CMRP site, although locating the CDF in a floodplain (nearshore CDF option) is less than ideal for long-term protection. The contaminated sediment could be contained inside perimeter dikes and covered with soil or an impermeable membrane and soil. Nearshore CDFs are more effective in the long term than CAD cells because the top cover is above the water level and can be monitored with greater reliability. There would also be less of a short-term impact to water quality because the dredged material is moved inside the perimeter dikes. Supernatant from the dredged material can be collected and treated, if needed.

Moving contaminated material into an on-site upland CDF is a highly effective option for the CMRP site. The contaminated material would be contained inside the perimeter dikes and covered with soil. Depending on the chemical concentrations in the sediment porewater and the site conditions, the bottom of an upland CDF could be lined with a geomembrane and a leachate collection system could be installed at the bottom to collect leachate from the dredged material.

On-site Consolidation. Moving the dredged/excavated sediment into a consolidation area would be effective for the CMRP site, although locating the consolidation area in the floodplain presents reliability concerns as described above for the nearshore CDF. The contaminated sediment would be contained under a cover with an isolation cap and armored slope designed to withstand erosion during flood events. However, the containment structure (armored slope and isolation cap) would not provide as effective protection in the long-term compared to a CDF constructed with perimeter berms and dikes.

Off-site Disposal at Permitted Facility. Shipping the dredged/excavated sediment off site for disposal at a permitted landfill is a highly effective option for the CMRP site. Whether or not treatment would be required would also need to be evaluated.

In summary, moving dredged material into a CAD cell, CDF, or on-site consolidation area or shipping the material off site for disposal would reduce risks to levels that would achieve the RAOs, and provide varying degrees of reliable long-term protection depending upon the option used. These technologies

would prevent exposure of human and ecological receptors to unacceptable levels of contamination. The CAD technology is moderately effective because of the potential for migration of contamination during implementation as well as issues regarding long-term protection. The nearshore CDF and on-site consolidation are moderately effective because of issues regarding long-term protection (contaminated material remains on site in the floodplain). Upland CDFs and shipping material off site for disposal are the most effective because the contaminated sediment would be removed from the river and ponds and outside the floodplain and it is easier to monitor containment facilities that are above the water surface.

Implementability

On-site CAD. The water is shallow in Allendale and Lyman Mill Ponds, and there are no natural depressions large enough to contain the volume of contaminated sediment for the CAD disposal option. Instead, a pit would need to be dredged to contain the contaminated sediment. In order to contain all of the contaminated sediment from the Allendale and Lyman Mill reaches and place a 4-ft thick layer of clean material over the contaminated material, a total of eight pits would be needed (four in each pond), and each pit would need to be approximately 18 ft deep. During implementation, the contaminated sediment would have to be removed and placed in a temporary stockpile. To construct a pit to the required depth, a large volume of clean sediment would also have to be removed and stockpiled. After the non-contaminated sediment was removed to the design depth, contaminated sediment from the stockpile and contaminated sediment from other areas of the ponds could be moved into the pit. When dredging was completed, a cap of non-contaminated material would be placed over the top of the CAD cell. The remaining non-contaminated material from the pits would need to be disposed of off site.

The thickness of soft sediment in Allendale and Lyman Mill Ponds is generally less than 10 ft. Below this depth, much harder material such as dense sands and gravels or bedrock is present. Geologic borings performed during the restoration of Allendale Dam indicated that bedrock ranged from 5 to 10 ft below the sediment surface in the vicinity of the dam (LEA, 2005). These types of materials would be very difficult to remove due to equipment limitations; only small equipment could be used at the CMRP site because of access limitations. Additionally, available land on and surrounding the site is limited and acquiring adequate space for the temporary stockpiles is expected to complicate implementation. As a result, the implementability of an on-site CAD cell is considered technically infeasible.

Off-site CAD. The implementability of the off-site CAD cell option (such as the Providence Harbor CAD cells) is expected to be administratively infeasible. Federally maintained CAD cells are intended for navigation projects (e.g., maintenance dredging and associated navigation-related dredging). There is no precedent for Superfund sites utilizing federally maintained CAD cells for the off-site disposal of contaminated sediment, especially dioxin-contaminated sediment originating from an inland location. Moreover, the Providence Harbor CAD facility has not accepted dioxin-contaminated sediments (Goulet, 2006) and may not be able to accept dioxin waste under federal law. Further, the large volume of dredged material from the CMRP site would substantially reduce the capacity of the Providence Harbor CAD facility, and impact other users (marine facilities) who have limited or no disposal options.

On-site Nearshore or Upland CDF. Disposal on site at a nearshore or upland CDF (i.e., monofill) is technically and administratively implementable because these options involve standard construction techniques and the construction equipment and materials are readily available. A nearshore CDF could be constructed along the shoreline of the ponds and an upland CDF could be constructed on site and above the 100-yr flood elevation. "On site" is defined as the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action (40 CFR §300.5). For purposes of this FS, the proposed locations for the upland CDF would all be

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considered on site as defined in the NCP. If the CDF was built over contaminated soil in the source area, it could be designed to further reduce leachate and precipitation infiltration into the soil, which would provide more protection to the groundwater. These disposal options would pose some administrative implementability issues, however, that would have to be addressed. For the nearshore CDF, there would be a reduction in water area and flood storage capacity. For the upland CDF, an acceptable location would need to be found and then a property interest acquired. In addition, treatment may be required for some materials if sediment waste is managed ex-situ (such as through dewatering in a separate container) or the CDF is located outside the "area of contamination". Both disposal options could also have potential impacts to wetland and/or floodplain areas that would have to be assessed (see Section 4.5.2.8).

On-site Consolidation. Disposal on site at a consolidation area constructed along the shoreline of the ponds is technically implementable as described above for nearshore CDFs. This disposal option, however, would present some administrative implementability issues that would have to be addressed. As described for the nearshore CDF disposal option, on-site consolidation would require a reduction in water area and would reduce flood storage capacity.

Off-site Disposal at Permitted Facility. Shipping contaminated sediment off site to a permitted landfill is technically and administratively implementable. The dredged/excavated material could be dewatered on site and then taken to an off-site facility for treatment and/or disposal.

In summary, implementation of the on- or off-site CAD cell options is considered infeasible whereas the on-site nearshore or upland CDF, on-site consolidation, and off-site disposal options are more easily implemented at this site.

Cost

Among the disposal options considered, on-site consolidation or construction of an on-site CDF (nearshore or upland CDF) is expected to be more cost effective compared to either the CAD cell or off-site disposal options. The off-site CAD cell option is expected to have higher costs due to the expected administrative difficulty to obtain approval for disposal. Disposal at an off-site permitted landfill can be very costly, especially if treatment is required.

Screening Result

On-site nearshore CDF, on-site upland CDF, on-site consolidation, and off-site disposal at a permitted facility are retained for alternative development. On- and off-site CAD cells are screened out.

4.2.9 Ex-Situ Treatment

4.2.9.1 Description of Ex-Situ Treatment

Ex-situ treatment technologies include physical, chemical, thermal, and biological processes. Ex-situ treatments typically are applied to achieve contaminant levels compatible with final disposal locations (e.g., to meet landfill acceptance criteria), reduce costs by generating material with less stringent disposal requirements or reducing the volume of contaminated material, generate material that can be beneficially reused either on or off site, or minimize liability. Ex-situ treatment technologies include stabilization, thermal treatment, biological treatment, and chemical treatment. Because CMRP sediments are contaminated with both organic and inorganic contaminants, these treatment technologies are assessed for their ability to address one or more contaminant types.

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Stabilization Technology

Stabilization involves the mixing of additives to reduce the chemical mobility of the sediment-borne contaminants. The difference between stabilization and solidification (Section 4.2.7) is that the objective of stabilization is to reduce the mobility of chemicals by reducing their solubility or leachability. Stabilization can be conducted on or off site at a disposal facility. Stabilization also can reduce contaminant bioavailability sufficiently to allow on- or off-site beneficial reuse. Sediment amendments used for stabilization typically include cementitious (e.g., portland cement), polymeric, soluble phosphate, or pozzolanac (e.g., fly ash and kiln dust) materials. Limestone can be an effective metal binding agent, and can lead to the precipitation or accretion of metals as carbonate precipitates.

Stabilization is typically accomplished using a mixing vessel, an additive feed system, and a dedicated curing area. Binding/stabilizing agents, additive ratios, mixing times and curing conditions are selected on a site by site basis, and are based on the results of bench-scale and/or pilot-scale treatability studies. Figure 4-10 shows a general schematic of the ex-situ stabilization process.

The advantages of stabilization are that it can be accomplished using readily available equipment (e.g., mixers) and additives (e.g., portland cement). Stabilization also is a relatively low-energy and low-intensity process, and is generally less expensive than other ex-situ treatment technologies such as thermal technologies or sediment washing. The disadvantages of stabilization are that it can be very difficult to formulate an appropriate stabilizer for complex suites of contaminants. Stabilization is much less effective for organic contaminants than for inorganic contaminants. In fact, certain organic contaminants can actually impede the stabilization reaction, particularly at high concentrations.

Pretreatment may be required before stabilization to achieve an appropriate sediment water content or to screen out debris. In addition, ECs can be required to minimize dust generation or air emissions during the stabilization process. Stabilization often results in an increased waste volume for ultimate disposal, due to the addition of the stabilizing agent(s).

Thermal Treatment Technology

Thermal desorption is used to treat organic or volatile organometallic contaminants in soil and sediment. The process involves heating and agitating sediment in a thermal reactor while exposing the sediment to a carrier gas or vacuum. The process does not destroy contaminants, but rather volatilizes constituents into the vapor phase. The carrier gas transports the volatilized contaminants to an off-gas treatment system. Typically, an off-gas treatment system consists of a particulate removal stage and a contaminant removal stage (e.g., activated carbon). In some cases, organic constituents are destroyed using a secondary combustion chamber or a catalytic oxidizer.

Low temperature (200°F to 600°F) thermal desorption is suitable for the treatment of VOCs and SVOCs (including lower-molecular weight PAHs). High-temperature (600°F to 1,000°F) thermal desorption is suitable for the treatment of PCBs, pesticides, and SVOCs with higher boiling points (including high-molecular-weight PAHs). Thermal desorbers are readily available as mobile or transportable units. This technology is therefore often conducted on site, which minimizes sediment transport requirements and costs.

The advantages of thermal desorption are that it is a well-proven technology for the treatment of organic contamination in soil. In fact, thermal desorption is a presumptive remedy at CERCLA sites with VOC contamination in soils (EPA, 1993). Thermal desorption can lead to volume reductions for solid waste disposal and to less costly solid waste disposal options. The disadvantages of thermal desorption are that

it is less proven when dealing with aquatic sediments as opposed to upland soils, and site-specific treatability studies often are required. A major obstacle to thermal desorption for contaminated sediments is the high water content in sediments, which requires greater energy input to raise sediment temperatures and may slow down the mass transfer of contaminants to the gas phase. The efficacy of thermal desorption decreases with increased sediment organic content and decreased sediment grain size (e.g., finer sediments).

Pretreatment is often required before the thermal desorption process is initiated to achieve an appropriate sediment water content and to screen out debris. After treatment, the sediment waste stream may require further treatment and/or stabilization depending on the residual contaminant levels.

Incineration Process Option

Incineration can be applied to treat most organic and organometallic contaminants in nonaqueous and aqueous media. Incinerators use controlled combustion of a fuel source to destroy organic contaminants via high temperature oxidation reactions within a contained reactor. Incineration can be implemented on site using mobile or transportable units, or off site at a permitted incineration facility. Most organic compounds are destroyed at temperatures ranging from 1,100°F to 1,200°F. Typical mobile incinerators operate between 1,400°F and 2,200°F and commercial hazardous waste incinerators operate from 1,200°F to 3,000°F. Figure 4-11 provides a schematic representation of a typical incineration process.

Incineration thermally oxidizes organic contaminants to basic mineral constituents, namely carbon dioxide, water, or simple acids (e.g., hydrochloric acid [HCl]). Incineration is capable of achieving destruction efficiencies for PCBs, PAHs, and dioxins on the order of 99.99% (National Research Council [NRC], 1997; Federal Remediation Technologies Roundtable [FRTR], 2002). To burn the dioxin-listed hazardous wastes, DRE of 99.9999% must be achieved (40 CFR §264.343(a)(2)); dioxin treatment technologies exist that are capable of achieving 99.9999% DRE (Poillon, 1991). More detailed information regarding the temperature range and residence time would be determined during design provided the remedy selected includes on-site thermal treatment. Inorganic constituents such as metals are typically concentrated in the resulting ash from the incineration process, and may require additional treatment, management, and disposal. The residue from incineration can be disposed of off site, or used beneficially under appropriate circumstances.

Off-gas treatment is commonly required with incineration. Off-gas treatment is necessary to remove particulates, to neutralize acid gases (e.g., NO_x, SO_x or HCl) that may be generated during the combustion process, and to protect against the potential release of dioxins or dioxin-like organic compounds. Off-gas treatment can be complicated if volatile metals (e.g., mercury) that are not fully destroyed by high temperature reactions are released.

On- and off-site incineration has been employed to treat organic contaminants at more than 150 Superfund sites nationwide (FRTR, 2002). At the Baird and McGuire site in Holbrook, MA, sediments impacted with dioxins, VOCs, PAHs, pesticides, and metals were incinerated in a rotary kiln incinerator, and the resulting solid material was reused on site (EPA, 1998c).

The advantages of incineration are that it is a proven technology with few technical limitations. Incineration is also suitable for a number of contaminants and for most environmental media, and generally is capable of significant contaminant destruction efficiencies. The disadvantages of incineration are that pretreatment is generally required (particularly for sediment dewatering and debris removal), incineration is very expensive for wet sediments, and controlling air emissions can be difficult and costly. Waste streams remaining after treatment include air and ash. Ash may require post-treatment stabilization if inorganic constituents are present (e.g., cadmium, chromium, and lead).

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Biological Treatment Technology

Biological treatment can be performed with either aerobic or anaerobic bacteria. In both methods, the sediment is mixed with the appropriate nutrients and the temperature and oxygen conditions are adjusted to accelerate degradation of the contaminants. Information on the results of recent demonstrations for upland soil is available from the FRTR web site (www.frtr.gov/costperf).

Ex-situ biological treatment systems are designed to provide optimal water content, aeration, nutrient levels, pH, and temperature to promote biological transformation and/or degradation of contaminants. In general, biological treatment is suitable only for certain organic constituents, and is accomplished by promoting degradation by indigenous (e.g., naturally occurring) organisms. However, microorganisms can be added to the reaction from some other source to accelerate biological degradation. Biological treatment can be implemented on or off site, but is more typically implemented on site.

The advantages of biological treatment technologies are that such systems can be constructed using readily available equipment (e.g., mixers and particle separators), and bioremediation is a relatively low-energy, low-intensity, and low-cost process. The disadvantages of biological treatment are that it can be difficult to formulate an appropriate amendment for complex suites of contaminants, and pretreatment, dewatering, and air emissions controls may be required. Waste streams can still remain after treatment, requiring further treatment, proper management, and/or disposal. Biological treatment is not a field-proven technology for sediments, particularly for PCB- and dioxin-contaminated sediment.

Chemical Treatment Technology

Chemical treatment is the technology of mixing chemicals into the sediment to change the form of the contaminant to a less toxic or less mobile form or to separate the contaminants from the sediment. Information on the results of recent demonstrations for upland soil is available from the FRTR web site (www.frtr.gov/costperf). Soil washing consists of separating fine soil particles with sorbed contaminants from bulk soil in an aqueous-based system on the basis of particle size. The process can be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.

Solvent or chemical extraction is a common form of chemical treatment using organic solvent as the extractant. It is typically used in combination with other technologies, such as solidification/stabilization, incineration, or soil washing, depending upon site-specific conditions. Solvent extraction can also be used as a standalone technology in some instances. Organically bound metals can be extracted along with the target organic contaminants, thereby creating residuals with special handling requirements. Traces of solvent may remain within the treated soil matrix, so the extractant toxicity is an important consideration. The treated media are usually returned to the site after having met Best Demonstrated Available Technology and other standards.

In some cases, solidification (Section 4.2.7) and stabilization technologies can be used to physically bind or enclose contaminants within a stabilized mass (solidification), or to induce chemical reactions between the stabilizing agent and contaminants to reduce their mobility (stabilization).

Reduction/oxidation treatments chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.

During the dehalogenation process, reagents such as alkaline polyethylene glycol or potassium polyethylene glycol (KPEG) are added to soils contaminated with halogenated organics. The dehalogenation process is achieved by either the replacement of the halogen molecules or the decomposition and partial volatilization of the contaminants. Base-catalyzed decomposition is a technology in which contaminated material is screened, processed with a crusher mill, and mixed with sodium bicarbonate. The mixture is heated to above 330 °C (630°F) in a reactor to partially decompose and volatilize the contaminants. The volatilized contaminants are captured, condensed, and treated separately.

Separation technologies attempt to concentrate contaminated solids using either physical or chemical techniques, such as sieving, magnetic separation, and gravity separation. SVOCs, fuels, and inorganics are the target contaminant classes for separation methods, but these alternatives can be used on selected VOCs and pesticides. Magnetic separation is specifically used on heavy metals, radionuclides, and magnetic radioactive particles. Physical separation is often used as a pre-treatment measure to chemical treatments based on the assumption that most of the contamination is sorbed to the finer soil or sediment fraction. One advantage of physical separation processes is that high throughputs can be achieved with relatively small equipment.

The most important factors in the evaluation of dredged/excavated material treatment are the concentrations and mobility of the contaminants present at the site and the post-treatment contaminant concentration goals. For Allendale and Lyman Mill sediments, the major contaminants are dioxins and PCBs, and selected pesticides, SVOCs, and metals (Sections 2.5 and 3.4).

The sediment at the CMRP site is dominated by silts and clays and the primary contaminants (dioxins and PCBs) have low water solubility, are strongly bound to the silt and clay sediment particles and their mean concentration is relatively low. The mean concentration is the most applicable to use in screening treatment technologies because sediment would be well mixed during the dredging, dewatering and pre-treatment processes which are necessary prior to starting treatment. In this situation, solvent extraction or chemical treatment is inefficient and ineffective because it is difficult to obtain contact between all sediment particles and the extraction solvent or chemical reagents. Even with crushing and mixing treatment equipment, some of the sediment remains in intact chunks and no treatment is possible inside the discrete chunks of contaminated sediment materials.

Treatment of sediment or soil is a complicated process. For all of the treatment technologies evaluated, the sediment would have to be dredged and transported to an upland or off-site processing area for treatment. For all the technologies, except solidification, the dredged material would have to be screened and dewatered prior to treatment.

4.2.9.2 Screening of Ex-Situ Treatment

Effectiveness

Stabilization. Stabilization is considered to have low effectiveness because the contaminants at the CMRP site are already relatively immobile.

Thermal Treatment. Thermal treatment by incineration, either on or off site, is highly effective in destroying most organic contaminants including dioxins, PCBs, and SVOCs (EPA, 1998d), thereby effectively reducing their toxicity. However, metals are largely unaffected by incineration and the incinerator emissions and byproducts may require additional treatment due to metals content.

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Biological Treatment. Dioxins are very resistant to biotic degradation; although microbial dioxin degradation has been observed in laboratory settings, the degradation rates are very slow. Biological treatment would have low effectiveness.

Chemical Treatment. Dehalogenation using KPEG and base catalyzed decomposition have been shown to be partially effective in treating dioxins on relatively small scales; however, FRTR notes that high clay and moisture content may affect effectiveness (and costs). Additionally, dehalogenation may not completely destroy a contaminant and simply result in the formation of another compound that may or may not be less toxic; dehalogenation will also not remove the treatment byproduct from the sediment or soil being treated. Chemical treatment would have low effectiveness.

Implementability

Stabilization. Stabilization could be implemented using conventional construction methods. Dredged material has been successfully treated with cement or lime type material for stabilization (or solidification) at several sites (PANYNJ, 1999). This technology has been used for sediment, but high water content, debris and difficulty in mixing sediments makes implementation moderately difficult.

Thermal Treatment. Thermal treatment is a proven technology, although concerns about air emissions from incinerators often make implementation difficult from an administrative perspective. For example, incineration was initially selected for treatment of PCB contaminated sediments at New Bedford Harbor (Massachusetts), but the remedy was changed based on strong public opposition. On-site incineration could have significant administrative implementability issues particularly if the public expressed opposition to this option. The limited availability of space to construct treatment facilities and stockpiling areas could also make this option technically difficult to implement. Off-site incineration would have fewer implementability issues because there are licensed, commercial facilities available that have experience in treating soils and sediment with the types of contamination present at the CMRP site.

Biological and Chemical Treatment. Biological and chemical treatments would be technically infeasible to implement. Treatment systems for the chemical and biological treatment of sediments are in the development stage and full-scale application of these technologies has not yet been proven. Either technology would require the acquisition of elaborate temporary equipment and material handling systems to implement.

All of the ex-situ treatment technologies except off-site thermal treatment might have potential impacts to wetlands and/or floodplain areas that would have to be assessed if an upland treatment area is not available (Section 4.5.2.9).

Cost

Stabilization. The costs for stabilization are the lowest of the treatment technologies, but are still considered moderate.

Thermal Treatment. The cost for on- or off-site thermal treatment would be very high. Incineration costs from completed projects were reported to be about $650 per cubic yard for treatment of sediment at the Bayou Bonfouca Superfund Site (FRTR, 1995) and $540 per ton for treatment of soil at the Baird and McGuire Superfund Site (EPA, 1998c). Additionally, the presence of metals in the sediments may result in higher costs associated with scrubbing stack emissions and treating metals in the ash.

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Biological Treatment. The cost for biological treatment is estimated to be high based on the costs projected for full-scale treatment. Additionally, this technology is typically not cost effective for large waste volumes and concentrations of chlorinated organics greater than 5% require large volumes of reagent. Finally, the capture and treatment of residuals (volatilized contaminants captured, dust, and other condensates) may be difficult, especially when the material contains high levels of fines and moisture.

Chemical Treatment. The cost for chemical treatment is estimated to be very high. For example, estimated costs were projected to be $1,000 per cubic yard for the chemical treatment of New Bedford Harbor sediments (FRTR, 1996).

Screening Result

Thermal treatment by incineration (both on and off site) is retained for alternative development. Although the costs associated with incineration are very high, the technology is proven and is very effective for most of the contaminants present at the CMRP site.

Stabilization is screened out due to low effectiveness. Biological and chemical treatment technologies are screened out because of limited effectiveness, high costs (chemical treatment), and difficulty in implementation.

4.3 General Response Actions and Technologies for Source Area Soils and Floodplain Soils

General response actions, technologies and process options for soils located in the source area, and floodplain soils located at the Allendale and Lyman Mill reaches of the river are described and evaluated in this section, and summarized in Table 4-2. Additional details regarding the soil response actions are provided in Appendix I.

4.3.1 Institutional Controls

4.3.1.1 Description of Institutional Controls

ICs are described in detail in Section 4.2.1. Potential ICs identified for the source area soils and floodplain soils include covenants and easements. Covenants could be used to prohibit future activities such as excavation that could potentially expose and mobilize the contaminated soils. Easements could be used to provide site access to the source area to monitor and maintain the caps and surfaces (parking lots, rip rap, landscaped areas) at the source area.

Governmental controls could include land or water use restrictions that could be used to restrict actions such as building, utility or other construction activities that could result in contaminated soil being released to the environment. Governmental controls could also include zoning ordinances, such as requirements for walkways or boardwalks, which would protect the public's health by restricting public access to limit exposure to contaminated soils.

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4.3.1.2 Screening of Institutional Controls

Effectiveness

ICs would be effective in reducing exposure to contamination by limiting the amount of direct contact with contaminated media. However, ICs to protect human health are only as effective as the enforcement of these controls. This is particularly true in the case where controls are required to be put in place to achieve long-term protection at a site. Additionally, ICs are not effective in protecting ecological receptors. As a standalone response action, ICs have low effectiveness.

Implementability

ICs are easily implemented at contaminated sites.

Cost

The cost is low because only administrative actions are required.

Screening Result

ICs are retained for alternative development. These controls would not be used as the sole element of any alternative, but could be used in combination with other options as part of several alternatives.

4.3.2 Engineering Controls

4.3.2.1 Description of Engineering Controls

ECs could include physical barriers, such as a perimeter fence, that would limit exposure by restricting public access.

4.3.2.2 Screening of Engineering Controls

Effectiveness

ECs would be effective in reducing exposure to contamination by limiting contact with contaminated media. ECs would have varying degrees of effectiveness depending on the type of physical barrier used. As a standalone measure, ECs would have low to moderate effectiveness.

Implementability

ECs are easily implemented at contaminated sites.

Cost

The cost is low because limited construction work is required.

Screening Result

ECs are retained for alternative development. These controls would not be used as the sole element of any alternative, but would be used in combination with other options as part of several alternatives.

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4.3.3 Monitored Natural Recovery

4.3.3.1 Description of Monitored Natural Recovery

MNR for source area soils and floodplain soils would rely upon natural processes, such as deposition of new soils and natural degradation of contaminants. The source area soils and floodplain soils are, by definition, in depositional areas; however, the deposition of clean material would typically be limited to over bank deposition occurring during flood events. Therefore, burial of contaminants would be a sporadic process. MNR could also rely on natural biological degradation of contaminants to reduce the risk that contamination in soil presents.

4.3.3.2 Screening of Monitored Natural Recovery

Effectiveness

MNR would not be an effective remedy for source area soils and floodplain soils because the majority of the soils at the source area have already been capped, and natural deposition of clean material over the floodplain soils would likely only occur during flood events. As a result, contaminants in the surface layers of the floodplain soils would remain exposed. In addition, covering source area soils and floodplain soil by MNR would not meet regulatory requirements for capping hazardous waste. Additionally, as described in Section 4.2.3.2, natural biodegradation of dioxins/furans and the inorganic contaminants would not be effective. Finally, all sources of contamination would need to be addressed to maximize the effectiveness of this response action. Sources of contamination at the source area have been mostly controlled, with the exception of the groundwater discharge under the Brook Village parking lot.

Implementability

MNR is easily implemented at contaminated sites. Technologies are available to predict rate of recovery and to monitor the long-term effectiveness.

Cost

MNR costs are low, and include costs associated with the generation of monitoring data (i.e., sample collection and analysis).

Screening Result

MNR is screened out for alternative development because it would not be an effective means of risk reduction and would not meet regulatory requirements for capping hazardous waste.

4.3.4 Containment (In-Situ Capping)

4.3.4.1 Description of Containment (In-Situ Capping)

Several types of caps are available to reduce human and ecological exposure by preventing direct contact with the soil and reducing the migration of contaminants to other media. Isolation capping and shoreline stabilization methods are described in Section 4.2.4.

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4.3.4.2 Screening of Containment (In-Situ Capping)

Screening results for isolation and shoreline stabilization cap technologies are the same as described for sediment in Section 4.2.4.2, and are summarized below.

Effectiveness

The source area is currently covered by caps or asphalt parking lots acting as a cap; these containment mechanisms have been effective thus far. Capping contaminated soil in the floodplain areas would be effective provided the caps were designed to meet regulatory requirements for capping hazardous waste. However, capping contaminated soil in floodplain areas is less than ideal because contamination is left in the floodplain in the long term and may present some ARAR compliance issues. Shoreline stabilization capping methods would be used to reduce potential erosional effects and prevent physical transport of materials.

Isolation and shoreline stabilization capping would both be moderately effective in reducing the risk associated with exposure to source area soils and floodplain soils. They would be effective in protecting human health and the environment by preventing direct contact with contaminated soil left in place. These capping technologies would also essentially eliminate contaminant migration to the surface water in the Woonasquatucket River provided the caps are not disturbed. Overall, the capping technologies could provide reliable long-term protection as long as the cap remained intact and was not disturbed. ICs and long-term O&M of the caps would be required to ensure their integrity.

Short-term impacts associated with capping contaminated source area soils would be low to medium because the existing interim caps would either be incorporated into the design of the new cap and contaminated soils would not be disturbed, or a new cap would be constructed which requires disturbance of underlying soil. The placement of caps over the floodplain soils would destroy existing habitat in the short term. Caps could be engineered so that the top layer included the appropriate soil and plantings to expedite re-establishment of floodplain habitat.

Overall, the isolation and shoreline stabilization capping technologies are considered to be moderately effective.

Implementability

The capping technologies listed are all proven methods and are technically implementable. The caps can be designed and implemented in the source area and floodplain reaches of Allendale and Lyman Mill, although cap placement in nearshore areas will likely be difficult due to the very soft sediment and shallow water (see Section 4.2.4.2). Placement of caps along shorelines has been successfully implemented at similar sites (Palermo et al., 1988), and the implementability and acceptability can be increased with the use of wetland caps or other habitat enhancement layers that improve the existing habitat.

The capping response action is technically implementable and the capping materials and construction and monitoring equipment and personnel are available from several commercial companies. Capping would result in impacts to wetland and floodplain areas, which would have to be assessed (see Section 4.5.3.3).

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Cost

All of the capping technologies would have moderate costs. The shoreline stabilization would require more advanced design and more specialized materials for construction.

Screening Result

Isolation capping and shoreline stabilization are retained for alternative development because they would be effective at reducing risk and are moderate in cost.

4.3.5 Soil Removal

4.3.5.1 Description of Soil Removal

Soil removal is the response action of moving contaminated soil from a current location to a new location. Removal of the contaminated soils will reduce the mobility of contaminants and reduces or eliminates the potential exposure to humans and ecological receptors by removing the contaminated soils from the environment. The two process options considered for soil removal are excavation and dredging inside flooded excavation. The latter option is considered in case materials below the groundwater table need to be removed.

Excavation

Excavation of contaminated soils using conventional earthmoving equipment is the primary technology for this response action and is described in detail in Section 4.2.5. The contaminated material is removed and transported for disposal, which are separate response actions (see Sections 4.3.6 through 4.3.8).

Some pretreatment of the soil may be required depending on the regulatory nature of the material and the location of disposal.

Dredging Inside Flooded Excavation

Mechanical or hydraulic dredging techniques, described in Section 4.2.5, would be used to remove contaminated material should the excavated areas flood during construction. The sediment transport and dewatering technologies discussed in Sections 4.2.6 and 4.2.7 would also be applicable to soils that had been removed from flooded excavation pits.

4.3.5.2 Screening of Soil Removal

Effectiveness

In general, soil removal is an effective response action because it removes the source of contamination that presents a risk to human health and the environment. There are several advantages to soil removal.

The risk of residual contamination and contaminant migration at the end of construction is minimized. Further, the risk of any restrictions on future site use or the need for long-term monitoring would be minimized as well.

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For floodplain soils, soil removal by either dredging or excavation would be effective provided confirmation sampling is conducted to confirm that the RAOs were achieved. However, the extent to which soil removal in the floodplain areas would destroy habitat would have to be evaluated.

For source area soils, soil removal by excavation would also be effective, except in the event of a large scale excavation where the magnitude of the short-term impacts would greatly limit the effectiveness of this option. Highly contaminated soil that remains in the source area is in close proximity to the Centredale Manor and Brook Village apartment buildings. Large scale removal of contaminated soils would likely be a major disruption for elderly residents and could present potential health risks due to dust generation and emissions, although these impacts could be addressed with engineering controls. Large scale removal of contaminated soils could also require relocation of residents which could present significant short-term health impacts that may be unacceptable as most residents are elderly. Soil removal by excavation would be more effective using focused excavation as appropriate to remove 'hot spot' soils.

Implementability

Soil removal is technically and administratively implementable, although soil removal by dredging in a flooded excavation area can be technically more challenging compared to excavation in dry areas. Soil removal by dredging in flooded excavation areas is possible if soil from below the groundwater table must be removed. This option may be less expensive than dewatering excavation pits, which could require sheet piles to be installed around the excavated area and pumping and treatment of the flood water. The technical implementability of soil removal by dredging in flooded excavation areas would be difficult.

Soil removal by excavation is a proven technology and would be technically implementable at the CMRP site, although the limited availability of space within which to work could pose some administrative implementability issues that would need to be addressed.

Overall, the soil removal technologies are technically implementable and the construction equipment and personnel are readily available. However, soil removal at the source area could be difficult to implement from an administrative perspective because of potential short-term impacts from construction activities to the elderly residents that live at the source area. In addition, excavation and dredging may result in impacts to wetland and floodplain areas that would need to be assessed (see Section 4.5.3.4).

Cost

The cost for dredging inside a flooded excavation area would be high. Excavation would have moderate costs.

Screening Result

Conventional excavation and dredging inside flooded excavation areas are retained for alternative development for soils.

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4.3.6 Transportation

4.3.6.1 Description of Transportation

The mechanical transport mechanisms (amphibious or wheeled vehicles, rail, or conveyors) described in Section 4.2.6 for dredged/excavated sediment are applicable for soils removed by either conventional excavation or dredging inside flooded excavation areas.

4.3.6.2 Screening of Transportation

Effectiveness

Mechanical transport is a highly effective and proven technology for moving contaminated materials from the excavation/dredging site to the treatment or disposal facility. Contaminated soil would be contained and moved with minimal risk of loss to the environment. The equipment reliability, safety, and accessibility are comparable to that of conventional construction equipment.

Implementability

Mechanical transport is routinely used on upland soil transportation projects, and would be technically and administratively implementable at the CMRP site. The construction equipment is readily available from numerous contractors and equipment rental companies.

Cost

Transportation costs depend upon the distance traveled. Costs associated with mechanical transport are moderate.

Screening Result

Mechanical transport is retained for alternative development.

4.3.7 Dewatering

4.3.7.1 Description of Dewatering

The dewatering technologies are the same as described in Section 4.2.7 for sediment, and include passive dewatering techniques (gravity separation and air drying), solidification, and mechanical dewatering methods (belt filter press, plate and frame press, and centrifugation). Source area soils would not require dewatering; however, some floodplain soils may have relatively high water content.

4.3.7.2 Screening of Dewatering

Effectiveness

Passive and mechanical dewatering are highly effective methods of reducing the volume of contaminated material for disposal and/or treatment. Passive dewatering is effective when adequate space is available to construct the detention ponds. Section 4.2.7 details the construction and space requirements of passive

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dewatering schemes. Mechanical methods would also be effective, although it is generally easier to dewater sand than silt or clay using these systems. Solidification would be highly effective in creating material with higher strength and lower water content.

Implementability

As discussed in Section 4.2.7.2, there is insufficient space for passive dewatering at the CMRP site and this technology is technically infeasible as a result.

Solidification has been used at other soil sites and can be implemented with moderate effort.

Mechanical dewatering, though easily implemented for saturated sediments, is more challenging and difficult for soils that include vegetated material. Additionally, available dewatering systems require the input to be in a slurry form, which would require adding water to most excavated/dredged soil. This would add to the complexity of the process. The technical implementability of mechanical dewatering is difficult for source area soils and floodplain soils.

All of the dewatering technologies might have potential impacts to wetland and floodplain areas that would have to be assessed if an upland processing area is not available (see Section 4.5.3.6).

Cost

Passive dewatering is a low cost technology. There are initial expenses of constructing the settling ponds, but once that has been completed there is minimal use of equipment or labor. Solidification is a moderate cost technology. Mechanical dewatering is a high cost technology because the vegetation in the excavated/dredged soil would need to be removed and the soil would also need to be made into a slurry before treatment.

Screening Result

Passive dewatering is screened out as technically infeasible. Mechanical dewatering of soils is eliminated because of the expected implementation difficulties. Moreover, mechanical treatment is not warranted because the water content of most soils is expected to be low initially. Solidification is retained for alternative development.

4.3.8 Soil Disposal

4.3.8.1 Description of Soil Disposal

This response action is the same as described for dredged sediment disposal in Section 4.2.8, and includes options for on-site disposal in a nearshore or upland CDF and off-site disposal at a permitted facility. CAD technologies are not considered for soils because these technologies are technically infeasible and were screened out in Section 4.2.8. Whether or not treatment would be required would also need to be evaluated. The most likely scenario for on-site disposal would be in combination with on-site disposal of sediments.

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4.3.8.2 Screening of Soil Disposal

Screening results for on-site disposal in a nearshore or upland CDF and off-site disposal at a permitted facility are the same as described for sediment disposal in Section 4.2.8.2, and are summarized below.

Effectiveness

On-site Nearshore or Upland CDF. Moving the dredged/excavated material into a nearshore CDF could also be effective for the CMRP site, although locating the CDF in a floodplain is less than ideal for long-term protection. The contaminated soil could be contained inside perimeter dikes and covered with soil or an impermeable membrane and soil. Supernatant from the dredged/excavated material can be collected and treated, if needed.

Moving contaminated soil into an on-site upland CDF is a highly effective option for the CMRP site. The contaminated material would be contained inside the perimeter dikes and covered with soil. Depending on the chemical concentrations in the porewater and the site conditions, the bottom of an upland CDF could be lined with a geomembrane and a leachate collection system could be installed at the bottom to collect leachate from the dredged/excavated material.

Off-site Disposal at Permitted Facility. Shipping the material off site for disposal at a permitted landfill is also a highly effective option for the CMRP site. Whether or not treatment would be required would also need to be evaluated.

In summary, moving dredged/excavated material into an on-site CDF or shipping the material off site for disposal would reduce risks to levels that would achieve the RAOs, and provide varying degrees of reliable long-term protection depending upon the option used. These technologies would prevent to varying degrees exposure of human and ecological receptors to unacceptable levels of contamination. On-site upland CDFs and shipping material off site for disposal are the most effective because the contaminated soil would be removed from the river, ponds and floodplain areas, and it is easier to monitor containment facilities that are above the water surface.

Implementability

On-site Nearshore or Upland CDF. Disposal on-site at a nearshore or upland CDF (i.e., monofill) is technically and administratively implementable because these options involve standard construction techniques and the construction equipment and materials are readily available. A nearshore CDF could be constructed along the shoreline of the ponds and an upland CDF could be constructed on site above the 100-yr flood elevation. If the CDF was built over contaminated soil in the source area, it could be designed to further reduce leachate and precipitation infiltration into the soil, which would provide more protection to the groundwater. These disposal options would pose some administrative implementability issues, however, that would have to be addressed. For the nearshore CDF, there would be a reduction in water area and flood storage capacity. For the upland CDF, an acceptable location would need to be found and then a property interest must be acquired. In addition, treatment may be required for some material if the soil waste is managed ex-situ or the CDF is located outside the "area of contamination". Both disposal options could also have potential impacts to wetland and/or floodplain areas that would need to be assessed (see Section 4.5.2.8).

Off-site Disposal at Permitted Facility. Disposal at an off-site CDF is technically and administratively implementable. The dredged/excavated material could be dewatered on site and then taken to an off-site facility for treatment and/or disposal.

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Cost

Among the disposal options considered, construction of an on-site CDF (nearshore or upland CDF) is expected to be more cost effective compared to off-site disposal options. Disposal at an off-site permitted landfill can be very costly, especially if treatment is required.

Screening Result

On-site nearshore CDF, on-site upland CDF, and off-site disposal at a permitted facility are retained for alternative development.

4.3.9 Ex-Situ Treatment

4.3.9.1 Description of Ex-Situ Treatment

Treatment technologies and process options considered for removed soil are the same as those described in Section 4.2.9 for dredged material treatment, and include stabilization, on- and off-site thermal treatment, biological treatment and chemical treatment.

As with treatment of dredged sediment, the most important factors in the evaluation of ex-situ soil treatment are the regulatory status of the material to be treated, concentrations and mobility of the contaminants, and their respective cleanup goals. Cleanup goals for source area soils were identified for dioxin TEQ, and selected pesticides, PCBs, SVOCs, metals, and VOCs (see Section 3.4). Cleanup goals for floodplain soil were identified for dioxins and PCBs (including total Aroclor and Aroclor 1254), pesticides (4,4'-DDE, dieldrin), and metals (antimony, arsenic, cadmium, lead, selenium, and zinc) (see Section 3.4).

For all of the treatment technologies considered, removed soil would need to be transported to a staging and processing area for treatment. Some floodplain soil may require dewatering prior to treatment using all technologies, except solidification.

4.3.9.2 Screening of Ex-Situ Treatment

Screening results are the same as described for dredged sediment treatment in Section 4.2.9.2, and are summarized below.

Effectiveness

Stabilization. Stabilization would have low effectiveness because treatment is not expected to have a substantive effect on contaminant mobility given that the primary contaminants are hydrophobic and strongly sorbed to soil particles.

Thermal Treatment. Thermal treatment by incineration, either on or off site, is highly effective in destroying most organic contaminants including dioxins, PCBs, and SVOCs (EPA, 1998d), thereby effectively reducing their toxicity. However, metals are largely unaffected by incineration and the incinerator emissions and byproducts may require additional treatment due to metals content.

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Biological and Chemical Treatment. Biological and chemical treatment would have low effectiveness as described in Section 4.2.9.2. Briefly, dioxins are very resistant to biotic degradation and the associated degradation rates are very slow. Chemical treatment may not completely destroy a contaminant, and may not be cost effective for large waste volumes.

Implementability

Stabilization. Stabilization could be implemented using conventional construction methods. Excavated soil could be effectively treated using cement or lime type material that has been successfully used for dredged sediments at several locations (PANYNJ, 1999). The presence of debris and vegetation that might require removal makes implementation moderately difficult.

Thermal Treatment. The equipment and operation of thermal treatment systems is an established technology; however, air quality concerns can make implementation difficult from an administrative perspective. On-site incineration would require addressing potential concerns from nearby residents. The limited availability of space to construct treatment facilities and stockpiling areas could also make this option technically difficult to implement.

Off-site incineration is technically and administratively implementable because there are licensed, commercial facilities available that have experience in treating soils (and sediment) with the contaminants found at the CMRP site.

Biological and Chemical Treatment. Biological and chemical treatments would be technically infeasible to implement. Treatment systems for the chemical and biological treatment of soil are in the development stage and full-scale application of these technologies has not yet been proven. Either technology would require the acquisition of elaborate temporary equipment and material handling systems to implement.

All of the ex-situ treatment technologies except off-site thermal treatment could result in additional administrative implementability issues that would have to be assessed if an upland treatment area is not available (Section 4.5.2.9).

Cost

Stabilization. The costs for stabilization are the lowest of the treatment technologies, but are still considered moderate.

Thermal Treatment. The cost for thermal treatment by on- or off-site incineration would be very high.

Biological and Chemical Treatment. The cost of biological and chemical treatment is high and very high, respectively.

Screening Result

Thermal treatment by incineration (both on and off site) is retained for alternative development. Stabilization is screened out due to low effectiveness. Biological and chemical treatment technologies are screened out because of low effectiveness, high costs, and difficulty in implementation.

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4.3.10 In-Situ Treatment

4.3.10.1 Description of In-Situ Treatment

In-situ soil treatment technologies and process options considered for the CMRP site include solidification and stabilization, thermal, and biological treatments (Table 4-2). The key difference between ex-situ soil treatment and in-situ soil treatment is that soil removal is not required for in-situ treatment. In-situ treatment would be applied to the in-place soil to a pre-determined depth.

General descriptions of all of the treatment technologies and process options are provided in Section 4.2.9, except for thermal treatments including in-situ thermal desorption, electrical resistance heating, and steam injection and a biological treatment option for phytoremediation. These treatments processes are described below.

Thermal Treatment Technology

Thermal treatment works according to the same principles described in Section 4.2.9. Generally, the heat increases the volatilization rate of organics to facilitate extraction. Volatilized contaminants are typically removed from the vadose zone using soil vapor extraction and aboveground treatment of the off-gas is required. When temperatures are sufficiently high, some breakdown of compounds occur in-situ.

The method of supplying the heat varies when treating soils in-situ. Specific types of thermal treatment process options include conductive heating/in-situ thermal desorption, electrical resistance heating, and steam heating.

In-Situ Thermal Desorption Process Option
Metal heaters are installed in subsurface wells or a metal blanket is placed over the soil. Heat flows into the soil primarily by conduction from heaters operating between 540°C and 815°C (1,000°F to 1,500°F). As the soil is heated, water boils and contaminants are volatilized. An applied vacuum draws contaminants toward vapor extraction wells for aboveground treatment. The conductive heating process is very uniform in its vertical and horizontal sweep, allowing high DRE of chlorinated VOCs, PCBs, and PAHs, and dioxins (Baker and Heron, 2004).

Electrical Resistance Heating Process Option
This option delivers an electrical current underground through steel wells. The heat from the current converts groundwater and the moisture in soil to steam, which volatilizes contaminants.

Steam Injection Process Option
Steam injection forces steam underground through wells. The steam heats the area and mobilizes volatile contaminants. Condensed water must be collected and treated aboveground. Soil temperatures reach up to 100 °C (212 °F).

Biological Treatment Technology

Biological treatment is an innovative technology and works according to the principles described in Section 4.2.9. Generally, bacteria are used to accelerate the degradation of contaminants in contaminated soils or sediments. Information on the results of recent demonstrations for upland soil is available from the FRTR Web site (www.frtr.gov/costperf).

Phytoremediation Process Option

Phytoremediation is the use of plants to remediate environmental media. This technology involves the interaction of plant roots and the microorganisms associated with these root systems to remediate contaminated soil and groundwater. Phytoremediation is generally used as an in-situ technology, but it can also be used ex-situ. The technology utilizes the natural hydraulic and metabolic processes of plants and is thereby passive and solar-driven. Phytoremediation can be used in combination with mechanical treatment methods or as a standalone treatment method.

4.3.10.2 Screening of In-Situ Treatment

Effectiveness

Solidification/Stabilization. These technologies have not been proven for use with dioxins on a large scale, and would not be practical for use in vegetated floodplain soil areas. These technologies are rated as having low effectiveness.

Thermal Treatment. One thermal process, in-situ thermal desorption (ISTD), uses conductive heating accompanied by vapor treatment, and has been shown to be highly effective for the in-situ remediation of dioxin contaminated soils as well as other organic contaminants such as PCBs, SVPCs and pesticides that need to be addressed at the site. Electrical resistance heating applies alternating current to heat soil until the boiling point of water at depth is reached, but would not be effective for the in-situ remediation of dioxin contaminated soils because dioxins and other low-vapor pressure chemicals will not vaporize at boiling water temperatures. Similarly, the steam stripping process option would not be effective for dioxin contaminated soils because the temperatures are too low.

Biological Treatment. Dioxins are very resistant to breakdown by microorganisms and biological treatments would have low effectiveness. Certain types of fungus can break down dioxins, but the process is very slow and has not been proven effective in large scale, field-based pilot studies. Similarly, phytoremediation, in which contaminants are taken up by plant roots and sometimes broken down, shows promise but has not yet been proven for persistent organic compounds.

Implementability

The solidification/stabilization and thermal treatment technologies would be very difficult to implement because of potential impacts to wetland and floodplain areas, the ecology and local residents. The biological treatment technology is also infeasible because appropriate microorganisms or plants to conduct biological treatment are not available.

All of the in-situ treatment technologies could have potential impacts to wetland and floodplain areas that would have to be assessed.

Cost

Solidification/Stabilization. These technologies are capital intensive and would have high costs.
Thermal Treatment. ISTD is a high cost option because of the high capital, energy, and treatment costs.
Biological Treatment. This technology has moderate costs largely due to the cost of materials or plants.

Screening Result

None of these in-situ treatment technologies is retained for alternative development.

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4.4 General Response Actions and Technologies for Groundwater

General response actions, technologies and process options for source area groundwater are described and evaluated in this section, and summarized in Table 4-3. Additional details regarding the groundwater response actions are provided in Appendix I.

4.4.1 Institutional Controls

4.4.1.1 Description of Institutional Controls

ICs for groundwater are similar to those considered for sediment (Section 4.2.1) and source area soils (Section 4.3.1). Potential ICs identified for source area groundwater include land and water use restrictions to restrict extraction of and contact with contaminated groundwater or restrict actions that could result in contaminated groundwater being released to the environment (e.g., excavation).

4.4.1.2 Screening of Institutional Controls

Effectiveness

ICs would not reduce residual risk or achieve the RAOs including preventing contaminant migration from groundwater at the impacted area to surface water. Hence, ICs are not effective as a standalone measure, but could be effective if used in conjunction with other options.

Implementability

ICs are easily implemented at contaminated sites.

Cost

The cost is low because no construction work is required.

Screening Result

ICs are retained for alternative development. These controls would not be used as the sole element of any alternative, but would be used in combination with other response actions.

4.4.2 Monitored Natural Attenuation

4.4.2.1 Description of Monitored Natural Attenuation

Monitored natural attenuation (MNA) for groundwater is comparable in some ways to MNR for sediment. For example, natural attenuation relies on natural processes to clean up or attenuate pollution in soil and groundwater. Natural attenuation occurs at most contaminated sites. However, the right conditions must exist underground to clean sites properly and in a timely manner. MNA involves testing groundwater concentrations to assess the extent that contaminants are naturally attenuating. Attenuation can occur through natural microbial biodegradation, adsorption of contaminants to soil, dispersion, and volatilization. MNA works best where the contaminant source has been removed.

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4.4.2.2 Screening of Monitored Natural Attenuation

Effectiveness

Dioxins are characterized as being highly recalcitrant within the natural environment, with extremely slow natural biological degradation rates. The presence of dioxins in groundwater indicates that natural adsorption of dioxin to soil particles with accompanying settling/deposition is not occurring fast enough to sufficiently remove the dioxins from the groundwater prior to reaching the river sediment. PCE and other VOCs, which are thought to be one of the mechanisms by which dioxin is mobilized in the groundwater at the CMRP site, can be treated using MNA. However, natural attenuation of these chemicals requires relatively low existing contaminant levels, and time and space to be effective and the proximity of the contaminated groundwater plume to the Woonasquatucket River poses a potential recontamination threat to the river and pond sediments. Therefore, MNA would not be effective.

Implementability

MNA is easily implemented at contaminated sites.

Cost

MNA costs are generally low, and would be limited to costs associated with the generation of monitoring data (i.e., sample collection and analysis).

Screening Result

MNA would not be effective and is screened out as a result.

4.4.3 Containment

4.4.3.1 Description of Containment

Containment of contaminated groundwater would reduce the potential exposure of human or ecological receptors to dioxin by reducing contaminant migration to surface water or sediment along the Woonasquatucket River. In-place containment technologies include using either subterranean hydraulic barriers or hydraulic pumping to limit groundwater movement. Establishment of hydraulic control has proven effective at many sites to protect downgradient receptors, but does not directly reduce contaminant toxicity within the impacted area.

Subterranean Hydraulic Barrier Technology

Subterranean physical barriers can include a slurry wall, a steel sheet pile wall, or chemical or cement ground injection. These technologies can be used to stop groundwater from flowing through or out of a location, thus preventing contaminant mobilization and transport.

Slurry Wall Process Option
Slurry walls are created by digging a trench around all, or part, of a contaminated site and filling the trench with a slurry, which forms an impermeable barrier when cured. Slurries are often made using bentonite clay and water, but may also contain chemical cementing agents or soil, depending upon the site conditions and contamination (Water Technology International Corporation [WTIC], 1997).

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Sheet Pile Wall Process Option
Impermeable barriers can also be created by placing sections of steel plate into the ground around all or part of a contaminated site. The steel is often corrugated to add strength and is driven into the ground using a pile driver. The edges interlock so that a continuous wall is formed; if a small gap is present between sheets, it can be injected with grout or will seal itself with fine particles over time (WTIC, 1997).

Cement or Chemical Grout Injection Process Option
This process option is very similar to a slurry wall, with the exception that grout (in the form of a slurry) is injected into the soil through boreholes instead of a trench. Injections are performed at numerous boreholes around the site so that a complete, impermeable barrier is formed (WTIC, 1997).

Ideally, the physical hydraulic barrier would extend vertically down into the confining aquifer layer to prevent groundwater from flowing beneath the barrier. The barrier could consist of any number of configurations, including a single downgradient barrier or a barrier that surrounds the entire groundwater impacted area. A downgradient barrier would require hydraulic pumping along the barrier to prevent groundwater from flowing around or underneath the barrier. A barrier that surrounds the entire impacted area may also require some form of capping to prevent water infiltration from precipitation, or hydraulic pumping to remove infiltrated water.

Hydraulic Control Technology

Hydraulic control of groundwater through pumping is established through an extraction trench or series of extraction wells located within or downgradient of the impacted groundwater area. Monitoring wells are needed to evaluate the effectiveness of the hydraulic control. In addition, the extracted groundwater generally requires aboveground treatment. Extracted groundwater treatment options are discussed in Section 4.4.5.

4.4.3.2 Screening of Containment

Effectiveness

In-place containment technologies of subterranean hydraulic barriers or hydraulic control would prevent migration of contaminated groundwater from reaching sediment or surface water but may not meet other requirements (e.g., GB standards). Also, the presence of NAPL could compromise the effectiveness if NAPLs migrate downward into the confining layer.

The success of a subterranean hydraulic barrier would depend on preventing groundwater from flowing around or under the barrier by (1) minimizing infiltration of groundwater into the impacted area through proper capping, (2) installing the barrier to an adequate depth to prevent flow under the barrier, and (3) either surrounding the entire impacted area or installing a groundwater extraction system to remove groundwater behind the barrier.

Hydraulic control through groundwater extraction has proven effective at many sites, as long as adequate groundwater capture is obtained.

There would be some reduction in toxicity or volume of contamination using hydraulic control (pumping with aboveground treatment), but no reductions in contamination through treatment using hydraulic containment. Both technologies could disturb the elderly occupants of the Brook Village to some degree. Therefore, both technologies are rated as having moderate effectiveness.

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Implementability

Subterranean hydraulic barriers and hydraulic control are proven technologies that can be implemented at the CMRP site. The site area is relatively small and the groundwater is relatively shallow, allowing implementation of either technology. However, the technologies would need to be implemented relatively deep to reach the confining bedrock layer located approximately 40 to 60 ft bgs. Hence, these hydraulic technologies are each considered as having moderate implementability.

Cost

The subterranean hydraulic barrier technology is a moderate cost technology because of the high initial capital cost but minimal long-term maintenance. The hydraulic control technology also has moderate costs because of the initial capital cost for the treatment system installation and long-term O&M costs.

Screening Result

Subterranean hydraulic barrier and hydraulic control technologies are retained for alternative development.

4.4.4 Excavation/Dewatering

4.4.4.1 Description of Excavation/Dewatering

This response action involves short-term removal of contaminated groundwater within the impacted area in conjunction with focused soil excavation (see Section 4.3.5) at a small area along the west side of the Brook Village parking lot (see Section 3.5.6, Figure 3-6). Combining these actions within the impacted area allows removal of a large portion of the contaminant mass, resulting in a substantial decrease in subsequent dissolved-phase contaminant concentrations. This response action provides long-term protection through reduction of contaminant mass.

Short-term Pumping Technology

Groundwater is pumped for several days prior to, during, and/or after soil has been excavated. The excavated pit may be left open for several days to allow additional infiltration of groundwater into the pit and subsequent pumping. The extracted groundwater generally requires aboveground treatment. Extracted groundwater treatment options are discussed in Section 4.4.5.

4.4.4.2 Screening of Excavation/Dewatering

Effectiveness

Generally, groundwater removal in conjunction with soil excavation within the saturated zone very effectively removes a large portion of the contaminant mass from groundwater at contaminated sites, allowing a significant reduction in chemical concentrations. At the CMRP site, once the excavation and dewatering are completed, groundwater monitoring would then be performed to confirm that the RAOs were met. The disadvantage of dewatering is that either on- or off-site temporary groundwater treatment

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would be required,[34] and groundwater concentrations may remain above cleanup goals if the contamination is not sufficiently removed. This response action would also disturb the elderly occupants of the Brook Village apartment building to some degree. Overall, dewatering is an effective technology to consider because it minimizes residual risk through removal of the contaminant source. Dewatering is given a moderate rating for effectiveness when combined with excavation because it will remove much, but not all, of the contaminant mass. Bench-scale testing of dewatering technologies is recommended if the selected process has not been previously demonstrated with site contaminants.

Implementability

Dewatering is a proven technology that can be implemented at the CMRP site. Dewatering in association with excavation is routine work that is frequently performed and there should be no administrative issues related to implementability. Dewatering would have easy implementability due to its minimal short-term impacts and ease to implement in conjunction with excavation. Potential impacts to the floodplain would also be temporary.

Cost

Dewatering is low cost because of its short-term duration and ability to use rented equipment and conventional treatment/disposal options.

Screening Result

Dewatering is retained for alternative development in conjunction with source area excavation.

4.4.5 Pump and Treatment

4.4.5.1 Description of Pump and Treatment

Groundwater pumping is a component of many pump-and-treat processes, which are some of the most commonly used groundwater remediation technologies at contaminated sites. Possible objectives of groundwater pumping include removal of dissolved contaminants from the subsurface, and containment of contaminated groundwater to prevent migration.

Treatment of the extracted groundwater may include the design of a train of processes such as filtration, NAPL phase separation, air strippers, carbon systems, bioreactor, or chemical reaction tailored to remove specific contaminants. These available treatment technologies are discussed below.

Physical Treatment Technology

Commonly used physical ex-situ groundwater treatment process options include precipitation/ coagulation/ flocculation, filtration, air stripping, and carbon adsorption.

[34] An area for a skid-mounted groundwater treatment system and/or holding tanks could be located at the Brook Village parking lot.

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Precipitation/Coagulation/Flocculation Process Option
This process transforms dissolved contaminants into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration (Figure 4-12). The process usually uses pH adjustment, addition of a chemical precipitant, and flocculation. These process options most frequently apply to inorganic compounds.

Filtration Process Option
Separation techniques concentrate contaminated wastewater through physical or chemical means. The separation may be based on a particle size (e.g., bag filter or cartridge filter) or specific density (e.g., gravity separation of NAPL phase). Advanced filtration may involve membranes. Lignin adsorption/sorptive clays are used to treat aqueous waste streams with organic, inorganic and heavy metals contamination. The waste stream is treated due to the molecular adhesion of the contaminants to an adsorptive surface.

Air Stripping Process Option
Figure 4-13 shows a schematic of a typical air stripping process. Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.

Activated Carbon Adsorption Process Option
Figure 4-14 shows a schematic of a typical activated carbon adsorption process. Groundwater is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required. Pretreatment for removal of suspended solids from streams to be treated is an important design consideration. If not removed, suspended solids in a liquid stream may accumulate in the column, causing an increase in pressure drop. When the pressure drop becomes too high, the accumulated solids must be removed (for example, by backwashing). The solids removal process necessitates adsorber downtime and may result in carbon loss and disruption of the mass transfer zone.

Biological Treatment Technology

The ex-situ biological groundwater process option considered for the CMRP site is anaerobic degradation. A general description of anaerobic degradation is provided in Section 4.2.9. Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors. In suspended systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin. In attached systems, such as rotating biological contractors and trickling filters, microorganisms are established on an inert support matrix.

Chemical Treatment Technology

The most widely applied chemical treatment technology for ex-situ treatment of groundwater containing organics involves reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert. This and other available chemical treatment technologies are discussed in Section 4.2.9. The most common redox chemical reaction process is ultraviolet (UV) oxidation, which uses UV light to oxidize organic compounds. The groundwater must be free of turbidity to prevent interference with the UV light.

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4.4.5.2 Screening of Pump and Treatment

Groundwater could be extracted either from an extraction trench or from a series of vertical groundwater extraction wells. Aboveground treatment could consist of any number of physical, biological, or chemical treatment technologies.

Effectiveness

Groundwater extraction is an option for addressing the types of contamination found in the groundwater at the impacted area. However, it generally takes decades to remove contaminant mass, as contaminant removal is diffusion limited. Dioxins in particular have such a low solubility and high partitioning coefficient for desorption that it would take hundreds of years to effect significant desorption from the soils to the aqueous phase using pump and treat. Hence, a groundwater extraction system would require operation for many years before acceptable levels are reached in the groundwater.

The treatment technologies applicable to both VOC and dioxin removal include:

- Physical filtration, including advanced filtration or activated carbon processes.
- Chemical treatment using UV oxidation after removal of sediment, turbidity, iron, and manganese.

A treatment train consisting of one or several of the above processes would be required and would be modified over time as influent concentrations change.

Pump and treat combined with physical or chemical treatment are moderately effective because of the time required to remove contaminant mass. Pumping and biological treatment would have low effectiveness, because the biological treatment of dioxins is ineffective.

Implementability

Pump and treat is a proven technology that is technically and administratively implementable at the site. However, potential impacts on the floodplain areas would need to be assessed (see Section 4.5.4.4). Pump and treat combined with physical or chemical treatment has moderate implementability. Pump and treat combined with biological treatment is not implementable.

Cost

Pump and treat using physical (filtration or adsorption) processes would have moderate costs because of their long-term duration and O&M costs. Pumping and chemical (UV oxidation process) or biological treatment is a high cost option.

Screening Result

Pump and treat combined with physical or chemical treatment is retained for alternative development. Pump and treat with biological treatment is screened out.

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4.4.6 In-Situ Treatment

4.4.6.1 Description of In-Situ Treatment

In-situ response actions are often implemented for cleanup of hazardous waste sites based on their effectiveness in removing mass and potentially lower costs than ex-situ treatment. In-situ groundwater technologies consist of physical, biological, and chemical treatment technologies.

Physical Treatment Technology

Two physical treatment process options, air sparging and thermal treatment, address volatile or recalcitrant organic compounds.

Air Sparging Process Option
Air sparging involves the injection of air or oxygen through a contaminated aquifer (Figure 4-15). Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes volatile and semivolatile organic contaminants by volatilization. The injected air helps to flush the contaminants into the unsaturated zone. Soil vapor extraction usually is implemented in conjunction with air sparging to remove the generated vapor-phase contamination from the vadose zone. Oxygen added to the contaminated groundwater and vadose-zone soils also can enhance biodegradation of contaminants below and above the water table.

Thermal Treatment Process Option
Thermal treatment technologies are usually applied to contaminated soil but may also be applied to groundwater. Thermal technologies are discussed in Section 4.2.9.

Biological Treatment Technology

In-situ biological groundwater process options considered for the CMRP site include anaerobic degradation, passive/reactive treatment walls, and phytoremediation. General descriptions of anaerobic degradation and phytoremediation are provided in Sections 4.2.9 and 4.3.10, respectively. Additional discussion is provided below for passive/reactive treatment walls.

Passive/Reactive Treatment Wall Process Options
Figure 4-16 shows a schematic of a typical passive treatment wall. Passive treatment walls, also known as permeable reactive barriers (PRBs) or chemical filters, are installed across the flow path of a contaminated groundwater plume. These barriers allow the passive flow of water while prohibiting the movement of contaminants by employing agents within the wall such as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, and microorganisms. The contaminants are either degraded or retained in a concentrated form by the barrier material, which may need to be replaced periodically. The wall could provide permanent containment for relatively benign residues or provide a decreased volume of the more toxic contaminants for subsequent treatment.

In its simplest form, a reactive barrier consists of a trench in the path of a dissolved groundwater plume. This trench is filled with an organic barrier or reactive material, such as tree mulch or granular iron. The main advantage of this system is that, generally, no pumping or aboveground treatment is required; the contaminated water passively moves through the barrier. Because there are no aboveground installations, the affected property can be put to productive use while it is being cleaned up. Passive treatment walls are increasingly being installed for cleanup based on their effectiveness, longevity, and low maintenance costs. This would be an effective mechanism for the treatment of VOCs. However, it is less clear how

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effectively a passive treatment wall would capture and degrade dioxins and eliminate their potential migration within the groundwater. This application of a reactive barrier would require treatability testing to examine the applicability for dioxins at the CMRP site.

Chemical Treatment Technology

The chemical treatment technologies most widely applied in-situ involve reduction/oxidation (redox) reactions that chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, or inert. This and other available chemical treatment technologies were discussed in Section 4.2.9.

4.4.6.2 Screening of In-Situ Treatment

Effectiveness

A number of in-situ technologies have proven effective with VOCs. While there are fewer case studies of in-situ removal of dioxin from groundwater, there are several technologies that would likely prove effective in reducing the mobility of the dioxin. A treatability study would be recommended to verify the site-specific effectiveness.

Physical Treatment. One physical process, ISTD, which uses conductive heating of both soil and groundwater, has proven effective for removal of recalcitrant compounds including dioxins. However, in order to be effective, this technology must be accompanied by vapor treatment and hydraulic control. These technologies are more effective above the groundwater table level because there is less soil moisture to heat. Below the groundwater table, it is more difficult to generate enough energy to raise the soil and groundwater temperature. Furthermore, the proximity to the river raises the concern of elevated water temperatures within the river. Hence, this technology would be moderately effective.

Biological Treatment. Dioxins are very resistant to breakdown by microorganisms. Certain types of fungus can break down dioxins, but the process is very slow. VOCs, on the other hand, are more readily biodegradable. Passive biowalls installed downgradient of a plume have been developed to allow in-situ anaerobic biodegradation of organic compounds. Recent work has been performed regarding the viability of biomulch walls for in-situ biodegradation of VOCs (Air Force Center for Engineering and the Environment, 2008). Given the high affinity of dioxins to sorb to organic material, there is a high probability that a passive biowall would effectively remove both VOCs and dioxin from groundwater. However, this technology has not been proven for dioxins. Biological treatment using biowalls would be moderately effective at treating VOCs. The effectiveness of dioxin reduction is uncertain.

Chemical Treatment. Chemical oxidation is an effective mechanism for degrading chlorinated solvents (tetra- and trichloroethylene). While dioxins are not readily oxidized, laboratory and limited field data indicate that the dioxins will be chemically oxidized when reacted with sufficiently strong radicals. Chemical treatment would be moderately effective, but this option would need to be evaluated in a treatability study.

Implementability

Physical Treatment. Known vendors exist for ISTD, but implementation of this innovative technology would be difficult because it has site-specific challenges and would be highly disruptive to the site.

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Biological Treatment. A number of passive biowalls have been installed at other groundwater sites, including biomulch treatment walls using natural tree products, which would be readily available in the local area. This technology is considered easy to implement.

Chemical Treatment. This technology has been used at other groundwater sites and the construction equipment and materials would be readily available. This technology is considered easy to implement.

Potential impacts to the floodplain would be temporary.

Cost

Physical Treatment. ISTD is a high cost option because of the high capital, energy, and ex-situ treatment costs.

Biological Treatment. The biowall process option would have moderate costs. Biowalls can be low cost in some situations because of the low capital cost (use native materials) and minimal long-term maintenance costs (may need to be refreshed once each decade). For the CMRP site, treatment of VOCs and dioxin is expected to be more complicated and a treatability study should be performed during design to provide more information on cost and effectiveness.

Chemical Treatment. This technology has moderate costs because of the generally high capital cost for chemicals and injection wells.

Screening Result

Biological (biowall) and chemical treatment technologies are retained for alternative development. Physical treatment is screened out.

4.5 Technology Impacts on Wetlands and Floodplains

Under the Clean Water Act § 404(b)(1) Guidelines, no discharge of dredged or fill material is permitted if there is a practical alternative to the proposed discharge that would have less adverse impact to the aquatic ecosystem so long as the alternative does not have other significant adverse environmental impacts (40 CFR § 230.10(a)). Under the Wetlands Executive Order 11990, and Floodplain Executive Order 11988, adverse impacts to these areas must be avoided wherever there is a practicable alternative to address contamination at a site. Floodplain requirements focus on avoiding to the extent practical the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. Wetlands requirements focus on avoiding to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. This section describes the potential long-term permanent adverse impacts of sediment, soil, and groundwater remediation technologies that were retained in Sections 4.1 through 4.4 on wetlands and floodplains consistent with the focus of these requirements. With regard to potential archeological impacts, no structures (e.g., dams) located at the action areas evaluated in this FS are listed on the National Register of Historic Places and the State of Rhode Island has not identified any historic structures within or adjacent to the action areas.

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The overall impacts associated with implementing the identified remedial technologies will best be understood once the alternatives have been developed and evaluated in Sections 5.0 and 6.0 of this FS. The establishment of temporary work areas and access ramps will result in a temporary occupancy in floodplain areas but no modification of the floodplain. Other activities discussed below could result in occupation and modification of floodplains. Before an alternative that results in occupation and modification of floodplains can be selected, EPA must look at all of the other options for cleanup and make a determination that there is no practical alternative to taking this action except for the alternative that results in occupation and modification of floodplains.

In areas where contamination is found above cleanup goals in wetland areas, there is no practical alternative to doing work in these wetland areas because this is where the contamination is located. In these cases, there is no practical alternative to the destruction of wetland areas. As a result, EPA must evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements. EPA also focuses on minimizing impacts to the wetland areas in these circumstances. Where activities are proposed that result in destruction of wetlands or the discharge of dredged or fill material in wetland areas where there is no contamination above cleanup goals, EPA must look at all of the other options for cleanup and make a determination that there is no practical alternative to taking this action. If this determination is made, EPA would then evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

Wetland definitions vary depending on the jurisdiction, but are generally recognized as wet habitats where the land is wet for some period of time each year, but not necessarily permanently wet, and supports a predominance of plant species adapted to living in wet conditions. For the purpose of this assessment, floodplain areas are defined as the area above the normal water elevation and below the 100-yr flood elevation. Wetland and floodplain areas border parts of the Woonasquatucket River that runs along the CMRP site (Figure 1-3, Section 2.3.10).

4.5.1 No Action

The No Action response was retained according to the NCP guidance (EPA, 1988). This action is common to sediment, soil, and groundwater at the CMRP site. The No Action response would not have any impact on wetlands and floodplains. However, No Action would not provide effective protection to human health and the environment from exposure to contaminated sediment, soil, or groundwater at the site.

4.5.2 Allendale and Lyman Mill Reach Sediment

Sediment addressed in this FS is located in the open water area upstream of the Allendale and Lyman Mill Dams during normal river flow. The action area is bounded to the north by the Route 44 Bridge and to the south by Lyman Mill dam. For purposes of the FS, contaminated sediment is not located in the floodplain. However, actions taken to address sediment may result in occupancy and modification of the floodplain, destruction and modification of wetlands or the discharge of dredged or fill material. Potential actions in wetlands and floodplains from implementation of the sediment technologies retained from the screening analysis (Section 4.2) are described below.

4.5.2.1 Institutional Controls

ICs would not have any impact on wetlands and floodplains.

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4.5.2.2 Engineering Controls

ECs identified for the CMRP site would not have any impact on wetlands and floodplains.

4.5.2.3 Monitored Natural Recovery

The MNR technology would not have any impact on wetlands and floodplains beyond what naturally occurs. The rate of sedimentation is estimated to vary between 0.5 to 0.8 cm/year in Allendale Pond and between 0.5 to 0.6 cm/year in Lyman Mill Pond. MNR would not change these natural sedimentation rates.

4.5.2.4 Containment (In-Situ Capping)

Capping contaminated media is an effective and proven technology used to protect human health and the environment from exposure to contamination at a site. By capping contamination in the ponds, approximately 7.1 acres of new floodplain areas would be created in shallow areas of the ponds where the water depth is less than the cap thickness, unless this technology is combined with sediment removal. Because this technology would result in the placement of a structure (cap) in the newly created floodplain, it would result in an occupancy and modification of the floodplain. Thus, a determination would first need to be made concluding that there is no other practicable alternative that would not also include floodplain occupancy and modification. In addition, capping would involve the discharge of dredged or fill material to "waters of the United States". EPA must look at all of the other options for cleanup to see if a determination can be made that there is no practical alternative to taking this action that would not also include discharge of dredged or fill material. If this determination is made, EPA would then evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

4.5.2.5 Sediment Removal

Sediment removal technologies, including dredging and excavation, would provide effective protection to human health and the environment by removing the source of contamination. There are no significant activities related to these actions that would result in occupancy and modification of the floodplain or destruction and modification of wetlands except to the extent that contamination is located in wetland areas. In addition, assuming dredging or excavation would result in other than a *deminimis* discharge of dredged or fill material to waters of the US, EPA must look at all of the other options for cleanup to see if a determination can be made that there is no practical alternative to taking this action. If this determination is made, EPA would then evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

4.5.2.6 Transportation

All in-situ capping and sediment removal alternatives rely on mechanical transportation to transport material at the construction site. In-situ capping alternatives also rely on the hydraulic transport of capping material to the pond areas. There are no significant activities related to these actions that would result in occupancy and modification of the floodplain or destruction and modification of wetlands except to the extent that contamination is located in wetland areas.

4.5.2.7 Dewatering

Dewatering technologies are often used in combination with sediment removal technologies to reduce the volume of material for disposal or treatment. For those sediment removal alternatives that include on-site

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containment in an upland CDF, on-site treatment, or off-site disposal, an upland processing area would be needed for mechanical dewatering and/or solidification. (Disposal in a nearshore CDF would not require dewatering.) Assuming there is an upland area available for this activity, there are no significant activities related to dewatering that would result in occupancy and modification of the floodplain or destruction and modification of wetlands except to the extent that contamination is located in wetland areas.

4.5.2.8 Disposal

Disposal technologies retained from the screening analysis include on-site containment, either in a nearshore CDF or an upland CDF, or off-site disposal at a licensed facility. The potential long-term impacts to wetlands and floodplains from these disposal alternatives are described below.

On-site Nearshore Confined Disposal Facility

Nearshore CDFs are constructed in open water, wetland or floodplain areas and are filled so that the top cover is above the normal water level. A permanent perimeter dike would be installed along the shoreline and adjacent to the floodplain area. Because this technology would include placement of contamination and a structure (dike) on existing floodplain as well as placement of a structure (cap) in the newly created floodplain, it would result in an occupancy and modification of the floodplain and destruction of wetlands. Thus, a determination would first need to be made concluding that there is no other practicable alternative. In addition, placement of the nearshore CDF would result in the discharge of dredged or fill material to waters of the US. As a result, EPA must look at all of the other options for cleanup to see if a determination can be made that there is no practical alternative to taking this action. If this determination is made, EPA would then evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

Upland Confined Disposal Facility

As discussed in Section 5.1.6.1, there are three potential upland CDF locations. The location south of the abandoned channel contains low-quality wetlands at the center of its footprint. Although this location does not have sufficient disposal capacity for all of the excavated sediment, it may be selected in combination with one of the other potential locations. Selection of a location for the upland CDF that contains wetlands would require a determination that there is no other practicable alternative. Capacity requirements and potential impacts to the floodplain and wetland areas will be evaluated in greater detail as the remedial alternatives are developed and analyzed in Sections 5.0 and 6.0 of this FS.

Off-site Disposal

Disposal off site would not have any impacts to wetlands or floodplain areas of the site.

4.5.2.9 Ex-Situ Treatment

Thermal treatment by on-site incineration would require a parcel of property comprising approximately 2 acres. There would be no impacts to wetlands or floodplains if on-site incineration were conducted in upland areas outside of wetlands or floodplains. If there is no such upland area that could be acquired, then a determination would need to be made that there is no practicable alternative before consideration could be given to locating the on-site incinerator in a floodplain.

Thermal treatment at an off-site licensed facility would not have any impact on wetlands or floodplains.

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4.5.2.10 Dam Removal or Replacement

Dam removal or replacement could happen in conjunction with one of the sediment technologies discussed above. As discussed in Section 2.3.10, wetland areas border parts of the Woonasquatucket River including areas located adjacent to the Allendale and Lyman Mill Dams (Figure 1-3). Along with anticipated beneficial effects on water quality and fish passage, dam removal or replacement may have long-term impacts such as a reduction in open water area and an increase in the spatial extent of floodplain and/or wetland habitat (the positive and negative effects potentially associated with dam removal will be discussed and evaluated in Section 6.2 of this FS). Dam removal or replacement would also result in the destruction of some bordering wetlands due to the lowering of the water table. A determination would first have to be made that there is no other practicable alternative to destroying/modifying wetlands before this alternative can be selected. In addition, Section 404 of the Clean Water Act establishes a policy of no net loss to wetlands (EPA and Department of the Army, 1990b). For dam removal to be acceptable, it (a) should not cause or contribute to significant degradation of the waters or result in a net loss of wetlands, (b) should be designed to have minimal adverse impact, (c) should not have any practicable alternatives, and (d) should be in the public interest. EPA will have to find that the benefits of dam removal outweigh the loss of wetlands, or that the loss of wetlands is mitigated by creation of wetlands elsewhere. Potential changes to the floodplain and wetland areas will be evaluated in greater detail as the remedial alternatives are developed and analyzed in Sections 5.0 and 6.0 of this FS.

4.5.3 Source Area Soils and Floodplain Soils

Soil addressed in this FS is located in the source area and wetland and floodplain areas at the reaches of Allendale and Lyman Mill. In the source area, specific wetland areas include riverbank wetland as administered by RIDEM and potential federal jurisdictional wetland that have or could become re-established along portions of Cap Area #3 (former mill tailrace located just east of the Centredale Manor apartment building). The source area soil action area is bounded to the north by the Brook Village apartment building and to the south by Cap Area #1. While this area is developed, approximately 85% of the area (approximately 7.6 acres) is located within the 100-yr flood elevation. The Allendale and Lyman Mill floodplain soil action areas are bounded by the normal water level and 100-yr flood elevations. The Lyman Mill action area also includes the Oxbow, a forested wetland located immediately west of the stream channel connecting Allendale and Lyman Mill Ponds. As a result, most of the soil contamination is located either in a floodplain or wetland. Potential long-term impacts to wetlands and floodplains from implementation of the soil technologies retained from the screening analysis (Section 4.3) are described below.

4.5.3.1 Institutional Controls

ICs would not have any impact on wetlands or floodplains.

4.5.3.2 Engineering Controls

ECs identified for the CMRP site would not have any impact on wetlands or floodplains.

4.5.3.3 Containment (In-Situ Capping)

Capping contaminated media is an effective and proven technology used to protect human health and the environment from exposure to contamination at a site. Because capping would result in a permanent modification and occupancy of floodplain areas a determination would first need to be made that there is no other practicable alternative before doing work in a floodplain area. Where contamination above

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cleanup goals is located in wetland areas, there is no practical alternative to doing work that will not result in the destruction of wetlands. In addition, capping in some areas would involve the discharge of dredged or fill material to waters of the US. EPA must look at all of the other options for cleanup to see if a determination can be made that there is no practical alternative to taking this action. If this determination is made, EPA would then evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

4.5.3.4 Soil Removal

Excavation would provide effective protection to human health and the environment by removing the source of contamination. Some soil contamination that presents an unacceptable risk is located in wetland areas. Removal of soil from these areas would result in the destruction of some wetlands. Where contamination above cleanup goals is located in wetland areas, there is no practical alternative to doing work that will not result in the destruction of wetlands. In addition, assuming dredging or excavation would result in other than a *deminimis* discharge of dredged or fill material to waters of the US, EPA must look at all of the other options for cleanup to see if a determination can be made that there is no practical alternative to taking this action. If this determination is made, EPA would then evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

4.5.3.5 Transportation

All in-situ capping and soil removal alternatives rely on mechanical transportation to transport material at the construction site. There are no significant activities related to these actions that adversely impact wetlands and floodplain areas of the site in the long term; potential short-term impacts and mitigation options are discussed in Section 6.0.

4.5.3.6 Dewatering

Dewatering technologies are often used in combination with sediment removal technologies to reduce the volume of material for disposal or treatment. Dewatering would probably not be necessary for soil, however, because source area soils are expected to be much drier than sediment and floodplain soils are expected to have high amounts of vegetation that would hinder the dewatering process. In the event that dewatering is needed for soil, impacts to floodplain areas are the same as described for dewatering sediment (Section 4.5.2.7).

4.5.3.7 Disposal

Potential impacts to wetlands and floodplains from on-site containment in a nearshore CDF or upland CDF or off-site disposal at a licensed facility is the same as described for sediment (Section 4.5.2.8).

4.5.3.8 Ex-Situ Treatment

Potential impacts on wetlands and floodplains from ex-situ treatment technologies is the same as described for sediment (Section 4.5.2.9).

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4.5.4 Source Area Groundwater

Groundwater addressed in this FS is located within the impacted area beneath the Brook Village parking lot and is bounded to the east by monitoring well GEC-5 and to the west by the Woonasquatucket River. This action area is located in the floodplain as well as riverbank wetland (as defined by RIDEM). However, no long-term impacts would occur unless a permanent treatment facility was constructed in the floodplain (see Section 4.5.4.4). The majority of the technologies would be implemented below the ground surface which is not considered part of the floodplain. Potential actions in wetlands and floodplains from implementation of the groundwater technologies retained from the screening analysis (Section 4.4) are described below. The potential short-term impacts associated with implementation of these technologies and mitigation options are discussed in Section 6.0.

4.5.4.1 Institutional Controls

ICs would not have any impact on wetlands or floodplains.

4.5.4.2 Containment

In-place containment at the CMRP site would not have any long-term impact on the floodplain. Implementation of the in-place containment technologies (e.g., subterranean hydraulic barrier such as a sheet pile wall or hydraulic control such as extraction wells) would occur below the ground surface which is not considered floodplain and would not result in occupancy and modification of the floodplain or destruction and modification of wetlands.

4.5.4.3 Excavation/Dewatering

There are no significant activities related to dewatering that would result in occupancy and modification of the floodplain or destruction and modification of wetlands.

4.5.4.4 Pump and Treatment

Groundwater pump-and-treat processes are some of the most commonly used groundwater remediation technologies at contaminated sites. This technology would require construction of a permanent groundwater treatment facility. There would be no additional significant impacts to wetlands or floodplains if the groundwater treatment facility was located in an upland area. If there is no upland area outside of floodplain and wetland areas that could be acquired to locate the groundwater treatment facility, then a determination would need to be made that there is no practicable alternative before consideration could be given to locating this in a floodplain or wetland area.

4.5.4.5 In-Situ Treatment

In-situ treatment of contaminated groundwater, using either biological or chemical treatment, would not result in occupancy and modification of the floodplain. In-situ treatment using either biological or chemical treatment would occur below the ground surface which is not considered a floodplain. For example, in-situ chemical treatment would include injection of an oxidizing agent into the subsurface soil.

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5.0 IDENTIFICATION AND SCREENING OF REMEDIAL ALTERNATIVES

The purpose of this section is to develop and screen a range of remedial alternatives to address contaminated sediment, soil, and groundwater at the CMRP site. The remedial alternatives are developed by assembling various technologies and process options screened in Section 4.0. Primary remedial technologies, such as capping or excavation, are combined with various process options and/or control measures (e.g., monitoring programs, ICs, and treatment or containment) to develop each of the alternatives. The alternatives presented meet the NCP requirement to assess a range of remedial approaches for a given site. In addition to the alternatives developed using the technologies described in Section 4.0, the No Action alternative is also evaluated as a stand-alone alternative according to the NCP requirements to serve as the baseline condition.

The proposed remedial alternatives are screened against the short- and long-term aspects of three broad criteria during this stage: effectiveness, implementability, and cost (described below). The screening is performed with a level of detail sufficient to distinguish among the alternatives and ensure that the alternatives are being compared on an equivalent basis. The goal of alternative screening is to reduce the number of alternatives that will undergo a more thorough and extensive analysis (EPA, 1988). With the exception of No Action, alternatives that are not protective of human health and the environment and that do not comply with ARARs (except where conditions for an ARAR waiver exist) are screened out. The alternatives with the most favorable evaluation of all three criteria are retained for a more detailed evaluation in Section 6.0.

Effectiveness

Each remedial alternative is evaluated based on its potential effectiveness in providing protection to human health and the environment and the reduction in toxicity, mobility, or volume of contamination that it will achieve through treatment. Both the short- and long-term effectiveness of each remedial alternative is evaluated, where:

- Short-term effectiveness refers to control of adverse impacts on human health and the environment posed during the construction and implementation period; and
- Long-term effectiveness refers to the ability of an alternative to maintain reliable protection of human health and the environment over time once the remedial action is complete and the RAOs (cleanup objectives) have been met.

Effectiveness is qualitatively evaluated using such terms as: not effective; or low, moderate, and high effectiveness.

Implementability

The implementability criterion considers both the technical and administrative feasibility of constructing, operating and maintaining a remedial alternative based on site conditions. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations until a remedial action is completed; O&M, replacement and monitoring aspects of an alternative also are considered as part of the technical feasibility. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies, the availability of treatment, storage, and disposal services and capacity. The requirements for, and availability of, specialized equipment or technical staff are also considered during the assessment of administrative feasibility.

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Implementability is generally evaluated using terms such as: infeasible or not possible, or complex/difficult, moderate, and easily (i.e., high) implementable.

Cost

During the screening of alternatives, the relative costs for each alternative are estimated so that the different options may be compared; relative cost accuracy is sufficient at this stage of the FS. Cost estimates for alternative screening are generally based on a variety of cost-estimating data and resources. These can include, but are not limited to, vendor information, cost curves, generic unit costs, cost-estimating guidance documents, engineering judgment and previous experience, and available historic information. For comparison purposes, costs are calculated as present value worth costs, which are calculated by applying a 7% discount rate per EPA guidance (1988 and 2000b). More accurate cost estimates, specific to the CMRP site, will be developed in support of the detailed analysis (Section 6.0).

The costs of the sediment and floodplain soil (Lyman Mill only) alternatives are compared using the descriptors and the associated ranges of dollar values below:

Very High	present worth cost greater than $75 million
High	present worth cost ranges from $50 million to $75 million
Moderate	present worth cost ranges from $25 million to $50 million
Low	present worth cost ranges from $1 million to $25 million
Very Low	present worth cost less than $1 million

Different cost ranges are used for the Allendale floodplain soil and source area soil and groundwater because these areas have smaller remedial footprints and, hence, substantially smaller volumes of material for remediation. The costs of alternatives for these areas are compared using the following descriptors and ranges of dollar values:

Very High	present worth cost greater than $10 million
High	present worth cost range from $5 million to $10 million
Moderate	present worth costs range from $3 million to $5 million
Low	present worth cost ranges from $1 million to $3 million
Very Low	present worth cost less than $1 million

The monitoring assumptions used for the cost estimates are considered reasonable and provide sufficient detail to compare technology costs in this FS. The actual, detailed monitoring strategies are created during the remedial design phase of the CERCLA process and are based on the selected remedies and site-specific conditions. The assumptions listed in this FS are strictly for the purpose of estimating costs so that the alternatives can be accurately compared. These assumptions (e.g., quantities and frequencies) are not intended to be prescriptive for the various remedies.

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5.1 Allendale and Lyman Mill Reach Sediment Alternatives

This section presents a range of alternatives designed to achieve cleanup objectives and address contaminated sediment at the reaches of Allendale and Lyman Mill that presents an unacceptable risk to human health and the environment. A total of 11 remedial alternatives are described and screened, which include some that rely on natural recovery and others that rely on containment, removal, or a combination of these options. Some of the alternatives rely on maintaining the Allendale and Lyman Mill Dams, whereas others include replacement of the dams with a smaller weir-type structure or removal of the dams altogether. Monitoring and ICs are common components to many of the sediment alternatives and all of the alternatives include five-year reviews.

Allendale and Lyman Mill Reach Sediment Alternatives

1	No Action
2	Limited Action
3	Monitored Natural Recovery
4	Enhanced Natural Recovery
5	Isolation Capping
6	Dredging and Disposal and/or Treatment
7	Excavation and Disposal and/or Treatment
8	Partial Excavation, Isolation Capping and Disposal and/or Treatment
9	Dam Removal and Isolation Capping
10	Dam Replacement, Excavation and Disposal and/or Treatment
11	Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

Shading represents alternatives retained for detailed evaluation in Section 6.0.

5.1.1 Alternative 1: No Action

5.1.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process to serve as the baseline condition. This alternative would entail no active remediation of the contaminated sediments at the reaches of Allendale and Lyman Mill. Five-year reviews and periodic monitoring, triggered by severe weather events, would be performed to assess conditions, but these are not requirements. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

5.1.1.2 Screening of No Action

Effectiveness

Alternative 1, No Action would not provide effective protection to human health and the environment because contaminated sediment that presents a risk would remain on site unaddressed. This alternative may not comply with ARARs for surface water quality. There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. This alternative would not provide long-term protection because no action would be taken to contain, reduce downstream transport, or remove the contaminated sediment that presents a risk. Nor would this alternative reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 1, No Action would be technically and administratively implementable at the CMRP site because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., dams and fences). The implementation of periodic monitoring would not present any unusual issues.

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Cost

The total present worth costs would be very low (<$1 million). There are no capital costs; rather, costs are based solely on periodic monitoring to support five-year reviews.

Screening Result

Alternative 1, No Action is retained for detailed evaluation in accordance with the NCP.

5.1.2 Alternative 2: Limited Action

5.1.2.1 Description of Limited Action

Alternative 2, Limited Action is the same as No Action except this alternative would include ICs to minimize the potential for human exposure, as follows:

- Restrict public consumption of area wildlife (e.g., fish, shellfish, turtles, or eels) and plants
- Restrict public swimming, wading, or water-based fishing
- Restrict contact with contaminated sediment
- Restrict future dredging or excavation
- Maintain signage and public outreach documents (e.g., *Do's and Don'ts for the Woonasquatucket River*)

This alternative would also include ECs to minimize the potential for human exposure to contaminated sediment. ECs could include physical barriers such as perimeter fences to restrict public access to the site and requirements for long-term maintenance of the Allendale and Lyman Mill Dams to ensure that the dams remain structurally sound and stable.

5.1.2.2 Screening of Limited Action

Effectiveness

Alternative 2, Limited Action would not provide effective protection to human health or the environment because contamination that presents a risk would remain on site. While ICs and ECs could be used to minimize human exposure and protect the public, the short- and long-term effectiveness of these measures is uncertain because they can be difficult to monitor and enforce particularly given the nature of this site (river with significant public access, etc.). Moreover, these controls would not protect ecological health because the current exposure pathways to ecological receptors would remain in place.

This alternative may not comply with ARARs for surface water quality. There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. This alternative would not provide long-term protection because no action would be taken to contain or remove the contaminated sediment that presents a risk. There would be no reductions in toxicity, mobility or volume of contamination through treatment under this alternative.

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Implementability

Alternative 2, Limited Action would be technically and administratively implementable at the CMRP site because it would require minimal construction and engineering. Additionally, some of the ICs and ECs required for this alternative are already in place at the CMRP site, including fishing advisory and signage and a perimeter fence at Allendale Pond. Hence, this alternative presents no unusual implementability issues.

Requirements for dam maintenance and restrictions on consumption of area wildlife could present some administrative implementability issues that would have to be addressed. Agreement for access from owners of the dams would be needed. Restrictions on consumption of area wildlife would have to be addressed in a similar manner to those actions currently used to restrict fishing (advisories and signage). These measures would require coordination with State and local governments and possibly affected landowners.

Cost

The cost of this alternative would be very low (<$1 million).

Screening Result

Alternative 2, Limited Action is screened out because it is not considered protective of human and ecological health.

5.1.3 Alternative 3: Monitored Natural Recovery

5.1.3.1 Description of Monitored Natural Recovery

The basic principles of MNR are described in Section 4.2.3. Site-specific, physical processes that would contribute to risk reduction must be well-understood to fully evaluate MNR. The sedimentation rates at the CMRP site have been estimated at 0.5 to 0.8 cm/yr in Allendale Pond and 0.5 to 0.6 cm/yr in Lyman Mill Pond (Section 2.3.8). Several other evaluations would be required to implement MNR in Allendale and Lyman Mill Ponds, as follows:

- Evaluation of frequency and intensity of potential erosion due to storms and floods;
- Evaluation of potential impact of future watershed changes in terms of sediment deposition; and,
- Monitoring the rate of natural recovery in surface sediment concentrations by monitoring the physical conditions at the site and sediment chemistry data.

Monitoring the rate of recovery is an important component of this alternative and one of the key differences between MNR and No Action. More monitoring would be required for this alternative than any other alternative to verify that the surface sediment concentrations are decreasing, and that contaminated sediment is not migrating downstream. For example, sampling and analysis of surface and subsurface sediment could be performed to evaluate the thickness of the sediment deposited over time and to confirm that the contaminated sediments have not migrated away from the site. Biota monitoring, including fish, would also be conducted to determine biota recovery and when the fish might be safe to eat. Cost estimates for this alternative are based on annual monitoring on a 30 year time period and assume that reviews would be conducted every five years. The long-term monitoring would be used to monitor impacts of the remedial action on downstream areas, to determine the extent to which surface

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sediments recover and the cleanup objectives are achieved, and to ensure long-term protection. Periodic reporting would be required to document MNR progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups are warranted.

ICs would be required in association with MNR because contamination above the cleanup goals would remain in the sediment during the recovery period. ICs could include recreational use restrictions and hunting and fishing advisories. Assuming cleanup goals were reached in surface sediment, long-term ICs, such as restrictive easements, would be needed to reduce the risk of exposing buried contamination. The future use restrictions could include, but not be limited to: limitations on the size of boat anchors allowed in the ponds, prohibition against digging in the sediment, restrictions on future excavation and dredging, and restrictions on future access to utilities. Additionally, this alternative assumes that low energy environments in Allendale and Lyman Mill Ponds would not change; therefore, the success of this alternative would also be contingent upon the maintenance of the Allendale and Lyman Mill Dams.

5.1.3.2 Screening of Monitored Natural Recovery

Effectiveness

Alternative 3, Monitored Natural Recovery would not provide effective protection to human health and the environment because site conditions are generally not conducive to MNR. That is, dioxin concentrations are high and widespread, the primary risk drivers (dioxin, PCBs) are known to bioaccumulate, and it may take several decades before surface concentrations are reduced by natural processes to levels not posing a risk to human health and the environment. In addition, ICs would not mitigate any short-term ecological risks. Natural recovery (i.e., burial of contaminated sediment by cleaner sediment) might be sufficient to effectively reduce risk in depositional areas of the ponds. However, a natural recovery trend is not apparent at this time (see Section 2.4.4). Further, based on the relatively low sedimentation rates at Allendale and Lyman Mill Ponds, it might take several decades to accumulate a 10 to 30 cm thick layer of clean sediment. MNR would not be effective at all in non-depositional areas of the ponds or the river channel north of Allendale Pond.

Natural biological degradation would also not be effective for reducing contaminant concentrations in the surface sediments to acceptable levels. Inorganic contaminants do not biodegrade, and while natural degradation of the primary risk drivers (dioxin and PCBs; Section 4.2.3), can theoretically occur, the rate would be very slow at the CMRP site based on the recalcitrant characteristics of these contaminants.

This alternative may not comply with ARARs for surface water quality. There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. However, this alternative would not provide long-term protection because high levels of contamination would continue to present unacceptable risk while MNR occurs, and some areas might never be sufficiently addressed. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 3, Monitored Natural Recovery would be technically and administratively implementable at the CMRP site. This alternative would require no action beyond a detailed baseline site characterization, monitoring, and continued execution and maintenance of the ICs. Requirements for dam maintenance could present some administrative implementability issues. That is, agreement for access from owners of the dams would be needed.

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Cost

The costs associated with MNR would be low (between $1 million and $25 million).

Screening Result

Alternative 3, Monitored Natural Recovery is screened out primarily due to the uncertainty associated with the effectiveness of the alternative and the very long implementation period expected before the cleanup objectives would be achieved, if at all.

5.1.4 Alternative 4: Enhanced Natural Recovery

5.1.4.1 Description of Enhanced Natural Recovery

In the Enhanced Natural Recovery (ENR) alternative, a thin layer of cover material would be placed over contaminated sediment to accelerate natural recovery processes and reduce exposure hazards to the benthic community. The cover would be placed over the entire pond bottoms at Allendale (Figure 3-1) and Lyman Mill (Figure 3-2) Ponds. The cover thickness and composition would be determined during the design phase, but a thickness of 6 inches is assumed for the screening analysis. The material used to create the cover could be chosen based on chemical isolation properties or the ability to provide suitable habitat for benthic organisms.

ENR would provide rapid and relatively inexpensive contaminant cover, and is suitable in low-energy and depositional environments if natural recovery processes are expected to occur over time. A thin-layer cover is not suitable in high-energy environments such as the river channel north of Allendale Pond. The channel would be armored under this alternative to prevent erosion and downstream transport of contaminated sediment during high flow events.

The monitoring and dam maintenance requirements, ICs, and periodic reporting to document remedy progress and efficacy would be the same as described for Alternative 3, Monitored Natural Recovery (Section 5.1.3). Long-term monitoring and maintenance of the thin-layer cover would also be required.

5.1.4.2 Screening of Enhanced Natural Recovery

Effectiveness

Alternative 4, Enhanced Natural Recovery would provide limited protection to human health and the environment. The thin-layer cover placed under this alternative would not be thick enough to provide long-term, reliable chemical isolation of contaminated sediment from the environment. A thin-layer cover is typically only 3 to 6 inches thick as compared to an isolation cap that is 24 inches thick. Natural biological activity and bioturbation would result in mixing of the clean thin-layer cover material with the underlying contaminated sediment, and, as a result, ENR would not isolate all burrowing benthic organisms from contact with contaminated sediment. Moreover, sedimentation rates at the Allendale and Lyman Mill Ponds are very low and it is expected to take decades for effective burial of contaminated sediment by cleaner sediment to reduce risks to human health and the environment.

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance. Short-term impacts to the local community would be minor (e.g., construction related noise) and of short duration. There would be some short-term impacts to the benthic community because sedentary and fragile organisms would be smothered by the cover material and recovery would depend upon recolonization rates. Placement of the thin-layer cover could have short-term impacts to water

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quality; however, the cover would be comprised of clean material and potential impacts would be minor provided appropriate techniques and controls are used. This alternative might not provide long-term, reliable protection because thin-layer covers are not typically armored to protect against erosion. Moreover, there would be uncertainty associated with the long- and short-term stability of the thin-layer cover, especially during floods or other periods of high water flow. Additionally, this alternative would not provide long-term protection in the non-depositional areas of the rivers/ponds because there would not be an adequate deposition of clean material over time. This alternative would not reduce the toxicity, mobility, or volume of contamination through treatment.

Implementability

Alternative 4, Enhanced Natural Recovery would be technically and administratively implementable at the CMRP site. The Allendale and Lyman Mill action areas are accessible from land, and to a lesser degree, from water, for the construction and placement of a thin-layer cover. The thin-layer cover would be constructed using clean sand, clay, silt, or a mixture of these materials, which are all readily obtainable. The implementation of a monitoring program and ICs would not present any unusual issues.

Requirements for dam maintenance, potential impacts from occupancy and modification of floodplain areas, and discharge of dredged and/or fill material to waters of the US could present some administrative implementability issues that would have to be assessed. Thus, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

Cost

Alternative 4, Enhanced Natural Recovery would have low costs (between $1 million and $25 million).

Screening Result

Alternative 4, Enhanced Natural Recovery is screened out based on the uncertainty associated with the long-term effectiveness of this alternative at the CMRP site, the ability to meet cleanup objectives in the long term, and the duration of the implementation period before cleanup objectives would be achieved.

5.1.5 Alternative 5: Isolation Capping

5.1.5.1 Description of Isolation Capping

The isolation capping technology is described in Section 4.2.4. Under this alternative, clean imported material would be placed over the entire pond bottom at Allendale and Lyman Mill Ponds (conceptual remediation footprints for both ponds shown in Figures 5-1 and 5-3; cross-section for Allendale Pond shown in Figure 5-2) to provide chemical isolation and prevent exposure to the contaminated sediment. Neither dredging nor excavation would be performed prior to placing cap material; therefore, the post-cap surface elevation would be higher than the existing sediment surface elevation. The cap would consist of an isolation layer and an erosion control layer; a typical cross-section is illustrated in Figure 5-2.

The screening level costs assume:

- The top 12–inch thick layer of the cap would be designed to provide habitat in areas that remain under water after capping and substrate for wetland vegetation in the marshy areas.

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- The average cap thickness over the entire pond area will be 24 inches, with a minimum thickness of 18 inches at any sub-region within the pond. Sand caps would be placed using a sand spreader barge (see Appendix I for further detail).
- The cap would be installed by placing thin layers (two 6-inch layers followed by a 12-inch layer) through the overlying water to prevent soft, contaminated sediments from being displaced by the heavier cap material.
- A production rate of 500 tons per day would be achievable, and it would take approximately 10 days to cap 1 acre.
- Water quality downstream would be monitored for total suspended solids during implementation.

The cap would be designed to be stable and resist erosion during flood events. The actual cap composition, thickness and placement techniques would be determined during the design phase. The 2 foot cap assumed for costing purposes would require 3,230 cy of cap material per acre (or 4,850 tons of sand/acre).

Placement of cap material without removal of sediment would result in a reduction of the depth of water in the ponds. The reduction in depth would be equal to the cap thickness minus the amount of consolidation settlement of the underlying native sediment. In areas where the water depth is less than net reduction in depth, cap placement would result in conversion of normal pond water area to floodplain soils because the top of the cap would be above the normal water level. The area where the water level is less than 2 ft (estimated cap thickness) is about 1.3 acres in Allendale Pond and 5.8 acres in Lyman Mill Pond for a total of 7.1 acres. This would also result in loss of flood storage capacity.

This alternative includes mitigation for short-term loss of habitat due to placing cap material over the existing sediment. Within the ponds, mitigation would consist of plantings in shallow water (that is less than about 2 ft) to provide improved habitat (e.g., fish refugia, nursery areas, and habitat structures such as submerged logs or woody structures). The vegetation types would be determined during final design. However, there are no areas where mitigation for the loss of 7.1 acres of open water is practical in the area of Allendale or Lyman Mill Ponds.

A quantitative analysis of cap stability against erosion during flood flows was performed for Allendale and Lyman Mill Ponds (Appendix E). This analysis evaluated the potential erosion that would occur with a 2-ft thick cap in place over the existing sediment. The cap stability was evaluated by performing a hydrodynamic analysis using a 100-yr flood flow rate of 2,300 cfs. The preliminary cap design discussed below was not specifically designed to withstand ice scour. Although the slower moving currents in the ponds will tend to reduce the risk to the cap integrity associated with ice scour, this is a concern at the upstream inlets and near the dams where current velocities are higher. The cap placed at these areas would need to be reinforced with cobble and coarse gravel to protect against erosion. The final cap design developed during the remedial design phase could consider ice scour should this alternative be selected.

An isolation cap is not suitable in high-energy environments such as the river channel north of Allendale Pond. Contaminated sediment within the river channel would be dredged to a removal depth of 2 ft (includes 1 foot over-dredge allowance) and backfilled with clean material (e.g., coarse gravel). The dredged sediment would be dewatered, stockpiled, characterized, and transported off site for disposal and/or treatment (Option e), as discussed in the dredging alternative (Section 5.1.6).

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Long-term monitoring, dam maintenance, and ICs would be required to maintain cap integrity and prevent other activities (e.g., excavation) that could expose contaminated sediment under the cap. A monitoring program would evaluate whether cap material has eroded and would measure the chemical concentrations in surface and subsurface sediments. Biota monitoring, including fish, would also be conducted to determine biota recovery and when the fish might be safe to eat. Finally, monitoring downstream of the Lyman Mill Dam would also be performed to monitor the impact of the remedial action on the downstream areas. Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups are warranted.

5.1.5.2 Screening of Isolation Capping

Effectiveness

Alternative 5, Isolation Capping would provide moderately effective protection to human health and the environment because the contamination would be isolated from the environment, thereby preventing exposure to contaminated sediment. The relatively low-energy environments of the Allendale and Lyman Mill Ponds are conducive to isolation capping; however, the potential for erosion at the river channel and northern inlets of the ponds during high flow events does reduce the potential effectiveness of this alternative. In addition, the threat to cap integrity posed by ice scour during winter months at the upstream inlets and near the dams also contributes to the reduced potential effectiveness. Site contamination sources, with the exception of discharge of contaminated groundwater to the Woonasquatucket River near the Brook Village parking lot, have been controlled, thereby minimizing the risk of future cap contamination.

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance. RCRA Subtitle C requirements are relevant but not appropriate for subaqueous closure and, therefore, do not have to be met. Placing the isolation fill would reduce flood storage capacity, create approximately 7 acres of new floodplain and change some habitat types, and result in the permanent occupancy and modification of the floodplain. Potential short-term impacts to the community (e.g., construction related noise) would be limited because the implementation period for this alternative is expected to be relatively short (e.g., on the order of 8 months for Allendale Pond and one year for Lyman Mill Pond). Capping could also have short-term impacts to water quality. However, the cap would be comprised of clean material and potential impacts would be minor provided appropriate techniques and controls are used. There would, however, be significant short-term impacts to ecological receptors because benthic organisms would be buried by the cap and it would likely take two to five years for the benthic macroinvetebrate community to recover. This alternative would provide long-term protection provided the cap is monitored and maintained. This alternative would not reduce the toxicity, mobility, or volume of contamination through treatment, although the mobility of contamination would be reduced by the cap.

Implementability

Alternative 5, Isolation Capping would be technically implementable at the CMRP site. The capping technology has been field proven and the capping materials (e.g., sand or gravel) are readily obtainable. The Allendale and Lyman Mill action areas are generally accessible from land; however, the shallow water might pose some obstacles and require specialized equipment to facilitate cap placement within the ponds. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance and impacts from occupancy and modification of floodplains and discharge of dredged and/or fill material to waters of the US could present some administrative implementability issues that would have to be assessed. Additionally, it is expected that mitigation for

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any open water areas converted to floodplain and replacement of flood storage capacity would be required to comply with the ARARs. This alternative would also require the permanent occupancy and modification of the floodplain, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

Cost

Alternative 5, Isolation Capping would have low costs (between $1 million and $25 million).

Screening Result

Alternative 5, Isolation Capping is screened out because it would only provide moderate long-term protection due to concerns of maintaining cap integrity during high flow events and in the winter from ice scour. In addition, this alternative would result in conversion of about 7.1 acres of open water to floodplain, which would require substantial mitigation to address.

5.1.6 Alternative 6: Dredging and Disposal and/or Treatment

5.1.6.1 Description of Dredging and Disposal and/or Treatment

Under Alternative 6, Dredging and Disposal and/or Treatment, contaminated sediment would be removed from the reaches at Allendale and Lyman Mill using dredging (dredging technologies are described in Section 4.2.5). Dredged material would be mechanically dewatered to reduce the volume of material for disposal and/or treatment. Five separate disposal and/or treatment options, described in detail below, are evaluated as part of this alternative, including options for on-site containment, on-site thermal treatment and off-site disposal and/or treatment.

Screening level costs for Alternative 6 are based on the following assumptions:

- Temporary work areas would have to be cleared and vessel launch ramps would have to be constructed at Allendale and Lyman Mill Ponds.
- Water-based, small, shallow-draft hydraulic dredging equipment would be used for sediment removal.
- The production rate is assumed to be 200 cubic yards per day (cy/d).
- A 1 foot over-dredge allowance is assumed for the volume calculations; because dredging equipment is typically not able to remove material to precise depths, it is necessary to allow for removal below the target depth.
- The dredged material would be mechanically dewatered prior to disposal and/or treatment and water removed from the material would be pumped into a treatment system. The extracted water would be tested on a regular basis to confirm that chemical concentrations are at levels acceptable for return to the surface water in accordance with ARARs.

The estimated dredge surfaces for Allendale and Lyman Mill Ponds are presented in Figures 5-1 and 5-3; the associated cross sections are illustrated in Figures 5-4 and 5-5. These were developed using the available chemistry and geotechnical data for surface and subsurface sediment samples in each pond. The depths and locations of sediment with contaminant concentrations above the cleanup goals in each pond

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were plotted on a grid in AutoCAD and the computer calculated the theoretical removal elevation (i.e., feet above mean sea level) that would be required to remove contaminated sediment. A computer program in AutoCAD was used to interpolate the dredge depth between the various locations. The total volume of sediment requiring removal, including the over-dredge allowance, was calculated to be 73,100 cy for Allendale reach (approximately 70,700 cy in Allendale Pond and 2,400 in the river channel north of Allendale Pond) and 129,000 cy for Lyman Mill Pond. The average dredge depth is 2.0 ft in Allendale Pond, 1 foot in the river channel, and 2.4 ft in Lyman Mill Pond (not including over-dredge allowance). The sediment from Allendale and Lyman Mill Ponds would be processed by mechanical dewatering to reduce the volume. After dewatering, the volume for disposal is estimated to be 127,000 cy (52,400 cy for Allendale Pond, 2,400 cy for the river channel,[35] and 72,000 cy for Lyman Mill Pond).

A surface water collection system would be installed to collect and pump precipitation and water separated from the dredged sediment to a treatment plant. For cost estimations, it is assumed that the water treatment plant would be built on land at the same site where the dredged material was dewatered.

Upon completion of dredging, bathymetric surveys and sediment sampling activities would be conducted to confirm that sediment was removed to the required elevations and to ensure that the post-dredge concentrations met the cleanup requirements. There is the potential for some residual contamination to remain at the sediment surface after dredging. Alternative 6 assumes that a thin-layer cover would be placed over residual contamination rather than conducting continuous dredging; the latter would not be practical considering the limited capacity for on-site disposal and the high cost of off-site disposal and/or treatment.

The monitoring and dam maintenance requirements, ICs, and periodic reporting of remedy progress and efficacy would be similar to that described for the capping alternative (Section 5.1.5), although less monitoring would be required after dredging because the residual concentrations and mass of contamination remaining in the sediment would be significantly reduced by removal. In addition, any disposal facilities constructed on site would require long-term monitoring and maintenance and ICs to protect the integrity of the facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDFs (e.g., limit the size of woody vegetation on top of the CDFs, prevent the construction of buildings with basements or burial of utilities on or in the CDF cap).

The five disposal and/or treatment options include:

Option 6a: On-site Containment in an Upland CDF
Dewatered, contaminated sediment could be contained in a CDF constructed on site and above the 100-year flood elevation. “On site” is defined as the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action (40 CFR §300.5). For purposes of this FS, the proposed locations for the upland CDF would all be considered on site as defined in the NCP. The CDF would be designed in accordance with the procedures given in the Upland Testing Manual (USACE, 2003b). CDF design and construction information are summarized below, and described in detail in Appendix I.

It is assumed that the CDF perimeter dikes would be constructed of sand and gravel and the very soft soils under the dike location would be replaced with compacted sand and gravel. The base of the CDF would consist of a layer of screened sand, a geomembrane liner, and a 12 inch layer of fine sand that would

[35] Sediment from the river channel is expected to be more coarse (e.g., gravel) with higher density compared to pond sediments. Sediment from the river channel would not be dewatered because dewatering is not expected to result in a substantive volume reduction.

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include a leachate collection system. Upon completion of removal activities, a cover system would be placed consisting of (a) a low-permeability soil layer, (b) geomembrane, (c) drain layer, (d) geotextile, and (e) protective soil layer. The top layer could be covered with either topsoil and vegetation or gravel and asphalt, depending on the expected future use.

Figure 5-6 shows three potential locations at Lyman Mill reach where a CDF could be constructed above the 100-year flood elevation; a representative cross section for the northern CDF is shown in Figure 5-7. The northern CDF could be built where the current ground surface slopes up to the northwest of Lyman Mill Pond. A second CDF would be built south of the abandoned channel where the current ground surface slopes up along the western border of the Oxbow. There would be containment dikes on the downhill side, but no dike would be needed on the uphill side of the areas. It is assumed that the dikes could not be higher than 10 ft above the existing ground surface. The combined maximum capacity available at the two CDF locations would be about 136,000 cy, assuming that the existing soil within the footprint of the CDF was removed down to the ground surface elevation at the downhill dike.[36] The combined capacity would be sufficient to contain all of the sediment (after mechanical dewatering), but would not have capacity for floodplain soils from Lyman Mill Reach. A third CDF with sufficient capacity (for sediment and floodplain soil) could be constructed further south, near the head of Lyman Mill Pond and above the 100-year flood elevation (Figure 5-6).

The northern CDF location is vegetated with mature forest trees and is part of one of the largest blocks of wooded riparian forest remaining in the lower Woonasquatucket River watershed (USACE, 2008). The other potential locations identified in Figure 5-6 are in various stages of regeneration (e.g., old field and early successional forest) following more recent disturbance (southern CDF) and which also contain some relatively low-value wetland habitat (CDF south of abandoned channel) (Figure 5-6). Use of these locations would result in some destruction of upland habitat and/or wetlands. As with remediation in the sediment action areas, mitigation for wetland impacts associated with construction of an upland CDF would need to be provided. Even if wetland impacts were avoided during siting of the upland CDF, the various options for placement would be evaluated with respect to their relative ecological functions and values during design. Consistent with the decision process outlined in the dredge material management technical framework document (EPA/USACE, 2004), a preference for siting the upland CDF on the location with the lowest relative functional value would be established providing that engineering requirements and other project objectives could also be met.

Option 6b: On-site Containment in a Nearshore CDF

Another containment option is to construct a nearshore CDF, which would be designed in accordance with the procedures in USACE (2003b). CDF design and construction information are summarized below, and described in detail in Appendix I.

The major differences between Options 6a and 6b are:

- Under Option 6b, the nearshore CDF would be constructed adjacent to an existing shoreline, in an area where the ground surface elevation is presently below the 100-year flood elevation and could be below the normal water level. The cover system would be designed to resist erosion during flood events.
- Under Option 6b, the nearshore CDF would not have a bottom liner or leachate collection system.
- Under Option 6b, the top of a nearshore CDF could be below the 100-year flood elevation and could provide floodplain area, or could be constructed above the 100-year flood elevation. Some destruction of bordering wetlands would occur where the CDF is placed.

[36] Existing soil would be tested and shipped off site for disposal at a certified facility.

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- Under Option 6a, some material may require treatment before it can be placed in the upland CDF or it must be taken off site for treatment prior to disposal. The amount of material requiring treatment could be reduced by obtaining a variance from the applicable treatment standards under the LDRs.

The construction materials used for the dikes and the process for capping the nearshore CDF would be identical to that described for Option 6a.

A nearshore CDF could potentially be constructed on top of the interim cover at Cap Area #1, with an extension into the adjacent floodplain at the northern end of Allendale Pond. Although a jurisdictional boundary delineation has not been conducted, the peninsula south of Cap Area #1 contains vegetated wetlands (Section 2.3.10), including both scrub/shrub and emergent marsh, and use of this area would result in some wetland impacts that would require mitigation. Figures 5-8 and 5-9 show the conceptual site plan and a cross-section for this facility. The maximum capacity would be approximately 60,000 cy, which is not sufficient to contain all of the contaminated sediment (and floodplain soil) under the full removal alternatives. Therefore, Option 6b would need to be used in conjunction with another disposal option.

Option 6c: On-site Containment in an Island CDF
Under Option 6c, contaminated sediment would be contained in an island CDF constructed entirely in the open-water area of one of the ponds. Structurally and conceptually, an island CDF would be similar to a nearshore CDF (Option 6b). The first step would be to construct perimeter dikes to contain the dredged sediment; once in place, surface water would be removed to allow placement and compaction of the dewatered dredged sediment using the same earthwork methods used for CDFs constructed under Options 6a and 6b.

Figure 5-10 shows the potential location for an island CDF at Allendale Pond; a cross-section of the CDF is shown in Figure 5-11. There are two variations of this disposal alternative because the containment facility could be capped in two different ways. A "wetland cap" could be implemented, in which the top of the cover would be designed to reach a lower surface elevation to provide new floodplain area. The second option would be to design the cap to reach a higher surface elevation and create an upland area within the pond (i.e., "island"). Both cover systems would be designed to resist erosion during flood events. The maximum capacity for the Option 6c, constructed with an upland cap, would be about 20,000 cy. This capacity is clearly insufficient to contain all of the dredged sediment.

Option 6d: On-site Thermal Treatment
Under Option 6d, dewatered, dredged material would be treated on site using thermal treatment, i.e., incineration. The thermal treatment technology is described in detail in Section 4.2.9 and Appendix I. The screening level cost estimates assume that:

- Dredged material would be dewatered and stockpiled prior to treatment.
- The three types of solids produced from the dewatering process (debris, sand/gravel, and silt/clay) would require separate treatment.
- Ash would need to be stockpiled and characterized prior to disposal.
- The ash would be transported off site by trucks to a regional rail loading facility for transportation to a designated disposal facility.

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Option 6e: Off-site Disposal and/or Treatment

This option is similar to Option 6d, except that the dewatered, dredged sediment would be shipped off site for disposal, and disposed either by containment in a designated facility or by thermal treatment. The dewatered, dredged material would be analyzed for dioxin and TCLP concentrations to determine the designation of the materials and to determine which type of landfill is required or if the materials need to be treated. Once the appropriate disposal facility is identified, the dewatered material would be loaded onto trucks and taken to a regional rail loading facility for transportation to the designated disposal facility.

5.1.6.2 Screening of Dredging and Disposal and/or Treatment

Effectiveness

Alternative 6, Dredging and Disposal and/or Treatment would provide moderately effective protection to human health and the environment, depending on the disposal and/or treatment option selected. Dredging by itself would provide moderate protection to human health and the environment. Residuals that are often associated with dredging operations could result in a residual risk to human health and the environment that exceeds the cleanup goals. This alternative assumes that a thin-layer cover would be placed over the pond bottom at the completion of dredging operations to prevent exposure to 'residual' sediment contamination. In the river channel north of Allendale Pond, a cover of coarse gravel would be placed over the channel bottom to prevent erosion and downstream transport of contaminated sediment during high flow events. The disposal and/or treatment options proposed are also field proven and effective options. The on-site containment options (Options 6a through 6c) would provide varying degrees of protection through chemical isolation, and would be designed to protect surface water, groundwater and air quality. On-site containment in an upland CDF (Option 6a) would be more effective compared to on-site containment in a nearshore CDF (Option 6b) or on-site containment in an island CDF (Option 6c) because the disposal facility would be located outside of the floodplain; under Options 6b and 6c the contamination would remain in the river/floodplain areas. Options 6d and 6e would provide the most reliable long-term protection because the organic contaminants would be destroyed through treatment (Option 6d) or the contaminated material would be removed from the CMRP site and shipped to a licensed facility for disposal and/or treatment (Option 6e).

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance under all options. Short-term impacts to the local community would be minor (e.g., construction related noise and possible odors) and of short duration. In contrast, short-term impacts to the environment would be significant, primarily because dredging would eliminate existing benthic habitat. Sediment resuspension and potential release of contamination during dredging activities could also impact water quality. Even with environmental dredges, it is impossible to remove sediment without causing some resuspension, which would be carried downriver. Flood storage capacity would be reduced under Options 6b (nearshore CDF) and 6c (island CDF). The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 6d (on-site thermal treatment) and under Options 6a (upland CDF) and 6e (off-site disposal and/or treatment) provided some of the material requires treatment.

Implementability

Dredging would be technically and administratively implementable at the CMRP site. Dredging is a proven technology, and while the equipment required to perform dredging in very shallow water is specialized, it is available from commercial contractors. Temporary roads, staging areas, and access areas are routinely constructed at sites similar to the CMRP site. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance (all options) and

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potential impacts to floodplain and wetland areas for Options 6b and 6c (and possibly wetland impacts for Option 6a) could present some administrative implementability issues that would have to be assessed. Replacement of flood storage capacity would be required under Options 6b (nearshore CDF) and 6c (island CDF).

The disposal and/or treatment options would be technically implementable at the CMRP site. The technologies are field proven and the construction equipment and materials required to implement this alternative are commercially available. All of the disposal and/or treatment options would present some administrative implementability issues that would have to be addressed. For example, there is limited space on site for sediment processing and land would have to be obtained to locate the processing facility. Additional issues specific to each of the options include:

- On-site containment in an upland CDF (Option 6a) – land would have to be obtained to locate the disposal facility and some of the sediment could require treatment to meet LDRs (Section 3.2.1.2). It is possible to reduce the amount of treatment needed by seeking a treatability variance that would require treatment of sediment consistent with the alternative soil treatment standards in 40 CFR §268.49. A treatability variance is appropriate here to encourage removal of the sediment from the floodplain. The upland CDF located south of the abandoned channel in the Oxbow area includes some low value wetland. As a result, if this location is selected as one of the upland CDFs, some destruction of wetlands would occur that would need to be assessed.
- On-site containment in a nearshore CDF (Option 6b) or island CDF (Option 6c) – neither of these options by themselves would have sufficient capacity to contain all the dredged sediment, and would need to be used in conjunction with another option. In addition, both of these options would require the permanent occupancy of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US, and a determination would need to be made that there was no other practicable alternative before selecting one of these options as the preferred remedy.
- On-site thermal treatment (Option 6d) – this option relies on the ability to obtain mobile incineration units capable of sustaining high temperatures needed for the destruction of dioxins and furans. In addition, while these units can be safely operated, local residents might express concern regarding emissions.
- Off-site disposal and/or treatment (Option 6e) – this option relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated sediment from the CMRP site, which is not expected to be a significant problem. In addition, some of the sediment might need to be treated to meet LDRs.

Cost

The estimated total cost for Alternative 6 ranges from high (between $50 million and $75 million) to very high (>$75 million), depending on the disposal and/or treatment option selected. The highest costs are estimated for Option 6d, On-site Thermal Treatment, followed by Option 6e, Off-site Disposal and/or Treatment. Estimated costs for on-site containment (Options 6a and 6b) are approximately half the cost for on-site thermal treatment (Option 6d) or off-site disposal and/or treatment (Option 6e). Estimated costs for On-site Containment in an Upland CDF (Option 6a) could increase depending on the amount of material requiring treatment.

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Screening Result

Alternative 6, Dredging and Disposal or Treatment is screened out because of the short-term water quality impacts, the difficulty in achieving the cleanup goals due to residual contamination, and the slow production rate when working in shallow water. While the disposal and/or treatment options (6a through 6e) are screened out in conjunction with dredging, the same options are also considered with excavation (Section 5.1.7).

5.1.7 Alternative 7: Excavation and Disposal and/or Treatment

5.1.7.1 Description of Excavation and Disposal and/or Treatment

Alternative 7 is similar to the dredging alternative (Alternative 6, Section 5.1.6) in that contaminated sediment with contaminant concentrations above the cleanup goals would be removed. The primary difference between the alternatives is that under the excavation alternative the water elevations would be lowered incrementally in both ponds and the exposed sediment would be removed using typical earthwork equipment. The river flow would be diverted to the eastern portion of the ponds while excavation was done in the western portion and then diverted to the western portion while excavation was done in the eastern portion.

The screening level cost estimates are based on the following assumptions:

- Temporary roadways or work platforms will likely need to be constructed using gravel or mats to provide stable work platforms for the earthmoving equipment.
- Low-ground pressure and long-reach equipment would be required because the surface sediment is very soft and would not have sufficient strength to support wheeled vehicles; in some areas, the low-ground pressure equipment might not even be supported.
- The gate structures in the Lyman Mill Dam would be repaired and gravity would be used to drain the pond.
- The production rate is assumed to be 400 cy/d. The work period is assumed to be approximately 7 months to excavate Allendale Pond (including the river channel) and 12 months to excavate Lyman Mill Pond.
- The excavated sediment would be mechanically dewatered to reduce the volume of material for disposal (except under Option 7b). The water removed from the material would be pumped into a treatment system. The extracted water would be tested on a regular basis to confirm that chemical concentrations are at levels acceptable for return to the surface water in accordance with ARARs. Conventional earthwork equipment would be used to manage the dewatered material.
- Under Option 7b (nearshore CDF), the excavated sediment would be moved directly into the nearshore CDF without dewatering.

The estimated excavation surfaces for Allendale and Lyman Mill Ponds are shown in Figures 5-1 and 5-3; the associated cross sections are illustrated in Figures 5-4 and 5-5 (surfaces and cross sections are the same as those for dredging). Removal using excavation would be more accurate than dredging because contaminated sediment would not be re-suspended by the removal work and less contaminated sediment would be left in place by the excavator than by a dredge. Therefore, only limited excavation below the depth of contamination would be needed. As a result, the volume of sediment excavated in this alternative would be substantially less than removed in the dredging alternative. The total volume of

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sediment requiring removal, including the over-excavation allowance, would be approximately 155,800 cy (2,400 cy in the river channel north of Allendale Pond, 52,900 cy in Allendale Pond, and 100,500 cy in Lyman Mill Pond). The sediment from Allendale Pond and Lyman Mill Pond would be processed by mechanical dewatering to reduce the volume. After dewatering, the volume for disposal is estimated to be 97,700 cy (2,400 cy for the river channel, 39,200 cy for Allendale Pond, and 56,100 cy for Lyman Mill Pond).

Upon completion of excavation, physical surveys and sediment sampling activities would be conducted to confirm that sediment was removed to the required elevations and to ensure that the post-excavation concentrations met the cleanup goals. This alternative includes a thin-layer cover as a contingency provided confirmation sampling reveals areas of deeper contamination or areas where the residual concentrations are above the cleanup goals. A thin-layer cover would be placed in order to reduce residual contaminant concentrations throughout the ponds to acceptable levels so that the RAOs could be achieved. Cost estimates assume the thin-layer cover will be required.

The monitoring and dam maintenance requirements, ICs, periodic reporting of remedy progress and efficacy, and disposal and/or treatment options are the same as described for the dredging alternative (Section 5.1.6). The disposal options are the same as described for the dredging alternative, except that Option 7b includes more sites for construction of a nearshore CDF as described below.

- *Option 7a: On-site Containment in an Upland CDF*
- *Option 7b: On-site Containment in a Nearshore CDF*
- *Option 7c: On-site Containment in an Island CDF*
- *Option 7d: On-site Thermal Treatment*
- *Option 7e: Off-site Disposal and/or Treatment*

Option 7b: On-site Containment in a Nearshore CDF
This disposal option is the same as described for Alternative 6, Option 6b (Section 5.1.6), except that more sites, in addition to the potential location at Cap Area #1, are considered for the nearshore CDFs. With the normal water elevation lowered, the newly exposed areas outside of the stream channel could be utilized for nearshore CDFs. Figure 5-12 shows potential locations where nearshore CDFs could be constructed within the Allendale Pond and Lyman Mill Pond footprints. Under this disposal option, excavation would not be required within the footprint of the nearshore CDFs, thereby reducing the total volume of sediment requiring removal to approximately 123,500 cy (2,400 cy for river channel north of Allendale Pond, 44,300 cy for Allendale Pond, and 76,800 cy for Lyman Mill Pond; volumes include over-excavation allowance). (Approximately 32,300 cy of contaminated sediment within the CDF footprints would remain in place.) Excavated sediment consolidated into the CDFs located within the pond footprint would not be dewatered. The CDFs would use the present day shoreline as part of the containment structure, with dikes constructed out from the newly formed shoreline to complete the enclosures (representative cross sections for the Allendale and Lyman Mill Ponds are shown in Figure 5-13a and 5-13b, respectively). Thus, new uplands might be created in these areas and new wetlands might be created in the other areas of the ponds outside of the areas occupied by the channel and pond/backwater areas.

The nearshore CDF located at Allendale Pond would encompass approximately 4 acres and the two nearshore CDFs at Lyman Mill Pond would encompass approximately 7 acres (Figure 5-12). The combined capacity of the nearshore CDFs would be approximately 125,000 cy, which is sufficient to contain all of the excavated sediment. The final design height could be increased approximately 1.5 feet to increase capacity to also contain floodplain soil removed from other action areas. Once all of the excavated sediment is consolidated into the CDFs, an appropriate cover system designed to resist erosion

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during flood events would be placed. The nearshore CDFs could be finished to grade to allow beneficial re-use or development of the created uplands after completion. The surface of each pond area would be restored to enhance the wetland environment and to provide for the long-term effectiveness of the alternative.

5.1.7.2 Screening of Excavation and Disposal and/or Treatment

Effectiveness

Alternative 7, Excavation and Disposal and/or Treatment would provide highly effective protection to human health and the environment. Excavation is a highly effective, field-proven option that allows for targeted, precise removal of contaminated sediment, thereby minimizing the risk of residual contamination and maximizing the long-term effectiveness. The disposal and/or treatment options are also field proven and effective options as described for the dredging alternative (Section 5.1.6.2).

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance under all options. Potential short-term impacts to the community would be minor, whereas impacts to the environment would be more significant, primarily because excavation would eliminate existing benthic habitat in the river/ponds. This alternative could also have short-term impacts on water quality, although this would be reduced to the maximum extent possible using excavation. Flood storage capacity would be reduced under Options 7b (nearshore CDF) and 7c (island CDF). The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 7d (on-site thermal treatment) and under Options 7a (upland CDF) and 7e (off-site disposal and/or treatment) provided some of the sediment requires treatment.

Implementability

Excavation would be technically and administratively implementable at the CMRP site. The earth moving equipment and low ground-pressure equipment required for the removal effort are readily available from commercial vendors, as is the pumping equipment required to lower the water level of Lyman Mill Dam. The repairs required to the gate structure at Lyman Mill Dam would be standard civil engineering construction and should not pose an obstacle for this alternative. Temporary roads, staging areas, and access areas are routinely constructed at sites similar to the CMRP site. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance (all options) and potential impacts to floodplain and wetland areas for Options 7b and 7c (and possibly wetland impacts for Option 7a) could present some administrative implementability issues that would have to be assessed. Replacement of flood storage capacity would be required under Options 7b (nearshore CDF) and 7c (island CDF).

All of the disposal and/or treatment options would have some administrative implementability issues that would need to be addressed. Under Option 7a (upland CDF), land would have to be obtained for the disposal facility, some wetlands could be destroyed depending on the CDF location (Section 5.1.6.2), and some of the sediment could require treatment to meet LDRs. The amount of required treatment could be reduced by obtaining a variance from the treatability standards. Under Option 7b (nearshore CDF), the CDF could be constructed within the pond footprints and would have sufficient capacity to contain all of the excavated sediment. The nearshore CDFs could also have sufficient capacity to contain all of the floodplain soil removed under the full removal alternatives for Allendale and Lyman Mill (Sections 5.2 and 5.3) provided the design height of the CDF was increased approximately 1.5 feet. However, on-site containment in a nearshore CDF (Option 7b) or island CDF (Option 7c) would require the permanent occupancy of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US, and a determination would need to be made that there was no other practical alternative

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before selecting this option as the preferred remedy. Option 7d (on-site thermal treatment) would require mobile incineration units, and while these units can be safely operated, local residents might express concern regarding emissions. Option 7e (off-site disposal and/or treatment) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated sediment from the CMRP site, which is not expected to be a significant problem. In addition, some of the sediment might need to be treated to meet LDRs.

Cost

The estimated total cost for Alternative 7 ranges from moderate (between $25 million and $50 million) to very high (>$75 million), depending on the disposal and/or treatment option selected. The highest costs are estimated for Option 7d, On-site Thermal Treatment, followed by Option 7e, Off-site Disposal and/or Treatment. Estimated costs for on-site containment (Options 7a through 7c) are approximately half the cost for on-site thermal treatment or off-site disposal and/or treatment (Options 7d or 7e). Estimated costs for On-site Containment in an Upland CDF (Option 7a) could increase depending on the amount of material requiring treatment.

Screening Result

Alternative 7, Excavation is retained because this alternative would be highly effective and implementable at the CMRP site. All of the disposal and/or treatment options are retained except Option c (Island CDF), which is screened out due to insufficient capacity. For Option b (Nearshore CDF), CDFs located within the existing pond footprints are retained but the CDF at Cap Area #1 is screened out due to insufficient capacity.

5.1.8 Alternative 8: Partial Excavation, Isolation Capping and Disposal and/or Treatment

5.1.8.1 Description of Partial Excavation, Isolation Capping and Disposal and/or Treatment

This alternative is a combination of Alternative 5, Isolation Capping (Section 5.1.5) and Alternative 7, Excavation and Disposal and/or Treatment (Section 5.1.7). The general descriptions were presented in the previous sections. One of the key differences between the excavation and partial excavation alternatives is that the design objectives for partial excavation are different.

Under the partial excavation alternative, it is not necessary to excavate to the full depth of contamination because an isolation cap (designed to resist erosion during flood events) will be placed over the entire pond bottoms, thereby covering any remaining contamination present at levels above the cleanup goals.

In this alternative, excavation would be conducted in:

- Areas where the current water depth is less than about 2 feet, so that the final elevation of the top of the cap will be below the normal pond levels,
- Areas of high erosion potential, to reduce risk of cap erosion, or
- Areas of highest contaminants concentrations in the sediment.

The monitoring and dam maintenance requirements, ICs, and periodic reporting of remedy progress and efficacy are the same as described for the capping alternative (Section 5.1.5). Disposal and treatment options are the same as described for the excavation alternative (Section 5.1.7), except that on-site containment in an island CDF (Option c) is not considered due to insufficient capacity.

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- *Option 8a: On-site Containment in an Upland CDF*
- *Option 8b: On-site Containment in a Nearshore CDF*
- *Option 8d: On-site Thermal Treatment*
- *Option 8e: Off-site Disposal and/or Treatment*

For Options 8a, 8d and 8e, the purposes of excavation would be to lower the surface where the water depth is less than 2 feet and to lower the surface in areas of highest erosion. These areas are illustrated in Figures 5-14 (Allendale) and 5-15 (Lyman Mill) and the associated cross-sections are presented in Figures 5-16 and 5-17. The total estimated removal volume, including the over-excavation allowance, is 64,400 cy (2,400 cy for river channel north of Allendale Pond, 23,000 cy for Allendale Pond, and 39,000 for Lyman Mill Pond). The sediment from Allendale Pond and Lyman Mill Pond would be processed by mechanical dewatering to reduce the volume. After dewatering, the volume for disposal is estimated to be 41,200 cy (2,400 for river channel north of Allendale Pond, 17,000 cy for Allendale Pond, and 21,800 cy for Lyman Mill Pond).

For Option 8b, the primary purpose of excavation would be to remove sediments with the highest contaminant concentrations (excavation areas are shown in Figures 5-18; cross sections for both ponds are shown in Figure 5-19a [Allendale Pond] and 5-19b [Lyman Mill Pond]). The total estimated removal volume is 56,500 cy (2,400 cy for river channel north of Allendale Pond, 23,060 cy for Allendale Pond, and 31,060 cy for Lyman Mill Pond; volumes include over-excavation allowance). A nearshore CDF would be constructed on the west bank of Lyman Mill Pond (Figure 5-18). The CDF would be about 5 acres in size and would be constructed so that the top of the final cover would be above the 100-year flood elevation.

5.1.8.2 Screening of Partial Excavation, Isolation Capping and Disposal and/or Treatment

Effectiveness

Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment would provide moderate protection to human health and the environment. Targeted excavation would be highly effective at removing sediment from areas with higher erosion potential, would maintain flood flow capacity and improve the long-term reliability of the caps. Isolation capping would be moderately effective because any remaining contamination on site would be chemically isolated from the environment to prevent exposure. Contamination above the cleanup goals, however, would remain in the river/ponds and this alternative is dependent upon long-term monitoring and O&M of the isolation cap to protect human health and the environment in the long term. In addition, the potential for erosion at the river channel and northern inlets of the ponds during high flow events does reduce the potential effectiveness of this alternative. The disposal and/or treatment options are field proven and effective options as described for the dredging alternative (Section 5.1.6.2).

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance under all options. RCRA Subtitle C capping requirements are relevant but not appropriate for subaqueous closure and, therefore, do not have to be met. Potential short-term impacts to the community (e.g., construction related noise) would be minor and of short duration. In contrast, short-term impacts to the environment would be significant, primarily because of the elimination of existing benthic habitat. Potential short-term impacts to downstream water quality would be reduced using excavation. This alternative would provide some long-term protection provided the cap was monitored and maintained. Flood storage capacity would be reduced under Option 8b (nearshore CDF). This alternative would reduce the toxicity, mobility, or volume of contamination through treatment under Option 8d (on-site

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thermal treatment) and under Options 8a (upland CDF) and 8e (off-site disposal and/or treatment) provided some of the material requires treatment.

Implementability

Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment would be technically and administratively implementable at the CMRP site. The excavation and capping technologies are field proven and the required construction equipment and materials are readily available. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance and potential impacts to wetland and floodplain areas could present some administrative implementability issues that would have to be assessed for all options.

The disposal and/or treatment options would also be technically and administratively implementable as described for the excavation alternative (Section 5.1.7.2). The technologies are field proven and the construction equipment and materials required to implement this alternative are commercially available. All of the disposal and/or treatment options would have some administrative implementability issues that would need to be addressed. Under Option 8a (upland CDF), land would have to be obtained for the disposal facility, some wetlands could be destroyed depending on the CDF location (Section 5.1.6.2), and some of the sediment could require treatment to meet LDRs (Section 3.2.1.2). The amount of required treatment could be reduced by obtaining a variance from the treatability standards. Option 8b (nearshore CDF) would require the permanent occupancy of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Replacement of flood storage capacity would also be required under Option 8b. Option 8d (on-site thermal treatment) would require mobile incineration units, and while these units can be safely operated, local residents might express concern regarding emissions. Finally, Option 8e (off-site disposal and/or treatment) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated sediment from the CMRP site, which is not expected to be a significant problem. In addition, some of the sediment might need to be treated to meet LDRs.

Cost

The estimated total cost for Alternative 8 ranges from moderate (between $25 million and $50 million) to high (between $50 million and $75 million), depending on the disposal and/or treatment option selected. The highest costs are estimated for Option 8d, On-site Thermal Treatment and Option 8e, Off-site Disposal and/or Treatment. Estimated costs for on-site containment (Options 8a and 8b) are approximately half the cost for on-site thermal treatment or off-site disposal and/or treatment (Options 8d and 8e). Estimated costs for On-site Containment in an Upland CDF (Option 8a) could increase depending on the amount of material requiring treatment.

Screening Result

Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment is carried forward to the detailed analysis. All of the disposal and/or treatment options are also retained.

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5.1.9 Alternative 9: Dam Removal and Isolation Capping

5.1.9.1 Description of Dam Removal and Isolation Capping

Under this alternative, the Allendale and Lyman Mill Dams would be permanently removed and an isolation cap would be placed over the entire river/pond bottoms (Figures 3-1 and 3-2). Sediment upstream of the dams would be removed to create a transition slope from the river bed elevation downstream of the dams and the new river bed upstream of the dams. The initial sand layers would be placed using hydraulic equipment, as described for Alternative 5 (Section 5.1.5). Surface water diversion and pond dewatering would be implemented to enable removal of the dams and placement of the isolation cap. Temporary roadways and equipment support facilities would be constructed so that low-ground pressure equipment could be used to transport and place cap materials within the area of the existing river/ponds.

Without the dams in place, the flow velocity of the river would be higher in the new channels than under current conditions and the river channel would become incised without armor rock to reduce erosion. A multi-layer cap made from the following layers (from bottom to top) would be placed over the river/pond bottoms to isolate the contaminated sediment and protect against erosion:

- Sand over existing contaminated sediment,
- Gravel layer over the sand, and
- Armor rock protection layer over the gravel.

The total thickness of the cap would vary over different areas of the river/ponds. For alternative screening, it is anticipated that the total thickness would be on the order of 4 to 6 ft. The post-cap surface elevation would be higher than the existing sediment surface because neither dredging nor excavation would be performed prior to placing cap material.

The monitoring requirements, ICs, and periodic reporting of remedy progress and efficacy are the same as described for the capping alternative (Section 5.1.5), except that maintenance of the dams would not be applicable under this alternative.

5.1.9.2 Screening of Dam Removal and Isolation Capping

Effectiveness

Alternative 9, Dam Removal and Isolation Capping would not provide adequate protection to human health and the environment. This alternative would not include any excavation or engineering of a stream channel that could improve the long-term reliability of the cap and protect against erosion and potential exposure of contamination that remains in place. Furthermore, with the dams removed the area that would become the active river channel would not be a stable or suitable area in which to place an isolation cap. While the cap would be constructed of large rock for stability, the flow velocity of the river would be much higher with the dams removed and the fast-flowing water might scour sediment below the armor rock resulting in potential exposure and migration of contaminated sediment that remained in place. It is unlikely that the river would erode the large armor rock themselves, but there could be localized areas in the new river channel where there would be higher flow velocities, which could scour finer grained sediment particles between the armor rocks.

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance. RCRA Subtitle C capping requirements are relevant but not appropriate for subaqueous closure and, therefore, do not have to be met. Dam removal and capping would also have significant

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short-term impacts to the environment, primarily because lowering of the surface water elevation and capping would eliminate the existing benthic macroinvetebrate community. Long-term protection is uncertain because contaminated sediment would remain under the cap and contaminant migration would be a continuing concern. This alternative would not reduce the toxicity, mobility, or volume of contamination through treatment.

Implementability

The technologies, construction equipment, and material required for dam removal and capping are readily available. However, isolation capping would not be implementable within the boundaries of the current ponds if the dams were removed because the necessary thickness of the cap (4 to 6 ft) would result in post-cap elevations several feet higher than existing conditions, which would significantly impact the flow of the Woonasquatucket River. It might also result in higher surface water elevations upriver from the site. The water upriver would be higher than under the existing conditions in order to develop the energy necessary for water flow over the new cap. This would apply to both normal river flow and flows during rainstorms. The impact would be the most detrimental during periods of flood flows and would likely result in unacceptable impacts (e.g., flooding) to the property owners along the river.

If this alternative was implemented, it is expected that the river would be forced to flow in a channel without adjacent pond areas. This would dramatically change the nature of the environment. Moreover, this alternative would require the permanent occupancy and modification of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US. Thus, a determination that there was no other practicable alternative would need to be made before selecting this option as the preferred remedy.

Cost

The estimated costs for this alternative would be low (between $1 million and $25 million).

Screening Result

Alternative 9, Dam Removal and Isolation Capping is screened out because it is not implementable and has low effectiveness.

5.1.10 Alternative 10: Dam Replacement, Excavation and Disposal and/or Treatment

5.1.10.1 Description of Dam Replacement, Excavation and Disposal and/or Treatment

This alternative is the same as Alternative 7, Excavation and Disposal and/or Treatment (Section 5.1.7), except that the Allendale and Lyman Mill Dams would be replaced with new weir structures and the size of the water body would be reduced depending on the disposal option used. The new weir structures would be lower than the existing dams and would be sloped on both the upstream and downstream sides to provide free flow of river water without any vertical drops. The general descriptions are consistent with Alternative 7 (Section 5.1.7), as are most of the site-specific details except that hydrodynamic modeling was performed to evaluate the effects of replacing the dams with weir structures on water flow and flooding potential (discussed in Section 6.0). Under this alternative, the weir structures would be designed to:

- maximize the size of the open water area to allow fish (including catadromous and anadromous species) to migrate upriver,

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- allow water to flow freely between the ponds at all times, and
- change the vertical profile of the river channel to provide ponded water surfaces at the locations of the existing ponds.

Prior to dam replacement, water diversion measures would be implemented to enable the excavation of sediments. The removal area and depth of excavation are assumed to be the same as for Alternative 7, except that under Option 10b (nearshore CDF) excavation would not be required within the footprint of the nearshore CDFs (Figure 5-20). This would reduce the in-place removal volumes for Option 10b to approximately 111,800 cy (2,400 cy for river channel north of Allendale Pond, 35,400 cy for Allendale Pond, and 74,000 cy for Lyman Mill Pond; volumes include over-excavation allowance).[37] This alternative includes a thin-layer cover as a contingency provided confirmation sampling reveals areas of deeper contamination or areas where the residual concentrations are above the cleanup goals. A thin-layer cover would be placed in order to reduce residual contaminant concentrations throughout the ponds to acceptable levels so that the RAOs could be achieved. Following excavation, sediment would be mechanically dewatered under all disposal options except Option 10b (nearshore CDF).

The spatial extent of the final water body would be reduced under all options because replacing the dams with smaller weir structures will lower the normal water elevation thereby converting open water to floodplain/wetland. The final water body would be further reduced (approximately 50% smaller compared to current conditions) under Option 10b (nearshore CDF) because the CDFs would be constructed within the pond footprints thereby converting open water to upland. Under Option 10b, the final water body would be comprised of the river channel and pond/backwater areas along the eastern shoreline of both ponds (Figure 5-20). The nearshore CDFs would be designed to be stable during a 100-year flood.

The monitoring requirements, ICs, and periodic reporting of remedy progress and efficacy are the same as described for the dredging alternative (Section 5.1.6). The new weirs would also need to be maintained in the long term. Disposal and treatment options are also the same as described for the dredging alternative (Section 5.1.6), except that containment in an Island CDF (Option c) was not considered due to insufficient capacity and with the dams removed there are more sites available for the nearshore CDFs (Option 10b). The four disposal and/or treatment options include:

- *Option 10a: On-site Containment in an Upland CDF*
- *Option 10b: On-site Containment in a Nearshore CDF*
- *Option 10d: On-site Thermal Treatment*
- *Option 10e: Off-site Disposal and/or Treatment*

Option 10b: On-site Containment in a Nearshore CDF
This disposal option is the same as described for Alternative 7, Option 7b (Section 5.1.7). With the dams removed and the normal water elevation lowered, the newly exposed areas outside of the new stream channel could be utilized for nearshore CDFs. Figure 5-20 shows potential locations where nearshore CDFs could be constructed within the Allendale and Lyman Mill Pond footprints. Within the Allendale Pond footprint, a CDF could be constructed along the western shoreline. Within the Lyman Mill Pond footprint, two CDFs could be constructed at the southern extent of the pond. These CDFs would use the present day shoreline as part of the containment structure with dikes constructed out from the newly

[37] Under the nearshore CDF option, only sediment outside the CDF footprint is excavated. The CDF footprint is slightly larger under Alternative 10b (Figure 5-20) compared to Alternative 7b (Figure 5-12) because excavation around the dams is required. As a result, the volume of sediment excavated outside the CDF footprint is slightly less under Alternative 10b (i.e., 111,800 cy) compared to Alternative 7b (123,500 cy).

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formed shoreline to complete the enclosures (representative cross sections for CDFs at both ponds are shown in Figures 5-21a and 5-21b). Thus, new uplands might be created in these areas and new wetlands might be created in the other areas of the ponds outside of the areas occupied by the channel and pond/backwater areas.

The nearshore CDFs located at Allendale and Lyman Mill Ponds (Figure 5-20) would encompass approximately 13 acres. Once all of the excavated sediment is consolidated in the CDFs, an appropriate cover system would be placed. The nearshore CDFs could be finished to grade to allow beneficial reuse. The surface of each pond area would be restored to enhance the wetland environment and to provide for the long-term effectiveness of the alternative.

5.1.10.2 Screening of Dam Replacement, Excavation and Disposal and/or Treatment

Effectiveness

Alternative 10, Dam Replacement, Excavation and Disposal and/or Treatment would provide highly effective protection to human health and the environment because as described for Alternative 7 (Section 5.1.7), the contaminated sediment would be removed and either confined on site in engineered CDFs, destroyed using treatment, or transported off site for disposal and/or treatment. Long-term effectiveness varies depending upon the disposal and/or treatment option selected. The on-site containment options (Options 10a and 10b) would provide varying degrees of protection through chemical isolation, and would be designed to protect surface water, groundwater and air quality. Option 10a (upland CDF) would be more effective compared to Option 10b (nearshore CDF) because the disposal facility would be located outside of the floodplain, whereas under Option 10b the contamination would remain in the river/floodplain areas. Options 10d and 10e would provide the most reliable long-term protection because the organic contaminants would be destroyed through treatment (Option 10d) or the contaminated material would be removed from the CMRP site and shipped to a licensed facility for disposal and/or treatment (Option 10e).

Floodplain/wetlands and Clean Water Act Section 404 requirements would have to be evaluated for compliance under all options. There would be significant short-term impacts because lowering of the surface water elevation and excavation would eliminate existing benthic habitat. Flood storage capacity would be reduced under Option 10b (nearshore CDF). The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 10d (on-site thermal treatment) and under Options 10a (upland CDF) and 10e (off-site disposal and/or treatment) provided some material required treatment.

Implementability

Alternative 10, Dam Replacement, Excavation and Disposal and/or Treatment would be technically implementable at the CMRP site. The technologies, construction equipment and materials required to implement this alternative are readily available as described for the excavation alternative with the dams in place (Section 5.1.7.2). Replacement of the Allendale and Lyman Mill Dams with weir structures would not affect the overall technical implementability of Alternative 10 because it involves standard construction equipment and civil engineering considerations. Dam replacement, however, will result in destruction of some wetlands and could present some administrative implementability issues that would have to be assessed. Moreover, local residents that live along the river might express concerns regarding replacing the dams, especially if this resulted in a reduction of open water area.

The disposal and/or treatment options would also be technically and administratively implementable at the CMRP site, although each of the options would present some administrative implementability issues

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that would need to be addressed as described for the excavation alternative with the dams in place (Section 5.1.7.2). Briefly, on-site containment in an upland CDF (Option 10a) would require that land be obtained for the disposal facility, some of the sediment could require treatment to meet LDRs (a treatability variance could be obtained to reduce the level of treatment needed), and some wetlands could be destroyed depending on the location of the CDF (Section 5.1.6.2). On-site containment in a nearshore CDF (Option 10b) would provide CDFs with sufficient capacity, but this option would require the permanent occupancy of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Replacement of flood storage capacity would also be required under Option 10b. On-site thermal treatment (Option 10d) would require mobile incineration units, and while these units can be safely operated, local residents might express concern regarding emissions. Finally, off-site disposal and/or treatment (Option 10e) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated sediment from the CMRP site, which is not expected to be a significant problem. In addition, some of the sediment might need to be treated to meet LDRs.

Cost

The estimated total cost for Alternative 10 ranges from moderate (between $25 million and $50 million) to very high (>$75 million), depending on the disposal and/or treatment option selected. The lowest costs are estimated for Option 10b, On-site Containment in a Nearshore CDF. The highest costs are estimated for Option 10d, On-site Thermal Treatment, followed by Option 10e, Off-site Disposal and/or Treatment. Estimated costs for Option 10a, On-site Containment in an Upland CDF could increase depending on the amount of material requiring treatment.

Screening Result

Alternative 10, Dam Replacement, Excavation and Disposal and/or Treatment is carried forward to the detailed analysis because this alternative would be highly effective and is expected to be implementable at the CMRP site. All of the disposal and/or treatment options are also retained.

5.1.11 Alternative 11: Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

5.1.11.1 Description of Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

This alternative is a combination of the Alternative 5 Isolation Capping (Section 5.1.5) and Alternative 10 Dam Replacement, Excavation and Disposal and/or Treatment (Section 5.1.10). The general descriptions in the previous sections, as well as most of the site-specific details are also pertinent to this alternative except that the final water body under Alternative 11 includes two potential configurations. The first configuration includes an engineered channel without a new weir structure (Figure 5-22 shows a site plan with associated cross sections illustrated in Figures 5-23a and 5-23b) and the second configuration includes an engineered channel with open water areas along the eastern shoreline upstream of new weir structures (Figure 5-24 shows a site plan with associated cross sections illustrated in Figures 5-25a and 5-25b). The key differences between the excavation (Alternative 10) and partial excavation (Alternative 11) alternatives are that the design objectives for partial excavation are different. In Alternative 11, the primary objectives of excavation are to:

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- Excavate contaminated sediment from areas within the existing footprint of the ponds that will be under water during average flow conditions[38] such that a specific river channel/pond configuration is achieved while minimizing the amount of sediment to be excavated for disposal and/or treatment.
- Maximize the open water area of the river channel/pond configuration that would result from the replacement of the dams with weirs by relocating clean sediment to shape the areas of the ponds. Following the removal of the contaminated sediment, underlying clean sediment would be relocated and placed over contaminated sediment that remains in place.
- Areas of contaminated sediment that remains in place would be covered with cap materials that are equivalent to those to be provided for the on-site CDF option.
- Construct the isolation caps to be resistant to high energy flows and potential erosion during flood events.

Because a cap would cover any contaminated sediment remaining in place, it would not be necessary to excavate sediment from the entire footprint of the ponds. The spatial extent of the excavation area is shown in Figures 5-22 (channel only configuration) and 5-24 (channel plus ponds configuration) for Allendale and Lyman Mill Ponds. Representative cross sections for the channel only configuration are shown in Figures 5-23a (Allendale Pond) and 5-23b (Lyman Mill Pond). Representative cross sections for the channel plus ponds configuration are shown in Figures 5-25a (Allendale Pond) and 5-25b (Lyman Mill Pond). Focused excavation to achieve a final water body comprised of the river channel only (Figure 5-22) would result in an estimated sediment removal volume for both ponds of approximately 33,600 cy (2,400 cy from river channel north of Allendale Pond, 14,300 cy from Allendale Pond, and 16,900 cy from Lyman Mill Pond). Focused excavation to achieve a final water body comprised of the river channel and ponds (Figure 5-24) would result in an estimated sediment removal volume for both ponds of approximately 59,800 cy (2,400 cy from river channel north of Allendale Pond, 20,700 cy from Allendale Pond, and 36,700 cy from Lyman Mill Pond). Once the contaminated sediment is removed, the underlying clean sediment would be relocated to shape the surface water body to maximize the size of the ponds. The clean sediment would be relocated over areas where contaminated sediment remains in place, and an appropriate cover system (comparable to that used for the upland CDF [Figure 5-7]) designed to resist erosion during flood events would be placed.

The new stream channel in both ponds would consist of engineered structures along the entire length of the channel to prevent erosion during high flow and migration of the Woonasquatucket River into the floodplain, which would still contain some contaminated material. The area of the channel and pond/backwater areas would be designed to be stable during a 100-year flood, and would be backfilled or armored, as necessary.

Excavation operations would generally be the same as previously described for Alternative 7 (Section 5.1.7), except that there would be additional construction measures to replace the dams. Capping operations would generally be the same as previously described for Alternative 5 (Section 5.1.5), except that the quantitative analysis of the capping alternative included an evaluation of the effects of replacing the dams with weir structures on water flow and flooding potential (discussed in Section 6.0). Monitoring and ICs would generally be the same as previously described for Alternative 5 (Section 5.1.5). The new weirs would also need to be maintained in the long term.

[38] Based on current conditions.

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There are five disposal options for Alternative 11, four of which are the same as described for Alternative 7 (Section 5.1.7), as well as a fifth option (Option 11f) unique to this alternative, as follows:

- *Option 11a: On-site Containment in an Upland CDF*
- *Option 11b: On-site Containment in an Nearshore CDF*
- *Option 11d: On-site Thermal Treatment*
- *Option 11e: Off-site Disposal and/or Treatment*
- *Option 11f: On-site Consolidation*

Option 11f: On-site Consolidation
Under Option 11f, the material removed from the new river channel and pond areas would be consolidated on top of contaminated sediment in what would become the new floodplain. Once all of the excavated sediment is consolidated, and an appropriate cover system (comparable to that used for the upland CDF [Figure 5-7] designed to resist erosion during flood events would be placed. The surface of the former pond bottom in each area would be restored to enhance the wetland environment and to provide for the long-term effectiveness of the alternative.

5.1.11.2 Screening of Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

Effectiveness

Alternative 11, Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment would provide moderate protection to human health and the environment because contamination would be removed, confined, destroyed or shipped off site. Under this alternative, the contaminated sediment within the stream channel and new pond areas would be removed, and as a result, the risk of downstream transport of contaminated material is minimized. While the new stream channel would be engineered for stability (resist erosion and prevent meandering) under a range of flood flows, it might not be conducive to habitat restoration. All of the disposal and/or treatment options would provide effective protection as described for Alternative 10 (Section 5.1.10.2), although on-site consolidation (Option 11f) would be less effective compared to the other options considered under this alternative (Options 11a, b, d, and e) because there is some potential for cap erosion during flooding and severe events, especially in areas where the cap would be below the 100-year flood elevation. Options 11a, 11d and 11e would provide greater protection than Options 11b and 11f because contamination would be relocated out of the floodplain.

Floodplain/wetland and Clean Water Act Section 404 requirements would have to be evaluated for compliance under all options. The short-term impacts to the community would include construction related noise and possible odors. There would be significant short-term impacts to ecological receptors because excavation and capping would eliminate existing benthic habitat. Potential short-term impacts to downstream water quality would be reduced because the majority of the excavation would be performed in the dry areas or in areas that were separated by dikes or sheet pile from the active channel. The long-term impacts of this alternative would include the reduction in open water area and an increase in the spatial extent of floodplain and/or wetland habitat. Monitoring and ICs would be required to verify the long-term effectiveness of the on-site containment options (Options 11a, b, and f) because contamination that presents a risk would remain on site. The toxicity, mobility or volume of contamination would be reduced through treatment under Option 11d (on-site thermal treatment) and under Options 11a (upland CDF) and 11e (off-site disposal and/or treatment) provided some material requires treatment.

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Implementability

Alternative 11, Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment would be technically implementable at the CMRP site. The technologies, construction equipment and materials required to implement this alternative are readily available as described for the dam replacement (Alternative 10, Section 5.1.10.2), excavation (Alternative 7, Section 5.1.7.2) and capping (Alternative 5, Section 5.1.5.2) alternatives. Key features of this alternative, however, could present some administrative implementability issues that would have to be addressed. Local residents that live along the river might express concerns regarding replacing the dams, especially because this would result in a reduction of open water area. In addition, all of the options would result in the destruction of some bordering wetlands and would require the permanent occupancy and modification of the floodplain. Hence, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

Cost

The estimated total cost for Alternative 11 ranges from moderate (between $25 million and $50 million) to high (between $50 million and $75 million), depending on the disposal and/or treatment option selected. The highest costs are estimated for Option 11d, On-site Thermal Treatment and Option 11e, Off-site Disposal and/or Treatment. The lowest costs are estimated for Option 11f, On-site Consolidation. Estimated costs for On-site Containment in an Upland CDF (Option 11a) could increase depending on the amount of material requiring treatment.

Screening Result

Alternative 11, Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment is carried forward to the detailed analysis because this alternative would be effective and potentially could be implementable at the CMRP site although significant wetlands/404 and floodplain issues would have to be addressed. The channel only configuration (Figure 5-22), however, is screened out because it is expected that there would be considerable public opposition due to the substantive reduction in the water area. The final water body configuration would be determined during the remedial design provided Alternative 11 is selected as the final remedy.

5.2 Allendale Reach Floodplain Soil Alternatives

This section presents a range of alternatives designed to achieve cleanup objectives and address contaminated floodplain soil at Allendale reach[39] (Figures 3-3a and 3-3b) that presents an exposure hazard to ecological receptors. Some wetland areas are located at this action area, including scrub/shrub and herbaceous marsh wetland vegetation in the floodplain located immediately south of Cap Area #1 (Section 2.3.10). In areas where contamination is found above cleanup goals in wetland areas, there is no practical alternative to doing work in these wetland areas because this is where the contamination is located. As a result, EPA wetlands/404 requirements focus on identifying the least damaging practicable alternative and minimizing impacts to the wetland areas.

[39] Appendix N describes how the proposed area for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

A total of five remedial alternatives are described and screened, which include some that rely on natural recovery and others that rely on containment or removal. Monitoring and ICs are common components to many of the alternatives, and all alternatives include five-year reviews. Although all of the alternatives except No Action assume that the Allendale and Lyman Mill Dams will remain in place, maintenance of the dams is not required because even if a catastrophic breech of the dam(s) occurred this would not result in the erosion and downstream transport of floodplain soils at Allendale reach. Therefore, the long-term effectiveness and permanence of a remedy to address contaminated floodplain soils at Allendale reach is not contingent upon the long-term maintenance of the Allendale or Lyman Mill Dams.

Allendale Reach Floodplain Soil Alternatives

1	No Action
2	Monitored Natural Recovery
3	Enhanced Natural Recovery
4	Isolation Capping
5	Excavation and Disposal and/or Treatment

Shading represents alternatives retained for detailed evaluation in Section 6.0.

5.2.1 Alternative 1: No Action

5.2.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process to serve as the baseline condition. This alternative would entail no active remediation of the contaminated floodplain soils at Allendale reach. Five-year reviews and periodic monitoring, triggered by severe weather events, would be performed to assess conditions, but these are not requirements. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

5.2.1.2 Screening of No Action

Effectiveness

Alternative 1, No Action would not provide effective protection to human health and the environment because contaminated floodplain soil that presents an exposure hazard to ecological receptors would remain on site unaddressed. This alternative will not comply with ARARs for residential direct exposure or EPA's recommended level for dioxin in soil (EPA, 1998b). There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. This alternative would not provide long-term protection because no action would be taken to contain, reduce downstream transport, or remove the contaminated floodplain soil that presents a risk. There also would be no reduction of toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 1, No Action would be technically and administratively implementable at the CMRP site because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., dams). The implementation of periodic monitoring would not present any unusual issues.

Cost

The total present worth costs would be very low (<$1 million). There are no capital costs; rather, costs are based solely on periodic monitoring to support five-year reviews.

Screening Result

Alternative 1, No Action is retained for detailed evaluation in accordance with the NCP.

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5.2.2 Alternative 2: Monitored Natural Recovery

5.2.2.1 Description of Monitored Natural Recovery

MNR is described in detail in Section 5.1.3.1. Briefly, this alternative relies on natural processes to reduce risk by containing or reducing the bioavailability or toxicity of contaminants in surface soils over time. There would be no direct, active remediation and the contaminated floodplain soils would remain in place.

A rigorous monitoring program would be conducted concurrently with sediment monitoring performed in support of the sediment alternatives (Section 5.1). The long-term monitoring would be used to monitor the impact of the remedial action on downstream areas, to monitor the rate of recovery and determine when the cleanup objectives were achieved. Monitoring would be conducted to verify that surface concentrations are decreasing, evaluate the thickness of material deposited over time, and confirm that contaminated floodplain soils have not migrated downstream or to adjacent areas. Long-term biota monitoring would also be conducted to determine biota recovery and when animal tissue was safe to eat. Cost estimates for this alternative are based on annual monitoring on a 30 year time period and assume that reviews would be conducted every five years. Periodic reporting would be required to document MNR progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups were warranted.

ICs would be required as part of this alternative to prevent the potential release of contamination and/or downstream transport of contaminated floodplain soil.

5.2.2.2 Screening of Monitored Natural Recovery

Effectiveness

Alternative 2, Monitored Natural Recovery would not provide effective protection to human health and the environment because site conditions are generally not conducive to MNR. Dioxin represents a bioaccumulation hazard, and it could take hundreds of years for 30 cm of clean soil to deposit in the floodplain and reduce surface concentrations to levels that do not pose a hazard to ecological receptors. Nor would natural biological degradation be effective for reducing contaminant concentrations in the surface soils to acceptable levels because while this process can theoretically occur, the rate would be very slow at the CMRP site based on the recalcitrant characteristics of the contaminants. Finally, the reach of the Woonasquatucket River at the CMRP site is prone to flooding, and contaminated material might migrate downstream during high flow events.

This alternative will not comply with ARARs for RCRA closure, residential direct exposure, or EPA's recommended residential level for dioxin in soil (EPA, 1998b). There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. However, this alternative would not provide long-term protection because contamination remaining on site would not be confined, and would continue to present an exposure hazard to ecological receptors while MNR occurs. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 2, Monitored Natural Recovery would be technically and administratively implementable at the CMRP site. This alternative would require no additional engineering or physical construction beyond a detailed baseline site characterization, monitoring, and continued execution and maintenance of the ICs.

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Cost

The costs associated with MNR would be very low (<$1 million).

Screening Result

Alternative 2, Monitored Natural Recovery is screened out primarily due to the uncertainty associated with the effectiveness of the alternative and the very long implementation period expected before the cleanup objectives would be achieved if at all. Nor would this alternative comply with ARARs.

5.2.3 Alternative 3: Enhanced Natural Recovery

5.2.3.1 Description of Enhanced Natural Recovery

Under this alternative, a thin-layer cover would be placed over contaminated floodplain soils within the remedial footprint[40] (Figures 3-3a and 3-3b) to accelerate natural recovery and reduce exposure hazards to the invertebrate community. The final composition and thickness of the cover would be determined during remedial design, but the screening level costs assume a cover thickness of 3 inches. Some vegetation might need to be cleared to create work areas prior to cover placement.

The monitoring, ICs, and periodic reporting of remedy progress and efficacy would be the same as described for Alternative 2, Monitored Natural Recovery (Section 5.2.2). Long-term monitoring and maintenance of the thin-layer cover would also be required.

5.2.3.2 Screening of Enhanced Natural Recovery

Effectiveness

Alternative 3, Enhanced Natural Recovery would provide limited protection to human health and the environment. Although soil exposures to wildlife would be reduced by the cover material, existing floodplain habitat would be eliminated and recovery would require some number of years. Contamination would remain in place, and the thin cover would not be thick enough to provide long-term, reliable chemical isolation of contaminated floodplain soil from the environment. Natural biological activity, which results in mixing of the surface and sub-surface soil, would not prevent contact of all invertebrate organisms with the contaminated soil. Nor would the cover be thick enough to resist erosion during flooding or high flow events. While surface concentrations would be reduced, deposition rates are slow and it might take hundreds of years for effective burial of contaminated soil in the floodplain to eliminate hazards to ecological receptors.

Because contamination above cleanup goals is located in wetland areas, there is no practical alternative to conducting work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. This alternative will not comply with ARARs for RCRA closure, residential direct exposure, or EPA's recommended residential level for dioxin in soil (EPA, 1998b). The short-term impacts to the local community would be minor (e.g., construction related noise) and of short duration. However, placement of clean cover material in the floodplain would destroy existing ecological habitat (both soil and vegetation) and reduce flood storage capacity. This alternative would provide

[40] Appendix N describes how the proposed area for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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limited long-term protection because of the uncertainty associated with the long-term stability of the cover, especially during floods or other periods of high water flow. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 3, Enhanced Natural Recovery would be technically implementable at the CMRP site. The required equipment and materials would be readily available from commercial vendors. The Allendale floodplain areas are accessible from land, although some vegetation would need to be cleared to construct work and staging areas, and temporary roads. The monitoring program and ICs would be easily implemented.

Impacts to wetlands and floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity.

Cost

Alternative 3, Enhanced Natural Recovery would have low costs (between $1 million and $3 million).

Screening Result

Alternative 3, Enhanced Natural Recovery is screened out because of its low effectiveness, the expected long implementation period, and significant implementability issues. Nor would this alternative comply with ARARs.

5.2.4 Alternative 4: Isolation Capping

5.2.4.1 Description of Isolation Capping

Under this alternative, an isolation cap would be placed over contaminated floodplain soils[41] (Figures 3-3a and 3-3b) to prevent the exposure to or downstream transport of contaminated material. Construction activities and production rates would be comparable to the isolation cap for sediments (Section 5.1.5), except that work would be performed above the normal water elevation and the cap material would be placed using upland earthwork equipment and methods. Briefly, some vegetation might need to be cleared to create work areas prior to cap placement. The cap composition and thickness would be determined during design, but a thickness of 42 inches is assumed for the screening analysis for a cap that would meet RCRA requirements. The post-cap surface elevation would be increased by approximately 3.5 feet wherever the cap is placed.

Long-term monitoring and ICs would be required to maintain cap integrity and prevent other activities that could result in the potential release and/or downstream transport of contaminated floodplain soil. The monitoring program, conducted concurrently with sediment monitoring, would evaluate whether cap material has eroded and would measure the chemical concentrations in surface and subsurface soils. Monitoring downstream of the Lyman Mill Dam would also be performed to monitor the impact of the remedial action on the downstream areas. Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups are warranted.

[41] Appendix N describes how the proposed area for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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5.2.4.2 Screening of Isolation Capping

Effectiveness

Alternative 4, Isolation Capping would provide moderately effective protection to human health and the environment because it would isolate the contamination, minimize the mobility of contaminated floodplain soil, and prevent exposure to the environment as long as the cap was properly monitored and maintained. As a result, hazards to ecological receptors would be reduced. The isolation cap would be engineered to resist erosion and be stable during flooding and high flow events. The uppermost layer of the cap could also be constructed of materials that would be conducive to supporting floodplain vegetation.

Because contamination above cleanup goals is located in wetland areas, there is no practical alternative to conducting work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. This alternative will comply with ARARs for RCRA closure (Subtitle C requirements for capping), residential direct exposure, and EPA's recommended residential level for dioxin (EPA, 1998b). The short-term impacts to the local community would be minor (e.g., construction related noise) and of short duration. Short-term impacts to the environment would be more substantive. Capping would destroy existing wetland and floodplain habitat. Capping would also raise the ground surface elevation in the floodplain, which would reduce flood storage capacity and result in a permanent occupancy and modification of the floodplain. Capping would provide long-term protection provided the cap was properly monitored and maintained. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment, although the mobility of the contamination would be reduced by the cap.

Implementability

Alternative 4, Isolation Capping would be technically implementable at the CMRP site. The capping technology is proven, capping materials are readily available, and implementation of a monitoring program and ICs would not present any unusual issues. Accessing the areas of the floodplain that require capping may pose some challenges. Most areas of the Allendale reach floodplain requiring remediation are located near residential properties and the ability to stage large equipment and trucks, as well as stockpile capping materials will be limited.

Impacts to wetlands and floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity.

Cost

Alternative 4, Isolation Capping would have low costs (between $1 million and $3 million).

Screening Result

Alternative 4, Isolation Capping is screened out because, while it is moderately effective, the short- and long-term impacts to the wetland and floodplain areas would make this alternative very difficult to implement.

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5.2.5 Alternative 5: Excavation and Disposal and/or Treatment

5.2.5.1 Description of Excavation and Disposal and/or Treatment

In Alternative 5, Excavation and Disposal and/or Treatment, contaminated floodplain soils would be removed using conventional excavation techniques. Construction activities and production rates would be comparable to the excavation alternative for sediments (Section 5.1.7), except that work would be performed in the floodplain. Briefly, contaminated soil within the remedial footprint (Figures 3-3a and 3-3b) would be removed to a depth of 1 foot, resulting in a removal volume of 2,400 cy (does not include over-excavation allowance).[42] A depth of 1 foot has been assumed because that is considered the depth to which ecological receptors are at risk of exposure through foraging or digging. (The excavation depth would extend deeper within the vadose zone to meet ARARs or EPA's dioxin requirements as necessary.) After excavation, confirmation samples would be collected to verify that the cleanup goals are met. Backfill would then be placed to restore the site grade to the existing elevation and provide substrate for re-vegetation of the area. The vegetation would consist of plantings similar in nature to species currently growing in the floodplain (e.g., black willow) and fruit-bearing wetland shrubs; planting specifics would be identified during the remedial design phase. Floodplain soils are expected to be drier than sediments, and are not expected to require dewatering prior to disposal and/or treatment.

Long-term soil monitoring would not be required provided that confirmation sampling demonstrated that the cleanup goals were achieved. Long-term biota monitoring would be conducted to determine biota recovery and when animal tissue was safe to eat. Monitoring downstream of the Lyman Mill Dam would also be performed to monitor the impact of the remedial action on the downstream areas. Further, any disposal facilities constructed on site would require long-term monitoring, maintenance, and ICs to protect the integrity of the facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDFs (e.g., limit the size of woody vegetation on top of the CDFs, prevent the construction of buildings with basements or burial of utilities on or in the CDF cap). Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups were warranted.

Disposal options are the same as those described for sediment Alternative 7, Excavation and Disposal and/or Treatment (Section 5.1.7), except that containment in an Island CDF (Option c) is not considered due to insufficient capacity (to contain all excavated sediment and floodplain soil).

- *Option 5a: On-site Containment in an Upland CDF*
- *Option 5b: On-site Containment in a Nearshore CDF*
- *Option 5d: On-site Thermal Treatment*
- *Option 5e: Off-site Disposal and/or Treatment*

It may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area soil alternatives (see Section 5.4.4.1) should this be implemented. This material would not need to comply with the LDRs because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal.

[42] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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5.2.5.2 Screening of Excavation and Disposal and/or Treatment

Effectiveness

Alternative 5, Excavation and Disposal and/or Treatment would provide highly effective protection to human health and the environment because the contaminated floodplain soil would be removed, and either confined on site in engineered CDFs, destroyed using treatment, or transported off site for disposal and/or treatment. The disposal and/or treatment options proposed are field proven and, in the case of containment facilities, widely used. Properly engineered and maintained CDFs would provide long-term, reliable containment of the contaminated soil (Options 5a, 5b, and 5e) although some options are more reliable than others. Option 5a (upland CDF) would be more effective compared to Option 5b (nearshore CDF) because the disposal facility would be located outside of the floodplain, whereas under Option 5b the contamination would remain in the river/floodplain areas. Options 5d and 5e would provide the most reliable long-term protection because the organic contaminants would be destroyed through treatment (Option 5d) or the contaminated material would be removed from the CMRP site and shipped to a licensed facility for disposal and/or treatment (Option 5e).

Because contamination above cleanup goals is located in wetland areas, there is no practical alternative to conducting work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. Option 5a could also have wetland impacts depending on the selected location of the CDF. Option 5b would impact wetlands and floodplains and include a discharge of dredged and/or fill material to waters of the US. Alternative 5 will comply with ARARs for RCRA closure, residential direct exposure and EPA's recommended residential level for dioxin in soil (EPA, 1998b). The short-term impacts to the local community would be minor (e.g., construction related noise and possible odors) and of short duration. Short-term impacts to the environment, however, would be more substantive, primarily because excavation would destroy existing wetland and floodplain habitat. This alternative would provide long-term protection because the contaminated soil would be removed, and the risk of residual contamination is low using excavation. Flood storage capacity would be reduced under Option 5b (nearshore CDF). This alternative would reduce the toxicity, mobility, or volume of contamination through treatment under Option 5d (on-site thermal treatment) and under Options 5a (on-site containment in an upland CDF) and 5e (off-site disposal and/or treatment) provided some of the soil requires treatment.

Implementability

Excavation would be technically and administratively implementable at the CMRP site. Excavation is a proven technology and the required equipment and materials are readily available from commercial vendors. The implementation of a monitoring program and ICs would not present any unusual issues. Impacts to wetlands and floodplains would need to be minimized and wetland restoration/replication would be required, as well as replacement of flood storage capacity under Option 5b (nearshore CDF).

The disposal and/or treatment options would be technically implementable at the CMRP site. The technologies are field proven and the required construction equipment and materials are commercially available. CDFs are widely used and the construction, operation and maintenance of CDFs are considered routine. The disposal and/or treatment options would present some administrative implementability issues that would have to be addressed. Briefly, on-site containment in an upland CDF (Option 5a) would require that land be obtained to locate the disposal facility and some wetlands could be destroyed depending on the location of the upland CDF (Section 5.1.6.2). Option 5b (nearshore CDF) would require the permanent occupancy and modification of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred

remedy. On-site thermal treatment (Option 5d) relies on the ability to obtain mobile incineration units capable of sustaining high temperatures needed for the destruction of dioxins and furans. In addition, while these units can be safely operated, local residents might express concern regarding emissions. Finally, off-site disposal and/or treatment (Option 5e) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated material from the CMRP site, which is not expected to be a significant problem.

Cost

It is assumed that the implementation of a remedial alternative to address the floodplain soils would be carried out concurrently with that of the sediments and the treatment or disposal options would be common to both areas to improve the overall efficiency of the selected remedies. Costs for the long-term O&M of the on-site CDF (Options 5a and 5b) are covered under the sediment excavation alternative (Section 5.1.7) and are not duplicated here.

Overall, the estimated costs of Alternative 5, Excavation and Disposal and/or Treatment range from low (between $1 million and $3 million) to moderate (between $3 million and $5 million), depending on the disposal and/or treatment option. Estimated costs for Option 5d, On-site Thermal Treatment and Option 5e, Off-site Disposal and/or Treatment are substantially higher compared to Option 5a, On-site Containment in an Upland CDF or Option 5b, On-site Containment in a Nearshore CDF.

Screening Result

Alternative 5, Excavation and Disposal and/or Treatment is retained for detailed analysis because this alternative is highly effective and expected to be implementable. All of the disposal options are retained. Option 5b, On-site Containment in a Nearshore CDF is implementable provided that there is no other practicable alternative.

5.3 Lyman Mill Reach Stream Sediment and Floodplain Soil (Including Oxbow) Alternatives

This section presents a range of alternatives designed to achieve cleanup objectives and address contaminated sediment and floodplain soil at the reach of Lyman Mill (Figures 3-4a and 3-4b).[43] Contaminated sediment in the stream channel and old mill raceway connecting Allendale and Lyman Mill Ponds and contaminated floodplain soil at the Oxbow (Figure 3-4a) presents an unacceptable risk to human health and the environment. Contaminated floodplain soil along the shore of Lyman Mill Pond (Figure 3-4b) presents an exposure hazard to ecological receptors. In areas where contamination is found above cleanup goals in wetland areas, there is no practical alternative to conducting work in these wetland areas because this is where the contamination is located. As a result, EPA wetlands/404 requirements focus on identifying the least damaging practicable alternative and minimizing impacts to the wetland areas. In addition, because of the critical and highly sensitive ecosystems located in this area (see Section 2.3.10), extensive excavation of contamination in the floodplain is not practical because it would destroy this habitat. As a result, there is no practical alternative to the occupancy and modification to floodplain areas in this portion of the site.

[43] Appendix N describes how the proposed area for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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A total of five remedial alternatives for Lyman Mill reach stream sediment and floodplain soil are described and screened, some that rely on natural recovery and others that rely on containment, removal, or a combination of these options. Monitoring and ICs are common components to many of the alternatives, and all alternatives include five-year reviews. All of the alternatives, with the exception of No Action, assume that the Allendale and Lyman Mill Dams will remain in place. Maintenance of Allendale Dam would be required because if a catastrophic breech of the dam occurred this could result in the erosion and downstream transport of contaminated stream sediment and floodplain soils at Lyman Mill reach (particularly those located in the Oxbow Area). Therefore, the long-term effectiveness and permanence of a remedy to address contaminated stream sediment and floodplain soil at Lyman Mill reach is contingent upon the long-term maintenance of the Allendale Dam. Consideration of the impacts of dam replacement is discussed in Section 6.0.

Lyman Mill Reach Stream Sediment and Floodplain Soil Alternatives

1	No Action
2	Monitored Natural Recovery
3	Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment
4	Excavation and Disposal and/or Treatment
5	Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Shading represents alternatives retained for detailed evaluation in Section 6.0.

5.3.1 Alternative 1: No Action

5.3.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process to serve as a baseline condition. This alternative would entail no active remediation of contaminated sediments and floodplain soils at the Lyman Mill reach. Five-year reviews and periodic monitoring, triggered by severe weather events, would be performed to assess conditions, but these are not requirements. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

5.3.1.2 Screening of No Action

Effectiveness

Alternative 1, No Action would not provide effective protection to human health and the environment because contaminated material that presents a risk would remain on site unaddressed. This alternative will not comply with ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b). There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. This alternative would not provide long-term protection because no action would be taken to contain, reduce downstream transport, or remove the contaminated material that presents a risk. Nor would this alternative reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 1, No Action would be technically and administratively implementable at the CMRP site because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., dams and fences). The implementation of periodic monitoring would not present any unusual issues.

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Cost

The total present worth costs would be very low (<$1 million), and would include periodic monitoring to support five-year reviews.

Screening Result

Alternative 1, No Action is retained for detailed evaluation in accordance with the NCP.

5.3.2 Alternative 2: Monitored Natural Recovery

5.3.2.1 Description of Monitored Natural Recovery

Alternative 2, Monitored Natural Recovery would rely on natural processes to reduce the bioavailability or toxicity of contaminants in surface sediments and floodplain soils over time, thereby reducing risk to human and ecological receptors. While the exact rate of deposition is not known for the Lyman Mill reach stream sediment and floodplain soils (including the Oxbow), it is expected that it may take on the order of hundreds of years for contaminated sediment and floodplain soil to be buried by 1 foot of clean material,[44] especially in the Oxbow. Site processes must be well-understood to show that MNR would be effective, and additional evaluations would need to be conducted to implement this alternative, as follows:

- determination of deposition rates within the Oxbow;
- evaluation of frequency and intensity of potential erosion or deposition due to storms and floods;
- evaluation of potential impact of future use in terms of sediment deposition; and,
- monitoring the rate of natural recovery in surface sediment and floodplain soil concentrations by monitoring the physical conditions at the site and sediment/soil chemistry data.

Monitoring the rate of recovery is an important component of this alternative and one of the key differences between MNR and No Action. More monitoring would be performed for this alternative than any other alternative to verify that the surface sediment/soil concentrations were decreasing, and that contaminated sediment/soil was not migrating downstream. For example, sampling and analysis of surface and subsurface sediment/soil samples could be performed to evaluate the thickness of the sediment/soil deposited over time and to confirm that the contaminated sediments and floodplain soils had not migrated away from this area of the site. Long-term biota monitoring would also be conducted to determine biota recovery and when animal tissue was safe to eat. Cost estimates for this alternative are based on annual monitoring on a 30 year time period and assume that reviews would be conducted every five years. The long-term monitoring would be used to monitor the impact of the remedial action on downstream areas, to determine the extent to which surface sediments and floodplain soils recovered and the cleanup objectives were achieved, and to determine whether or not this alternative was protective in the long term. Periodic reporting would be required to document MNR progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups were warranted.

[44] Section 2.3.8 indicates that it would take approximately 40 to 60 years for 1 foot of clean sediment to deposit at Allendale and Lyman Mill Ponds based on the estimated sedimentation rates for these areas. Sedimentation rates at the Oxbow are expected to be even lower because sediment is only deposited during periods of flooding. Assuming that sedimentation rates at the Oxbow are approximately 5 to 10 times slower than Allendale and Lyman Mill Ponds, then it might take on the order of hundreds of years for 1 foot of clean sediment to deposit in the Oxbow.

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ICs would be required in association with MNR because contamination above the cleanup goals would remain in the sediment/soil during the very long recovery period. ICs could include recreational use restrictions and hunting and fishing advisories. Assuming cleanup goals in surface sediment/soil were reached, long-term ICs, such as restrictive easements and recreational use restrictions, would be needed to reduce the risk of exposing buried contamination. The future use restrictions could include, but not be limited to: restrictions on future excavation and dredging and restrictions on future access to utilities. Additionally, this alternative assumes that low energy environments in the Oxbow would not change; therefore, the success of this alternative would also be contingent upon the maintenance of the Allendale Dam. Should the dam be removed or replaced with a smaller weir structure, then additional evaluations would need to be conducted to better understand the impact of dam removal and/or replacement on hydrodynamics and depositional processes at the Lyman Mill reach, including the Oxbow. A preliminary analysis suggests that dam removal and/or replacement is expected to minimally impact water levels and groundwater flow patterns at the Oxbow (USACE, 2007).

5.3.2.2 Screening of Monitored Natural Recovery

Effectiveness

Alternative 2, Monitored Natural Recovery by itself would not provide effective protection to human health and the environment because no action would be taken to remove, isolate or treat contaminated material that presents a risk. Moreover, site conditions are generally not conducive to MNR and natural processes (e.g., deposition of clean material, degradation of contaminants) are expected to take a long time (in excess of a century) to reduce site risks to acceptable levels. While the majority of this area would likely have low potential for erosion, sediment deposition occurs predominantly during flood events and the sedimentation rate is too low for MNR to work within a reasonable timeframe. The areas with the highest erosion potential are those within, and in immediate proximity to, the stream channel connecting Allendale and Lyman Mill Ponds. Although risks to human health could be managed with ICs (e.g., restricted access and boardwalks) to minimize exposure to contaminated material (assuming they were effectively monitored and enforced), risk to ecological receptors would not be reduced for a very long time because the current exposure pathways to ecological receptors would remain in place. MNR also would not reduce the potential for contaminated materials to be transported downstream.

This alternative will not comply with ARARs for RCRA closure, residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b). There would be no short-term impacts because no construction would be performed that could disrupt the local community or habitat. However, this alternative would not provide long-term protection because no action would be taken to remove, contain or reduce downstream transport of contaminated material, and contamination would continue to present a risk while MNR occurs. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 2, Monitored Natural Recovery would be technically and administratively implementable at the CMRP site. The only construction that might be required would be for mechanisms to limit exposure to human receptors (e.g., fencing and/or a boardwalk). The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance could present some administrative implementability issues that would have to be addressed. That is, agreement for access from owners of the dams would be needed.

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Cost

The costs associated with MNR would be low (between $1 million and $25 million).

Screening Result

Alternative 2, Monitored Natural Recovery is screened out because by itself it would not be protective of human health and the environment, the implementation period would be prohibitively long, the risks to ecological receptors would not be reduced for a very long time, and ARARs would not be met.

5.3.3 Alternative 3: Targeted Excavation, Enhanced Natural Recovery (Thin-layer Cover) and Disposal and/or Treatment

5.3.3.1 Description of Targeted Excavation, Enhanced Natural Recovery (Thin-layer Cover) and Disposal and/or Treatment

This alternative relies on a combination of targeted excavation and ENR to achieve the cleanup objectives. Under this alternative, contaminated sediment and floodplain soil would be removed from targeted areas using conventional excavation techniques. Construction activities and production rates would be comparable to the excavation alternative for sediments (Section 5.1.7), except that work would also be performed in wetland and floodplain areas. Briefly, targeted excavation would be used to remove the top 1 foot of sediment from the stream channel connecting Allendale and Lyman Mill Ponds (this area is not suitable for thin-layer cover) and the top 1 foot of floodplain soil from areas where contaminant concentrations are in excess of ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b) (Figures 5-26a and 5-26b show the targeted excavation areas).[45] The approximate excavation area and volume are 4.8 acres and 9,700 cy (based on excavation depth of 1 foot and over-excavation allowance of 0.25 ft; the excavation depth would extend deeper within the vadose zone as necessary to meet ARARs or EPA's dioxin requirements), respectively. The excavated material would not be dewatered due to the high amount of vegetation. After excavation, confirmation samples would be collected to verify that the cleanup goals were met. Backfill would then be placed to design grades throughout excavated areas; backfill material utilized in the wetland areas would be sandy loam from upland borrow pits and backfill material in the stream channel would be gravel and cobbles from upland sources. Backfill in the wetland areas would provide substrate for re-vegetation of the area. The vegetation would consist of plantings similar in nature to species currently growing in the floodplain; planting specifics would be identified during the remedial design phase. Excavation of the stream channel would also cause some loss of vegetation and destabilization of the bank itself requiring focused restoration including regrading, stabilization techniques as warranted, and plantings. Potential restoration activities are described in further detail in Section 6.0.

A thin-layer cover (ENR) would be placed over areas within the remedial footprint that were not excavated (i.e., 16.8 acres, see Figures 5-26a and 5-26b) to accelerate the natural recovery processes. ENR would provide a rapid and relatively inexpensive contamination cover and is suitable in low-energy and depositional environments where natural recovery processes are expected to occur over time. ENR would also reduce exposure of aquatic and floodplain organisms to contaminated material, while minimizing the destruction of the wetland habitat. The cover thickness and composition would be determined during the design phase, and the cover material would provide suitable substrate for

[45] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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indigenous flora and fauna. For costing purposes, a thickness of 3 inches is assumed. To minimize impacts to the ecological habitat, the thin-layer cover would be applied during the dormant season using a broadcast or spraying technique analogous to lawn hydro-seeding.

This alternative also includes flow control structures to divert stream flow into the Oxbow to accelerate the natural recovery processes and allow for the burial of contaminated material in this area. Opportunities to minimize potential short-circuiting of floodwaters through the Oxbow (e.g., regrading and/or backfilling portions of the channel remnant) would also be evaluated in the final design phase.

The monitoring and dam maintenance requirements, ICs, and periodic reporting to document remedy progress and efficacy would be the same as those described for Alternative 2, Monitored Natural Recovery (Section 5.3.2). The thin-layer cover and any disposal facilities constructed on site would require long-term monitoring and maintenance to protect the integrity of the cover and facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDF (e.g., limit the size of woody vegetation on top of the CDFs) or expose contamination beneath the thin-layer cover. Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups were warranted.

Disposal options are similar to those described for sediment Alternative 7, Excavation and Disposal and/or Treatment (Section 5.1.7), except that containment in an Island CDF (Option c) is not considered.

- *Option 3a: On-site Containment in an Upland CDF*
- *Option 3b: On-site Containment in a Nearshore CDF*
- *Option 3d: On-site Thermal Treatment*
- *Option 3e: Off-site Disposal and/or Treatment*

As mentioned in Section 5.2.5.1, it may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area soil alternatives (see Section 5.4.4.1) should this be implemented. This material would not need to comply with the LDRs because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal.

5.3.3.2 Screening of Targeted Excavation, Enhanced Natural Recovery (Thin-layer Cover) and Disposal and/or Treatment

Effectiveness

Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment would provide moderately effective protection to human health and the environment. Targeted excavation from the stream channel would reduce downstream transport of contaminated sediment/soil during high flow events and targeted excavation from areas that exceed residential direct exposure criteria and/or EPA's recommended residential level for dioxin in soil (EPA, 1998b) would provide protection to human health. While contamination would remain on site at areas not excavated, placement of a thin-layer cover at these areas would minimize direct contact and reduce surface concentrations, which in turn would reduce the risk to human and ecological receptors, further increasing the overall effectiveness. Implementation of ICs would provide further protection to human health by lowering the potential for human exposure; ICs are only effective if adequately monitored, enforced, and maintained. ICs would not reduce exposure to ecological receptors; however, the local habitat (which currently provides both shelter and foraging

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opportunities to the entire floodplain community) would not be destroyed as part of the remedy. As with MNR, this alternative relies upon natural processes to reduce risk over time, such as the burial of contaminated material by clean sediment/soil (deposition) and degradation of contaminants. The deposition rate is expected to be relatively low and the overall implementation period of this alternative is expected to take a long time. The utilization of various flow changing techniques (e.g., groins, vanes, or barbs) in the free-flowing portion of the river adjacent to the Oxbow could be considered during the design phase. By enhancing the lateral migration of sediment-laden floodwaters, such structures have the potential to increase sediment deposition rates in the floodplain and improve the overall effectiveness of this alternative (Natural Resources Conservation Service, 2007; Federal Interagency Stream Restoration Working Group [FISRWG], 2001).

The disposal and/or treatment options proposed are field proven and, in the case of CDFs, widely used. Properly engineered and maintained CDFs would provide long-term, reliable containment of the contaminated material (Options 3a, 3b, and 3e). Among the on-site disposal options, Option 3a (upland CDF) would provide more effective long-term protection compared to Option 3b (nearshore CDF) because the disposal facility would be located outside of the floodplain, whereas under Option 3b the contamination would remain in the river/ponds. Among all disposal options, Options 3d and 3e would provide the most reliable long-term protection because the organic contaminants would be destroyed through treatment (Option 3d) or the contaminated material would be removed from the CMRP site and shipped to a licensed facility for disposal and/or treatment (Option 3e).

Because contamination above cleanup goals is located in wetland areas, there is no practical alternative to conducting work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. Option 3a could also have wetland impacts depending on the selected location of the CDF. Option 3b would also impact wetlands and floodplains and include a discharge of dredged and/or fill material to waters of the US. This alternative will comply with ARARs for residential direct exposure and EPA's recommended residential level for dioxin in soil (EPA, 1998b). However, without a waiver, it would not comply with the RCRA, Subtitle C, closure regulations. Short-term impacts to the local community would be minor and of short duration. Short-term impacts to the habitat could be more substantive. In areas that are excavated, the wetlands will be destroyed. In areas where the thin-layer cover is placed (which represents the majority of the cleanup area), the cover would be applied during the dormant season using low-impact methods to minimize impact on the existing wetland vegetation. This alternative might not be protective in the long term primarily because thin-layer covers are not typically armored to protect against erosion that may occur during high flow events. Flood storage capacity will be reduced under Option 3b (nearshore CDF). This alternative would reduce the toxicity, mobility, or volume of contamination through treatment under Option 3d (on-site thermal treatment) and under Options 3a (upland CDF) and 3e (off-site disposal and/or treatment) provided some of the sediment/soil requires treatment.

Implementability

Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment would be technically and administratively implementable at the CMRP site. The construction needs would be minimal; however, working in the relatively soft, wet soils may pose some challenges, and specialized low-ground pressure equipment might be required. Locating sufficient cap material of suitable composition, particularly an acceptable organic content, might also pose some implementability challenges. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance and potential impacts to the wetland and floodplain areas could present some administrative implementability issues that would have to be assessed. For dam maintenance, agreement for access from owners of the dams would be needed. Impacts to wetlands and

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floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity.

The disposal and/or treatment options would be technically implementable at the CMRP site. The technologies are field proven and the required construction equipment and materials are commercially available. CDFs are widely used and the construction, operation and maintenance of CDFs are considered routine. All of the disposal and/or treatment options would present some administrative implementability issues that would have to be addressed. Briefly, on-site containment in an upland CDF (Option 3a) would require that land be obtained to locate the disposal facility, some wetlands could be destroyed depending on the location of the upland CDF (Section 5.1.6.2), and some of the sediment/soil could require treatment. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 3a (Section 5.1.6.2). Option 3b would require the permanent occupancy and modification of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. On-site thermal treatment (Option 3d) relies on the ability to obtain mobile incineration units capable of sustaining high temperatures needed for the destruction of dioxins and furans. In addition, while these units can be safely operated, local residents might express concern regarding emissions. Finally, off-site disposal and/or treatment (Option 3e) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated material from the CMRP site, which is not expected to be a significant problem.

Cost

The costs associated with Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment would be low (between $1 million and $25 million). Estimated costs for On-site Containment in an Upland CDF (Option 3a) could increase depending on the amount of material requiring treatment.

Screening Result

Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment is retained for detailed analysis. While the implementation period is long, this alternative would provide moderate protection and minimize short-term impacts to ecological habitat. This alternative would result in the destruction of some wetland and floodplain habitat (i.e., 4.8 acres), but is considered implementable provided that there is no other practicable alternative. The implementation of ENR should not substantially impact habitat value because the vegetative structure is vertically stratified and herbaceous groundcover is just one component of the overall habitat provided, which could be restored relatively quickly. Moreover, ENR would be implemented during the dormant season to minimize impacts to the wetland and floodplain areas.

5.3.4 Alternative 4: Excavation and Disposal and/or Treatment

5.3.4.1 Description of Excavation and Disposal and/or Treatment

Under this alternative, contaminated sediment and floodplain soils would be removed using conventional excavation techniques. Construction activities and production rates would be comparable to the excavation alternative for sediments (Section 5.1.7), except that work would also be performed in wetland and floodplain areas. Briefly, vegetation and contaminated sediment and floodplain soil within the 21.6 acre remedial footprint (Figures 3-4a and 3-4b) would be removed to a depth of 1 foot, resulting in a

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removal volume of approximately 43,500 cy (includes 0.25 ft over-excavation allowance).[46] A depth of 1 foot is considered to be protective of human and ecological receptors (the excavation depth would extend deeper within the vadose zone as necessary to meet ARARs or EPA's dioxin requirements). The excavated material would not be dewatered due to the high amount of vegetation. After excavation, confirmation samples would be collected to verify that the cleanup goals are met. Backfill would then be placed to design grades throughout excavated areas; backfill material utilized in the wetland areas would be sandy loam from upland borrow pits and backfill material in the stream channel would be gravel and cobbles from upland sources. Backfill in the wetland areas would provide substrate for re-vegetation of the area. The vegetation would consist of plantings similar in nature to species currently growing in the floodplain; planting specifics would be identified during the remedial design phase. Excavation of the stream channel would also cause some loss of vegetation and destabilization of the bank itself requiring focused restoration including regrading, stabilization techniques as warranted and plantings. Potential restoration activities are described in further detail in Section 6.0.

Long-term sediment/soil monitoring would not be required provided the confirmation sampling demonstrates that the cleanup goals were achieved. Long-term biota monitoring would be conducted to determine biota recovery and when animal tissue was safe to eat. Monitoring downstream of the Lyman Mill Dam would also be performed to monitor the impact of the remedial action on the downstream areas. Further, any disposal facilities constructed on site would require long-term monitoring and maintenance to protect the integrity of the facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDF (e.g., limit the size of woody vegetation on top of the CDFs). Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups were warranted.

Disposal options are similar to those described for sediment Alternative 7, Excavation and Disposal and/or Treatment (Section 5.1.7), except that containment in an Island CDF (Option c) is not considered due to insufficient capacity.

- *Option 4a: On-site Containment in an Upland CDF*
- *Option 4b: On-site Containment in a Nearshore CDF*
- *Option 4d: On-site Thermal Treatment*
- *Option 4e: Off-site Disposal and/or Treatment*

As mentioned in Section 5.2.5.1, it may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area soil alternatives (see Section 5.4.4.1) should this be implemented. This material would not need to comply with the land disposal restrictions because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal.

5.3.4.2 Screening of Excavation and Disposal and/or Treatment

Effectiveness

Alternative 4, Excavation and Disposal or Treatment would provide highly effective protection to human health and the environment because contaminated material would be removed and replaced with clean backfill, thereby reducing human and ecological exposure to site contamination. Further, the removed

[46] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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material would be confined on site in engineered CDFs, destroyed through treatment, or transported off site for disposal and/or treatment. The disposal and/or treatment options proposed are field proven and, in the case of CDFs, widely used. Properly engineered and maintained CDFs would provide long-term, reliable containment of the contaminated material (Options 4a, 4b, and 4e). Among the on-site disposal options, Option 4a (Upland CDF) would provide more effective long-term protection compared to Option 4b (Nearshore CDF) because the disposal facility would be located outside of the floodplain, whereas under Option 4b the contamination would remain in the river/ponds. Among all the disposal options, Options 4d and 4e would provide the most reliable long-term protection because the organic contaminants would be destroyed through treatment (Option 4d) or the contaminated material would be removed from the CMRP site and shipped to a licensed facility for disposal and/or treatment (Option 4e).

Because contamination above cleanup goals is located in wetland areas, there is no practical alternative to doing work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. Option 4a could also have wetland impacts depending on the selected location of the CDF. Option 4b would also impact wetlands and floodplains and include a discharge of dredged and/or fill material to waters of the US. This alternative will comply with ARARs for RCRA closure, residential direct exposure and EPA's recommended residential level for dioxin in soil (EPA, 1998b). The short-term impacts to the local community would be minor (e.g., construction related noise and possible odors) and of short duration. Short-term impacts to the environment, however, would be more substantive, primarily because excavation would destroy wetland areas and ecological habitat including some forested areas that could take decades to recover. This alternative would provide long-term protection because the contamination would be removed and either confined, destroyed, or shipped off site. Moreover, the risk of residual contamination would be low using this alternative. Flood storage capacity would be reduced under Option 4b (nearshore CDF). The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 4d (on-site thermal treatment) and under Options 4a (upland CDF) and 4e (off-site disposal and/or treatment) provided some of the sediment/soil requires treatment.

Implementability

Excavation would be technically and administratively implementable at the CMRP site. Excavation is a proven technology, and the required equipment is available from commercial vendors, although specialized, low-ground pressure equipment might be needed to work in areas with wet, organic rich soils. Locating sufficient backfill material of suitable composition, particularly an acceptable organic content, might pose some implementability challenges. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance and potential impacts to the wetland and floodplain areas could present some administrative implementability issues that would have to be assessed. For dam maintenance, agreement for access from owners of the dams would be needed. Impacts to wetlands and floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity.

The disposal and/or treatment options would be technically implementable at the CMRP site. The technologies are field proven and the required construction equipment and materials are commercially available. CDFs are widely used and the construction, operation and maintenance of CDFs are considered routine. All of the disposal and/or treatment options would present some administrative implementability issues that would have to be addressed. For example, there is limited space on site for sediment/soil processing and land would have to be obtained to locate the processing facility (all options). On-site containment in an upland CDF (Option 4a) would require that land be obtained to locate the disposal facility, some wetlands could be destroyed depending on the location of the upland CDF (Section 5.1.6.2), and some of the sediment/soil could require treatment. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 4a (Section 5.1.6.2). On-site

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containment in a nearshore CDF (Option 4b) would require the permanent occupancy and modification of the floodplain and destruction of wetlands/discharge of dredged and/or fill material into waters of the US, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. On-site thermal treatment (Option 4d) relies on the ability to obtain mobile incineration units capable of sustaining high temperatures needed for the destruction of dioxins and furans. In addition, while these units can be safely operated, local residents might express concern regarding emissions. Finally, off-site disposal and/or treatment (Option 4e) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated material from the CMRP site, which is not expected to be a significant problem.

Cost

The estimated costs for Alternative 4 range from low (between $1 million and $25 million) to high (between $50 million and $75 million), depending on the disposal and/or treatment option selected. Estimated costs for on-site containment (Options 4a and 4b) are substantially lower compared to costs for Option 4d, On-site Thermal Treatment or Option 4e, Off-site Disposal and/or Treatment. Estimated costs for Option 4a, On-site Containment in an Upland CDF could increase depending on the amount of material requiring treatment.

Screening Result

Alternative 4, Excavation and Disposal and/or Treatment is screened out because of significant effectiveness and implementability issues regarding the destruction of wetland and floodplain areas that could take many decades to recover. This alternative would result in the complete destruction of the entire (i.e., 21.6 acres) Oxbow floodplain/wetland system that provides valuable wildlife habitat and is one of the largest tracts of mature forested riparian habitat remaining in the lower Woonasquatucket River watershed.

5.3.5 Alternative 5: Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

5.3.5.1 Description of Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

This alternative is similar to Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment (Section 5.3.3), except that a larger area within the cleanup area will be remediated using excavation. The general descriptions were presented in the Section 5.3.3. Under this alternative, the top 1 foot of floodplain soil would be excavated from areas where contaminant concentrations are in excess of ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b), as well as from areas targeted to maximize mass removal, areas of highest potential human exposure and areas with higher potential for downstream transport of contaminated sediment and floodplain soil (Figures 5-27a and 5-27b), as follows:

- The old mill raceway – contaminant concentrations in sediments are above the cleanup goals in this area, and may pose a human health risk to nearby residents. Much of the area surrounding the raceway is maintained as lawns and one segment of the raceway is immediately adjacent to the Allendale condominiums, and could pose a higher risk of human exposure relative to other areas.

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- The stream channel connecting Allendale and Lyman Mill Ponds – contaminant concentrations in the stream sediments are above the cleanup goals, and this area is included to reduce the potential for downstream transport of contaminated material to Lyman Mill Pond.
- The bank along the western side of the stream channel – this area appears to be a desirable location for fishing, and is included to reduce the potential risk to anglers visiting the area.
- The abandoned channel within the Oxbow – this area serves as aquatic habitat, at least seasonally, and according to the exposure assumptions developed in the BERA, this area may pose a risk to ecological receptors. Further, this area was in communication with the river during times of high water, and appears to have been impacted by site activities evidenced by contamination above the cleanup goals.
- The area of emergent marsh and scrub/shrub vegetation south of the abandoned channel and the small peninsula north of the confluence of Assapumpset Brook and Lyman Mill Pond – heavy vegetation in these areas could have trapped contaminated sediments and floodplain soils over time, especially during flooding. Contaminated material at these areas could migrate to and recontaminate pond areas during normal flow (river channel and brook flow through these areas) and/or high flow or flood events. Excavation within these areas is expected to reduce area-wide contamination, thereby reducing risk, and should also remove potentially contaminated material that could be transported downstream. Finally, the vegetation present in these areas is expected to become reestablished relatively quickly after remedy implementation (i.e., on the order of a decade).

Figures 5-27a and 5-27b show the partial excavation footprint.[47] The approximate removal area and volume is 13.5 acres and 27,300 cy (based on the excavation depth of 1 foot and 0.25 ft over-excavation allowance; the excavation depth would extend deeper within the vadose zone as necessary to meet ARARs or EPA's dioxin requirements), respectively. The excavated material would not be dewatered due to the high amount of vegetation. Following excavation, confirmation samples would be collected to verify that the cleanup goals had been achieved and the excavated areas would be backfilled to design grades throughout excavated areas with clean, suitable material. Backfill material utilized in the wetland areas would be sandy loam from upland borrow pits and backfill material in the stream channel would be gravel and cobbles from upland sources. Backfill in the wetland areas would provide substrate for re-vegetation of the area. The vegetation would consist of plantings similar in nature to species currently growing in the floodplain; planting specifics would be identified during the remedial design phase.

A thin-layer cover identical to that described in Alternative 3 (Section 5.3.3) would be placed over areas within the remedial footprint that were not excavated (Figures 5-27a and 5-27b). This alternative would impact the streambank along the entire reach of the river channel; in addition to some loss of vegetation and destabilization throughout, there would be substantial loss of bank tree canopy in the portion of the bank on the west side that is targeted for excavation. As a result, focused restoration including regrading, stabilization techniques as warranted and plantings would be required to mitigate these impacts. Potential restoration activities are described in further detail in Section 6.0.

This alternative also includes flow control structures to divert stream flow into the Oxbow to accelerate the natural recovery processes and allow for the burial of contaminated material in this area. Opportunities to minimize potential short-circuiting of floodwaters through the Oxbow (e.g., regrading and/or backfilling portions of the channel remnant) would also be evaluated in the final design phase.

[47] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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Long-term monitoring and dam maintenance requirements, ICs, and periodic reporting to document remedy progress and efficacy would be the same as described for the Alternative 3 (Section 5.3.3). Disposal options are similar to those described for sediment Alternative 7, Excavation and Disposal and/or Treatment (Section 5.1.7), except that containment in an Island CDF (Option c) is not considered due to insufficient capacity.

- *Option 5a: On-site Containment in an Upland CDF*
- *Option 5b: On-site Containment in a Nearshore CDF*
- *Option 5d: On-site Thermal Treatment*
- *Option 5e: Off-site Disposal and/or Treatment*

Any disposal facilities constructed on site would require long-term monitoring and maintenance to protect the integrity of the facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDFs or expose contamination that remains on site at levels above the cleanup goals.

As mentioned in Section 5.2.5.1, it may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area soil alternatives (see Section 5.4.4.1) should this be implemented. This material would not need to comply with the LDRs because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal.

5.3.5.2 Screening of Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Effectiveness

Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment would provide moderately to highly effective protection to human health and the environment because contaminated sediment and floodplain soil would either be removed and replaced with clean backfill, or covered with a thin-layer of clean material. Excavation would target areas that exceed residential direct exposure criteria and/or EPA's recommended residential level for dioxin in soil (EPA, 1998b), areas for mass removal, and areas of higher potential for human exposure and downstream migration, whereas ENR would target more sensitive ecological habitat areas. The combination of focused removal and ENR would reduce surface contamination, as well as reduce exposure and risk to human and ecological receptors. ICs would provide further protection to human health by lowering the potential for human exposure; ICs are only effective if adequately monitored, enforced, and maintained. ICs would not reduce exposure to ecological receptors; however, the local habitat (which currently provides both shelter and foraging opportunities to the entire floodplain community) would not be destroyed as part of the remedy. The disposal and/or treatment options would contribute to the long-term effectiveness of the remedy, either by confining the material on site (Options 5a and 5b), destroying the material through treatment (Option 5d), or transporting it off site for disposal and/or treatment (Option 5e) as described for Alternative 3 (Section 5.3.3.2).

Because contamination above acceptable levels is located in wetland areas, there is no practical alternative to conducting work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. Option 5a could also have wetland impacts depending on the selected location of the CDF. Option 5b would also impact wetlands and floodplains and include a discharge of dredged and/or fill material to waters of the US. This alternative will comply with ARARs for residential direct exposure and EPA's recommended residential level for dioxin in soil (EPA, 1998b).

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Without a waiver, however, this alternative would not comply with the Subtitle C closure regulations under RCRA. The short-term impacts to the local community would be minor (e.g., construction related noise and possible odors) and of short duration. Short-term impacts to the environment, however, would be more substantive, primarily because excavation would destroy some wetland and floodplain habitat, and recovery of scrub/shrub type wetland plants could take over a decade. Long-term effectiveness is moderate because while much of the contamination would be removed, some contamination above the cleanup goals would remain in areas that rely on ENR. (The ENR areas would have to be continually monitored and maintained.) The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 5d (on-site thermal treatment) and under Options 5a (upland CDF) and 5e (off-site disposal and/or treatment) provided some of the sediment/soil requires treatment.

Implementability

Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment would be technically implementable at the CMRP site as described for the full excavation alternative (Section 5.3.4.2). Requirements for dam maintenance and impacts to wetland and floodplain areas could present some administrative implementability issues that would have to be addressed. For dam maintenance, access from owners of the dams would be needed. Impacts to wetlands and floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity.

The disposal and/or treatment options would be technically implementable at the CMRP site. The technologies are field proven and the required construction equipment and materials are commercially available. CDFs are widely used and the construction, operation and maintenance of CDFs are considered routine. All of the disposal and/or treatment options would present some administrative implementability issues that would have to be addressed. For example, there is limited space on site for sediment/soil processing and land would have to be obtained to locate the processing facility (all options). On-site containment in an upland CDF (Option 5a) would require that land be obtained to locate the disposal facility, some wetlands could be destroyed depending on the location of the CDF (Section 5.1.6.2), and some of the sediment/soil could require treatment. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 5a (Section 5.1.6.2). On-site containment in a nearshore CDF (Option 5b) would require the permanent occupancy and modification of the floodplain and further destruction of wetlands, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. On-site thermal treatment (Option 5d) relies on the ability to obtain mobile incineration units capable of sustaining high temperatures needed for the destruction of dioxins and furans. In addition, while these units can be safely operated, local residents might express concern regarding emissions. Finally, off-site disposal and/or treatment (Option 5e) relies on the ability to identify permitted facilities with sufficient capacity to handle the volume of contaminated material from the CMRP site, which is not expected to be a significant problem.

Cost

The estimated costs for Alternative 5 range from low (between $1 million and $25 million) to moderate (between $25 million and $50 million), depending on the disposal and/or treatment option selected. Costs for on-site containment (Options 5a and 5b) are approximately half that of costs for Option 5d, On-site Thermal Treatment or Option 5e, Off-site Disposal and/or Treatment. Estimated costs for Option 5a, On-site Containment in an Upland CDF could increase depending on the amount of material requiring treatment.

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Screening Result

Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment is retained for detailed analysis. This alternative would provide effective protection to human health and the environment and focused excavation (i.e., approximately 13.5 acres) would reduce the extent of habitat destruction during remedy implementation.

5.4 Source Area Soil Alternatives

Site actions were taken in the late 1990s and early 2000s to reduce the immediate human health threat to residents on and near the site from exposure to contaminated soils in the source area (see Section 2.2.2 and Table 2-1). Among the actions taken was the construction of three protective caps to cover contaminated soils in the source area (Figure 1-2), as follows:

- Construction of an interim protective cap (Cap Area #1) in a formerly wooded area immediately south of the Centredale Manor parking lot. This area was prone to flooding and had some of the highest concentrations of dioxin and PCBs in surface soil at the site. Contaminated source area soils were capped with intermediate cover material (6 inches minimum thickness), a geotextile liner, and approximately 12 inches of final cover material. The uppermost layer consisted of 4 inches of loam and a vegetative cover.
- Construction of a second interim cap (Cap Area #2) between the Woonasquatucket River and the Centredale Manor building. This area also was prone to flooding and contained elevated concentrations of dioxin in surface soils. Contaminated source area soils were capped with a geotextile fabric liner, 6 inches of sand fill, and 12 inches of common fill. The uppermost layer consisted of loam and a vegetative cover. A flood control berm was constructed along the western edge of the cap to reduce erosion.
- Construction of a permeable protective cap (Cap Area #3) over contaminated soils and sediments in the former tailrace, installation of a precast modular storm water control structure at the terminus of a storm drain at the north end of the tailrace, and construction of a drainage swale along the length of the capped area (LEA, 2003 and 2004). The majority of the tailrace was capped with a cellular containment system consisting from the bottom up of approximately 6 inches of sand, a geotextile fabric, and a 6-inch-thick cellular containment system filled with and covered by 1.5-inch aggregate material. A soil cap consisting of geotextile fabric covered by 20 inches of bank run gravel and 4 inches of loam was constructed at the north end of the tailrace.

These site actions were taken to minimize human exposure to contaminated soils and prevent soil erosion and runoff into the Woonasquatucket River. An evaluation of the protectiveness from exposure to the source area soils and of the integrity of the existing interim caps, rip rap, and pavement at the source area is presented in this section as part of the process of selecting components of the permanent remedy.

The source area soil action area is located within the floodplain (Figure 1-2), and approximately 85% of the area is between the normal water and 100-yr flood elevations. This area also includes riverbank wetland resource areas as well as wetland vegetation that may become re-established within the former tailrace (Cap Area #3) (Section 2.3.10). In areas where contamination is found above cleanup goals in wetland areas, there is no practical alternative to doing work in these wetland areas because this is where the contamination is located. As a result, EPA wetlands/404 requirements focus on identifying the least damaging practicable alternative and minimizing impacts to the wetland areas.

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A total of five remedial alternatives, designed to achieve the cleanup objectives and address contaminated soil at the source area, are described and screened in this section. Some of the alternatives rely on using the existing interim caps and parking lots as the component of the remedy and others rely either on upgrading the existing interim caps and parking lots or removing the contaminated source area soils using excavation. Monitoring and ICs are common components to many of the alternatives, and all alternatives include five-year reviews.

Source Area Soil Alternatives

1	No Action
2	Monitor and Maintain Existing Surfaces
3	Targeted Excavation, Upgrade and Maintain Existing Surfaces, and Disposal and/or Treatment
4	Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment
5	Excavation and Disposal and/or Treatment

Shading represents alternatives retained for detailed evaluation in Section 6.0.

5.4.1 Alternative 1: No Action

5.4.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process to serve as the baseline condition. This alternative would entail no active remediation of the contaminated soils at the source area. Five-year reviews and periodic monitoring, triggered by severe weather events, would be performed to assess conditions, but these are not requirements. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

5.4.1.2 Screening of No Action

Effectiveness

Alternative 1, No Action would not provide adequate protection of human health and the environment. The existing parking lots and interim caps are currently effective at minimizing human exposure to contaminated source area soils and preventing soil erosion and runoff into the Woonasquatucket River. However, without long-term monitoring and maintenance of the parking lots and caps, which is not required under this alternative, the long-term reliability and effectiveness of this alternative is low.

This alternative will not comply with the ARARs for TSCA closure, residential direct exposure, GB leachability, or EPA's recommended residential level for dioxin in soil (EPA, 1998b). There would be no short-term impacts because no construction would be performed that could disrupt the local community or environment. This alternative would not provide long-term protection because maintenance of the existing interim caps and parking lots is not required under this alternative. Nor would this alternative reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 1, No Action would be technically and administratively implementable at the CMRP site because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., caps or parking lots). The implementation of periodic monitoring would not present any unusual issues.

Cost

The estimated total present worth costs would be very low (<$1 million).

Screening Result

Alternative 1, No Action is retained for detailed evaluation in accordance with the NCP.

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5.4.2 Alternative 2: Monitor and Maintain Existing Surfaces

5.4.2.1 Description of Monitor and Maintain Existing Surfaces

Under this alternative, long-term monitoring and maintenance of the existing surfaces, including the existing interim caps, parking lots, paved surfaces, rip rap and landscaped areas (Figure 3-5),[48] would be performed to prevent erosion and potential exposure of contaminated source area soils. Long-term monitoring and maintenance would include annual inspections and maintenance of the caps, parking lots, monitoring wells, rip rap and landscape areas. Maintenance activities could include seeding the cap areas, mowing the caps, and sealing cracks in the parking lot pavement. Periodic monitoring would also be performed to verify that contamination left in place remains contained, and that no future releases occur.

ICs would be implemented to prevent human exposure, and would include, but not be limited to, prohibiting future excavation, restricting access for buried utilities, and preventing the construction of buildings with pilings or basements. Periodic reporting would be required to document remedy progress and efficacy.

5.4.2.2 Screening of Monitor and Maintain Existing Surfaces

Effectiveness

Alternative 2, Monitor and Maintain Existing Surfaces would provide some protection to human health and the environment. Long-term monitoring and maintenance of the existing interim caps and paved surfaces would verify that the surfaces remain intact, thereby preventing direct contact with the contaminated soils below. However, the existing caps would not reduce precipitation infiltration into the groundwater, nor would this alternative actively remediate the area where contaminants in the groundwater are above the GB groundwater criteria and where contaminants in the soil are above the GB leachability criteria. Periodic monitoring would be performed to verify that contamination left in place remained relatively immobile, and that no releases had occurred. ICs would be implemented to restrict any excavation activities on the site and prevent exposure to contaminated source area soils. Potential exposure to contaminated source area soils in several small landscape areas that are not paved or capped could still occur.

The existing interim caps and parking lots in the source area currently appear to be effective in limiting the leaching of contaminants into groundwater, except in the vicinity of Well MW-05S in the Brook Village parking lot where discharge of contaminated groundwater to the Woonasquatucket River occurs. Measures to prevent the migration of contaminated groundwater to the river are addressed with the groundwater alternatives (Section 5.5).

Because contamination above cleanup goals is located in wetland areas, there is no practical alternative to doing work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. This alternative will not comply with the ARARs for RCRA or TSCA closure, residential direct exposure, GB leachability, or EPA's recommended residential level for dioxin in soil (EPA, 1998b). These requirements must be met or waived in order for this alternative to meet CERCLA requirements. Short-term impacts to the local community would be minor because activities would be limited to maintenance activities. Long-term O&M activities, however, could result in the destruction of wetlands. This alternative provides some long-term protection because the existing surfaces, which cover the majority of contaminated soils in the source area, would continue to prevent

[48] Appendix N describes how the cleanup area would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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exposure to contamination as long as they are adequately monitored and maintained. However, potential exposure to contaminated source area soils at several small landscape areas could still occur. In addition, no action would be taken to address VOCs in soil that leach to groundwater. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 2, Monitor and Maintain Existing Surfaces is technically and administratively implementable at the CMRP site. Impacts to wetlands and floodplains would need to be minimized, and wetland restoration/replication would be required. Long-term monitoring, O&M of the existing surfaces, and ICs would not present any unusual issues.

Cost

The estimated total present worth costs for Alternative 2, Monitor and Maintain Existing Surfaces, would be very low (<$1 million).

Screening Result

Alternative 2, Monitor and Maintain Existing Surfaces is screened out because it does not comply with ARARs**.**

5.4.3 Alternative 3: Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

5.4.3.1 Description of Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

This alternative includes targeted excavation to remove principal threat waste and contaminated soil that exceed the TSCA and GB leachability criteria, as well as upgrading and maintaining the existing surfaces to prevent exposure to or migration of contaminated soil at the source area. Excavated material would be shipped off-site for disposal and/or treatment.

Conventional earth moving equipment would be used to excavate the principal threat waste and contaminated soil. Figure 5-28 shows the areas that would be excavated under this alternative.[49] The spatial extent of the principal threat waste excavation area encompasses the area interpreted as having the highest potential for containing buried bulk metallic materials (Roy F. Weston, 1999, see Section 2.4.5). The vertical extent of this excavation area is 4 ft bgs, which is based on the average fill thickness at the source area and confirmed by soil borings collected at this area (TTNUS, 2002). The TSCA/GB leachability excavation areas encompass all locations where there are chemical concentrations above the TSCA/GB leachability criteria.[50] Each location represents a polygon shaped area of contamination, where the spatial extent of the area extends approximately half-way between contaminated locations and clean locations. The vertical extent of these excavation areas ranges from 1 to 5 ft bgs, and encompasses

[49] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).
[50] The existing paved surfaces are considered an impermeable barrier. Contaminated soil beneath the paved surfaces with GB leachability exceedances would not be excavated; areas under paved surfaces with TSCA exceedances, however, would be excavated.

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the depth to clean (i.e., depth at which there are no exceedances of the cleanup goals). The total volume of source area soil that would be excavated under this alternative is 9,800 cy (does not include over-excavation allowance).

This alternative includes an initial assessment to identify design improvements needed to restore the existing interim caps to meet the requirements of the original designs; a more detailed analysis would be performed during design. After the principal threat waste and contaminated soil was removed, the existing interim caps, parking lots, paved surfaces, and rip rap areas shown in Figure 5-28 would be repaired where necessary. In addition, the existing interim caps would be extended to cover landscape areas within the proposed remedial footprint (Figures 3-5 and 5-28). Construction activities and production rates would be comparable to the isolation cap for floodplain soils (Section 5.2.4). The costs for this alternative assume that the cap upgrade would consist of removing vegetation, placing 1 foot of additional material over the existing interim caps, and hydro-seeding all capped areas to accelerate grass growth which would control soil erosion. The post-cap surface elevation would be increased by approximately 1 foot at all cap areas and landscape areas where the cap is extended. Upgrades to the parking lots would include placement of asphalt sealant over the entire parking lot areas.

Monitoring and ICs would be required because contamination above the residential direct exposure criteria would remain on site. Long-term O&M of the existing surfaces (caps, parking lots, paved surfaces, and rip rap) would be required. ICs would be implemented to prevent human exposure, and would include, but not be limited to, prohibiting future excavation, restricting access for buried utilities, preventing the construction of buildings with pilings or basements, and maintenance of the caps and parking lots. Periodic reporting would be required to document remedy progress and efficacy.

The disposal and/or treatment option includes:

Option 3e: Off-site Disposal and/or Treatment
Under Option 3e, principal threat waste, debris, excavated source area soils, and vegetation debris would be transported to a staging and processing area. Composite samples would be analyzed for dioxin, other contaminants, and TCLP to determine the designation of the materials and to determine which type of landfill is required or if the materials need to be treated prior to disposal. Once the appropriate disposal facility was identified, the excavated source area soil would be loaded onto trucks and taken to a regional rail loading facility for transportation to the disposal facility. The vegetation removed would be managed as hazardous debris and shipped off site for disposal and/or treatment.

5.4.3.2 Screening of Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

Effectiveness

Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces, and Disposal and/or Treatment would provide moderate protection to human health and the environment. This alternative would be effective in preventing direct contact with contamination by people who might use the source area, as long as the cover was properly maintained and monitored. Upgrades to the existing interim caps and parking lots in conjunction with extending the caps and/or paved surfaces to cover contaminated soils at landscaped areas and long-term O&M would also prevent surface erosion and exposure to the underlying contaminated source area soils. The disposal and/or treatment option proposed would provide reliable long-term protection because the contaminated material would be removed from the source area and shipped to a licensed facility for disposal and/or treatment (Option 3e).

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Because contamination above acceptable levels is located in wetland areas, there is no practical alternative to doing work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. This alternative will comply with ARARs for TSCA, residential direct exposure, GB leachability, and EPA's recommended residential level for dioxin in soil (EPA, 1998b). Without a waiver, however, this alternative would not comply with the Subtitle C closure regulations under RCRA. These requirements must be met or waived in order for this alternative to meet CERCLA requirements. There would be short-term impacts because construction activities could be disruptive to residents. However, all work would be performed in phases and actions would be taken during construction to minimize impacts to the community. Excavation would result in the destruction of existing wetlands. Placement of clean cover in the floodplain would result in the permanent occupancy and modification of the floodplain and destruction of existing wetlands, and would reduce flood storage capacity. This alternative would reduce the toxicity, mobility, or volume of contamination through treatment provided some of the material shipped off site for disposal requires treatment.

Implementability

Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment would be technically and administratively implementable at the CMRP site. The materials and equipment required to upgrade and maintain the caps are readily available from commercial vendors and there would be minimal engineering required for this alternative. There is limited space for staging areas; however, this should not present any significant issues because previous site actions have included construction of caps at the source area. Long-term monitoring and ICs would not present any unusual issues.

Resident concerns about disruptions from construction activities and impacts to floodplain and wetland areas would present some administrative implementability issues that would need to be assessed. Construction activities would occur in close proximity to the resident apartment buildings, and residents might raise concerns about disruptions during construction. All work would be performed in phases and engineering controls would be implemented to minimize impacts to the residents. Impacts to wetlands and floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity. Placement of clean cover material at the source area would require the permanent occupancy and modification of the floodplain and destruction of wetlands, and a determination would need to be made that there is no other practicable alternative before selection of this option as the preferred remedy.

Cost

The estimated costs for Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment would be very high (greater than $10 million).

Screening Result

Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment is carried forward for detailed analysis. This alternative would be moderately effective and is considered implementable. This alternative would result in the permanent occupancy and modification of the floodplain and destruction of wetlands, and a determination would first need to be made that there was no other practicable alternative.

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5.4.4 Alternative 4: Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

5.4.4.1 Description of Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

In this alternative, principal threat waste would be removed and the existing surfaces would be upgraded to meet the guidance for caps over unlined hazardous waste landfills in EPA, Region 1 (EPA, 2001b).

Conventional earth moving equipment would be used to excavate principal threat waste and the excavated material would be transported off site for disposal and/or treatment. Figure 5-29 shows the area that would be excavated under this alternative.[51] The spatial extent of the principal threat waste excavation area encompasses the area interpreted as having the highest potential for containing buried bulk metallic materials (Roy F. Weston, 1999). The vertical extent of this excavation area is 4 ft bgs, which is based on the average fill thickness at the source area and confirmed by soil borings collected at this area (TTNUS, 2002). The total volume of source area soil that would be excavated under this alternative is 5,500 cy (does not include over-excavation allowance).

After the principal threat waste was removed, the existing interim caps and parking lots would be upgraded to meet the guidance for caps over unlined hazardous waste landfills in EPA, Region 1 (EPA, 2001b). The RCRA cap specifications would also be TSCA compliant. In addition, the RCRA/TSCA caps would be extended to cover landscape areas within the proposed remedial footprint (Figures 3-5 and 5-29). Two cross-sections, designated S-1 and S-2, showing the placement of a RCRA/TSCA cap at the source area are shown in Figures 5-30a and 5-30b. The cross sections extend from the Woonasquatucket River on the west to Cap Area #3 on the east.

The guidance (EPA, 2001b) prescribes a cover system with the following components (listed from top to bottom); descriptions of the layers are described in detail in Section 6.8.3:

1. Topsoil Layer
2. Protective Soil Layer
3. Geotextile
4. Drainage Layer
5. Geomembane
6. Bottom Low-Permeability Layer
7. Gas Vent Layer (optional)
8. Base (leveling) Layer

In the three soil cap areas, the interim soil material previously placed would serve as the Base Layer, Gas Vent Layer and Bottom Low-Permeability Layer. The following work elements would be required to upgrade the existing soil covers:

1. Regrade the site to provide a minimum slope of 3%.
2. Install a Geomembrane Layer using 60 mil thick linear low density polyethylene (LLDPE) or HDPE.
3. Install a sand and gravel Drain Layer. For estimating costs in this FS, assume that imported sand and gravel would be used with a thickness of 12 inches.

[51] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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4. Install a geotextile on top of the Drain Layer to prevent fine-grained soil from the top layers from migrating into the pore spaces and reducing the permeability.
5. Install a Protective Soil Layer. For costing purposes, this is assumed to be 12 inches thick.
6. Install a Topsoil Layer. This is assumed to be 6 inches thick for this FS.

For the source area, a total thickness of 18 inches for the Topsoil and Protective Layers would be sufficient to protect the Drain Layer and Low-Permeability Layers. The use of a sand and gravel drain layer instead of a thinner geocomposite drain provides a total of 30 inches of soil over the geomembrane layer, which is more than the total of 24 inches shown in the EPA Region 1 Guidance. The climate at this site is more moderate than northern New England so a total thickness of 30 inches would be sufficient to protect the geomembrane from damage by frost or future use. The sand and gravel in the Drain Layer would not be susceptible to damage from frost or future use.

In the paved areas, the existing asphalt would be removed and recycled into new asphalt for the new paving. The existing soils under the pavement would serve as the Base Layer and Gas Vent Layer. The following work elements would be required to upgrade the existing pavement areas:

1. Remove and grind the existing asphalt.
2. Install a Bottom Low-Permeability Layer and regrade the site to provide a minimum slope of 3%. This layer could potentially be made using contaminated floodplain soil excavated as part of the Allendale and Lyman Mill floodplain soil alternatives.
3. Install a Geomembrane Layer using LLDPE or HDPE.
4. Install a sand and gravel Drain Layer. For estimating costs in the FS, assume that imported sand and gravel would be used with a thickness of 12 inches. Install a geotextile on top of the Drain Layer to prevent fine-grained soil from the top layers from migrating into the pore spaces and reducing the permeability.
5. Install a total of 12 inches of gravel base and asphalt pavement to replace the pavement and serve as the Protective Layer.

This would provide a total of 24 inches of gravel, sand or asphalt over the Geomembrane Layer, which would protect it from frost damage or from damage due to traffic loads.

Long-term monitoring requirements, ICs, and periodic reporting to document remedy progress and efficacy would be the same as described for Alternative 2 (Section 5.4.2.1). Excavated material and debris would be shipped off site for disposal and/or treatment (Option 4e) as described for Alternative 3 (Section 5.4.3.1).

5.4.4.2 Screening of Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

Effectiveness

Excavating principal threat waste and converting the existing interim caps and parking lots to RCRA/TSCA caps and maintaining them would provide highly effective and long-term, reliable protection of human health and the environment. The RCRA/TSCA caps would be impermeable and would prevent both direct exposure and leaching of contaminants from source area soil to the underlying groundwater. These engineered caps are widely used and field proven to be effective at isolating contaminated material and protecting human and ecological receptors from exposure to contaminated

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material. The disposal and/or treatment option proposed would provide reliable long-term protection because the contaminated material would be removed from the source area and shipped to a licensed facility for disposal and/or treatment (Option 4e).

Because contamination above acceptable levels is located in wetland areas, there is no practical alternative to doing work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. This alternative is expected to comply with ARARs for RCRA/TSCA closure, residential direct exposure and GB leachability, and EPA's recommended residential level for dioxin in soil (EPA, 1998b). There would be short-term impacts because construction activities could be disruptive to the residents; however, the implementation time would be relatively short (less than one year) and all work would be performed in phases and actions would be taken during construction to minimize impacts to the community. Excavation would result in the destruction of existing wetlands. Placement of clean cover in the floodplain would result in the permanent occupancy and modification of the floodplain and destruction of existing wetlands, and would reduce flood storage capacity. This alternative would reduce the toxicity, mobility, or volume of contamination through treatment provided some of the material shipped off site for disposal requires treatment. The mobility of the contamination would be reduced by the RCRA/TSCA caps.

Implementability

Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment would be technically and administratively implementable at the CMRP site as described for Alternative 3 (Section 5.4.3.2). Briefly, the capping technologies are field proven, the construction materials and equipment are readily available, and there would be minimal engineering requirements. There is limited space for staging areas; however this should not present any significant technical implementability issues because previous site actions have included construction of caps at the source area. Long-term monitoring and ICs would not present any unusual issues.

Resident concerns about disruptions from construction activities and impacts to floodplain and wetland areas would present some administrative implementability issues that would need to be assessed. Construction activities would occur in close proximity to the resident apartment buildings, and residents might raise concerns about disruptions during construction. All work would be performed in phases and engineering controls would be implemented to minimize impacts to the residents. Impacts to wetlands and floodplains would need to be minimized. Wetland restoration/replication would be required as well as replacement of flood storage capacity. Placement of clean cover material at the source area would require the permanent occupancy and modification of the floodplain and destruction of wetlands, and a determination would need to be made that there is no other practicable alternative before selection of this option as the preferred remedy.

Cost

The estimated costs for Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain, and Disposal and/or Treatment would be very high (greater than $10 million).

Screening Result

Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment is retained for detailed analysis because it is expected to be highly effective and implementable at the CMRP site. This alternative would result in the permanent occupancy and modification of the floodplain and destruction of some wetlands, and a determination would first need to be made that there was no other practicable alternative.

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5.4.5 Alternative 5: Excavation and Disposal and/or Treatment

5.4.5.1 Description of Excavation and Disposal and/or Treatment

Under Alternative 5, principal threat waste and contaminated source area soils beneath the existing surfaces (Figure 3-5) and above the groundwater table elevation would be excavated using conventional earth moving equipment and transported off site for disposal and/or treatment.

The volume of source area soil that would be removed under this alternative is 62,900 cy (does not include over-excavation allowance).[52] The practical depth of removal would be limited to the depth of the groundwater table, which varies with precipitation levels and climate throughout the year, but averages approximately 5 feet (Battelle, 2005a) at the source area.

Because the site contains two buildings with residential units, the work would be performed in multiple phases and underground utilities in the excavation area would be kept in service with temporary supply lines. The utilities would have to be replaced when the excavation was complete.

After the principal threat waste and source area soil were removed, they would be replaced with clean imported fill and the site grade restored. It would not be practical to leave the ground surface 5 ft lower than the current conditions because without filling, the ground surface would be below flood levels. In addition, the storm drains and sanitary sewer lines likely would not function if they were re-installed 5 feet deeper than current conditions. After the site was filled to grade, the pavement would be replaced and new topsoil and vegetation would be planted in the soil areas.

While a large volume of contaminated source area soil would be removed from the site under this alternative, it is not possible to completely remove all of the contaminated soil from the source area. The existing apartment buildings have to remain in service and contaminated source area soil beneath these buildings would not be removed as a result. Further, the groundwater table is controlled by the Woonasquatucket River and it is not practical to remove all soil below the groundwater table. Therefore, ICs similar to those currently in place would be required at the CMRP site to prohibit future excavation, restrict access for buried utilities and prevent the construction of buildings with pilings or basements.

Excavated material and debris would be shipped off site for disposal and/or treatment (Option 5e) as described for Alternative 3 (Section 5.4.3.1).

5.4.5.2 Screening of Excavation and Disposal and/or Treatment

Effectiveness

Alternative 5, Excavation and Disposal and/or Treatment would provide highly effective and long-term, reliable protection to human health and the environment because the principal threat waste and a majority of the contaminated soils would be removed and transported off site for disposal and/or treatment.

Because contamination above acceptable levels is located in wetland areas, there is no practical alternative to doing work in a wetland and so the focus would be on identifying the least damaging practicable alternative and minimizing impacts. This alternative is expected to comply with all ARARs because the majority of the contaminated soil would be removed and the excavation areas back-filled with clean fill. While engineering controls would be used to minimize short-term impacts and potential risk,

[52] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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the short-term impacts would be significant, primarily because dust and noise from the construction activities could pose a risk to residents during remedy implementation. It is unclear if excavation could be conducted safely given the close proximity of contamination to residences and residents of the two apartment buildings might need to be relocated during construction. Because of the age and health of the residents in these buildings, relocation could have significant impacts. Excavation would also result in the destruction of existing wetlands. The toxicity, mobility or volume of contamination would be reduced through treatment provided some of the material shipped off site for disposal requires treatment.

Implementability

Alternative 5, Excavation and Disposal and/or Treatment would be extremely difficult to implement due to significant logistical and administrative implementability issues. For example, it could be difficult to maintain functioning utilities during construction. This alternative could also potentially require that the residents of the two apartment buildings be relocated. Impacts to wetlands and floodplains would need to be minimized, and wetland restoration/replication would be required. This alternative would result in the destruction of wetlands, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

Cost

The estimated costs for Alternative 5, Excavation and Disposal and/or Treatment would be very high (>$10 million).

Screening Result

Alternative 5, Excavation and Disposal and/or Treatment is screened out primarily because of the significant short-term impacts and implementability issues including the potential need to relocate the residents of the Brook Village and Centredale Manor apartment buildings.

5.5 Source Area Groundwater Alternatives

The groundwater action area is located along the bank of the Woonasquatucket River (Figure 3-6) and includes riverbank wetland resource areas (Section 2.3.10). In areas where contamination is found above cleanup goals in wetland areas, there is no practical alternative to doing work in these wetland areas because this is where the contamination is located. As a result, EPA wetland requirements focus on identifying the least damaging practicable alternative and minimizing impacts to the wetland areas. This section presents a range of alternatives designed to achieve cleanup objectives and address contaminated groundwater at the source area. A total of five remedial alternatives are described and screened, some that rely on containment and others that rely on removal and/or treatment. Monitoring and ICs are common components to many of the groundwater alternatives, and all alternatives include five-year reviews.

Source Area Groundwater Alternatives

1	No Action
2	Excavation/Dewatering
3a	Hydraulic Containment Barrier
3b	Hydraulic Control through Pump and Treat
3c	Combined Hydraulic Barrier and Hydraulic Control
4	Permeable Reactive Barrier (Biowall)
5	In-Situ Chemical Oxidation

Shading represents alternatives retained for detailed evaluation in Section 6.0

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5.5.1 Alternative 1: No Action

5.5.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process to serve as the baseline condition. This alternative would entail no active remediation of the groundwater at the source area. Five-year reviews and periodic monitoring, triggered by severe weather events, would be performed to assess conditions, but these are not requirements. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative. RIDEM would maintain the GB groundwater classification, preventing the use of groundwater as a drinking water source although this is not a component of the alternative.

5.5.1.2 Screening of No Action

Effectiveness

Alternative 1, No Action would not provide effective protection to human health and the environment. No action would be taken to remove the contamination or prevent migration of contaminated groundwater to the Woonasquatucket River. This alternative will not comply with ARARs for state groundwater quality. Discharges of contaminants from the source area could continue to degrade water quality of the river and groundwater contamination at three locations in the source area exceeds the state GB groundwater objectives (see Section 2.4.3.2). There would be no short-term impacts because no action would be taken that could disrupt the local community or habitat. By itself, this alternative would not provide long-term protection because no action would be taken to address contaminated groundwater. This alternative would not reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

Alternative 1, No Action is technically and administratively implementable at the CMRP site because no physical construction would be required. Nor would this alternative require any institutional or access controls, O&M activities, or maintenance of existing features. The implementation of periodic monitoring would not present any unusual issues.

Cost

The estimated costs for the No Action alternative would be very low (<$1 million), and would include costs for periodic monitoring and five-year reviews.

Screening Result

Alternative 1, No Action is carried forward for detailed evaluation in accordance with the NCP.

5.5.2 Alternative 2: Excavation/Dewatering

5.5.2.1 Description of Excavation/Dewatering

This alternative is similar to the excavation and disposal and/or treatment alternative for source area soils (Alternative 5, Section 5.4.5), except that the aerial extent of the excavation footprint would be substantially smaller, focusing only on the groundwater-impacted area on the west side of the Brook Village parking lot (Figure 3-6). Excavation would also continue below the water table to remove all

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contaminant sources. In this alternative, groundwater within the impacted area would be lowered through pumping, exposed soil would be excavated using conventional earthwork equipment to a pre-determined depth, and additional dewatering within the excavation would continue for several days as needed. The excavated area would be backfilled with clean soil and the site restored.

The screening costs assume that approximately 1,300 cy of source area soil would be removed from the impacted area (Figure 3-6), resulting in approximately 80,000 gal of extracted groundwater for treatment. The source area soils would be stockpiled, characterized and transported off site for disposal and/or treatment, as discussed in the excavation alternative for source area soil (Section 5.4.5, Option 5e). Extracted groundwater would be temporarily stored in tanks until treated and discharged to the river. The water would be tested on a regular basis to confirm that chemical concentrations were at levels acceptable for return to the surface water in accordance with ARAR requirements.

This alternative includes ICs to maintain the groundwater classification, restricting future site groundwater use as a potential drinking water source. Periodic monitoring would be conducted in support of the five-year reviews.

5.5.2.2 Screening of Excavation/Dewatering

Effectiveness

Alternative 2, Excavation/Dewatering would provide moderately to highly effective protection to human health and the environment because the source of contamination to groundwater would be removed, thereby preventing migration of contamination to the river.

State wetlands and Clean Water Act Section 404 requirements would have to be evaluated for compliance. This alternative will comply with ARARs for state groundwater quality (the source area soil remedy will also address compliance with leachability criteria for the source area soil action area). Potential short-term impacts (e.g., noise and dust) to local residents during construction would be of short duration. In addition, engineering measures would be taken to minimize impacts to residents during construction. Excavation could result in the destruction of some riverbank wetland resource areas. This alternative would provide long-term protection because excavation allows for targeted, precise removal of contaminated soils that act as a continuing source of contamination to the groundwater, and there is minimal risk of residual contamination. The toxicity, mobility, or volume of contamination would be reduced through treatment because a portion of the soil transported off site would likely require treatment to meet LDRs (see Section 3.2.1.2).

Implementability

Alternative 2, Excavation/Dewatering would be technically and administratively implementable at the CMRP site. The excavation, dewatering, disposal and/or treatment technologies are field proven and have been implemented successfully on numerous projects. Construction equipment and personnel would be readily available from commercial companies in the region.

This alternative could present some administrative implementability issues that would have to be addressed. Construction activities could be disruptive to residents, although these activities would be contained to the Brook Village parking lot and engineering measures would be taken to minimize impacts to residents. Contaminated soils in the floodplain would be excavated, the area backfilled with clean soil and the floodplain restored at the completion of construction. Impacts to wetlands would need to be minimized and mitigated as necessary.

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Cost

The estimated cost for Alternative 2 would be low (between $1 million and $3 million), but will depend on the final volumes of source area soil excavated and groundwater dewatered, and the cost of off-site disposal and/or treatment (e.g., incineration).

Screening Result

Alternative 2, Excavation/Dewatering is retained for detailed evaluation because this alternative would be effective and implementable.

5.5.3 Alternative 3a: Hydraulic Containment Barrier

5.5.3.1 Description of Hydraulic Containment Barrier

A hydraulic barrier provides hydraulic containment by creating a physical barrier preventing groundwater flow. This alternative would include barrier installation, groundwater elevation monitoring, and ICs.

As presented in Section 4.4.3, physical barriers might be constructed using an injected slurry, a driven steel sheet pile, or cement or chemical grout injection. This technology has occasionally been implemented at contaminated groundwater sites at depths exceeding 50 or 60 ft.

Available monitoring data for the CMRP site indicate that groundwater flow at the source area is to the east-southeast and that the river recharges the aquifer everywhere except in the immediate vicinity of a small groundwater mound located beneath the Brook Village parking lot near MW-05S (see Section 2.3.7). This local groundwater high may be due to groundwater perched above a low-permeability silt lens or man-made structure (Battelle, 2005a). Because of the hydraulic mound, a successful hydraulic barrier would need to completely encircle the groundwater impacted area to effectively prevent further migration of contaminated groundwater to the river. In addition, because the confining bedrock is located 40 to 60 ft bgs, the hydraulic barrier would need to extend approximately 60 ft bgs. For purposes of the FS, a 350-ft perimeter, 60-ft deep barrier is estimated, as illustrated in Figure 5-31.

A number of techniques can be employed to prevent groundwater from bypassing a physical hydraulic barrier, including hydraulic control (e.g., French drains; groundwater pumping) and surface caps to prevent infiltration. For Alternative 3a, it is assumed that one of the source area soil alternatives would be selected with this alternative to prevent water infiltration into the hydraulically contained area, and that no groundwater extraction would be necessary. (Alternative 3a would be most effective when used in combination with Source Area Soil Alternative 4, which includes a RCRA cover that would prevent water infiltration into the hydraulically contained area.) Piezometers would be installed on each side of the barrier to ensure that groundwater does not build up within the containment barrier. If Alternative 3a was selected and proved ineffective in preventing groundwater flow to the river, hydraulic control could be added as a contingency. This option is explored separately in Alternative 3c (Section 5.5.5).

The present worth costs of Alternative 3a are based on a 30-year total implementation duration, consisting primarily of monitoring groundwater elevations throughout this period.

A hydraulic containment barrier would be expected to be compatible with current and future land uses at Brook Village. The hydraulic containment barrier would be located entirely underground, primarily under the existing parking lot. ICs would be required to prevent the exposure of groundwater as a result of excavation, demolition, or other activities. ICs would also be required to maintain the groundwater classification, restricting future site groundwater use as a potential drinking water source.

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5.5.3.2 Screening of Hydraulic Containment Barrier

Effectiveness

Alternative 3a, Hydraulic Containment Barrier would provide moderately effective protection to human health and the environment. While this alternative would not destroy contaminants, it would contain the contamination and prevent its migration to the river. The success of the alternative, however, depends on the ability of the surface cap to prevent infiltration. Also, the presence of NAPL could compromise the effectiveness if NAPLs migrate downward over time into the confining layer.

State wetland requirements would have to be evaluated for compliance. This alternative is expected to comply with ARARs for state water quality by preventing discharges of contamination from the impacted area that could continue to degrade water quality of the river. However, this alternative may not comply with ARARs for state groundwater quality, especially at Well MW-05S. Potential short-term impacts (e.g., noise and dust) to local residents during construction would be of short duration. In addition, engineering measures would be taken to minimize impacts to residents during construction. This alternative would provide long-term protection provided the containment barrier and surface cap are maintained. This alternative would not reduce the toxicity, mobility, or volume of contamination through treatment.

Implementability

Alternative 3a, Hydraulic Containment Barrier would be technically difficult to implement at the CMRP site. While hydraulic containment is a proven technology and the construction equipment and materials would be readily available, installation of a 60 ft deep hydraulic barrier into bedrock near a river at the site would be challenging. This alternative could present some administrative implementability issues that would have to be addressed. The large equipment required would cause some disruption to nearby residents, but the impact would be limited in time and scope (i.e., less than one year). Impacts to wetlands would need to be minimized and mitigated as necessary. Overall, the implementation of the hydraulic containment barrier alternative is considered low.

Cost

The estimated costs for Alternative 3a would be low (between $1 million and $3 million).

Screening Result

Alternative 3a, Hydraulic Containment Barrier is screened out because this alternative may not meet all ARARs and would be technically difficult to implement.

5.5.4 Alternative 3b: Hydraulic Control through Pump and Treat

5.5.4.1 Description of Hydraulic Control through Pump and Treat

Hydraulic control consists of hydraulic containment achieved through pumping and treatment of groundwater. Hydraulic control would include extraction well installation, pump and treatment, groundwater monitoring, and ICs.

As presented in Section 4.4.3, containment might be achieved by establishing hydraulic control of groundwater. As presented in Section 4.4.5, aboveground treatment of the extracted groundwater could

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consist of any number of physical, biological, or chemical treatment technologies. Physical treatment using separation, filtration, or adsorption processes would likely be the most cost effective for the CMRP site, and are commonly applied at groundwater sites.

Based on analysis of available site data, hydraulic control could be achieved throughout the impacted groundwater area using a single extraction well with an anticipated extraction rate of one (1) gallon per minute (gpm). Groundwater pumping would counteract the apparent groundwater mound located near MW-05S, and prevent further migration of groundwater from MW-05S towards the river. Additional monitoring wells would be installed to verify groundwater flow patterns. For purposes of the FS, one extraction well and two monitoring wells would be installed, as illustrated in Figure 5-32.

Depths of the extraction wells would be explored in the design phase. For purposes of the cost estimate, well depths to 20 ft bgs are assumed. Additional soil and groundwater characterization data would be collected during well installation.

Groundwater treatment would be achieved using physical treatment consisting of the following unit operations: an air stripper to remove high concentrations of VOCs, an advanced filtration system to remove dioxins, and carbon for further polishing. The treated groundwater would be tested on a regular basis to confirm that chemical concentrations meet ARAR requirements before discharge to the river. The groundwater treatment system would be housed in a building to protect equipment and to reduce noise and safety hazards to nearby residents.

System operation would consist of daily and weekly O&M labor, supplies, and utilities. In addition, groundwater elevations and concentrations would be monitored periodically (assumed quarterly during the first 5 years, then reduced to semiannually thereafter).

The present worth costs of Alternative 3b are based on a 30-year total implementation duration, consisting of groundwater pumping, system O&M, and groundwater monitoring throughout this period. The ICs required for this alternative would be the same as Alternative 3a.

5.5.4.2 Screening of Hydraulic Control through Pump and Treat

Effectiveness

Alternative 3b, Hydraulic Control through Pump and Treat would provide some protection to human health and the environment because it provides both containment and, to some extent, removal and treatment of contaminants, thus preventing migration to the river. State wetlands and Clean Water Act Section 404 requirements would have to be evaluated for compliance. This alternative is expected to comply with ARARs for state water quality. This alternative may not comply with ARARs for state groundwater quality, especially at Well MW-05S.

There would be some short-and long-term disruption to nearby residents during remedy implementation. This alternative would provide long-term protection because the contaminated groundwater would be hydraulically contained in the long term to prevent additional releases to surface water. There would be some reduction in the toxicity, mobility, or volume of contamination through treatment.

Implementability

Alternative 3b, Hydraulic Control through Pump and Treat would be technically implementable at the CMRP site. Hydraulic control is a proven technology, and the construction equipment and materials would be readily available.

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This alternative could present some administrative implementability issues that would have to be addressed. This alternative would require construction of a permanent groundwater treatment facility, and land would have to be obtained to locate the facility. If an upland area could not be acquired to locate the groundwater treatment facility, then a determination would need to be made that there was no practicable alternative before consideration could be given to locating this facility in the floodplain at the source area. If the groundwater treatment facility was located at the source area, it could cause some short- and long-term disruption to nearby residents. Impacts to wetlands would need to be minimized and mitigated as necessary.

Cost

The estimated costs for Alternative 3b, Hydraulic Control would be high (between $5 million and $10 million), primarily because of the long-term O&M required under this alternative.

Screening Result

Alternative 3b, Hydraulic Control through Pump and Treat is screened out because it may not meet all ARARs, there could be significant implementability issues siting a permanent groundwater treatment facility if an upland area is not available, and the relatively high costs associated with the long-term O&M expected for this alternative.

5.5.5 Alternative 3c: Combined Hydraulic Barrier and Hydraulic Control

5.5.5.1 Description of Combined Hydraulic Barrier and Hydraulic Control

This alternative combines the installation of a hydraulic barrier (Alternative 3a, Section 5.5.3), such as sheet piling, with hydraulic control using pumping and treatment (Alternative 3b, Section 5.5.4). This technology has been successfully implemented at a number of contaminated groundwater sites, most often using a French drain to collect groundwater accumulating in front of the hydraulic barrier.

5.5.5.2 Screening of Combined Hydraulic Barrier and Hydraulic Control

Effectiveness

Alternative 3c, Combined Hydraulic Barrier and Hydraulic Control would provide highly effective protection to human health and the environment because it provides both containment and, to some extent, removal and treatment of contaminants, thus preventing migration to the river.
State wetlands and Clean Water Act Section 404 requirements would have to be evaluated for compliance. This alternative is expected to comply with ARARs for state water quality by preventing discharges of contamination from the impacted area that could continue to degrade water quality of the river. This alternative may not comply with ARARs for state groundwater quality, especially at Well MW-05S. There would be short-term impacts to the nearby residents during both subsurface and aboveground construction work, and hence the nearby residents would be impacted more than with either Alternatives 3a or 3b (Sections 5.5.3 and 5.5.4). However, the short-term impacts would be of short duration (i.e., on the order of several months). Under this alternative, contaminated groundwater would be hydraulically contained in the long term to prevent additional releases to surface water. There would be some reduction in the toxicity, mobility, or volume of contamination through treatment.

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Implementability

Alternative 3c, Combined Hydraulic Barrier and Hydraulic Control would be technically implementable at the CMRP site. Hydraulic containment and control are proven technologies and the required materials and equipment would be readily available.

This alternative could present some administrative implementability issues that would have to be addressed. For example, this alternative would require construction of a permanent groundwater treatment facility, and land would have to be obtained to locate the facility. If an upland area could not be acquired to locate the groundwater treatment facility, then a determination would need to be made that there was no practicable alternative before consideration could be given to locating this facility in the floodplain at the source area. If the groundwater treatment facility were to be located at the source area, it could cause some short-term and long-term disruption to nearby residents. Impacts to wetlands would need to be minimized and mitigated as necessary.

Cost

The estimated costs for Alternative 3c would be high (between $5 million and $10 million), based on both large capital costs and the extent of long-term O&M required under this alternative.

Screening Result

As discussed in Alternative 3a, the effectiveness of a hydraulic barrier alone is uncertain at the CMRP site, and adding hydraulic control would effectively prevent groundwater from flowing over or below the hydraulic barrier. However, there are few advantages over Alternative 3b, which would be equally effective in preventing groundwater migration. Alternative 3c, Combined Hydraulic Barrier and Hydraulic Control is screened out based on high costs associated with the long-term O&M, difficulty in siting a treatment facility, and the alternative may not meet all ARARs.

5.5.6 Alternative 4: Permeable Reactive Barrier (Biowall)

5.5.6.1 Description of Permeable Reactive Barrier (Biowall)

Biowalls are one form of PRBs shown to be effective in providing passive in-situ groundwater treatment. Alternative 4 includes biowall installation, groundwater monitoring, and ICs. The proposed location of the biowall is shown in Figure 5-33.

A biowall is a PRB constructed of natural biological materials (such as tree mulch, compost, or other plant material) and/or activated carbon to provide a long-term carbon source. The biowalls provide a long-term carbon source to stimulate anaerobic degradation of contaminants in groundwater over a period of 10 years or more (Henry et al., 2005). Piping can be installed to allow soluble food-grade vegetable oil or a similar carbon substrate to be added to regenerate the biowall.

As groundwater flows through the biowall, VOCs would be removed through anaerobic dechlorination and biogeochemical processes. In addition, dioxins could be removed from groundwater through two mechanisms: (1) sorption and (2) biodegradation. Sorption would occur as colloids transporting mobilized dioxins (Hoffman and Wendelborn, 2007) were caught within the biowall and the dioxins, which are hydrophobic, sorbed onto the organic material present within the biowall. Anaerobic dechlorination of the dioxins would also proceed slowly within the aqueous phase (Krumins et al., 2007). Feasibility testing is recommended prior to full-scale implementation to evaluate how effective these dioxin removal mechanisms would be within the biowall.

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Installation of a passive biowall would likely not impact observed groundwater flow patterns. Hence, additional hydraulic control is not necessary. Groundwater monitoring wells would be installed along the wall to measure removal of VOCs and dioxins from groundwater.

For the purposes of this FS evaluation, the present worth costs of Alternative 4 are based on a 30-year total implementation duration, consisting primarily of monitoring to evaluate the effectiveness of the biowall and replenishment of the biowall with a degradable substrate at five-year intervals. Groundwater elevations and concentrations of VOCs and dioxin in groundwater upgradient and downgradient of the biowall would be monitored.

A biowall would be expected to be compatible with current and future land uses at Brook Village. The biowall would be located entirely underground, primarily under the existing parking lot. ICs would be required to prevent the exposure of groundwater as a result of excavation, demolition, or other activities. ICs would also be required to maintain the groundwater classification, restricting future site groundwater use as a potential drinking water source.

5.5.6.2 Screening of Permeable Reactive Barrier (Biowall)

Effectiveness

The effectiveness of Alternative 4, Permeable Reactive Barrier, is uncertain with regards to protection of human health and the environment. This alternative biodegrades VOCs and may immobilize dioxin contaminants, thus preventing their migration to the river while enhancing long-term reductive dechlorination of the dioxins. However, the success of this alternative depends on the ability of the biowall (1) to fully degrade VOCs and (2) to permanently remove dioxins from groundwater. PCE and TCE degradation forms the intermediary degradation products dichloroethene and vinyl chloride, which may accumulate if conditions are not sufficiently reducing. Bench scale testing may be needed to evaluate the potential for DCE-stall and whether bioaugmentation is warranted. Also, permanent removal of dioxins from groundwater using biowalls has not yet been demonstrated in field applications and therefore feasibility testing would be required to confirm the effectiveness.

State wetlands and Clean Water Act Section 404 requirements would have to be evaluated for compliance. This alternative may not comply with ARARs for state groundwater quality, based on leaving contaminants untreated upgradient of the biowall and based on the uncertain effectiveness of permanent treatment within the biowall. The large equipment required would cause some short-term impacts to nearby residents, but the disruption would be of short duration (i.e., less than one year). This alternative would provide long-term protection by the removal of VOCs from the contaminated groundwater; dioxins would also likely be removed but the long-term effectiveness of dioxin removal is uncertain. There would be some reduction in the toxicity, mobility, or volume of contamination through treatment.

Implementability

Alternative 4, Permeable Reactive Barrier would be technically and administratively implementable at the CMRP site. Biowall materials would be readily available from local vendors. Obtaining specialized deep trenching equipment and an experienced crew might require a mobilization from outside the region, but such firms do exist.

This alternative could present some administrative implementability issues that would have to be addressed. Construction activities would be disruptive to nearby residents. Impacts to wetlands would need to be minimized and mitigated as necessary.

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Cost

The estimated cost for Alternative 4 would be low (between $1 million and $3 million).

Screening Result

Alternative 4, Permeable Reactive Biowall is screened out because it may not meet ARARs and it is unproven with respect to removal of dioxins from groundwater.

5.5.7 Alternative 5: In-Situ Chemical Oxidation

5.5.7.1 Description of In-Situ Chemical Oxidation

As described in Section 4.4.6, in-situ chemical oxidation would involve the injection of an oxidizing agent such as ozone, hydrogen peroxide, or persulfate into the impacted groundwater in the vicinity of well MW-05S (Figure 3-6). The oxidizing agent would cause the rapid chemical destruction of chlorinated compounds in groundwater, including PCE, TCE, and dioxins. Although studies are limited, successful oxidation of dioxins has been demonstrated (Lundy, 2005).

The area to be treated is estimated as 50 ft by 100 ft and 12 ft deep. Periodic monitoring would be conducted to evaluate the effectiveness of the remedy, and to support the five-year reviews. ICs would be required to prevent the exposure of groundwater as a result of excavation, demolition, or other activities. ICs would also be required to maintain the groundwater classification, restricting future site groundwater use as a potential drinking water source.

5.5.7.2 Screening of In-Situ Chemical Oxidation

Effectiveness

Alternative 5, In-Situ Chemical Oxidation will destroy chlorinated solvents. While field applications for dioxins are limited, some or all of the dioxins might be directly oxidized and destroyed by the reagent. Therefore, the effectiveness depends on the ability of the reagent to contact and react with the dioxins and solvents. This, in turn, depends directly on (1) the adequacy of source zone characterization, and (2) adding sufficient reagent volume to contact and destroy the solvents. Subsequent applications might be needed if a rebound in contamination is observed; two to three applications are routine.

State wetlands requirements would have to be evaluated for compliance. This alternative is expected to comply with ARARs, although a waiver may be required if injections are made within 50 feet of the river. There would be limited short-term impacts to the local community during remedy implementation because the remediation activities would be confined to a very small area at the Brook Village parking lot and smaller equipment would be required compared to the other groundwater alternatives. Short-term impacts to habitat are a concern due to oxidation within 50 feet of the river, though these impacts would likely be minimized through the use of a fast-acting reagent focused on in-situ application within the impacted area of groundwater contamination. This alternative might be effective in the long term assuming dioxin destruction is effective. This alternative would reduce the toxicity, mobility or volume of contamination through treatment.

Implementability

There are some administrative implementability issues that would need to be addressed under this alternative. A waiver may be required if underground injections of chemical oxidants occur within 50 ft

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of a river. This ARAR could impede implementation of this technology, which is otherwise implementable at the CMRP site. Impacts to wetlands would need to be minimized and mitigated as necessary. As with other groundwater treatment alternatives, obtaining the specialized equipment and an experienced crew might require mobilization from outside the region, but such equipment and staff are commercially available.

Cost

The estimated costs for Alternative 5 would be low (between $1 million and $3 million), but will depend on the size of the treated area and the number of injections required. There would be minimal long-term operation costs required.

Screening Result

Alternative 5, In-Situ Chemical Oxidation is retained for detailed evaluation because this alternative is expected to be moderately effective and implementable, and has low costs.

5.6 Alternatives Retained for Detailed Analysis

Alternatives discussed above were screened based upon the screening criteria required by the NCP. With the exception of No Action, alternatives that are not protective of human health and the environment or do not comply with ARARs (except where conditions for an ARAR waiver exist) were screened out. Based on the screening evaluation, the following remedial alternatives are developed in more detail in Section 6.0, along with the No Action alternative (Alternative 1).

Allendale and Lyman Mill Reach Sediment

- a full excavation alternative with the dams remaining in place (Alternative 7) or with the dams replaced with new weir structures (Alternative 10), and
- a partial excavation and isolation capping alternative with the dams remaining in place (Alternative 8) or with the dams replaced with new weir structures (Alternative 11, water body configuration comprised of river channel and small ponds).

Allendale Reach Floodplain Soil

- a full excavation alternative (Alternative 5).

Lyman Mill Reach Stream Sediment and Floodplain Soil (Including Oxbow)

- a targeted excavation and ENR alternative (Alternative 3), and
- a partial excavation and ENR alternative (Alternative 5).

Source Area Soil

- a targeted excavation and cap upgrade alternative (Alternative 3), and
- a targeted excavation and RCRA cap alternative (Alternative 4).

Source Area Groundwater

- an excavation and dewatering alternative (Alternative 2), and
- in-situ treatment using chemical oxidation (Alternative 5).

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6.0 DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

In this section, the remedial alternatives that were developed to address contaminated sediment, soil, and groundwater at the CMRP site and were retained from the screening analysis (Section 5.6) are evaluated in more detail. This evaluation is performed in two stages. The first step is to evaluate each remedial alternative individually against the NCP criteria. The second step is to perform a comparative analysis of all of the alternatives relative to each other using the same criteria. The alternatives are compared so that the key tradeoffs among them are identified. This approach to analyzing alternatives is designed to provide sufficient information to adequately compare the alternatives, select an appropriate remedy for a site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD.

6.1 NCP Evaluation Criteria

The NCP, 40 CFR Section 300.430(e)(9)(iii), describes nine criteria to be used for a detailed analysis of alternatives after the remedial alternative screening is complete. The criteria fall into three categories: threshold, primary balancing, and modifying, as described below.

Threshold criteria are factors that an alternative must meet in order to be eligible for selection; these criteria relate directly to statutory findings that must ultimately be made in the ROD. The two threshold criteria are as follows:

- Overall protection of human health and the environment, and
- Compliance with ARARs.

Five primary balancing criteria are used to evaluate those alternatives that meet the threshold criteria. The level of detail required to analyze each alternative against these evaluation criteria depends on site- and project-specific factors, as well as the technologies under consideration. This analysis is conducted with sufficient detail so that the significant aspects of each alternative and any uncertainties associated with the evaluation are understood. The primary balancing criteria are as follows:

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

Finally, two modifying criteria need to be considered. The assessment of the modifying criteria is generally not completed until after state and public comments on the Proposed Plan are received. The two modifying criteria are identified as:

- State acceptance, and
- Community acceptance.

Each of these nine criteria is discussed in greater detail below.

6.1.1 Overall Protection of Human Health and the Environment

Each alternative must be assessed to determine whether it can adequately protect human health and the environment. The evaluation of the overall protection of human health and the environment for each alternative draws upon the factors assessed under other evaluation criteria. The criteria specifically

considered are long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

This assessment focuses on whether a specific alternative achieves adequate protection, and describes how the site risks posed through the exposure pathways addressed in the FS are eliminated, reduced, or controlled through treatment, engineering, or ICs. This evaluation also considers whether an alternative poses any unacceptable short-term or cross-media impacts.

6.1.2 Compliance with ARARs

This criterion is used to determine whether an alternative will comply with the federal and state ARARs introduced in Section 3.2 and identified in Table 3-1; alternative-specific ARARs are identified in the detailed evaluation of alternatives. ARARs are those cleanup standards, standards of control, or other substantive environmental protection requirements promulgated under federal or state environmental laws. Only substantive portions of laws and regulations are ARARs (ARARs do not include administrative or procedural requirements). In addition, under CERCLA, permits are not required to be obtained for actions conducted on site and only the substantive requirements thereof must be met. The detailed analysis for each alternative summarizes which requirements are applicable or relevant and appropriate, and describes how the alternative meets the requirements.

"Applicable" requirements are those substantive environmental requirements that specifically address a hazardous substance, pollutant, contaminant, remedial action, or other circumstance found at a CERCLA site. "Relevant and appropriate" requirements are such standards that, while not applicable, address problems or situations sufficiently similar to those encountered at the site where their use is indicated.

The following three types of ARARs are addressed for each alternative:

- compliance with chemical-specific ARARs (e.g., maximum contaminant levels);
- compliance with location-specific ARARs (e.g., preservation of historic sites, protection of wetlands); and,
- compliance with action-specific ARARs (e.g., RCRA minimum technology standards)

According to EPA (1996b), a waiver is available under CERCLA if any one of six bases exists with respect to the remedial alternative, as follows:

1) The alternative is an interim measure that will become part of a total remedial action that will attain the ARAR;
2) Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
3) Compliance with the requirement is technically impracticable from an engineering perspective;
4) The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method;
5) With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or

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6) For Superfund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites.

6.1.3 Long-Term Effectiveness and Permanence

The long-term effectiveness criterion addresses the ability of an alternative to maintain reliable protection of human health and the environment over time once the RAOs (cleanup objectives) have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. This assessment of long-term effectiveness is made considering the following two major factors:

- the magnitude of the residual risk posed by waste remaining at the completion of remedial activities, and
- the adequacy and reliability of controls.

Residual risks consider the volume, toxicity, mobility and bioavailability of the untreated waste and treatment residuals and residual contamination, as well as their propensity to bioaccumulate (EPA, 1988; 2005). As a component of the overall comparative analysis, the residual risks associated with a given action-based alternative are compared to the total site risk associated with current conditions when contrasted to the no-action alternative.

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element.

This evaluation considers the following specific factors:

- the treatment processes employed and the materials treated;
- the amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated including how the principal threat(s) will be addressed or recycled;
- the degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude);
- the degree to which the treatment will be irreversible;
- the type and quantity of treatment residuals that will remain following treatment; and
- whether the alternative would satisfy the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

Short-term effectiveness refers to control of adverse impacts on human health and the environment posed during the construction and implementation of an alternative until remedial response objectives are achieved. Alternatives should be evaluated with respect to their effects on human health and the environment during implementation of the proposed remedial action including the length of time until protection is achieved.

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6.1.6 Implementability

The implementability criterion refers to the technical and administrative feasibility of implementing a given remedial alternative. Implementability refers to the ease or difficulty of implementing an alternative considering the following factors, as appropriate:

- technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy;
- administrative feasibility, including activities needed to coordinate with other offices and agencies; and,
- availability of services and materials, including the availability of adequate off-site treatment, storage capacity and disposal services; the availability of necessary equipment and specialists and provisions to ensure any necessary additional resources; the availability of services and materials including the potential for obtaining competitive bids; and the availability of prospective technologies.

6.1.7 Cost

The cost criterion refers to the initial capital cost to design, purchase, construct, and implement the remedial alternative, as well as the cost of operating and maintaining the alternative. For each remedial alternative, a cost estimate is developed based on conceptual engineering data, unit costs available from EPA guidance documents when available, costs developed based on treatability tests, other literature available, vendor quotes, and engineering design experience. The cost estimate for a remedial alternative consists of three principal elements:

- Capital Costs: Capital costs consist of direct (construction) and indirect (non-construction and overhead) costs. Direct costs include the cost for equipment, labor, and materials incurred to develop, construct, and implement a remedial action. Examples of direct costs include expenses for construction, equipment, land and site-development, buildings and services, relocation, and disposal. Indirect costs include expenditures for engineering, financial, and other services that are not part of the actual installation activities but are required to complete the installation of remedial activities. Examples of indirect costs may include pre-design sampling, design, construction quality control and quality assurance, engineering expenses, license and permit costs, startup and demobilization costs, and contingency allowances.
- Annual O&M Costs: Annual O&M costs refer to the post-construction cost items that are necessary to ensure the continued effectiveness of a remedial action. These costs typically consist of long-term power and material costs (primarily applicable to the operational costs of a water treatment facility), equipment replacement costs, and long-term O&M costs.
- Present Worth Analysis: This type of analysis is used to compare expenditures for various alternatives that may occur over different time periods by evaluating all of the costs on a common base year. This allows the costs for different remedial action alternatives to be compared on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life.

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As stated in the EPA guidance for preparing cost estimates for feasibility studies (EPA, 2000b), the recommended discount rate of 7% should be used. The discount rate represents the time value of money. As specified in the FS guidance, a 30-year performance period is assumed for all alternatives. The remedial design and construction actions would be implemented in a shorter time period, but cost estimates for ICs, maintenance and long-term activities are based on a 30-year time period in those alternatives where contaminated sediment, soil, or groundwater remains on the site. This does not mean that the monitoring or maintenance and operations would stop after 30 years. Monitoring and five-year reviews could continue indefinitely.

The alternatives have been developed conceptually in this FS using the data available from the investigation reports, and the cost estimates are intended to reflect the actual cost of the remedial alternative to within an accuracy of +50% to -30%. The estimated costs presented in this report are prepared for alternative comparison and selection of the recommended remedial action. The costs are based on the information available at the time of the estimate; cost estimates include the acquisition of property associated with remedy implementation. The actual costs of remediation depend on many variables, including quantity of contaminated sediments, disposal fees, health and safety regulations, ARAR requirements, labor and equipment costs, and the final project scope. As a result, the final project costs will vary from the estimates presented herein. Costs are expected to be within the range of accuracy typical for FS or conceptual engineering cost estimates (+50% to -30%). Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper evaluation and adequate funding.

6.1.8 State Acceptance

This criterion evaluates the position and key concerns of the State of Rhode Island related to the alternatives. This assessment will not be completed until comments on the FS and Proposed Plan are received. Responses to state concerns and comments would be documented in the ROD.

6.1.9 Community Acceptance

This criterion evaluates the issues and/or concerns raised by the public regarding each of the alternatives being considered. This assessment will not be completed until comments on the FS and Proposed Plan are received. Comments may be submitted during the public comment period.

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6.2 Detailed Evaluation of Allendale and Lyman Mill Sediment Alternatives

The five Allendale and Lyman Mill sediment alternatives retained from the screening analysis are described further in this section and are evaluated against the NCP criteria (excluding State and Community Acceptance, which are considered after comments to the FS and Proposed Plan are received). All alternatives include five-year reviews. The excavation alternatives assume that implementation of a sediment remedy would be performed in an upstream to downstream direction (beginning at Allendale reach) to prevent re-contamination of excavated areas within the river/ponds. The Allendale and Lyman Mill Dams should also be inspected prior to implementing a sediment remedy.

Allendale and Lyman Mill Reach Sediment Alternatives Retained for Detailed Analysis

1	No Action
7	Excavation and Disposal and/or Treatment
8	Partial Excavation, Isolation Capping and Disposal and/or Treatment
10	Dam Replacement, Excavation and Disposal and/or Treatment
11	Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

6.2.1 Alternative 1: No Action

6.2.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process, and is used as a basis of comparison to the other alternatives. This alternative would entail no active remediation of the contaminated sediments. Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. For cost estimating, it is assumed that there would be one biological survey (annual sampling and fish tissue chemistry testing) and report to EPA on the conditions of the site every five years.

Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

6.2.1.2 Evaluation of No Action

Results from the evaluation of Alternative 1, No Action against the NCP criteria are discussed below and summarized in Table 6-1.

Overall Protection of Human Health and the Environment

This alternative would not provide effective protection because contaminated sediment that presents a risk to human health and the environment would remain on site unaddressed. With the exception of VOC-contaminated groundwater discharge to the river at the Brook Village parking lot, most sources of contamination to the sediment have been controlled, and natural recovery may reduce risk to human health and the environment by reducing the contaminant concentrations in the surface sediment over time. However, there would be no data to demonstrate this reduction and no monitoring of natural recovery processes or contingency action to limit or control future migration of sediment contamination. Moreover, natural recovery is expected to take a long time (i.e., 40 to 60 years for 1 foot of clean sediment to deposit; see Section 2.3.8) based on the estimated sedimentation rates at Allendale and Lyman Mill Ponds.

Compliance with ARARs

ARARs specific to the No Action alternative are summarized in Table 6-2.

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Long-Term Effectiveness and Permanence

The No Action alternative would not be effective in the long term because no action would be taken to contain, reduce erosion and downstream transport, or remove the contaminated sediment that presents a risk. The residual risk remains high as no actions are taken to address sediment and no controls are in place to adequately and/or reliably prevent exposure in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment

There would be no reduction of toxicity, mobility or volume of contamination through treatment.

Short-Term Effectiveness

This alternative would be highly effective in the short term because there would not be any intrusive work into the contaminated sediments that could disrupt the local community or environment or present a risk to on-site workers. However, it would not achieve the cleanup objectives.

Implementability

This alternative would be easily implemented because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., dams and fences). The implementation of periodic monitoring would not present any unusual issues.

Cost

Detailed cost estimates are presented in Appendix J. There would be no capital associated with the No Action alternative; however, periodic monitoring and five-year reviews are estimated to cost $36,000, resulting in a total present worth cost of approximately $450,000.

6.2.2 Alternative 7: Excavation and Disposal and/or Treatment

6.2.2.1 Description of Excavation and Disposal and/or Treatment

In Alternative 7, Excavation and Disposal and/or Treatment, contaminated sediment with contamination above the cleanup goals would be removed using excavation. Prior to excavation, the pond water elevations would be lowered so that the exposed sediment could be excavated using conventional earthwork equipment. The water level in Allendale Pond would be lowered by opening the gates at the Allendale Dam and letting the water drain. In order to minimize the amount of suspended sediment transported downstream, the gates would be lowered incrementally and the water would be discharged at a controlled rate. In addition, a turbidity barrier would be installed upstream from the dam gate structure to reduce the potential for migration of suspended sediment downstream from the gate structure. The water level for Lyman Mill Pond could be incrementally lowered by pumping around the dam or by repairing the gates at the dam.[53] The actual method used would be determined during final design if this alternative is selected; however, costing estimates in this FS assume that the gates would be repaired and gravity drainage used to lower the water level.

[53] The gates are not currently operational and would require repair prior to initiating the construction sequence.

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Disposal and/or treatment options are described in more detail below and include: Option 7a, On-site Containment in an Upland CDF; Option 7b, On-site Containment in a Nearshore CDF; Option 7d, On-site Thermal Treatment and Option 7e, Off-site Disposal and/or Treatment. The work in the pond areas would be the same for each option, except as noted in the following paragraphs.

The river channel, within the ponds and north of Allendale Pond, would still be present. As presented in Section 2.3.9, the mean average flow in the Woonasquatucket River at Centredale ranged from 50 to 100 cfs in most years. The flow increases significantly during flood events and the estimated flows are 893 and 2,300 cfs for flood return periods of 5 and 100 years, respectively. The areas of active sediment removal would be separated from the active river channel by a hydraulic barrier. For purposes of estimating costs in this FS, it is assumed that steel sheet pile would be driven along the length of the ponds to separate removal areas from river flow. The removal work would be done on the west side of the barrier while the river flowed on the east side, and then the flow would be switched for removal on the east side.

During design and work plan preparation, contingency plans would be developed to handle the flood flows that may occur during the time of sediment excavation. Since the removal of sediment would take several months (as described below), it is likely that some flooding would occur during the time this work is conducted. The flood flows could be handled by one half of the pond area outside the work zone, thereby not impacting the construction activities.

In order to attain the RAOs (cleanup objectives) related to biota consumption (Section 3.1.1) as quickly as possible, an attempt will be made to collect all fish stranded during the construction phase. All stranded fish would be euthanized and taken off site for disposal. Disposal of stranded fish will prevent secondary contamination of sensitive species via scavenging of contaminated fish and prevent disease generation from decaying biomass. No attempt to collect other aquatic animals such as turtles and amphibians would be made because much greater resources would be required to collect them (i.e., these biota would not be stranded like fish once the pond water was withdrawn) and they do not appear to pose as significant an exposure threat to humans and wildlife receptors at the site. The removal of resident fish from the ponds would effectively reduce the fish consumption risks to humans and piscivorous wildlife immediately although the temporary loss of this resource would impact aquatic-dependent wildlife species until the fishery had recovered (see further discussion in Appendix K).

The surface sediment in both ponds is very soft and would not be able to support wheeled vehicles, even after drying for several days. In this case, low-ground pressure equipment would be used (i.e., crawler mounted equipment with extra-wide tracks). In areas too soft to even support low-ground pressure equipment, hydraulic excavators with extra-long booms would be used to remove sediment. The excavators would work from a network of temporary roadways that could be constructed using gravel or mats placed over the sediment after the water level was lowered.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples), and the excavated sediment would be disposed of and/or treated. The sequence of excavation activities, excavation volumes and rates, sediment processing, mitigation/restoration activities, long-term monitoring and ICs, and disposal or treatment options are described below.

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Construction Sequence

A typical construction sequence for disposal Options 7a, 7d and 7e is described below:

1. Clear temporary work areas and build access ramps to the ponds.
2. For the on-site disposal options, construct CDF disposal facility and water treatment system prior to sediment removal.
3. Construct sediment dewatering area, install dewatering equipment and water treatment equipment and truck loading and decontamination facilities prior to excavation.
4. Drain the ponds one at a time beginning with Allendale Pond, excavate sediment from the ponds in an upstream to downstream direction, dewater using mechanical means and move excavated material into the CDF or transport off site for disposal.
5. For the on-site disposal options, operate the CDF water treatment system during excavation.
6. For the on-site disposal options, place a cap over the CDF.
7. Evaluate sediment confirmation samples and determine need for a thin-layer of soil cover.
8. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

A typical construction sequence for disposal Option 7b (on-site nearshore CDF) is similar to Option 7a, except that the CDFs would be constructed within the pond footprint and excavated sediment would not be dewatered, as described below:

1. Clear temporary work areas and build access ramps to the ponds.
2. Drain the ponds one at a time beginning with Allendale Pond and construct perimeter containment walls for the CDF.
3. Install water treatment equipment and truck loading and decontamination facilities prior to excavation.
4. Excavate sediment from the ponds in an upstream to downstream direction and consolidate excavated material into the CDF.
5. Place a cap over the CDF. The cap would be designed to resist erosion during flood events.
6. Evaluate sediment confirmation samples and determine need for a thin-layer of soil cover.
7. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

Excavation Volumes and Rates

Estimated excavation surfaces for Allendale and Lyman Mill Ponds (Figures 5-1 and 5-3) are the same as presented in Section 5.1.7. These surfaces were developed using the available chemistry and geotechnical data for surface and subsurface sediment samples in each pond.

- For Options 7a, 7d and 7e, the total volume of sediment requiring excavation was calculated to be 155,800 cy (2,400 cy in the river channel north of Allendale Pond, 52,900 cy in Allendale Pond and 100,500 cy in Lyman Mill Pond). The back-calculated, average

excavation depth in Allendale Pond is 2.2 ft and 2.7 ft in Lyman Mill, assuming an over-excavation thickness of 0.25 ft.

- For Option 7b, the contaminated sediment within the perimeter of the CDFs would not have to be excavated (Figure 5-12). The total volume of sediment requiring excavation under Option 7b was calculated to be 123,500 cy (2,400 in river channel north of Allendale Pond, 44,300 cy in Allendale Pond and 76,800 cy in Lyman Mill Pond; 32,300 cy within the CDF footprint would remain in place).

The rate of excavation would be controlled by the rate of material transport from the ponds to the sediment processing area and the rate of mechanical dewatering. It is assumed that one long-reach excavator working to remove a thin layer of soft sediment would remove about 400 in-situ cy/day for Options 7a, 7d and 7e and 500 cy/day for Option 7b. This volume could be dewatered (Options 7a, 7d, and 7e only) with modular equipment that could be delivered by trucks and stockpiled on the site. For Options 7a, 7d and 7e, sediment excavation would take approximately 28 weeks for Allendale Pond and 50 weeks for Lyman Mill Pond. For Option 7b, sediment excavation would take approximately 19 weeks for Allendale Pond and 31 weeks for Lyman Mill Pond.

Sediment Processing

Except for Option 7b, it is assumed that the excavated sediment would be dewatered, and after dewatering, the sediment would be placed and compacted in a CDF using conventional earthwork equipment or stockpiled to await on-site treatment or off-site disposal/treatment. Because space is limited at the CMRP site, mechanical dewatering would be employed and the dewatered sediment (filter cake) would then be handled with conventional earthmoving equipment to place into stockpiles or into a CDF. If the material was being disposed off site, the material would be properly characterized and classified and then loaded onto trucks for transport to an appropriately licensed disposal facility. (Under Option 7a, sediment would be characterized during the remedial design phase.) Mechanical dewatering would reduce the overall volume of contaminated sediment for disposal or treatment by approximately 37%.[54]

Water separated from the excavated material would be pumped to a treatment system. The treatment system would consist of a settling basin sized to provide time for suspended sediment to settle, followed by additional treatment as necessary to meet discharge criteria. The water would be tested on a regular basis to confirm that chemical concentrations were at levels acceptable for return to the surface water in accordance with ARAR requirements. The costs in this FS are based on the assumption that treatment by sand filtration and activated carbon adsorption would be sufficient. However, this would be evaluated in further detail as part of the final design.

Upland space would be required for the mechanical dewatering and water treatment facilities. In addition, it is assumed that the dewatered sediment would be stockpiled and tested for designation prior to off-site disposal to determine if the material could be placed into a solid waste landfill, hazardous waste landfill or require treatment prior to disposal.

Testing sediment samples for dioxins is a complicated analysis and cannot be performed quickly; the standard turn-around time is 3 weeks. Removal of 2,000 in-situ cubic yards per week would produce approximately 1,100 cy of dewatered sediment for disposal. The material could be stored between concrete blocks stacked 6-ft high on temporary asphalt pavement pads. The volume of material generated

[54] Dewatering to increase the sediment solids content from an average of 40% in Allendale and 32% in Lyman Mill to 50% by weight, would reduce the disposal/treatment volume from 155,800 cy to 97,700 cy. It is assumed that no volume reduction would be obtained in the 2,400 cy dredged from the river channel.

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in one week would require a storage area of approximately 5,000 square feet or an area of 50 ft by 100 ft. A storage area large enough to contain the material from 4 weeks of removal activities would be needed due to the standard turn-around time for dioxin testing. The sediment stockpiles would be covered to prevent infiltration of rainwater, which would increase the sediment weight and decrease the strength. Simply covering the stockpiles with tarps is not sufficient because they cannot keep all the water out and are labor intensive to install, maintain and remove. The sediment would need to be stockpiled under temporary "car-port" type structures with a roof and walls on three sides. These structures could be pre-engineered steel buildings or buildings made from fabric placed over a steel or aluminum frame and placed over the asphalt and concrete pads described above.

An area of 2 to 3 acres would be required for the treatment equipment and sediment stockpiles. One possible location would be on Cap Area #1 in the source area. The cap area is approximately 85,000 square feet (2 acres). For Option 7b, no dewatering would be needed because the wet sediment could be placed directly into the nearshore CDFs.

Cover Placement

It is conservatively estimated that there could be areas of the river/ponds where dioxin concentrations remain above the cleanup goals, even after excavation. Deeper excavation over a significant percentage of the surface area is considered to be impractical because of the limited capacity of the on-site disposal areas and the high cost of off-site disposal and/or treatment options. In addition, this cover, if needed, will result in risk reduction sufficient to meet RAOs. Therefore, this alternative includes a contingency to place a thin-layer cover over areas of the ponds where dioxin concentrations are above the cleanup goals after excavation (based on evaluation of confirmation samples). The cover thickness and composition would be determined during the design phase, but a six inch cover comprised of sand is assumed for costing purposes (a thinner cover would be difficult to place using routine construction equipment, and would not be as protective as a 6 inch cover).

Mitigation

With the exception of Option 7b (nearshore CDF) and possibly Option 7a (upland CDF), there would be no loss of aquatic or wetland/floodplain area associated with this alternative. However, remedy implementation would involve the destruction of an existing aquatic habitat structure (both benthic and pelagic) and the temporary extirpation of the vast majority of the fish[55] and invertebrate communities. Secondary impacts include the markedly reduced aquatic productivity anticipated in the years following implementation of the remedy that will impact aquatic-dependent wildlife and anglers that fish in these ponds. Collateral impacts to floodplain soils, including destruction of vegetation and soil compaction, are also anticipated due to the movement of heavy machinery across the floodplains to access existing aquatic areas during remediation.

Figure 6-1 presents an overview of the different habitat features associated with this alternative and possible mitigation components for each. If a thin layer cover was necessary (contingency to address cleanup goal exceedances), it could be designed as a benthic habitat layer consisting of optimal grain size and organic carbon content for growth of benthic and epibenthic macroinvertebrates and submerged woody material could be included to provide some interim structural diversity. Populations of important species such as bass and sunfish could be re-stocked to expedite recovery of the community. The movement of heavy equipment across the floodplain could be limited to as few access points as possible and weight-dissipating structures could be laid down to distribute the weight so that soil compaction

[55] Resident fish would be collected and euthanized to ensure that the contaminated fish consumption pathway was reduced as part of the remedy implementation.

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concerns were minimized to the extent possible. Following implementation of the sediment remedy, the impacted floodplain soil could be manually aerated[56] and then revegetated with appropriate floodplain/riparian shrubs and tree species.

Option 7b (nearshore CDF) would involve the permanent loss of approximately 11 acres of aquatic habitat (approximately 4 acres in Allendale Pond and 7 acres in Lyman Mill Pond; Appendix K, Table K-1). Out-of-kind mitigation for this lost habitat could be provided adjacent to the river, most likely along the western shore of Lyman Mill Pond[57] and developing a permanent buffer zone. In addition, historical filling activities near the southwestern corner of the Oxbow Area and possibly at the confluence of Assapumpset Stream with the river provide opportunities for wetland restoration.[58] The fill material could be removed, the original soil material tested for contamination (and further excavated as necessary), the land surface graded to re-establish proper wetland hydrology and then replanted to develop 11 acres of emergent marsh, scrub/shrub or palustrine forest habitat as specified in the mitigation planning document. Appendix K provides an overview of possible mitigation requirements and planning for the sediment action area.

Long-Term Monitoring, Dam Maintenance and Institutional Controls

Long-term monitoring is included in this alternative because it is conservatively estimated that some contamination might remain in the ponds after excavation, even after RAOs have been achieved. Long-term monitoring and ICs would be required for on-site containment Options 7a and 7b (upland and nearshore CDFs). Long-term monitoring is also necessary to confirm that this alternative remains protective in the long term and to support five-year reviews. Details of the monitoring plan would be developed during final design. The general approach for monitoring and the assumptions used to estimate annual costs are described in a conceptual long-term monitoring approach presented in Appendix H.

Sediment monitoring would be performed to confirm that the sediment is meeting cleanup objectives. The monitoring program would also include benthic community analysis, surface water chemistry to assess water quality, and fish chemistry to determine progress in achieving the biota tissue targets (Appendix F, Attachment F-1). Monitoring downstream of the Lyman Mill Dam would also be performed to assess impacts of the remedial action on the downstream areas. Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results will be used by the Agencies to determine if additional evaluations or clean-ups are warranted.

Any disposal facilities constructed on site (Options 7a and 7b) would require long-term monitoring, maintenance and ICs to protect the integrity of the facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDFs (e.g., limit the size of woody vegetation on top of the CDFs, prevent the construction of buildings with basements or burial of utilities on or in the CDF cap). Maintenance of the Allendale and Lyman Mill Dams would be required to ensure that the dams remain structurally sound and stable for any options where inherent hazard remains in the river or floodplain.

[56] If the floodplain soil within the particular access point was also within the soil footprint, then it would be remediated concurrently with the sediment and the aeration step would not be necessary.
[57] Several candidate locations along the western edge of Lyman Mill Pond include the mouth of Assapumpset Stream and former wetland situated southwest of the river channel remnant in the Oxbow area (Appendix K, Figure K-1), which was filled sometime between 1962 and 2003 (USACE, 2008). The USACE report also identified a couple other potential restoration opportunities along the eastern shoreline of Lyman Mill Pond (see Figure 6 in USACE, 2008).
[58] Low-value wetland habitat is present within the boundary of this area which has been proposed as a potential upland CDF location (Appendix K, Figure K-1). Consequently, if this area were selected under Option 7a, some compensatory mitigation would be required for this alternative as well.

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Disposal and/or Treatment Options

The disposal and/or treatment options evaluated for Alternative 7 are:

Option 7a: On-site Containment in an Upland CDF
Option 7b: On-site Containment in a Nearshore CDF
Option 7d: On-site Thermal Treatment
Option 7e: Off-site Disposal and/or Treatment

The disposal and/or treatment options are described below.

Option 7a – On-site Containment in an Upland CDF

This option provides for construction of a CDF on site and above the 100-year flood elevation. "On site" is defined as the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action (40 CFR §300.5). For purposes of this FS, the proposed locations for the upland CDF would all be considered on site as defined in the NCP. The CDF would be designed in accordance with the procedures given in the Upland Testing Manual (USACE, 2003b). The CDF would be designed and built to meet state landfill regulations for hazardous waste (see Appendix L) and RCRA requirements. As discussed in Section 3.2.1.2, excavated sediment processed by mechanical dewatering and placed in an upland CDF would have to meet LDRs. For Option 7a, it is assumed that a treatability variance could be obtained to reduce the amount of treatment needed and that 10% of the sediment would need to be taken off site for disposal by incineration (as described in Option 7e).

A generalized sequence of construction for a CDF is listed below:

1. Clear site vegetation.
2. Remove soil to prepare the ground surface for installation of bottom liner and leachate collection system. In some sites, it may be possible to increase the capacity by lowering the ground surface elevation by removing additional clean material from the current ground surface.
3. Construct perimeter dikes, install a base liner and leachate collection system.
4. Connect the leachate collection and storm water collection system to a water treatment plant. This could be a separate plant at the CDF site or a connection to the water treatment plant used to treat return water separated from the excavated sediment. The option of discharging leachate to a public sewer facility would be evaluated during design, if this alternative was selected.
5. Place excavated, dewatered sediment into the CDF.
6. Install a cover over contaminated sediment and prepare surface for future use.

For this FS, it is assumed that the perimeter dikes would be built with sand and gravel supplied by commercial vendors. In order to provide a stable foundation, very soft soils under the dike location would have to be removed and replaced with compacted sand and gravel. The dikes would have an outside slope of three horizontal to one vertical (3H:1V) and an inside slope of 2H:1V. The inside slope can be steeper because it only has to be stable before the sediment is placed inside and does not have to support the lateral pressure from sediment on the outside of the dike.

Because a CDF is designed and built to contain only one type of material, a single geomembrane liner would be sufficient to protect the environment. The liner system would be designed to meet requirements

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in state regulations (see Appendix L). A support layer of screened sand would be placed, then covered with a geomembrane, which in turn would be covered with a layer of fine sand about 12 inches thick. The sand layer would include perforated pipes to collect leachate that would be generated as the sediment compressed.

When the sediment was placed to the final design height, a cover system would be installed. The cover system would meet the requirements for alternate RCRA covers, as described in Section 6.8.3.1 for the source area soils and would meet RCRA Subtitle C capping requirements. As shown in Figure 5-7, the cap would consist of (a) a 12-inch-thick low-permeability layer of soil to support a geomembrane, (b) a geomembrane to reduce infiltration of precipitation, (c) a 12-inch-thick sand drain layer to protect the geomembrane and to drain precipitation, (d) a geotextile separation layer, (e) a 12-inch-thick protection layer of soil and (f) a 6-inch-thick layer of topsoil. The topsoil and vegetation could be replaced with gravel and asphalt for future use. Future uses could include public parks or recreation uses such as a greenway and bike paths that could be developed in coordination with ongoing watershed initiatives and in coordination with regional partners, or commercial development. Site use restrictions would limit the size of trees or woody vegetation and would prohibit the construction of buildings with basements or buried utilities.

Figure 5-6 shows three potential locations at Lyman Mill reach where a CDF could be constructed above the 100-year flood elevation as described in Section 5.1.6; a representative cross section for the northern CDF is shown in Figure 5-7. The northern CDF would be built where the current ground surface slopes up to the west of Lyman Mill Pond. A second CDF would be built south of the abandoned channel where the current ground surface slopes up along the western border of the Oxbow. There would be containment dikes on the downhill side, but no dike would be needed on the uphill side of the areas. The top of the final cover would be sloped with a grade of 2% (i.e., 2 ft vertical drop per 100 ft of horizontal distance) to provide the minimum slope for drainage and also provide a nearly level area for future use. The height of the downhill dike would be limited by the strength of the underlying native soils and to avoid the visual impact of creating new hills. It is assumed that the dikes could not be higher than 10 ft above the existing ground surface. The combined maximum capacity available at the two CDF locations would be about 136,000 cy (Table 6-3), assuming that the existing soil was removed down to the ground surface elevation at the downhill dike.[59] The combined capacity would be sufficient to contain all of the river/pond sediment (after mechanical dewatering) and floodplain soil removed under the excavation alternatives. A third CDF with sufficient capacity could also be constructed further south, near the head of Lyman Mill Pond and above the 100-year flood elevation (Figure 5-6).

One of the potential CDFs (northern CDF) contains established hardwood forest and use of this area would result in destruction of valuable ecological habitat. Another of the potential CDFs (south of the abandoned channel) contains low-value wetlands (Appendix K, Figure K-1). During the design phase, the relative environmental services provided by individual areas identified as potential upland CDF locations would be evaluated as one set of criteria in the selection process.

Option 7b – On-site Containment in a Nearshore CDF

Under this disposal alternative, a nearshore CDF encompassing approximately 4 acres would be constructed within the existing footprint and along the western shoreline of Allendale Pond as shown in Figure 5-12. Nearshore CDFs encompassing approximately 7 acres would be constructed within the existing footprint and at the southern extent of Lyman Mill Pond as shown in Figure 5-12. The combined capacity of the nearshore CDFs would be approximately 125,000 cy, which is sufficient to contain all the

[59] Existing soil would be tested and disposed off site at a permitted facility.

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excavated sediment. The final design height could be increased approximately 1.5 feet to increase capacity to also contain floodplain soil removed from other action areas.

The layout is based on the assumption that the perimeter containment walls would be constructed from cast-in-place reinforced concrete (Figures 5-13a and 5-13b). During final design the use of other types of containment structures would be evaluated. The perimeter walls would require a foundation supported by either dense soil or piles. The type and strength of the sediments at the perimeter wall locations are not known at this time. The cost estimate assumes steel pilings would be needed. Upon placing the sediment to the final design height, a cover system would be installed. This cover system would be the same as described for the upland CDF.

The anticipated sequence of construction activities for sediment excavation and containment in a nearshore CDF with the dams remaining in place is as follows:

1. Site preparation.
2. After lowering the water level in the pond, excavate sediment to the containment wall footing subgrade.
3. Install support piles for the containment wall, if needed.
4. Construct perimeter containment wall.
5. Consolidate excavated sediment into the CDF.
6. Install a cover over contaminated sediment and prepare surface for future use. The cover system would be designed to resist erosion during flood events.

A quantitative hydrodynamic analysis of Alternative 7 Option 7b was performed to evaluate the effects of constructing the nearshore CDF on water flow and flooding potential. The results of this analysis included an estimate of the extent of channel and floodplain inundation, water depth and surface water elevation, current velocity, bed shear stress, and stable bed particle size (QEA, 2007). Based on an evaluation of the model output, this option would result in predicted flood inundation that has limited effect beyond that for existing conditions for the areas adjacent to Allendale and Lyman Mill Ponds, even for 100-year flood events. This option would result in negligible effect on flood stage height and floodplain inundation during high-flow events in the region downstream of Lyman Mill Dam.[60] Overall, Alternative 7b would result in the loss of approximately 62,000 cy of flood storage capacity, which would be replaced by excavation for the out-of-kind mitigation described above.

Option 7d: Treatment using On-site Thermal Treatment

Under this option, the excavated, dewatered sediment would be treated on site using thermal treatment (incineration). A typical construction sequence consists of:

1. Clear temporary work areas and build vessel launch ramps.
2. Construct sediment dewatering area, install dewatering and water treatment equipment, and construct incineration facility prior to the start of excavation.
3. Excavate sediment, dewater, place into stockpile or begin feeding into the incineration unit.
4. Remove the temporary vessel launch ramps and restore vegetation in the temporary work areas.

[60] Alternative 4 in the QEA analysis is (2007) the same Alternative 7, Option 7b in this FS.

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It is not practical to assume that the dewatered, excavated material could be loaded directly into the incinerator from the dewatering equipment. The dewatering process produces water and three types of solids: debris, sand/gravel, and silt/clay. Each type of material would be stockpiled and treated separately.

The ash produced from the incineration process would be stockpiled and sampled for characterization prior to disposal. Once the material was characterized and an appropriate landfill designated for disposal, the ash would be loaded onto trucks and taken to a regional rail loading facility for transportation to the designated disposal facility.

Option 7e: Off-site Disposal and/or Treatment

This option is similar to Option 7d, except that excavated, dewatered sediment would be disposed of off site, by containment at a permitted facility and/or treatment.

Each of the three types of solids produced by the dewatering process, debris, sand/gravel, and silt/clay would be placed into separate stockpiles and sampled on a daily basis because the post-processing contaminant concentrations in the sediment will be different than the in-situ concentrations. Representative, composite samples would be taken and analyzed for total dioxin and furans to determine if disposal by incineration is required according to the LDRs (see Section 3.2.1.2). Representative, composite samples would also be taken and analyzed for TCLP concentrations to determine the designation of the materials as solid or hazardous waste and to determine which type of landfill is required. Once the appropriate disposal facility is identified, the dewatered material would be loaded onto trucks and taken to a regional rail loading facility for transportation to the designated disposal facility.

Dewatered sediment that is designated as hazardous waste would be subject to LDRs. F-listed or characteristic sediment waste with an underlying hazardous constituent that meets the treatment standards in 40 CFR §268.40 would be taken to a licensed hazardous waste landfill for disposal. F-listed or characteristic sediment waste that exceeds treatment standards in 40 CFR §268.40 would be taken to an off-site incinerator. Approximately 50% of the Allendale and Lyman Mill sediment samples contain dioxin at concentrations in excess of the treatment standards in 40 CFR §268.40 (Section 3.2.1.2). Therefore, the costs are based on the assumption that 50% of the sediments would be taken to an off-site landfill and that 50% would be taken to an off-site incinerator for treatment.

6.2.2.2 Evaluation of Excavation and Disposal and/or Treatment

Results from the evaluation of Alternative 7, Excavation and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-4.

Overall Protection of Human Health and the Environment

Excavation would provide high overall protection by removing the source of contamination, which would lower the concentration of contaminants in the surface sediment where exposure is likely, and quickly reduce human health and ecological risk to acceptable levels. The depth of excavation would be designed to remove all sediment in the river/ponds that contain contamination above the cleanup goals. However, the sediment cleanup goal for dioxin (i.e., 2,3,7,8-TCDD) is based on background and it may be difficult to achieve that in all areas of the river/pond. If, following excavation, it was determined that cleanup goals had not been universally achieved, then a contingency action involving placement of a thin-layer cover over areas where dioxin remains above background would be implemented. Placement of the thin-

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layer cover would reduce contaminant concentrations throughout the ponds to acceptable levels so that the RAOs could be achieved.

Excavation would be effective in the long term because nearly all of the sediment with contamination above the cleanup goals would be removed from the river/ponds and either contained in a secure disposal facility or treated by incineration. This would reduce the human health risk to background levels and would eliminate the risk of sediment with contaminants above the cleanup goals migrating downstream due to erosion during flood flows for Options 7a, 7d, and 7e. The contamination remains in the floodplain under Option 7b and therefore would be less protective overall.

Compliance with ARARs

ARARs specific to Alternative 7 are summarized in Table 6-5. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Clean Water Act Section 404 requirements are triggered by excavation. In addition, the thin cover (all options), dewatering (all options except 7b), nearshore CDF (Option 7b), and possibly the upland CDF (Option 7a) also trigger Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under Option 7a (upland CDF), selection of the CDF that contains low-quality wetlands would result in the destruction of the wetlands. Option 7b (nearshore CDF) would impact wetlands and floodplains and include a discharge of dredged and/or fill material to waters of the US. In addition, a portion of the nearshore CDF would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Flood storage capacity would be reduced under Option 7b. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 7a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 7b) that is within the area of contamination.

Long-Term Effectiveness and Permanence

Excavation would remove contaminated sediment from the river/ponds to provide a very high level of risk reduction and low residual risk. In order to meet the RAOs, a thin-layer cover might be needed if post-excavation contaminant concentrations exceeded the cleanup goals in some areas. Inherent hazard would be further reduced for Options 7d and 7e because sediment would be incinerated on site (Option 7d) or taken off site for disposal or treatment (Option 7e). The inherent hazard is somewhat higher for the upland (Option 7a) and nearshore (Option 7b) CDFs as sediment above cleanup levels remains untreated on site. However, under both of the options contaminated sediment is either removed from the river/ponds and placed in secure upland locations (Option 7a) or consolidated along the shore in nearshore CDFs (Option 7b). The upland CDF would have a liner and would be outside of the floodplain while the nearshore CDF would not be lined and would be located within the floodplain thereby increasing the inherent hazard and reliance on other controls. Long-term monitoring, maintenance and ICs are necessary to protect the integrity of both CDF options. These controls are only effective if adequately monitored and enforced. Dam maintenance would also be critical for the effectiveness of Alternative 7 for any options where inherent hazard remains in the river/ponds or floodplain.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Options 7a (upland CDF), 7d (on-site thermal treatment), and 7e (off-site disposal and/or treatment). The nearshore

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CDF option (Option 7b) would reduce the mobility of the contaminated sediment particles, although not through treatment.

Short-Term Effectiveness

During the construction and implementation period for this alternative, potential short-term impacts to human health would be limited and of short duration, whereas short-term impacts to the environment would be more substantive. Excavation would require temporary work areas in areas that border and occupy parts of the floodplain. The temporary work areas would be cleared of vegetation and access ramps would be constructed to provide access to the river/ponds. One access point would be required at each pond.

During pond lowering, there would be potential for contaminated sediment to be eroded and carried downstream through the open gates in the dams. This would be limited by controlling the rate of water release and water monitoring would be performed downriver of the dams to verify compliance with water quality ARARs. Engineering controls will be a component of this alternative and dust suppression techniques would be employed in conjunction with work area and site perimeter air (dust) monitoring. With those measures in place, releases of contaminants beyond the work zone at levels of concern for the community would not occur. People working and living in the neighboring area would not have access to the work zone during excavation and capping activities.

For the on-site containment options (Options 7a and 7b), there would be additional minimal construction impacts at the CDF site from site clearing and earthwork construction. The potential for exposure to hazardous substances by remedial workers would be addressed and controlled by the health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment.

For the on-site incineration option (Option 7d), there would be air emissions from the incinerator operation. Incineration of sediment requires that the sediment particles be heated to high temperatures, which requires burning fossil fuel, such as natural gas or fuel oil and will result in emission of combustion byproducts. However, this technology would be conducted consistent with approved designs that would require that the air emissions of contaminants or additional byproducts produced during treatment be at levels below regulatory standards.

For Options 7a, 7d, and 7e, there would be truck traffic into and out of the processing area. With the assumed removal of 400 in-situ cy/d, there would be approximately 12 to 15 truck and trailer loads of sediment removed per work day. There would be material and fuel deliveries and traffic from worker vehicles. Traffic routes would be designed to minimize impact(s) on the community. Engineering controls would be implemented to minimize releases of contaminants during such transport (transport vehicles would need to be contained, and any off-site transport would be performed in a manner that does not remove impacted sediment from the work area except in a containerized manner).

There would be significant short-term impacts to ecological receptors because excavation would result in the destruction of the existing benthic habitat in both ponds and the elimination of the fish communities and other species that use surface water as habitat. It is expected that the site would be re-colonized by organisms from upriver that would migrate into both ponds (see Appendix K). This loss would have a significant short-term impact on the overall ecological health of the ponds because the entire surface area of both ponds would be affected. Full recovery, with respect to overall biomass and species diversity of the benthic macro invertebrate community, would likely require on the order of between two to five years. During this time, those higher trophic level species that depend on pond biological productivity (e.g., fish, piscivorous and insectivorous wildlife) would also be impacted. Under this alternative, it is anticipated

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that the existing warm-water fishery in Allendale and Lyman Mill Ponds would fully recover within 5 years and that future use scenarios for the fishery would be similar to existing conditions.

The RAOs would be achieved at the completion of remedy implementation, which is estimated to take approximately two years.

Implementability

The construction and operation of all options present some technical issues that can be addressed. Excavation of soft sediments after lowering overlying surface water is a proven technology and has been successfully implemented at other contaminated sediment sites. Because the very soft sediment is too weak to support conventional earthmoving equipment, the work would be performed using low-ground pressure, track-mounted excavators with extra long booms. Temporary haul roads covered with geotextile fabric and gravel would be constructed to provide roadways for off-road trucks.

Requirements for dam maintenance and potential impacts to floodplain and wetland areas under the nearshore CDF (Option 7b) and possibly the upland CDF (Option 7a) options (discussed below) could present some administrative implementability issues that would have to be addressed. For dam maintenance, agreement for access from owners of the dams would be needed. All of the disposal and/or treatment options would also present some technical or administrative implementability issues that would have to be addressed. For example, there is limited space on the site for sediment processing and disposal facilities. As described above, mechanical dewatering would be used for Options 7a, 7d, and 7e to increase the solids content of the excavated sediment, which would reduce the weight and volume that requires treatment or disposal. Upland land area is required for the sediment dewatering and water treatment facilities. The specific location for the upland processing and support area has not been determined, so obtaining property access will be required. All treatment and/or disposal options will require monitoring including air monitoring during construction/excavation. If issues are detected, work at the site would cease and corrective measures would be taken. For the upland CDF (Option 7a), monitoring would be required to ensure that the cap is properly maintained. For the nearshore CDF (Option 7b), increased monitoring would be required because of the additional risk presented from the location of the CDF in the floodplain. Air emissions monitoring is an integral component of the on-site incinerator option (Option 7d). In addition, temperatures must be monitored so that the appropriate destruction efficiency is met. Finally, no additional monitoring is required at the site for the off-site disposal/treatment option (Option 7e) beyond what would be required during excavation and in the long term to assess recovery and support five-year reviews.

Implementability of Option 7a, On-site Containment in an Upland CDF depends on obtaining use of approximately 8 acres of property adjacent to the ponds. In addition, some of the sediment could require treatment to meet LDRs. A treatability variance could be obtained to reduce the amount of treatment needed. In addition, one of the upland CDF locations contains some low-quality wetlands.

Implementability of Option 7b, On-site Containment in a Nearshore CDF depends on filling approximately 30% of the pond area to construct the CDFs. Although the pond area below the normal pond surface elevation is not floodplain, there would be a portion of the nearshore CDFs built in areas of existing floodplains between the existing pond shoreline and existing upland area. Therefore, a portion of the CDFs would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, the nearshore CDF may have technical reliability issues given that construction of the CDF is partially in the river and partially in the floodplain. Although the CDF will be constructed to withstand erosion, the possibility still exists for catastrophic failure. Replacement of lost flood storage capacity would be required under Option 7b.

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Implementability of Option 7d, On-site Thermal Treatment relies on the ability to obtain mobile incineration units capable of sustaining high temperatures needed for the destruction of dioxins and furans. These units have limited availability. Temporary access for the incineration facility will be needed. Moreover, while these units can be safely operated, local residents might express concern regarding emissions.

Implementability of Option 7e, Off-site Disposal and/or Treatment requires permitted facilities with sufficient capacity to handle the volume of contaminated sediment from the CMRP site. Based upon contacts with permitted facilities, it appears that facilities with sufficient capacity are available to receive this material. It is assumed that the sediment would have to be tested to determine if the material could be taken to a hazardous waste landfill without treatment. F-listed or characteristic sediment waste with underlying hazardous constituents that meet the treatment standards (40 CFR §268.40) would be taken to a licensed hazardous waste landfill for disposal. F-listed or characteristic sediment waste that exceeds the treatment standards in 40 CFR §268.40 would be taken to an off-site incinerator.

Cost

The detailed cost evaluations for Alternative 7, Excavation and Disposal and/or Treatment, is presented in Appendix J. The capital, operation and monitoring, and present worth costs are listed below:

Option 7a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$58,000,000
	Annual cost for years 1 to 30	$220,000
	Present worth costs	$61,000,000
Option 7b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$44,000,000
	Annual cost for years 1 to 30	$230,000
	Present worth costs	$47,000,000
Option 7d: On-site Thermal Treatment	Capital cost and baseline monitoring	$115,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$118,000,000
Option 7e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$114,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$116,000,000

6.2.3 Alternative 8: Partial Excavation, Isolation Capping and Disposal and/or Treatment

6.2.3.1 Description of Partial Excavation, Isolation Capping and Disposal and/or Treatment

Under this alternative, contaminated sediment would be removed from targeted areas using excavation and an isolation cap designed to withstand erosion during flood events would be placed over the entire pond bottom at Allendale and Lyman Mill to provide chemical isolation and prevent exposure to contaminated sediment that remains in place. Under the partial excavation alternative, it is not necessary to excavate to the full depth of contamination above the cleanup goals because a cap (designed to resist erosion during flood events) will cover any remaining contamination to isolate it from the environment. The general descriptions for excavation, as well as most of the site-specific details described for Alternative 7 (Section 6.2.2), are pertinent to this alternative. The principles of isolation capping are discussed in Section 4.2.4.

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In this alternative, excavation would be conducted in:

- Areas where the current water depth is less than about 2 feet, so that the final elevation of the top of the cap will be below the normal pond levels,
- Areas of high erosion potential, to reduce risk of cap erosion, or
- Areas of highest contaminated concentrations in the sediment.

Following removal, the excavated sediment would be disposed of and/or treated. The sequence of excavation, capping, and mitigation activities are described below. There are four disposal and/or treatment options, which are the same as described for Alternative 7 (Section 6.2.2):

Option 8a: On-site Containment in an Upland CDF
Option 8b: On-site Containment in a Nearshore CDF
Option 8d: On-site Thermal Treatment
Option 8e: Off-site Disposal and/or Treatment

Excavation Volumes and Rates

For Options 8a, 8d, and 8e, the purposes of excavation would be to lower the surface where the water depth is less than 2 feet and to lower the surface in areas of highest erosion. These areas are illustrated in Figure 5-14 (Allendale) and Figure 5-15 (Lyman Mill) and the associated cross-sections are presented in Figures 5-16 and 5-17.

- The total estimated removal volume, including the over-excavation allowance, is 64,400 cy (2,400 cy for river channel north of Allendale Pond, 23,000 cy for Allendale Pond, and 39,000 for Lyman Mill Pond).
- The sediment from Allendale Pond and Lyman Mill Pond would be processed by mechanical dewatering to reduce the volume. After dewatering, the volume for disposal is estimated to be 41,200 cy (2,400 cy for river channel north of Allendale Pond, 17,000 cy for Allendale Pond, and 21,800 cy for Lyman Mill Pond).

For Option 8b, the primary purpose of excavation would be to remove sediments with the highest contaminated concentrations. These areas are illustrated in Figure 5-18 and the associated cross-section is presented in Figure 5-19a.

- The total estimated removal volume is 56,500 cy (2,400 for the river channel north of Allendale Pond, 23,060 cy for Allendale Pond and 31,060 cy for Lyman Mill Pond).
- A nearshore CDF would be constructed on the west bank of Lyman Mill Pond. The CDF would be about 5 acres in size and would be constructed so that the top of the final cover would be above the 100-year flood elevation (Figures 5-18 and 5-19b).

The rate of excavation is the same as described for Alternative 7 (Section 6.2.2). For Options 8a, 8d and 8e, sediment excavation would take approximately 13 weeks for Allendale Pond and 20 weeks for Lyman Mill Pond. For Option 8b, sediment excavation would take approximately 10 weeks for Allendale Pond and 12 weeks for Lyman Mill Pond. Excavated sediment would be processed for disposal and/or treatment as described for Alternative 7 (Section 6.2.2).

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Isolation Cap

Following removal, a two-layer sand and gravel cap, consisting of an isolation layer overlain by an erosion control/ bioturbation layer, would be placed over the entire pond bottom at Allendale and Lyman Mill Ponds. The estimated total thickness of the cap is determined by considering the components detailed below:

- For sediments in both Allendale and Lyman Mill Ponds a bottom isolation layer thickness of 12 inches is expected to be protective because the contaminants have low water solubility and are bound to the organic-rich sediment particles.
- Bioturbation depths vary from site to site, but surficial mixing is typically 4 inches (10 cm) for freshwater sediment and total bioturbation depths are typically in the range of 8 to 12 inches (20 to 30 cm for sand sediment in fresh water [USACE, 2001]). For Allendale and Lyman Mill Ponds, a top bioturbation layer thickness of 4 to 8 inches (6 inch average thickness) is expected to be protective because deeper burrowing species are unlikely in the limited areas within the two ponds.
- Allendale and Lyman Mill Ponds are sheltered from wind and waves; therefore, no significant wave or current erosion is expected under normal conditions. Even so, the top erosion control/bioturbation layer would be designed to protect against potential erosion during high flow events and provide habitat in open water areas and substrate for wetland vegetation in the marsh areas.
- For caps made with sand or gravel, the consolidation thickness is essentially zero, therefore the cap thickness is not expected to change and extra material would not need to be applied to account for consolidation.

The total minimum cap thickness is 18 inches, which is the sum of the bottom isolation layer (12 inches) and the top erosion control/bioturbation layer (6 inches). Because the cap in Alternative 8 will be placed after excavation in the "dry", the cost estimate is based on a placement thickness of 1.5 feet. The actual thickness would be determined during final design. Moreover, the thickness of the isolation layer would be revised during design based on modeling of chemical flux through the cap material. The analysis would be done using a procedure similar to the model described in Appendix B of guidance for subaqueous cap design (Palermo et al., 1998). This model accounts for chemical movement through the cap due to (a) advection resulting from porewater migration caused by consolidation settlement of the contaminated sediment under the cap, (b) diffusion of chemicals from porewater in the contaminated sediment to the porewater in the cap material and (c) advection caused by porewater migration from the contaminated sediment through the cap material caused by groundwater flow to the surface water. For hydrophobic contaminants (such as PCBs, PAHs, and dioxins) the isolation layer thickness required for diffusion during consolidation settlement is a small fraction of the sediment consolidation.

Based on current conditions in Allendale and Lyman Mill Ponds it is anticipated that some remediated aquatic habitat will become revegetated by aquatic plants, particularly in areas with slower current flow and shallow depth. Freshwater emergent plants (i.e., those that are rooted in sediment with stems that grow above the water level) could include the invasive common reed (*Phragmites australis*), cattail (*Typha spp*.), and potentially bulrush (*Scirpus spp*.). Typical root penetration depth of these plant types is summarized in Table 6-6. Although the roots may extend into the bottom isolation layer, only bulrush roots have the potential to extend completely through a cap with average thickness of 24 inches. Even if roots did completely penetrate the cap, it is unlikely that this would pose a significant recontamination issue. Extremely hydrophobic chemicals such as dioxins and PCBs will tend to remain bound to the sediment matrix underneath the cap rather than being translocated into the water-based vascular system of

emergent plants. Additionally, unlike woody vascular plants that may be uprooted by strong winds or flood conditions, the stems of emergent plants will generally bend and rupture (lodge) if the current velocity becomes too large. Trees will not grow in the cap area within the ponds. Finally, there would be no impacts to groundwater recharge in the vicinity of the two ponds because the cap would be comprised of permeable materials.

Cap Placement

The cap would be placed following excavation in the "dry". For alternative evaluation and cost estimating, it is assumed that caps would be placed using low-ground pressure equipment. The soft native sediment would consolidate under the weight of the cap material, which would result in porewater containing dissolved contaminants migrating upward into the porewater in the cap material. Porewater from the cap would then be displaced into the surface water. Porewater and potential contaminant movement would be evaluated during design as part of the contaminant transport analysis. The cap would be designed so that contaminant movement would have an insignificant impact on the cap material and overlying surface water.

The cost for cap placement depends on the daily cost of crew and equipment, and the production rate. For this evaluation, a production rate of 500 tons per working day is assumed. The total quantity of cap material required is approximately 188,000 tons for Options 8a, 8d and 8e and 124,000 tons for Option 8b. Therefore, cap installation time would be 25 weeks (Option 8b) to 38 weeks (Options 8a, 8d, and 8e) using two work crews (Appendix J).

River Channel

An isolation cap is not suitable in high-energy environments such as the river channel north of Allendale Pond. Contaminated sediment within the river channel would be dredged to a removal depth of 2 ft (includes 1 foot over-dredge allowance), and backfilled with clean material such as coarse gravel.

Cap Stability and Design

A quantitative analysis of cap stability against erosion during flood flows was performed for Allendale and Lyman Mill Ponds (Appendix E) for Alternative 5 (Section 5.1.5), which was for the case where a two-foot thick cap was placed over the existing sediment. The analysis also evaluated the stability of the existing sediment surface. The top of the cap for Alternative 8 would be lower than the cap evaluated for Alternative 5, but higher than the existing sediment surface. Therefore, the erosion potential for the cap in this alternative can be assessed by interpolating between results for the existing surface and two-foot thick cap.

The cap stability was evaluated by performing a hydrodynamic analysis using a 100-yr flood flow rate of 2,300 cfs. The preliminary cap design discussed below was not specifically designed to withstand ice scour. Although the slower moving currents in the ponds will tend to reduce the risk to the cap integrity associated with ice scour, this is a concern at the upstream inlets and near the dams where current velocities are higher. The cap placed at these areas would need to be reinforced with cobble and coarse gravel to protect against erosion. The final cap design developed during the remedial design phase could consider ice scour should this alternative be selected.

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The top layer of the cap would be designed to withstand potential erosion during a 100-year flood.[61] In order to properly evaluate this alternative and estimate construction costs, the average grain size of cap particles required to withstand erosion was calculated (Appendix E). The cap grain size that would be needed is summarized below for a two-foot thick cap:

- For the majority of Allendale Pond, the average grain size would be less than 10 millimeters (mm), or (0.39 inches). Cap material with an average grain size of about 10 mm would be classified as sandy gravel and would typically contain a range of particle sizes from gravel-sized particles less than 38 mm (1.5 inches) to fine sand with grain sizes of greater than 0.1 mm (0.004 inches).
- In the northern portion of the pond, where it connects to the main river channel, the average grain size would have to be greater than 80 mm (3 inches). In these areas, the cap material would be classified as cobble or coarse gravel and would typically contain particle sizes from cobbles less than 300 mm (12 inches) to coarse sand with grain sizes greater than 10 mm (0.4 inches).
- For the southern area of Lyman Mill Pond where the water is deeper, and the eastern pond area, the average grain size would be 10 mm (0.39 inches), or less, as indicated by the two blue shading zones.
- In the narrow center area of Lyman Mill Pond, where there is less water depth, the average grain size would be about 20 to 40 mm (0.8 to 1.6 inches), as indicated by the yellow and light-green zones on the figures. This material would be classified as gravel and would typically contain particle sizes from gravel less than 80 mm (3 inches) to coarse sand with grain sizes greater than 10 mm (0.4 inches).
- In the northern portion of the Lyman Mill Pond, where it connects to the main river channel, the average grain size would have to be greater than 80 mm (3 inches).

An assessment of the impact of more rare floods to a cap was performed by evaluating the erosion resulting from a 500-year flood. In Allendale Pond, the average grain size required for the majority of the cap would be the same for the 500-year flood as the 100-year flood. There is some difference in the northern end of the pond where the flow velocities would be higher. In Lyman Mill Pond, the cap grain size would be the same in the deeper water in the southern and eastern portions of the pond. In the narrow center area, a cap with an average grain size on the upper end of the range for a 100-year flood (40 mm) would also be stable with the flow from a 500-year flood. As with Allendale Pond, there is some difference in the northern end of the pond where the flow velocities would be higher.

In summary, the quantitative hydrodynamic analysis shows that the cap could be stable in both Allendale and Lyman Mill Ponds in a 100-year flood. Additionally, a cap designed for a 100-year flood would likely be stable in the unlikely event of even higher flows, except for small areas in the north end of both ponds where they connect to the main river channel. Because this analysis is based upon modeling, some uncertainty remains regarding the actual stability of the cap that covers this highly contaminated sediment.

[61] A 100-yr flood is a probabilistic assessment that means a given event has a one in one hundred chance (1 percent) of occurrence in any given year, or a "return period" of once every 100 years. These assessments are based on statistical frequency of collected data (see Section 2.3.9). It should be understood that the 100 year return period storm has a 9.6% chance of occurrence in 10 years, 22% chance in 25 years, 39% chance in 50 years, and 63% chance in 100 years. (chance of occurrence = $1-[1-(1/\text{return period})]^{\text{number years}}$).

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Construction Monitoring

Water quality downstream of the dams would be monitored during excavation and placement of the cap. The cap material would not have chemical contamination, and hence there would be no potential for impacts to water quality chemistry from the cap material. A physical survey would be conducted at the completion of construction activities to confirm that the isolation cap has been placed over the entire pond bottom and meets the design thickness.

Mitigation

Water depth in the ponds would be reduced and there would be short-term loss of habitat due to placing cap material over the existing sediment. Remedy implementation would involve the destruction of existing aquatic habitat structure (both benthic and pelagic) and the temporary extirpation of the vast majority of the fish[62] and invertebrate communities. Secondary impacts to aquatic-dependent wildlife and anglers that fish in these ponds and collateral impacts to floodplain soils, would be similar to those described in Alternative 7 (Section 6.2.2).

Figure 6-2 presents an overview of the different habitat features associated with this alternative and possible mitigation components for each. The cap could be designed to include a benthic habitat layer consisting of optimal grain size and organic carbon content for growth of benthic and epibenthic macroinvertebrates and submerged woody material could be included to provide some interim structural diversity.

Populations of important species such as bass and sunfish could be re-stocked to expedite recovery of the community. Following implementation of the sediment remedy, the floodplain soil could be revegetated with appropriate floodplain/riparian shrubs and tree species.

Option 8b (nearshore CDF) would involve the permanent loss of approximately 5 acres of aquatic habitat in the lower portion of Lyman Mill Pond (Appendix K, Table K-1). Out-of-kind mitigation for the lost aquatic habitat could be provided as described in Alternative 7; 5 acres of emergent marsh, scrub/shrub or palustrine forest habitat could be restored as specified in the mitigation planning document.[63] Appendix K provides an overview of possible mitigation requirements and planning for the sediment action area.

Long-Term Monitoring, Dam Maintenance, and Institutional Controls

Monitoring, dam maintenance and ICs would be consistent with those outlined for Alternative 7 (Section 6.2.2), except that additional ICs, monitoring and maintenance would be required for the isolation cap. These ICs such as deed and use restrictions would be required to prevent contact with contaminated sediment beneath the isolation cap. The ICs could include, but may not be limited to: restrictions on future excavation or dredging on site, limitations on the size of boats allowed on the ponds and restricted access for utilities and utility crossings. According to EPA (2005), monitoring an in-situ cap includes assessing both cap performance (e.g., retention qualities and erosion) and recovery of the biological communities (especially macro invertebrates) that support the river ecosystem. The monitoring program would be designed to ensure that the cap material had not been eroded and to measure the chemical

[62] Resident fish would be collected and euthanized to ensure that the contaminated fish consumption pathway was reduced as part of the remedy implementation.
[63] Low-value wetland habitat is present within the boundary of this area which has been proposed as a potential upland CDF location (Appendix K, Figure K-1). Consequently, if this area were selected under Option 8a, some compensatory mitigation would be required for this alternative as well.

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concentrations in surface and subsurface sediments. Maintenance of the dams would be required to ensure that the dams remain structurally sound and stable because if the dams failed, the resulting increase in water flow velocity would have the potential to erode the cap material and underlying contaminated sediment.

6.2.3.2 Evaluation of Partial Excavation, Isolation Capping and Disposal and/or Treatment

Results from the evaluation of Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-7.

Overall Protection of Human Health and the Environment

Partial excavation followed by capping would provide some overall protection by removing and containing the source of contamination, which would lower the concentration of contaminants in the surface sediment where exposure is most likely. Targeted excavation would address sediment in the areas most susceptible to erosion which would reduce the risk of potential cap erosion during periods of flood flows. Placement of clean cap material over the entire pond bottom would reduce the surface concentrations so that exposure to contaminated sediment would be reduced. The results of the RI and hydrodynamic modeling performed for this FS show that the risk of erosion is low in the majority of the pond areas. The cap thickness and material types would be designed to restrict potential contaminant migration from contaminated sediment through the cap by either diffusion or advection. The cap would be designed using methods developed by EPA and USACE, which would provide long-term isolation of contaminants in the underlying sediments. The combination of excavation and capping would reduce the risk of direct exposure to background levels and would reduce the risk of downstream migration of sediment with contaminants above the cleanup goals.

Compliance with ARARs

ARARs specific to Alternative 8 are summarized in Table 6-8. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Section 404 requirements are triggered by excavation. In addition, the isolation cap (all options), the nearshore CDF (Option 8b) and possibly the upland CDF (Option 8a) also trigger Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. In addition, isolation capping and the nearshore CDF (Option 8b) would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 8a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 8b) that is within the area of contamination

Long-Term Effectiveness and Permanence

Partial excavation would provide some risk reduction because sediment in the areas most susceptible to erosion or sediment with highest contamination would be removed and either contained in an engineered facility or treated by incineration. Residual risk after the contaminated sediment is excavated and a cap is installed will be reduced, provided the cap is designed, constructed and maintained to provide long-term isolation of contaminants. Where contamination remains under the cap in the river/ponds inherent hazard of waste remains and there is potential for future migration of contaminated sediment particles downriver

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as a result of flood flows. However, the cap is in a relatively stable depositional area and would provide fairly reliable chemical isolation with the top layer of the cap designed to withstand erosion.

The inherent hazard of the disposal and/or treatment options is the same as Alternative 7 (Section 6.2.2.2). All options rely heavily upon ICs to prevent disturbance to the river bed to remain effective in the long term. These controls are only effective if adequately monitored and enforced. Long-term monitoring, maintenance, including maintenance of the dams, and ICs would be critical to control physical disturbances and protect the integrity of the cap or any type of on-site disposal facility (Options 8a and 8b) for the long-term effectiveness of this alternative.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Options 8a (upland CDF), 8d (on-site thermal treatment), and 8e (off-site disposal and/or treatment). The nearshore CDF option (Options 8b) and isolation cap (all options) would reduce the mobility of the contaminated sediment particles, although not through treatment.

Short-Term Effectiveness

Potential impacts to the community and environment posed during the construction and implementation period would be consistent with Alternative 7 (see Section 6.2.2.2). The RAOs would be achieved at the completion of remedy implementation, which is estimated to take approximately two years.

Implementability

All of the implementation issues identified for Alternative 7 (as related to excavation and Options 7a, d, and e) are the same for this alternative, except under Option 8a (upland CDF) a smaller parcel of land (6 acres) would be required because a smaller volume of sediment would be removed under the partial excavation alternative compared to full excavation (Alternative 7). In addition, requirements for replacement flood storage capacity would be smaller under Option 8b (i.e., approximately 28,000 cy lost under Option 8b compared to 62,000 cy lost under Option 7b).

Cost

The detailed cost evaluation for Alternative 8, Partial Excavation, Isolation Capping, and Disposal and/or Treatment, is presented in Appendix J. The capital, operation and monitoring, and present worth costs are listed below:

Option 8a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$41,000,000
	Annual cost for years 1 to 30	$370,000
	Present worth costs	$45,000,000
Option 8b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$32,000,000
	Annual cost for years 1 to 30	$370,000
	Present worth costs	$36,000,000
Option 8d: On-site Thermal Treatment	Capital cost and baseline monitoring	$63,000,000
	Annual cost for years 1 to 30	$340,000
	Present worth costs	$67,000,000
Option 8e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$62,000,000
	Annual cost for years 1 to 30	$340,000
	Present worth costs	$66,000,000

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6.2.4 Alternative 10: Dam Replacement, Excavation and Disposal and/or Treatment

6.2.4.1 Description of Dam Replacement, Excavation and Disposal and/or Treatment

This alternative is the same as Alternative 7, Excavation and Disposal and/or Treatment (Section 6.2.2), except that the Allendale and Lyman Mill Dams would be replaced with new weir structures and the size of the water body would be reduced depending on the disposal option used. The new weir structures would be lower than the existing dams and would be sloped on both the upstream and downstream sides to provide free flow of river water without any vertical drops. The general descriptions are consistent with Alternative 7 (Section 6.2.2), as are most of the site-specific details except that hydrodynamic modeling was performed to evaluate the effects of replacing the dams with weir structures on water flow and flooding potential.

The key difference between Alternatives 7 and 10 is that under Alternative 10 the Allendale and Lyman Mill Dams would be replaced with weir structures, which would be designed to:

- maximize the size of the open water area to allow fish (including catadromous and anadromous species) to migrate upriver,
- allow water to flow freely between the ponds at all times, and
- change the vertical profile of the river channel to provide ponded water surfaces at the locations of the existing ponds.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples), and the excavated sediment would be disposed of and/or treated. Excavation operations, sediment processing, construction monitoring, and long-term monitoring and ICs would generally be the same as previously described for Alternative 7 (Section 6.2.2), except that dams would be replaced with weir structures that would be maintained in the long term. There are four disposal options for Alternative 10, which are the same as described for Alternative 7 (Section 6.2.2) as follows:

Option 10a: On-site Containment in an Upland CDF
Option 10b: On-site Containment in a Nearshore CDF
Option 10d: On-site Thermal Treatment
Option 10e: Off-site Disposal and/or Treatment

The construction sequence, excavation volumes and rates, and mitigation activities for Alternative 10 are described below.

Construction Sequence

A typical construction sequence for disposal Options 10a, 10d and 10e is described below:

1. Clear temporary work areas and build access ramps to the ponds.
2. For the on-site disposal options, construct CDF disposal facility and water treatment system prior to sediment removal.
3. Construct sediment dewatering area, install dewatering equipment and water treatment equipment and truck loading and decontamination facilities prior to excavation.

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4. Drain the ponds one at a time beginning with Allendale Pond and excavate sediment from the river/ponds in an upstream to downstream direction.
5. Remove sediment upstream of dams, existing timbers, and dam concrete.
6. Dewater excavated sediment using mechanical means and place dewatered material in the on-site CDF or transport off site for disposal. Take debris to off-site disposal facilities.
7. For the on-site disposal options, operate the CDF water treatment system during excavation.
8. For the on-site disposal options, place a cap over the CDF.
9. Evaluate sediment confirmation samples and determine need for a thin-layer of soil cover.
10. Install new weir structures to replace dams.
11. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

A typical construction sequence for disposal Option 10b (on-site containment in a nearshore CDF) is similar, except for the sequence of construction the CDFs, as described below:

1. Clear temporary work areas and build access ramps to the ponds.
2. Drain the ponds one at a time beginning with Allendale Pond and construct perimeter containment walls for the CDF.
3. Install water treatment equipment and truck loading and decontamination facilities prior to excavation.
4. Excavate sediment from the river/ponds in an upstream to downstream direction and consolidate sediment into CDFs.
5. Remove sediment upstream of dams, existing timbers, and dam concrete.
6. Place sediment into CDF and take debris to off-site disposal facilities.
7. Place a cap over the CDF. The cap would be designed to resist erosion during flood events.
8. Evaluate sediment confirmation samples and determine need for a thin-layer of soil cover.
9. Install new weir structures to replace dams.
10. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

A quantitative hydrodynamic analysis was performed for Alternative 10 Option 10b (nearshore CDF) to evaluate the effects of dam replacement and constructing the nearshore CDF on water flow and flooding potential. The results of this analysis included an estimate of the extent of channel and floodplain inundation, water depth and surface water elevation, current velocity, bed shear stress, and stable bed particle size (QEA, 2007). Based on an evaluation of the model output, this option would result in predicted flood inundation that has no appreciable effect beyond that for existing conditions for the areas adjacent to Allendale and Lyman Mill Ponds, even for 100-year flood events. This option would result in negligible effect on flood stage height and floodplain inundation during high-flow events in the region downstream of Lyman Mill Dam.[64] Alternative 10b would result in the loss of approximately 76,000 cy of flood storage capacity within the CDF footprint, which would be replaced by the increase in storage capacity behind the new weir structures. The new water surface will be about 5.5 feet lower in Allendale

[64] Alternative 2 in the QEA analysis (2007) is the same Alternative 10, Option 10b in this FS.

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and 3.0 feet lower in Lyman Mill (Figure 5-21a and 5-21b). The flood storage gained between the existing and proposed water surfaces is about 166,000 cy, which is greater than the loss due to the CDFs.

Excavation Volumes and Rates

The excavation surfaces, method (long-reach excavator) and rate (400 cy/d for Options 10a, d, and e and 500 cy/d for Option 10b) of sediment excavation would be the same as Alternative 7 (Section 6.2.2).

- For Options 10a, 10d and 10e, the total volume of sediment requiring excavation would be approximately 155,800 cy (2,400 cy in the river channel north of Allendale Pond, 52,900 cy in Allendale Pond and 100,500 cy in Lyman Mill Pond).
- For Option 10b, the contaminated sediment within the perimeter of the nearshore CDFs would not have to be excavated (Figure 5-20). The total volume of sediment requiring excavation would be approximately 111,800 cy (2,400 cy in the river channel north of Allendale Pond, 35,400 cy in Allendale Pond and 74,000 cy in Lyman Mill Pond; 44,000 cy within the CDF footprint would remain in place).[65]

For Options 10a, 10d, and 10e, sediment excavation would take approximately 28 weeks for Allendale Pond and 50 weeks for Lyman Mill Pond. For Option 10b, sediment excavation would take about 15 weeks for Allendale Pond and 30 weeks for Lyman Mill Ponds.

Mitigation

This alternative would result in the conversion of approximately 5 acres of aquatic habitat to wetland/floodplain (i.e., approximately 1 acre in Allendale Pond and 4 acres in Lyman Mill Pond; Appendix K, Table K-1) due to removal of dams and reconfiguration of the ponds. In addition, Option 10b (nearshore CDF) would result in the permanent conversion of an additional 13 acres to upland. Remedy implementation would involve the destruction of existing aquatic habitat structure (both benthic and pelagic) and the temporary extirpation of the vast majority of the fish[66] and invertebrate communities. Secondary impacts to aquatic-dependent wildlife and anglers that fish in these ponds and collateral impacts to floodplain soils would be similar to those described in Alternative 7 (Section 6.2.2).

Figure 6-3 presents an overview of the different habitat features associated with this alternative and possible mitigation components for each. The thin layer cover could be designed as a benthic habitat layer consisting of optimal grain size and organic carbon content for growth of benthic and epibenthic macroinvertebrates and submerged woody material could be included to provide some interim structural diversity. Populations of important species such as bass and sunfish could be re-stocked to expedite recovery of the community. Potential mitigation for fish community impacts could also be provided by the increased fish passage possible with the removal of the dams under this alternative, which could result in the recolonization of portions of the watershed by anadromous fish species (e.g., alewifes, herring). Under this alternative, it is anticipated that the existing aquatic habitat in Allendale and Lyman Mill Ponds would gradually transition toward a cooler water fishery. Although future use scenarios for the fishery would be similar to existing conditions, the presence of more attractive game species could attract broader angler use of the river. According to the AMEC (2009) study conducted to evaluate ecological

[65] Under the nearshore CDF option, only sediment outside the CDF footprint is excavated. The CDF footprint is slightly larger under Alternative 10b (Figure 5-20) compared to Alternative 7b (Figure 5-12) because excavation around the dams is required. As a result, the volume of sediment excavated outside the CDF footprint is slightly less under Alternative 10b (i.e., 111,800 cy) compared to Alternative 7b (123,500 cy).
[66] Resident fish would be collected and euthanized to ensure that the contaminated fish consumption pathway was reduced as part of the remedy implementation.

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impacts associated with the dam removal alternatives, "Although the weirs would restrict flow, they would still allow a certain degree of water flow between ponds thereby allowing some fish species to migrate above, below, and between the ponds." Additional analysis regarding impacts to fish passage (e.g., assessment by fish passage experts to determine if weir design is functional for fish passage) could be performed during the design phase.

There would be an overall conversion of aquatic to upland (floodplain) habitat and a shift from aquatic-dependent to terrestrial wildlife species under this alternative. Following implementation of the sediment remedy, 5 acres of floodplain could be revegetated with appropriate floodplain/riparian shrubs and tree species as mitigation for the lost (converted) aquatic habitat. This in-place mitigation would enhance the visual appeal and functioning of the existing riparian habitat. Out-of-kind mitigation for the additional aquatic habitat lost under Option 10b (nearshore CDF) could be provided as described in Alternative 7 (Section 6.2.2); 13 acres of emergent marsh, scrub/shrub or palustrine forest habitat could be restored as specified in the mitigation planning document. Appendix K provides an overview of possible mitigation requirements and planning for the sediment action area.

6.2.4.2 Evaluation of Dam Replacement, Excavation and Disposal and/or Treatment

Results from the evaluation of Alternative 10, Dam Replacement, Excavation and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-9.

Overall Protection of Human Health and the Environment

Excavation would provide high overall protection by removing the source of contamination, which would lower the concentration of contaminants in the surface sediment where exposure is likely, and quickly reduce human health and ecological risk to acceptable levels. The depth of excavation would be designed to remove all sediment in the river/ponds that contain contamination above the cleanup goals. However, the sediment cleanup goal for dioxin (i.e., 2,3,7,8-TCDD) is based on background and it may be difficult to achieve that in all areas of the pond. If, following excavation, it was determined that cleanup goals had not been universally achieved, then a contingency action involving placement of a thin-layer cover over areas where dioxin remains above background would be implemented. Placement of the thin-layer cover would reduce exposure to contaminant concentrations throughout the ponds so that the RAOs could be achieved.

Excavation would be effective in the long term because all or nearly all of the sediment with contamination above the cleanup goals would be removed from the river/ponds and either contained in a secure disposal facility or treated by incineration. This would reduce the human health risk to background levels and would eliminate the risk of sediment with contamination above cleanup goals migrating downstream due to erosion during flood flows for Options 10 a, 10d, and 10e. The contamination remains in the floodplain under Option 10b and therefore would be less protective overall.

Compliance with ARARs

ARARs specific to Alternative 10 are summarized in Table 6-10. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Section 404 requirements are triggered by excavation. In addition, the nearshore CDF (Option 10b) and possibly upland CDF (Option 10a), dam replacement and thin cover (all options) also trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under Option 10b (on-site confinement in a nearshore CDF) a portion of the nearshore CDF would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was

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no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 10a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 10b) that is within the area of contamination.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence would be the same as Alternative 7 (Section 6.2.2.2). Inspections and long-term maintenance of the weir structure would be required for Alternative 10.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Options 10a (upland CDF), 10d (on-site thermal treatment), and 10e (off-site disposal and/or treatment). The nearshore CDF option (Option 10b) would reduce the mobility of the contaminated sediment particles, although not through treatment.

Short-Term Effectiveness

The short-term impacts would be the same as Alternative 7 (Section 6.2.2.2), except that dam replacement would substantially alter the ecological habitat associated with Allendale and Lyman Mill Ponds such that species assemblages more characteristic of running water rather than lacustrine (i.e., lake) conditions would be favored post-construction.[67] Under this alternative, the river edge would come to be located up to 150 to 200 feet farther west of its present boundary and many residents located along the eastern edge of Allendale and Lyman Mill Ponds would lose waterfront.

The RAOs would be achieved at the completion of remedy implementation, which is estimated to take approximately two years.

Implementability

The implementability issues are the same as for Alternative 7 (Section 6.2.2.2), except that the flood storage lost under Option 10b would be replaced by the increase in storage capacity behind the new weir structures. In addition, replacement of the Allendale and Lyman Mill Dams with weir structures involves standard construction equipment and civil engineering considerations. Potential public opposition to dam replacement would have to be addressed.

Cost

The capital, operation and monitoring, and present worth costs for Options 10a, 10d, and 10e would be the same as costs presented for Alternative 7, except that the capital and present worth costs would increase by approximately $1 million to account for costs associated with dam replacement and mitigation. The detailed cost evaluation for Option 10b, On-site Containment in a Nearshore CDF, is presented in Appendix J. The capital, operation and monitoring, and present worth costs for all options are listed below:

[67] The proposed design does include provision for several pool features.

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Option 10a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$59,000,000
	Annual cost for years 1 to 30	$220,000
	Present worth costs	$62,000,000
Option 10b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$47,000,000
	Annual cost for years 1 to 30	$240,000
	Present worth costs	$50,000,000
Option 10d: On-site Thermal Treatment	Capital cost and baseline monitoring	$116,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$119,000,000
Option 10e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$115,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$117,000,000

6.2.5 Alternative 11: Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

6.2.5.1 Description of Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

This alternative is a combination of the Alternative 8 Partial Excavation, Isolation Capping and Disposal and/or Treatment (Section 6.2.3) and Alternative 10 Dam Replacement, Excavation and Disposal or Treatment (Section 6.2.4). The general descriptions in the previous sections, as well as most of the site-specific details, are still pertinent to this alternative except that (a) the quantitative analysis of the capping alternative included an evaluation of the effects of removing the dams on water flow and flooding potential and (b) the cap would be placed using land-based equipment, rather than floating equipment. The key differences between the excavation alternative and partial excavation alternative are that the design objectives for partial excavation are different. In Alternative 11, the primary objectives of excavation are to:

- Excavate contaminated sediment from areas within the existing footprint of the river/ponds that will be under water during average flow conditions such that a specific river channel/pond configuration is achieved while minimizing the amount of sediment to be excavated for disposal and/or treatment.
- Maximize the open water area of the river channel/pond configuration that would result from the replacement of the dams with weirs by relocating clean sediment to shape the areas of the ponds. Following the removal of the contaminated sediment, underlying clean sediment would be relocated and placed over contaminated sediment that remains in place.
- Cover areas of contaminated sediment that remains in place with cap materials that are equivalent to those to be provided for the on-site CDF option.
- Construct the isolation caps to be resistant to high energy flows and potential erosion.

Because a cap would cover any contaminated sediment remaining in place, it would not be necessary to excavate sediment from the entire footprint of the ponds.

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Focused excavation to achieve a final water body comprised of the river channel and ponds (Figure 5-24) would result in an estimated sediment excavation volume for both ponds of approximately 59,900 cy. Once the contaminated sediment is removed, the underlying clean sediment would be relocated to shape the surface water body to maximize the size of the ponds (cross sections shown in Figures 5-25a and 5-25b). The clean sediment would be relocated over areas where contaminated sediment remains in place, and an appropriate cover system (RCRA cap comparable to that used for the upland CDF [Figure 5-7]) would be placed to complete the cap over sediment that remains in place. The cover system would be designed to resist erosion during flood events.

It is likely that soft sediment would consolidate under the weight of the cap material, causing pore water containing water soluble contaminants to migrate upward into the pore water in the cap material. Pore water from the cap would then be displaced into the surface water. Pore water and potential contaminant movement would be evaluated during design as part of the contaminant transport analysis. The cap would be designed so that contaminant movement would have an insignificant impact on the cap material. Construction monitoring would be performed to confirm that surface water quality is protected during construction and would include monitoring water quality downstream of the dams during placement of the cap. In addition, a physical survey would be conducted at the completion of construction activities to confirm that the isolation caps meet the design thickness and have been placed over all of the contaminated sediments remaining in place.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples), and the excavated sediment would be disposed of and/or treated. Excavation operations would generally be the same as previously described for Alternative 7 (Section 6.2.2), except that there would be additional construction measures to replace the dams with new weir structures. The cap materials would be placed using land-based equipment and methods because the ponds will be drained when the cap is placed. Sand would be delivered to the site by truck and placed in temporary stockpiles. Cap material would be loaded into off-road trucks and delivered to the cap area, where it would be spread using a grader and small dozer.

Requirements for sediment processing, construction monitoring, and long-term monitoring and ICs would generally be the same as described for Alternative 8 (Section 6.2.3). There are five disposal options for Alternative 11, four of which are the same as described for Alternative 7 (Section 6.2.2) as well as a fifth option (Option 11f) unique to this alternative, as follows:

Option 11a: On-site Containment in an Upland CDF
Option 11b: On-site Containment in a Nearshore CDF
Option 11d: On-site Thermal Treatment
Option 11e: Off-site Disposal and/or Treatment
Option 11f: On-site Consolidation

The construction sequence, excavation volum es an d rates, cap stability and design, and m itigation activities for Alternative 11 are described below.

Construction Sequence

A typical construction sequence for sediment excavation and isolation capping with disposal Options 11a, 11d and 11e and dam replacement is described below:

1. Clear temporary work areas and build access ramps to the ponds.

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2. For the on-site disposal option, construct CDF disposal facility and water treatment system prior to sediment removal.
3. Construct sediment dewatering area, install dewatering equipment and water treatment equipment and truck loading and decontamination facilities prior to excavation.
4. Drain the ponds one at a time beginning with Allendale Pond and excavate sediment from the ponds in an upstream to downstream direction.
5. Import cap materials and cover contaminated sediments.
6. Dewater excavated sediment using mechanical means and place dewatered material in the CDF or transport off site for disposal. Take debris to off-site disposal facilities.
7. For the on-site disposal option, operate the CDF water treatment system during excavation.
8. For the on-site disposal option, place a cap over the CDF.
9. Evaluate sediment confirmation samples and determine need for a thin-layer soil cover over the excavated areas.
10. Remove sediment upstream of dams, existing timbers, and dam concrete.
11. Place a cap over sediment from dam removal work.
12. Install new weir structures to replace dams.
13. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

The anticipated sequence of construction activities for sediment excavation and isolation capping with disposal Option 11b (on-site nearshore CDF) and dam replacement is described below:

1. Clear temporary work areas and build access ramps to the ponds.
2. Drain the ponds one at a time beginning with Allendale Pond and construct perimeter containment walls for the CDF.
3. Install water treatment equipment and truck loading and decontamination facilities prior to excavation.
4. Excavate sediment from the ponds in an upstream to downstream direction and place into CDFs.
5. Consolidate sediment into CDF and take debris to off-site disposal facilities.
6. Import cap material and cover contaminated sediment.
7. Evaluate sediment confirmation samples and determine need for a thin-layer soil cover over the excavated areas.
8. Remove sediment upstream of dams, existing timbers, and dam concrete.
9. Place a cap over the CDF. The cap would be designed to resist erosion during flood events.
10. Install new weir structures to replace dams.
11. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

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The anticipated sequence of construction activities for sediment excavation and isolation capping with disposal Option 11f (on-site consolidation) and dam replacement is described below:

1. Clear temporary work areas and build access ramps to the ponds.
2. Drain the ponds one at a time beginning with Allendale Pond.
3. Excavate sediment from the ponds in an upstream to downstream direction and place into the consolidation areas.
4. Import cap materials and cover contaminated sediments.
5. Remove sediment upstream of dams, existing timbers, and dam concrete.
6. Place sediment into consolidation areas and take debris to off-site disposal facilities.
7. Place a cap over sediment from dam removal work. The cap would be designed to resist erosion during flood events.
8. Install new weir structures to replace dams.
9. Remove the temporary vessel launch ramps and restore the vegetation in the temporary work areas.

A quantitative hydrodynamic analysis was performed for Alternative 11 Option 11f (nearshore CDF) to evaluate the effects of dam replacement and constructing the on-site consolidation area on water flow and flooding potential. The results of this analysis included an estimate of the extent of channel and floodplain inundation, water depth and surface water elevation, current velocity, bed shear stress, and stable bed particle size (QEA, 2007). Based on an evaluation of the model output, this option would result in predicted flood inundation that has no appreciable effect beyond that for existing conditions for the areas adjacent to Allendale and Lyman Mill Ponds, even for 100-year flood events. This option would result in negligible effect on flood stage height and floodplain inundation during high-flow events in the region downstream of Lyman Mill Dam.[68] Alternative 11f (and 11b) would result in the loss of approximately 68,000 cy of flood storage capacity within the on-site consolidation area, which would be replaced by the increase in storage capacity behind the new weir structures. The new water surface will be about 5 feet lower in Allendale and 3 feet lower in Lyman Mill (Figure 5-25a and 5-25b). The flood storage gained between the existing and proposed water surfaces is about 175,000 cy, which is greater than the loss due to the consolidation area.

Excavation Volumes and Rates

Estimated excavation surfaces for Allendale and Lyman Mill Ponds are shown in Figure 5-24. The same excavation footprint would be used for all disposal or treatment options, resulting in approximately 59,800 cy of contaminated sediment from Allendale and Lyman Mill Ponds combined (including the river channel north of Allendale Pond). The excavation method (long-reach excavator) and rate (400 cy/d for Options 11a, 11d, and 11e and 500 cy/d for Option 11b and 11f) for sediment excavation would be the same as Alternative 7 (Section 6.2.2). Excavation and disposal or treatment of approximately 59,800 cy would take about 30 weeks for Options 11a, 11d, and 11e and about 24 weeks for Options 11b and 11f. Importing and placing approximately 150,000 tons of cap material would take about 30 weeks, with two crews for Option 11f.

[68] Alternative 3 in the QEA analysis (2007) is the same Alternative 11, Option 11f in this FS, except that the QEA analysis assumed a 2-ft isolation cap cover system for the consolidation area rather than a RCRA cap.

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Cap Stability and Design

A quantitative hydrodynamic analysis of the partial excavation and isolation capping alternative was performed to evaluate the effects of replacing the dams with weir structures on water flow and flooding potential. The results of this analysis included an estimate of the extent of channel and floodplain inundation, water depth and surface water elevation, current velocity, bed shear stress, and stable bed particle size (QEA, 2007). Based on an evaluation of the model output, this alternative would result in predicted flood inundation that has no appreciable effect beyond that for existing conditions for the areas adjacent to Allendale and Lyman Mill Ponds, even for 100-year flood events. Also, this alternative would result in reasonable predicted ranges of current velocities and current speeds indicating that the alternative may be engineered to minimize erosion. This analysis was used to identify the stable bed particle size for a 24-inch cap placed over contaminated sediment. The predicted stable bed particle size is commercially available and would protect against erosion during flood flows. The stability analysis was performed using a 100-year flood flow rate of 2,300 cfs. The quantitative hydrodynamic analysis shows that the cap would be stable in both Allendale and Lyman Mill Ponds in a 100-year flood.

The top layer of the cap would be designed to resist potential erosion during a 100-year flood. To properly evaluate this alternative and estimate construction costs, the grain size of cap particles required to resist erosion were obtained from the predicted stable bed particle sizes.

Mitigation

This alternative would result in the conversion of approximately 23 acres of aquatic habitat to wetland/floodplain and/or upland (Appendix K, Table K-1). Remedy implementation would involve the destruction of existing aquatic habitat structure (both benthic and pelagic) and the temporary extirpation of the vast majority of the fish[69] and invertebrate communities. Secondary impacts to aquatic-dependent wildlife and anglers that fish in these ponds and collateral impacts to floodplain soils would be similar to those described in Alternative 7 (Section 6.2.2).

Figure 6-4 presents an overview of the different habitat features associated with this alternative and possible mitigation components for each. The thin-layer cover could be designed as a benthic habitat layer consisting of optimal grain size and organic carbon content for growth of benthic and epibenthic macroinvertebrates and submerged woody material could be included to provide some interim structural diversity. Similar to the other excavation alternatives, mitigation for fish community impacts could be achieved through re-stocking of important species and (as with Alternative 10) the increased fish passage allowed by the replacement of the dams with weir structures. Following implementation of the sediment remedy, the created floodplain habitat (i.e., approximately 23 acres under Options 11a, d, and e and 11 acres under Options 11b and 11f) could be vegetated with appropriate floodplain/riparian herbaceous and shrubs species as mitigation for lost aquatic habitat.

Out-of-kind/place mitigation for the additional aquatic habitat lost under Options 11b and 11f could be provided as described in Alternative 7 (Section 6.2.2); 12 acres of emergent marsh, scrub/shrub or palustrine forest habitat could be restored as specified in the mitigation planning document prepared as part of the final design. Additional out-of-place mitigation may be required under all options for this alternative. During design it may be determined that uncontrolled growth of vegetation in some portion of the new floodplain area would pose an unacceptable risk of future exposure and recontamination

[69] Resident fish would be collected and euthanized to ensure that the contaminated fish consumption pathway was reduced as part of the remedy implementation.

following storm damage or tree death.[70] If this determination were made, vegetation maintenance could be required and the resulting habitat would likely be incapable of fully compensating for the lost (aquatic) habitat that currently exists. Appendix K provides an overview of possible mitigation requirements and planning for the sediment action area.

6.2.5.2 Evaluation of Dam Replacement, Partial Excavation, Isolation Capping and Disposal or Treatment

Results from the evaluation of Alternative 11, Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-11.

Overall Protection of Human Health and the Environment

Partial excavation followed by capping would provide some overall protection by removing and containing the source of contamination, which would lower the concentration of contaminants in the surface sediment where exposure is most likely. Targeted excavation would address sediment in the areas most susceptible to erosion which would reduce the risk of potential cap erosion during periods of flood flows. Placement of clean cap material over the entire pond bottom would reduce the surface concentrations so that the cleanup goals would be achieved at the end of construction. The results of the RI and hydrodynamic modeling performed for this FS show that the risk of erosion is low in the majority of the pond areas. The cap thickness and material types would be designed to restrict potential contaminant migration from contaminated sediment through the cap by either diffusion or advection. The cap would be designed using methods developed by EPA and USACE, which would provide long-term isolation of contaminants in the underlying sediments. The combination of excavation and capping would reduce the risk of direct exposure to background levels and would reduce the risk of downstream migration of sediment with contaminants above the cleanup goals. Option 11f would be less protective overall compared to the other options because the contamination would be capped in place, rather than contained in a controlled disposal facility or incinerated.

Compliance with ARARs

ARARs specific to Alternative 11 are summarized in Table 6-12. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Section 404 requirements are triggered by excavation. In addition, dam replacement, the isolation cap, the nearshore CDF (Option 11b), consolidation (Option 11f) and possibly the upland CDF (Option 11a) also trigger Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. In addition, isolation capping (all options), the nearshore CDF (Option 11b) and consolidation (Option 11f) would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 11a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a

[70] According to United States Department of Agriculture (USDA) Plants database (http://plants.usda.gov/), the minimum rooting depth of several common riparian/floodplain tree species (including red maple and black willow) approach 3 feet; minimum rooting depths for common shrubs species (e.g., alder and sweet pepperbush) are on the order of 1.5 feet.

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nearshore CDF (Option 11b) that is within the area of contamination. The same would be true for the on-site consolidation option (Option 11f).

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence would be the same as Alternative 8 (Section 6.2.3.2), except there are additional reliability issues for Option 11f (on-site consolidation) because the contaminated sediment would be consolidated and capped in place rather than contained in a controlled disposal facility. Inspections and long-term maintenance of the weir structures would be required for Alternative 11.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Options 11a (upland CDF), 11d (on-site thermal treatment), and 11e (off-site disposal and/or treatment). Isolation capping (all options) and the on-site containment options (Options 11b and 11f) would reduce the mobility of the contaminated sediment particles, although not through treatment. Contaminated sediment particles may be more mobile under Option 11f because the material would be consolidated and capped in place, rather than contained in a controlled disposal facility.

Short-Term Effectiveness

The short-term impacts are the same as those identified for Alternative 10 (Section 6.2.4.2), except that more aquatic habitat is lost and converted to floodplain/wetland under Alternative 11 (approximately 18 additional acres of aquatic habitat is lost compared to Options 10a, 10d and 10e and approximately 5 additional acres of aquatic habitat is lost compared to Option 10b). The RAOs would be achieved at the completion of remedy implementation, which is estimated to take approximately one year for Option 11f (on-site consolidation) and upwards of two years for the other options. As with Alternative 10, the transition from a warm- to a cool-water fishery could attract broader angler use of the river.

Implementability

The implementability issues are the same as for Alternative 10 (Section 6.2.4.2), except under Option 11a (upland CDF) a smaller parcel of land would be required because a smaller volume of sediment would be removed under the partial excavation alternative compared to full excavation (Alternative 10).

Cost

The capital, operation and monitoring, and present worth costs for Options 11a, 11d, and 11e would be about $3 million less than costs presented for Alternative 8 because the capital and present worth costs would increase for costs associated with dam replacement and mitigation, and decrease for reduction in cap material volume. The same is true for Option 11b, except that the overall costs would be approximately $500,000 higher compared to Alternative 8b to cover additional mitigation costs. The detailed cost evaluations for Option 11f, On-site Consolidation, is presented in Appendix J. The capital, operation and monitoring, and present worth costs for all options are listed below:

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Option 11a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$38,000,000
	Annual cost for years 1 to 30	$370,000
	Present worth costs	$42,000,000
Option 11b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$32,000,000
	Annual cost for years 1 to 30	$370,000
	Present worth costs	$37,000,000
Option 11d: On-site Thermal Treatment	Capital cost and baseline monitoring	$60,000,000
	Annual cost for years 1 to 30	$340,000
	Present worth costs	$64,000,000
Option 11e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$59,000,000
	Annual cost for years 1 to 30	$340,000
	Present worth costs	$63,000,000
Option 11f: On-site Consolidation	Capital cost and baseline monitoring	$30,000,000
	Annual cost for years 1 to 30	$370,000
	Present worth costs	$35,000,000

6.3 Comparative Analysis of the Allendale and Lyman Mill Sediment Alternatives

The five alternatives for Allendale and Lyman Mill sediments (Alternative 1, No Action; Alternative 7, Excavation and Disposal and/or Treatment; Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment; Alternative 10, Dam replacement, Excavation and Disposal and/or Treatment; and Alternative 11, Dam replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment) are compared below to better understand the key tradeoffs among the alternatives; key features of the alternatives are summarized in Table 6-13.

Overall, among the sediment alternatives evaluated, full removal using excavation (Alternatives 7 and 10) would provide the highest level of protection to human health and the environment. Disposal options that use on-site thermal treatment (Alternatives 7d and 10d) or off-site disposal and/or treatment (Alternatives 7e and 10e) will provide the highest level of long-term effectiveness and permanence, but the costs are substantially higher than the on-site containment options. Disposal options that use on-site containment (7a, 7b, 10a and 10b) would provide effective long-term protection at costs that are substantially lower than the on-site treatment or off-site disposal and/or treatment options.

6.3.1 Overall Protection of Human Health and the Environment

As discussed previously in Section 6.2, the human health and ecological risk drivers are directly tied to the contaminated sediments and the consumption of contaminated prey or fish such that the cleanup objectives can be attained by remediating the surface sediments, or the biologically active zone. The No Action alternative would not provide any protection of human health or the environment because no active remediation would be conducted.

Among the alternatives evaluated, Alternatives 7 (Excavation and Disposal and/or Treatment), and 10 (Dam Replacement, Excavation and Disposal and/or Treatment) provide the greatest overall protection of human health and the environment by removing the source of contamination from the river/ponds which would lower the concentration of contaminants in the surface sediment where exposure is likely, and quickly reduce human health and ecological risk to acceptable levels. Excavation would be highly effective in the long term because all or nearly all of the sediment with contamination above the cleanup goals would be removed from the river/ponds and either contained in a secure disposal facility or treated

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by incineration. This would reduce the human health risk to background levels and would eliminate the risk of sediment with contamination above cleanup goals migrating downstream due to erosion during flood flows as would be the case for Alternatives 8 and 11. The contamination remains in the floodplain under Options 7b and10b and therefore these options would be less protective overall relative to the other options under Alternatives 7 and 10.

Alternative 8 (Partial Excavation, Isolation Capping and Disposal and/or Treatment) and Alternative 11 (Dam Replacement/ Partial Excavation, Isolation Capping and Disposal and/or Treatment) provide some overall protection by partially removing and containing the source of contamination, which would lower the concentration of contaminants in the surface sediment where exposure is most likely. Placement of clean cap material over the entire pond bottom would reduce the surface concentrations so that the cleanup goals would be achieved at the end of construction. Although all of these alternatives would be designed to be secure, some risk remains that sediment above safe levels could be released in the future should catastrophic events occur or if monitoring, maintenance and/or ICs are not effective in the long term. As a result, the overall protection of human health and the environment of these alternatives while greater than the No Action alternative, is less than those alternatives that remove contamination from the river.

6.3.2 Compliance with ARARs

All alternatives other than the No Action alternative have floodplain/wetlands and Section 404 impacts, although some Alternatives (7 and 10) have considerably fewer impacts than others (Alternatives 8 and 11) because the latter two include capping considerable areas of contaminated sediment in wetlands/floodplain areas. All alternatives must be evaluated to determine the least damaging practicable alternative for wetlands purposes. Alternatives 7b, 8b, 10b, and 11 would involve permanent occupancy and modification of the floodplain. For those alternatives with floodplain impacts, a determination would need to be made that there was no other practicable alternative before selecting any of these alternatives as the preferred remedy. Alternatives 7a, 8a, 10a, and 11a could potentially result in the destruction of low-quality wetlands that may be located in areas selected for the upland CDF. In addition, these alternatives may require a treatability variance to reduce the amount of treatment required prior to disposal.

6.3.3 Long-Term Effectiveness and Permanence

The No Action alternative is not considered effective with respect to long-term effectiveness and permanence as the residual risk remains high and there are no controls to prevent exposure. Those alternatives that require full excavation and on-site thermal treatment or off-site disposal and/or treatment (Alternatives 7d, 7e, 10d, and 10e) provide the greatest long-term effectiveness and permanence. Under these alternatives, the excavated material would either be completely removed from the site or treated by incineration, which would destroy the organic contaminants.

Residual Risk

Tables 6-14 and 6-15 summarize the residual risks (i.e., the risks based on anticipated contaminant exposures following attainment of the cleanup objectives) to human health and ecological receptors for Allendale and Lyman Mill Ponds sediment, respectively. The calculated residual risks are equivalent for all active remedies and in most cases are considerably less than the No Action alternative.[71] The residual risks are summarized in the following sections with detailed analysis provided in Appendix K.

[71] The residual risk estimates assume that contamination in fish and other prey organism tissues in the river/ponds are at or below risk-based concentrations for consumer organisms. If contaminated organisms remained in the

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Allendale Pond (and river channel north of pond). For each active remedial alternative, the residual carcinogenic risk to humans is 5.E-05, which is within the EPA cancer risk range and two orders of magnitude less than residual risks under the No Action alternative (Table 6-14a). Organ-specific noncarcinogenic hazards to exposed human receptors are less than 1 under all remedial alternatives (Table 6-14b).

Residual risks to ecological receptors (fish and wildlife) are also lower under the active remedial alternatives (Table 6-14d) compared to the No Action alternative (Table 6-14c). Under the No Action alternative, residual risks to piscivorous and insectivorous wildlife are 40 and 20, respectively; these risks are considerably lower for the action alternatives (i.e., 0.7 and 0.04, respectively). In the case of fish receptors, residual risks under the active remedial alternatives are lower than for the No Action alternative (i.e., 30 versus 70, respectively); however, in all cases, elevated risks remain because background concentrations of several contaminants exceed risk-based sediment threshold concentrations. Technical chlordane accounts for the majority (i.e., 27/30 = 90%) of the elevated risks but selenium and zinc also contribute (Table 6-14d).

Lyman Mill Pond. For each active remedial alternative, the residual carcinogenic risk to humans is 6.E-05 (Table 6-15b), which is within the EPA cancer risk range and two orders of magnitude less than residual risks under the No Action alternative (Table 6-15a). Organ-specific noncarcinogenic hazards to exposed human receptors are less than 1 under all remedial alternatives (Table 6-15b).

Residual risks to ecological receptors (fish and wildlife) are also lower under the active remedial alternatives (Table 6-15d) compared to the No Action alternative (Table 6-15c). Under the No Action alternative, residual risks to piscivorous and insectivorous wildlife are both 10; these risks are considerably lower for the action alternatives (i.e., 4 and 0.5, respectively). None of the alternatives is capable of achieving a Target Hazard of 1 for wildlife because background pesticide (i.e., 4,4'-DDE and 4,4'-DDD) concentrations exceed the risk-based sediment concentrations. In the case of fish receptors, residual risks under the active remedial alternatives are lower than for the No Action Alternative (i.e., 60 versus 100, respectively for demersal fish and 50 versus 80, respectively, for pelagic fish). The elevated risks that remain are due to background concentrations of several contaminants that exceed risk-based sediment threshold concentrations. Technical chlordane accounts for nearly half (i.e., 29/60 = 48%) of the elevated residual risk to demersal fish with minor contributions from other inorganic contaminants including aluminum, barium, selenium, vanadium and zinc (Table 6-15d).

Inherent Hazard

The inherent hazard is reduced for excavation alternatives where upland and nearshore CDFs are used (Alternatives 7a, 7b, 10a, and 10b). Under these alternatives some or all sediment above cleanup levels remains untreated on site. However, under these alternatives contaminated sediment is either removed from the river and placed in secure upland locations or consolidated along the shore in nearshore CDFs. The upland CDF (Alternatives 7a and 10a) would have a liner, would be outside of the floodplain, and some waste may be treated while the nearshore CDF (Alternatives 7b and 10b) would not be lined, would be located within the floodplain, and no waste would be treated. ICs are necessary to prevent the disturbance of the caps for both CDF options. These controls are only effective if adequately monitored and enforced. There are additional reliability issues for Alternatives 7b and 10b because the CDF is

river/ponds following the conclusion of remedial activities, then these residual risk estimates would apply once the tissue had equilibrated with the remediated sediment substrate. Alternatively, contaminated fish could be removed from the river/ponds during implementation of the selected remedial alternative, which would cause an immediate reduction in risk to the levels presented above.

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located in the river/floodplain that would affect overall protection. Those alternatives that require treatment or off-site disposal (Alternatives 7d, 7e, 10d and 10e) have the least inherent hazard.

The inherent hazard is highest for those alternatives where contaminated sediment is capped in place (Alternatives 8 and 11). Those alternatives that require treatment (8d, 8e, 11d and 11e) have slightly less inherent hazard. Even though the cap would provide reliable chemical isolation, the inherent hazard remains high as contaminated sediment remains in the river at high levels. Although the top layer of the cap would be designed to withstand erosion and the site is a stable depositional area, long-term maintenance and monitoring are critical for these alternatives to adequately and reliably prevent exposure to contamination in the long term. Because contaminated sediment would remain in place, there would still be potential for migration of contaminated sediment downstream. In addition, Alternatives 8 and 11 rely significantly on long-term ICs including possibly restricting some boating and recreational activities in the river to prevent disturbance of the cap. These controls are only effective if adequately enforced.

6.3.4 Reduction of Toxicity, Mobility or Volume through Treatment

Alternatives 7d, 7e, 10d, and 10e require the greatest reduction of toxicity, mobility and volume through treatment followed by Alternatives 8d, 8e, 11d, and 11e. Some material would also be treated under Alternatives 7a, 8a, 10a, and 11a. The No Action and excavation alternatives utilizing on-site containment in a nearshore CDF (7b, 8b, 10b, and 11b) or consolidation (Option 11f) do not require treatment of contaminated material, although all of these alternatives with the exception of No Action reduce mobility.

6.3.5 Short-Term Effectiveness

The No Action alternative has no short-term impacts to the community, the environment or workers. The short-term impacts to the community are fairly similar for all alternatives although there are some minor differences for the alternatives that require on-site treatment (Alternatives 7d, 8d, 10d and 11d) and those alternatives that require on-site containment (Alternatives 7a, 7b, 8a, 8b, 10a, 10b, 11a, 11b, and 11f). Those options that require operation of a treatment facility would have air emissions albeit at very low levels. The incinerator exhaust would be treated; however, it is typically not possible to remove all contaminants or odors from the emissions. An on-site incinerator would also utilize fuels such as natural gas or fuel oil, the combustion of which would result in additional exhaust emissions. Alternatives including on-site containment options (Alternatives 7a, 7b, 8a, 8b, 10a, 10b, 11a, 11b, and 11f) would also have some short-term impacts to the areas and community surrounding the CDF sites. Construction activities will temporarily increase during the time work is done in these areas. The short-term impacts to workers are all relatively the same under all alternatives.

There are however, some differences in impacts to the environment under the different alternatives. For those alternatives that require a cap (Alternatives 8 and 11) there could be some short-term water quality impacts due to increased suspended materials during cap placement. Additionally, the placement of the cap material would result in the burial and complete loss of the benthic macroinvertebrate community. Similarly, the excavation or partial excavation alternatives (Alternatives 7, 8, 10 and 11) would result in the complete elimination of the benthic macroinvertebrate and fish communities. One potential difference in short-term impacts between the capping and excavation alternatives would be if the capping alternatives required a more erosion-resistant cover substrate than the excavation alternative. If the capping substrate was less favorable for recolonization by macroinvertebrates, the delay in the reestablishment of the base of the aquatic food web in the ponds could in turn delay the recovery of the fishery and wildlife populations.

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As discussed in further detail in Appendix K, the time for the pond ecosystems to recover to a point where expected services are again routinely provided is dependent on the degree to which habitat restoration features are included in the final design. It is assumed that any restoration (e.g., biological habitat cap layer, restoration of SAV or riparian vegetation) could be components of any of the active remedial alternatives so that the short-term effectiveness criterion would not be a discriminator among them. However, as noted above, design criteria associated with the construction of nearshore CDFs (i.e., Alternatives 7b, 8b, 10b, and 11b) would limit or prevent the establishment of a functional riparian zone in perpetuity.

With regard to the community, the river edge under the dam replacement alternatives (Alternatives 10 and 11) would come to be located up to 150 to 200 feet farther west of its present boundary and many residents located along the eastern edge of Allendale and Lyman Mill Ponds would lose waterfront. On the other hand, that area would provide the natural beauty of the developing riparian habitat.

6.3.6 Implementability

All of the alternatives, except the No Action alternative, present different technical and administrative feasibility issues. Those alternatives that require excavation and on-site containment (Alternatives 7a, 7b, 8a, 8b, 10a, 10b, 11a, and 11b) will require adequate space for the disposal facility which makes implementability of these options more difficult. In addition, those alternatives that require on-site incineration (Alternatives 7d, 8d, 10d, and 11d) would require the acquisition of adequate land for dewatering, stockpiling, and treatment areas. Additionally, vendors specializing in on site, high-temperature incineration of hazardous waste are needed and the incinerator would be required to meet the air-quality ARAR criteria. Gaining public acceptance is an important component of these options. These issues make implementability of the on-site treatment options (Alternatives 7d, 8d, 10d, and 11d) more difficult. Those alternatives that require dam replacement (Alternatives 10 and 11) will also present public acceptance issues that may make implementation more difficult. Under all alternatives other than No Action, impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable wetland impacts and replacement of lost flood storage capacity would be required. Requirements for out-of-place compensatory mitigation for unavoidable losses of aquatic habitat would be higher for Alternative 10b, followed by Alternatives 11b, 11f, 7b and 8b. Alternatives 7b and 8b would require greater flood storage replacement than Alternatives 10 and 11, which would gain capacity behind the new weir structures. Finally, alternatives with upland disposal (Alternatives 7a, 8a, 10a, and 11a) may need to obtain a treatability variance to reduce the amount of treatment required prior to disposal.

6.3.7 Cost

The costs for all the Allendale and Lyman Mill sediment alternatives are presented in Table 6-13. Present worth costs for No Action (Alternative 1) is $450,000. Present worth costs for the action-based alternatives range from $35,000,000 for dam replacement, partial excavation, isolation capping and on-site consolidation (Alternative 11f) to $119,000,000 for dam replacement, excavation and on-site treatment (Alternative 10d).

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6.4 Detailed Evaluation of Allendale Floodplain Soil Alternatives

The two Allendale floodplain soil alternatives retained from the screening analysis are described further in this section and are evaluated against the NCP criteria (excluding State and Community Acceptance, which are considered after comments to the FS and Proposed Plan are received). All alternatives include five-year reviews. It is assumed that implementation of a floodplain soil remedy would be carried out concurrently with the sediment remedy at Allendale, and that all work would be performed in an upstream to downstream direction to prevent re-contamination of areas previously remediated.

Allendale Reach Floodplain Soil Alternatives Retained for Detailed Analysis

1	No Action
5	Excavation and Disposal and/or Treatment

Some wetland areas are located at this action area, including scrub/shrub and herbaceous marsh wetland vegetation in the floodplain located immediately south of Cap Area #1 (Section 2.3.10). Because some soil contamination is located in wetland areas, there is no practical alternative to destruction of these wetlands.

6.4.1 Alternative 1: No Action

6.4.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process, and is used as a basis of comparison to the other alternatives. This alternative would entail no active remediation of the contaminated floodplain soils. Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. For cost estimating, it is assumed that these activities would be covered under the sediment No Action alternative (Section 6.2.1). Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

6.4.1.2 Evaluation of No Action

Results from the evaluation of Alternative 1, No Action against the NCP criteria are discussed below and summarized in Table 6-16.

Overall Protection of Human Health and the Environment

This alternative would not provide overall protection of human health and the environment because the contaminated floodplain soil that presents an exposure hazard would remain on site unaddressed. Because some of the primary sources of contamination to the floodplain soils have been controlled (see Section 2.2.2), natural recovery may reduce risk to human health and the environment by reducing the contaminant concentrations in the surface soil over time. However, there would be no data to demonstrate this reduction and no monitoring of natural recovery processes or contingency action to limit or control future migration of soil contamination or exposure to soil.

Compliance with ARARs

The No Action alternative does not comply with state ARARs for residential direct exposure or EPA's recommended residential level for dioxin (EPA, 1998b) (Table 6-17).

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Long-Term Effectiveness and Permanence

The No Action alternative would not be effective in the long term because no action would be taken to contain, reduce erosion and downstream transport, or remove the contaminated floodplain soil that presents a risk. The residual risk remains high as no actions are taken to address floodplain soil and no controls are in place to adequately and/or reliably prevent exposure in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment

There would not be a reduction of toxicity, mobility or volume of contamination through treatment.

Short-Term Effectiveness

This alternative has no short-term impacts because there would not be any intrusive work or construction that would result in short-term impacts to the local community, habitat or workers. This alternative, however, would not achieve the cleanup objectives.

Implementability

This alternative would not present any implementation issues because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., dams and fences). The implementation of periodic monitoring would not present any unusual issues.

Cost

There would be no capital or long-term monitoring costs for the No Action alternative. Costs for periodic monitoring and five-year reviews are covered under the No Action alternative for sediment (Section 6.2.1.2).

6.4.2 Alternative 5: Excavation and Disposal and/or Treatment

6.4.2.1 Description of Excavation and Disposal and/or Treatment

In Alternative 5, Excavation and Disposal and/or Treatment, contaminated floodplain soils that present an exposure hazard would be removed using conventional excavation techniques (Figures 3-3a and 3-3b show areas where floodplain soil would be excavated). For cost estimating in this FS, it is assumed that contaminated floodplain soil would be removed to a depth of 1 foot, replaced with clean fill, and the floodplain habitat restored. A depth of 1 foot was assumed because this is generally considered the depth to which the majority of relevant ecological exposures occur as a result of foraging or burrowing activities. The actual depth of excavation would extend deeper within the vadose zone to meet ARARs or EPA's dioxin requirements as necessary, and would be determined during design based on sampling and analysis of deeper soil samples.

It is assumed that removal of floodplain soils would be carried out concurrently with the sediment excavation alternative(s), and that pond water levels would be below the normal water levels so that all work would be performed above the water level.

The surface soils in the floodplain areas are expected to be soft and may not be able to support wheeled vehicles, even after drying for several days. In this case, low-ground pressure equipment would be used (i.e., crawler mounted equipment with extra-wide tracks). With the pond water level lowered, the

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excavated soils would be transported using off-road trucks on temporary haul roads along the pond shoreline to a temporary work area at the source area. This would eliminate the need for any trucks hauling contaminated soil on the local residential streets.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples). The sequence of excavation activities, excavation volumes and rates, soil processing, mitigation activities, long-term monitoring and ICs, and disposal and/or treatment options are described below. This alternative assumes that soil dewatering would not be required.

Construction Sequence

A typical construction sequence is described below:

1. Clear temporary work areas and build access ramps to the ponds. (Use same areas cleared for pond sediment removal, if the removal or partial removal alternative is selected for Allendale Pond).
2. For the on-site disposal option, construct CDF disposal facility prior to soil removal.
3. Construct stockpiling, truck loading and decontamination facilities prior to excavation.
4. Lower the water level in Allendale Pond, excavate floodplain soils in an upstream to downstream direction, and place excavated material in the CDF or transport off site for disposal.
5. For the on-site disposal options, operate the CDF water treatment system during excavation.
6. For the on-site disposal options, place a cap over the CDF.
7. Evaluate confirmation samples, place backfill, and restore site grade and habitat.
8. Remove the temporary roadways and restore the vegetation in the temporary work areas.

Excavation Volumes and Rates

Figures 3-3a and 3-3b show the areas that will be excavated under this alternative. The estimated volume of soil that will be excavated is approximately 2,400 cy (does not include over-excavation allowance).[72] The rate of excavation would be controlled by the rate of material transport from the floodplain areas to the upland processing area. It is assumed that one long-reach excavator working to remove a 1-foot thick layer of soil would remove about 400 in-situ cy/d. Soil excavation would take approximately 1 week.

Floodplain Soil Processing

It is assumed that the excavated floodplain soils would be much drier than the pond sediments and would likely not require any kind of dewatering prior to disposal or treatment.

Floodplain soils would be stockpiled in the same processing area established for pond sediments; an area of 2 to 3 acres would be required. One possible location would be on Cap Area #1 in the source area, which has an area of approximately 2 acres. Stockpiled floodplain soils would be tested as needed for off-site disposal, and then loaded onto trucks or rail cars for transport to an appropriately licensed disposal facility. (Under Option 5a, floodplain soil would be characterized during the remedial design phase.)

[72] Appendix N describes how the proposed area for cleanup would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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Mitigation

Figure 6-5 presents an overview of the different habitat features associated with this alternative (1.5 acres) and possible mitigation components for each. After excavation and evaluation of the confirmation samples, imported backfill would be placed to restore the site grade to existing elevation and to provide subgrade for re-vegetation of the area. The area could be planted with common floodplain trees (e.g., black willow, red maple) and fruit-bearing wetland shrubs such as elderberry and highbush blueberry. The specific species, planting specifications and monitoring requirements would be identified during the remedial design phase.

Long-Term Monitoring and Institutional Controls

A conceptual long-term monitoring approach is presented in Appendix H. Long-term monitoring would be required to determine biota recovery and when animal tissue was safe to eat, to assess the impact of the remedial action on the downstream areas, and to determine if additional evaluations or clean-ups are warranted.

Any disposal facilities constructed on site (Options 5a and 5b) would require long-term monitoring, maintenance and ICs to protect the integrity of the facility. Future use restrictions would be required to prevent excavation or other activities that could adversely impact the integrity of the CDFs (e.g., limit the size of woody vegetation on top of the CDFs, prevent the construction of buildings with basements or burial of utilities on or in the CDF cap).

Disposal or Treatment Options

It is assumed that the implementation of a remedial alternative to address the floodplain soil would be carried out concurrently with the sediment remediation, and the disposal and/or treatment options would be common to both action areas to improve the overall efficiency of the selected remedies. It is assumed that the on-site disposal and/or treatment option(s) for floodplain soil would only be used if the on-site disposal and/or treatment option(s) was also implemented for the sediment remediation. The off-site disposal and/or treatment option could be implemented independent of the selected alternative for the sediments.

It may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area soil alternatives (see Section 6.8.3.1) if this alternative is selected. This material would not need to comply with the land disposal restrictions because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal.

The disposal and/or treatment options include:

Option 5a: On-site Containment in an Upland CDF

One option for containment of the floodplain soils is an on-site upland CDF as described in Section 6.2.2. The maximum capacity available would be about 136,000 cy (Table 6-3), which would provide sufficient capacity for both the sediments and the floodplain soils.

The capital cost estimate is based on the back-calculated unit cost per cubic yard of capacity in the CDF. Costs for the long-term O&M of the on-site CDF are covered under the sediment excavation alternative and are not duplicated here. The costs assume that treatment is not required because existing floodplain

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soil data for Allendale reach meet the LDR alternative treatment standards in 40 CFR §268.49 (applicable to soil only); this assumption would be confirmed during design.

Option 5b: On-site Containment in a Nearshore CDF

One option for containment of the floodplain soils is a nearshore CDF as described in Section 6.2.2. The maximum capacity available for the nearshore CDFs would be about 125,000 cy (Table 6-3), which would provide sufficient capacity for both the sediments and the floodplain soils.

The capital cost estimate is based on the back-calculated unit cost per cubic yard of capacity in the CDF. Costs for the long-term O&M of the on-site CDF are covered under the sediment excavation alternative and are not duplicated here.

Option 5d: On-site Thermal Treatment

Under this option, the excavated floodplain soil would be treated on site using thermal treatment (incineration) as described in Section 6.2.2. Because the contaminated material would be removed, treated, and then disposed of at an off-site facility, ICs would not be required to restrict any future use of the area.

Option 5e: Off-site Disposal and/or Treatment

Under this option, the excavated floodplain soil would be disposed of off site as described in Section 6.2.2, either by containment in a designated facility or thermal treatment. Representative, composite samples would be taken and analyzed for dioxin and furans to determine if disposal by incineration is required according to the LDRs (i.e., F-listed or characteristic soil waste with an underlying hazardous constituent that exceeds 10 times the UTS in 40 CFR §268.48 will need to be treated prior to disposal, see Section 3.2.1.2). Representative, composite samples would also be taken and analyzed for TCLP concentrations to determine the designation of the materials as solid or hazardous waste and to determine which type of landfill is required. Once the appropriate disposal facility is identified, the excavated floodplain soil would be loaded onto trucks and transported to the appropriate location. The costs assume that all of the excavated floodplain soil would meet the LDR alternative treatment standards in 40 CFR §268.49 (applicable to soil only). These assumptions would be confirmed during design. There would be no restrictions of future use at the site under this alternative.

6.4.2.2 Evaluation of Excavation and Disposal or Treatment

Results from the evaluation of Alternative 5, Excavation and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-18.

Overall Protection of Human Health and the Environment

Excavation of the surface 1 foot (or deeper within vadose zone to meet ARARs) of floodplain soil and backfill with clean material would provide high overall protection of human health and the environment because all of the soil with contaminant concentrations above the cleanup goals would be removed from the floodplains and either contained in a secure CDF or treated by incineration.

Compliance with ARARs

ARARs specific to Alternative 5 are summarized in Table 6-19. Placement of backfill in wetland areas, the nearshore CDF (Option 5b), and possibly the upland CDF (Option 5a) trigger wetlands/Section 404

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requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under Option 5b, a portion of the nearshore CDF would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Under Options 5a and 5e, some of the floodplain soil could require treatment if it exceeds the alternative treatment standards for contaminated soil set forth in the LDRs (40 CFR § 268.49); however this is unlikely based on the existing data. Floodplain soil excavated and contained in a nearshore CDF (Option 5b) would not need to meet the treatment standards set forth in the LDRs because it would be consolidated in an area of contamination and would not require any dewatering or other ex-situ activities.

Alternative 5 will comply with ARARs for residential direct exposure and EPA's recommended residential level for dioxin (EPA, 1998b), as well as Subtitle C closure requirements under RCRA.

Long-Term Effectiveness and Permanence

Excavation would remove contaminated floodplain soil and provide a very high level of risk reduction and low residual risk. Inherent hazards would be further reduced for Options 5d and 5e because floodplain soil would be incinerated on site (Option 5d) or taken off site for disposal or treatment (Option 5e), and would not rely on ICs and long-term monitoring to remain effective in the long term. The inherent hazard is higher for the upland (Option 5a) and nearshore (Option 5b) CDFs as floodplain soil above cleanup levels remains untreated on site. However, under both of the options contaminated floodplain soil is either removed from the floodplain and either placed in secure upland locations (Option 5a) or consolidated along the shore in nearshore CDFs (Option 5b). The upland CDF would have a liner and would be outside of the floodplain while the nearshore CDF would not be lined and would be located within the floodplain thereby increasing the inherent hazard and reliance on other controls. Long-term monitoring, maintenance and ICs are necessary to protect the integrity of both CDF options. These controls are only effective if adequately monitored and enforced.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 5d (on-site thermal treatment). The on-site containment options (Options 5a and 5b) and off-site disposal option (Option 5e) would reduce the mobility of the contaminated soil particles, although not through treatment.

Short-Term Effectiveness

During the construction and implementation period for this alternative, potential short-term impacts to the community from excavation would be limited and of short duration and are basically those associated with standard small-scale construction projects. Because the disposal and/or treatment options required under Alternative 5 are combined with the disposal and/or treatment options for the sediment excavation alternatives (Section 6.2), the short-term impacts to the community as a result of disposal and/or treatment will be the same as for Alternative 7 for Allendale and Lyman reach sediment (Section 6.2.2.2).

Short-term impacts to the environment would be substantial for this alternative. Birds and animals that use the floodplain for habitat would be displaced during construction, but would be expected to return once the remediation was completed and soil infauna and vegetation had become re-established. Excavation would result in destruction of the existing habitat. At least several years would be required before the remediated areas had recovered sufficiently to provide the environmental services that this habitat typically provides. In that time period, the invertebrate soil community and riparian vegetation

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would have become re-established and thus capable of providing shelter and forage opportunities to wildlife. Obviously, longer lengths of time would be required to replace adult floodplain trees but every reasonable step would be taken to avoid damaging them under this alternative. The ecological recovery process would be facilitated by including habitat enhancement features in the construction sequence; as mentioned above, these components would include using an organic loam for backfill and selecting and planting appropriate riparian vegetation with high wildlife value.

There would be no unusual issues related to worker impacts under this alternative.

The RAOs would be achieved at the completion of remedy implementation, which is estimated to take approximately one month.

Implementability

Overall, this alternative raises some limited implementation issues. Construction in areas having soft soils can pose unique challenges; however, specialized, low ground-pressure equipment would be used in conjunction with the establishment of temporary work platforms and access roads. There are no unusual implementability issues related to the availability of services and materials. Sandy loam cover material is expected to be readily available from local construction supply companies.

Impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable wetland impacts and lost flood storage capacity would be required.

Because the disposal and/or treatment options required under this alternative are combined with the disposal and/or treatment options for the sediment excavation alternatives (Section 6.2), the implementability issues that result from disposal and/or treatment will be the same as for Alternative 7 for Allendale and Lyman reach sediment (Section 6.2.2.2), except that treatment would probably not be required under Option 5a (upland CDF) because the existing soil data meet the LDR alternative treatment standards in 40 CFR §268.49.

Cost

The detailed cost evaluations for Alternative 5, Excavation and Disposal and/or Treatment, are presented in Appendix J. The capital, operation and monitoring, and present worth costs are listed below. Annual monitoring and maintenance costs include costs for vegetation monitoring and invasive species management; all other annual monitoring and maintenance costs are covered under the sediment excavation alternative.

Option 5a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$1,300,000
	Annual cost for years 1 to 30	$7,000
	Present worth costs	$1,400,000
Option 5b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$1,300,000
	Annual cost for years 1 to 30	$7,000
	Present worth costs	$1,400,000
Option 5d: On-site Thermal Treatment	Capital cost and baseline monitoring	$4,200,000
	Annual cost for years 1 to 30	$7,000
	Present worth costs	$4,300,000
Option 5e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$3,100,000
	Annual cost for years 1 to 30	$7,000
	Present worth costs	$3,200,000

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6.5 Comparative Analysis of the Allendale Floodplain Soil Alternatives

The two alternatives for Allendale floodplain soils (Alternative 1, No Action and Alternative 5, Excavation and Disposal and/or Treatment) are compared below to better understand the key tradeoffs among the alternatives; key features of the alternatives are summarized in Table 6-20. Overall, excavation (Alternative 5) will provide a higher level of protection to human health and the environment and, used in conjunction with on-site thermal treatment (Alternative 5d) or off-site disposal and/or treatment (Alternative 5e), will provide higher long-term effectiveness and permanence because the excavated material would be incinerated or removed from the site.

6.5.1 Overall Protection of Human Health and the Environment

The primary exposure pathways for floodplain soils are exposure by ecological receptors to contaminants in floodplain soil, either directly or through biological uptake. Hazards posed under current conditions are above the EPA criteria. Contaminant concentrations in floodplain soil also exceed state standards for residential direct exposure and EPA's recommended residential level for dioxin in soil (EPA, 1998b). The No Action alternative would not provide any protection to human health or the environment because no active remediation would be performed. The excavation and disposal and/or treatment alternative (Alternative 5) provides the greatest overall protection of human health and the environment by removing the source of contamination from the floodplain which would quickly reduce risk to acceptable levels. Excavation would lower the concentrations of contaminants in the surface soil, effectively reducing ecological hazards to background levels. All soil contamination above the cleanup goals would be removed from the floodplain and contained in a disposal facility or treated. This would prevent human and ecological exposure to contamination and eliminate the risk of contaminant migration downstream due to erosion during flood flows, as would be the case for Alternative 1. Under Alternative 5b, the contamination is contained in a CDF constructed in the floodplain, and would be less protective overall relative to the other options under Alternative 5.

6.5.2 Compliance with ARARs

The No Action alternative does not comply with ARARs for state residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b). Alternative 5 would have wetlands/Section 404 impacts, so the focus would be on identifying the least damaging practical alternative and minimizing impacts. Among the disposal and/or treatment options, the on-site containment options (Alternatives 5a and 5b) would present more ARAR issues. Alternative 5a would result in the destruction of wetlands if the selected upland CDF location contains wetlands. Alternative 5b would require a permanent occupancy and modification of the floodplain, and may also result in the filling of wetlands. For these alternatives, a determination would need to be made that there was no other practicable alternative to the filling of wetlands and/or the occupancy or modification of the floodplain before selecting this option as the preferred remedy.

6.5.3 Long-Term Effectiveness and Permanence

The No Action alternative is not effective or permanent in the long term and the residual risk remains high. In addition, there are no controls to prevent exposure. Alternative 5 would provide a very high level of risk reduction and low residual risk because the contamination would be removed and either contained in a disposal facility or treated. Among the disposal and/or treatment options, on-site thermal treatment or off-site disposal and/or treatment (Alternatives 5d and 5e) would provide the greatest long-term effectiveness and permanence as the inherent hazard is very low, and these options would not rely on ICs and long-term monitoring to be effective in the long term.

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Tables 6-21a and 6-21b summarize the residual risks associated with the two alternatives (Alternative 1, No Action and Alternative 5, Excavation and Disposal and/or Treatment, respectively) considered under this analysis. As discussed previously, dioxin is the only contaminant posing unacceptable risk for Allendale reach floodplain soil and the short-tailed shrew (insectivorous wildlife) is the primary receptor of concern. The active remedial alternative would cause an order of magnitude reduction in the residual risk relative to the No Action alternative (0.5 versus 20, respectively).

The inherent hazard is somewhat higher for the on-site containment options (Alternatives 5a and 5b) because floodplain soil above cleanup levels remains untreated on site, and these options would rely on other controls to be effective in the long term. There are additional reliability issues for Alternative 5b because the CDF is located in the river/floodplain. Long-term monitoring, maintenance and ICs are necessary to protect the integrity of both CDF options. These controls are only effective if adequately monitored and enforced.

6.5.4 Reduction of Toxicity, Mobility or Volume through Treatment

Alternative 5d requires the greatest reduction of toxicity, mobility and volume through treatment. No Action and all the excavation alternatives utilizing on-site containment (Alternatives 5a and 5b) or off-site disposal (Alternative 5e) would not require treatment of contaminated material, although the containment options do reduce mobility.

6.5.5 Short-Term Effectiveness

The No Action alternative has no short-term impacts to the community, the environment or workers. The short-term impacts to the community are fairly similar for all options under Alternative 5 although there are some minor differences for Alternative 5d (on-site treatment) and those alternatives that require on-site containment (Alternatives 5a and 5b). The alternative that requires operation of a treatment facility (Alternative 5d) would have air emissions albeit at very low levels. The incinerator exhaust would be treated; however, it is typically not possible to remove all contaminants or odors from the emissions. An on-site incinerator would also utilize fuels such as natural gas or fuel oil, the combustion of which would result in additional exhaust emissions. Alternatives including on-site containment (Alternatives 5a and 5b) would also have some short-term impacts to the areas and community surrounding the CDF sites. Construction activities will temporarily increase during the time work is done in these areas. The short-term impacts to workers are all relatively the same under all alternatives.

All options under Alternative 5 would have short-term impacts on the environment due to the elimination of floodplain soil infauna and riparian vegetation and collateral impacts to wildlife that rely on this habitat for shelter and food. The short-term environmental impacts would be minimized by including habitat restoration as a component of the excavation alternative. The use of an organic loam to backfill excavated areas followed by planting appropriate riparian vegetation (both trees and shrubs) would facilitate the ecological recovery process.

6.5.6 Implementability

There are no implementability issues for the No Action alternative because no construction activities would be required. The disposal and/or treatment options under Alternative 5 present different technical and administrative feasibility issues. The options that require on-site containment (Alternatives 5a and 5b) in conjunction with the sediment on-site disposal options (Section 6.2), will require adequate space for the disposal facility which makes implementability of these options more difficult. In addition, the option that requires on-site incineration (Alternative 5d) would require the acquisition of adequate land for dewatering, stockpiling, and treatment areas for both, sediment and soil. Additionally, vendors

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specializing in on-site, high-temperature incineration of hazardous waste are needed and the incinerator would be required to meet the air-quality ARAR criteria. Gaining public acceptance is an important component of this option. These issues make implementability of Alternative 5d more difficult. The options that require the filling of wetlands (Alternative 5b and possibly Alternative 5a if the selected upland CDF contains wetlands) would require a determination that there was no other practicable alternative before selecting this alternative as the preferred remedy. Alternative 5b presents floodplain issues that would have to be addressed and replacement of flood storage capacity would be required.

6.5.7 Cost

The costs for all the Allendale floodplain soil alternatives are presented in Table 6-20. Total present worth cost for Alternative 1, No Action, is $0 because costs for periodic monitoring and five-year reviews are covered under the sediment No Action alternative (see Section 6.2.1.2). Total present worth costs for Alternative 5, Excavation and Disposal and/or Treatment range from $1,400,000 for on-site containment (Alternatives 5a and 5b) to $4,300,000 for on-site thermal treatment (Alternative 5d).

6.6 Detailed Evaluation of Lyman Mill Reach Stream Sediment and Floodplain Soil (including Oxbow) Alternatives

The three Lyman Mill reach stream sediment and floodplain soil alternatives retained from the screening analysis are described further in this section and are evaluated against the NCP criteria (excluding State and Community Acceptance, which are considered after comments to the FS and Proposed Plan are received). All alternatives include five-year reviews. All of the alternatives, with the exception of No Action, assume that the Allendale and Lyman Mill Dams will remain in place. It is also assumed that implementation of a floodplain soil remedy would be carried out concurrently with the sediment remedy at Lyman Mill, and that all work would be performed in an upstream to downstream direction to prevent re-contamination of areas previously remediated.

Lyman Mill Reach Stream Sediment and Floodplain Soil Alternatives Retained for Detailed Analysis

1	No Action
3	Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment
5	Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Some wetlands are located at this action area, including the Oxbow, a forested wetland located southwest of Allendale Dam (Section 2.3.10). Because some soil contamination is located in wetland areas, there is no practical alternative to destruction of these wetlands.

6.6.1 Alternative 1: No Action

6.6.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process, and is used as a basis of comparison to the other alternatives. This alternative would entail no active remediation of the contaminated sediment or floodplain soils. Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. For cost estimating, it is assumed that there would be one physical survey and report to EPA on the conditions of the site every five years. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

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6.6.1.2 Evaluation of No Action

Results from the evaluation of Alternative 1, No Action against the NCP criteria are discussed below and summarized in Table 6-22.

Overall Protection of Human Health and the Environment

The No Action alternative would not provide overall protection because contaminated material that presents a risk to human health and the environment would remain on site unaddressed. Assuming additional actions are taken upstream to address groundwater, soil and sediment, future migration of contaminated sediment from Allendale Pond to the Lyman Mill reach would be reduced. Natural deposition of cleaner material at Lyman Mill reach may eventually reduce the overall risk with time; however, because rigorous long-term monitoring would not be conducted, there would be no way to demonstrate or evaluate this reduction.

Compliance with ARARs

This alternative will not comply with ARARs for state residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b) (Table 6-23).

Long-Term Effectiveness and Permanence

The No Action alternative would not be effective in the long term because no action would be taken to contain, reduce erosion and downstream transport, or remove the contaminated sediment/soil that presents a risk. The residual risk remains high as no actions are taken to address sediment/soil and no controls are in place to adequately and/or reliably prevent exposure in the long term.

Reduction of Toxicity, Mobility or Volume through Treatment

There would be no reduction of toxicity, mobility or volume of contamination through treatment.

Short-Term Effectiveness

This alternative would have no short-term impacts because there would not be any intrusive work into the contaminated sediment/soil that could disrupt the local community or environment or present a risk to on-site workers. However, it would not achieve the cleanup objectives.

Implementability

This alternative would be easily implemented because it would not require engineering or physical construction. Nor would this alternative require any institutional or access controls or maintenance of existing features (e.g., dams). The implementation of periodic monitoring would not present any unusual issues.

Cost

There would be no capital costs for this alternative. The cost for periodic monitoring of site conditions and five-year reviews would be approximately $20,000 for a present worth cost of approximately $250,000.

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6.6.2 Alternative 3: Targeted Excavation, Enhanced Natural Recovery (Thin-Layer Cover) and Disposal and/or Treatment

6.6.2.1 Description of Targeted Excavation, Enhanced Natural Recovery (Thin-Layer Cover) and Disposal and/or Treatment

Alternative 3 includes excavation and removal of contaminated sediment and floodplain soil from targeted areas within the remedial footprint and placement of a thin-layer cover over the remaining areas to accelerate the natural recovery processes by placing clean material over the underlying contaminated material.

Under this alternative, access areas would need to be created so that all areas of the remedial footprint could be reached. Additionally, staging areas to stockpile the cover material would be required; space surrounding the site is limited and any work would need to be closely coordinated with local authorities to ensure access to residential properties is not compromised and to ensure that measures would be taken to protect public health during remedy implementation. It is assumed that the remedy selected for this area would be implemented concurrently with the remedy for Lyman Mill Pond sediments and would use the staging areas and access roadways installed for the sediment remediation and that any excavation activities would be conducted after the pond water levels were temporarily lowered.

Targeted excavation would be used to remove the top 1 foot of sediment from the stream channel connecting Allendale and Lyman Mill Ponds (this area would not be suitable for a thin-layer cover) and the top 1 foot of floodplain soil from areas where contaminant concentrations are in excess of state ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b). A depth of 1 foot was assumed because this is generally considered the depth to which the majority of relevant ecological exposures occur as a result of foraging or burrowing activities, as well as human exposure. The actual depth of excavation would extend deeper within the vadose zone as necessary to meet ARARs or EPA's dioxin requirements, and would be determined during design based on sampling and analysis of deeper sediment/soil samples. Excavation and backfill volumes will also be evaluated during design to ensure no net loss of flood storage capacity from placement of the thin-layer cover in wetland/floodplain areas.[73] Data needs would include, but may not be limited to, the collection of floodplain soil and sediment samples within the cleanup area, as well as a survey to more precisely delineate the boundaries between the various vegetation types represented.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples), and the excavated sediment/soil would be disposed or treated. The sequence of excavation activities, excavation/backfill volumes and rates, cover placement, sediment/soil processing, flow control structures, mitigation activities, long-term monitoring and ICs, and disposal or treatment options are described below.

Construction Sequence

A typical construction sequence is presented below:

1. Construct temporary access roads and staging areas.

[73] With an average of 1.25 ft of excavation (includes 0.25 ft over-excavation allowance), the volume of backfill and thin-layer cover would be greater than the excavation volume, which would result in a small loss of flood storage capacity. Excavation an average of 0.5 ft deeper would be one way to increase flood storage capacity equal to the volume of backfill.

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2. Clear debris and vegetation as necessary.
3. Excavate contaminated soil/sediment in an upstream to downstream direction, stockpile and dispose.
4. If material was to be disposed off site, testing would be conducted to determine the appropriate disposal designation.
5. Evaluate confirmation samples and backfill excavated areas with clean material.
6. Place enhanced natural cover in areas that were not remediated with excavation, which could be performed concurrently with backfill placement.
7. Plant appropriate types of vegetation within the excavation footprint to enhance ecosystem recovery.

Excavation/Backfill Volumes and Rates

Sediment and floodplain soil would be removed during periods of low water level in Lyman Mill Pond, so that no additional lowering of surface water would be required. In this alternative, 4.8 acres would be excavated (Figures 5-26a and 5-26b) and backfilled with clean material to provide subgrade for re-vegetation of the area.[74]

- Approximately 9,700 cy of floodplain soil and stream sediment would be removed from the excavation footprint under this alternative, including a 0.25 foot over-excavation allowance.
- Approximately 10,100 tons (or 6,800 cy) of soil would be placed for the thin-layer cover.

The excavation rate for sediments and floodplain soils is assumed to be 200 cy/d; the placement rate of clean backfill is assumed to be 500 tons/day; placement of thin-layer cover is assumed to be 70 tons/day; and the rate of replanting vegetation is assumed to be 7,400 square feet per day (sq ft/d). Including the required wetland mitigation and streambank restoration activities (see discussion on mitigation below), it is estimated that this alternative would take approximately one year to implement.

Cover Design and Placement

The final composition and thickness of the cover would be determined during the design phase; however, for the purposes of evaluating this alternative, a cover thickness of 3 inches with a composition similar to the existing soils is assumed.

The cover material would be placed over 16.8 acres of contaminated sediments and floodplain soils within the entire remedial footprint (21.6 acres) that were not remediated by excavation (Figures 5-26a and 5-26b). The conventional method of placing soil cover material would be to deliver material to the site by dump truck, dump the soil onto the ground, and spread with crawler tractors with bulldozing blades. This method would require that all trees and shrubs be removed and would trample and uproot a significant portion of the existing grass type vegetation in the wetland area. In order to reduce the need for tree and shrub removal and to minimize the impact on the existing roots, an alternative method of cover placement would be used in this alternative. Under this alternative, cover material would be placed using a hydraulic slurry method which involves adding water to the cover material to form a slurry and then spraying the slurry over the area until the appropriate thickness is achieved. Although the concept of

[74] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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pumping soil slurries has been used for placing aquatic caps and is used in the mining industry, use of this technology for placing wetland covers is an innovative application.

In order to create a soil slurry that could be pumped, water would be added to the soil in a hopper and the slurry fed into pumps connected to a network of pipes and hoses for distribution. A temporary network of slurry pipes would be installed to allow access to the cleanup area. These pipes would be placed on the existing ground surface and held in place with temporary earth anchors or weights (such as sand bags). The pipe and hoses could be placed using small low-ground pressure equipment commonly used in landscape maintenance work. This would have much less impact on the existing vegetation than conventional heavy earthmoving equipment, which can harm or kill trees through soil compaction. Most of the water added to form the slurry (referred to as carriage water) would quickly separate from the cover soil and would drain into the wetland. The flow rate of carriage water would be about 300 gpm. It is expected that this water would result in a temporary increase in the water surface elevation in the wetland; however, no adverse impacts are expected because the wetland is periodically inundated with water during periods of natural flooding.

Placement of 3 inches of clean material would require approximately 10,100 tons of cover material. For cost estimating and scheduling purposes, it is assumed that the slurry would be placed using a 4-inch diameter hose with a sand slurry discharge rate of approximately 350 gpm.

Sediment/Floodplain Soil Processing

The wetland soils would contain more vegetation and would have higher in-situ solids content than the river/pond sediments. Therefore, the wetland soils and sediments removed using excavation would not be processed with mechanical dewatering. It is assumed that the final volume and weight in a disposal facility would be the same as the in-situ volume and weight. The excavated soil/sediment would be stockpiled in the same processing area established for pond sediments. Stockpiled soil/sediment would be tested as needed for off-site disposal, and then loaded onto trucks for transport to an appropriately licensed disposal facility. (Under Option 3a, floodplain soil would be characterized during the remedial design phase.)

Flow Control Structures

This alternative would be further developed during the design phase to include diverting some of the flow from the Woonasquatucket River into and through the Oxbow area to increase the rates of natural sediment deposition. Some site regrading would also be conducted within the Oxbow, including filling and the creation of baffles in portions of the river channel remnant; this is intended to minimize the short-circuiting of floodwaters through the wetland system and increase sediment deposition rates. This aspect of the alternative may be important if the selected remedy for the sediment includes the removal of Allendale and Lyman Mill Dams. If Lyman Mill Dam was removed, the normal water level would be lower compared to current conditions and the habitat within the Lyman Mill reach could transition from aquatic to riparian wetland and/or floodplain habitat or even upland in some areas . Deposition rates are expected to be lower in an upland setting than in a wetland setting, and removing dams could retard natural recovery processes in these areas.[75]

[75] Some uncertainty remains regarding the potential impacts of replacing the Lyman Mill Dam with a weir structure on hydrological conditions within the Oxbow area. Although a hydrological analysis concluded that there would be no substantive effects on water balance in the wetlands because the area receives much of its water from precipitation and runoff from adjoining upland areas (USACE, 2007), a more detailed assessment during final design would be warranted in the event that this alternative were selected.

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Mitigation

This remedy would involve the destruction of some existing forested and/or scrub/shrub habitat structure and jurisdictional wetland. Soil excavation and application of a soil cover would either eliminate (soil excavation) or potentially degrade (thin-layer cover) the floodplain soil community. In addition, remediation of the lotic portion of the river would destroy benthic habitat and the benthos itself and sediment excavation would destroy a portion of the adjacent riverbank including some riparian vegetation and tree root system.

The application of the cover material could be performed during the dormant season to minimize damage to the existing vegetation. This application process significantly reduces the amount of vegetation that would need to be removed or mowed prior to cap placement; however, the placement of 3 inches of cover material may have deleterious effects to the trees within the Oxbow. For example, the cover may make it more difficult for trees to access sufficient oxygen, and could also damage the shallow root systems typical of trees growing in hydric soils. Limited data are available to speculate about which species of trees currently at the Oxbow may be most affected by application of the thin-layer cover. The Iowa State University Forestry Extension Web site provides a classification system based on tolerance to root damage. For the species that have been documented occurring in the Oxbow wetland (USACE, 2008), red oak and swamp white oak are classified as being "very sensitive", red maple is considered to be "moderately sensitive", and black willow and cottonwood are considered "somewhat tolerant" to root damage effects. Sensitive species, such as oaks, can be killed by the addition of even a couple inches of fill on existing grade. These effects can be minimized by using cover material that allows air passage (e.g., sandy loam much better than clay), avoiding compaction of existing soil, and limiting grade changes to outside the dripline. It is anticipated that the majority of the dominant canopy species (e.g., red maple) can be preserved if remedy implementation practices are mindful of the above provisions.

Figure 6-6 presents an overview of the different habitat features associated with this alternative and possible mitigation components for each. After excavation and evaluation of the confirmation samples, imported backfill (with appropriate humic content to facilitate infaunal recolonization) could be placed to established design grades to provide subgrade for re-vegetation of the area. The area could be planted with common floodplain trees (e.g., black willow, red maple) and fruit-bearing wetland shrubs such as elderberry and highbush blueberry. An appropriate herbaceous seed mix could be applied to rapidly stabilize the soils. The specific species, planting specifications and monitoring requirements would be identified during the remedial design phase. The vegetation could consist of canopy species saplings (e.g., red maple, cottonwood, and swamp white oak), balled shrubs (e.g., highbush blueberry, alder, and northern arrowwood), and a wetland grass mix (to stabilize exposed soil in the short term).

Mitigation for impacts associated with the sediment remediation could include back-filling with sediment of similar composition to emulate current benthic habitat structure (and provide similar sediment stability). Restoration of the entire section of river bank could include use of techniques to ensure bank stability (e.g., installation of "Biolog" or equivalent at toe of the slope and biodegradable erosion control blanket) along with shrub plantings to compensate for loss of riparian vegetation.

Long-Term Monitoring, Dam Maintenance and Institutional Controls

Long-term monitoring, maintenance of Allendale Dam, and ICs would be required to maintain the integrity of the thin-layer cover and stream restoration and prevent activities (e.g., excavation) that could expose the underlying contaminated sediment/soil. Long-term monitoring would be designed to evaluate the integrity of the thin-layer cover and stream restoration, whether any downstream transport of contaminated sediment/soil is occurring, and the rate at which recovery is occurring after the placement of the natural cover material.

For example, sediment/soil monitoring would be performed to evaluate the thickness of the sediment/soil deposited over time and to confirm that the contaminated sediment/soils had not migrated away from this area of the site. Long-term biota monitoring would be conducted to determine biota recovery and when animal tissue was safe to eat. Water quality monitoring would be performed to assess the quality of the surface water and potential for downriver transport. Monitoring downstream of the Lyman Mill Dam would also be performed to assess impact of the remedial action on the downstream areas. Periodic reporting would be required to document remedy progress and efficacy, and the long-term monitoring results would be used by the Agencies to determine if additional evaluations or clean-ups were warranted. Details of the monitoring plan would be developed during final design. The general approach for monitoring and the assumptions used to estimate annual costs are described in a conceptual long-term monitoring approach presented in Appendix H.

Maintenance of the Allendale Dam would be required to prevent sudden release of water that could erode the cover or contaminated sediment/soil, which would not be the case with the downstream Lyman Mill Dam. However, both dams could be removed in a controlled fashion without impact to this alternative. ICs restricting site access and use would be required to prevent the disturbance of the CDFs (Options 3a and 3b) and thin-layer cover (all options). In addition, ICs (such as boardwalks and fencing) could be used to enhance remedy effectiveness by further reducing human exposure.

Disposal and/or Treatment Options

It is assumed that the implementation of a remedial alternative to address floodplain soil would be carried out concurrently with the sediment remediation, and the disposal and/or treatment options would be common to both action areas to improve the overall efficiency of the selected remedies. It is assumed that the on-site disposal and/or treatment option(s) for floodplain soil would only be used if the on-site disposal and/or treatment option(s) was also implemented for the sediment remediation. The off-site disposal and/or treatment option could be implemented independent of the selected alternative for the sediments.

It may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area soil alternatives (see Section 6.8.3.1) assuming this alternative was selected. This material would not need to comply with the land disposal restrictions because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal

Disposal and/or treatment options are the same as described for sediment (Section 6.2.2) and include:

Option 3a: On-site Containment in an Upland CDF
Option 3b: On-site Containment in a Nearshore CDF
Option 3d: On-site Thermal Treatment
Option 3e: Off-site Disposal and/or Treatment

Option 3a: On-site Containment in an Upland CDF

Under this option, the costs assume that a treatability variance could be obtained to reduce the amount of treatment needed for sediment and that treatment would not be required because all of the sediment would meet the treatability variance (existing sediment data from the stream channel and old mill raceway meet 10x the UTS). The costs also assume that treatment would not be required for the floodplain soil because existing floodplain soil data for Lyman Mill reach meet the LDR alternative treatment standards in 40 CFR §268.49 (applicable to soil only). These assumptions would be confirmed during design.

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Option 3b: On-site Containment in a Nearshore CDF

Under this option, the costs assume that treatment is not required because the excavated sediment/soil would be consolidated in-situ in a nearshore CDF within an "area of contamination."

Option 3d: On-site Thermal Treatment

Under this option, the excavated sediment/soil would be treated on site using thermal treatment (incineration) as described in Section 6.2.2.

Option 3e: Off-site Disposal and/or Treatment

Under this option, the excavated sediment/soil would be disposed of off site as described in Section 6.2.2, either by containment in a designated facility or thermal treatment. Representative, composite samples would be taken and analyzed for dioxin and furans to determine if disposal by incineration is required according to the LDRs (i.e., F-listed or characteristic soil waste with an underlying hazardous constituent that exceeds 10 times the UTS in 40 CFR §268.48 will need to be treated prior to disposal, see Section 3.2.1.2). Representative, composite samples would also be taken and analyzed for TCLP concentrations to determine the designation of the materials as solid or hazardous waste and to determine which type of landfill is required. Once the appropriate disposal facility is identified, the excavated floodplain soil would be loaded onto trucks and transported to the appropriate location. The costs assume that approximately 50% of the sediment from the stream channel and old mill raceway would require treatment to meet the LDRs and that all of the floodplain soil would meet the LDR alternative treatment standards in 40 CFR §268.49 (applicable to soil only). These assumptions would be confirmed during design.

6.6.2.2 Evaluation of Targeted Excavation, Enhanced Natural Recovery (Thin-Layer Cover) and Disposal and/or Treatment

Results from the evaluation of Alternative 3, Targeted Excavation, Enhanced Natural Recovery (Thin-Layer Cover) and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-24.

Overall Protection of Human Health and the Environment

This alternative would provide some protection of human health and the environment because some contaminated sediment/soil would be removed and surface concentrations would be reduced by the thin-layer cover. Contaminated sediment from the stream channel (an erosional area) and floodplain soil from areas with contaminant concentrations in excess of ARARs or EPA's dioxin requirements would be removed and either contained in a disposal facility or treated. However, because some contaminated sediment/soil would remain in place under the thin-layer cover, ICs restricting site access and use would be required to prevent the disturbance of the CDFs (Options 3a and 3b) and thin-layer cover (all options). In addition, ICs (such as boardwalks and fencing) could be used to enhance remedy effectiveness by further reducing human exposure. This alternative would provide some reduction in ecological exposures in the short term; however, ecological receptors may continue to be at risk of harm over an extended period of time from exposure to contaminated sediment/soils. Ecological receptors are thought to have the ability to burrow or dig to depths of 1 foot or greater; therefore, there is a potential that some may burrow through the thin-layer cover and into contaminated sediment/soil.

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Compliance with ARARs

ARARs specific to Alternative 3 are summarized in Table 6-25. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Clean Water Act Section 404 requirements are triggered by excavation. In addition, placement of backfill in wetland areas, the nearshore CDF (Option 3b), and possibly the upland CDF (Option 3a) also trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. The thin-layer cover (all options) and nearshore CDF (Option 3b) would also require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 3a. The Subtitle C requirements under RCRA would have to be waived for this alternative. The waiver would be based on the determination that the placement of a RCRA-compliant cap would result in greater risk to the environment. Specifically, the cover proposed under this alternative would allow for preservation of a majority of the existing forested wetland that provides a regionally-important habitat to a variety of birds and animals (including potential threatened/endangered vernal pool species). However, requiring a thicker, impermeable cap would permanently eliminate one of the largest areas of remaining forested riparian habitat remaining along the Woonasquatucket River downstream of the Smithfield town line.

Long-Term Effectiveness and Permanence

Alternative 3 would provide some risk reduction because sediment in the areas most susceptible to erosion (stream channel) and floodplain soil with contamination in excess of ARARs or EPA's dioxin requirements would be removed and either contained in an engineered facility or treated by incineration. Additionally, placement of a thin-layer cover would reduce surface concentrations, where exposure is most likely. However, where contamination remains under the cover inherent hazard of waste remains and there is potential for future exposure to and migration of contaminated sediment/soil particles downriver as a result of flood flows. Because of the potential for erosion and redeposition during severe storm events, maintenance and monitoring are critical to the long-term adequacy and reliability of this alternative. Implementation of ICs would provide further protection to human health by lowering the potential for human exposure; ICs are only effective if adequately monitored, enforced, and maintained. ICs are not reliable or effective in addressing ecological risk.

Inherent hazard of the disposal and/or treatment options is the same as the sediment excavation alternative (Alternative 7, Section 6.2.2.2). Long-term monitoring, maintenance, including maintenance of Allendale Dam, and ICs would be critical to control physical disturbances and protect the integrity of the cover (all options) or any type of on-site disposal facility (Options 3a and 3b) for the long-term effectiveness of this alternative.

Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Options 3d (on-site thermal treatment) and 3e (off-site disposal and/or treatment). The on-site containment options (Option 3a and 3b), and to a lesser extent the thin-layer cover (all options), would reduce the mobility of the contaminants, although not through treatment.

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Short-Term Effectiveness

Alternative 3 is expected to have some short-term impacts. However, potential short-term impacts to human health, on-site workers and the community would be limited. Temporary work areas and an access roadway would be set up and the work areas cleared of vegetation. There would be truck traffic into and out of the area to deliver the cover material and fuel; traffic would also increase slightly due to site workers traveling back and forth to the job site. The application of cover material will also require petroleum powered engines and generators; therefore, there will be some short-term low level air emissions associated with this alternative.

Potential short-term impacts to the environment would be minimized to the extent practical by conducting construction activities during the dormant season, limiting excavation to targeted areas, and placing the soil cover using an innovative hydraulic slurry system. In the targeted excavation areas, removal of sediment and floodplain soil and placement of backfill would result in the destruction of approximately 4.8 acres existing habitat, which may take at least a decade to become reestablished in areas of emergent marsh. Placement of the soil cover using the hydraulic slurry method would not destroy the existing shrub and tree vegetation and would minimize the magnitude of the impacts to the red maple swamp habitat, which would result in fewer short-term impacts to this portion of the site. As discussed in the wetland delineation and functions and values assessment of the Oxbow (USACE, 2008), the mature red maple floodplain forest found in the Oxbow provides a number of environmental functions (including a unique recreational area) to both people and the local ecosystem, and these would be lost if the area was cleared using the traditional earthwork approach.

The application of a 3 inch layer of material is not expected to have deleterious effects on the majority of the indigenous vegetation, particularly if a porous cover material is used and sensitive species such as swamp white oak are avoided (or the cover thickness is reduced). Damage would be further minimized by applying the cover material during the dormant season (e.g., late fall or early winter). It is expected that some small areas of habitat would be disrupted due to the installation of temporary access roadways along the main river channel; however, the locations of these areas would be designed to minimize ecological impact as much as possible.

Placement of the soil cover would not impact mobile animals in the wetland because they would have time to move away from the construction activities. Non-mobile animals, such as soil invertebrates that live in the wetland soils, would be buried by the cover; however, it is expected that they would quickly colonize the newly applied cap material both from below and from areas outside the soil cover. The thinness of the proposed cover is anticipated to minimize mortality to soil macroinvertebrate communities during the construction phase.

The ecological exposures would diminish over time, as the layer of clean material deposited within the area increased in thickness and chemical degradation (organic contaminations only) occurred. However, the rate of deposition of clean material is expected to be low and the time to achieve RAOs for this alternative may be on the order of several decades to well over a century. Based on the model analysis for the most sensitive ecological receptor, the time to reach the cleanup goals for this alternative varies from 30 to a couple hundred years, with an expected duration of approximately 60 years.[76] The cleanup

[76] Appendix M describes the results of a sensitivity analysis conducted to evaluate the predictive floodplain soil contaminant exposure model for ecological receptors; results are summarized Table M-15. The sensitivity analysis assessed the impact of a range of potential values for the two most important determinants of future exposure and risk (i.e., the average annual deposition rate and the chemical half-life of organic contaminants in floodplain soil). In addition to a no deposition scenario, the deposition rate was assumed to vary by an order of magnitude between 0.024 and 0.24 inches per year. The annual half-life (i.e., time for half of the contaminant mass to degrade) for

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goals for the passive recreational visitor receptor is expected to be reached in about 15 years (Appendix M).

Implementability

Overall, this alternative raises some limited implementation issues. Construction in areas having soft soils can pose unique challenges; however, specialized, low ground-pressure equipment would be used in conjunction with the establishment of temporary work platforms and access roads. As mentioned above, use of a hydraulic slurry method for the placement of a wetland cover is not routine. However, such a broadcast placement method has been successfully demonstrated at other sites including an EPA demonstration project in Casper, Wyoming in early 2000 (A. Fitzpatrick, 2002). There are no unusual implementability issues related to the availability of services and materials. Sandy loam cover material is expected to be readily available from local construction supply companies.

Because this alternative leaves contaminated sediment and floodplain soil in place over an extended period of time, technical problems could occur in the future. Monitoring and enforcement of ICs would be necessary to ensure the successful implementation of this alternative. The implementation of a monitoring program and ICs would not present any unusual issues. Requirements for dam maintenance and impacts to wetland/floodplain areas could present some implementability issues that would have to be assessed. For dam maintenance, agreement for access from owners of the dams would be needed. Impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable wetland impacts and replacement for lost flood storage capacity would be required. In addition, this alternative will face additional implementation issues if the presence of vernal pool habitat is confirmed within the current remediation footprint. The animals that occur in vernal pools are typically very sensitive to environmental disturbances and special care would have to be taken during the design and construction aspects of these alternatives to mitigate these concerns. Even the application of a 3 inch layer of natural soil cover could have some deleterious effects on these areas. Finally, as discussed above, a waiver from the RCRA Subtitle C closure regulations would have to be obtained for this alternative.

Because the disposal and/or treatment options required under Alternative 3 are combined with the disposal and/or treatment options for the sediment excavation alternatives (Section 6.2), the implementability issues that result from disposal and/or treatment will be the same as for Alternative 7 for Allendale and Lyman reach sediment (Section 6.2.2.2).

2,3,7,8-TCDD, the primary human health and ecological risk driver for floodplain soil, was assumed to vary between 6.5 to 51.7 years; a no degradation scenario was also conducted. Time estimates to achieve the RAOs are based on the model analysis for the most sensitive ecological receptor (i.e., short-tailed shrew) and for the contaminant 2,3,7,8-TCDD.

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Cost

The detailed cost evaluation for Alternative 3, Targeted Excavation, Enhanced Natural Recovery (Thin-Layer Cover) and Disposal and/or Treatment, is presented in Appendix J; costs for water quality monitoring are captured under the sediment alternatives. The capital, operation and monitoring, and present worth costs are listed below:

Option 3a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$7,000,000
	Annual cost for years 1 to 30	$220,000
	Present worth costs	$9,700,000
Option 3b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$7,000,000
	Annual cost for years 1 to 30	$220,000
	Present worth costs	$9,700,000
Option 3d: On-site Thermal Treatment	Capital cost and baseline monitoring	$16,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$19,000,000
Option 3e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$13,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$16,000,000

6.6.3 Alternative 5: Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

6.6.3.1 Description of Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Under this alternative, the top 1 foot of contaminated sediment and floodplain soil would be removed using excavation from areas where contaminant concentrations are in excess of ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b), as well as at areas with the highest potential for future erosion, from low-lying channels where contaminated sediment has accumulated, and from areas with the most frequent human exposure. After excavation, these areas would be backfilled with clean material and the site restored. Areas within the remedial footprint that are not excavated would rely on ENR (Section 6.6.2) in conjunction with ICs to further reduce potential human exposure to site contamination.

A depth of 1 foot was assumed because this is generally considered the depth to which the majority of relevant ecological exposures occur as a result of foraging or burrowing activities, and the depth of most likely human exposure. The actual depth of excavation would extend deeper within the vadose zone as necessary to meet ARARs or EPA's dioxin requirements, and would be determined during design based on sampling and analysis of deeper sediment/soil samples. Excavation and backfill volumes will also be evaluated during design to ensure no net loss of flood storage capacity from placement of the thin-layer cover in wetland/floodplain areas.[77] Data needs would include, but may not be limited to, the collection of floodplain soil and sediment samples within this area, as well as a survey to more precisely delineate the boundaries between the various vegetation types represented.

[77] There would be no net loss of flood storage capacity if the backfill volume excludes the over-excavation allowance (0.25 ft).

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It is assumed that this remedy would be implemented concurrently with the remedy selected for Lyman Mill Pond sediments and that any excavation activities would be conducted after the pond water levels were temporarily lowered. Temporary gravel access roadways would be constructed on the east and west side of the pond and along the river channel between Lyman Mill Pond and Allendale Dam. These roadways would also provide access to this action area.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples), and the excavated sediment/soil would be disposed or treated. The sequence of excavation activities, excavation/backfill volumes and rates, cover placement, floodplain soil/sediment processing, long-term monitoring and ICs, and disposal or treatment options are described below.

Construction Sequence

A typical construction sequence is presented below:

1. Construct temporary access roads and staging areas.
2. Clear debris and vegetation as necessary.
3. Excavate contaminated soil/sediment in an upstream to downstream direction, stockpile and dispose.
4. If material was to be disposed off site, testing would be conducted to determine the appropriate disposal designation.
5. Evaluate confirmation samples and backfill excavated areas with clean material.
6. Place enhanced natural cover in areas that were not remediated with excavation, which could be performed concurrently with backfill placement.
7. Plant appropriate types of vegetation within the excavation footprint to enhance ecosystem recovery.

Excavation/Backfill Volumes and Rates

Sediment and floodplain soil would be removed during periods of low water level in Lyman Mill Pond, so that no additional lowering of surface water would be required. In this alternative, 13.5 acres would be excavated (Figures 5-27a and 5-27b) and backfilled with clean material to provide subgrade for re-vegetation of the area.[78]

- Approximately 27,300 cy of floodplain soil and sediment would be removed from the excavation footprint under this alternative, including a 0.25 foot over-excavation allowance.
- Approximately 4,900 tons (or 3,200 cy) of soil would be placed for the thin-layer cover.

The excavation rate for sediments and floodplain soils is assumed to be 200 cy/d; the placement rate of clean backfill is assumed to be 500 tons/day; placement of thin-layer cover is assumed to be 70 tons/day; and the rate of replanting vegetation is assumed to be 7,400 sq ft/d. Including the required wetland mitigation and streambank restoration activities (see discussion on mitigation below), it is estimated that this alternative would take approximately one year to implement.

[78] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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Cover Placement

Under this alternative, a thin-layer cover would be placed using the same methods as described in Alternative 3 (Section 6.6.2). The cover would be placed over the 8.0 acre area within the remedial footprint that is not excavated (Figures 5-27a and 5-27b). The final composition and thickness of the cover would be determined during the design phase; however, for the purposes of evaluating this alternative, a cover thickness of 3 inches with a composition physically similar to the soils indigenous to the Oxbow area is assumed. Placement of a soil cover in the 8.0 acre area would preserve the existing shrub and tree vegetation to the maximum extent possible.

The 8.0 acre area would require approximately 4,900 tons of cover material to place a 3 inch thin-layer cover. For cost estimating and scheduling purposes, it is assumed that the cover would be placed at a discharge rate of approximately 350 gpm. This would place approximately 70 tons per working day.

Sediment/Floodplain Soil Processing

The excavated sediment/soil would be processed for disposal as described for Alternative 3 (Section 6.6.2).

Flow Control Structures

Similar to Alternative 3 (Section 6.6.2), this alternative would be further developed during the design phase to include diverting some of the flow from the Woonasquatucket River into and through the Oxbow area to increase the rates of natural sediment deposition.

Mitigation

Similar to Alternative 3 (Section 6.6.2), this remedy would involve the destruction of some existing forested and/or scrub/shrub habitat structure and jurisdictional wetland. Soil excavation and application of a soil cover would either eliminate (soil excavation) or potentially degrade (thin-layer cover) the floodplain soil community. In addition, remediation of the lotic portion of the river would destroy benthic habitat and the benthos itself and sediment excavation would destroy a portion of the adjacent riverbank including some riparian vegetation and tree root system. In addition, a more extensive width of river bank habitat located along the western shore opposite and upriver of the Lee Romano Ballfield would be destroyed.

Figure 6-7 presents an overview of the different habitat features associated with this alternative and possible mitigation components for each. Mitigation measures including plantings would be similar to that described in Section 6.6.3.1. The riverbank restoration of the western side would be more extensive (approximately 25 feet wide) and in addition to bank stabilization measures, as described under Alternative 3, tree and shrub plantings would be included as mitigation for these impacts. Finally, contaminated soil that was excavated under Alternative 5b would be contained on site in a nearshore CDF and mitigation for the incremental loss of aquatic habitat involved could be provided by the same measures described previously for the sediment alternatives (i.e., preservation uplands and/or wetland restoration).

Long-Term Monitoring, Dam Maintenance and Institutional Controls

Long-term monitoring, dam maintenance and ICs would be required as described for Alternative 3 (Section 6.6.2) to ensure that the thin-layer cover remained in place, to prevent activities (e.g., excavation) that could expose the underlying contaminated material, and to quantify the recovery

occurring within the area. Details of the monitoring plan would be developed during final design. The general approach for monitoring and the assumptions used to estimate annual costs are described in a conceptual long-term monitoring approach presented in Appendix H.

Maintenance of the Allendale Dam would be required to prevent a sudden release of water that could erode the cover or contaminated sediment/soil, which is not a case with the downstream Lyman Mill Dam. However, both dams could be removed in a controlled fashion without impact to this alternative. ICs restricting site use and limiting access would be used to further limit human exposure to contaminated material that remained on site. These controls could include, but not be limited to, access restrictions (i.e., fencing and requirements for boardwalks) and future use restrictions to prevent excavation in the area. Long-term monitoring and ICs would also be required to maintain any type of on-site containment facility.

Disposal and/or Treatment Options

Disposal and/or treatment options are the same as described for Alternative 3 (Section 6.6.2.2) and include:

Option 5a: On-site Containment in an Upland CDF
Option 5b: On-site Containment in a Nearshore CDF
Option 5d: On-site Thermal Treatment
Option 5e: Off-site Disposal and/or Treatment

Under Option 5a, the costs assume that no treatment is required because the sediment would meet the treatability variance and the floodplain soil would meet the LDR alternative treatment standards in 40 CFR §268.49 (applicable to soil only). Under Option 5e, the costs assume that approximately 50% of the sediment from the stream channel and old mill raceway would require treatment to meet the LDRs and that all of the floodplain soil would meet the LDR alternative treatment standards in 40 CFR §268.49 (applicable to soil only). These assumptions would be confirmed during design.

It may also be possible to use some of the excavated floodplain soil to assist in grading and building the bottom layer of the cap to be constructed under Alternative 4 of the Source Area Soils Alternatives (see Section 6.8.3.1) should this alternative be selected. This material would not need to comply with the LDRs because it would be consolidated within an area of contamination. Use of some of the excavated floodplain soils in this way would reduce the amount of material requiring disposal

6.6.3.2 Evaluation of Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Results from the evaluation of Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment, against the NCP criteria are discussed below and summarized in Table 6-26.

Overall Protection of Human Health and the Environment

Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment, would provide some overall protection of human health and the environment, and would help balance the long-term benefits of soil/sediment removal with the short-term benefit of protecting valuable existing wetland tree and shrub habitat. The primary risk to human health is from direct contact with sediments and floodplain soils; this risk would be eliminated in areas that were excavated and backfilled, and minimized elsewhere by the combination of placement of a thin-layer cover and use of appropriate ICs to restrict access and prevent digging or excavation within the remedial footprint.

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The risks to ecological receptors, which are based on direct contact or ingestion of contaminated prey, would also be reduced under this alternative. Such risks would be eliminated in areas that were excavated and backfilled. The shrub and forested wetland in the 8.0 acres not excavated would continue to provide habitat to ecological receptors. Additionally, the placement of a 3 inch layer of natural cover material in the remaining area of the footprint will provide further reduction in exposure to contaminants. However, because the cover material is only estimated to be 3 inches thick, the potential for exposure of burrowing organisms would not be eliminated until cleanup objectives are met. Similarly, the bioaccumulation hazard to wildlife would be reduced but not eliminated over an extended period of time.

Compliance with ARARs

ARARs specific to Alternative 5 are summarized in Table 6-27. Excavation, placement of backfill/cover material in wetland areas, the nearshore CDF (Option 5b), and possibly the upland CDF (Option 5a) will trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. The thin-layer cover (all options) and nearshore CDF (Option 5b) would also require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 5a. The Subtitle C requirements under RCRA would have to be waived for this alternative. The waiver would be based on the determination that the placement of a RCRA-compliant cap would result in greater risk to the environment. Specifically, the cap proposed under this alternative would allow for preservation of a majority of the existing forested wetland that provides a regionally-important habitat to a variety of birds and animals (including potential threatened/endangered vernal pool species). However, requiring a thicker, impermeable cap would permanently eliminate one of the largest areas of remaining forested riparian habitat remaining along the Woonasquatucket River downstream of the Smithfield town line.

Long-Term Effectiveness and Permanence

Partial excavation would be somewhat effective in the long term because the contaminated sediment/soil would be removed and either contained in a disposal facility or treated. In addition, placement of a thin-layer cover would facilitate risk reduction through natural recovery. All sediment and floodplain soil will be excavated from areas with contamination in excess of ARARs or EPA's dioxin requirements, as well as from areas of highest potential for future erosion, from low-lying channels where contaminated sediment has accumulated, and from areas with potential for frequent human exposure. As a result, the residual risk would be significantly reduced particularly for human receptors. The elevated post-construction ecological residual risk from contamination remaining in place under the thin-layer cover would be further reduced over time as clean material was deposited within the area. However, inherent hazard of waste remains wherever contamination remains on site (under the thin-layer cover and contained in the upland and nearshore CDFs).

Inherent hazard of the disposal and/or treatment options is the same as the sediment excavation alternative (Alternative 7, Section 6.2.2.2). Long-term monitoring, maintenance, including maintenance of the Allendale Dam, and ICs would be critical to control physical disturbances and protect the integrity of the thin-layer cover (all options) or any type of on-site disposal facility (Options 5a and 5b) for the long-term effectiveness of this alternative. Implementation of ICs would provide further protection to human health by lowering the potential for human exposure; ICs are only effective if adequately monitored, enforced, and maintained. ICs are not reliable or effective in addressing ecological risk.

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Reduction of Toxicity, Mobility or Volume through Treatment

The toxicity, mobility, or volume of contamination would be reduced through treatment under Option 5d (on-site thermal treatment) and Option 5e (off-site disposal and/or treatment). The on-site containment options (Options 5a and 5b) and to a lesser extent the thin-layer cover (all options) would reduce the mobility of the contaminated sediment/soil particles, although not through treatment.

Short-Term Effectiveness

This alternative would have the same short-term impacts as Alternative 3 (Section 6.6.3.2), although adverse impacts to the environment would be more extensive because a larger area would be excavated under this alternative. Excavation and removal of sediment and floodplain soil and placement of backfill would result in the destruction of approximately 13.5 acres of existing habitat, including emergent marsh, scrub/shrub and forested areas (Figures 5-27a and 5-27b). It may take at least a decade for habitat to become reestablished in areas of emergent marsh, and a considerably longer time (on the order of several decades) in areas with a well-developed tree canopy.

As discussed in Section 6.6.2.2, anticipated human and ecological exposures will diminish over time, as the layer of clean material deposited within the area increased in thickness and chemical degradation (organic contaminations only) occurred. However, the rate of deposition of clean material is expected to be low and the time to achieve RAOs for this alternative may be on the order of several decades to well over a century. Based on the sensitivity results presented in Appendix M (Table M-15) the time for 2,3,7,8-TCDD to reach the clean-up goal for the most sensitive ecological receptor under this alternative[79] varies from 30 to over 250 years, with an expected duration of approximately 55 years. The clean-up goal for the passive recreational visitor receptor is expected to be reached in less than 8 years.

Implementability

Overall, this alternative raises the same limited implementability issues as Alternative 3 (Section 6.6.3.2).

Cost

The detailed cost evaluation for Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment, is presented in Appendix J; costs for water quality monitoring are captured under the sediment alternatives. The capital, operation and monitoring, and present worth costs are:

Option 5a: On-site Containment in an Upland CDF	Capital cost and baseline monitoring	$14,000,000
	Annual cost for years 1 to 30	$220,000
	Present worth costs	$16,000,000
Option 5b: On-site Containment in a Nearshore CDF	Capital cost and baseline monitoring	$13,000,000
	Annual cost for years 1 to 30	$220,000
	Present worth costs	$16,000,000
Option 5d: On-site Thermal Treatment	Capital cost and baseline monitoring	$40,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$42,000,000
Option 5e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$29,000,000
	Annual cost for years 1 to 30	$200,000
	Present worth costs	$32,000,000

[79] This is based on the most sensitive ecological receptor for this contaminant, which is the short-tailed shrew.

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6.7 Comparative Analysis of the Lyman Mill Reach Stream Sediment and Floodplain Soil Alternatives

The three alternatives for Lyman Mill reach stream sediments and floodplain soils (Alternative 1, No Action; Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment; and Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment) are compared below to better understand the key tradeoffs among the alternatives; key features of the alternatives are summarized in Table 6-28. Overall, among the alternatives evaluated, partial excavation (Alternative 5) will provide the highest level of protection to human health and the environment and a higher level of long-term effectiveness and permanence because a larger volume of contaminated material would be removed from the system. None of the alternatives, however, would provide immediate, complete protection of ecological receptors from exposures to contaminated material. Rather, a minimum of several decades would likely be required to attain the ecological cleanup objectives. This delay in achieving the remedial goals for ecological receptors is balanced by the need to preserve the habitat necessary to maintain the receptors warranting protection.

6.7.1 Overall Protection of Human Health and the Environment

The human health and ecological risks for this action area are associated with direct contact exposure with contaminated sediments and soils and consumption of prey items that have bioaccumulated contaminants from these media. Due to the high value of much of the ecological habitat in this area, the cleanup objectives have been developed in an effort to obtain an optimal balance between the ecological benefits of the removal of contaminated sediment and soil versus the loss and destruction of sensitive habitat. Because of the mature nature of this floodplain forest along with its relative scarcity in this urbanized watershed, the impacts associated with large-scale excavation in the Oxbow would extend out for many decades. As a result, overall protection balances the benefits of reducing human risk with the benefits of protecting valuable existing wetland tree and shrub habitat in the long term.

The No Action alternative would provide little protection to either human health or the environment because nothing would be performed to address the risks associated with the current exposure pathways.

Alternatives 3 and 5 would provide more protection to human health and the environment, with Alternative 5 (Partial Excavation and ENR) providing greater protection of human health and the environment. Both Alternatives 3 and 5 would protect human health through the targeted excavation of sediment and floodplain soil in areas where there is a greater likelihood of human exposure with Alternative 5 requiring more of the material that presents a risk to be removed.

Alternative 5 would provide some protection of ecological receptors even though a larger portion of the area would be excavated and backfilled. The application of the thin-layer cover in the remaining area would also accelerate the natural recovery, but would not provide significant risk reduction in the short term, as discussed above. This alternative would reduce the potential for downstream transport of contaminants into Lyman Mill Pond compared to Alternative 3. Alternative 3 would be somewhat less protective of human health because of the reduced excavation footprint. Alternative 3 also includes placement of the thin-layer cover and, thus, would be similar to Alternative 5 in terms of short-term impacts to ecological receptors.

6.7.2 Compliance with ARARs

Alternative 1 (No Action) would not comply with state ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b). The action-based alternatives (Alternatives 3 and 5) would both involve the placement of fill in waters of the state/US, the destruction

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of wetlands, and the permanent occupancy and modification of the floodplain. Therefore, a determination would need to be made that there was no other practicable alternative before selecting any of these alternatives as the preferred remedy. None of the alternatives would satisfy the Subtitle C regulations under RCRA. For Alternatives 3 and 5, a waiver could be obtained on the basis that placement of a RCRA-compliant cap would create a greater risk to the environment than the proposed cap.

With respect to the disposal component of these alternatives, Alternatives 3b and 5b would involve additional permanent occupancy and modification of the floodplain, and the filling of wetlands. Alternatives 3a and 5a could also result in the filling of wetlands if the selected upland CDF location contains wetlands. In addition, under Alternatives 3a and 5a, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed.

6.7.3 Long-Term Effectiveness and Permanence

The three alternatives evaluated in the detailed analysis exhibit a range with respect to the long-term effectiveness and permanence of the remedy. Alternative 1 (No Action) would not be effective in the long term because the risk remains high and there are no controls to prevent exposure.

Alternatives 3 (Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment) and 5 (Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment) would be more effective in the long term than the No Action alternative. Excavation of contaminated sediment/soil and placement of clean backfill in areas of potential human exposure and potential downstream migration would provide an increased level of long-term protection of human health and the environment. Alternative 5 would provide a greater level of risk reduction than Alternative 3 throughout the post-construction period because more of the contamination would be removed and either contained in a disposal facility or treated. Ultimately (estimated duration of 55 to 60 years), both action-based alternatives would achieve a low residual risk. Although not necessary to achieve RAOs, ICs are included as a component of both Alternatives 3 and 5 in order to provide enhanced protectiveness by reducing human exposure to contamination. ICs would be necessary to prevent the disturbance of the CDFs (Alternatives 3a, 3b, 5a and 5b) and thin-layer cover under Alternatives 3 and 5. These controls are only effective if adequately monitored and enforced. ECs (walkways) could be used under Alternatives 3 and 5 to provide further protection to human health. There are additional reliability issues for Alternatives 3b and 5b because the CDF is located in the river/floodplain.

Residual Risk

Table 6-29 summarizes the calculated residual risks (i.e., the risks based on anticipated contaminant exposures following attainment of the cleanup objectives) to human health and ecological receptors for Lyman Mill reach stream sediment and floodplain soil. The residual risks are equivalent for all active remedies and in most cases are considerably less than the No Action alternative. The residual risks are summarized in the following sections with detailed analysis provided in Appendix M.

For each active remedial alternative, the residual carcinogenic risk to humans is 7.E-06, which is well within the EPA cancer risk range and more than an order of magnitude less than residual risks under the No Action alternative (Table 6-29a). Organ-specific noncarcinogenic hazards to exposed human receptors are less than 1 under all remedial alternatives (Tables 6-29a and 6-29b).

Residual risks to ecological receptors (fish and wildlife) are also lower under the active remedial alternatives (Table 6-29d) compared to the No Action alternative (Table 6-29c). Under the No Action alternative, residual risks to birds and mammals are 50 and 400, respectively; these risks are considerably

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lower for the action alternatives (i.e., 7 and 5, respectively). In the case of soil invertebrates, residual risks under the active remedial alternatives are lower than for the No Action alternative (i.e., 100 versus 300, respectively); however, in all cases, elevated risks remain because background concentrations of several contaminants exceed risk-based sediment threshold concentrations. Dieldrin and cadmium accounts for the majority of the elevated risks but 4,4'-DDE and zinc also contribute (Table 6-29d).

Inherent Hazard

The inherent hazard remains under all action alternatives because contamination above the cleanup goals remains in place in the floodplain under the thin-layer cover for an extended period of time. Among the disposal options, the inherent hazard is higher for the on-site containment options (Alternatives 3a, 3b, 5a and 5b) because floodplain soil above cleanup levels remains untreated on site, and these options would rely on other controls to be effective in the long term. There are additional reliability issues for Option 5b because the CDF is located in the river/floodplain. Long-term monitoring, maintenance and ICs are necessary to protect the integrity of both CDF options. These controls are only effective if adequately monitored and enforced.

6.7.4 Reduction of Toxicity, Mobility or Volume through Treatment

Alternatives 5d and 3d would require the greatest reduction of toxicity, mobility and volume through treatment, followed by Alternatives 5e and 3e. The thin-layer cover (Alternatives 3 and 5) and on-site containment options (Alternatives 3a, 3b, 5a, and 5b) would reduce the mobility of the contaminated sediment/soil, although not through treatment. The No Action (Alternative 1) would not provide any treatment or reduction in mobility, toxicity or volume.

6.7.5 Short-Term Effectiveness

The No Action alternative has no short-term impacts to the community, the environment or workers. The short-term impacts to the community and on-site workers are fairly similar for the remaining alternatives. Both Alternatives 3 and 5 would result in increased traffic around the site. Generators, heavy equipment, and large trucks would be used during remedy implementation. This would result in a temporary increase in noise and air emissions. These emissions would be within acceptable safe levels.

Disposal of sediment/soils would involve transport of excavated materials to an on-site or off-site facility. Engineering controls would be implemented to eliminate releases of contaminants during such transport. Additionally, if on-site treatment is utilized (Alternatives 3d and 5d), there would be air emissions associated with the incinerator operations. These emissions would be within acceptable safe levels.

Alternative 5, which includes excavating and backfilling, as well as construction activities related to the various disposal options, would present the most short-term impacts to the environment. The removal footprint for this alternative is approximately 13.5 acres and includes areas of emergent marsh, scrub/shrub vegetation, as well as some areas with mature trees. The remaining 8.0 acres would be covered with 3 inches of enhanced natural cover, which is less invasive, but not without some adverse effects. It is unlikely that 3 inches of material placed within this area would have a substantial deleterious effect on resident biota; however, there would be some disruption to the soil community and the herbaceous stratum. Any sediment removal and backfilling activities will result in destruction of the habitat in the removal and staging areas. Although the remedy would include placing topsoil and planting vegetation at the conclusion of implementation, the emergent marsh and scrub/shrub area is expected to take approximately a decade to fully develop. Mature trees would take even longer (on the order of decades) to become fully restored with respect to vegetative biomass and canopy cover criteria.

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Alternative 3 would have somewhat fewer short-term impacts to the environment than Alternative 5 due to the reduced excavation footprint (4.8 acres excavated under Alternative 3 compared to 13.5 acres excavated under Alternative 5). The targeted excavation area in this alternative is limited to those areas that exceed state ARARs for residential direct exposure and EPA's recommended residential level for dioxin (EPA, 1998b), as well as the stream channel (which would not be suitable for the thin cover). Areas not remediated by excavation would be covered with 3 inches of enhanced natural cover, which is less invasive, but not without some adverse effects (e.g., some disruption to the soil community and the herbaceous stratum, same as Alternative 5). However, in contrast to Alternative 5, the time to achieve the Target Hazard for 2,3,7,8-TCDD is anticipated to take approximately 60 rather than 55 years under this alternative. This time differential is the tradeoff associated with the reduced footprint (i.e., approximately 8.7 fewer acres of impact to wetland vegetation). The delay in achieving the remedial goals (for ecological receptors) is balanced by the need to preserve the habitat necessary to maintain the receptors to be protected. As has been noted previously, this area provides a unique environmental function in the lower Woonasquatucket River watershed as one of the largest remaining tracts of undisturbed forested wetland.

Comparing across the three remedial alternatives for a given model scenario, the difference between the most and least effective remedies can range up to 100 years (Table M-15). Based on the current understanding of the hydrodynamics of this reach of the Woonasquatucket River and professional judgment concerning likely soil degradation rates, the best estimates of the amount of time to reach the desired Target Hazard is 55 years (Alternative 5), 60 years (Alternative 3) and 105 years (No Action alternative).[80] The RAOs for human health will be achieved in less than 8 and 15 years for Alternatives 5 and 3, respectively (Figure 6-8). The No Action alternative is expected to achieve the RAO (again based on 2,3,7,8-TCDD) in approximately 55 years (Figure 6-8).

6.7.6 Implementability

All of the alternatives except the No Action alternative present technical and administrative feasibility issues. Alternative 3, however, may have fewer implementability issues compared to Alternative 5 because the magnitude of wetlands destruction is reduced (i.e., 4.8 acres of wetlands destroyed under Alternative 3 compared to 13.5 acres destroyed under Alternative 5).

Alternatives 3 and 5 would require space for construction activities such as material stockpiling and equipment staging. Space is very limited on site and the surrounding land is privately owned and, in most cases, already developed. In addition, both alternatives will require construction in areas having soft soils. Alternatives 3 and 5 will both face additional implementation issues if the presence of vernal pool habitat is confirmed within the current remediation footprint. The animals that occur in vernal pools are typically very sensitive to environmental disturbances and special care would have to be taken during the design and construction aspects of these alternatives to mitigate these concerns. Even the application of a 3 inch layer of natural soil cover could have some deleterious effects on these areas. Both alternatives will also require a determination that there is no other practicable alternative before they can be selected as the remedy because of the resulting permanent occupancy and modification of the floodplain.

Alternatives 3 and 5, the nearshore CDF (Alternatives 3b and 5b), and possibly the upland CDF (Alternatives 3a and 5a) would have wetlands and Section 404 requirements. Alternatives 3 and 5 would

[80] This is based on an assumed annual deposition rate of 0.12 inches/year and a half-life of 2,3,7,8-TCDD in soil of 12.9 years for the action-based alternatives and a slower deposition rate (0.048 inches/year) but same assumed half-life for the No Action alternative (highlighted in Appendix M, Table M-15). The faster deposition rate assumed for Alternatives 3 and 5 is based on the inclusion of engineering structures to divert floodwaters into the Oxbow and to maximize retention time within the area (Appendix M).

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also result in the permanent occupancy and modification of the floodplain. The application of slurry for cap placement has been widely used in aquatic settings; however, using this method for cover placement in wetland or more terrestrial regimes is an innovative application and may pose some unforeseen challenges.

The implementability of Alternatives 3 and 5 is largely determined by the various disposal options associated with this alternative. Those options that include on-site treatment and/or disposal facilities (Alternatives 3a, 3b, 3d, 5a, 5b, and 5d) will require adequate space for such facilities. The option that requires on-site incineration (Alternatives 3d and 5d) would have additional implementability issues because of the need for vendors specializing in on-site, high-temperature incineration of hazardous waste. Gaining public acceptance is an important component as well.

6.7.7 Cost

The costs for the four alternatives are presented in Table 6-28. The present worth costs for No Action is $250,000. Present worth costs for the action-based alternatives range from $9,700,000 for targeted excavation, ENR and on-site containment (Alternatives 3a and 3b) to $42,000,000 for partial excavation, ENR and on-site thermal treatment (Alternative 5d).

6.8 Detailed Evaluation of Source Area Soil Alternatives

The three source area soil alternatives retained from the screening analysis are described further in this section and are evaluated against the NCP criteria (excluding State and Community Acceptance, which are considered after comments to the FS and Proposed Plan are received). All alternatives include five-year reviews. The source area soil action area is located within the floodplain (Figure 1-2). This area also includes riverbank wetland resource areas as well as wetland vegetation that may become re-established within the former tailrace (Cap Area #3) (Section 2.3.10). Because some soil contamination is located in wetland areas, there is no practical alternative to destruction of these wetlands.

Source Area Soil Alternatives Retained for Detailed Analysis

1	No Action
3	Targeted Excavation, Upgrade Caps and Maintain and Disposal and/or Treatment
4	Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

As described in Section 3.1, the cleanup objectives for source area soils are:

- Prevent direct human exposure to source area soils that contain contamination in excess of ARARs (e.g., RIDEM residential direct exposure and TSCA requirements for PCBs) and EPA's recommended residential level for dioxin (EPA, 1998b); and
- Prevent leaching or migration of contaminants from vadose zone soils that would result in groundwater contamination in excess of ARARs (e.g., RIDEM GB leachability criteria).

Site actions were completed in 1999-2000 and 2003-2004 to reduce the immediate human health threat to residents on and near the site from exposure to contaminated soils in the source area (see Section 2.2.2 and Table 2-1). The work done in 1999-2000 was a TCRA that included protective caps in Areas #1 and #2, as described below:

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- Construction of an interim protective cap (Cap Area #1) in a formerly wooded area immediately south of the Centredale Manor parking lot. This area was prone to flooding and had some of the highest concentrations of dioxin and PCBs in surface soil at the site. Contaminated source area soils were capped with intermediate cover material (6 inches minimum thickness), a geotextile liner, and approximately 12 inches of final cover material. The uppermost layer consists of 4 inches of loam and a vegetative cover.

- Construction of a second interim cap (Cap Area #2) between the Woonasquatucket River and the Centredale Manor building. This area also was prone to flooding and contained elevated concentrations of dioxin in surface soils. Contaminated source area soils were capped with a geotextile fabric liner, 6 inches of sand fill, and 12 inches of common fill. The uppermost layer consists of loam and a vegetative cover. A flood control berm was constructed along the western edge of the cap to reduce erosion.

The work done in 2003-2004 was a TCRA that included protective caps in Area 3 and stormwater control facilities, as described below.

- Construction of a permeable protective cap (Cap Area #3) over contaminated soils and sediments in the former tailrace, installation of a precast modular stormwater control structure at the terminus of a storm drain at the north end of the tailrace, and construction of a drainage swale along the length of the capped area (LEA, 2004). The majority of the tailrace is capped with a cellular confinement system consisting from the bottom up of approximately 6 inches of sand, a geotextile fabric, and a 6-inch-thick cellular confinement system filled with and covered by 1.5-inch aggregate material. A soil cap consisting of geotextile fabric covered by 20 inches of bank run gravel and 4 inches of loam was constructed at the north end of the tailrace.

The ground surface elevations in a significant percentage of Cap Areas #1, #2, and #3 are below the 100-year flood elevation (Figure 1-2), as are some of the parking lots, paved surfaces and landscaped areas. Approximately 85% (7.6 acres) of the source area is below the 100-year flood elevation, indicating that these areas may be subject to erosion during flooding. In 2002, Atlantic Environmental Technologies, Inc. (AET) performed an assessment of the condition of the interim caps (AET, 2002). The report notes the following findings:

- Some areas on the Interim Caps have been impacted by limited amounts of erosion as evidenced by the apparent lack of vegetative cover in these locations.
- Areas of "raindrop" erosion and the initial stages of "sheet" erosion, as defined by the 1989 editions of the State of Rhode Island's Soil Erosion and Sediment Control Handbook, were also observed.
- Interim Caps #1 and #2 appeared to have experienced settlement, which resulted in hummocking (uneven grades) across both caps.
- Stormwater in Cap Area #1 is more likely to be recharged directly through the site soils than directed to overland flow to the tributary areas (due to the hummocking and site grading).
- The swale drainage system did not fully encompass the perimeter of Cap Area #1 or Cap Area #2.

As described in Section 2.4.3.1, there is widespread contamination above the state ARARs for residential direct exposure in vadose zone soils at the source area, as well as dioxin contamination above EPA's recommended residential level for dioxin in surface soil (representative contaminants dioxin TEQ and total PCB shown in Figures 2-12 and 2-13, respectively). The majority of the exceedances, however, are in paved or capped areas. Concentrations of total PCB were above the TSCA criteria (40 CFR 761; 50

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mg/kg total PCB) in samples from 15 locations at the source area (Figure 2-13). The majority of exceedances (10 out of 15) occur at the central and southern portions of the source area under Cap Area #1 and the Centredale Manor parking lots.

Leachability criteria for VOCs were exceeded, but only in samples from six locations (Figure 2-14). Leaching of contaminants from soil has led to localized groundwater contamination, particularly on the west side of the Brook Village parking lot adjacent to the Woonasquatucket River (Appendix G, Figure G-9). Concentrations of dioxin and VOCs (PCE and TCE) were above the cleanup goals in samples from five locations at the Brook Village parking lot. These data suggest that the existing surfaces (existing interim caps, pavement, and rip rap) appear to be protective of the underlying groundwater at the source area, except at the west side of the Brook Village parking lot.

Remedial alternatives for the vadose zone soil and groundwater at the Brook Village parking lot are addressed as a separate action area in Sections 6.10 and 6.11. Potential remediation of the vadose zone soil and groundwater contamination for the other areas (Figure 3-5, Table 6-30) is considered as part of the residential soil remediation in this section.

6.8.1 Alternative 1: No Action

6.8.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process, and is used as a basis of comparison to the other alternatives. This alternative would entail no active remediation of the contaminated source area soils or maintenance of the prior removal actions. Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. For cost estimating, it is assumed that there would be one physical survey and report to EPA on the conditions of the site every five years. Monitored natural recovery processes, ICs, and rigorous long-term monitoring are not components of this alternative.

6.8.1.2 Evaluation of No Action

Results from the evaluation of Alternative 1, No Action against the NCP criteria are discussed below and summarized in Table 6-31.

Overall Protection of Human Health and the Environment

The No Action alternative would not provide additional overall protection of human health and the environment. Three "removal actions"[81] have been completed including the installation of three interim soil covers at the source area which provide a cap that reduces direct human exposure to vadose zone soils. The existing interim caps currently provide some overall protection, but without long-term monitoring, maintenance and ICs to maintain the integrity of the soil caps conditions would likely deteriorate over time. For example, a site inspection in 2002 showed a limited amount of erosion had occurred at Cap Area #1 and Cap Area #2, likely because the caps are located within flood zones (Figure 1-2) and have no apparent maintenance program (AET, 2002).

[81] The term "removal actions" refers to remediation measures taken before a ROD is issued and the action can include containment of contaminated soils as a remedial measure. The term does not mean that contaminated soils were excavated and taken off site.

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Compliance with ARARs

ARARs specific to the No Action alternative are summarized in Table 6-32. This alternative will not comply with ARARs for residential direct exposure, GB leachability, TSCA closure or EPA's recommended residential level for dioxin in soil (EPA, 1998b).

Long-Term Effectiveness and Permanence

The residual risk and inherent hazard remains high without an applicable RCRA and TSCA closure. In addition, contamination above acceptable levels would remain in areas that are not capped. There would be no adequate or reliable controls to prevent exposure in the long term or maintain the controls currently in place. Without long-term monitoring and ICs to maintain the integrity of the existing surfaces, there would be risk of future uncontrolled exposure and migration of contaminated soils by erosion and transport to the Woonasquatucket River and Allendale Pond.

Reduction of Toxicity, Mobility or Volume through Treatment

There would not be a reduction of toxicity, mobility or volume of contamination through treatment with this alternative.

Short-Term Effectiveness

This alternative has no short-term impacts on the community, the environment or workers because there would not be any construction or intrusive work required under this alternative.

Implementability

There are no implementability issues as no activities are required under this alternative.

Cost

There would be no costs associated with the No Action alternative if no monitoring was conducted. If periodic monitoring is implemented, the annual cost for monitoring would be $14,000 and the present worth costs would be $170,000.

6.8.2 Alternative 3: Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

6.8.2.1 Description of Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

Alternative 3 includes targeted excavation to remove principal threat waste and contaminated soil that exceeds the TSCA or GB leachability criteria, as well as extending the existing caps to cover existing landscape areas and upgrading and maintaining the existing surfaces to prevent exposure to or migration of contaminated soil at the source area (Figure 5-28). Excavated material would be shipped off site for disposal and/or treatment (Option 3e).

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The health and safety of residents would be protected during construction. This is especially important for the source area because the residents in the Brook Village and Centredale Manor apartment buildings, located at the source area are mostly elderly. Elderly populations are typically more sensitive to contaminants in the air and soil and to uncontaminated dust and chemicals used in standard construction. Additional steps would be taken so that the work was performed in a manner that would protect the health and safety of the residents, would protect the existing facilities from contamination and provide continuous access to the facilities. All work would be coordinated with management of Brook Village and Centredale Manor to provide continuous access to the residents and building service providers. The remedial action work plans, which would be submitted to EPA and the state before construction, would include a traffic control plan, a contamination migration control plan, and a resident health and safety plan.[82] These plans would describe measures that would be implemented to provide continuous access, protect existing property, and protect residents' health and safety during construction. The management of Brook Village and Centredale Manor would be contacted during the preparation of these plans to facilitate coordination and obtain their input into the procedures. After approval by EPA, these plans would be provided to the residential facilities management.

Following removal, confirmation sampling would be conducted to verify that the cleanup goals were achieved (see Appendix J for assumptions regarding types and quantities of confirmation samples). The sequence of excavation activities, excavation/backfill volumes and rates, soil processing, construction to upgrade existing surfaces, construction monitoring, long-term monitoring and ICs, and disposal and/or treatment options are described below. Construction activities would occur at the source area, where there is limited area for stockpile of material and equipment storage.

Construction Sequence

The work would be done in phases to minimize disruption to the residents. An example construction sequence is described below:

1. Construct stockpiling, truck loading and decontamination facilities prior to excavation.
2. Excavate principal threat waste and transport off site for treatment/disposal.
3. Clear vegetation and install upgraded cap in Cap Area #1.
4. Excavate source area soils (TSCA/GB leachability areas) in Cap Area #3 east of Centredale Manor and transport off site for treatment/disposal.
5. Upgrade cap in Cap Area #3.
6. Excavate source area soils (TSCA/GB leachability area) in area north of Centredale Manor and transport off site for treatment/disposal.
7. Upgrade cap in landscape areas north of Centredale Manor.
8. Excavate source area soil (TSCA/GB leachability area) on north end of Cap Area #2 and transport off site for treatment/disposal.
9. Upgrade cap in Cap Area #2.

[82] State and federal wetlands may be associated with the source area soil action area and mitigation for any losses to these resource areas would need to be provided for if unavoidable impacts occurred as a result of remedy implementation. However, the developed nature of the source area (i.e., buildings, pavement and cover systems) introduces some questions regarding the need for mitigation in this area that would need to be resolved with the appropriate regulatory authorities during the design phase. Any potential impacts would be evaluated and provided for at that time as one component of the overall mitigation planning for the project.

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10. Upgrade cap in landscape areas around Centredale Manor
11. Apply sealer to asphalt parking lot areas
12. Remove the temporary roadways and restore the vegetation in the temporary work areas.

Excavation/Backfill Volumes and Rates

Conventional earth moving equipment would be used to excavate the principal threat waste and contaminated soil. Figure 5-28 shows the areas that would be excavated under this alternative.[83] The spatial extent of the principal threat waste excavation area encompasses the area interpreted as having the highest potential for containing buried bulk metallic materials (Roy F. Weston, 1999). The vertical extent of this excavation area is 4 ft bgs, which is based on the average fill thickness at the source area and confirmed by soil borings collected at this area (TTNUS, 2002). The TSCA/GB leachability excavation areas encompass all locations where there are chemical concentrations above the TSCA/GB leachability criteria.[84] Each location represents a polygon shaped area of contamination, where the spatial extent of the area extends approximately half-way between contaminated locations and clean locations. The vertical extent of these excavation areas ranges from 1 to 5 ft bgs, and encompasses the depth to clean (i.e., the depth at which contamination does not exceed TSCA and/or GB leachability criteria). The total volume of source area soil that would be excavated under this alternative is 9,800 cy (5,500 cy in principal threat area and 4,300 cy in TSCA/GB leachability area; does not include over-excavation allowance). Approximately 15,900 tons of backfill would be placed in the excavated area.

The excavation and backfill rates are assumed to be approximately 400 cy/d and 500 tons/day, respectively. Based on these rates, it will take approximately 5 weeks to excavate the principal threat waste and contaminated soil and 6 weeks to place backfill. After excavation and evaluation of the confirmation samples, imported backfill would be placed to restore the site grade to existing elevation and to provide subgrade for the soil cap or asphalt.

Source Area Soil Processing

The excavated soil will generally be above the elevation of the groundwater table, so continual groundwater pumping and treatment will not be required. However, some of the deeper excavations may be below shallow groundwater during some seasons in the year. Therefore, this alternative includes provisions for pumping groundwater and stormwater from the excavations and treatment in a temporary treatment system.

Upgrade Existing Surfaces

This alternative includes an initial assessment to identify design improvements needed to restore the existing interim caps to meet the requirements of the original designs; a more detailed analysis would be performed during design. Construction to upgrade the existing surfaces would be performed following completion of excavation activities (above).

In the three existing interim cap areas the upgrade would include the following:

- Remove existing vegetation and take off site for disposal as hazardous debris. There are no trees in the cap areas and the vegetation that has grown since the caps were placed would be removed.

[83] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).
[84] The existing paved surfaces are considered an impermeable barrier under state law. Contaminated soil beneath the paved surfaces with GB leachability exceedances would not be excavated.

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- Import loam type soil to fill depressions in the cap area where water could form shallow ponds and to provide soil with nutrients for healthy vegetation. For cost estimating purposes, it is assumed that an average fill thickness of 0.5 ft would be needed to fill low areas to provide soil for vegetation.
- Place hydro-seed to establish grass that would control soil erosion.
- The new soil and grass would cover any areas where erosion has exposed the geotextile fabric that was placed for the existing soil caps.

Excavation activities would be limited to some small landscape areas, and all work would be performed where the existing ground surface is above the normal water levels in Woonasquatucket River and Allendale Pond, so dewatering would not be required.

In the parking lot and paved areas, asphalt sealant would be placed over the entire paved surfaces. The asphalt sealing would have to be performed in one area at a time to provide residents with continuous access and vehicle parking.

In the landscaped areas, which encompasses approximately 60,500 square feet at the source area, the top 2.5 ft of soil would be removed and replaced with a cap that matches the existing interim cap. This would include from bottom to surface (a) 6 inches of fill, (b) a geotextile fabric layer, (c) 12 inches of imported fill and (d) 6 inches of topsoil. Once the cap was in place, the areas could be covered with grass or decorative landscape plantings with shallow (< 6 inches) root systems.

Overall, a total of approximately 11,000 tons of imported fill would be required to upgrade the existing interim caps and extend the caps to cover the landscaped areas. This would require approximately 275 truck loads of material, which could be delivered at a rate of 25 trucks per day for 2 weeks. The estimated construction duration to upgrade the existing interim caps and extend the caps to cover the landscaped areas is approximately four weeks. It would take approximately two weeks to install asphalt sealant on the site.

In this alternative, the ground surface elevation after upgrading the caps would be an average of 0.5 ft higher and this has the potential to impact flood storage especially because a significant percentage of the cap areas are below the 100-yr flood elevation (Figure 1-2). The volume of fill for all three cap areas would be 93,000 cubic feet. The estimated flows during flood events are 893 and 2,300 cfs for flood return periods of 5 and 100 years, respectively. The potential impact to flood storage can be assessed by calculating the time it would take flood flows to fill a volume equal to the fill volume. For this assessment, assume that all the cap areas are below the 100-year flood elevation. In this simplified case, for the floods with 5-year and 100-year return periods, the flood flows would be equal to the fill volume in 100 and 40 seconds, respectively. Mitigative measures to replace lost flood storage capacity would be evaluated during design if this option is selected as the remedy.

Construction Monitoring

During all construction, work would be limited to normal work hours. During earthwork construction, dust and noise would be controlled to protect the health of the residents of the two on-site buildings and surrounding neighborhoods. Air and noise monitoring and abatement would be performed to ensure that the residents were not exposed to unsafe levels of particulates or volatiles in the air or unsafe noise levels. Dust and erosions controls may include actions such as applying water to keep the soil moist, covering exposed soil with straw or natural fiber mats, covering soil stockpiles with fabric, or installing silt fences around the perimeter of the site. Noise controls may include features such as mufflers on all equipment, or enclosing generators and air compressors in sound-reduction enclosures.

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Long-Term Monitoring and Institutional Controls

A conceptual long-term monitoring approach is presented in Appendix H. Because the contamination would remain on site, ICs would be required to prevent contact with contaminated source area soil. The ICs would prohibit future excavation, restrict access for buried utilities, prevent the construction of buildings with pilings or basements, and require maintenance of the caps, parking lots, paved surfaces, and rip rap areas. The existing groundwater monitoring wells would be protected and used for long-term groundwater monitoring. Periodic reporting would be required to document remedy progress and efficacy.

Disposal or Treatment Options

The disposal and/or treatment option evaluated for Alternative 3 is described below:

Option 3e: Off-site Disposal and/or Treatment

The excavated soil would be sampled on a daily basis. Representative, composite samples would be taken and analyzed for total dioxin and furans to determine if disposal by incineration is required according to the LDRs (see Section 3.2.1.2). Representative, composite samples would also be taken and analyzed for TCLP concentrations to determine the designation of the materials as solid or hazardous waste and to determine which type of landfill is required. Once the appropriate disposal facility is identified, the excavated soil would be loaded onto trucks or rail cars and transported to the appropriate location.

F-listed or characteristic soil waste with an underlying hazardous constituent that meets the alternative treatment standards in 40 CFR §268.49 would be taken to a licensed hazardous waste landfill for disposal. F-listed or characteristic soil waste that exceeds treatment standards in 40 CFR §268.49 would be taken to an off-site incinerator. Approximately 10% of the source area soil samples (from the planned excavation areas) contain dioxin or PCBs at concentrations in excess of the treatment standards in 40 CFR §268.49 (Section 3.2.1.2). Therefore, the costs are based on the assumption that 90% of the soils would be taken to an off-site landfill and that 10% would be taken to an off-site incinerator for treatment. Costs assume that 100% of the principal threat waste and hazardous debris would be taken to the off-site facility for incineration.

6.8.2.2 Evaluation of Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

Results from the evaluation of Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment, against the NCP criteria are discussed below and summarized in Table 6-33.

Overall Protection of Human Health and the Environment

Removal of principal threat waste and contaminated soil that exceeds TSCA/GB leachability criteria in conjunction with extending and upgrading the soil caps would provide moderate overall protection of human health and the environment. Targeted removal of principal threat waste would remove highly toxic or highly mobile waste that generally cannot be reliably contained and could present a significant risk to human health or the environment should exposure occur. Targeted removal of contaminated soil that exceeds TSCA would prevent exposure to toxic soils. Targeted removal of contaminated soil that exceeds GB leachability criteria, extending the caps over landscape areas, and upgrading the existing surfaces would be effective in preventing erosion of surface soils and migration of the contaminants in

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eroded soil at the source area, and would effectively isolate contaminants from human exposure. The risk of exposure to contamination that remains in place would be reduced with ICs restricting site activities.

The soil caps would not prevent precipitation infiltration into the groundwater. The pavement in the existing parking lots reduces infiltration in the parking lot areas, but re-directs the run-off to the edges of the parking lot where it can infiltrate into the ground. Moreover, a waiver would be required for the RCRA closure requirements.

Compliance with ARARs

ARARs specific to Alternative 3 are summarized in Table 6-34. This alternative would not comply with RCRA closure requirements. In addition, excavation and placement of fill in wetland areas would result in the destruction of existing wetlands and will trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under this alternative, there would be permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

Long-Term Effectiveness and Permanence

Excavation and removal of the principal threat waste and contaminated soil that exceeds TSCA/GB leachability will be effective in the long term. Upgrading the existing surfaces and extending the caps over landscaped areas would increase the effectiveness of this alternative. Some contaminated soil would remain in the floodplain. Inherent hazard of contamination will remain on site under an upgraded cap but without an applicable RCRA closure. Risk reduction will be high as long as the cap is designed, constructed and maintained to provide long-term isolation of contaminants.

Long-term monitoring and maintenance of the upgraded surfaces would be required to prevent erosion and exposure of the underlying contaminated soils. In addition, ICs would be required to prevent human exposure, and could include restrictions on excavation, access for buried utilities, and construction with pilings or basements. However, these controls are only effective if adequately monitored and enforced.

Periodic monitoring would also be performed to verify that contamination left in place remains relatively immobile, and that no future releases occur.

Reduction of Toxicity, Mobility or Volume through Treatment

There would be a reduction of toxicity, mobility or volume of contamination through treatment with this alternative. The mobility of the contaminated soil would be reduced by the isolation cap, although not through treatment.

Short-Term Effectiveness

There would be some short-term impacts to the community, environment and workers during construction of this alternative. There would be some potential risk to on-site residents from dust generated during construction activities and VOCs generated during installation of asphalt sealants. However, access to the work zone during construction activities would be prohibited and all appropriate measures including engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring would be taken to mitigate risks to the residents and community. Additionally, all work would be performed in phases to

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minimize these impacts, and measures would be taken to provide residents continued access to the buildings and parking areas.

Site workers would be protected by dust and erosion control measures implemented during construction. Potentially contaminated soil would be transported in covered trucks, and trucks would be cleaned to prevent contaminated soil being deposited within the site. ECs and personal protection equipment would be used to meet worker safety regulations.

Excavation and placement of fill in wetland areas would result in the destruction of existing wetlands.

The RAO to prevent direct human contact with the contaminated vadose zone soil would be achieved at the completion of remedy implementation, which is expected to be approximately three months. Achieving this RAO, however, is contingent on long-term monitoring and maintenance of the existing surfaces that would continue after construction activities are complete.

The time to achieve the RAO to prevent migration or leaching of contaminants to soil and groundwater is unknown, because some precipitation infiltration to the underlying soil and groundwater could still occur under this alternative. However, contaminated soil that exceeds the GB leachability criteria would be removed and should reduce the potential leaching of contaminants from soil to groundwater.

Implementability

Alternative 3 would be moderately difficult to implement. The cap materials and pavement sealing materials would be available from common commercial sources and all work could be performed with conventional earthwork or paving equipment. Although the construction would be routine, implementation at this site would be more difficult because remediation work would be conducted in close proximity to apartment buildings with a sensitive population. In addition, there is limited space available for equipment, material stockpiles and efficient work operations. The sequence of work would be constrained by the need to maintain access to Brook Village and Centredale Manor and the lack of space. As stated above, work would be limited to normal business hours Monday through Friday. The contractors would develop a traffic control plan and coordinate with the management of Brook Village and Centredale Manor to provide continuous access to residents and building service providers.

This alternative results in a permanent occupancy and modification of floodplain and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable wetland impacts would be required, as well as replacement of flood storage capacity. In addition, a waiver from the Subtitle C closure requirements of RCRA would need to be obtained.

Cost

The detailed cost evaluation for Alternative 3, Targeted Excavation, Upgrade and Maintain the Existing Surfaces and Off-site Disposal and/or Treatment, is presented in Appendix J. The capital, operation and monitoring, and present worth costs are listed below:

Option 3e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$19,100,000
	Annual cost for years 1 to 30	$37,000
	Present worth costs	$19,600,000

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6.8.3 Alternative 4: Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

6.8.3.1 Description of Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

In this alternative, principal threat waste would be removed by excavation and existing interim caps and paved surfaces (Figure 5-29) would be upgraded to meet the guidance for caps over unlined hazardous waste landfills. The cap would also be extended to cover landscaped areas within the proposed remedial footprint (Figure 5-29). Measures would be taken to provide continuous access, protect existing property, and protect site worker and resident's health and safety during construction as described for Alternative 3 (Section 6.8.2).

The sequence of excavation activities, excavation/backfill volumes and rates, soil processing, construction to convert the existing surfaces to RCRA caps, relocation of utilities, construction monitoring, long-term monitoring and ICs, and disposal and/or treatment options are described below. Construction activities would occur at the source area, where there is limited area for stockpile of material and equipment storage.

Construction Sequence

The work would be done in phases to minimize disruption to the residents. An example construction sequence is described below:

1. Construct stockpiling, truck loading and decontamination facilities prior to excavation.
2. Excavate principal threat waste and transport off site for disposal/treatment.
3. Relocate underground utilities.
4. Clear vegetation and install RCRA cap in Cap Area #1.
5. Install RCRA cap in Cap Area #3.
6. Install RCRA cap in Cap Area #2.
7. Install RCRA cap in landscape areas around Centredale Manor
8. Install RCRA cap in asphalt parking lot and access roadway southwest of Centredale Manor.
9. Install RCRA cap in asphalt parking lot and access roadways north of Centredale Manor.
10. Install RCRA cap in parking lot and access roadways south of Brook Village.
11. Remove the temporary roadways and restore the vegetation in the temporary work areas.

Excavation/Backfill Volumes and Rates

Conventional earth moving equipment would be used to excavate the principal threat waste from the southern portion of the source area at Cap Area #1 (Figure 5-29). The spatial extent of the principal threat waste excavation area encompasses the area interpreted as having the highest potential for containing buried bulk metallic materials (Roy F. Weston, 1999). The vertical extent of this excavation area is 4 ft bgs, which is based on the average fill thickness at the source area and confirmed by soil borings collected at this area (TTNUS, 2002). The total volume of source area soil that would be excavated under

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this alternative is 5,500 cy (does not include over-excavation allowance).[85] Approximately 8,900 tons of backfill would be placed in the excavated area.

The excavation and backfill rates are assumed to be approximately 400 cy/d and 500 tons/day, respectively. Based on these rates, it will take approximately 3 weeks to excavate the principal threat waste and contaminated soil and 4 weeks to place backfill. After excavation, imported backfill would be placed to restore the site grade to existing elevation and to provide subgrade for the soil cap or asphalt.

Source Area Soil Processing

The excavated soil will generally be above the elevation of the groundwater table, so continual groundwater pumping and treatment will not be required. However, some of the deeper excavations may be below shallow groundwater during some seasons in the year. Therefore, this alternative includes provisions for pumping groundwater and stormwater from the excavations and treatment in a temporary treatment system.

Cap Design and Construction

The RCRA cap would be designed to meet the requirements of the EPA Region 1 guidance for RCRA covers over unlined hazardous waste landfills (EPA, 2001b); the RCRA cap will meet TSCA requirements. A cross-section showing the placement of a RCRA cap at the source area, bounded to the west by the Woonasquatucket River and to the east by the steps to the Centredale Manor apartment building, is shown in Figure 5-30b. A cross-section of a representative RCRA cap showing the cover system is presented in Figure 5-30a. As shown on Table 6-30, the total area of the existing interim soil caps is 186,000 square feet (4.3 acres) and the total area of existing pavement is 93,000 square feet (2.1 acres).

In the three soil cap areas, the interim soil material previously placed would serve as the Base Layer, Gas Vent Layer and Bottom Low-Permeability Layer. The following work elements would be required to upgrade the existing soil covers:

1. Regrade the site to provide a minimum slope of 3%. This could be performed with contaminated floodplain soil excavated from the ponds as part of the Allendale and Lyman Mill floodplain soil alternatives (see Sections 6.4 and 6.6). Approximately 14,900 tons of imported soil would be required.
2. Install a Geomembrane Layer using 60 mil thick LLDPE or HDPE. This would cover the cap area of 186,000 square feet.
3. Install a Drain Layer. For estimating costs in the FS, it is assumed that imported sand and gravel would be used, with a layer thickness of 12 inches. Install a geotextile on top of the Drain Layer to prevent fine-grained soil from the top layers from migrating into the pore spaces and reducing the permeability. Approximately 12,000 tons would be required.
4. Install a Protective Soil Layer. For this FS, this layer is assumed to be 12 inches thick. Approximately 12,000 tons would be required.
5. Install a Topsoil Layer. For this FS, this layer is assumed to be 6 inches thick. Approximately 6,000 tons would be required.

[85] Appendix N describes how the excavation area and volume would change using EPA's new proposed residential level for dioxin (EPA, 2009).

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For the source area, a total thickness of 18 inches for the Topsoil and Protective Layers would be sufficient to protect the Drain Layer and Low-Permeability Layers. The use of a sand and gravel drain layer instead of a thinner geocomposite drain provides a total of 30 inches of soil over the geomembrane layer, which is more than the total of 24 inches shown in the Region 1 guidance (EPA, 2001b). The climate at this site is more moderate than northern New England so a total thickness of 30 inches would be enough to protect the geomembrane from damage by frost or future use. The sand and gravel in the Drain Layer would not be susceptible to damage from frost or future use.

In the paved areas, the existing asphalt would be removed and recycled into new asphalt for the new paving, or transported to an off-site disposal or recycling facility. The existing soils under the pavement would serve as the Base Layer and Gas Vent Layer. The following work elements would be required to upgrade the existing pavement areas:

1. Remove existing asphalt and take to an off-site disposal or recycling facility.
2. Install a Bottom Low-Permeability Layer and regrade the site to provide a minimum slope of 3%. This layer could be made using contaminated floodplain soil excavated as part of the Allendale and Lyman Mill floodplain soil alternatives (see Sections 6.4 and 6.6). Approximately 6,000 tons of imported soil would be required.
3. Install a Geomembrane Layer using 60 mil thick LLDPE or HDPE over an area of about 93,000 sf.
4. Install a sand and gravel Drain Layer. For estimating costs in the FS, it is assumed that imported sand and gravel would be used, with a layer thickness of 12 inches. Install a geotextile on top of the Drain Layer to prevent fine-grained soil from the top layers from migrating into the pore spaces and reducing the permeability. Approximately 6,000 tons would be required.
5. Install a total of 12 inches of gravel base and asphalt pavement to replace the pavement and serve as the Protective Layer. Approximately 6,000 tons would be required.

This would provide a total of 24 inches of gravel, sand or asphalt over the Geomembrane Layer, which would protect it from frost damage or from damage due to traffic loads.

The total weight of imported fill materials required would be about 72,000 tons (45,000 tons for the interim cap areas, 18,000 tons for pavement areas, and 8,900 tons for the excavation areas). This would require 25 trucks per day for about 125 working days, or 25 weeks. The estimated construction time for the three interim cap areas is approximately 25 weeks and the estimated time for the pavement areas is approximately 10 weeks, for a total construction time of 35 weeks, or 8 months.

In the landscaped areas (1.4 acres) that are not capped, 3.5 ft of soil would be removed and a 12 inch thick layer of silt installed. The silt layer would be covered with a geomembrane, drain layer, protective soil layer and topsoil as described above for the three cap areas. The total thickness of the new cap would be 3.5 ft, so that the future ground surface would be the same elevation as the existing ground.

In this alternative, the ground surface elevation after upgrading the caps would be an average of 2.5 ft higher and this has the potential to impact flood storage, especially because a significant percentage of the cap areas are below the 100-yr flood elevation (Figure 1-2). The volume of fill for all three cap areas would be 248,000 cubic feet and the volume for imported cap materials would be 372,000 cubic feet, for a total volume of 620,000 cubic feet in the three cap areas. The estimated flows during flood events are 893 and 2,300 cfs for flood return periods of 5 and 100 years, respectively. The potential impact to flood storage can be assessed by calculating the time it would take flood flows to fill a volume equal to the fill volume. For this assessment, assume that all the cap areas are below the 100-year flood elevation. In this

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simplified case, for the floods with 5-year and 100-year return periods, the flood flows would be equal to the fill volume in 690 and 270 seconds, respectively. Mitigative measures to replace lost flood storage capacity would be evaluated during design if this option is selected as the remedy.

Relocation of Utilities

This alternative also includes placement of underground utilities into trenches with only clean soils. Because the two buildings on the property are occupied, continuous service must be provided to the buildings. If the residents remain on site during the construction, the most practical method to accomplish this construction would be to install new underground utilities parallel to the existing utilities, then remove the existing lines. The new utilities would include the following:

- Sanitary sewer lines – The costs are based on the assumption that the trenches would be an average of 4 ft wide and 10 ft deep.
- Water, natural gas and storm drains – The costs are based on the assumption that the trenches would be an average of 2 ft wide and 4 ft deep.
- Electric power, telephone, communication cable and parking lot lighting – The costs are based on the assumption that all lines would be inside rigid conduit and that the trenches would be an average of 2 ft wide and 4 ft deep.

After the new utilities were installed, connected, and buried in trenches with clean soil, the existing utilities would be excavated and removed. It is assumed that the soil removed from both new trenches and existing trenches would be contaminated and would be placed in the existing soil cap areas, then covered with the new RCRA caps.

Construction Monitoring

During all construction, work would be limited to normal work hours. During earthwork construction, dust and noise would be controlled to protect the health of the residents of the two on-site buildings and surrounding neighborhoods. Air and noise monitoring and abatement would be performed to ensure that the residents were not exposed to unsafe levels of particulates or volatiles in the air or unsafe noise levels. Dust and erosion controls may include actions such as applying water to keep the soil moist, covering exposed soil with straw or natural fiber mats, covering soil stockpiles with fabric, or installing silt fences around the perimeter of the site. Noise controls may include features such as mufflers of all equipment, or enclosing generators and air compressors in sound-reduction enclosures.

Long-Term Monitoring and Institutional Controls

A conceptual long-term monitoring approach is presented in Appendix H. Because the contamination would remain on site, ICs would be required to prevent contact with contaminated source area soil. The ICs would include prohibiting future excavation, restricting access for buried utilities, preventing the construction of buildings with pilings or basements, and maintenance of the caps and parking lots. The existing groundwater monitoring wells would be protected and raised to the new ground surface elevations and used for long-term groundwater monitoring.

Disposal or Treatment Options

This alternative includes one disposal option: *Option 4e, Off-site Disposal and/or Treatment.*

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Principal threat waste, hazardous debris and excavated soil would be treated/disposed of off site at a permitted facility.

The excavated soil would be sampled on a daily basis. Representative, composite samples would be taken and analyzed for total dioxin and furans to determine treatment for LDRs (see Section 3.2.1.2). Representative, composite samples would also be taken and analyzed for TCLP concentrations to determine the designation of the materials as solid or hazardous waste and to determine which type of landfill is required. Once the appropriate disposal facility is identified, the soil would be loaded onto trucks and transported to the appropriate location.

Excavated soil that is designated as hazardous waste would be subject to LDRs. F-listed or characteristic soil waste with an underlying hazardous constituent that meets the alternative treatment standards in 40 CFR §268.49 would be taken to a licensed hazardous waste landfill for disposal. F-listed or characteristic soil waste that exceeds treatment standards in 40 CFR §268.49 would be taken to an off-site incinerator. The costs are based on the assumption that all of the principal threat waste, hazardous debris and excavated soils would be taken to an off-site incinerator for treatment.

6.8.3.2 Evaluation of Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

Results from the evaluation of Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment against the NCP criteria are discussed below and summarized in Table 6-35.

Overall Protection of Human Health and the Environment

Removal of principal threat waste and converting the existing surfaces to RCRA caps would provide high overall protection of human health and the environment. Targeted removal of principal threat waste would remove highly toxic or highly mobile waste that generally cannot be reliably contained and could present a significant risk to human health or the environment should exposure occur. The RCRA caps would prevent direct human contact with contaminated soils and prevent migration or leaching of contaminants from soil that would result in soil or groundwater contamination in excess of ARARs. The RCRA cap would be effective in the long term because caps constructed of natural earth materials and geosynthetics would be stable in the long term and would provide effective and reliable containment of contaminated soils. The RCRA cap would also essentially eliminate precipitation infiltration into the vadose zone soil, which would provide additional protection against contaminant migration and leaching into the soil and groundwater.

Compliance with ARARs

ARARs specific to Alternative 4 are summarized in Table 6-36. This alterative will comply with all ARARs, including requirements for TSCA and RCRA closure. Excavation and placement of fill in wetland areas will result in the destruction of existing wetlands and will trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under this alternative, there would be permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

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Long-Term Effectiveness and Permanence

Excavation and off-site disposal/treatment of the principal threat waste will be effective in the long term. Capping contaminated soils with a RCRA and TSCA cap would increase the long-term effectiveness of this alternative by providing highly reliable chemical isolation. Risk reduction will be high as the cap will be designed, constructed and maintained in compliance with RCRA and TSCA closure requirements. Because contaminated soil is only contained and remains under the cap, inherent hazard of waste also remains. Long-term monitoring, maintenance, and ICs would be required to protect integrity of the caps. ICs would also be required to prevent human exposure, and could include restrictions on excavation, access for buried utilities, and construction with pilings or basements. However, these controls are only effective if adequately monitored and enforced. Finally, there are additional reliability issues for this alternative because the cap is located in the floodplain.

Reduction of Toxicity, Mobility or Volume through Treatment

There would be a reduction of toxicity, mobility or volume of contamination through treatment with this alternative. The mobility of the contaminated soil would be reduced by the RCRA cap, although not through treatment.

Short-Term Effectiveness

Short-term impacts to the community and the environment would be similar to Alternative 3 (Section 6.8.2.2). The RAOs would be achieved at the completion of remedy implementation, which is expected to be approximately eight months.

Implementability

The cap, membrane cover, pavement and utility materials would be available from common commercial sources and all work could be performed with conventional earthwork or paving equipment. Although the construction would be routine, implementation at the source area would be more difficult because the remedial work would be conducted in close proximity to apartment buildings with a sensitive population. In addition, there is limited space available for equipment, material stockpiles and efficient work operations. Construction of the clean utility corridor would also present some logistical issues. The sequence of work would be constrained by the need to maintain access to Brook Village and Centredale Manor, maintain utilities, and the lack of space. As stated above, work would be limited to normal business hours Monday through Friday. The contractors would develop a traffic control plan and coordinate with the management of Brook Village and Centredale Manor to provide continuous access to residents and building service providers.

With the installation of the new caps, the existing ground surface would be higher than the existing grades, except in the drainage area of Cap Area #3 where some excavation would be performed to maintain the site grade. This would not impact the Centredale Manor apartment building because the ground floor is higher than the surrounding parking lots and there would simply be fewer steps up to the main entrance. The new cap would be installed under the parking lot south of Brook Village building, but not in the access roadways or lawn areas to the east, north or west. Therefore, this would not impact the access or stormwater drainage around Brook Village. Placement of permanent fill in the floodplain, however, would result in a permanent occupancy and modification of floodplain areas, and a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. This alternative also requires the filling of wetland areas. Impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable wetland impacts would be required, as well as replacement of flood storage capacity.

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Cost

The detailed cost evaluation for Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Off-site Disposal and/or Treatment, is presented in Appendix J. The capital, operation and monitoring, and present worth costs are listed below:

Option 4e: Off-site Disposal and/or Treatment	Capital cost and baseline monitoring	$20,800,000
	Annual cost for years 1 to 30	$38,000
	Present worth costs	$21,300,000

6.9 Comparative Analysis of the Source Area Soil Alternatives

The three alternatives for source area soils (Alternative 1, No Action; Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment; and Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment) are compared below to better understand the key tradeoffs among the alternatives; key features of the alternatives are summarized in Table 6-37. Overall, among the alternatives evaluated, the targeted excavation and upgrade to RCRA cap alternative (Alternative 4) would provide the highest level of protection to human health and the environment and higher long-term effectiveness and permanence. This is the only alternative that will comply with all ARARs, including RCRA and TSCA closure requirements.

6.9.1 Overall Protection of Human Health and the Environment

The cleanup objectives for source area soils are to 1) prevent direct human contact with source area soils that contain contamination above ARARs and EPA's recommended residential level for dioxin and 2) prevent leaching or migration of contaminants in vadose zone soils that would result in groundwater contamination in excess of ARARs for leachability. The previously described removal actions and installation of the existing interim caps in three areas at the source area prevent direct human contact to the soils., The No Action alternative would provide no additional overall protection of human health and the environment. Because this alternative does not include any long-term monitoring, it would not be possible to determine or evaluate the risks of future exposure.

Alternative 3 (Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment) would provide a higher level of protection compared to the No Action alternative and Alternative 4 (Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment) would provide a higher level of protection when compared to Alternative 3. Both types of caps would be very effective at preventing human contact with the contaminated source area soil, and with proper monitoring and maintenance, these types of caps are stable and reliable in the long term.

Alternative 4 would provide the highest level of overall protection to human health and the environment. This is the only alternative that would comply with RCRA closure requirements and eliminate precipitation infiltration to the caps and in areas where soil or groundwater contains VOCs above the ARARs for GB leachability and groundwater quality.

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6.9.2 Compliance with ARARs

The No Action alternative will not comply with ARARs. Among the alternatives evaluated, only Alternative 4 will comply with all ARARs, including RCRA Subtitle C requirements for closure. The RCRA cap would also comply with TSCA regulations and would prevent exposure to PCB-contaminated waste as long as the caps are maintained. Alternative 3 would comply with all ARARs except requirements for RCRA closure; these requirements would not be met without a waiver.

Alternatives 3 and 4 would require the filling of wetlands. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Both alternatives would result in a permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting any of these options as the preferred remedy.

6.9.3 Long-Term Effectiveness and Permanence

For Alternative 1, No Action, the residual risk remains high and there are no ICs to prevent exposure or actions required to maintain the controls currently in place. Although the inherent hazard remains under Alternatives 3 and 4, there are ICs to prevent exposure and actions required to maintain the controls would be included as part of these alternatives. These controls are only effective if adequately monitored and enforced. Among the alternatives, Alternative 4 would provide the highest long-term effectiveness and permanence because the RCRA/TSCA caps would provide reliable chemical isolation and would be designed, constructed and maintained in compliance with RCRA and TSCA closure requirements.

6.9.4 Reduction of Toxicity, Mobility or Volume through Treatment

Alternative 3e would require the greatest reduction of toxicity, mobility and volume through treatment, followed by Alternative 4e. The caps under Alternatives 3 and 4 would reduce the mobility of the contaminated soil, although not through treatment. The No Action (Alternative 1) would not provide any treatment or reduction in mobility, toxicity or volume.

6.9.5 Short-Term Effectiveness

Alternative 1 would have fewer short-term impacts on the community, the environment and workers compared to Alternatives 3 and 4 because no construction activities would be performed for Alternative 1 and there would be little disruption to the residents of Centredale Manor, Brook Village, or the nearby community.

Alternatives 3 and 4 could be accomplished using routine construction methods and asphalt paving could be performed using the materials and equipment typically used for routine road construction. However, both alternatives would involve some disruption to the local residents, as well as exposure of workers to contamination during excavation activities. Appropriate health and safety measures would be used to protect workers. The total time for on-site construction of Alternative 3 would be about 3 months and the construction time for Alternative 4 would be about 8 months. Although construction activities would be conducted during regular business hours, there would be an increase in the volume of traffic and noise in the immediate vicinity of the site.

6.9.6 Implementability

The No Action alternative would not require any action to be taken at the site and therefore does not present any implementability issues.

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Although the construction work for Alternatives 3 and 4 would be routine, implementation at this site would be more difficult because the remediation area is in close proximity to apartment buildings with a sensitive population and there is limited space available for material stockpiles, equipment storage and efficient work operations. In addition, both of these alternatives would result in the filling of wetlands and the permanent occupancy and modification of the floodplain. Impacts to wetlands and floodplains would need to be minimized to the extent possible and mitigation for unavoidable floodplain/wetland impacts would be required, as well as replacement of flood storage capacity.

Alternative 4 is comparatively more difficult to implement compared to Alternative 3 because construction activities would be more extensive, especially in the parking areas with respect to placing the RCRA cap and installing a clean utility corridor.

6.9.7 Cost

The costs for the Source Area soil alternatives are presented in Table 6-37. Present worth costs for No Action (Alternative 1) is $170,000. Present worth costs for the action-based alternatives range from $19,600,000 for targeted excavation with the cap upgrade (Alternative 3e) to $21,300,000 for targeted excavation with the RCRA cap upgrade (Alternative 4e).

6.10 Detailed Evaluation of Source Area Groundwater Alternatives

The three Source Area groundwater alternatives retained from the screening analysis are described further in this section and are evaluated against the NCP criteria (excluding State and Community Acceptance, which are considered after comments to the FS and Proposed Plan are received). All alternatives include five-year reviews. The groundwater action area is located along the bank of the Woonasquatucket River (Figure 3-6) and includes riverbank wetland resource areas (Section 2.3.10). Because some soil contamination is located in wetland areas, there is no practical alternative to destruction of these wetlands.

Source Area Groundwater Alternatives Retained for Detailed Analysis

1	No Action
2	Excavation/Dewatering
5	In-Situ Chemical Oxidation

A leachability evaluation (Battelle, 2004c) indicated that leaching of contaminants from soil to groundwater does not appear to be a major pathway of concern at the source area, except at the Brook Village parking lot where concentrations of PCE and TCE in the groundwater were one to two orders of magnitude above the RIDEM GB groundwater objectives. High concentrations of dioxin (2,3,7,8-TCDD) were also measured in groundwater at this location, and a plume of VOC-contaminated groundwater is discharging to the river within 30-ft of this location. Supplemental groundwater investigations demonstrated that the groundwater plume is likely an ongoing source or migration pathway of dioxin (2,3,7,8-TCDD) from the source area to the Woonasquatucket River (Section 2.4.3.2). Hence, the cleanup objectives for source area groundwater focus on preventing migration and discharge of contaminated groundwater into the Woonasquatucket River, and reducing groundwater contamination so that ARARs (i.e., RIDEM GB groundwater objectives) are met.

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6.10.1 Alternative 1: No Action

6.10.1.1 Description of No Action

In accordance with the NCP requirements, the No Action alternative must be carried through the entire FS process, and is used as a basis of comparison to the other alternatives. This alternative would entail no active remediation of the contaminated groundwater. Five-year reviews and periodic monitoring (conducted in conjunction with source area soils), triggered by severe weather events, are incorporated into this alternative. For cost estimating, it is assumed that there would be one groundwater monitoring event and report to EPA every five years. Monitored natural attenuation processes, ICs, and rigorous long-term monitoring are not components of this alternative.

6.10.1.2 Evaluation of No Action

Results from the evaluation of Alternative 1, No Action against the NCP criteria are discussed below and summarized in Table 6-38.

Overall Protection of Human Health and the Environment

Alternative 1, No Action would not provide any overall protection of human health and the environment. Contaminants already within the saturated zone are above cleanup goals and no action would be taken to remove the contamination or prevent migration of contaminated groundwater to the Woonasquatucket River.

Compliance with ARARs

ARARs specific to Alternative 1, No Action are summarized in Table 6-39. This alternative would not comply with the ARARs for groundwater and surface water quality. Concentrations of PCE and TCE remain above RIDEM GB groundwater objectives and discharges of dioxin from the site could continue to degrade the Woonasquatucket River.

Long-Term Effectiveness and Permanence

The residual risk remains high under this alternative as no action is taken to address the contamination and the existing dioxins in the groundwater are resistant to natural biodegradation and would likely continue to migrate to the Woonasquatucket River. There are no actions required to adequately and reliably control the contamination that remains in place.

Reduction of Toxicity, Mobility or Volume through Treatment

There would not be a reduction of toxicity, mobility or volume of contamination through groundwater treatment under this alternative. Groundwater concentrations might be naturally attenuated over time, but without rigorous long-term monitoring it would not be possible to measure this reduction.

Short-Term Effectiveness

This alternative has no short-term impacts on the community, the environment or workers because there would not be any construction or intrusive work required under this alternative.

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Implementability

The No Action alternative does not present any implementability issues as no actions are required under this alternative.

Cost

The detailed cost evaluation for Alternative 1, No Action is presented in Appendix J. The capital, operation and monitoring, and present worth costs of this alternative are listed below:

Capital cost and baseline monitoring	$0
Annual cost for years 1 to 30	$22,000
Present worth costs	$270,000

6.10.2 Alternative 2: Excavation/Dewatering

6.10.2.1 Description of Excavation/Dewatering

Removing the source of pollution is one of the most effective means to reduce long-term impacts on groundwater. In this remedial alternative, groundwater within the proposed cleanup area (Figure 3-6) would be lowered through pumping, steel shoring will be installed along the eastern bank of the Woonasquatucket River, and exposed soil would be excavated using conventional earthwork equipment to a pre-determined depth. Additional dewatering within the excavation would continue for several weeks. The soils would be stockpiled, characterized, and transported off site for disposal and/or treatment, as discussed in the excavation alternative for source area soil (Alternative 3e, Section 6.8.2). The excavation area would be backfilled with clean soil and the site restored. It is estimated that this alternative would take approximately four weeks to implement.

The health and safety of residents would be protected during construction. This is especially important for the source area because the residents in the Brook Village and Centredale Manor apartment buildings, located at the source area are mostly elderly. Elderly populations are typically more sensitive to contaminants in the air and soil and to uncontaminated dust and chemicals used in standard construction.

Additional steps would be taken so that the work was performed in a manner that would protect the health and safety of the residents and would protect the existing facilities from contamination. All work would be coordinated with management of Brook Village and Centredale Manor to provide continuous access to the residents, building service providers, and to the facilities. The remedial action work plans, which would be submitted to EPA and the state before construction, would include a traffic control plan, a contamination migration control plan and a resident health and safety plan. These plans would describe measures that would be implemented to provide continuous access, protect existing property and protect resident's health and safety during construction. The management of Brook Village and Centredale Manor would be contacted during the preparation of these plans to facilitate coordination and obtain their input into the procedures. After approval by EPA, these plans would be provided to the residential facilities management.

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Excavation

In this alternative, long-term impacts on groundwater and the Woonasquatucket River would be effectively reduced by excavating vadose-zone and saturated soils in the vicinity of MW-05S that contain contamination impacting groundwater. This in turn will reduce the groundwater impact to the Woonasquatucket River. Excavation would target the VOC and dioxin-impacted areas at the west side of the Brook Village parking lot (see Section 3.5.6, Figure 3-6). The impacted area is approximately 0.13 acres and extends along approximately 100 ft of the eastern river bank (Figure 3-6). The vertical extent of the cleanup area ranges from an estimated 89 ft to 96 ft mean sea level (MSL), which encompasses the expected depth of contaminated soils that appear to be serving as contaminant sources to groundwater (Appendix G, Figures G-6, G-7, and G-8). Dioxin concentrations below these excavation depths appear to be below the cleanup goals.

This alternative assumes that the excavation area extends to the river, and that shoring in conjunction with pumping would be required to prevent surface water from entering the excavation area. This approach would result in a total excavation volume of approximately 1,300 cy of soil (or 2,000 tons), which would remove the contaminated soils that are serving as contaminant sources to groundwater. Post-construction monitoring would be performed to evaluate groundwater quality at the groundwater action area.

Dewatering

With groundwater at 1 to 3 ft bgs, dewatering would be required throughout the excavation process. The dewatering, in addition to facilitating the removal of saturated soils, would allow removal of contaminated groundwater. Dewatering would require the use of electrical pumps. Extracted groundwater would be temporarily stored in tanks until treated and discharged. Based on analysis of available site data, the anticipated extraction rate from the area near MW-05S is 1 gpm. Assuming that dewatering takes place over the course of 28 days and providing a safety factor of 2, an estimated 80,000 gallons would be generated. Dewatering fluids removed from within the soil excavation area during the course of excavation would either be transported and disposed off site or treated on site and discharged to the river. For costing purposes, on-site treatment and discharge was assumed using a treatment system consisting of the following components: an oil/water separator, a fractionation tank, bag filters, advanced filtration system to remove dioxins, and granular activated carbon filters.

Overall, it is estimated that soil/groundwater removal and dewatering would take approximately 4 to 5 weeks, based on a production rate of 50 to 60 cy/d.

Construction Monitoring

During all construction, work would be limited to normal work hours. During earthwork construction, dust and noise would be controlled to protect health of the residences of the two on-site buildings, which include sensitive populations, and surrounding neighborhoods. Air and noise monitoring and abatement would be performed to ensure that the residents were not exposed to unsafe levels of particulates or volatiles in the air or unsafe noise levels. Dust and erosion controls may include actions such as applying water to keep the soil moist, covering exposed soil with straw or natural fiber mats, covering soil stockpiles with fabric, or installing silt fences around the perimeter of the site. Noise controls may include feature such as mufflers on all equipment, or enclosing generators and air compressors in sound reduction enclosures. Treated groundwater would be tested on a regular basis to confirm that chemical concentrations were at levels acceptable for return to the surface water in accordance with ARAR requirements.

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Long-Term Monitoring and Institutional Controls

This alternative includes periodic monitoring (Appendix H) to support five-year reviews and ICs to prevent the use of groundwater.

Off-Site Disposal and/or Treatment

Target excavation concentrations for PCE, TCE, and 2,3,7,8-TCDD are near or above the UTS identified in 40 CFR 268.48. Based on the site history and concentrations of contaminants, it is assumed that the excavated soils would be designated as hazardous waste and would be subject to LDRs. Excavated soils that contain underlying hazardous constituents less than 10 times the UTS would be taken to a licensed hazardous waste landfill for disposal. Dewatered soil that contains underlying hazardous constituents more than 10 times the UTS, would be taken to an off-site incinerator. Based on limited site data, the costs assume that 80% of the soils would be taken to an off-site hazardous waste landfill and that 20% would be taken to an off-site incinerator for treatment.

6.10.2.2 Evaluation of Excavation/Dewatering

Results from the evaluation of Alternative 2, Excavation/Dewatering against the NCP criteria are discussed below and summarized in Table 6-40.

Overall Protection of Human Health and the Environment

Alternative 2, Excavation/Dewatering would provide high overall protection and would achieve the cleanup objectives by removing the contaminant source from soil and groundwater, which in turn would reduce PCE and TCE concentrations in groundwater to levels that meet the RIDEM GB groundwater objectives and prevent future migration of contaminated groundwater towards the Woonasquatucket River.

Compliance with ARARs

ARARs specific to Alternative 2 are summarized in Table 6-41. This alternative is expected to comply with ARARs for groundwater and surface water quality. Excavation, dewatering, and placement of the sheet pile wall as a permanent structure in the river would trigger Clean Water Act Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. Excavation could result in the destruction of some riverbank wetland resource areas and state wetlands requirements will need to be addressed.

Long-Term Effectiveness and Permanence

Excavation would be highly effective in the long term because the residual risk is very low as contaminated source area soils and groundwater would be permanently removed from the impacted area. This would achieve the cleanup objectives by reducing the mass of contaminants of interest (PCE, TCE, and dioxins) from migrating toward the river. The long-term effectiveness of this alternative would rely on ICs to prevent the use of groundwater. These controls are only effective if adequately monitored and enforced.

Reduction of Toxicity, Mobility or Volume through Treatment

This alternative will reduce toxicity, mobility or volume of contamination through treatment as at least a portion of the excavated material will require treatment prior to disposal.

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Short-Term Effectiveness

There are some short-term impacts to the community under this alternative. There is the potential for exposure to contaminated soils during excavation, stockpiling and loading of contaminated soils. However, standard safety measures would be put in place to reduce the risk of exposure. Worker and resident health would be protected by dust and erosion control. Potentially contaminated soil would be transported in covered trucks, and trucks would be cleaned to prevent contaminated soil from being deposited within the site. ECs and personal protection equipment would be used to meet worker safety regulations. Air and noise monitoring and abatement would be performed to ensure that the residents are not exposed to unsafe levels of particulates or volatiles in the air or unsafe noise levels. In addition, because of the location of this work in parking lots used by the residents, a plan would need to be implemented to ensure that there is minimal disruption to those using the parking lots.

The RAOs would be achieved at completion of the construction activities, which are estimated to take approximately one month.

Implementability

The equipment and expertise required to excavate the soil and dewater the excavation would be readily available from commercial vendors and is a highly reliable means for addressing this type of contamination. Earth moving equipment is readily available, as is the pumping equipment required to lower the groundwater. Excavation near the river and below the groundwater presents an added degree of difficulty, as shoring and dewatering are required. Sufficient capacity exists for off-site treatment and disposal.

As stated above, work would be limited to normal business hours Monday through Friday. The contractors would develop a traffic control plan and coordinate with the management of Brook Village and Centredale Manor to provide continuous access to residents and building service providers

Impacts to riverbank wetland resource areas would need to be minimized consistent with federal and state requirements.

Cost

The detailed cost evaluation for Alternative 2, Excavation/Dewatering is presented in Appendix J. The capital, operation and monitoring, and present worth costs of this alternative are listed below:

Capital cost and baseline monitoring	$2,700,000
Annual cost for years 1 to 30	$24,000
Present worth costs	$3,000,000

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6.10.3 Alternative 5: In-Situ Chemical Oxidation

6.10.3.1 Description of In-Situ Chemical Oxidation

As described in Section 5.5.7, in-situ chemical oxidation would involve the injection of an oxidizing agent such as ozone, hydrogen peroxide, or persulfate into the groundwater in the vicinity of Well MW-05S. The oxidizing agent would cause the rapid chemical destruction of the PCE and TCE in the groundwater, and possibly dioxins.

The oxidation technology proposed for the CMRP site is hydrogen peroxide added using the Cool-Ox™ process. Modified Fenton's reagent and persulfate processes could also be considered. The Cool-Ox™ process injects an aqueous suspension of solid peroxygen compounds that slowly hydrolyze in-situ to generate hydrogen peroxide. This process does not release known free radical sinks such as carbonates. Unlike Fenton's reagent, this process does not generate heat. Also, the relative insolubility of the solid peroxygen compounds allows the oxidizers to be produced over an extended period of time.

Unlike Fenton's reactions that require a low acidic pH, the optimum pH of the Cool-Ox™ process is approximately pH 8. This allows the hydrogen peroxide to more easily oxidize a variety of contaminants including phenolic, chloro-phenolic, and chlorinated organic compounds (including dioxins) that become increasingly soluble in aqueous solutions as the pH is increased. The effective oxidation of phenols and dioxins was demonstrated in a recent field study using this process (Lundy, 2005). Field studies using persulfate to treat dioxins are in progress at a Kalispell, Montana site (Trihydro, 2009). Soil mixing can be performed to maximize treatment effectiveness.

Pre-Construction Activities

Treatability testing would be conducted prior to full-scale implementation to evaluate the soil oxidant demand, optimize oxidant type and injection concentrations, and to evaluate the need for soil mixing. Toxic by-products or intermediates will be monitored during the treatability testing of the in-situ chemical oxidation so as to demonstrate its effectiveness in completely destroying dioxin groundwater contaminants. In addition, confirmation soil sampling would be conducted during design to confirm spatial and vertical extent of the impacted area. For the purposes of this FS, the area to be treated is estimated as 50 ft by 100 ft and up to 12 ft deep.

Construction Activities

The solid peroxygen compounds would be injected using a direct-push technology rig at approximately 5-foot spacings. This alternative would not yield contaminated material that would require disposal. The construction time for this alternative would be approximately four weeks.

Construction Monitoring

Soil and groundwater monitoring will be performed during construction activities to measure the removal of VOCs and dioxin in groundwater and soil at the impacted area.

Long-Term Monitoring and Institutional Controls

A conceptual long-term monitoring approach is presented in Appendix H. Chemical oxidation would significantly reduce PCE and TCE concentrations in groundwater at the site and would prevent the migration of dioxins to the river. However, periodic monitoring would be conducted to evaluate the effectiveness of the remedy, and to support the five-year reviews. ICs may be required to prevent

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exposure to groundwater as a result of excavation, demolition, or other activities; ICs would also be required to prevent the use of groundwater.

6.10.3.2 Evaluation of In-Situ Chemical Oxidation

Results from the evaluation of Alternative 5, In-Situ Chemical Oxidation against the NCP criteria are discussed below and summarized in Table 6-42.

Overall Protection of Human Health and the Environment

Alternative 5, In-Situ Chemical Oxidation would provide moderate overall protection of human health and the environment as concentrations of PCE and TCE would probably be reduced near or below the RIDEM GB groundwater objectives and removing the contaminant source from source area soil and groundwater would reduce or eliminate future migration of dioxins towards the Woonasquatucket River.

Compliance with ARARs

ARARs specific to Alternative 5 are summarized in Table 6-43. This alternative will probably comply with ARARs for groundwater quality. This alternative may not comply with ARARs for surface water quality because the technology is unproven with respect to destruction of low-level dioxin contamination. A non-CERCLA waiver may be required if underground injections of chemical oxidants occur within 50 ft of a river. State wetlands requirements would have to be evaluated for compliance.

Monitoring wells would be installed and monitored between the application area and the Woonasquatucket River to ensure that application chemicals do not impact the surface water.

Long-Term Effectiveness and Permanence

In-situ chemical oxidation would effectively destroy chlorinated solvents and possibly dioxins. Bench-scale and pilot testing would be required to confirm the effectiveness for dioxins and site-specific conditions. Risk reduction could be high although there is some uncertainty regarding the technology. The alternative depends on the ability of the reagent to contact and react with the dioxin and solvents. Soil mixing during application would increase contact. Follow-on treatments would be applied if rebound in contamination levels was observed

Periodic monitoring of groundwater will be conducted to assess the efficacy of the remedy. ICs would be required to prevent the exposure to groundwater as a result of excavation, demolition, or other activities. ICs restricting future site groundwater use would also be required. However, these controls are only effective if adequately monitored and enforced.

Reduction of Toxicity, Mobility or Volume through Treatment

This alternative would reduce the toxicity, mobility, and volume of PCE, TCE and dioxin through chemical treatment.

Short-Term Effectiveness

There would be limited short-term impacts to the local community during remedy implementation because the remediation activities would be confined to a very small area at the Brook Village parking lot and smaller, mobile equipment would be used. Workers would implement appropriate engineering controls and use personal protection equipment to ensure safety.

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Short-term impacts to habitat are a concern due to oxidation within 50 feet of the river, though these impacts would likely be minimized through the use of a fast-acting reagent focused on in-situ application within areas of groundwater contamination. The reactants also would not generate subsurface heat.

The RAOs are expected to be achieved immediately upon completion of construction activities, which are estimated to take approximately one month.

Implementability

There are some implementability issues that would need to be addressed under this alternative. Obtaining the specialized equipment and an experienced crew may require mobilization from outside the region, but such equipment and staff are commercially available. The space required for the mobile equipment is the equivalent of several parking spaces, so there would be minimal impact on residents.

There is some question regarding the reliability of this technology to reduce contaminant concentrations to cleanup goals although follow-on treatments could be applied. There are limited case studies supporting the effectiveness of this technology with respect to dioxins. Bench-scale testing and a field demonstration with adequate monitoring may be desired to confirm the safety and effectiveness of the in-situ chemical oxidation alternative. Monitoring along the river is a key component of this alternative to ensure that application chemicals do not impact the surface water. In addition, a non-CERCLA waiver may be required if chemical oxidants are injected within 50 ft of a river. Impacts to riverbank wetland resource areas would need to be addressed consistent with federal and state requirements.

Cost

The detailed cost evaluation for Alternative 5, In-Situ Chemical Oxidation is presented in Appendix J. The capital, operation and monitoring, and present worth costs of this alternative are listed below:

Capital cost and baseline monitoring	$880,000
Annual cost for years 1 to 30	$27,000
Present worth costs	$1,200,000

6.11 Comparative Analysis of the Source Area Groundwater Alternatives

The three alternatives for source area groundwater (Alternative 1, No Action; Alternative 2, Excavation/Dewatering; and Alternative 5, In-Situ Chemical Oxidation) are compared below to better understand the key tradeoffs among the alternatives. Overall, among all the alternatives evaluated, the excavation/dewatering alternative (Alternative 2) would provide the highest level of both protection to human health and the environment and long-term effectiveness and permanence.

6.11.1 Overall Protection of Human Health and the Environment

The source area groundwater alternatives would protect human health and the environment as follows.

- Alternative 1, No Action, offers no overall protection of human health and the environment, as this alternative does not remove or prevent migration of PCE, TCE, and dioxin at the impacted area.
- Alternative 2, Excavation/Dewatering, provides the highest overall protection because PCE, TCE, and dioxin in soil and groundwater are permanently removed from the impacted area although there is some short-term disruption to the community.

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- Alternative 5, In-Situ Chemical Oxidation, appears promising in its ability to reduce both the toxicity and volume of PCE, TCE, and dioxins in groundwater, and migration of these contaminants into the Woonasquatucket River, though there are limited case studies supporting the effectiveness with respect to dioxins. Although this alternative will clearly reduce contaminant concentrations, it is unclear if it will meet cleanup levels. As a result, this alternative provides some overall protection of human health and the environment.

6.11.2 Compliance with ARARs

Among the alternatives evaluated, only Alternative 2, Excavation/Dewatering, would clearly comply with ARARs. Alternative 1, No Action, does not comply with ARARs for groundwater and surface water quality. Alternative 5, In-Situ Chemical Oxidation, may not comply with ARARs for surface water quality and a non-CERCLA waiver may be required if chemical oxidants are injected within 50 ft of a river.

6.11.3 Long-Term Effectiveness and Permanence

Alternative 1, No Action, offers the least long-term effectiveness, as PCE, TCE, and dioxins are left in place at the impacted area, and no action would be taken to contain or remove the contamination or prevent the migration of contamination to the river. As a result, the residual risk remains high and there are no adequate or reliable controls in place to otherwise address the contamination.
Alternative 2, Excavation/Dewatering, generally has a high degree of long-term effectiveness and permanence, as PCE, TCE, and dioxins in groundwater and soil are removed from the impacted area. As a result, the residual risk is very low.

The long-term effectiveness of Alternative 5, In-Situ Chemical Oxidation, depends on the success of the chemical delivery and ability to contact contaminants. Also, the effectiveness depends on the ability of the reagents to oxidize dioxins, which limited studies indicate will occur. Bench-scale and pilot studies will be needed prior to implementation to confirm effectiveness for dioxins and site-specific conditions. In addition, sufficient characterization and monitoring data will need to be obtained to ensure adequate destruction.

6.11.4 Reduction of Toxicity, Mobility or Volume through Treatment

Among the alternatives evaluated, Alternative 2 Excavation/Dewatering, and Alternative 5, In-Situ Chemical Oxidation, would reduce the toxicity, mobility and volume of contamination through treatment.

6.11.5 Short-Term Effectiveness

Of the active source area groundwater alternatives, Alternative 5, In-Situ Chemical Oxidation, has the fewest short-term impacts, as follows:

- There are no short-term impacts to the community, workers or the environment under Alternative 1, No Action, because it does not involve construction. However, contaminated groundwater would continue to migrate to the Woonasquatucket River and impact surface water quality.
- Alternative 2, Excavation/Dewatering, has some short-term impacts to the community during the construction phase because excavation would occur in close proximity to the Brook Village apartment building and some disruption to residents' activities is expected.

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- Alternative 5, In-Situ Chemical Oxidation, has fewer impacts on the community as it uses a mobile, small rig that treats PCE, TCE, and dioxin in-situ, and therefore has much fewer impacts than Alternative 2 to residents.

Neither Alternative 2 nor Alternative 5 has any significant short-term impacts to workers or the environment.

6.11.6 Implementability

Alternative 1 No Action, would not present any implementability issues. Alternatives 2 and 5 would each have limited implementability issues. Alternative 2 (Excavation/Dewatering) would require specialized experience and equipment for working near the river. Alternative 5 (In-Situ Chemical Oxidation) may require mobilization from outside the region, and a non-CERCLA waiver may be required if chemical oxidants are injected within 50 ft of a river. Impacts to riverbank wetland resource areas would need to be minimized and wetlands mitigation may be required under Alternatives 2 and 5.

6.11.7 Cost

The total present worth costs for No Action (Alternative 1) is $270,000. Present worth costs for the action-based alternatives range from $1,200,000 for in-situ chemical oxidation (Alternative 5) to $3,000,000 for excavation/dewatering (Alternative 2).

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7.0 SUMMARY AND CONCLUSIONS

This FS was prepared to develop and evaluate suitable and appropriate remedial alternatives to address contaminated sediment, soil and groundwater at the CMRP site located in North Providence, Rhode Island. The primary objectives of the FS are to identify the contaminants in sediment, soil, and groundwater that present a risk to human health and the environment; develop RAOs (cleanup objectives), identify potential ARARs and TBCs, and develop cleanup goals; identify areas at the CMRP site that require remedial action; select appropriate remediation technologies that would be effective at the site; and develop remedial alternatives to address contamination, including estimates of anticipated costs, that would achieve the RAOs.

Contaminants that Present Risk at the CMRP Site

Remedial investigations have been conducted to characterize the nature and extent of contamination, better understand contaminant fate and transport processes, and develop appropriate human health and ecological risk assessments. Conclusions from these investigations were integrated into a CSM for the site. These investigation activities have previously been described in detail during the RI phase, and are summarized in this FS. Overall, the greatest risks at the CMRP site are associated with consumption of contaminated fish or prey, and direct contact with contaminated sediment and floodplain soil. Contaminants include dioxin, PCBs, pesticides, SVOCs, metals, and VOCs.

RAOs, ARARs and Cleanup Goals

The RAOs were developed to protect human and ecological receptors from potential adverse effects associated with ingestion of or contact with contaminants, as well as to minimize potential migration of contaminants to protect groundwater quality and the surface water of the Woonasquatucket River. ARARs and TBCs that would be pertinent to the remediation at the CMRP site were identified, and include local, state, and federal action-specific, chemical-specific, and location-specific laws, regulations, and guidance. Cleanup goals were developed based on an evaluation of risk-based PRGs (for the most sensitive receptor or exposure pathway), potential ARARs and TBCs, and site background data. Where a risk-based PRG and ARAR or TBC was available for the same contaminant, the lower, more protective value was used in the cleanup goal determination. In general, the cleanup goals are based on the risk-based PRG (and/or ARAR/TBC) or background, whichever is higher because it is not possible to clean up below background. Overall, proposed cleanup goals are frequently based on background for sediment and floodplain soil, and on ARARs for source area soil and groundwater.

Proposed Cleanup Areas and Volumes for the CMRP Site

Action Area/Media	Cleanup Area		In-Situ Removal Volume (cy)
	(sq ft)	(acre)	
Allendale Reach/Sediment	673,600	15.5	48,200
Lyman Mill Reach/Sediment	1,022,000	23.5	91,000
Allendale Reach/ Floodplain Soil	64,600	1.5	2,400
Lyman Mill Reach/Stream Sediment and Floodplain Soil	940,000	21.6	34,800
Source Area/Soil	339,500	7.8	62,900
Source Area/ Groundwater	5,500	0.13	1,300

Areas at the Site that Require Remedial Action

Based on the extent of contaminant concentrations exceeding cleanup goals in sediment, soil, and groundwater at the CMRP site, the following areas and volumes were evaluated for remediation:

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Screening of Remedial Alternatives

Alternatives that were evaluated initially in this FS for remediation of contaminated sediment and floodplain soil at the reaches of Allendale and Lyman Mill and contaminated soil and groundwater at the source area are summarized below.

Allendale and Lyman Mill Sediment and Floodplain Soil – Alternatives that were evaluated for remediation of contaminated sediment and floodplain soil include alternatives based on No Action, limited action, MNR, ENR, capping, dredging, and excavation. Sediment alternatives consider leaving the dams in place, removing the dams, or replacing the dams with new weir structures designed to allow fish (including catadromous and anadromous species) to migrate upriver. The dredging and/or excavation alternatives would remove contaminated sediment and floodplain soil to a depth needed to reach the cleanup goals. Hybrid alternatives were also evaluated that use a combination of partial removal with either isolation capping for sediment or ENR (thin cover) for floodplain soil. Under these hybrid alternatives, excavation would be used to remove sediment to a uniform depth from areas of shallow water and high erosion potential or areas with the highest contaminant concentrations or remove floodplain soil from areas that present higher potential for exposure, downstream migration, or risk. Sediment and floodplain soil removed under the excavation alternatives would be contained on site in a CDF, treated on site by thermal treatment, or shipped off site for disposal and/or treatment. An additional disposal option utilizing on-site consolidation and capping was also considered for the sediment partial excavation alternative with the dams replaced.

All of the alternatives except No Action include long-term monitoring to assess recovery and risk reduction, and to assess the impact of the remedial action on the downstream areas. Long-term monitoring, maintenance, and ICs would also be required to prevent exposure to contamination that remains in place or protect the integrity of the thin cover (ENR), isolation cap, or any on-site containment facilities. Maintenance of the Allendale and Lyman Mill Dams (or weir structures) would also be required for alternatives where contamination remains in the river/floodplain. All of the alternatives include periodic reporting of remedy progress and efficacy, as well as five-year reviews.

Source Area Soil – Alternatives evaluated for remediation of source area soil include alternatives based on No Action, maintaining existing surfaces, targeted excavation combined with either upgrading or converting existing surfaces to RCRA caps, and excavation. The maintenance alternative would provide long-term operation and maintenance of the existing surfaces (caps, parking lots, paved surfaces, rip rap, landscape areas) to prevent erosion and potential exposure of contaminated soils. The targeted excavation and cap upgrade alternative would include excavation to remove principal threat waste and contaminated soil that exceeds the TSCA/GB leachability criteria in conjunction with evaluating and repairing the existing surfaces where necessary, and extending the existing caps to cover contaminated landscape areas. The targeted excavation and RCRA cap alternative would include targeted excavation to remove principal threat waste in conjunction with upgrading the existing surfaces (caps, parking lots, paved surfaces, landscape areas) to meet the requirements for caps over unlined hazardous waste landfills in EPA Region 1. The excavation alternative would remove principal threat waste and contaminated soil to a uniform depth (5-feet bgs, average thickness of vadose zone), backfill to restore site grade, and re-vegetate the soil areas. Soil, principal threat waste, and hazardous debris removed under the excavation alternatives would be shipped off site for disposal and/or treatment.

All of the remedial alternatives except No Action would include long-term monitoring and maintenance to verify that contamination left in place remains relatively immobile. ICs would also be required to prevent future releases and potential future human exposure to contaminated soil. The ICs would prohibit future excavation, restrict access for buried utilities, prevent the construction of buildings with pilings or

basements, and require maintenance of the caps, parking lots, paved surfaces, and rip rap areas. All of the alternatives include periodic reporting of remedy progress and efficacy, as well as five-year reviews.

Source Area Groundwater – Alternatives evaluated for remediation of groundwater at the source area include alternatives based on No Action, excavation, hydraulic containment, and in-situ treatment. The excavation/dewatering alternative is a removal alternative that relies on excavation below the groundwater table to remove submerged contaminated soils that serve as a contaminant source to the groundwater and dewatering to remove contaminated groundwater within the excavation area. The hydraulic containment alternatives include options either to install a barrier around the groundwater impacted area to prevent the discharge of contaminated groundwater to the Woonasquatucket River or to provide hydraulic control through pump and treat. Groundwater removed under the excavation alternative or extracted under the pump and treat options would be treated to remove contaminants and returned to the Woonasquatucket River. In-situ treatment alternatives evaluated include biological and chemical treatment. For in-situ biological treatment, a PRB comprised of clean, organic rich material would be installed between the groundwater impacted area and the Woonasquatucket River. The barrier would allow the passive flow of water while either degrading or retaining the contaminants. VOCs would be removed through anerobic dechlorination and biogeochemical processes and dioxin would be removed by sorption to the organic material and biodegradation. For in-situ chemical treatment, an oxidizing agent would be injected into the groundwater at the impacted area that would cause the rapid chemical destruction of the VOCs in the groundwater, and oxidation of dioxins. Feasibility testing would be required to demonstrate the effectiveness of dioxin removal using either of the in-situ treatment alternatives. A field demonstration with adequate monitoring of toxic by-products or intermediates may also be desired to confirm the safety and effectiveness of the in-situ chemical oxidation alternative.

All of the remedial alternatives except No Action would include ICs to prevent the use of groundwater, as well as periodic monitoring to support five-year reviews. The in-situ chemical oxidation alternative would also require ICs to prevent the exposure of groundwater as a result of excavation, demolition, or other activities.

Remedial Alternatives Retained for Detailed Analysis

Alternatives discussed above were screened based upon the screening criteria required by the NCP. With the exception of No Action, alternatives that are not protective of human health and the environment or do not comply with ARARs (except where conditions for an ARAR waiver exist) were screened out. Based on the screening evaluation, the following remedial alternatives were evaluated in more detail, along with the No Action alternative (Alternative 1).

Allendale and Lyman Mill Reach Sediment

- a full excavation alternative with the dams remaining in place (Alternative 7) or with the dams replaced with new weir structures (Alternative 10), and
- a partial excavation and isolation capping alternative with the dams remaining in place (Alternative 8) or with the dams replaced with new weir structures (Alternative 11, water body configuration comprised of river channel and small ponds).

Allendale Reach Floodplain Soil

- a full excavation alternative (Alternative 5).

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Lyman Mill Reach Stream Sediment and Floodplain Soil (Including Oxbow)

- a targeted excavation and ENR alternative (Alternative 3), and
- a partial excavation and ENR alternative (Alternative 5).

Source Area Soil

- a targeted excavation and cap upgrade alternative (Alternative 3), and
- a targeted excavation and RCRA cap alternative (Alternative 4).

Source Area Groundwater

- an excavation and dewatering alternative (Alternative 2), and
- an in-situ treatment alternative using chemical oxidation (Alternative 5).

All of the Allendale and Lyman Mill reach sediment and floodplain soil alternatives include disposal options based on on-site containment in an upland or nearshore CDF, on-site thermal treatment, or off-site disposal and/or treatment. All of the source area soil and groundwater alternatives include disposal options based on off-site disposal and/or treatment.

Comparative Analysis of Alternatives

Overall, the remedial alternatives proposed in the FS would address contaminated sediment, soil, and groundwater that presents a risk to human health and the environment, and would achieve the cleanup objectives at varying levels of effectiveness as described below. The No Action alternative (Alternative 1) would not provide effective protection because contaminated material that presents a risk to human health and the environment would remain on site unaddressed.

- Allendale and Lyman Mill Sediment Alternatives 7 and 10 would provide the greatest overall protection because all sediment above the cleanup goals would be removed from the river/ponds, which would quickly reduce human health and ecological risk to acceptable levels. Alternatives 8 and 11 would also reduce human health and ecological risks, but sediment above the cleanup goals would remain in place under the isolation cap and could be released in the future should catastrophic events occur or if monitoring, maintenance and/or ICs were not effective in the long term. Among the disposal options, on-site thermal treatment (Alternatives 7d, 8d, 10d, or 11d) or off-site disposal and/or treatment (Alternatives 7e, 8e,10e, or 11e) would provide the highest level of long-term effectiveness and permanence because the contaminated sediment would either be destroyed or shipped off site for disposal. Disposal options that use on-site containment in a CDF (Alternatives 7a, 7b, 8a, 8b, 10a, 10b, 11a, and 11b) would also provide very effective long-term protection at costs that are substantially lower than the on-site treatment or off-site disposal and/or treatment options, although under Alternatives 7b, 8b, 10b, and 11b contaminants would remain in the floodplain in CDFs. Contaminated sediment would also remain in the floodplain under Alternative 11f.
- Allendale Reach Floodplain Soil Alternative 5 would remove all soil above the cleanup goals and quickly reduce risk to acceptable levels. Although significantly more expensive than other disposal options, on-site thermal treatment (Alternative 5d) or off-site disposal and/or treatment (Alternative 5e) would provide the highest level of long-term effectiveness and permanence.
- Lyman Mill Reach Stream Sediment and Floodplain Soil Alternatives 3 and 5 would achieve human health objectives quickly through targeted excavation. These alternatives would not provide immediate, complete protection of ecological receptors from exposures to contaminated material, rather, a minimum of several decades may be required to attain the ecological cleanup

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objectives. This delay in achieving the remedial goals for ecological receptors is balanced by the need to preserve the habitat necessary to maintain the receptors to be protected. Alternative 3 would provide a somewhat lower level of ecological protection than Alternative 5 because a smaller volume of contaminated material would be removed from the system. However, it would preserve nearly nine additional acres of a regionally important forested wetland complex that is providing habitat to a variety of plants, invertebrates, and wildlife populations including possibly vernal pool species. Although the time for risk reduction until ecologically-based RAOs are achieved is extended by about 5 years under this alternative compared to Alternative 5, the impacts to wildlife populations from eliminating this valuable hardwood forest habitat outweigh the potential benefits of reducing the risk in a slightly quicker fashion.

- Source Area Soil Alternative 4 would provide the greatest overall protection because principal threat waste that could be highly toxic or highly mobile would be removed and all existing surfaces would be upgraded to RCRA caps, which would effectively isolate the contamination that remains in place and comply with all ARARs, including RCRA and TSCA closure requirements. Alternative 3 would also provide effective protection of human health and the environment, although the upgraded caps under this alternative would not comply with RCRA closure requirements or eliminate rainwater/snowmelt infiltration into the underlying soil and groundwater.
- Source Area Groundwater Alternative 2 would provide the greatest overall protection because the contaminant source would be removed, which would reduce contamination in groundwater to acceptable levels, as well as prevent future migration of contaminated groundwater to the Woonasquatucket River. This is the only alternative that will comply with all ARARs. Alternative 5 would provide some overall protection of human health and the environment, but the long-term effectiveness with respect to dioxin removal is unproven and it might not comply with ARARs for surface water quality.

All of the sediment and soil alternatives constitute a discharge of dredged or fill material into the waters of the state/US, thereby triggering state and federal wetlands requirements that would have to be addressed. Moreover, because contamination is found above cleanup goals in wetland areas, there is no practical alternative to the destruction of wetland areas. As a result, actions would need to be taken to minimize impacts and EPA would need to evaluate alternatives to select the least damaging practicable alternative consistent with Clean Water Act requirements.

Uncertainties

Important uncertainties associated with this FS are summarized below, and the potential effects of the uncertainties on the FS conclusions are described. Once selected, following the public comment period, the remedy for the site will be documented in a ROD, and will be further developed through a detailed design to address these uncertainties.

- Cleanup Goals – Additional sampling and analysis will be needed during the remedial design to verify the proposed cleanup goals. Specifically, additional background sampling is required to verify background conditions at the time of site remediation and the statistical comparisons, and assess impacts, if any, to the proposed cleanup goals for floodplain soil, sediment and surface water. Additional sampling and analysis is also required to verify that "undetected" contaminants are not present in site soil and surface water at concentrations in excess of ARARs or TBCs (see Appendix F); the analytical methods must be capable of measuring contaminants at concentrations below the ARARs and TBCs.
- Cleanup Areas – The proposed cleanup areas or remedial footprints are conceptual and more precise cleanup footprints will be developed during the remedial design. For example,

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additional coring will need to be performed at Allendale and Lyman Mill Ponds to confirm the vertical extent of the contamination. Additional sampling and analysis will also be needed to confirm the horizontal and vertical extent of the remedial footprints for Allendale and Lyman Mill reach floodplain soils. Additional investigations should also be considered to confirm the presence of vernal pool habitat within the current remediation footprint for the Oxbow.

- Disposal Options – The off-site disposal and/or treatment options evaluated in this FS are based on the assumption that contaminated media at the CMRP site is an F-listed waste or characteristic waste, and that approximately 50% of the sediment waste could require incineration to meet treatment standards listed in 40 CFR §268.40 and all of the floodplain soils would meet the LDR alternative treatment standards for soil in 40 CFR §268.49. (Excavated sediment and soil would be characterized for waste-disposal requirements, including hazardous waste criteria, and handled and disposed appropriately.)

  The on-site upland CDF disposal option evaluated in this FS assumes that a treatability variance will be obtained to reduce the amount of treatment required before disposal of sediment waste in the upland CDF, and that 10% of the sediment waste would be shipped off site for treatment. The on-site nearshore CDF disposal option assumes that all waste can be addressed without treatment, regardless of its characterization or contaminant concentrations, if such waste is consolidated or treated in-situ within an "area of contamination." On-site disposal costs could increase if the treatability variance is not obtained under the upland CDF option or if the nearshore CDF is not located within the area of contamination and some of the material needs to be shipped off site for incineration to meet LDRs.

  Potential changes to waste disposal regulations or location of a potential on-site disposal facility, that could impact the cost estimates will be assessed during the remedial design phase.

  In the event that the selected remedy includes on-site containment in an upland CDF, potential upland CDF locations should be evaluated with respect to acquisition potential and environmental services (wetlands or other valued habitat attributes) that could be lost or degraded if the land was converted to a containment structure.

- Sediment Processing – In the event that a sediment alternative is selected that includes mechanical dewatering, additional bench-scale testing using site sediment is recommended to evaluate the effectiveness of the plate and frame filter press and belt press process options.

- Source Area Groundwater – In the event that Alternative 5, In-situ Chemical Oxidation is selected as the preferred remedy, bench-scale and pilot testing would be required to confirm the effectiveness of this response action to capture, degrade, or destroy low-concentration dioxins and eliminate their potential migration within the groundwater. A field demonstration with adequate monitoring of toxic by-products or intermediates may be desired to confirm the safety and effectiveness of this response action.

- Mitigation –The action-based alternatives for sediment and soil will result in unavoidable wetland loss and/or impacts requiring mitigative measures. In some areas federal/state resource determinations and/or functional assessments would be necessary to quantify the amount of required mitigation. In addition, in-place mitigation may not feasible or sufficient to fully compensate for the projected impacts in many cases (e.g., nearshore CDFs) and it is assumed that appropriate land could be acquired to address this project need. (Estimated costs for out-of-kind mitigation included under the sediment alternatives assume soil removed in support of the mitigation has low-level contamination.) Finally, the successful restoration

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of wetlands and particularly forested habitats depends on a number of factors that interact in ways that cannot be fully understood beforehand. As a result, there are considerable uncertainties regarding the outcome of the mitigation efforts, whether the lost functional attributes can be fully replaced and if so, the length of time required to reach this goal.

For sediment Alternative 11 (Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment), additional out-of-place mitigation and vegetation maintenance may be required if it is determined that uncontrolled growth of vegetation in some portion of the new floodplain area would pose an unacceptable risk of future exposure. If this finding is made, the resulting habitat would likely be incapable of fully compensating for the lost (aquatic) habitat that currently exists.

Mitigation measures to replace floodplain storage capacity that could be lost under selected alternatives would also be evaluated during design. For example, excavation and backfill volumes will need to be evaluated during design to ensure no net loss of flood storage capacity from placement of the thin-layer cover in wetland/floodplain areas under the Lyman Mill reach stream sediment and floodplain soil alternatives.

- Consistent with EPA's risk management principals, contamination at the CMRP site has been and will continue to be addressed in an iterative fashion. This FS evaluated a range of remedial alternatives for contaminated sediment at the Allendale and Lyman Mill reaches of the Woonasquatucket River. It is anticipated that an adaptive management approach will be used in the assessment of the downgradient reaches of the river. The collection and evaluation of monitoring data following implementation of the selected upstream sediment remedy will help determine whether downgradient conditions are improving following control of upgradient sources.

Next Steps

The remedy considered most appropriate to achieve the cleanup objectives will ultimately be selected by EPA in close coordination with the State of Rhode Island. The remedy is subject to review by the EPA National Remedy Review Board. The proposed remedy for the site will be described in a Proposed Plan, which will be available for review and comment by the public. After consideration of public comments, the remedy selection decision will be documented in a ROD.

Following collection of additional baseline data and implementation of the selected remedy itself, the long-term monitoring plan will be executed to assess overall performance. Using an adaptive management approach, information from the monitoring plan and review process will be evaluated to determine whether potential down river contamination concerns may also need to be addressed.

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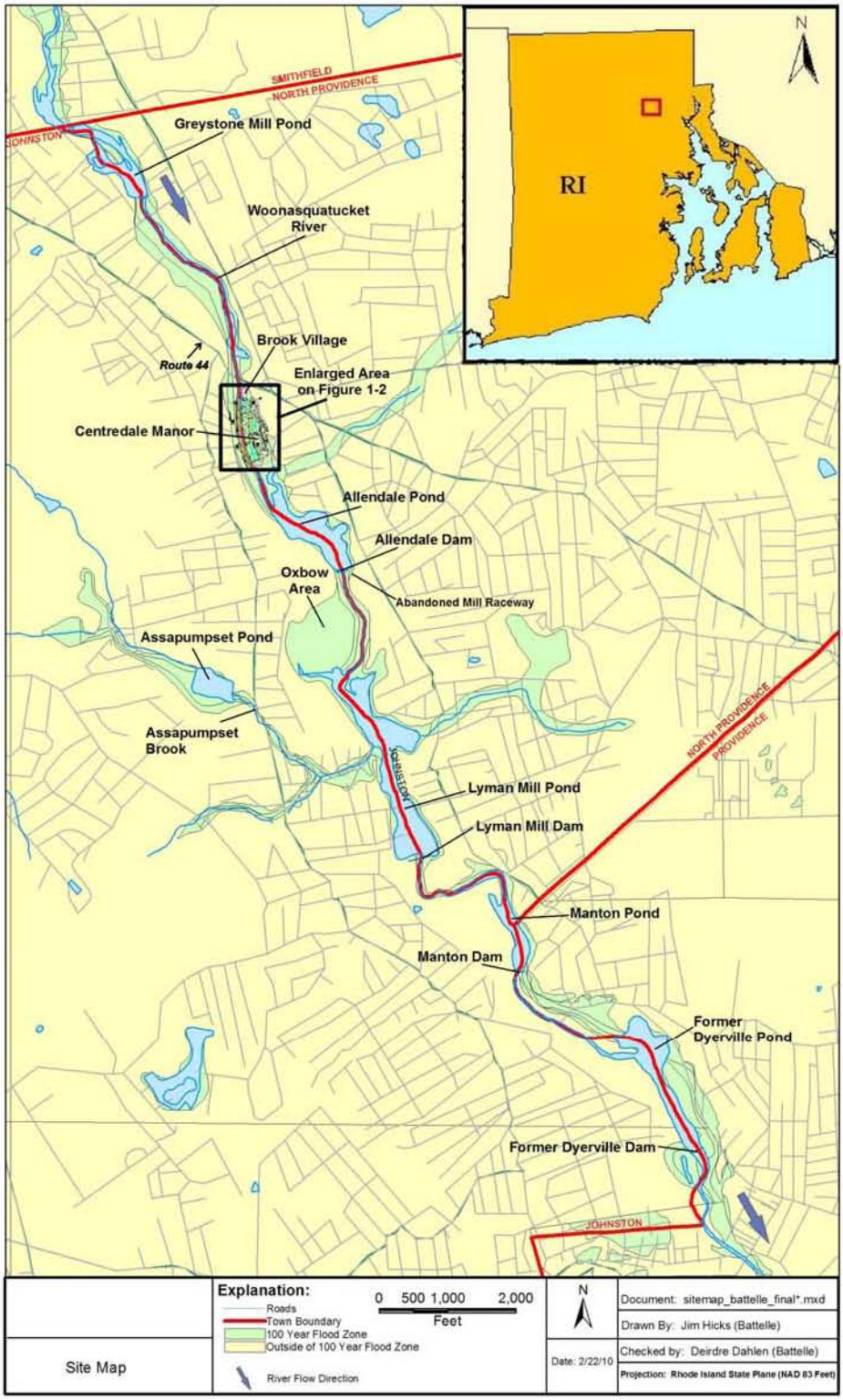
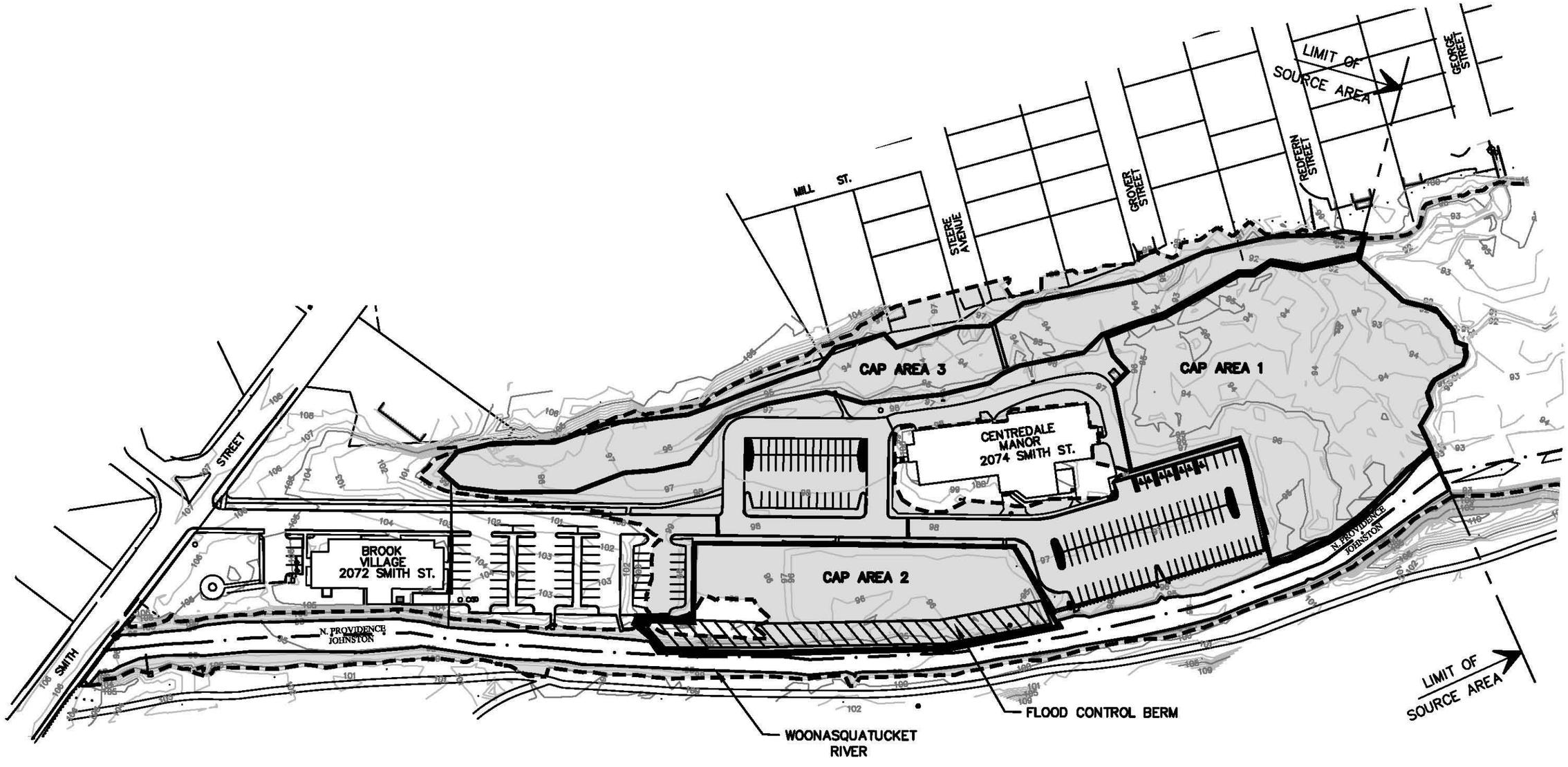


Figure 1-1. Site Map

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Battelle

Scale: 0 120 240 FEET

Figure 1–2

Explanation: SOURCE AREA BASE MAP

90 EXISTING GROUND ELEVATION (FT)

FLOODPLAIN AREA BETWEEN NORMAL AND 100–YR– FLOOD ELEVATION

100 YR FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST. TO 97.0' AT LIMIT OF SOURCE AREA)

Date: 02/26/10

Document: Fig 1–2_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

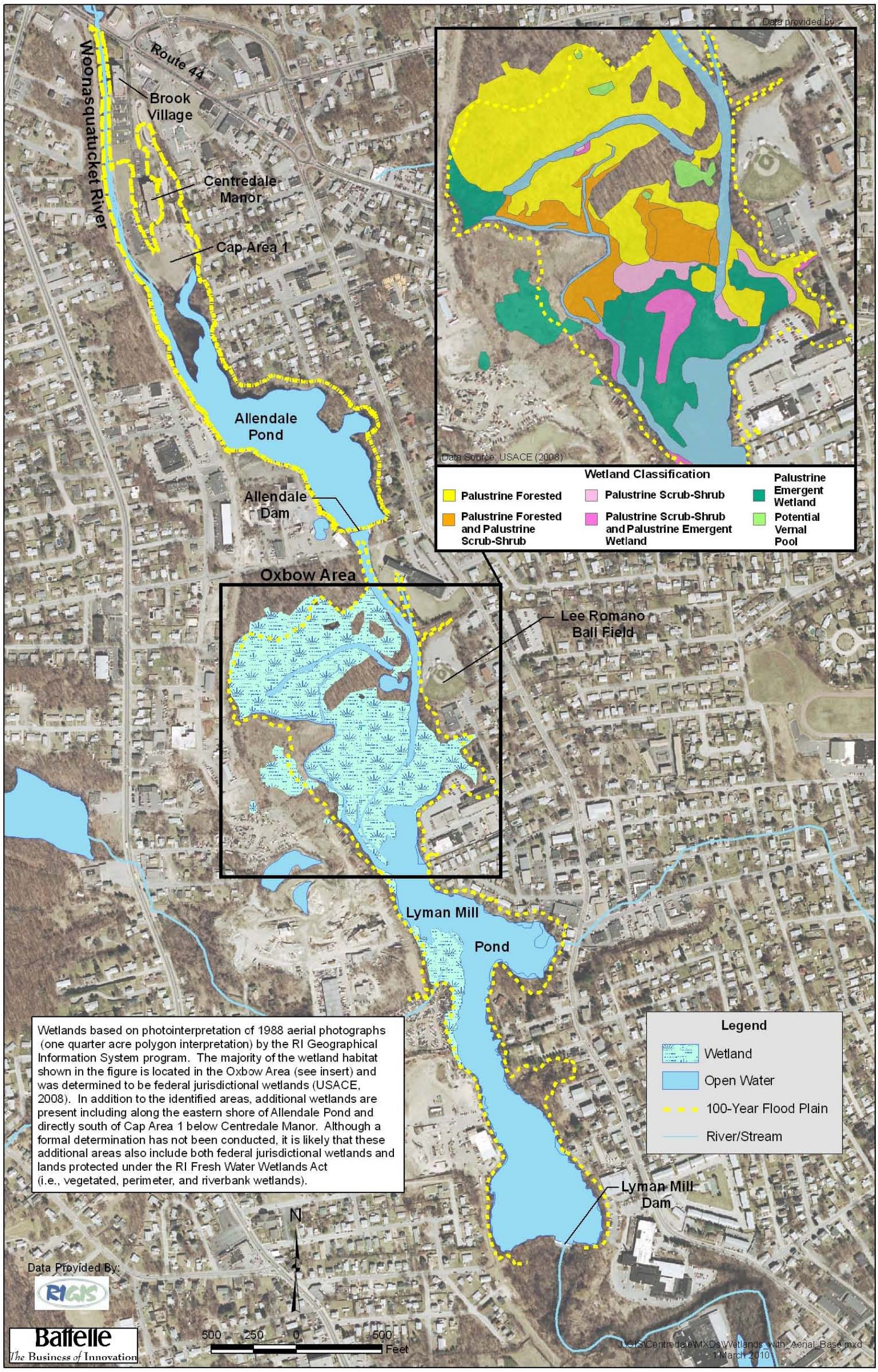


Figure 1-3. Floodplain and RIGIS Wetland Areas that Border Parts of the Woonasquatucket River along the Reaches of Allendale and Lyman Mill

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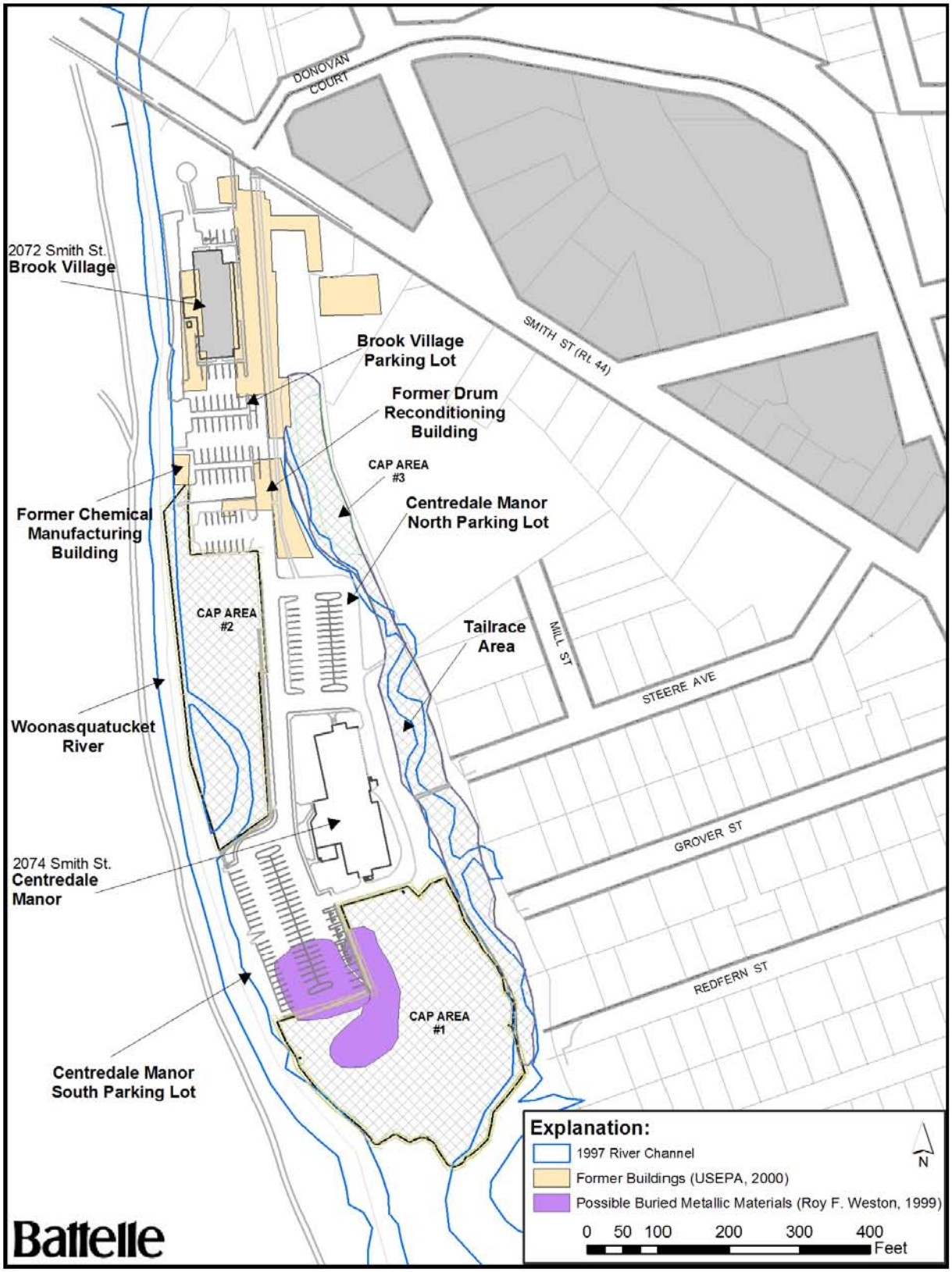


Figure 2-1. Historical Features of the Source Area

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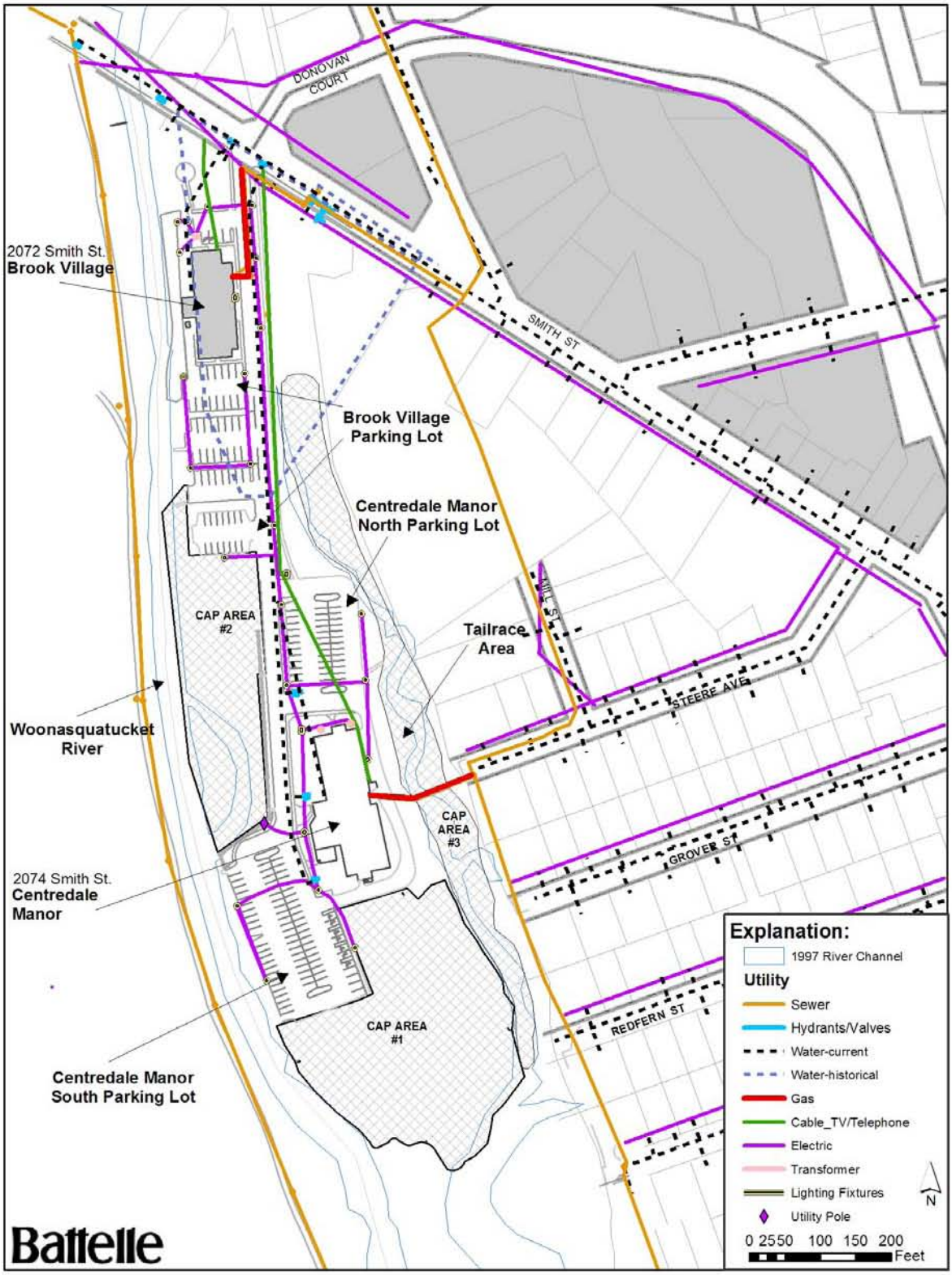


Figure 2-2. Location of Known Underground Utilities at the Source Area

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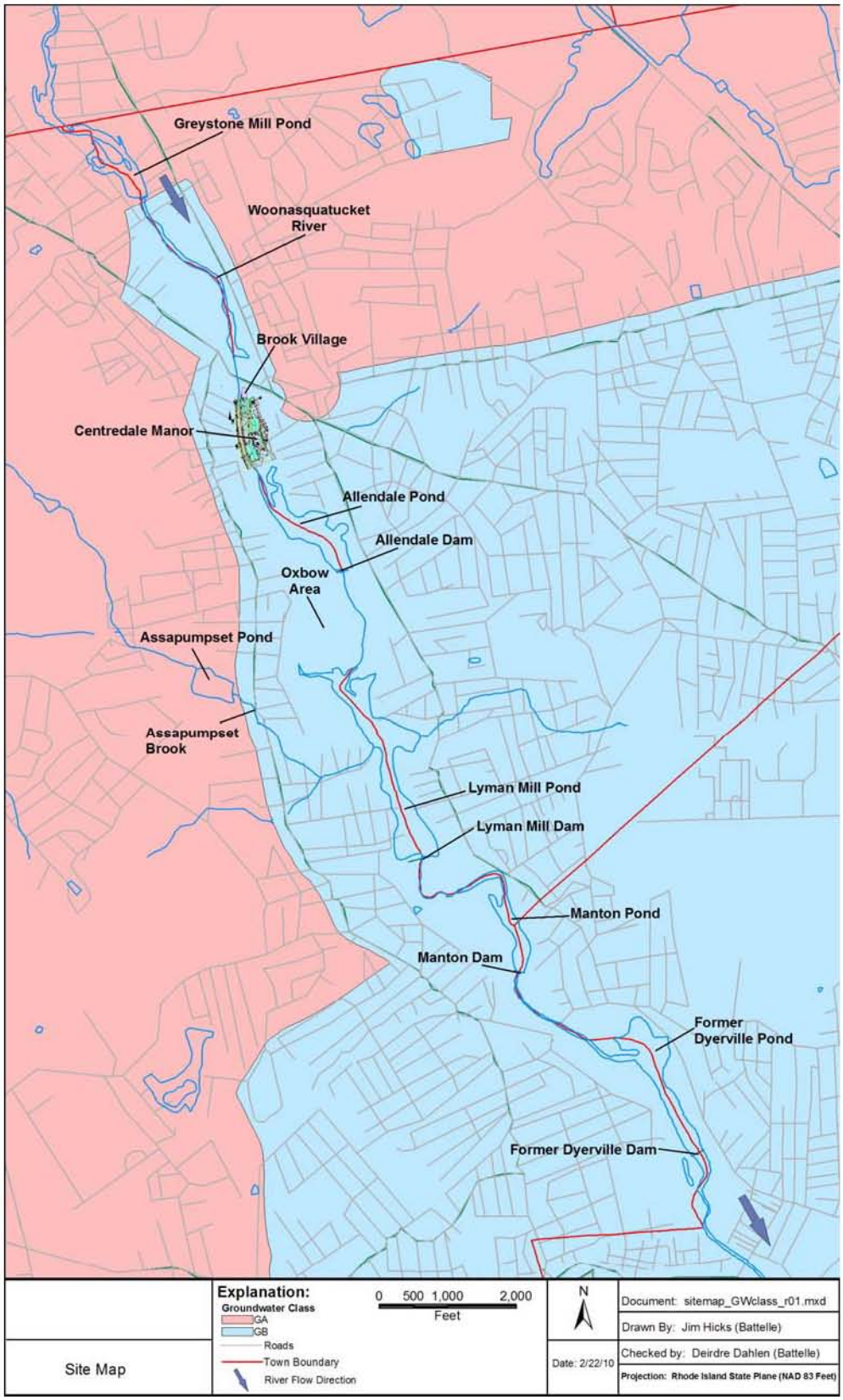


Figure 2-3. RIDEM Groundwater Classification Map

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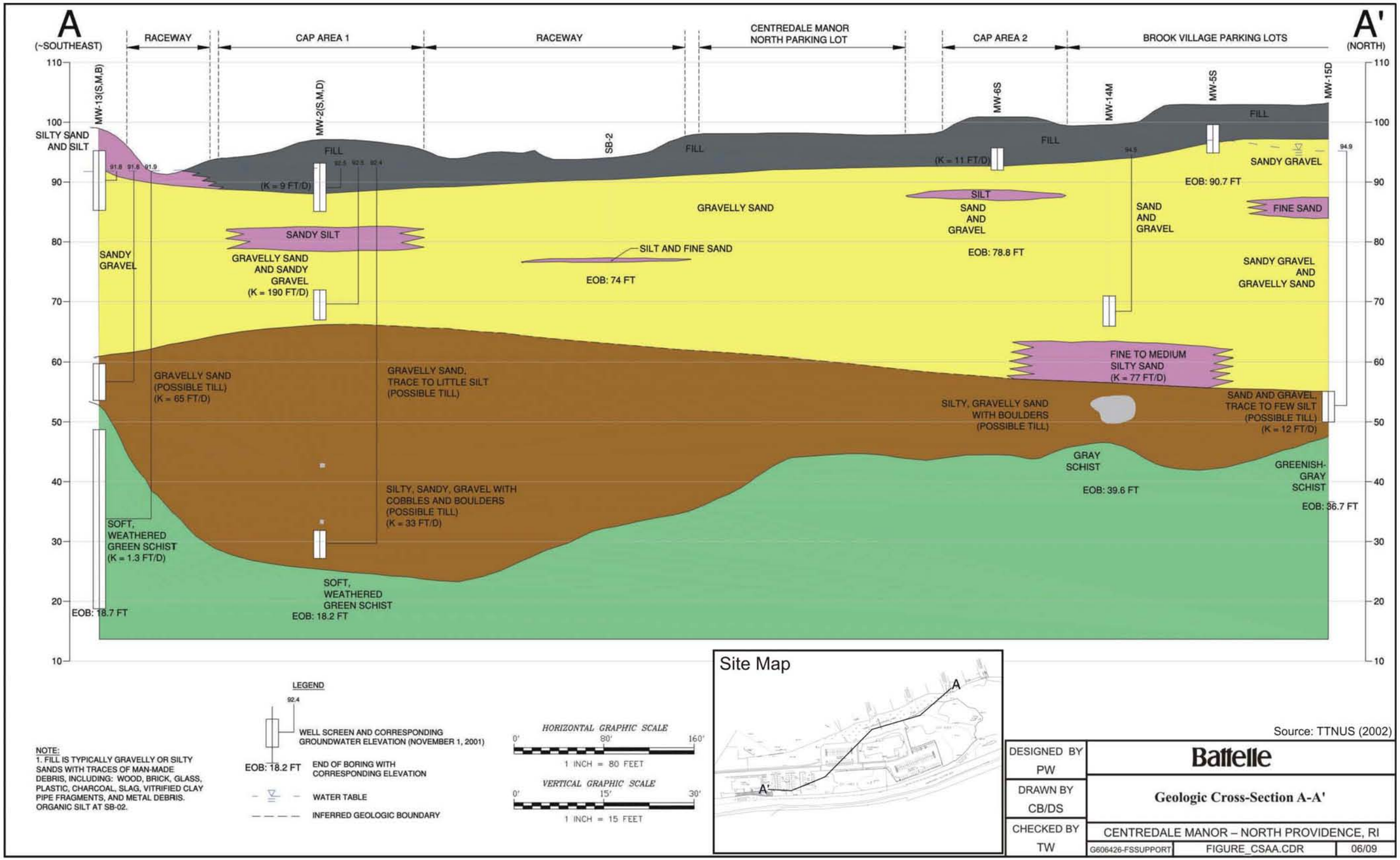


Figure 2-4. Source Area Stratigraphy

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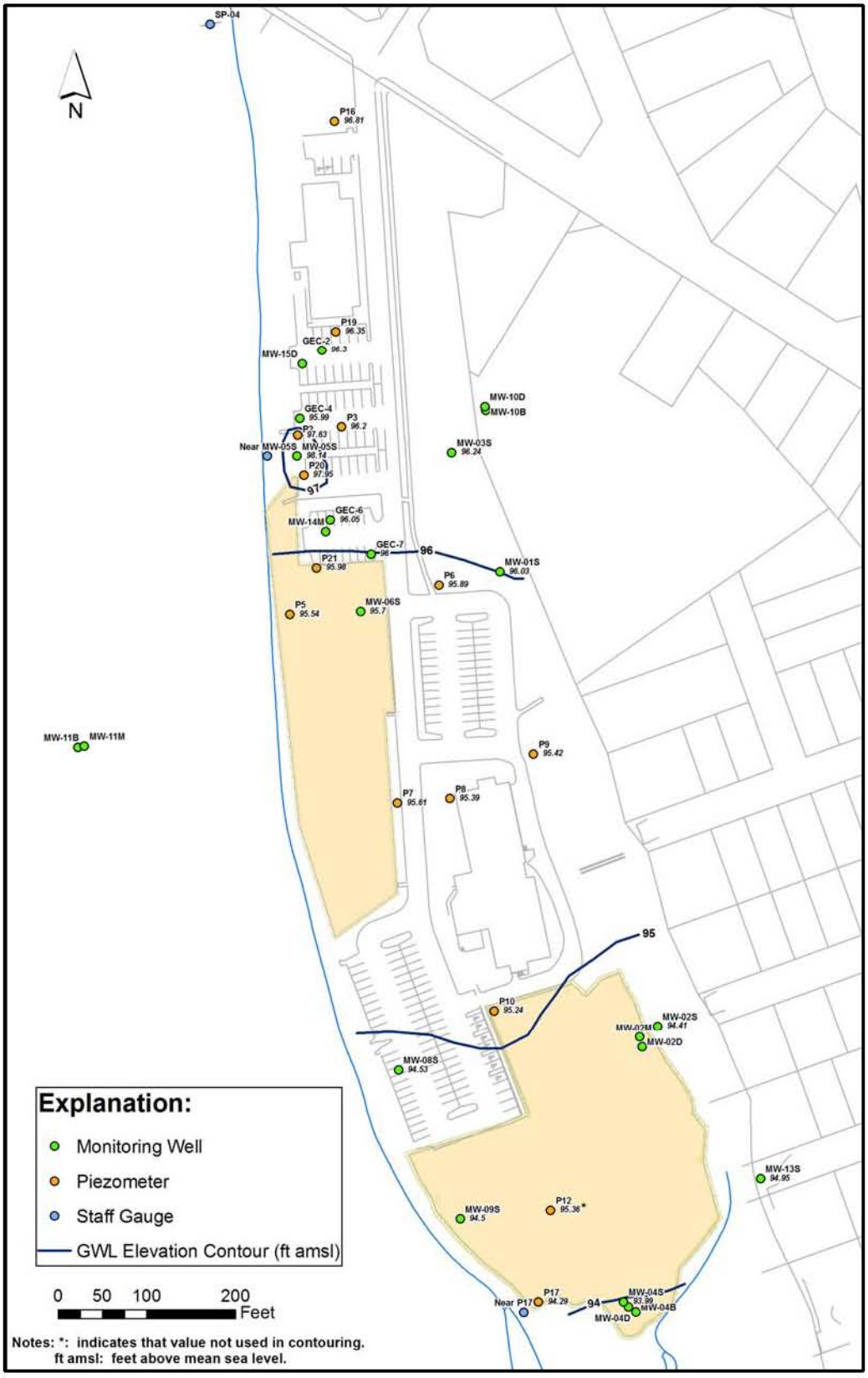


Figure 2-5. Water Table Elevations at the Source Area, December 2006

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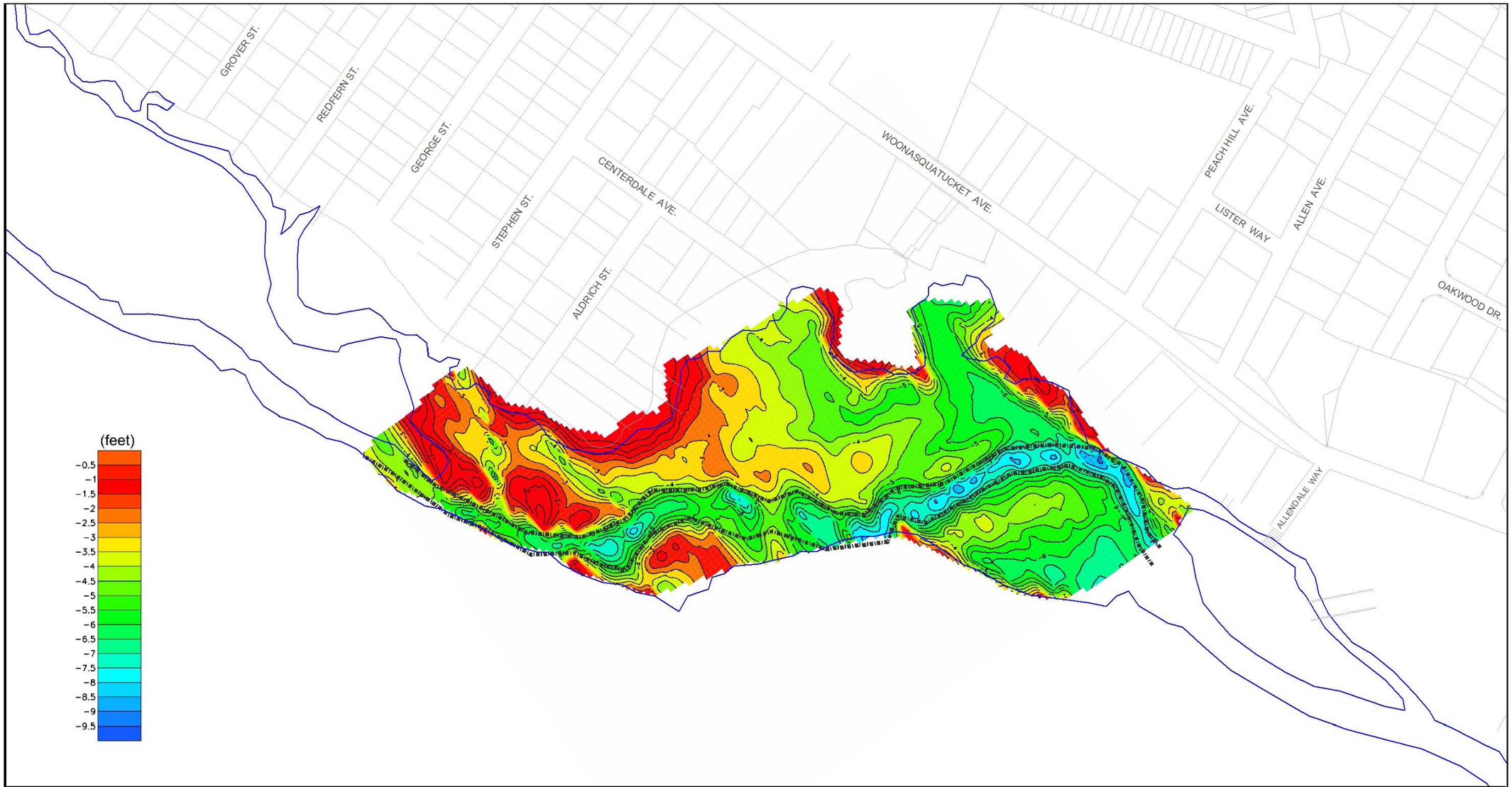


Figure 2-6. Water Depth in Allendale Pond

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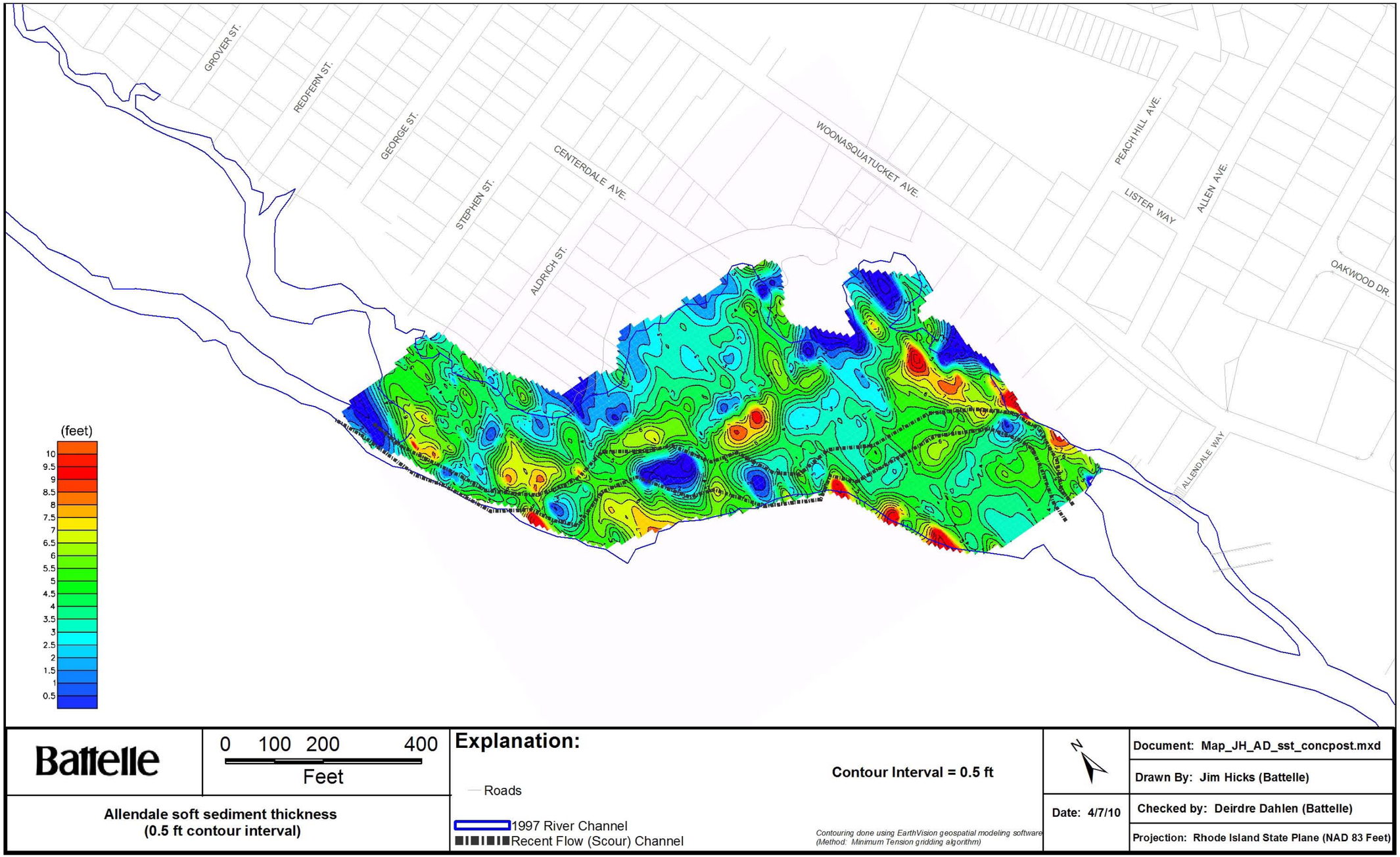


Figure 2-7. Apparent Soft Sediment Thickness in Allendale Pond

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Figure 2-8. Site Map of the Oxbow Area

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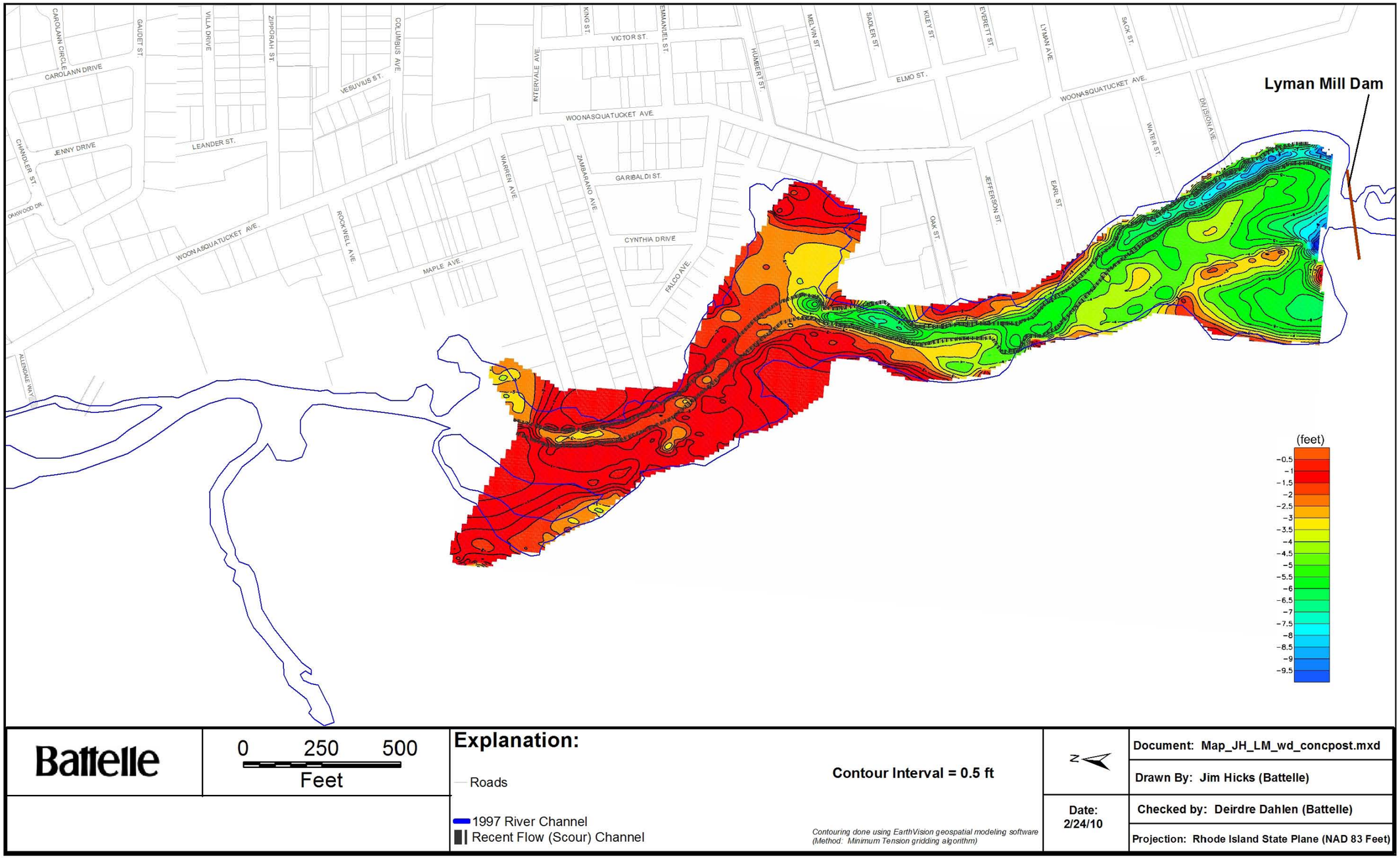


Figure 2-9. Water Depth at Lyman Mill Pond

US EPA ARCHIVE DOCUMENT

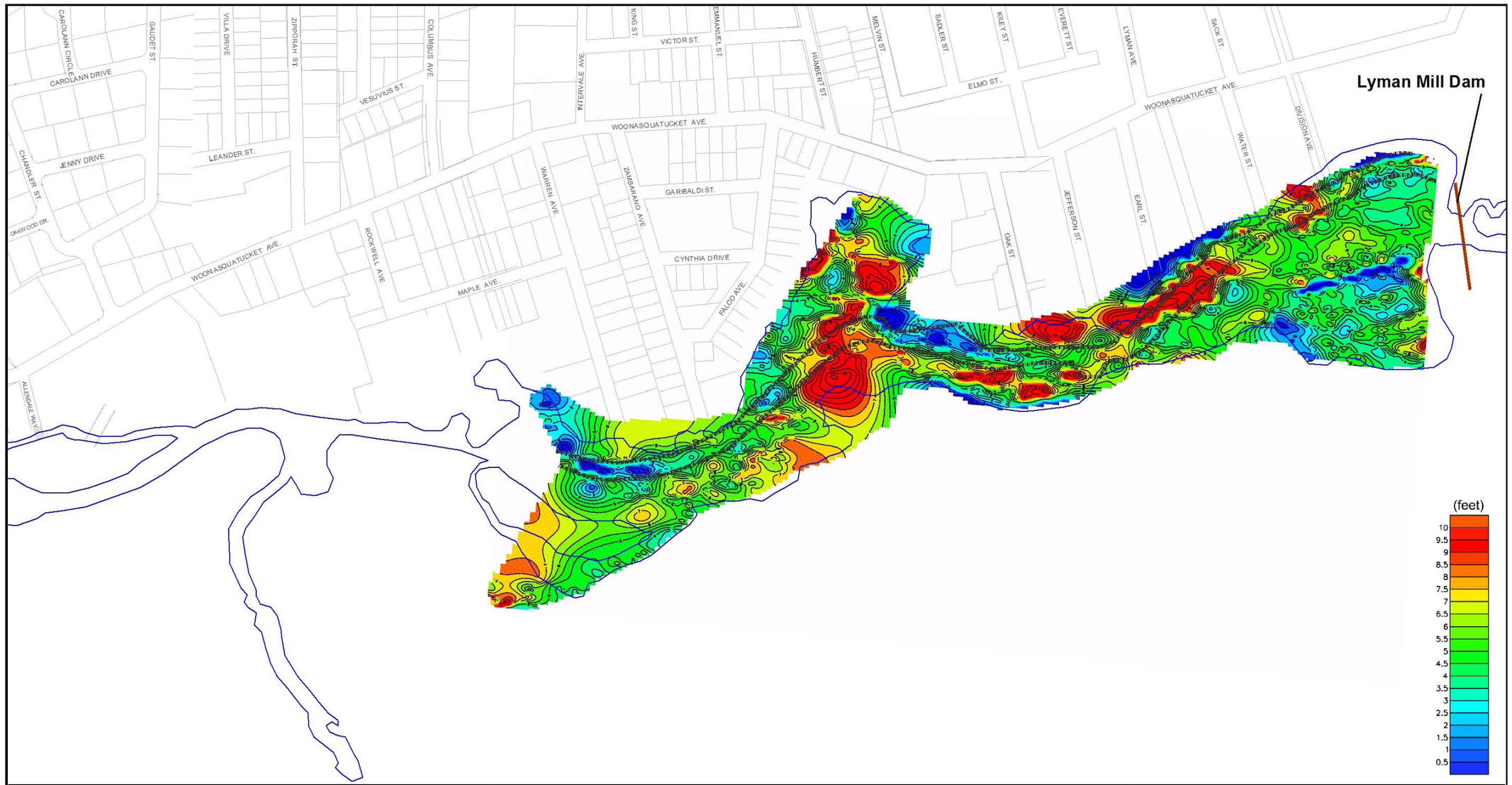


Figure 2-10. Apparent Soft Sediment Thickness at Lyman Mill Pond

US EPA ARCHIVE DOCUMENT

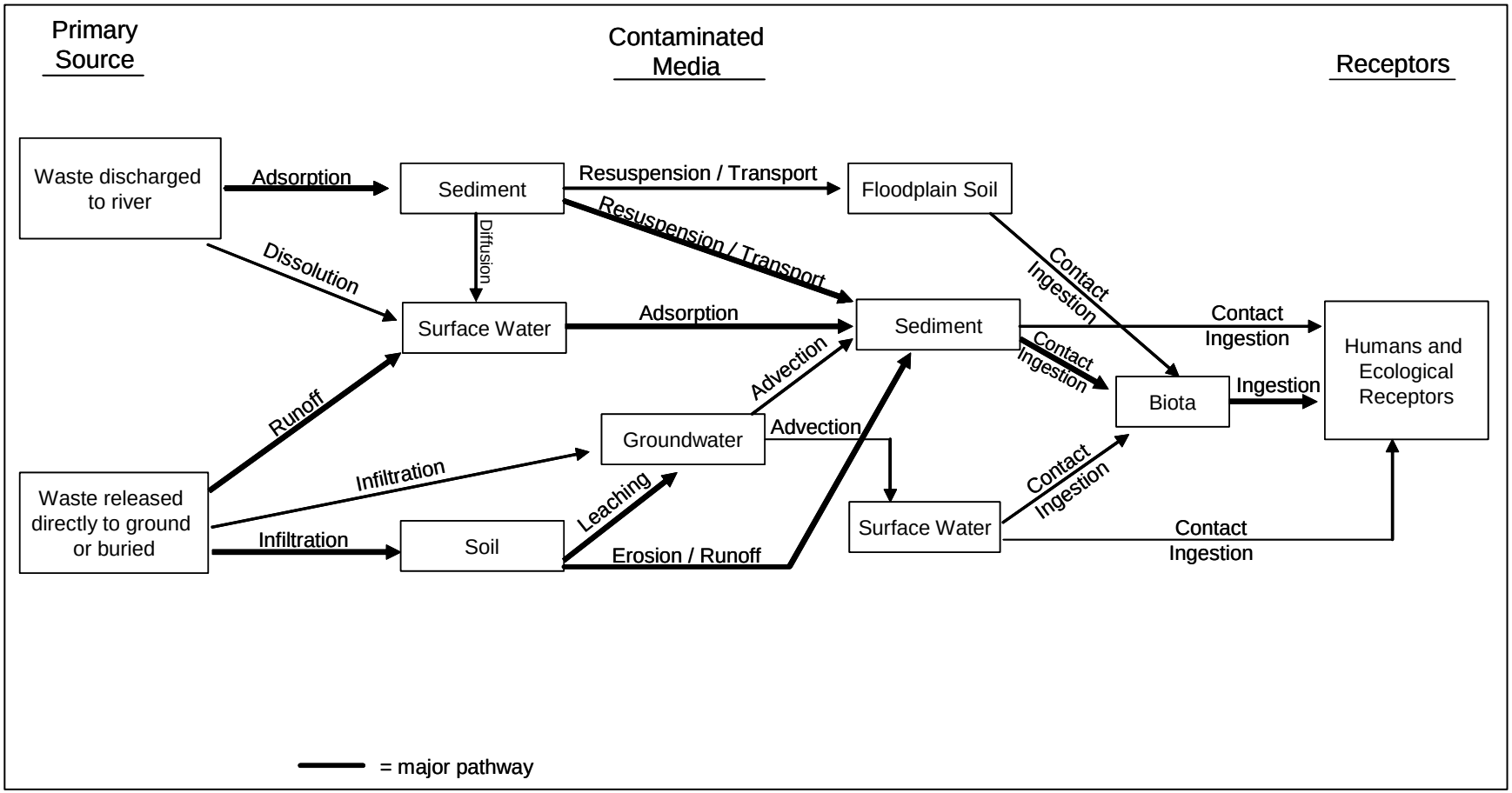


Figure 2-11a. Generalized Conceptual Site Model for the CMRP Site

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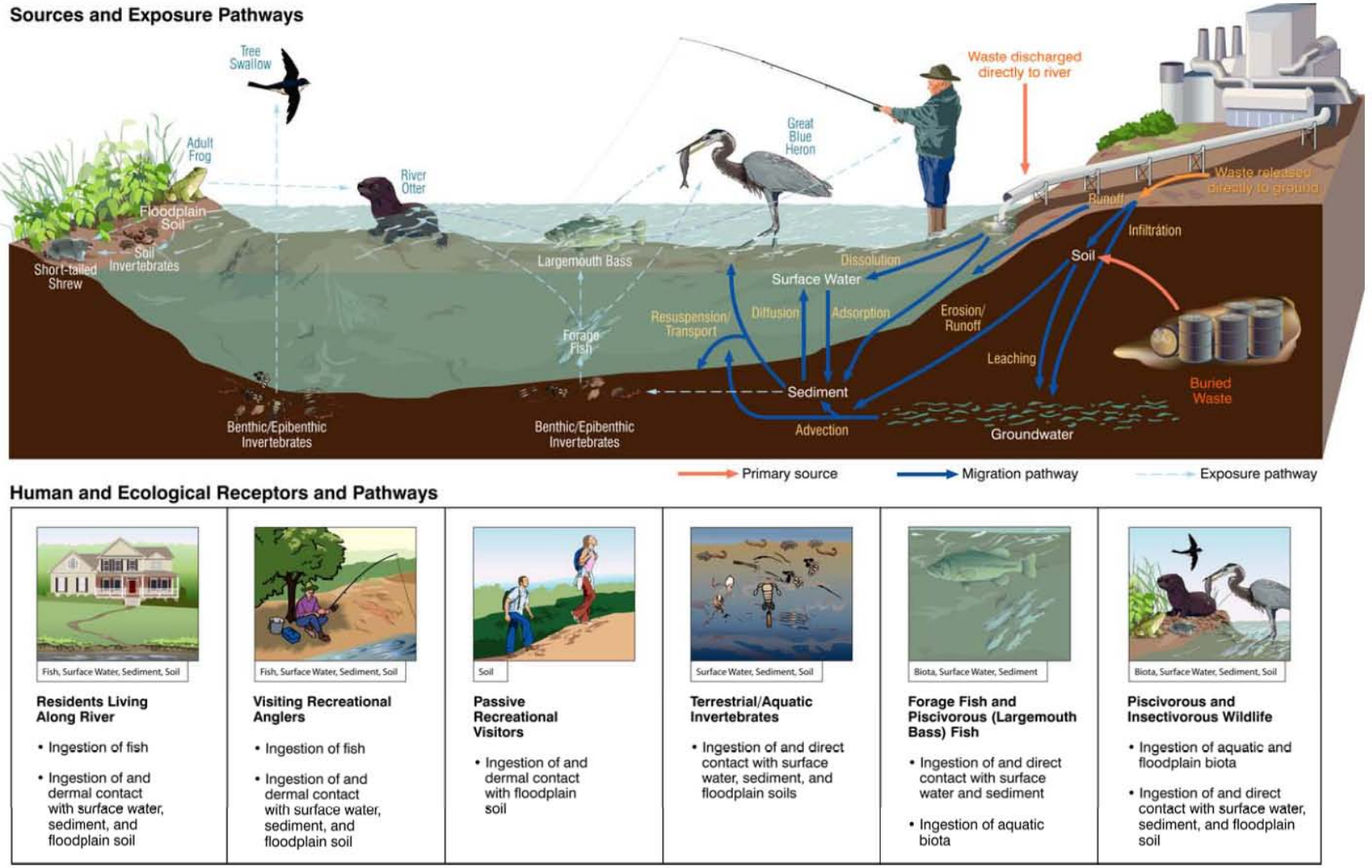


Figure 2-11b. Illustration of the Generalized Conceptual Site Model for the CMRP Site

US EPA ARCHIVE DOCUMENT

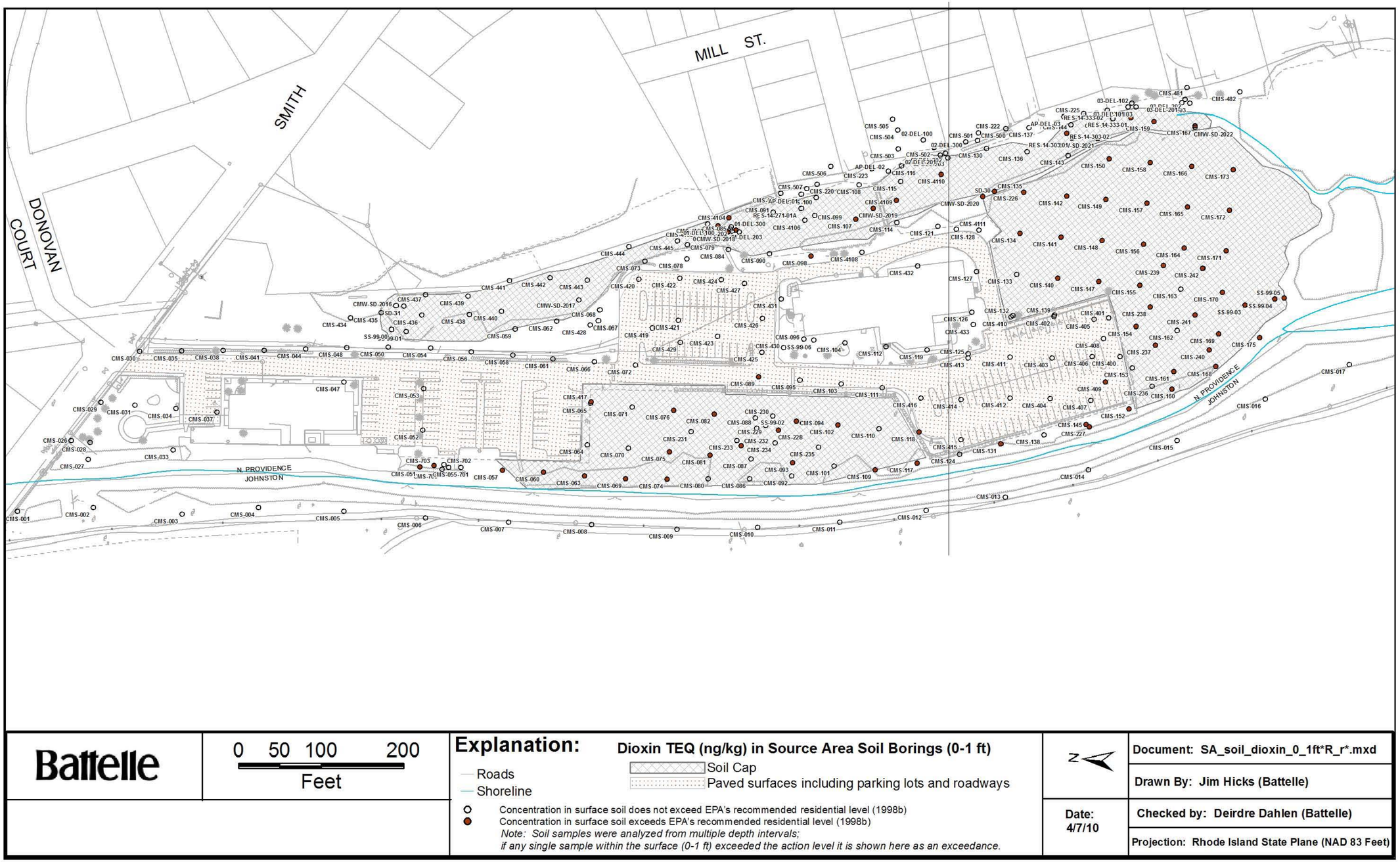


Figure 2-12. Dioxin TEQ Concentration in Source Area Soils, Surface (0-1 feet)

US EPA ARCHIVE DOCUMENT

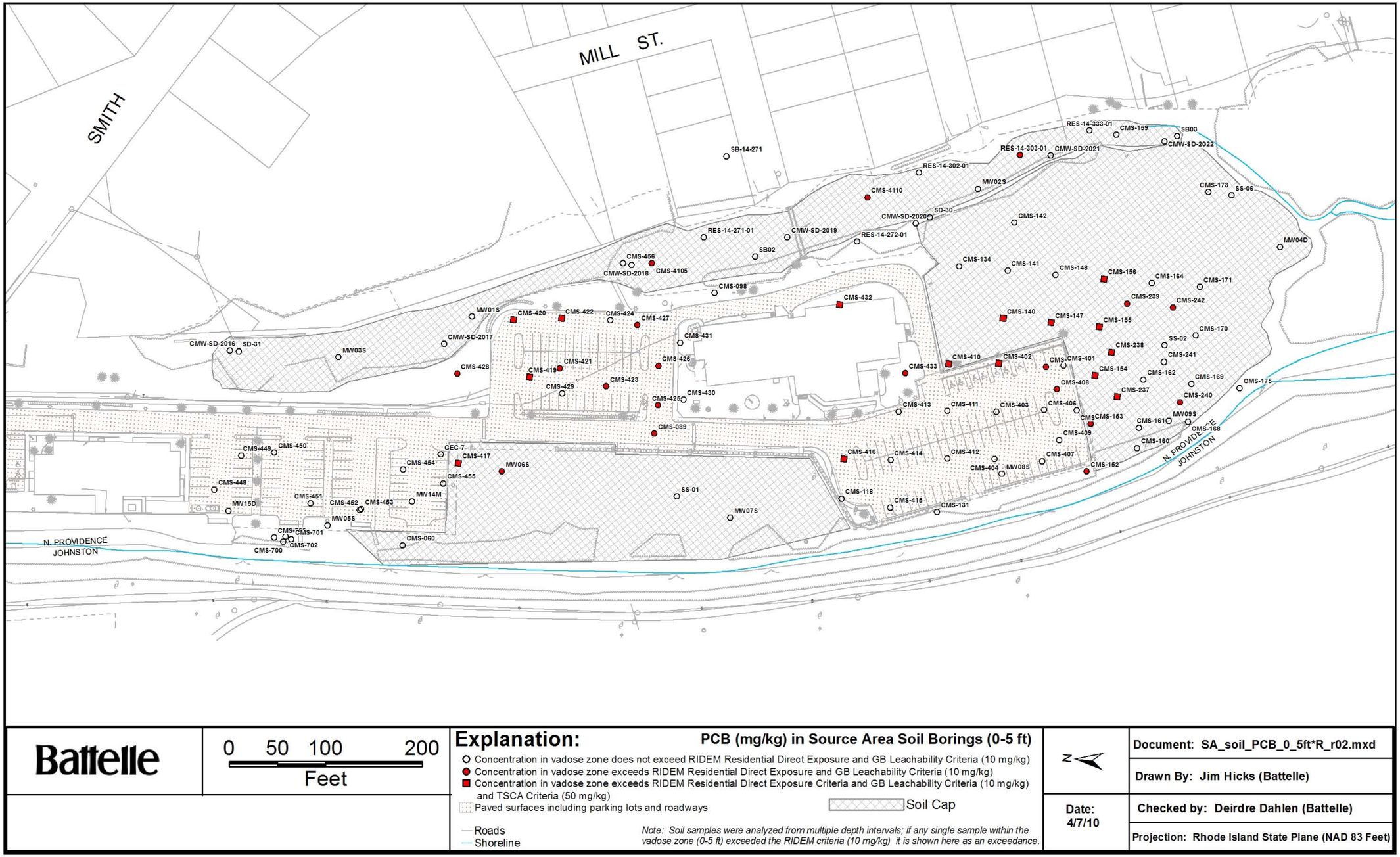


Figure 2-13. Total PCB Concentration in Source Area Soils, Vadose Zone (0-5 feet)

US EPA ARCHIVE DOCUMENT

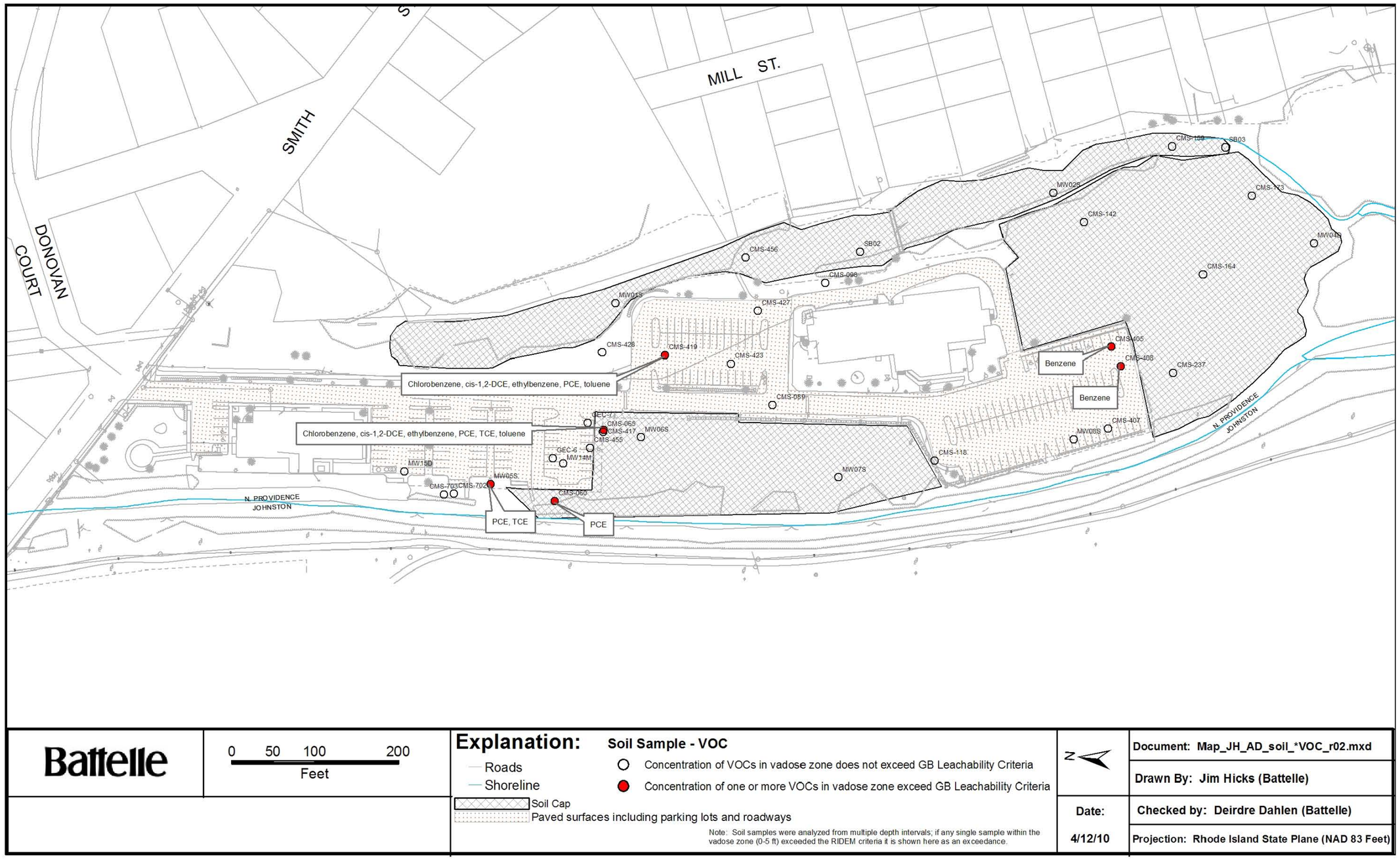


Figure 2-14. Source Area Soil Locations where VOCs in Vadose Zone (0-5 feet) Exceed GB Leachability Criteria

US EPA ARCHIVE DOCUMENT

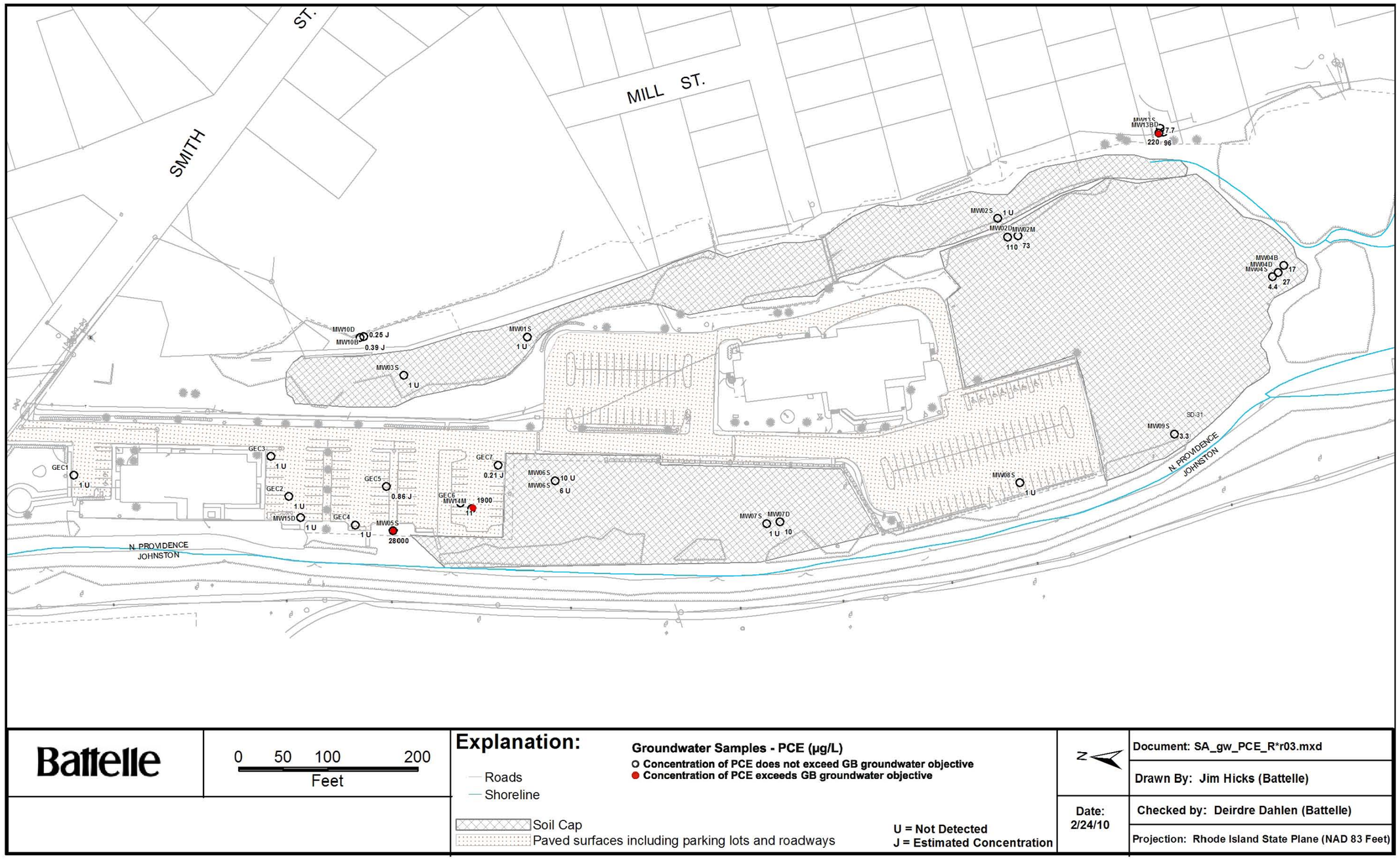


Figure 2-15. Source Area Groundwater Locations where PCE Concentrations Exceed GB Groundwater Objective, 2002

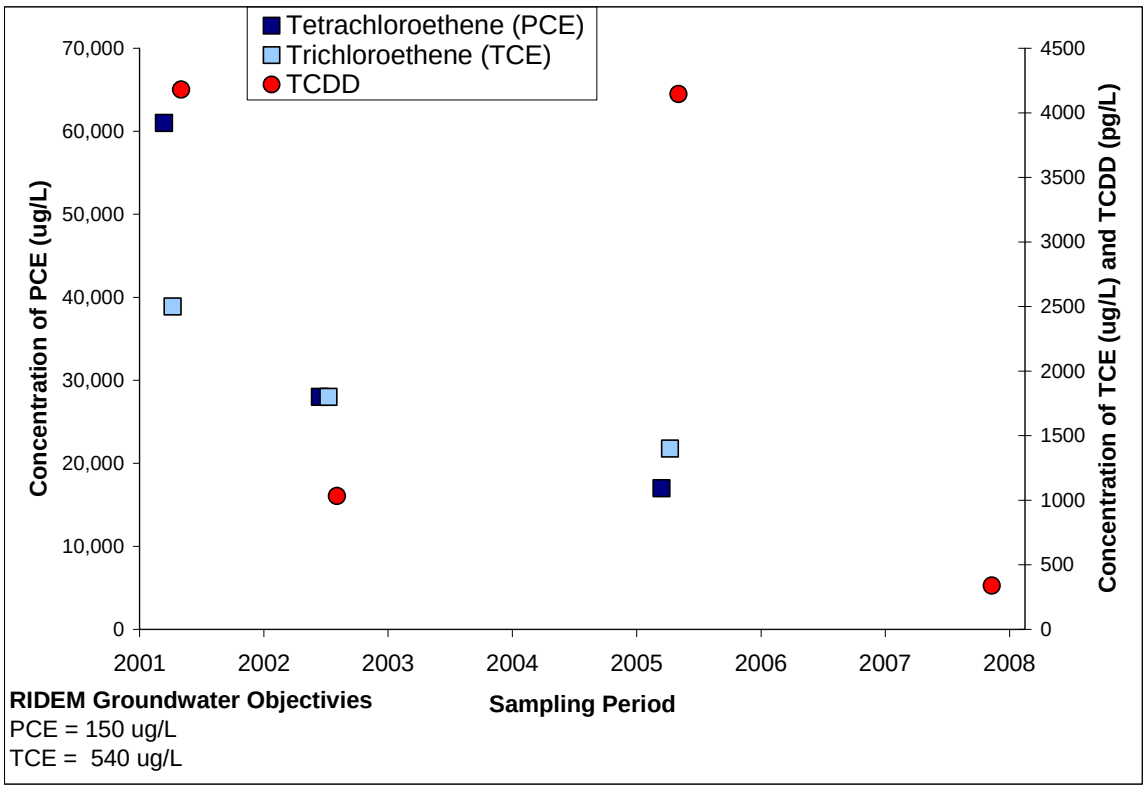


Figure 2-16. VOC (PCE and TCE) and Dioxin (2,3,7,8-TCDD) Concentrations in Groundwater at Well MW-05S, 2001 to 2008 Sampling Periods

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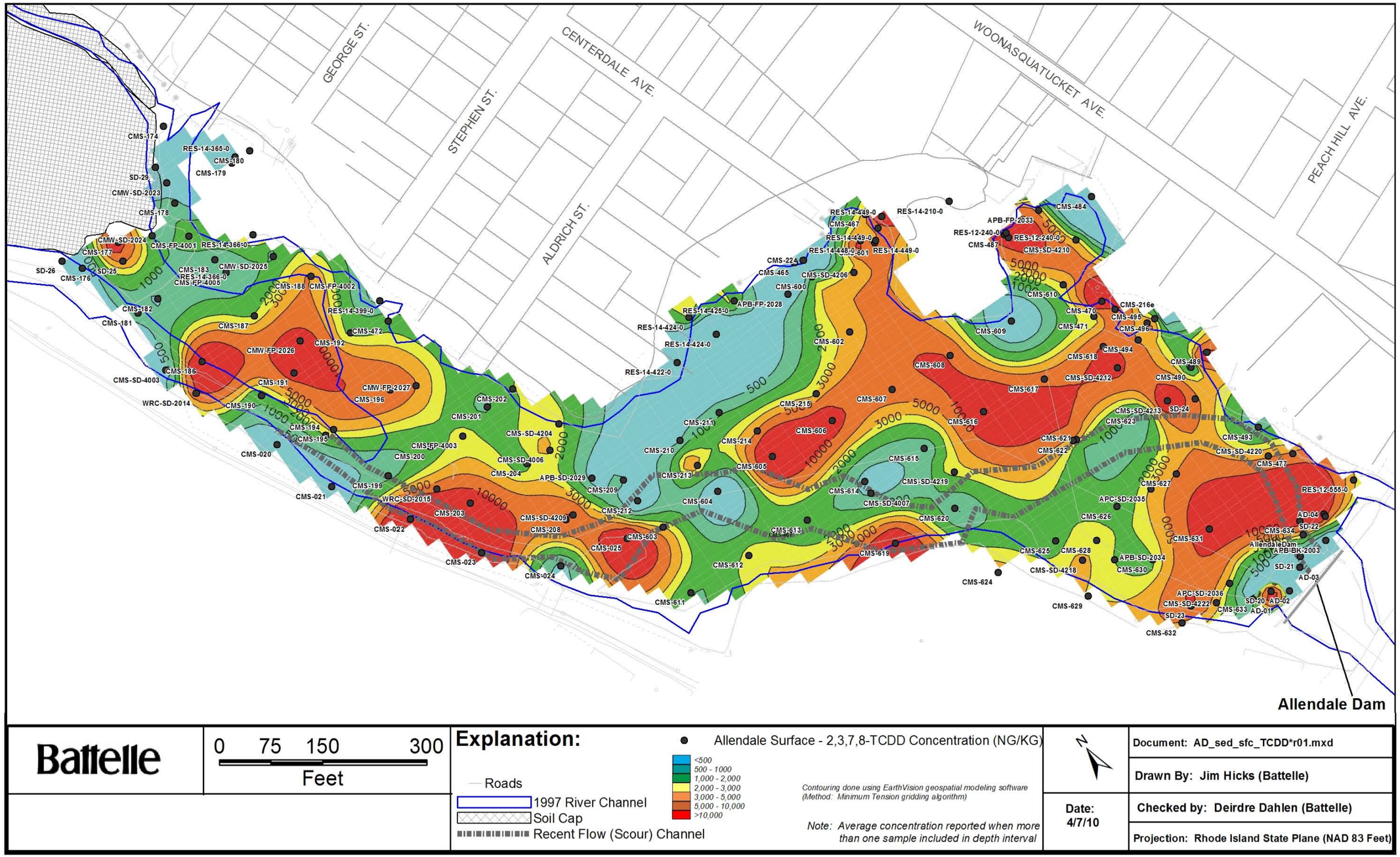
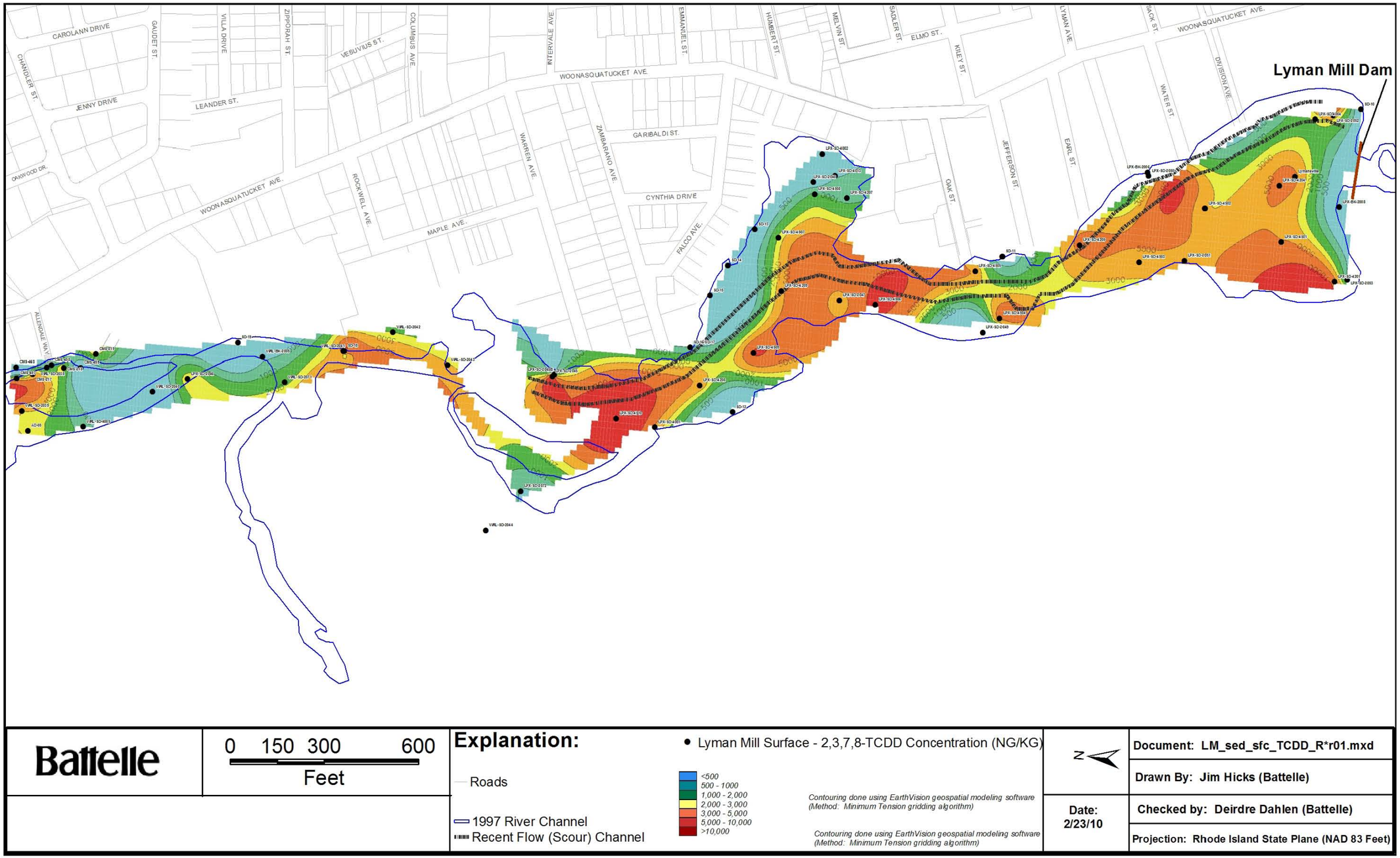


Figure 2-17. Dioxin (2,3,7,8-TCDD) Concentrations in Surface Sediment (0-1 feet) at Allendale Pond

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Figure 2-18. Dioxin (2,3,7,8-TCDD) Concentrations in Surface Sediment (0-1 feet) at Lyman Mill Pond

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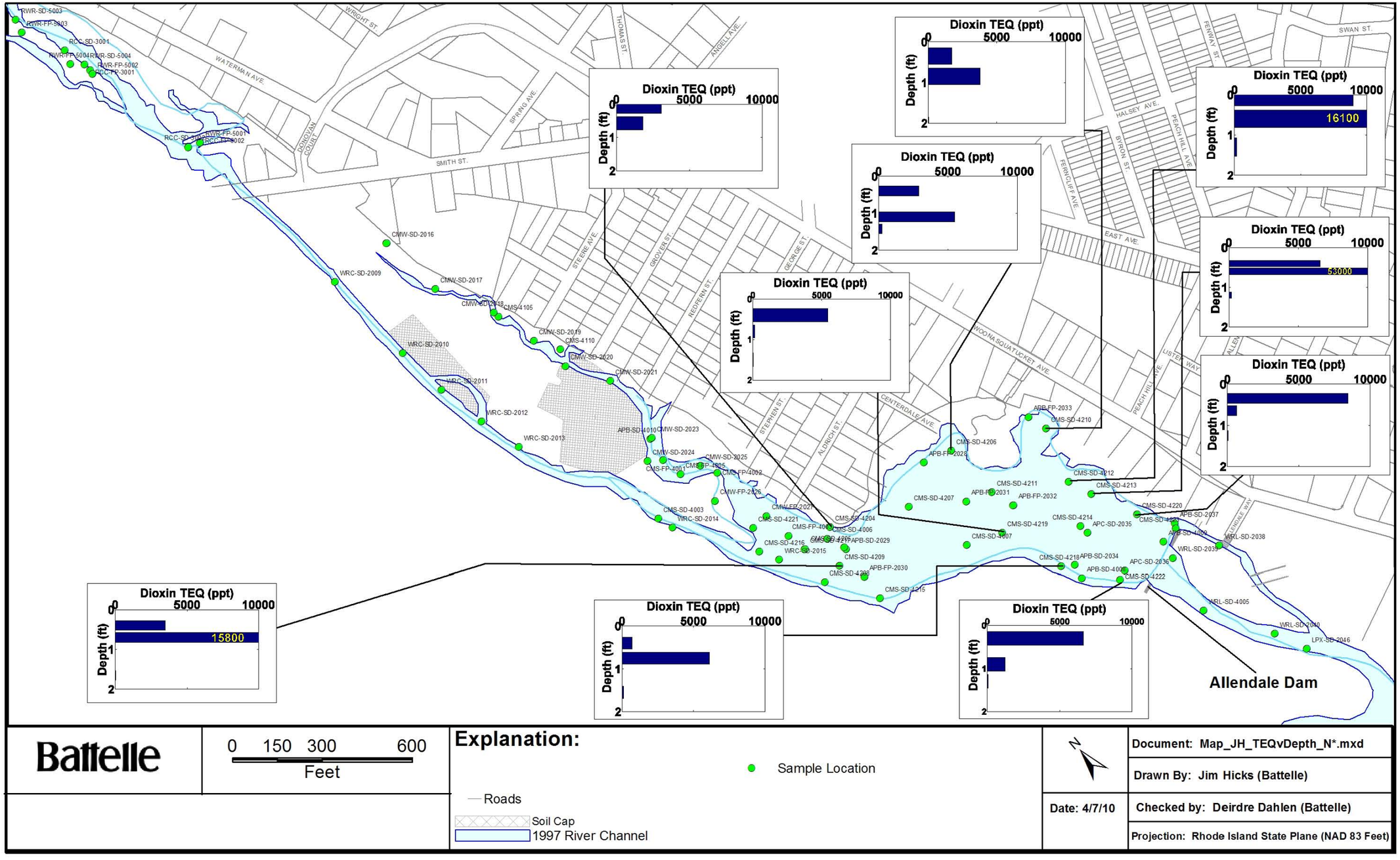


Figure 2-19. Vertical Profiles of Dioxin (TEQ) Concentrations at Allendale Pond Sediment, May 2003

US EPA ARCHIVE DOCUMENT

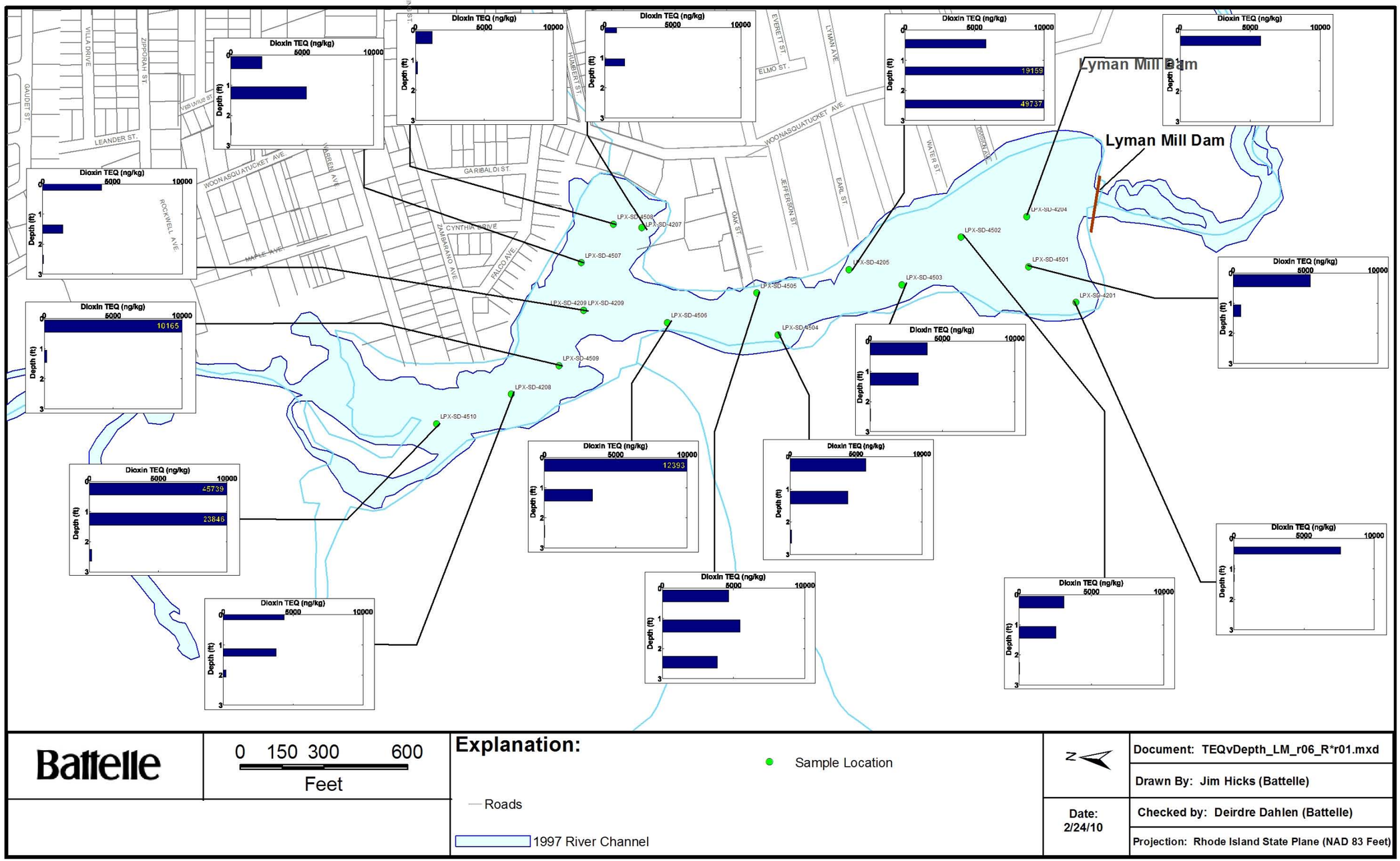
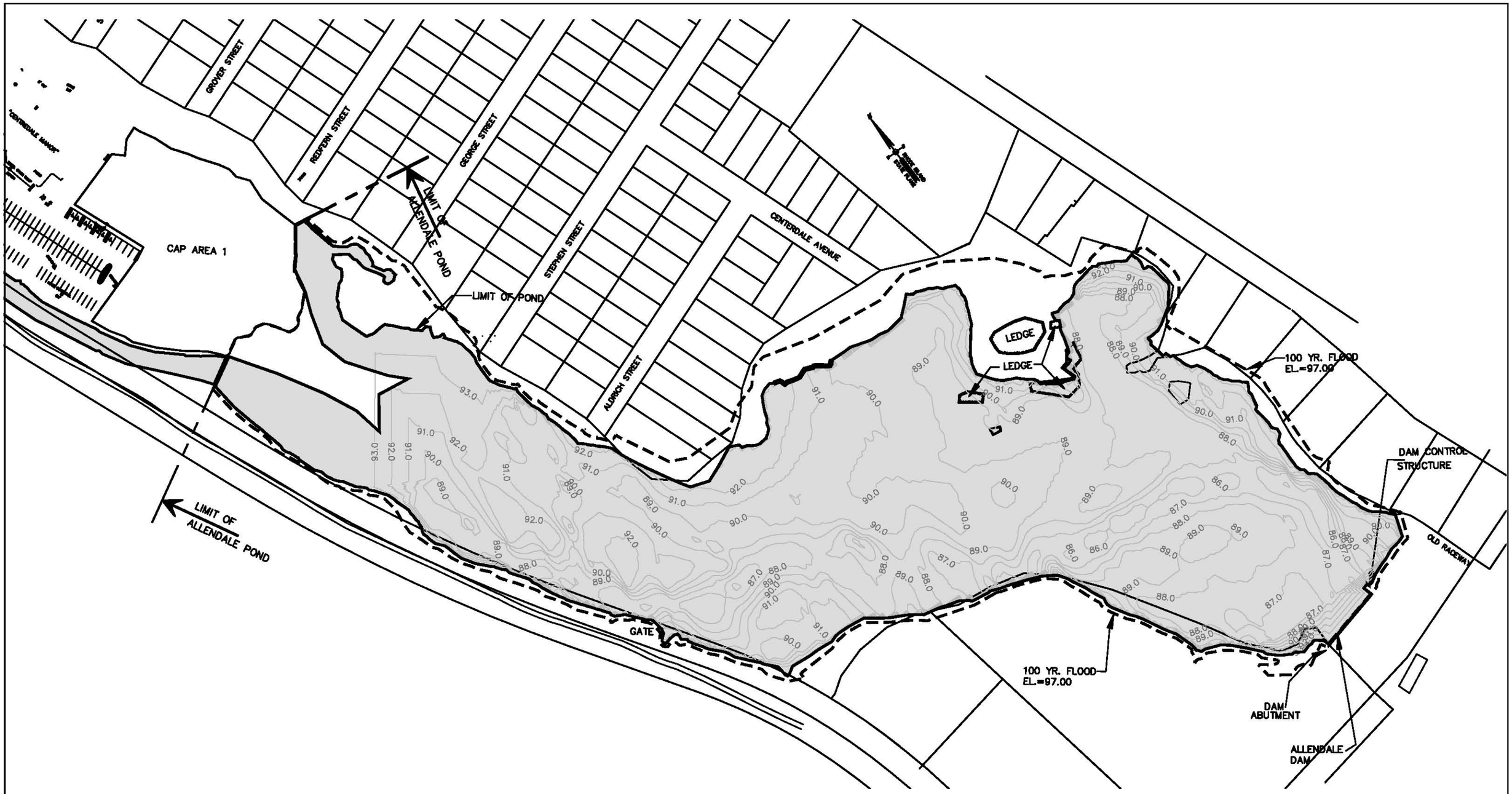


Figure 2-20. Vertical Profiles of Dioxin (TEQ) Concentrations at Lyman Mill Pond Sediment, May 2003 and March 2005



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Scale: 0 150 300 Feet

Figure 3–1

Explanation: ALLENDALE POND SEDIMENT REMEDIAL FOOTPRINT

- 90.0 EXISTING POND BOTTOM ELEVATION
- LIMIT OF PROPOSED CLEANUP AREA (EL=93.5')
- 100 YR. FLOOD ELEVATION (EL=97.0')
- PROPOSED CLEANUP AREA

Date: 6/1/09

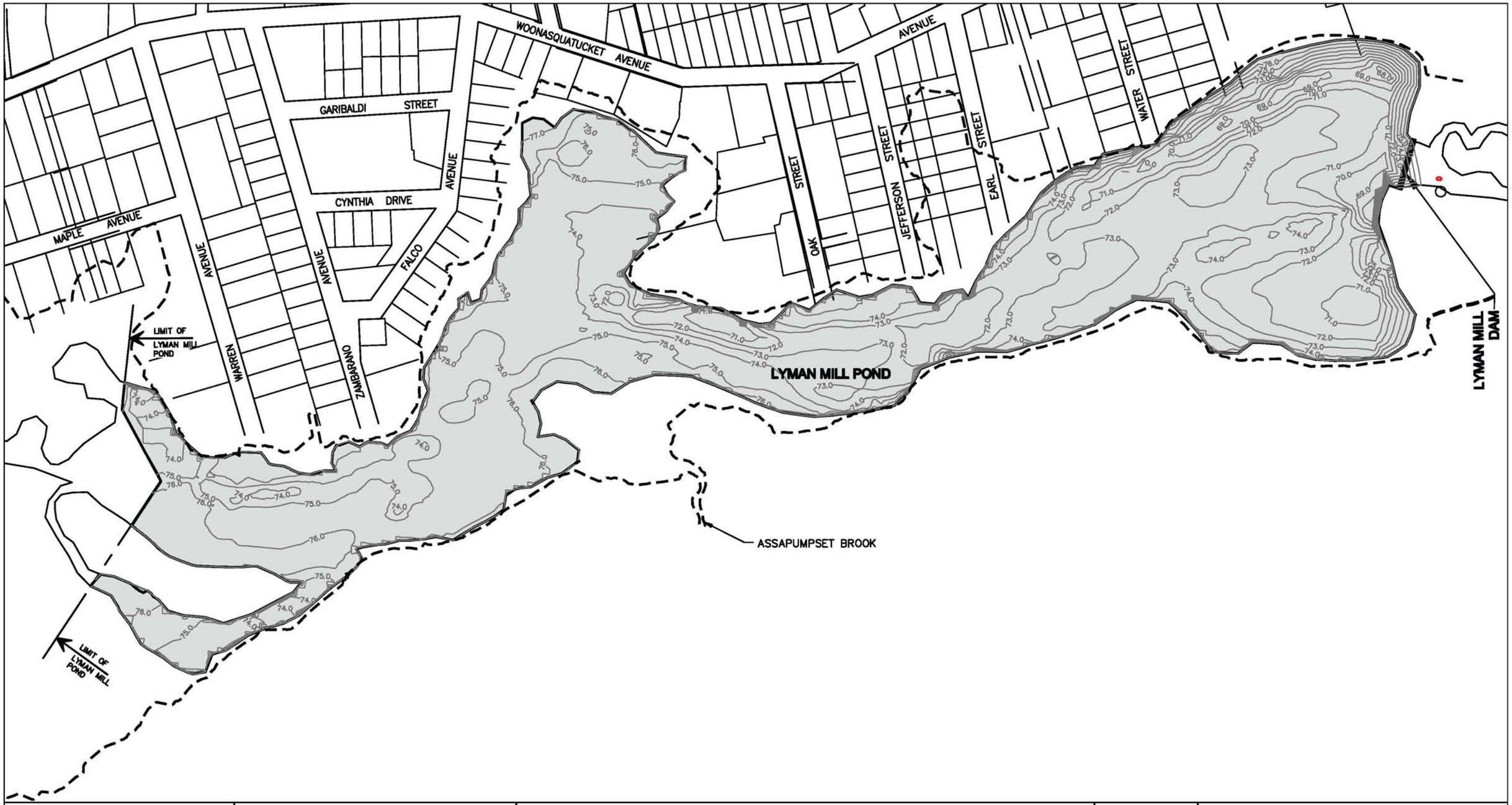
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Drawn By: J. Hannaford (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



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Scale: 0 200 400 FEET

Figure 3–2

Explanation: LYMAN MILL POND SEDIMENT REMEDIAL FOOTPRINT

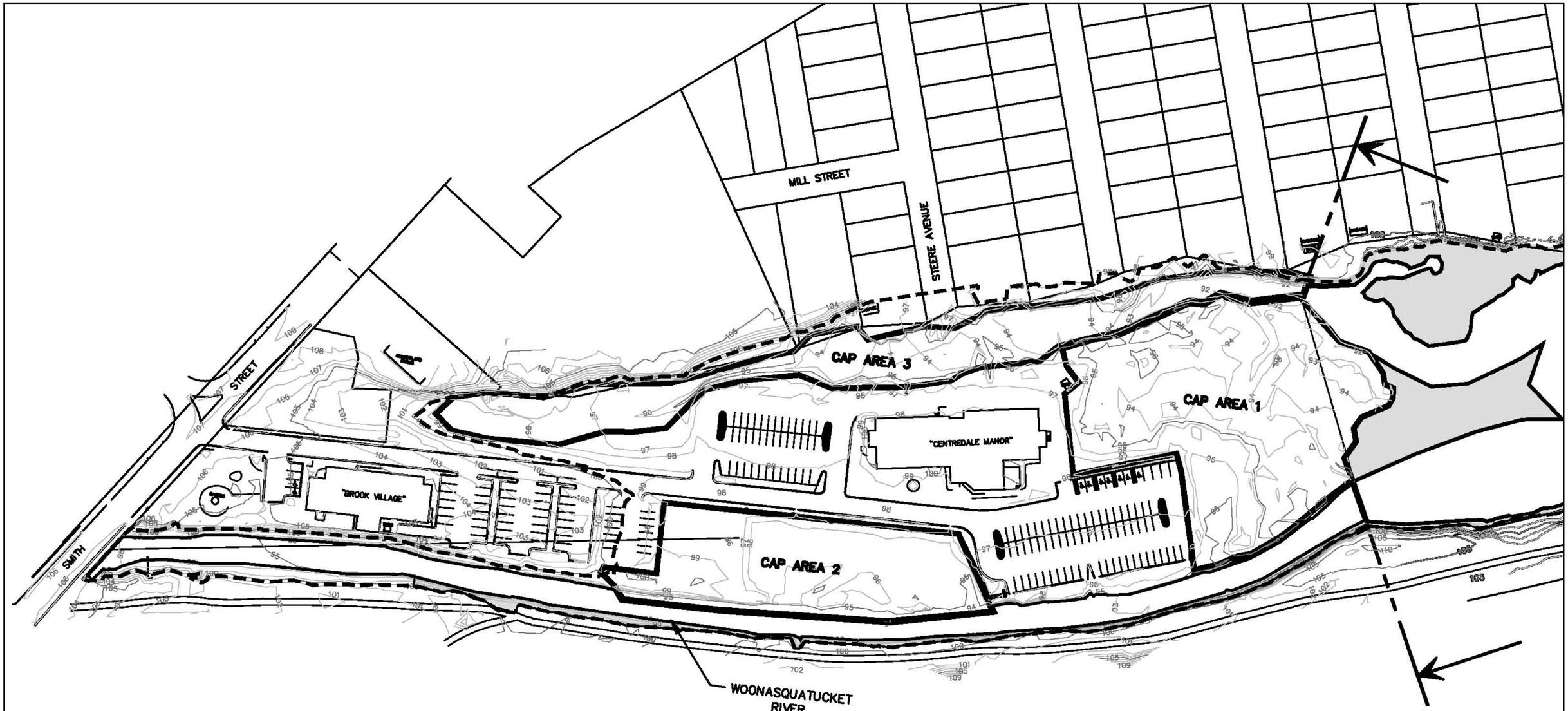
—75.0— EXISTING POND BOTTOM ELEVATION
LIMIT OF PROPOSED CLEANUP AREA (EL=77.0')
100 YR. FLOOD ELEVATION (EL=80.6')
PROPOSED CLEANUP AREA

RHODE ISLAND STATE PLANE

Date: 02/26/10

Document: Fig 3–2_REV0.dwg
Drawn By: L. Bouchard (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

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Battelle

Scale: SCALE: 1"=120'
0 120' 240'

Figure 3–3a

Explanation: ALLENDALE REACH FLOODPLAIN SOIL REMEDIAL FOOTPRINT

- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT ALLENDALE DAM)
- PROPOSED CLEANUP AREAS

Date: 5/28/09

Document: Fig 3–3a.dwg
Drawn By: S. Brown (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



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Scale: 0 150' 300' FEET

Figure 3–3b

Explanation: ALLENDALE REACH FLOODPLAIN SOIL REMEDIAL FOOTPRINT

- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT ALLENDALE DAM)
- PROPOSED CLEANUP AREAS

Date: 4/9/10

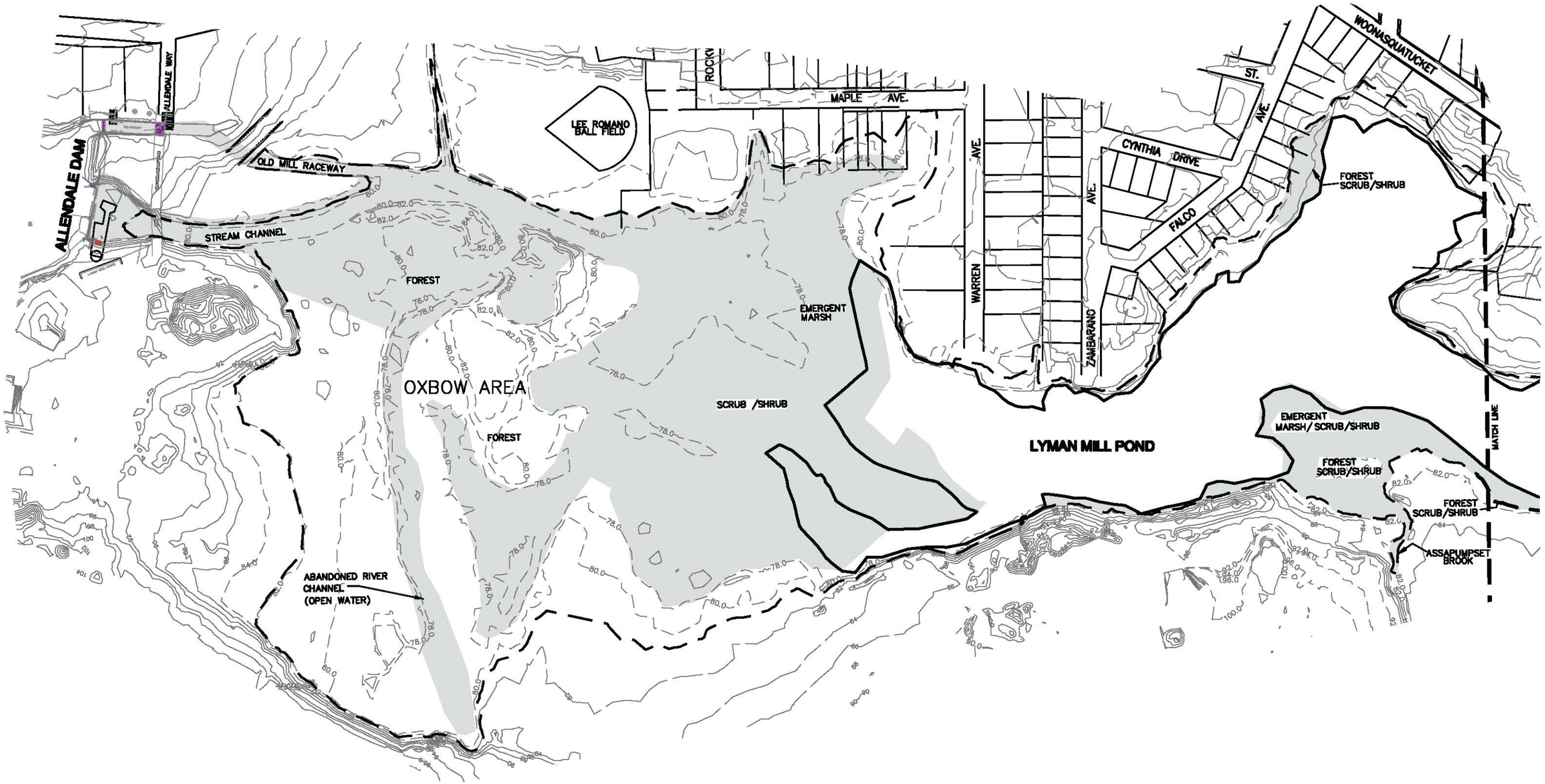
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Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

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Battelle

Scale: 0 200 400 FEET

Figure 3–4a

Explanation: LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL(OXBOW AREA) REMEDIAL FOOTPRINT

- 80.0 EXISTING TOPOGRAPHY
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- PROPOSED CLEANUP AREAS

Date: 04/08/10

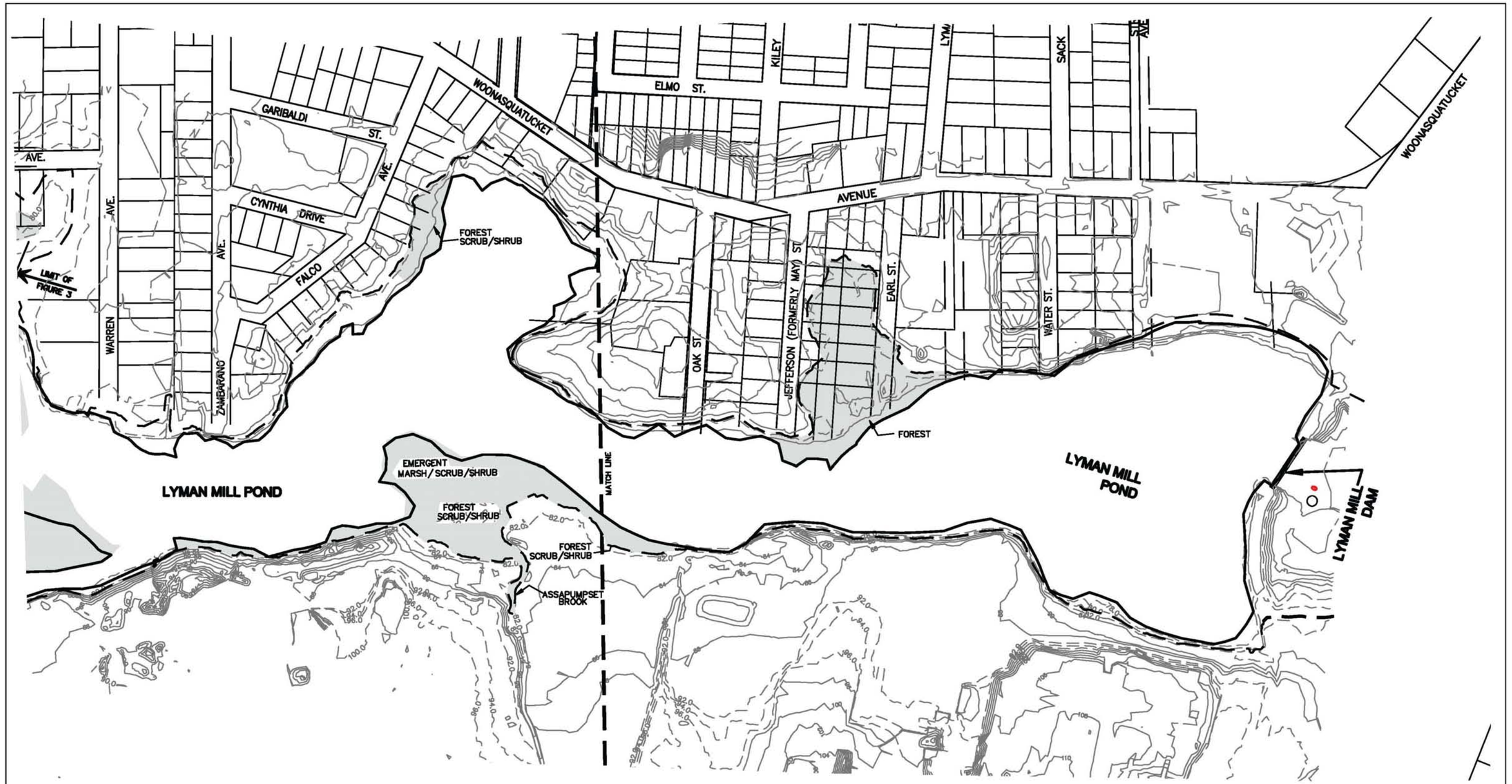
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Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

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Scale: 0 200 400 FEET

Figure 3–4b

Explanation: LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL(OXBOW AREA) REMEDIAL FOOTPRINT

- 80.0 EXISTING TOPOGRAPHY
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- PROPOSED CLEANUP AREAS

Date: 04/08/10

Document: Fig 3–4a&b_REV0.dwg

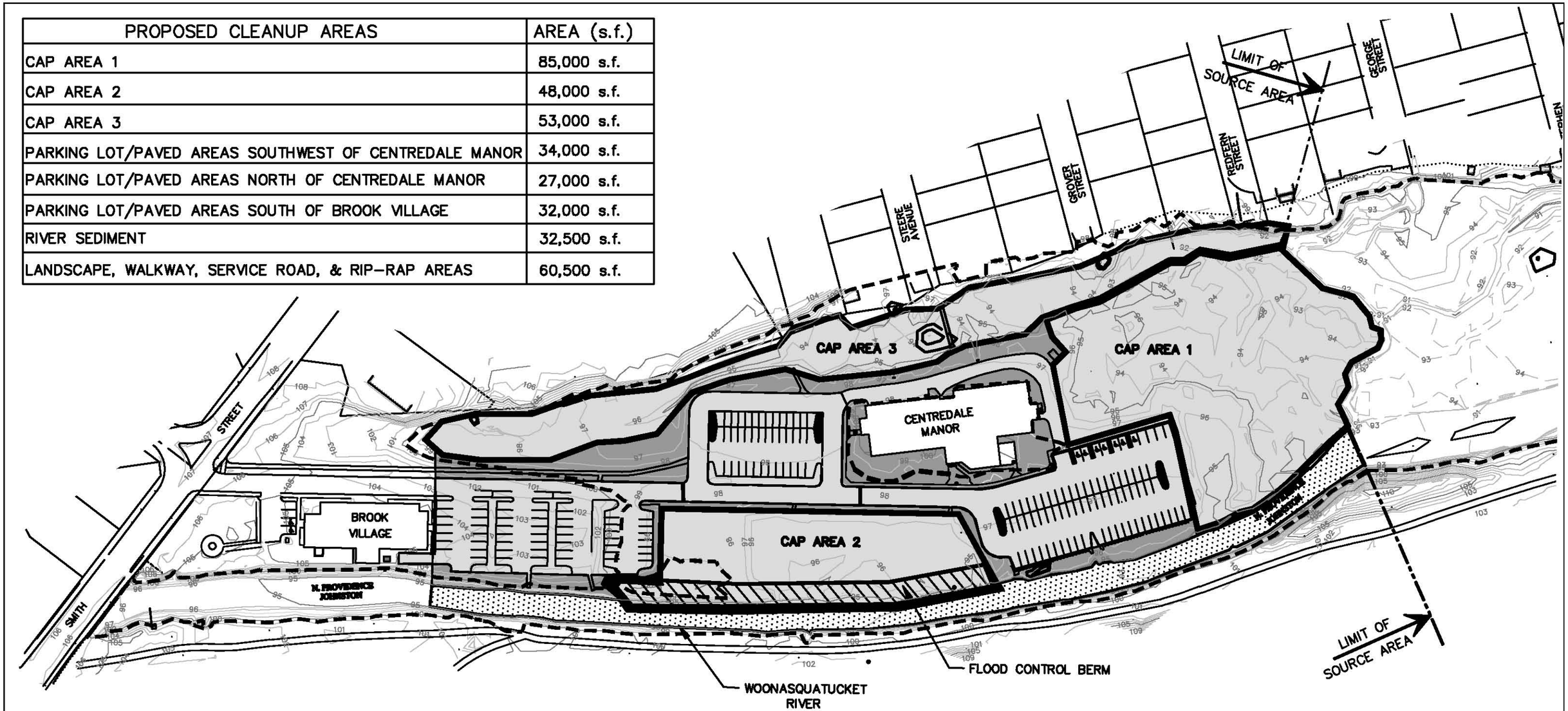
Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

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PROPOSED CLEANUP AREAS	AREA (s.f.)
CAP AREA 1	85,000 s.f.
CAP AREA 2	48,000 s.f.
CAP AREA 3	53,000 s.f.
PARKING LOT/PAVED AREAS SOUTHWEST OF CENTREDALE MANOR	34,000 s.f.
PARKING LOT/PAVED AREAS NORTH OF CENTREDALE MANOR	27,000 s.f.
PARKING LOT/PAVED AREAS SOUTH OF BROOK VILLAGE	32,000 s.f.
RIVER SEDIMENT	32,500 s.f.
LANDSCAPE, WALKWAY, SERVICE ROAD, & RIP-RAP AREAS	60,500 s.f.



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Scale: 0 120' 240' FEET

Figure 3-5

Explanation: SOURCE AREA SOIL AND RIVER SEDIMENT REMEDIAL FOOTPRINTS

- 90 EXISTING GROUND ELEVATION (FT)
- PROPOSED SOIL CLEANUP AREAS
- PROPOSED SOIL CLEANUP AREAS (LANDSCAPE AREAS)
- PROPOSED RIVER SEDIMENT CLEANUP AREA
- 100 YR FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT LIMIT OF THE SOURCE AREA)

Date: 02/26/10

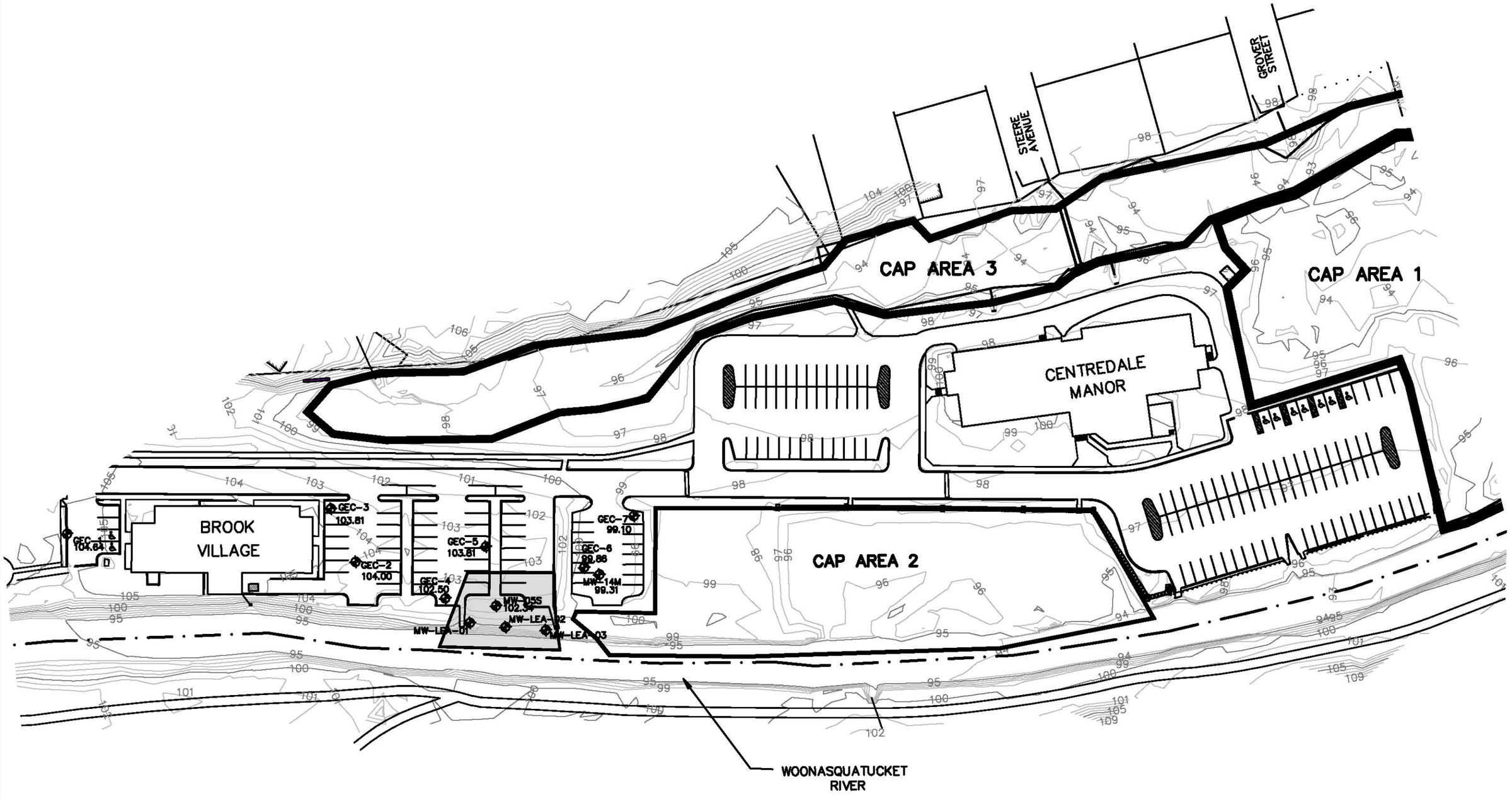
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Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

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Scale: SCALE: 1"=80' (0, 80, 160)

Figure 3–6

Explanation: SOURCE AREA GROUNDWATER REMEDIAL FOOTPRINT

- 90 EXISTING GROUND ELEVATION (ft)
- EXISTING GROUNDWATER MONITORING WELL
- PROPOSED CLEANUP AREA

RHODE ISLAND STATE PLANE

Date: 5/20/09

Document: Fig 3–6.dwg

Drawn By: S. Brown (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT

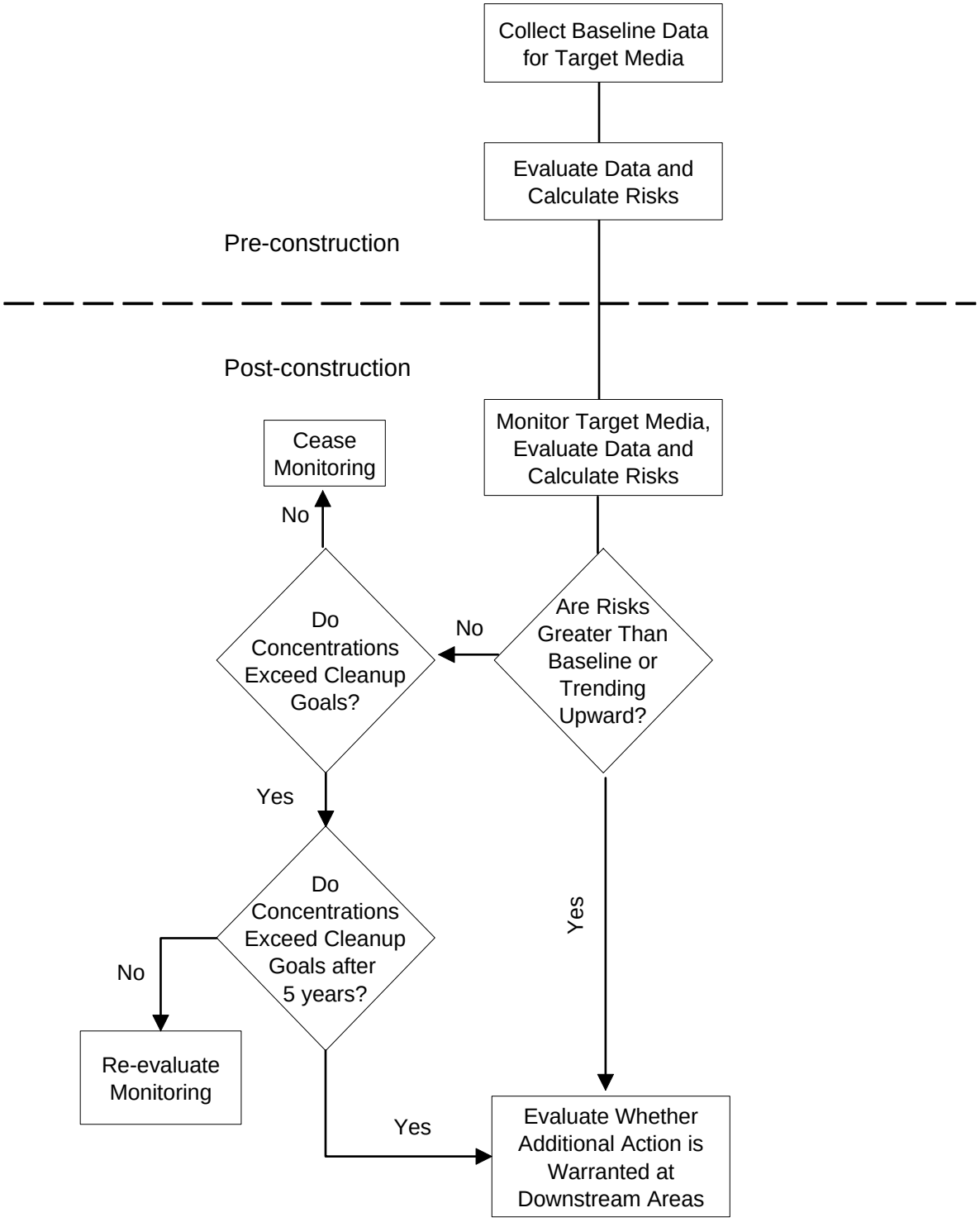
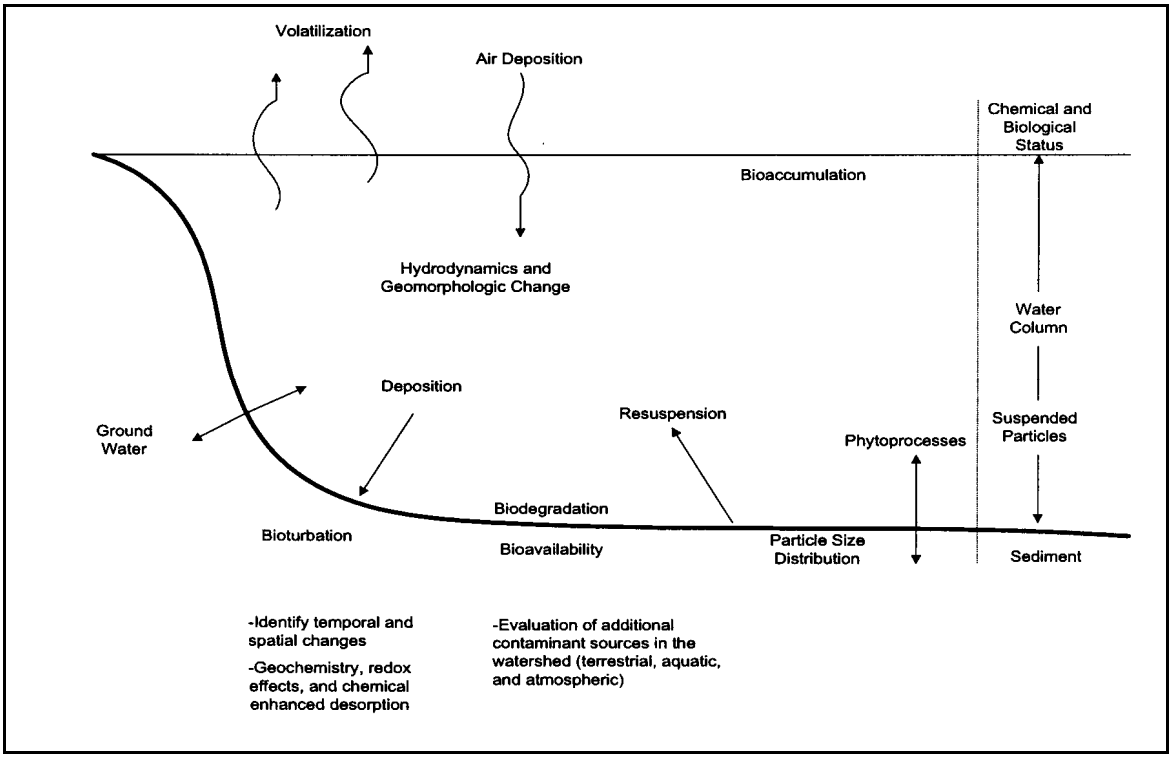


Figure 3-7. Adaptive Management Decision Tree to Address Contaminated Sediments in Downstream Areas

US EPA ARCHIVE DOCUMENT



Source: USEPA (2002a)

Figure 4-1. Example Natural Processes for Consideration of Monitored Natural Recovery

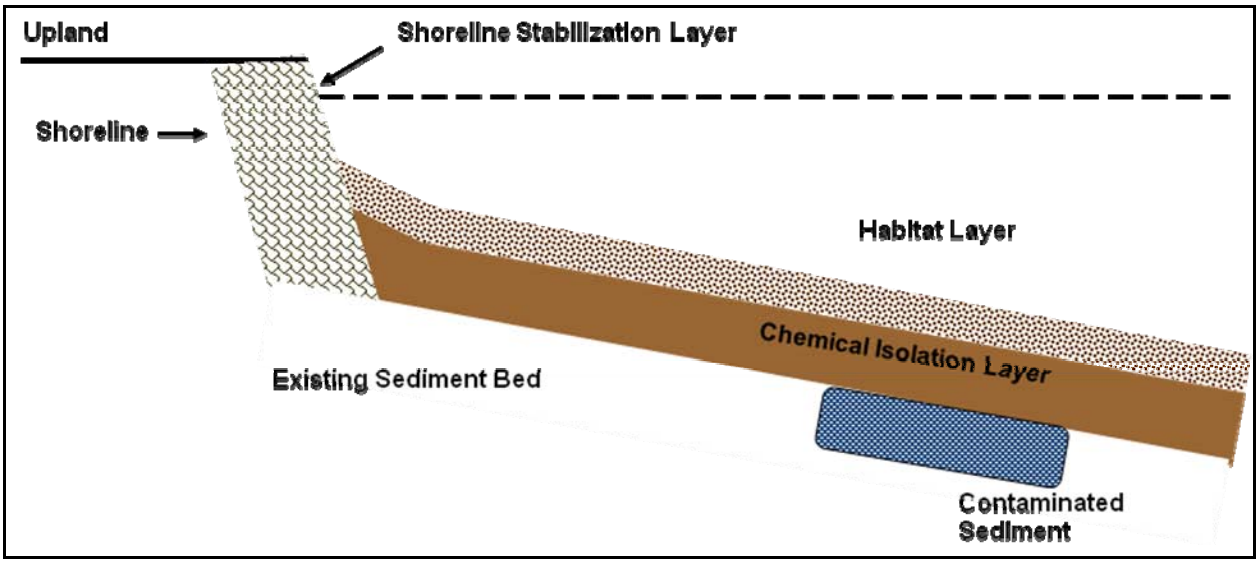


Figure 4-2. Example Cross-section for an Isolation Cap Placed Along a Shoreline

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Figure 4-3. Typical Enclosed Environmental Dredging Bucket

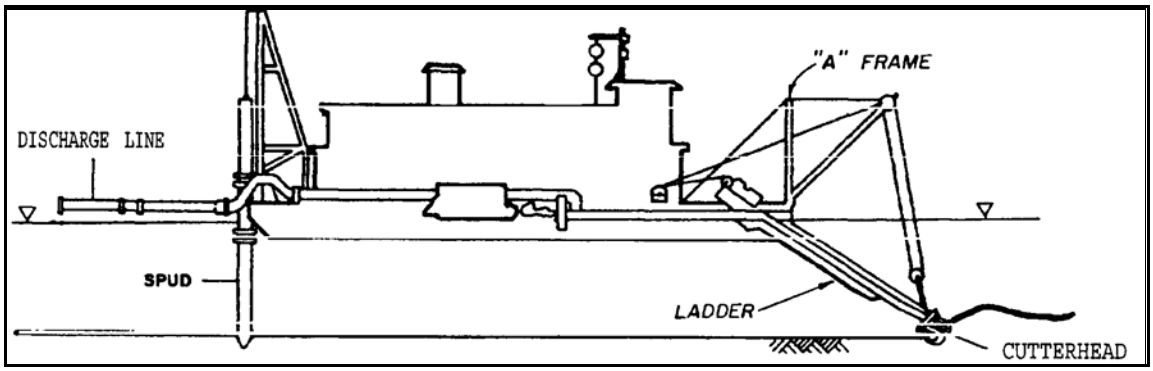


Figure 4-4. Typical Hydraulic Dredge and Pipeline Transport System

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Figure 4-5. Photograph of an Example Cofferdam

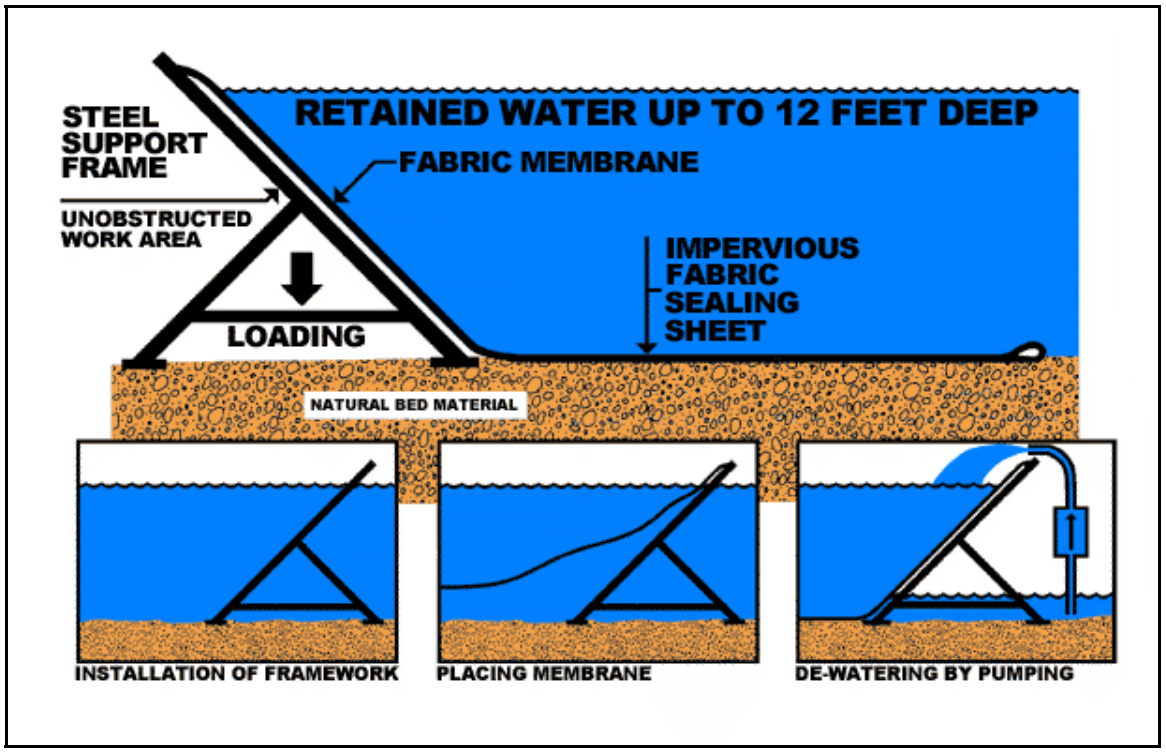


Figure 4-6. Diagram of a Portable Dam used to Contain Water

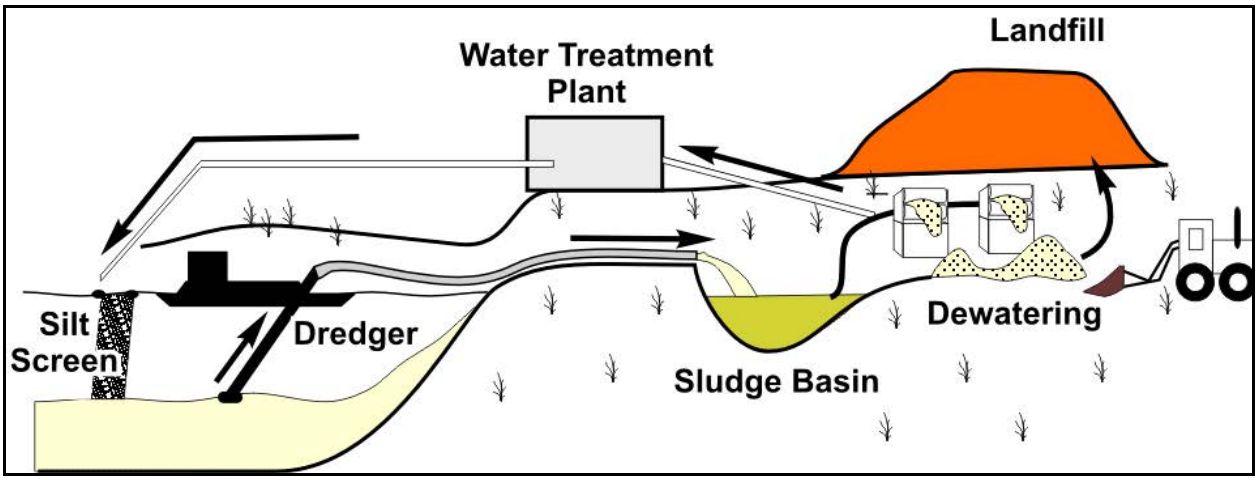


Figure 4-7. Example of a Typical Dredging, Dewatering, and Water Treatment System

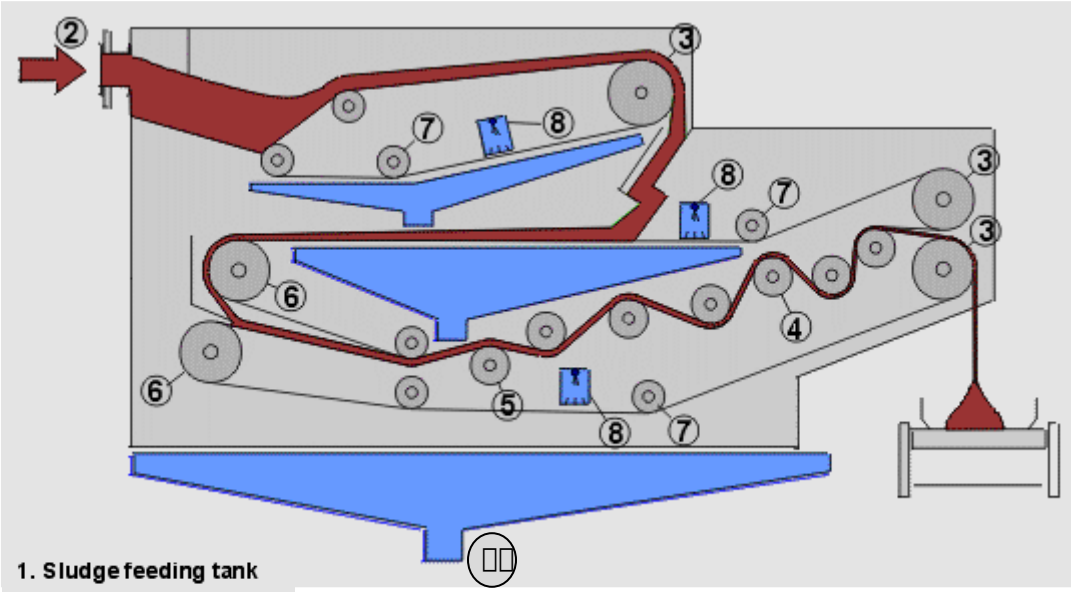


Figure 4-8. Schematic of a Typical Belt Dewatering Process

US EPA ARCHIVE DOCUMENT

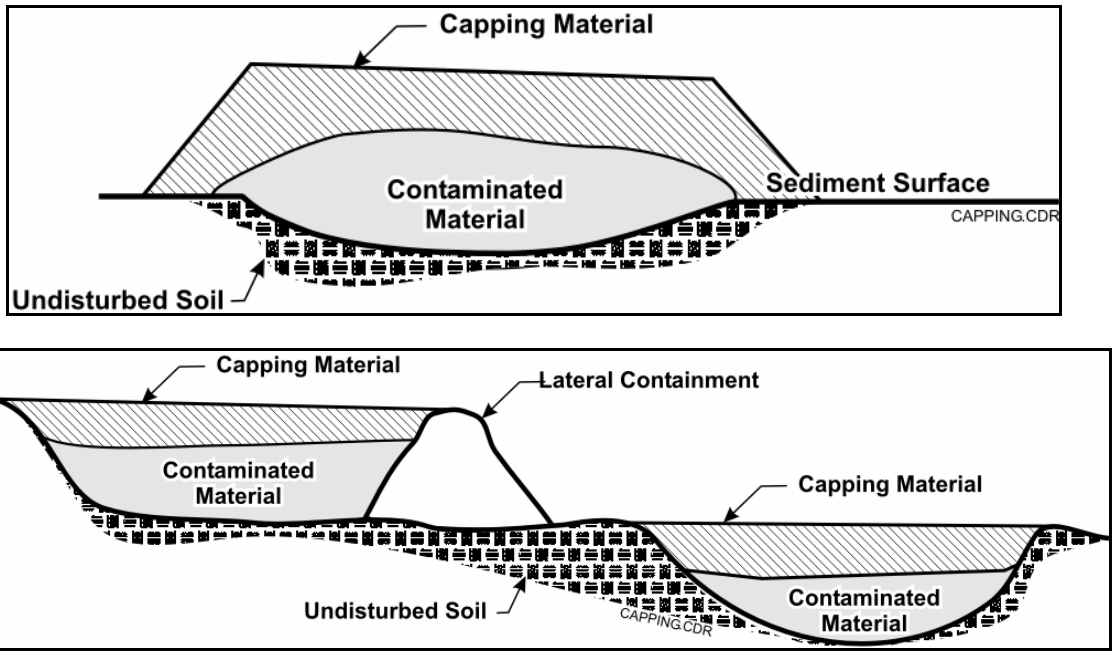


Figure 4-9. Typical CAD Designs

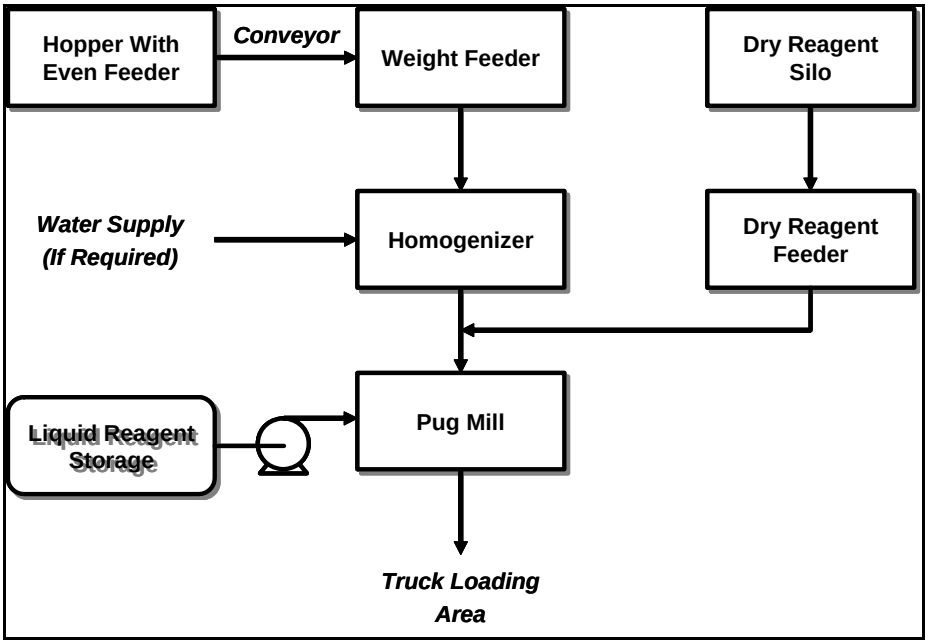


Figure 4-10. Schematic of the Ex-situ Stabilization Process used to Treat Sediment or Soil

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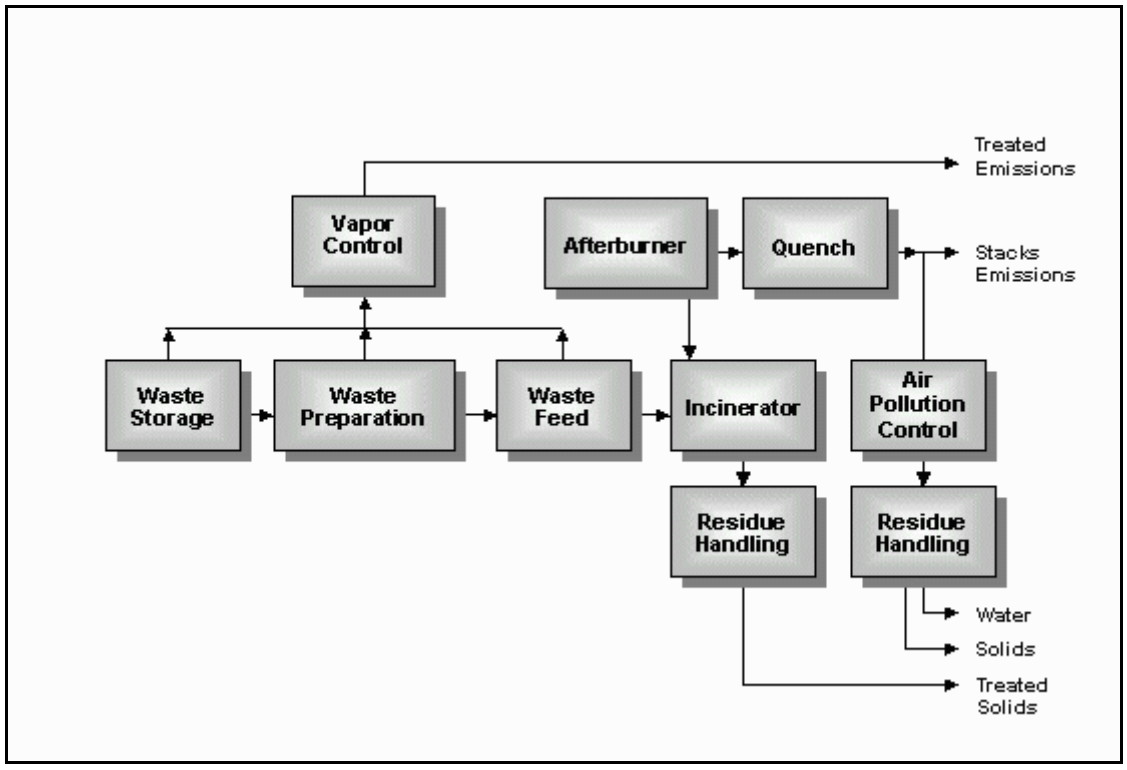


Figure 4-11. Schematic of a Typical Incineration Process

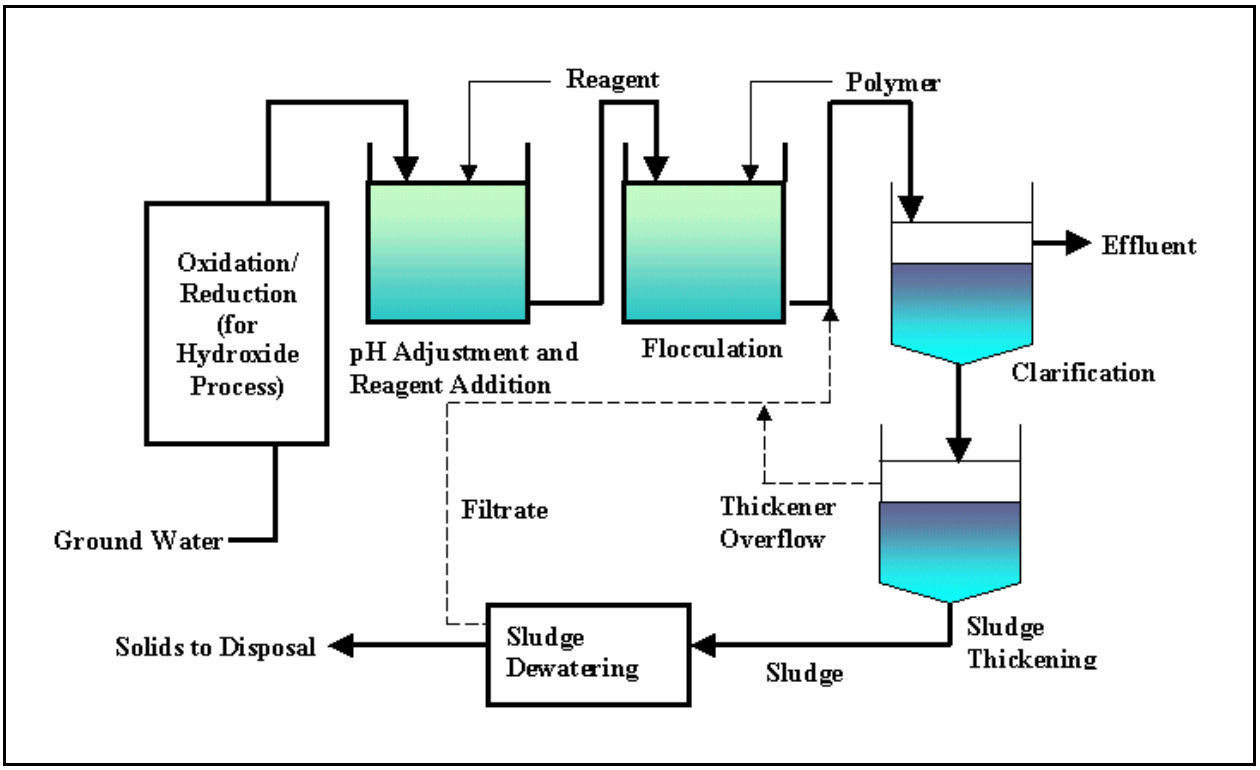


Figure 4-12. Schematic of a Precipitation Process used to Treat Extracted Groundwater

US EPA ARCHIVE DOCUMENT

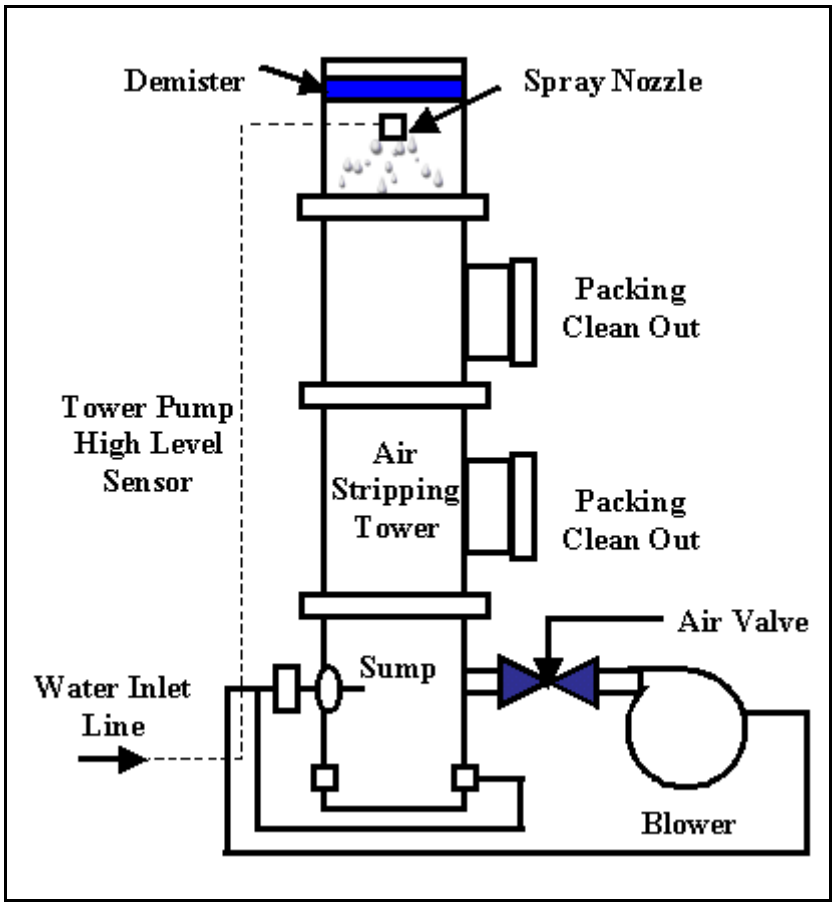


Figure 4-13. Schematic of a Air Stripping Process used to Treat Extracted Groundwater

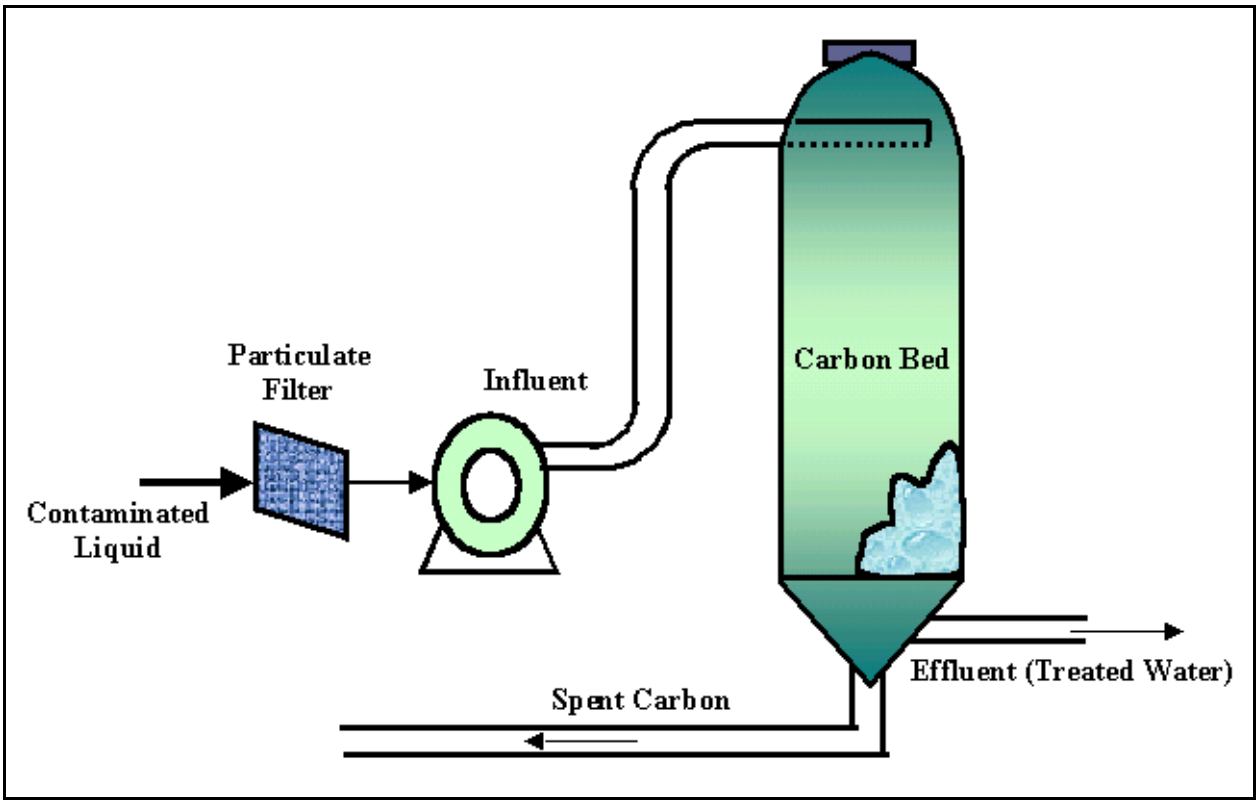


Figure 4-14. Schematic of an Activated Carbon Adsorption Process used to Treat Extracted Groundwater

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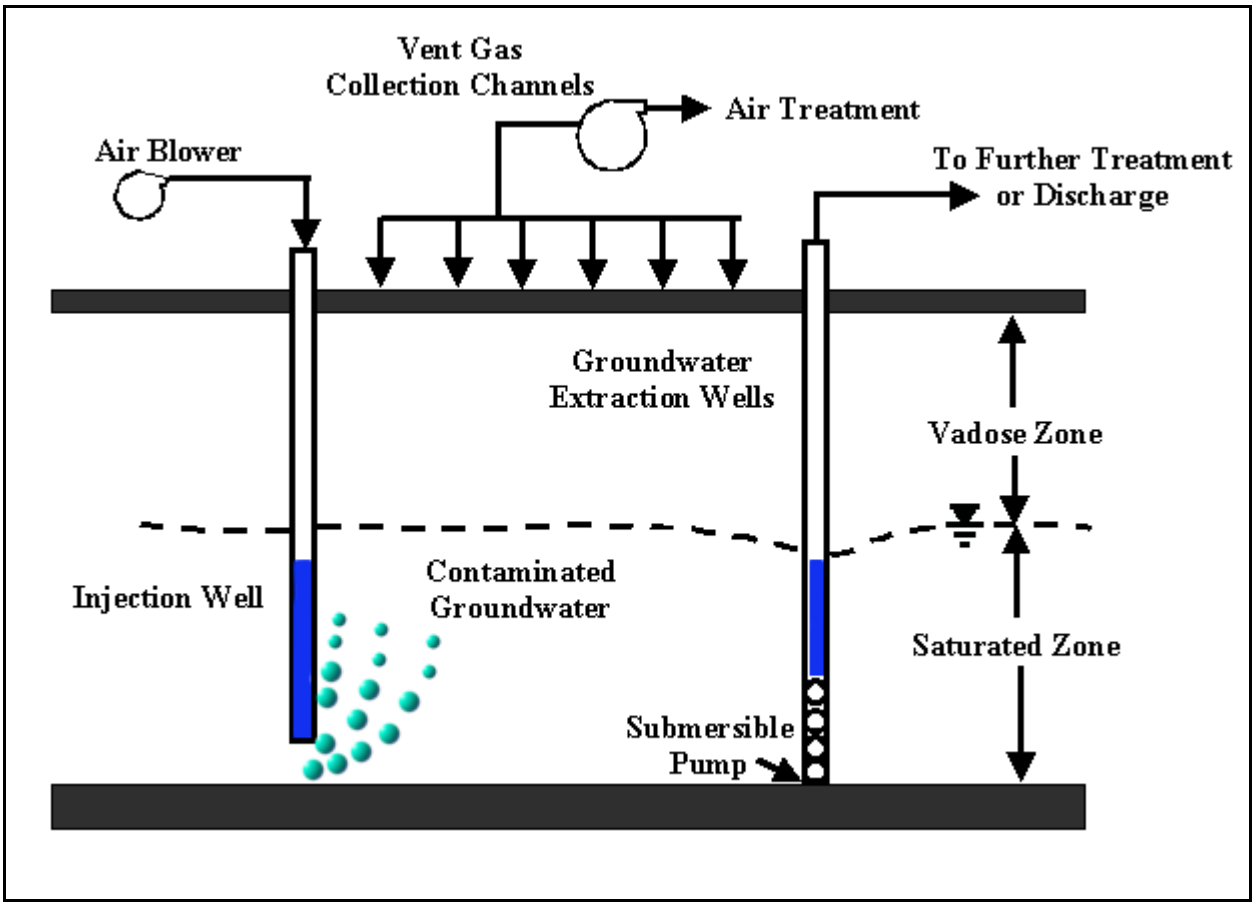


Figure 4-15. Schematic of an Air Sparging Process used for In-situ Treatment of Groundwater

US EPA ARCHIVE DOCUMENT

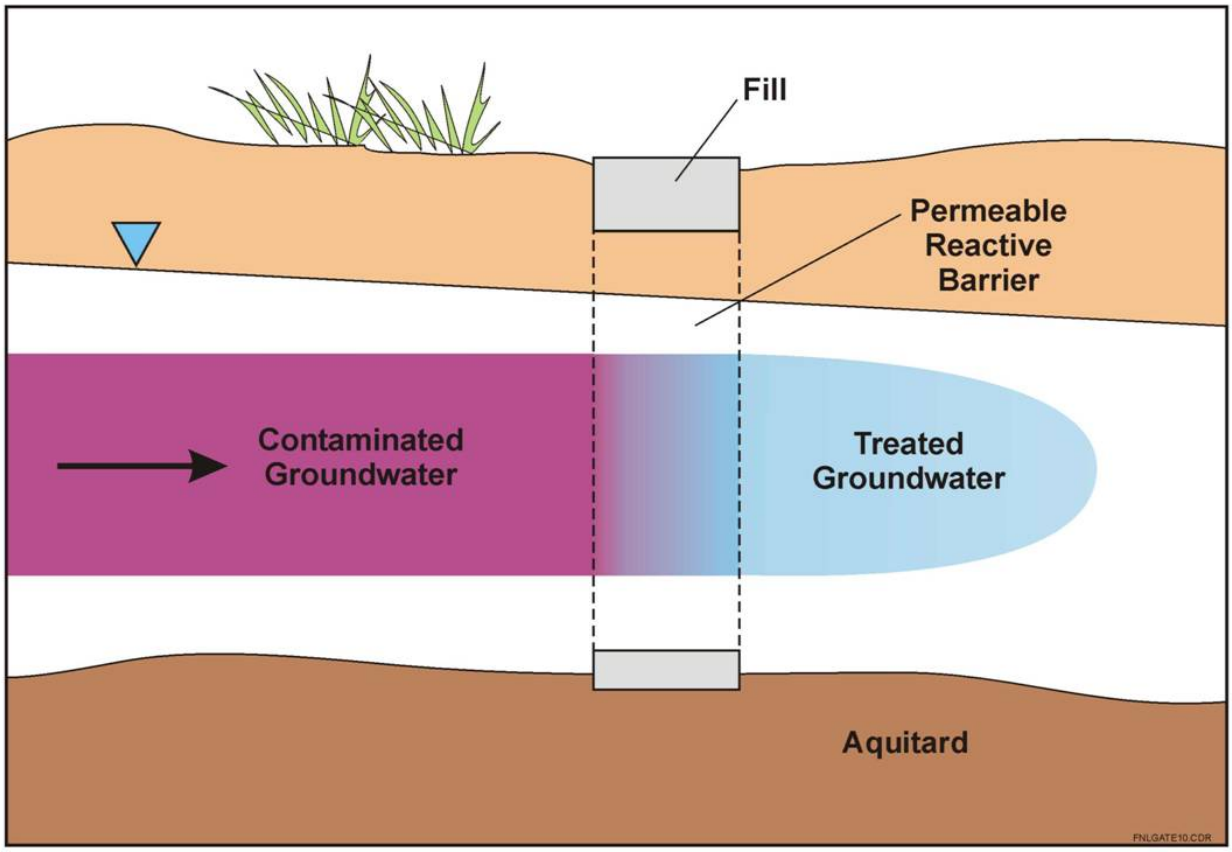
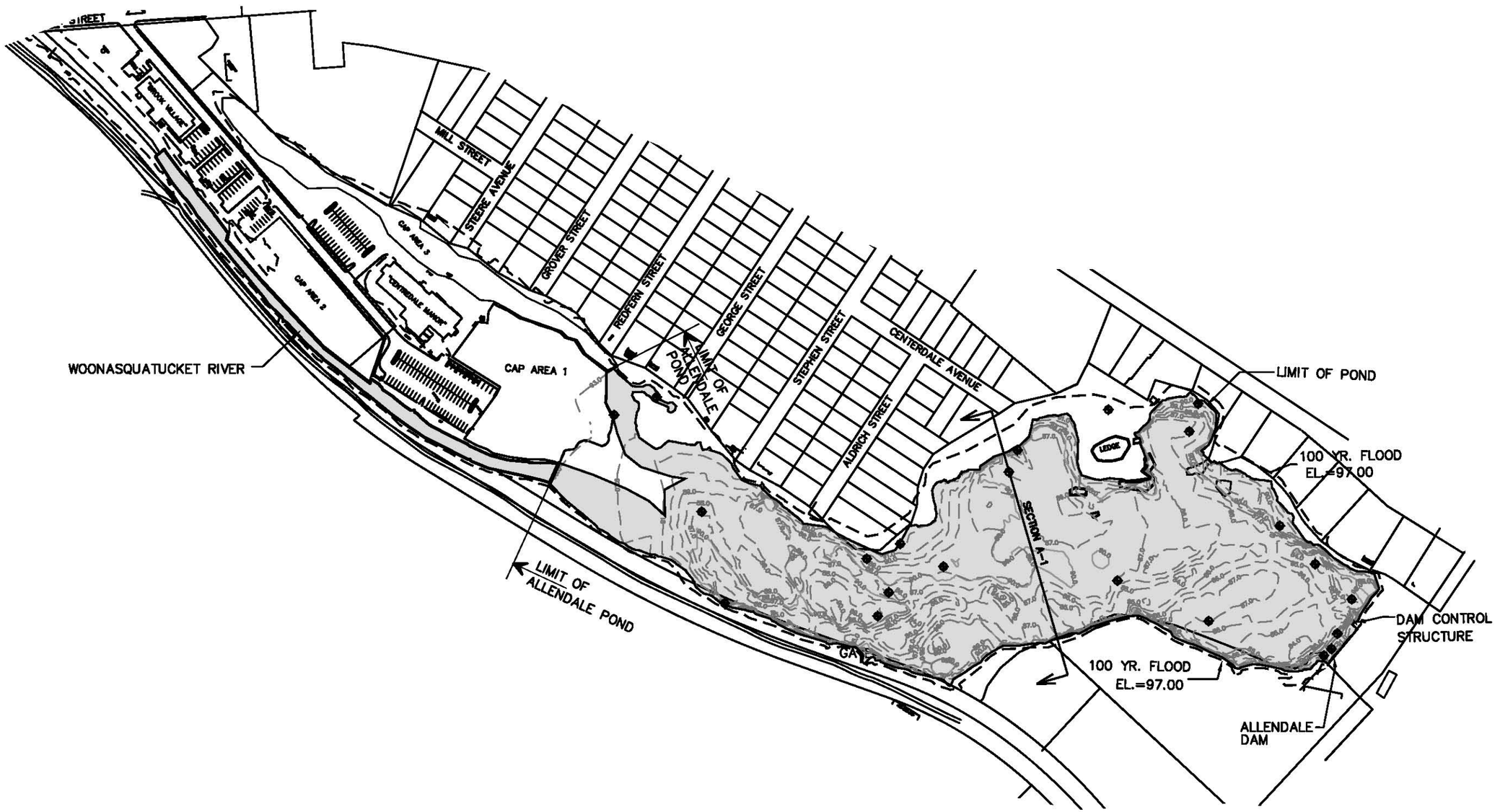


Figure 4-16. Conceptual Illustration of a Permeable Reactive Barrier

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Scale: 0 250' 500' FEET

Figure 5–1

Explanation:

ALLENDALE REACH SEDIMENT CONCEPTUAL REMEDIATION ALTERNATIVE

- PROPOSED POND BOTTOM AFTER SEDIMENT REMOVAL
- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT LIMIT OF SOURCE AREA)
- SEDIMENT CORES
- PROPOSED CLEAN UP AREA

Date: 02/26/10

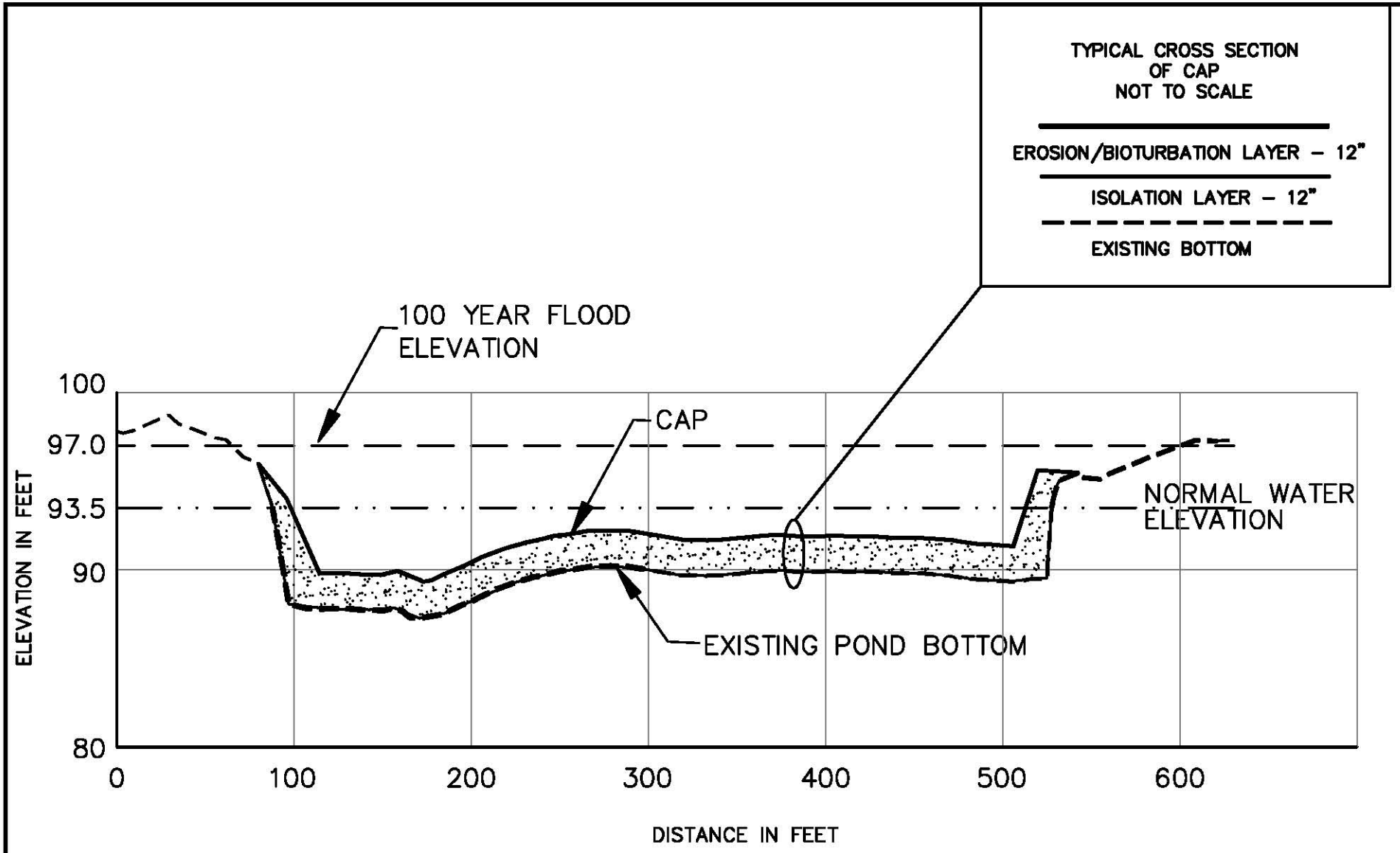
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Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

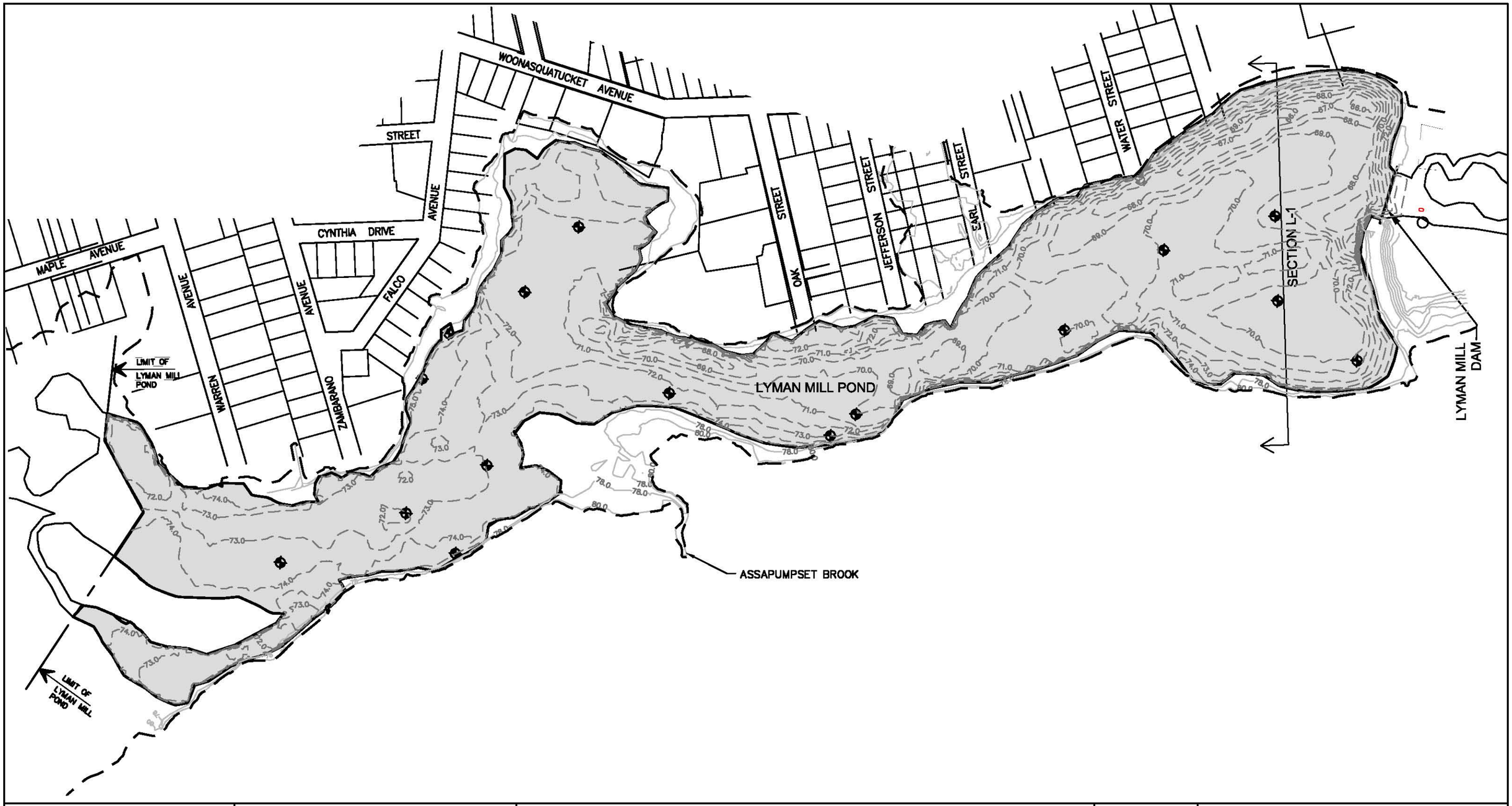
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle	Scale: 1"=80' HORIZONTAL 1"=8' VERTICAL	Explanation: SECTION A–1 CROSS SECTION OF AN ISOLATION CAP		Document: Fig 5–2_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5–2			Date: 02/26/10	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 200 400 FEET

Figure 5–3

Explanation: LYMAN MILL REACH SEDIMENT CONCEPTUAL REMEDIATION ALTERNATIVE

- PROPOSED POND BOTTOM AFTER SEDIMENT REMOVAL
- NORMAL WATER ELEVATION (EL=77.0')
- 100 YR. FLOOD ELEVATION (EL=80.6')
- SEDIMENT CORES
- PROPOSED CLEANUP AREA

RHODE ISLAND STATE PLANE

Date: 02/26/10

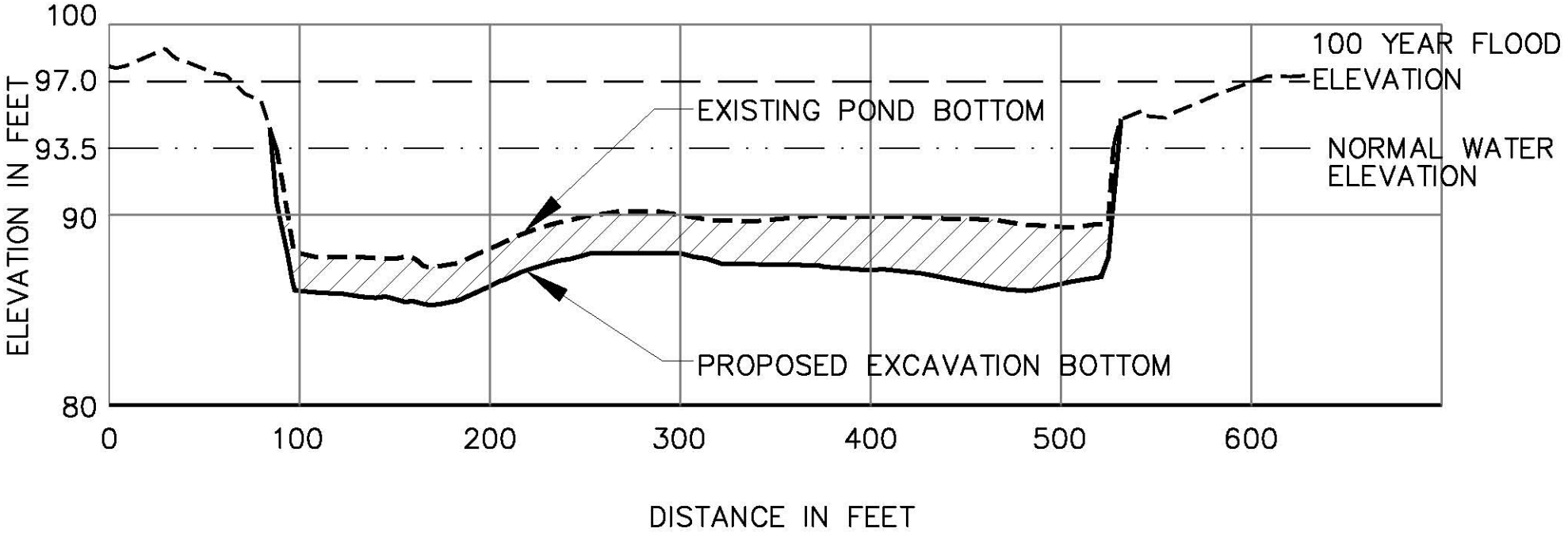
Document: FIG 5-3_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

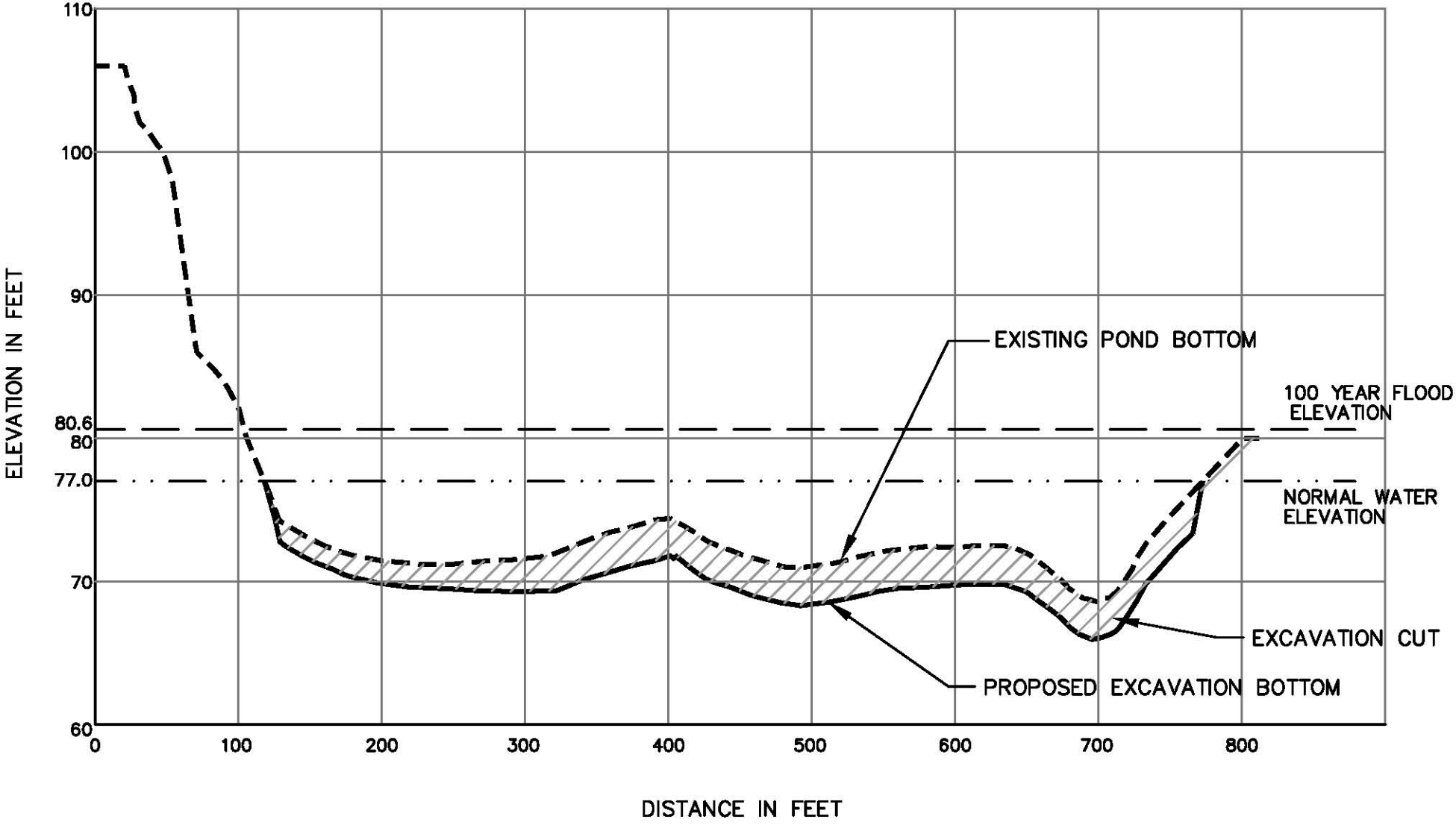
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



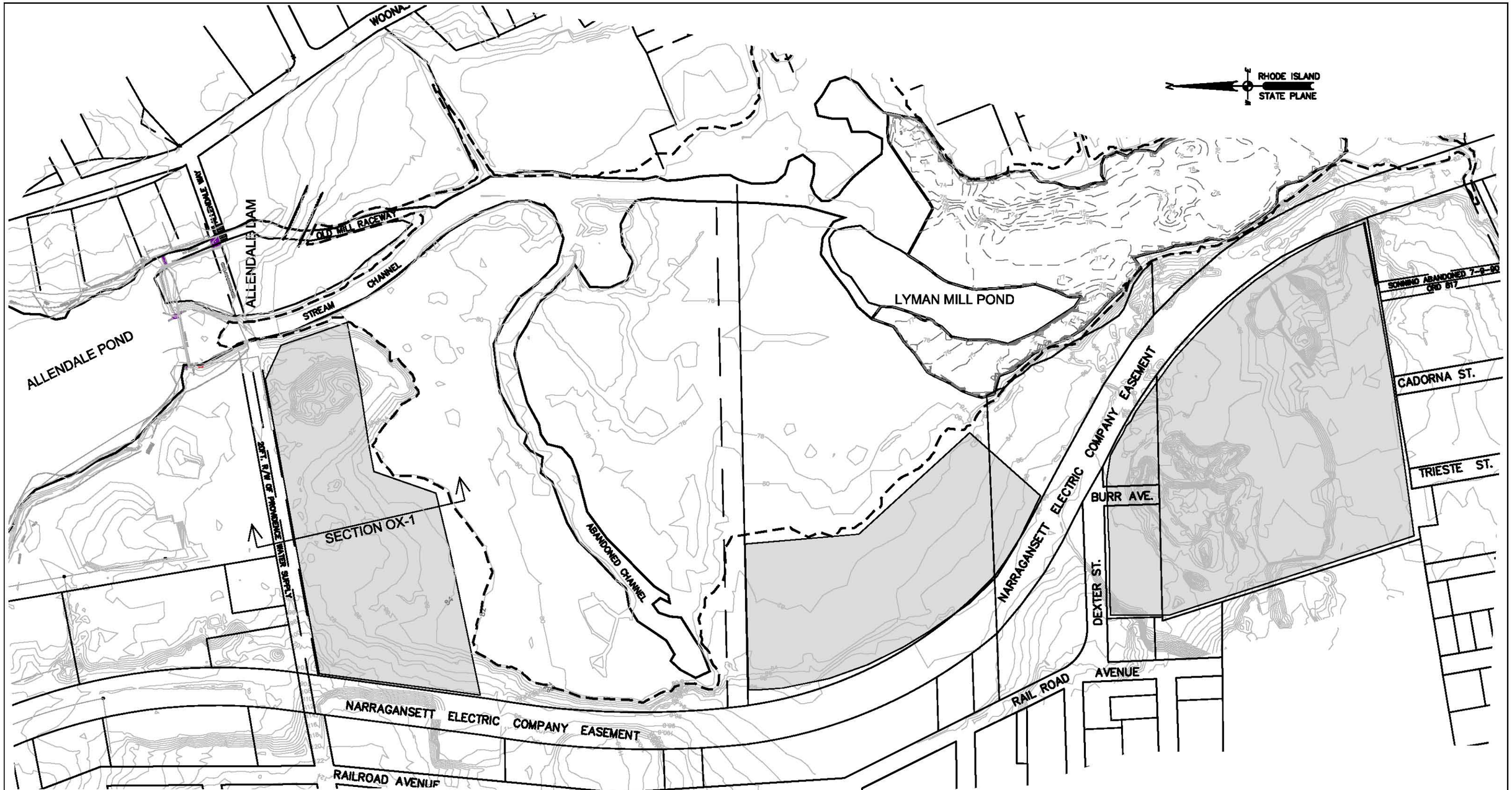
Battelle	Scale: 1"=80' HORIZONTAL 1"=8' VERTICAL	Explanation: SECTION A–1 ALLENDALE REACH SEDIMENT CONCEPTUAL REMOVAL ALTERNATIVE		Document: Fig 5–4.dwg
				Drawn By: J. Hannaford (Watermark)
Figure 5–4			Date: 11/5/07	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle	Scale: 1"=100' HORIZONTAL 1"=10' VERTICAL	Explanation: SECTION L–1 LYMAN MILL REACH SEDIMENT CONCEPTUAL REMOVAL ALTERNATIVE		Document: Fig 5–5.dwg
				Drawn By: J. Hannaford (Watermark)
Figure 5–5			Date: 11/5/07	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: SCALE: 1"=200'
0 200 400

Figure 5–6

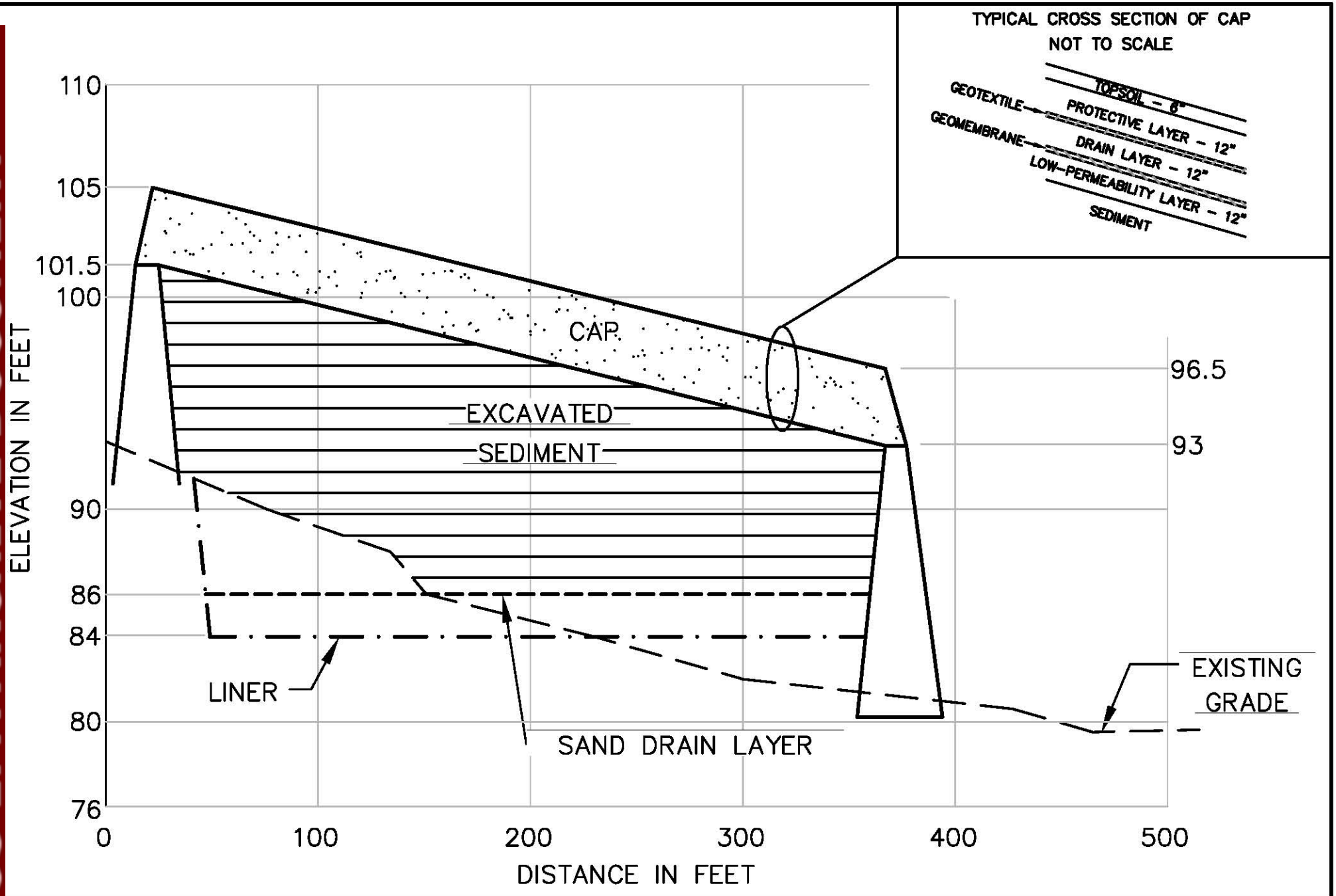
Explanation: POTENTIAL ON–SITE CDF AREAS

- EXISTING TOPOGRAPHY
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- POTENTIAL CDF LOCATION

Date: 4/9/09

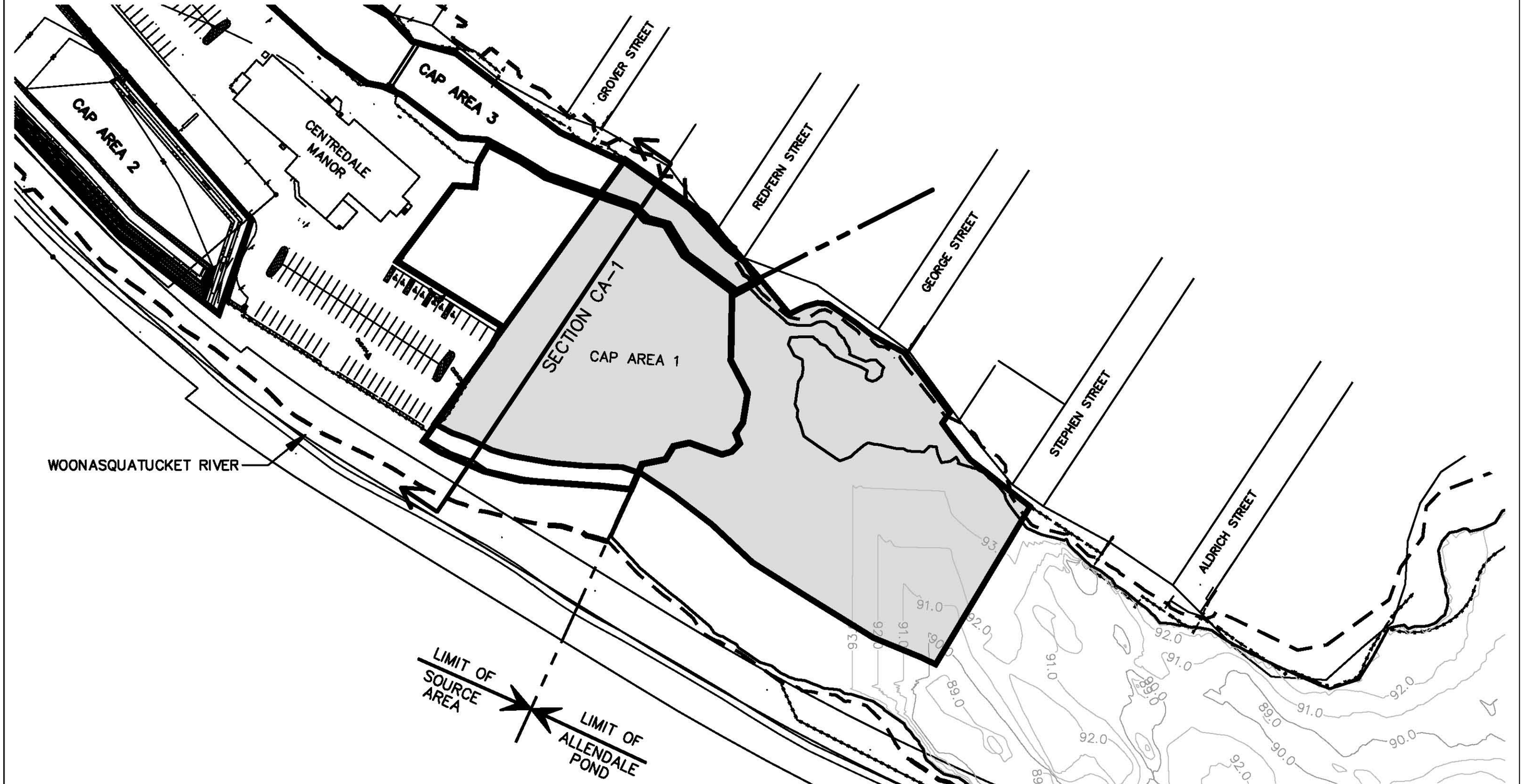
Document: Fig 5–6.dwg
Drawn By: S. Brown (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle	Scale: 1"=60' HORIZONTAL, 1"=6' VERTICAL	Explanation: SECTION OX-1 ON-SITE UPLAND CDF		Document: Fig 5-7_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5-7			Date: 02/19/10	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: SCALE: 1"=100'
0 100' 200'

Figure 5-8

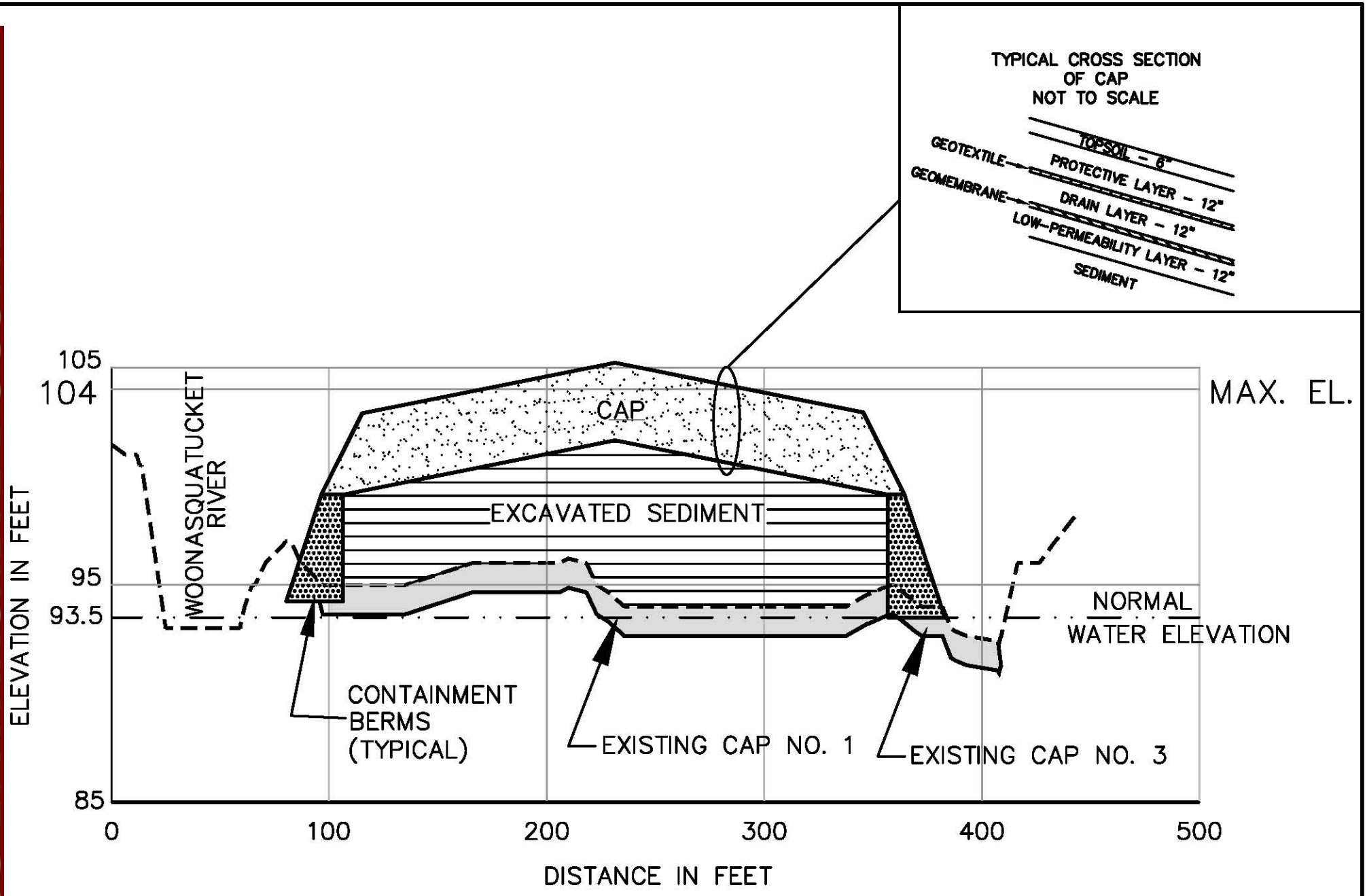
Explanation: POTENTIAL NEARSHORE CDF AREA

- EXISTING POND BOTTOM OR GROUND ELEVATION
- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT ALLENDALE DAM)
- FENCE
- POTENTIAL NEARSHORE CDF

Date: 5/28/09

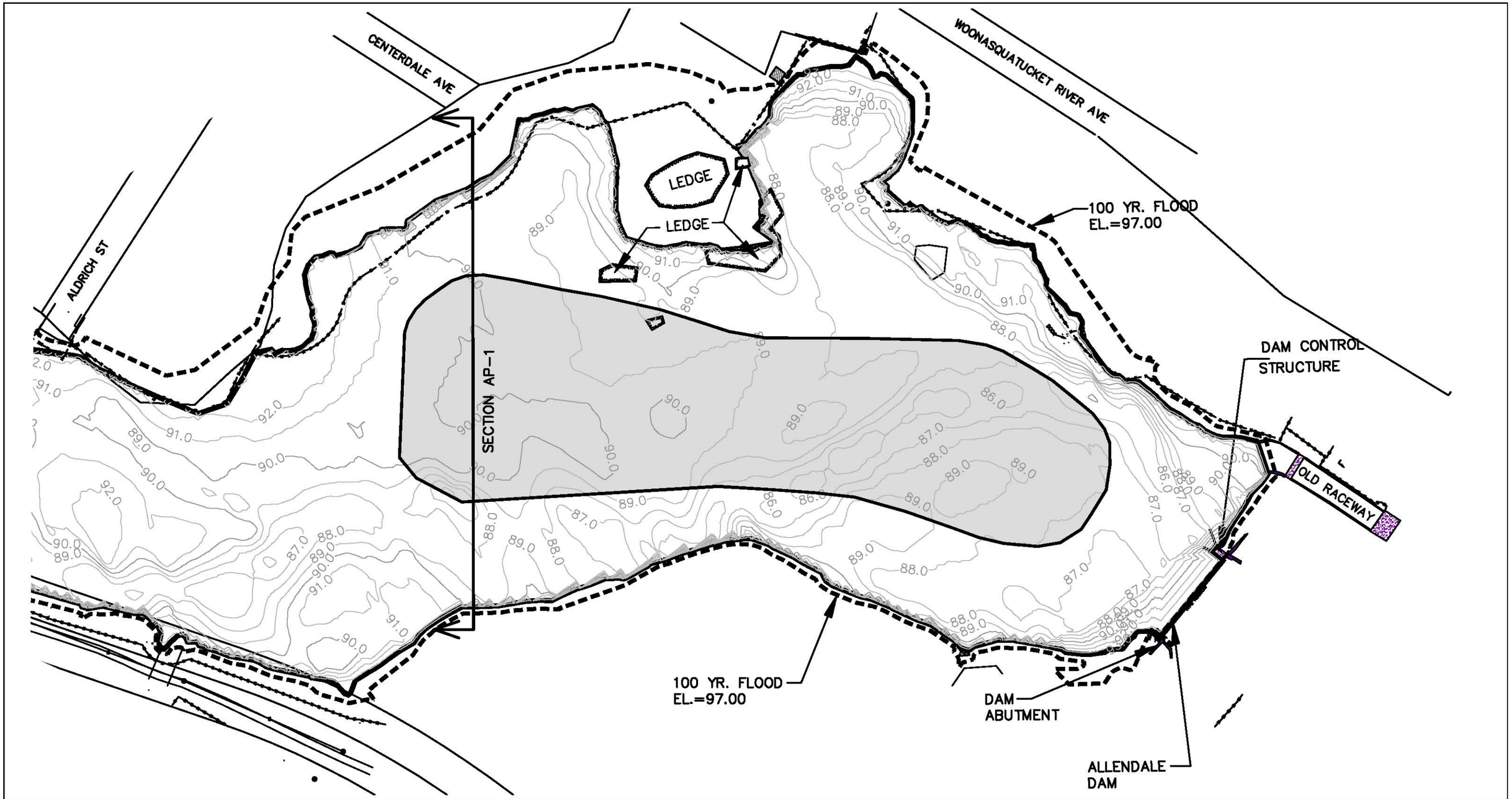
Document: Fig 5-8.dwg
Drawn By: S. Brown (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle	Scale: 1"=60' HORIZONTAL, 1"=6' VERTICAL	Explanation: SECTION CA-1 NEARSHORE CDF		Document: Fig 5-9_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5-9			Date: 02/26/10	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 100 200 FEET

Figure 5–10

Explanation: POTENTIAL ALLENDALE POND CDF AREA

- EXISTING POND BOTTOM ELEVATION
- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (EL=97.0')
- FENCE
- POTENTIAL ISLAND CDF AREA

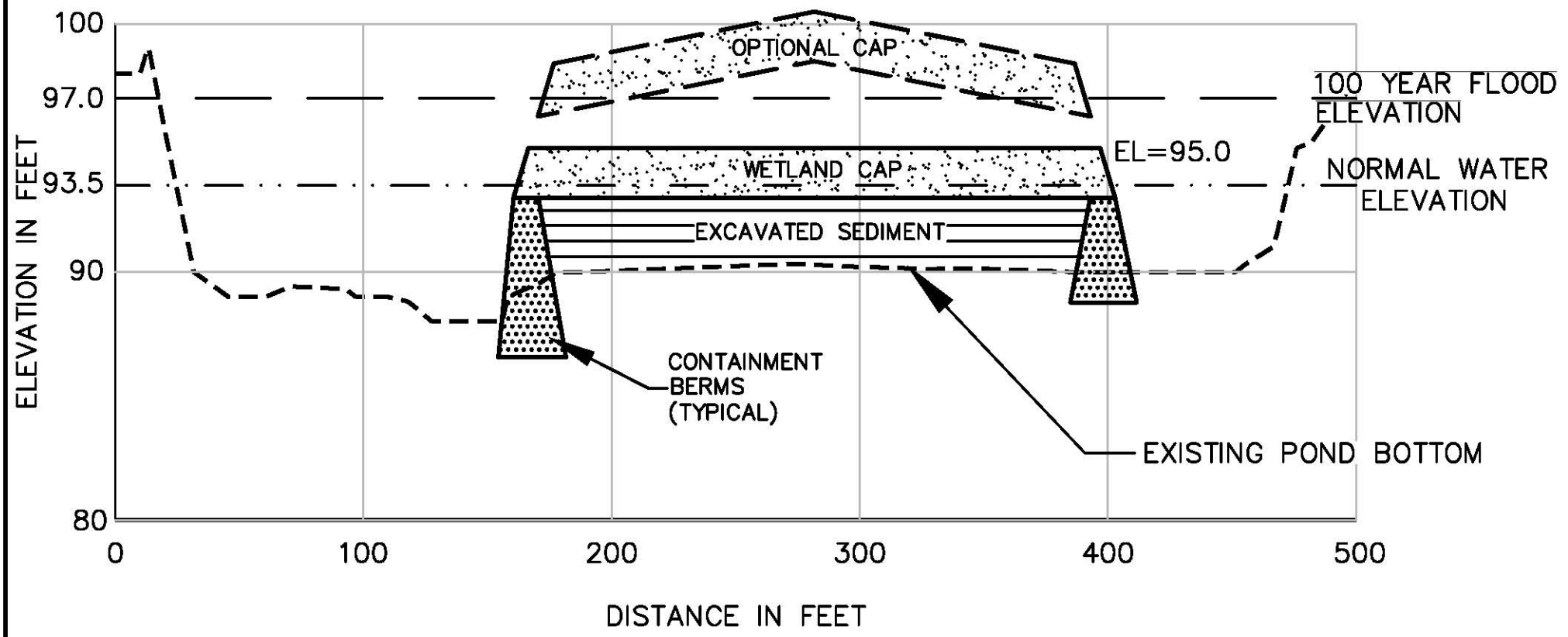
Date: 04/08/10

Document: Fig 5–10_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)



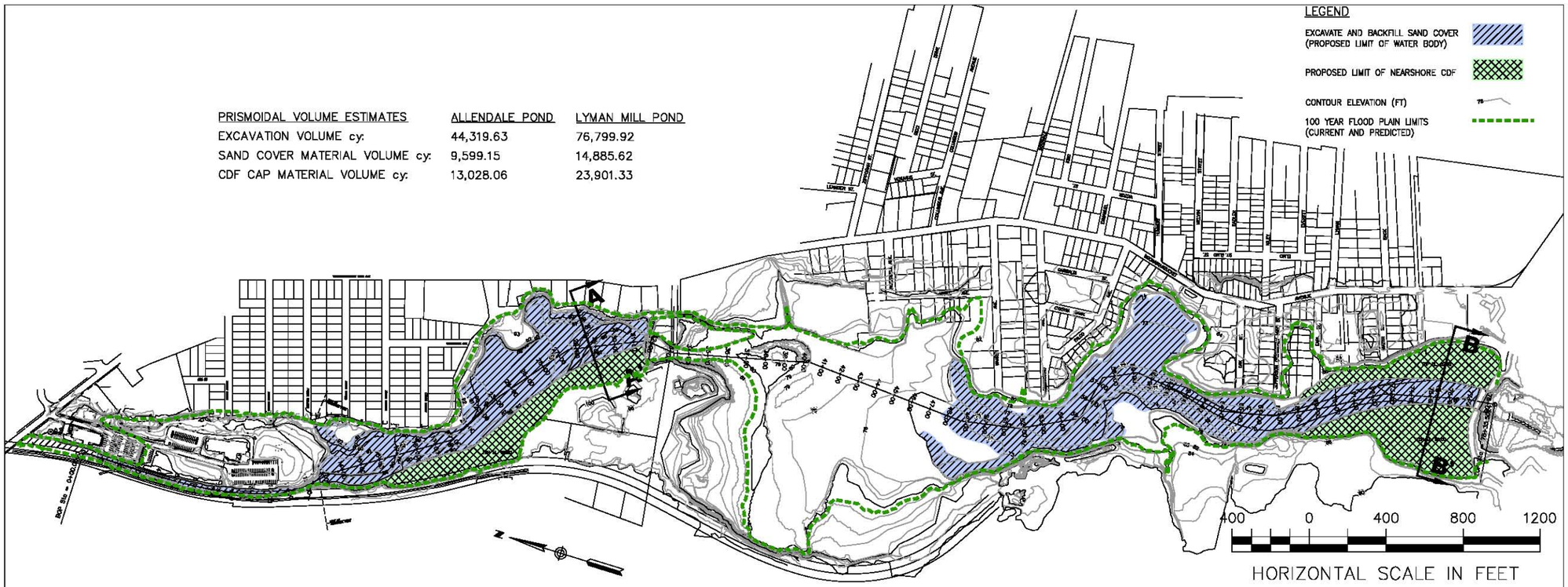
Battelle	Scale: 1"=60' HORIZONTAL 1"=6' VERTICAL	Explanation: SECTION AP–1 ALLENDALE POND CDF		Document: Fig 5–11_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5–11			Date: 02/12/10	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT

PRISMOIDAL VOLUME ESTIMATES	ALLENDALE POND	LYMAN MILL POND
EXCAVATION VOLUME cy:	44,319.63	76,799.92
SAND COVER MATERIAL VOLUME cy:	9,599.15	14,885.62
CDF CAP MATERIAL VOLUME cy:	13,028.06	23,901.33

LEGEND

- EXCAVATE AND BACKFILL SAND COVER (PROPOSED LIMIT OF WATER BODY)
- PROPOSED LIMIT OF NEARSHORE CDF
- CONTOUR ELEVATION (FT)
- 100 YEAR FLOOD PLAIN LIMITS (CURRENT AND PREDICTED)



PROFILE
HORIZONTAL SCALE 1" =800'-0"
VERTICAL SCALE 1" = 20'-0"

400 0 400 800 1200
HORIZONTAL SCALE IN FEET

10 0 10 20 30
VERTICAL SCALE IN FEET

LEA

Scale: AS SHOWN

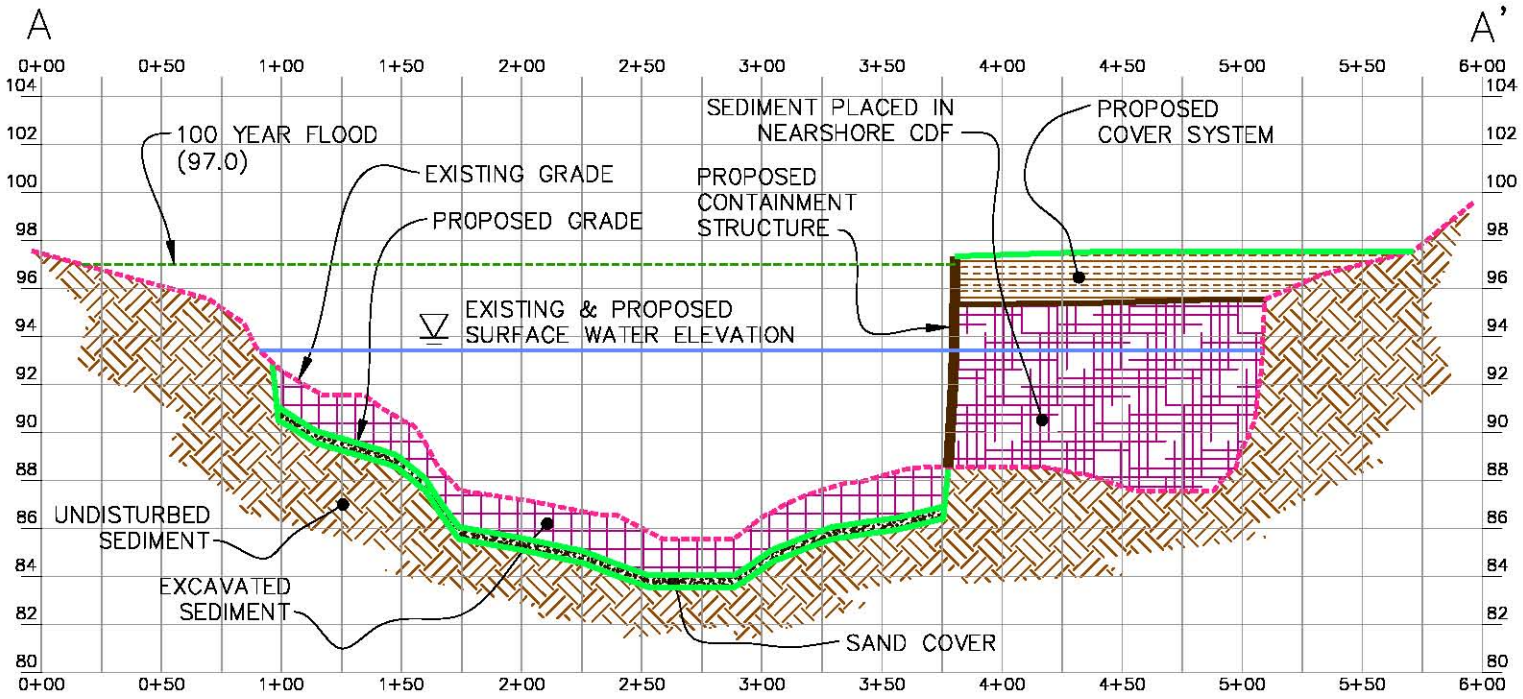
FIGURE 5-12

Explanation: ALTERNATIVE 7b
EXCAVATION AND CONTAINMENT
IN NEARSHORE CDF

Date: 04/08/10

Document: FIG
Drawn By: A.C.L.
Checked By: D.N.S.
Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

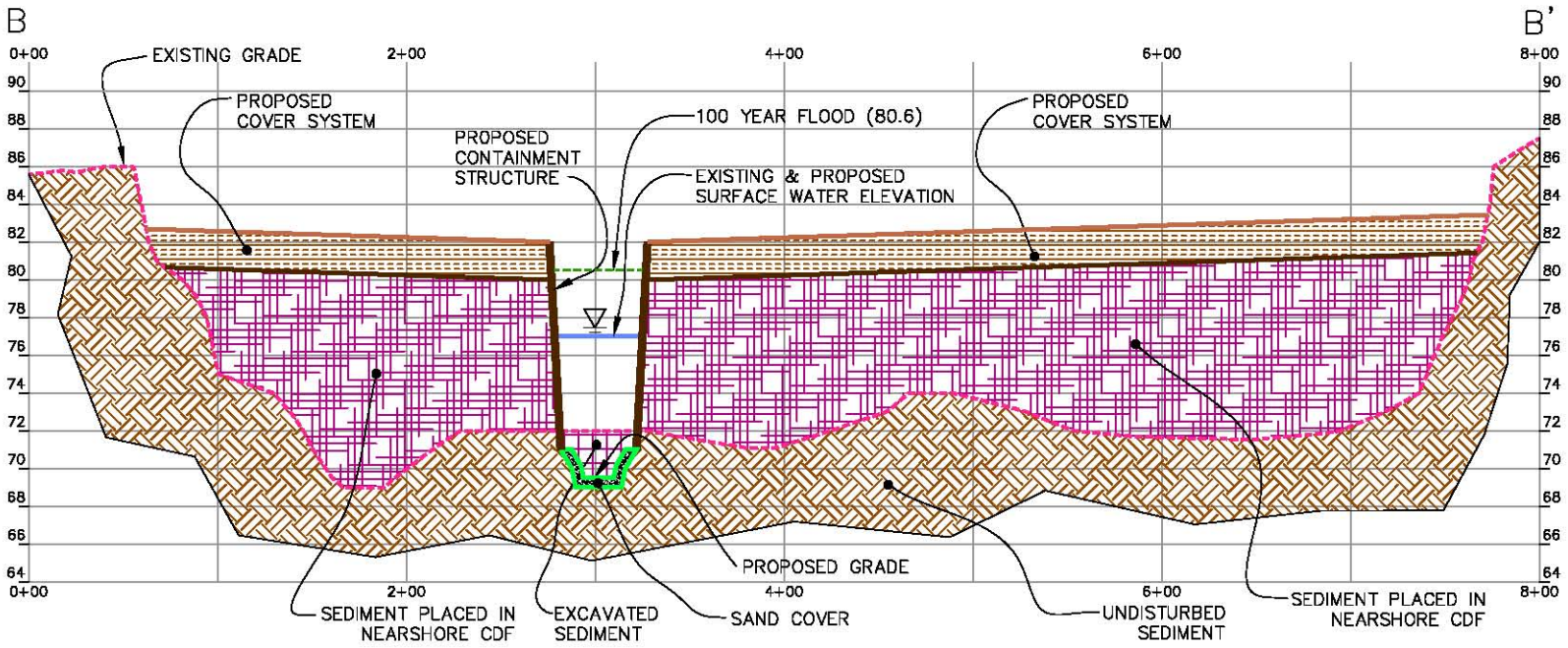
US EPA ARCHIVE DOCUMENT



SECTION A–A'
HORIZONTAL SCALE 1" = 80'–0"
VERTICAL SCALE 1" = 8'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 7b EXCAVATION AND CONTAINMENT IN NEARSHORE CDF SECTION A–A'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–13a			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

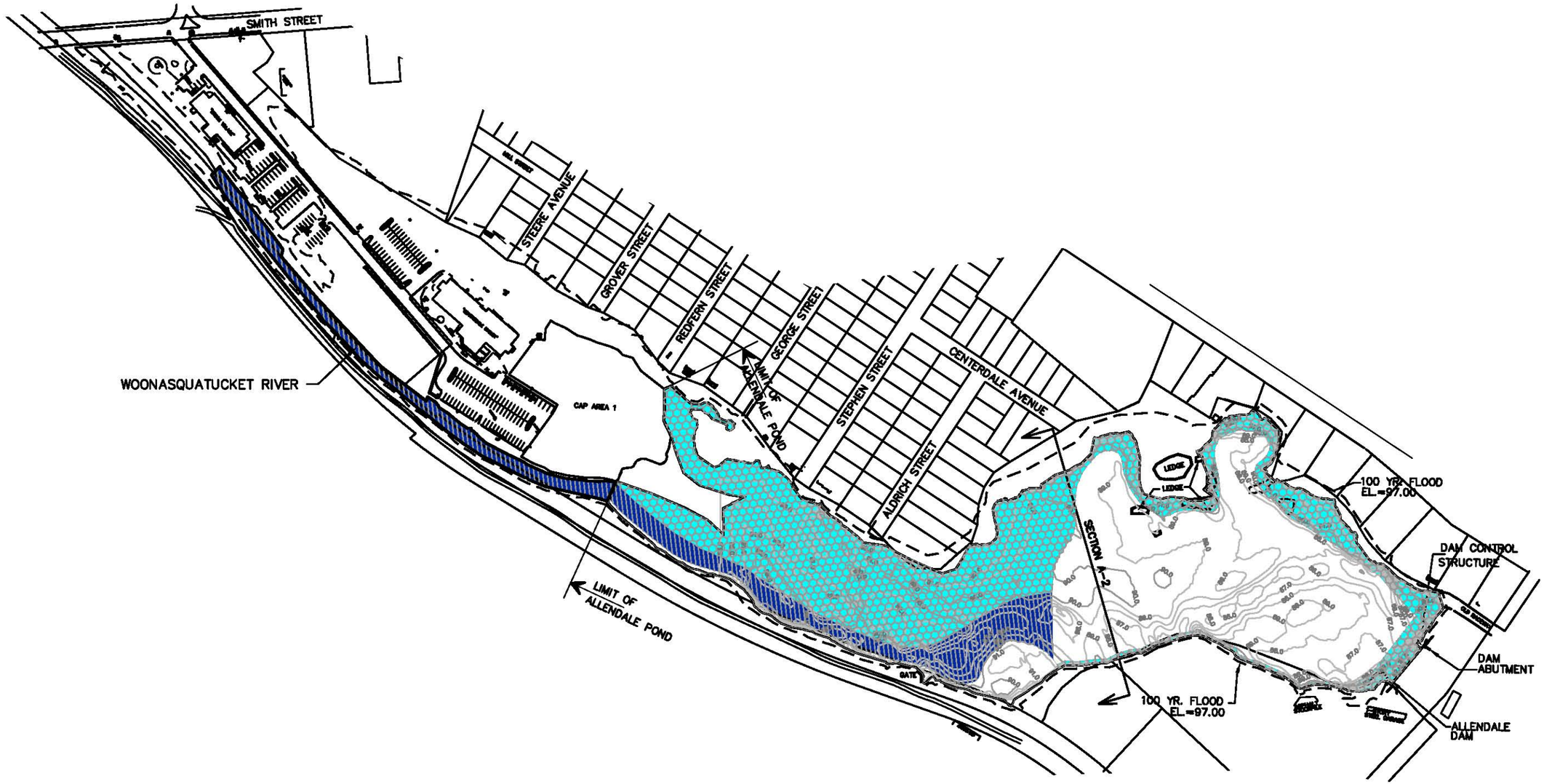
US EPA ARCHIVE DOCUMENT



SECTION B–B'
HORIZONTAL SCALE 1" = 100'–0"
VERTICAL SCALE 1" = 10'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 7b EXCAVATION AND CONTAINMENT IN NEARSHORE CDF SECTION B–B'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–13b			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 250 500 FEET

Figure 5–14

Explanation: CONCEPTUAL PARTIAL REMOVAL AND CAPPING ALTERNATIVE FOR ALLENDALE REACH SEDIMENT

- 90.0 EXISTING POND BOTTOM ELEVATION
- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (EL=97.0' at Allendale Dam)
- EXCAVATE FOR WATER DEPTH
- EXCAVATE FOR POTENTIAL SCOUR

Date: 02/26/10

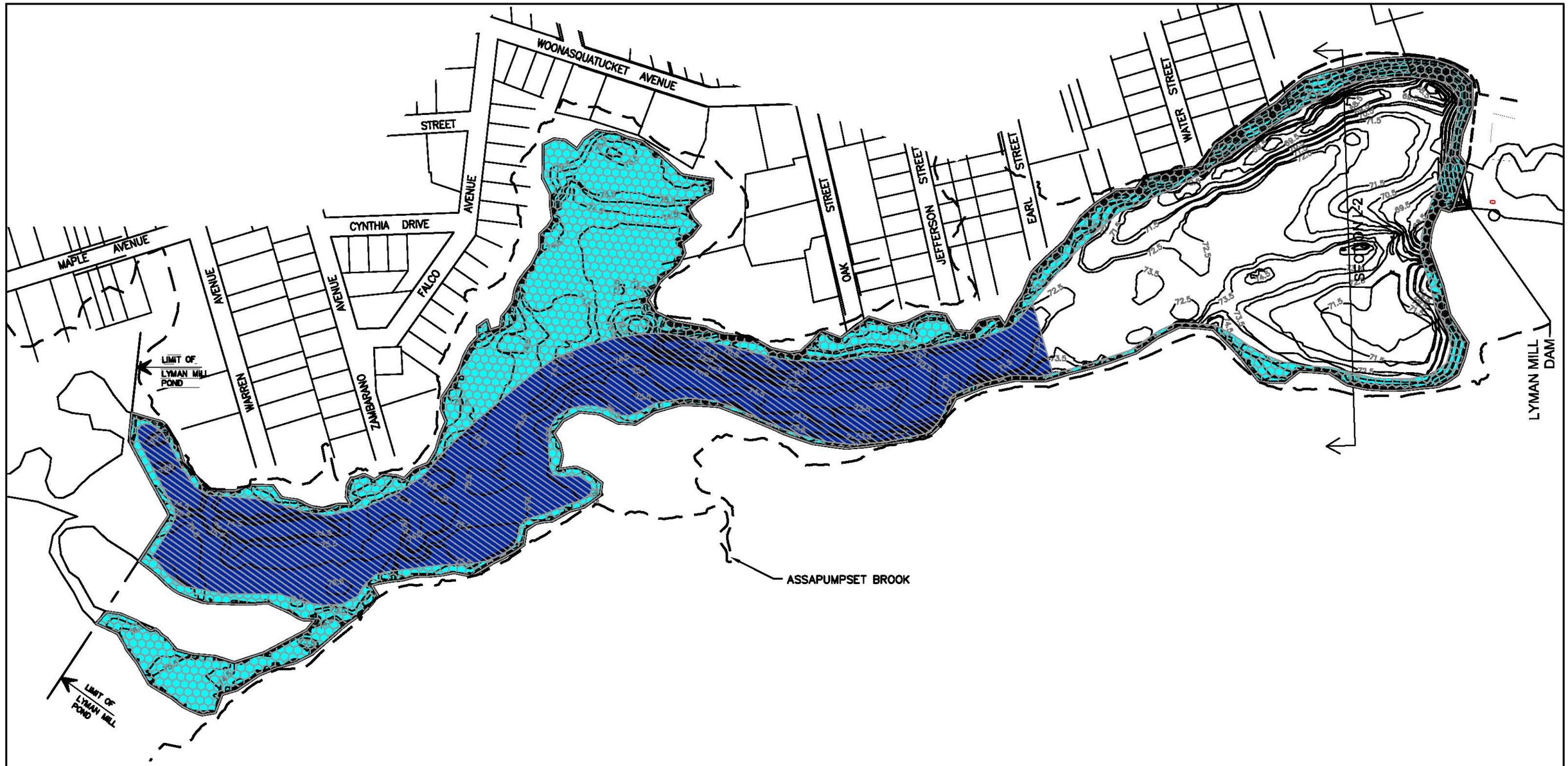
Document: Fig 5–14_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 200 400 FEET

Figure 5–15

Explanation: CONCEPTUAL PARTIAL REMOVAL AND CAPPING ALTERNATIVE FOR LYMAN MILL REACH SEDIMENT

- EXISTING POND BOTTOM ELEVATION
- NORMAL WATER ELEVATION (EL=77.0')
- 100 YR. FLOOD ELEVATION (EL=80.6')
- EXCAVATE FOR WATER DEPTH
- EXCAVATE FOR WATER DEPTH AND FOR POTENTIAL SCOUR

RHODE ISLAND STATE PLANE

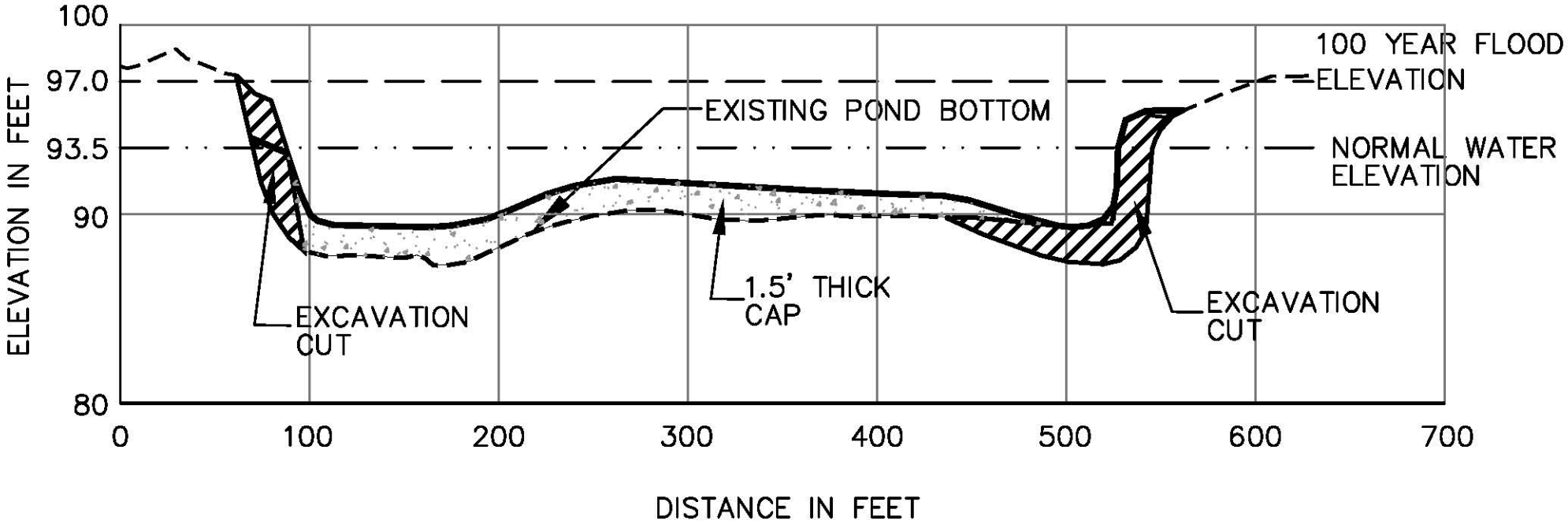
Date: 02/26/10

Document: Fig 5–15_REV0.dwg

Drawn By: L. Bouchard (Watermark)

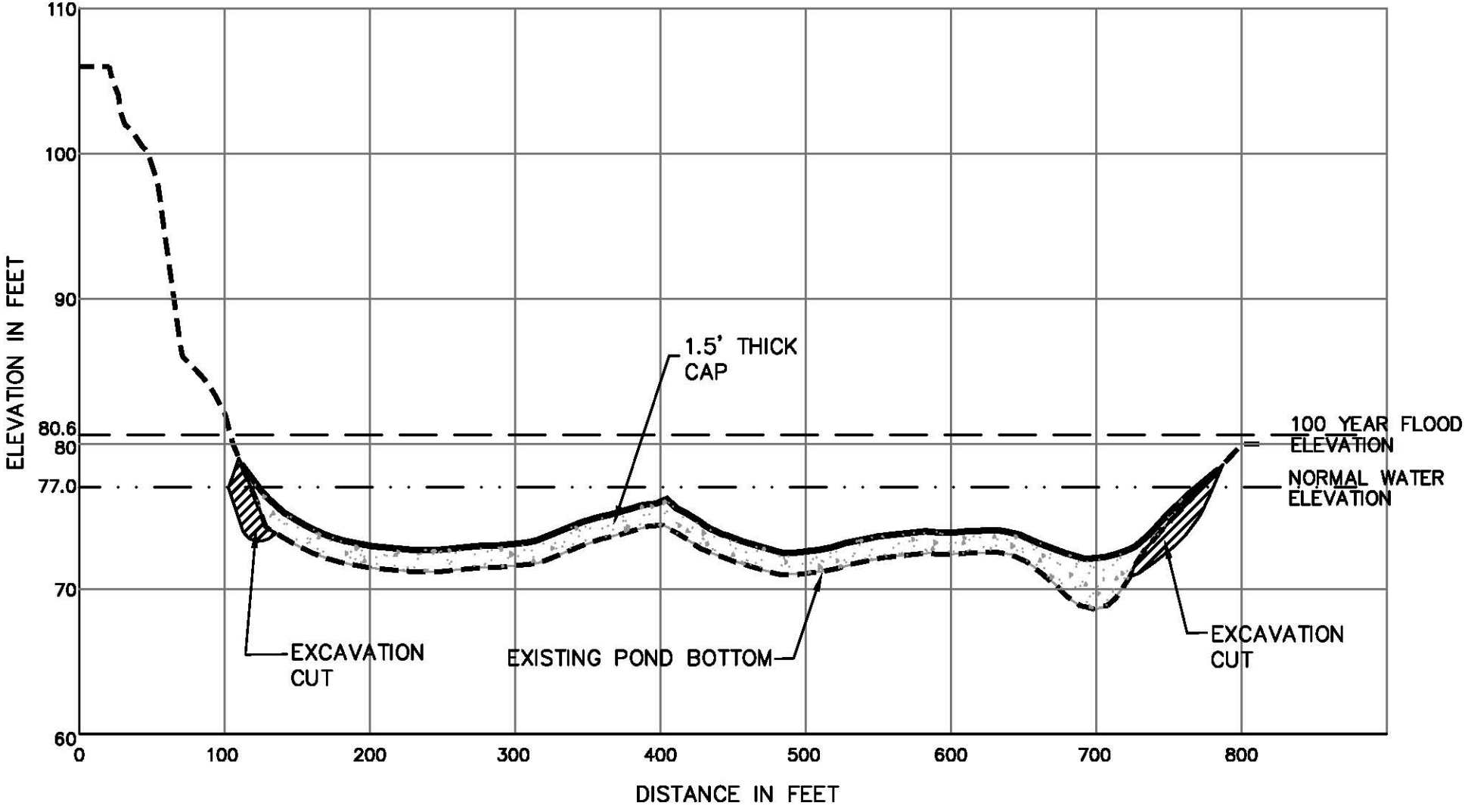
Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)



Battelle	Scale: 1"=80' HORIZONTAL 1"=8' VERTICAL	Explanation: SECTION A–2		Document: Fig 5–16_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5–16		CONCEPTUAL PARTIAL REMOVAL AND CAPPING ALTERNATIVE FOR ALLENDALE REACH SEDIMENT	Date: 02/12/10	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



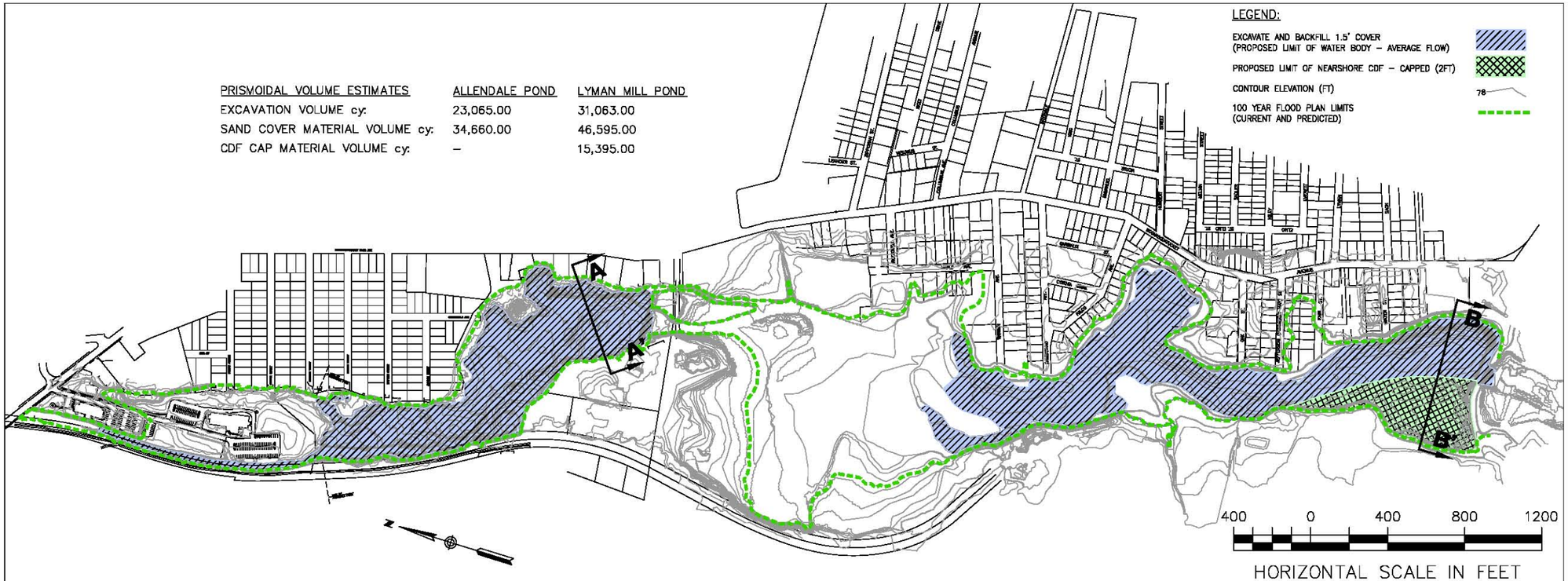
Battelle	Scale: 1"=100' HORIZONTAL 1"=10' VERTICAL	Explanation: SECTION L–2		Document: Fig 5–17_REV0.dwg
		CONCEPTUAL PARTIAL REMOVAL AND CAPPING ALTERNATIVE FOR LYMAN MILL REACH SEDIMENT		Drawn By: L. Bouchard (Watermark)
Figure 5–17			Date: 02/12/10	Checked By: D. Dahlen (Battelle)
				Projection: R. I. State Plane (NAD 83 Feet)

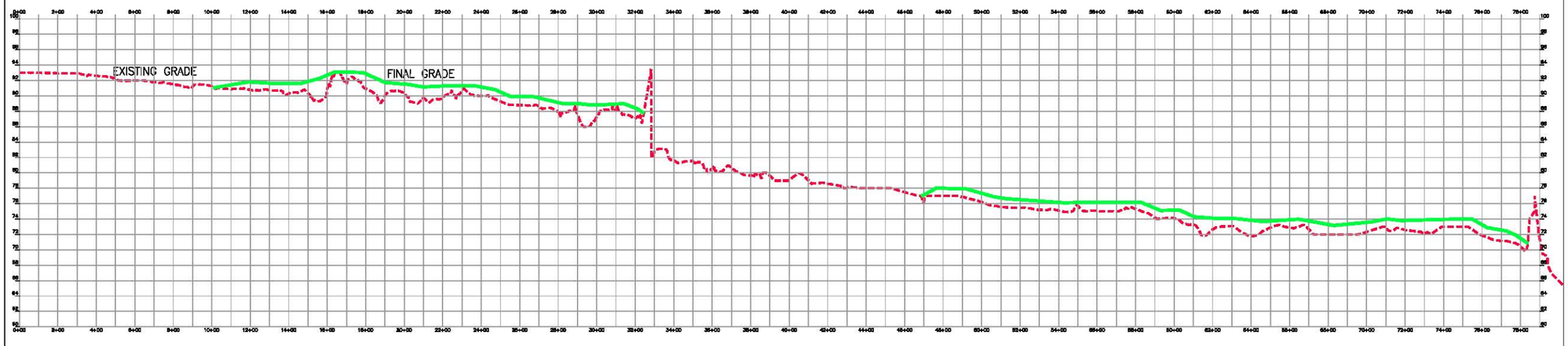
US EPA ARCHIVE DOCUMENT

PRISMOIDAL VOLUME ESTIMATES	ALLENDALE POND	LYMAN MILL POND
EXCAVATION VOLUME cy:	23,065.00	31,063.00
SAND COVER MATERIAL VOLUME cy:	34,660.00	46,595.00
CDF CAP MATERIAL VOLUME cy:	–	15,395.00

LEGEND:

- EXCAVATE AND BACKFILL 1.5' COVER (PROPOSED LIMIT OF WATER BODY – AVERAGE FLOW)
- PROPOSED LIMIT OF NEARSHORE CDF – CAPPED (2FT)
- CONTOUR ELEVATION (FT) 78
- 100 YEAR FLOOD PLAN LIMITS (CURRENT AND PREDICTED)





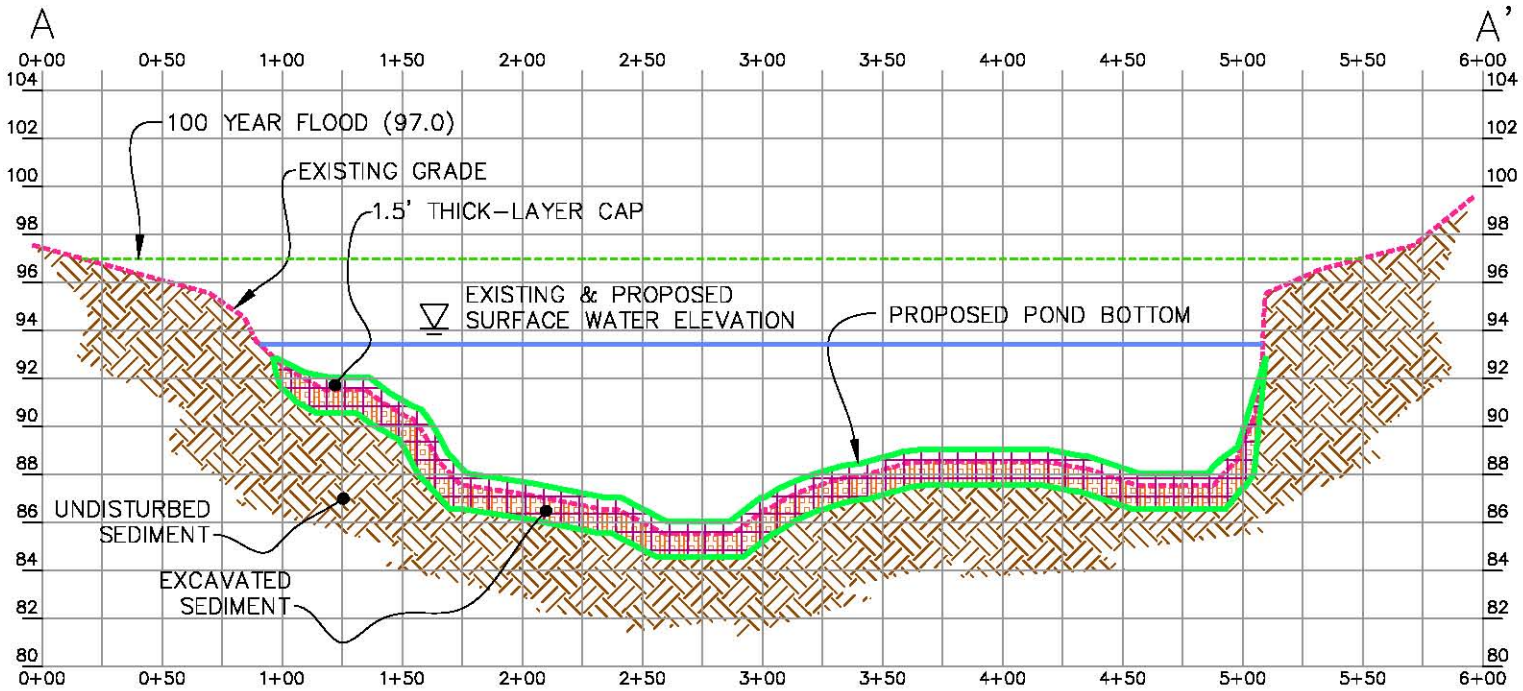
PROFILE
HORIZONTAL SCALE 1" =800'–0"
VERTICAL SCALE 1" = 16'–0"

400 0 400 800 1200
HORIZONTAL SCALE IN FEET

10 0 10 20 30
VERTICAL SCALE IN FEET

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 8b PARTIAL EXCAVATION, ISOLATION CAPPING AND CONTAINMENT IN NEARSHORE CDF		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–18			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

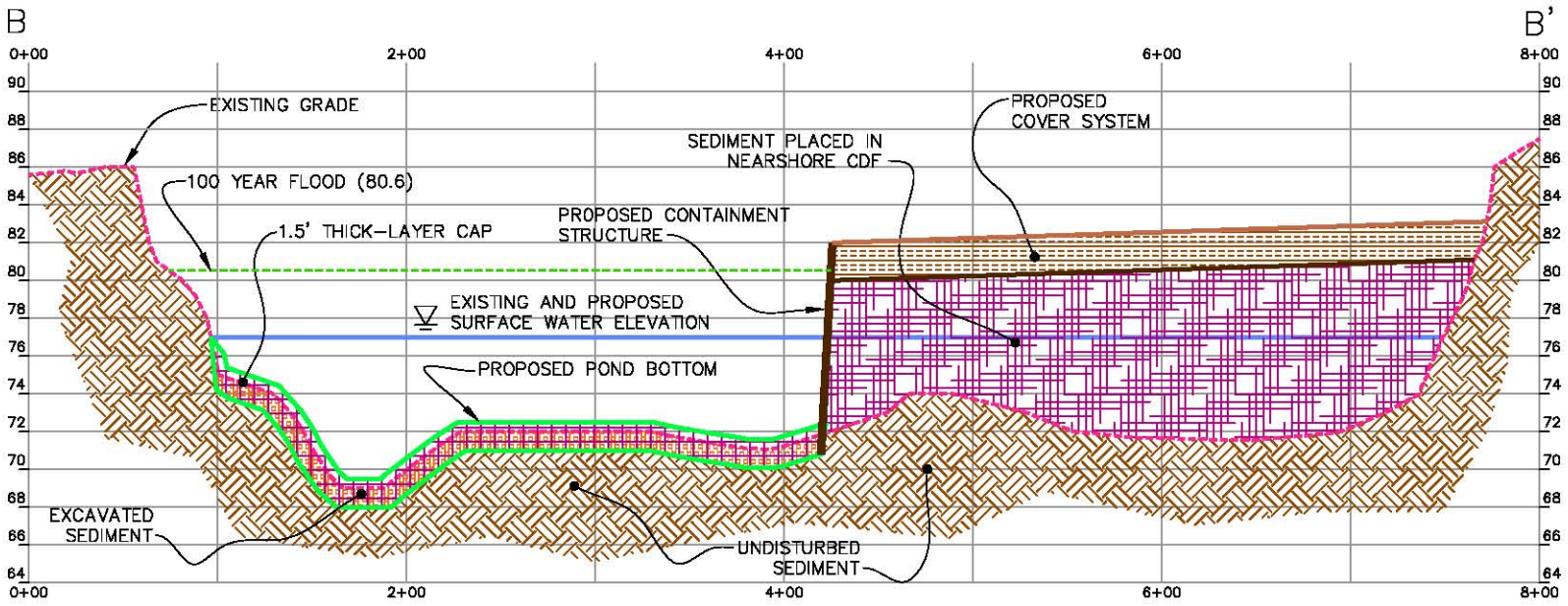
US EPA ARCHIVE DOCUMENT



SECTION A–A'
HORIZONTAL SCALE 1" = 80'–0"
VERTICAL SCALE 1" = 8'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 8b PARTIAL EXCAVATION, ISOLATION CAPPING AND CONTAINMENT IN NEARSHORE CDF SECTION A–A'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–19a			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

US EPA ARCHIVE DOCUMENT



SECTION B–B'
HORIZONTAL SCALE 1" = 100'–0"
VERTICAL SCALE 1" = 10'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 8b PARTIAL EXCAVATION, ISOLATION CAPPING AND CONTAINMENT IN NEARSHORE CDF SECTION B–B'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–19b			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

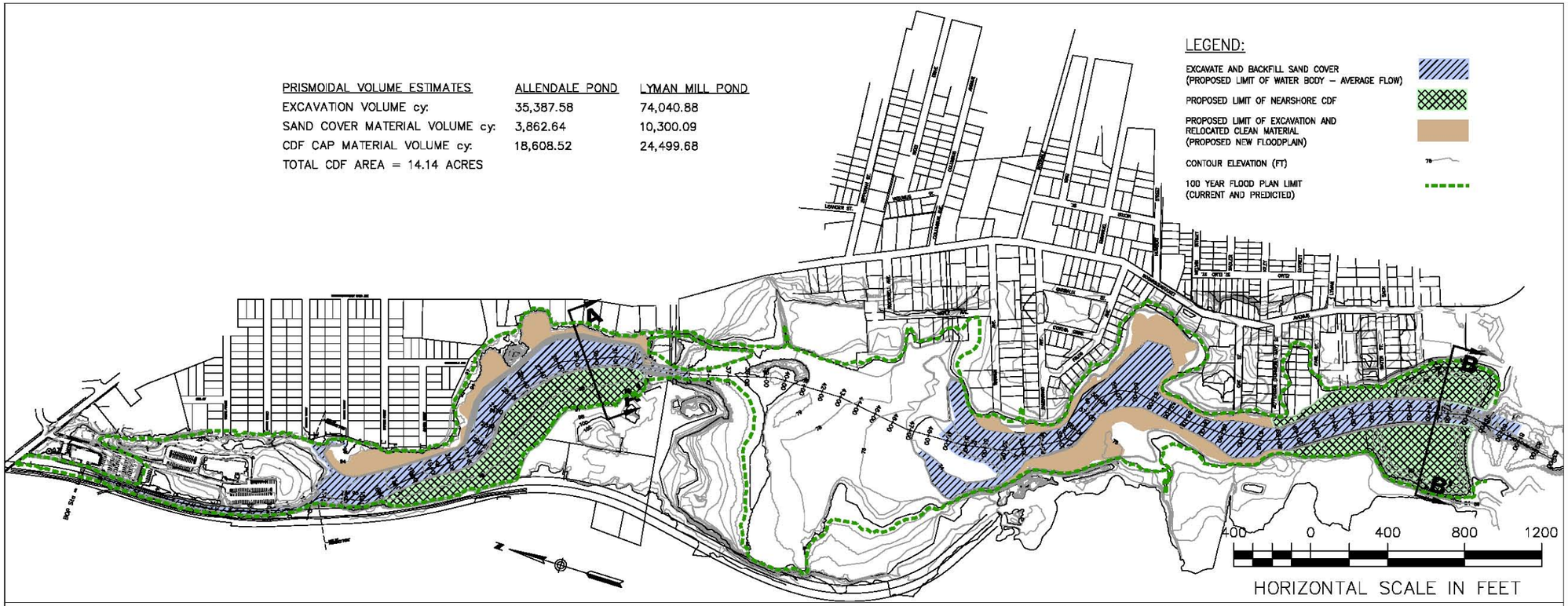
US EPA ARCHIVE DOCUMENT

PRISMOIDAL VOLUME ESTIMATES	ALLENDALE POND	LYMAN MILL POND
EXCAVATION VOLUME cy:	35,387.58	74,040.88
SAND COVER MATERIAL VOLUME cy:	3,862.64	10,300.09
CDF CAP MATERIAL VOLUME cy:	18,608.52	24,499.68

TOTAL CDF AREA = 14.14 ACRES

LEGEND:

- EXCAVATE AND BACKFILL SAND COVER (PROPOSED LIMIT OF WATER BODY – AVERAGE FLOW)
- PROPOSED LIMIT OF NEARSHORE CDF
- PROPOSED LIMIT OF EXCAVATION AND RELOCATED CLEAN MATERIAL (PROPOSED NEW FLOODPLAIN)
- CONTOUR ELEVATION (FT)
- 100 YEAR FLOOD PLAN LIMIT (CURRENT AND PREDICTED)



PROFILE
HORIZONTAL SCALE 1" =800'–0"
VERTICAL SCALE 1" = 20'–0"

400 0 400 800 1200
HORIZONTAL SCALE IN FEET

10 0 10 20 30
VERTICAL SCALE IN FEET

LEA

Scale: AS SHOWN

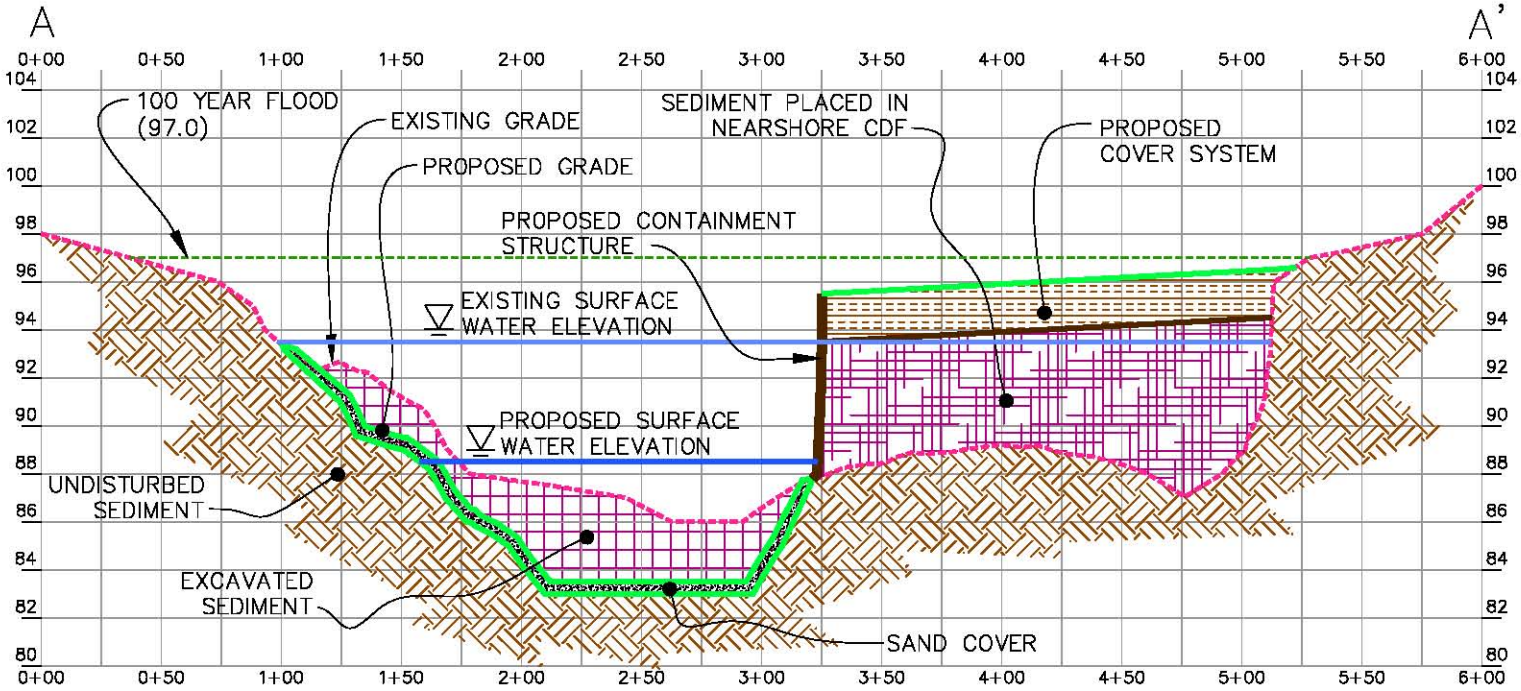
Explanation: ALTERNATIVE 10b
DAM REPLACEMENT, EXCAVATION AND CONTAINMENT IN NEARSHORE CDF

Date: 04/08/10

Document: FIG
Drawn By: A.C.L.
Checked By: D.N.S.
Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

FIGURE 5–20

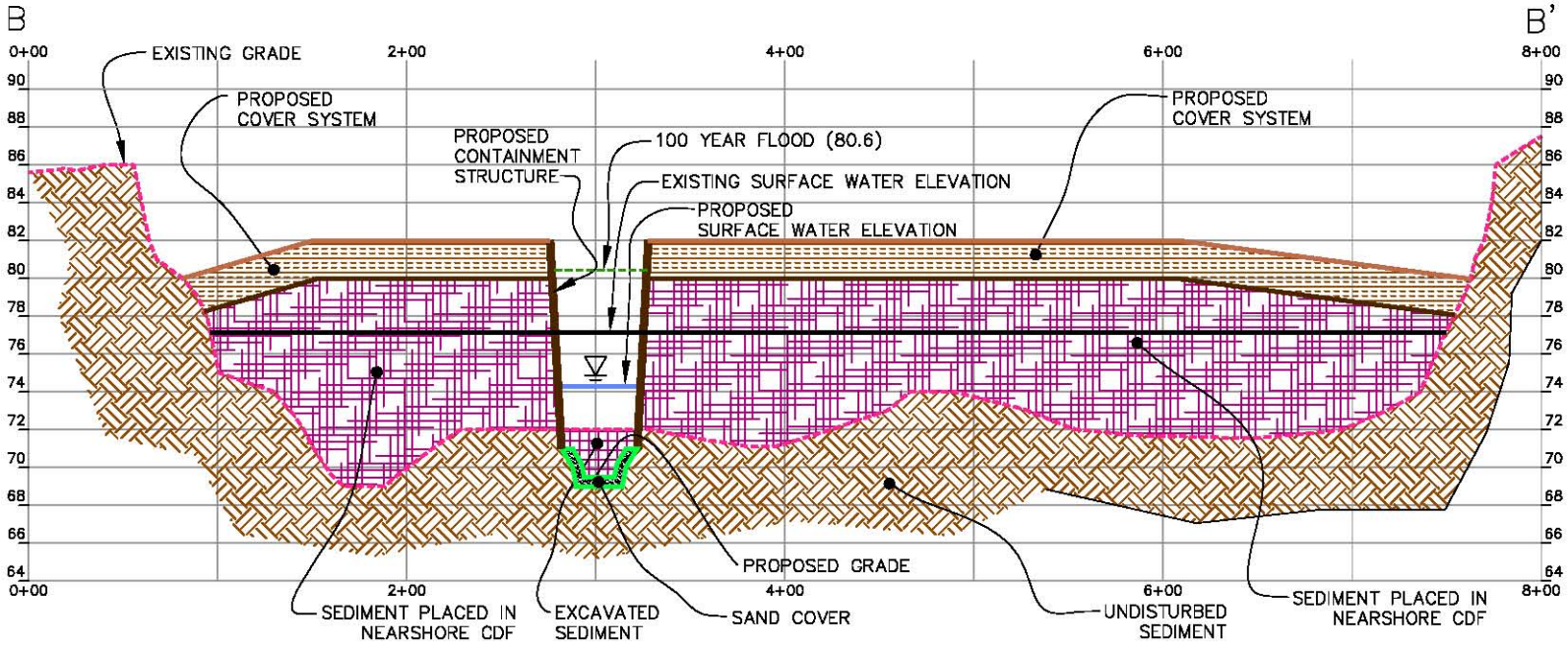
US EPA ARCHIVE DOCUMENT



SECTION A–A'
HORIZONTAL SCALE 1" = 80'–0"
VERTICAL SCALE 1" = 8'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 10b DAM REPLACEMENT, EXCAVATION AND CONTAINMENT IN NEARSHORE CDF SECTION A–A'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–21a			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

US EPA ARCHIVE DOCUMENT



SECTION B–B'
HORIZONTAL SCALE 1" = 100'–0"
VERTICAL SCALE 1" = 10'–0"

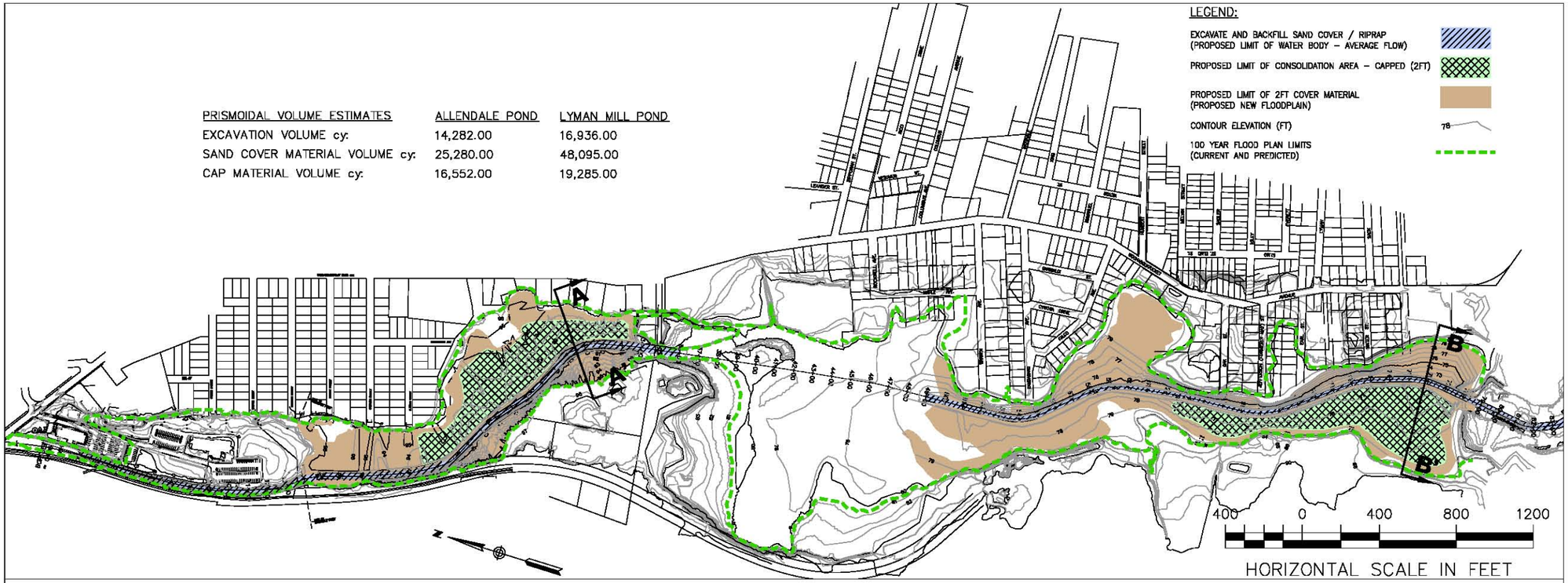
LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 10b DAM REPLACEMENT, EXCAVATION AND CONTAINMENT IN NEARSHORE CDF SECTION B–B'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–21b			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

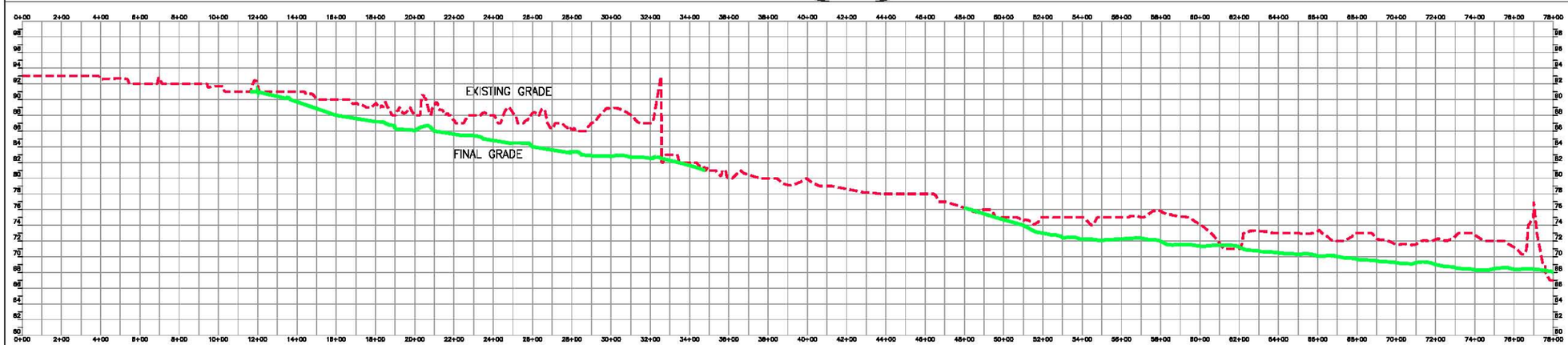
US EPA ARCHIVE DOCUMENT

PRISMOIDAL VOLUME ESTIMATES	ALLENDALE POND	LYMAN MILL POND
EXCAVATION VOLUME cy:	14,282.00	16,936.00
SAND COVER MATERIAL VOLUME cy:	25,280.00	48,095.00
CAP MATERIAL VOLUME cy:	16,552.00	19,285.00

LEGEND:

- EXCAVATE AND BACKFILL SAND COVER / RIPRAP (PROPOSED LIMIT OF WATER BODY – AVERAGE FLOW)
- PROPOSED LIMIT OF CONSOLIDATION AREA – CAPPED (2FT)
- PROPOSED LIMIT OF 2FT COVER MATERIAL (PROPOSED NEW FLOODPLAIN)
- CONTOUR ELEVATION (FT) 78
- 100 YEAR FLOOD PLAN LIMITS (CURRENT AND PREDICTED)

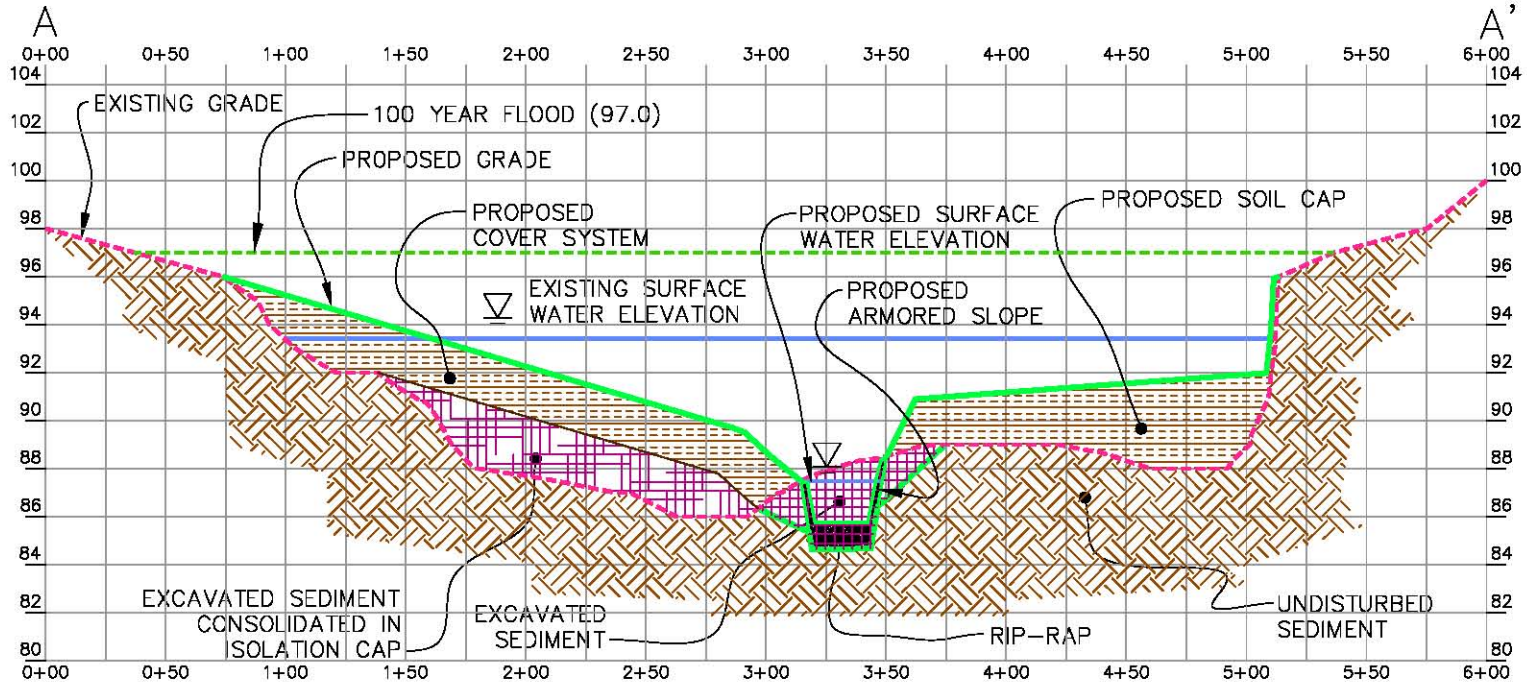




PROFILE
HORIZONTAL SCALE 1" =800'–0"
VERTICAL SCALE 1" = 20'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 11f RIVER CHANNEL CONFIGURATION – DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING AND ON–SITE CONSOLIDATION	Document: FIG
			Drawn By: A.C.L.
FIGURE 5–22		Date: 04/08/10	Checked By: D.N.S.
			Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

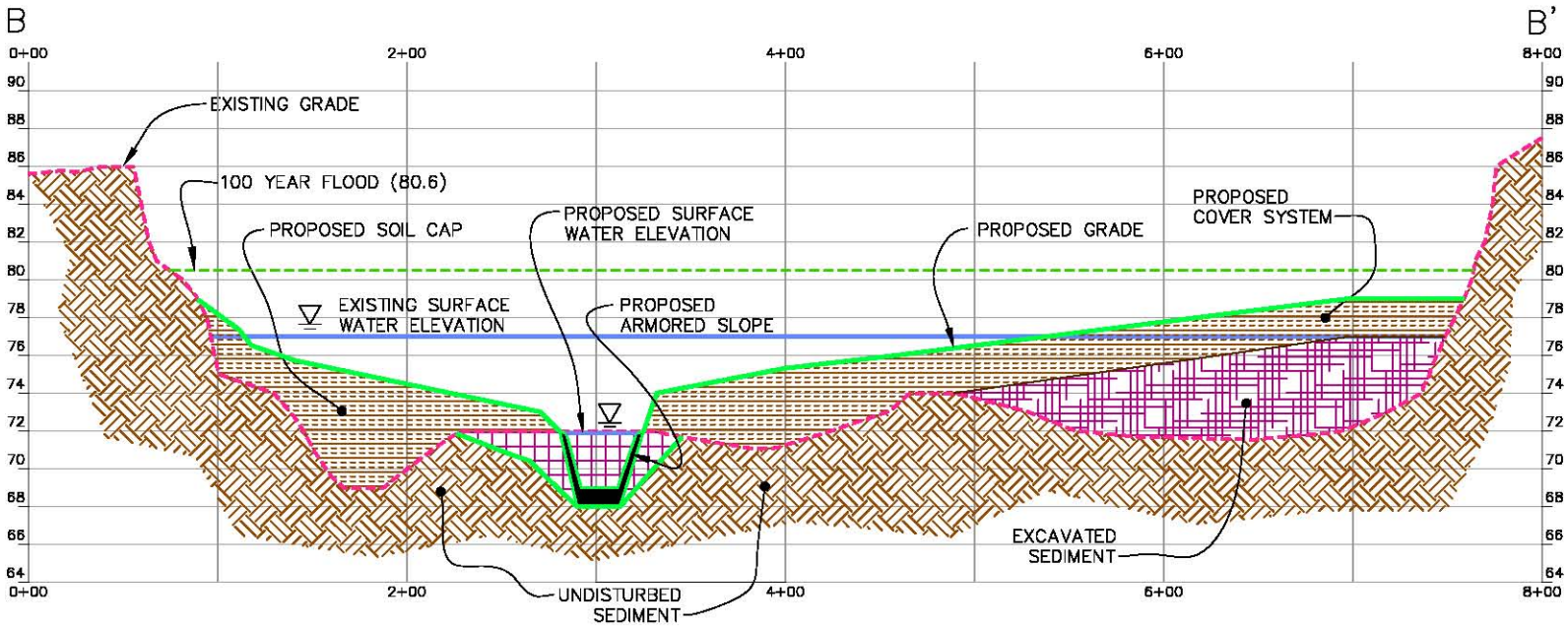
US EPA ARCHIVE DOCUMENT



SECTION A–A'
HORIZONTAL SCALE 1" = 80'–0"
VERTICAL SCALE 1" = 8'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 11f RIVER CHANNEL CONFIGURATION – DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING AND ON-SITE CONSOLIDATION SECTION A–A'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–23a			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

US EPA ARCHIVE DOCUMENT



SECTION B–B'
HORIZONTAL SCALE 1" = 100'–0"
VERTICAL SCALE 1" = 10'–0"

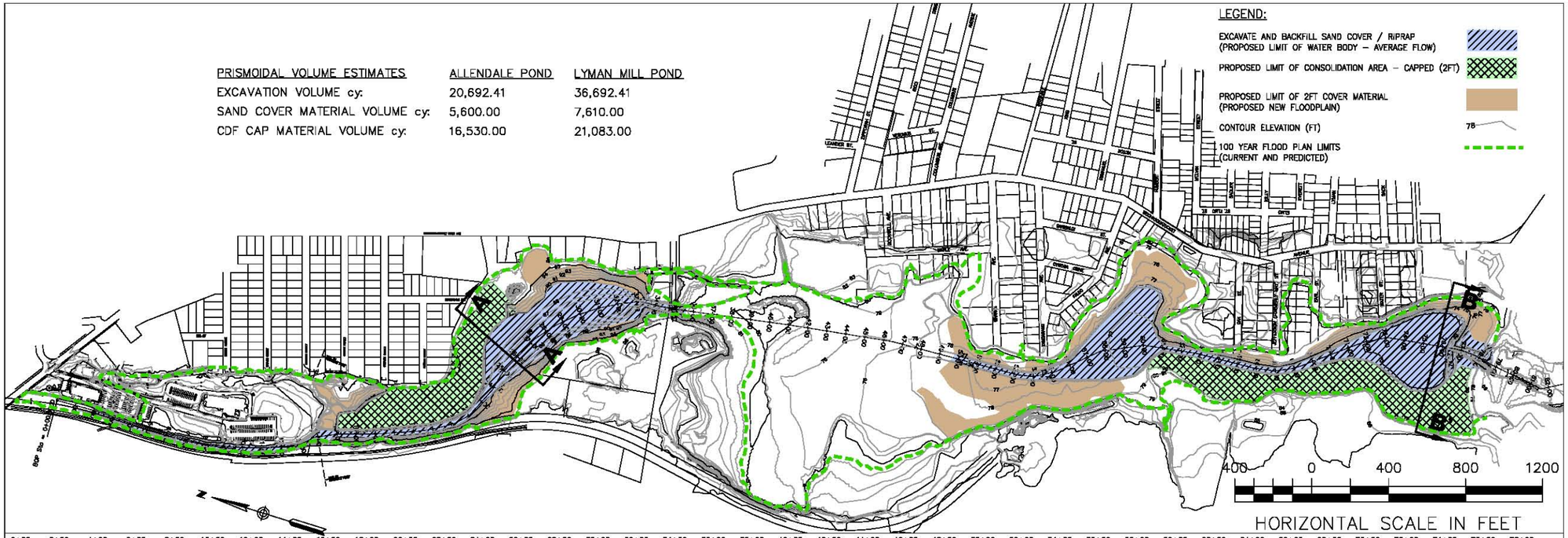
LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 11f RIVER CHANNEL CONFIGURATION – DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING AND ON-SITE CONSOLIDATION SECTION B–B'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–23b			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

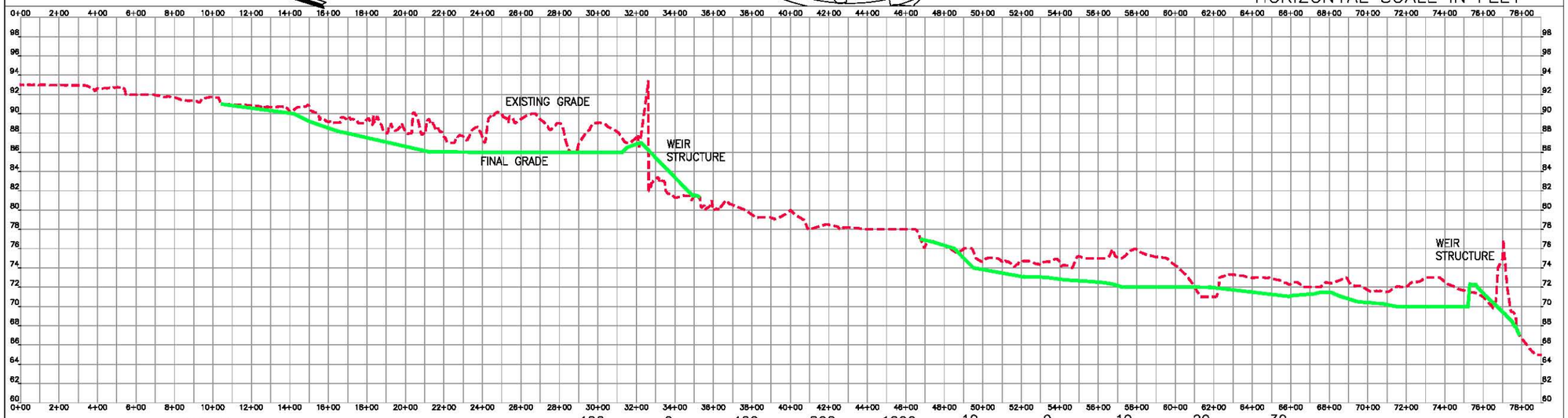
US EPA ARCHIVE DOCUMENT

PRISMOIDAL VOLUME ESTIMATES	ALLENDALE POND	LYMAN MILL POND
EXCAVATION VOLUME cy:	20,692.41	36,692.41
SAND COVER MATERIAL VOLUME cy:	5,600.00	7,610.00
CDF CAP MATERIAL VOLUME cy:	16,530.00	21,083.00

LEGEND:

- EXCAVATE AND BACKFILL SAND COVER / RIPRAP (PROPOSED LIMIT OF WATER BODY – AVERAGE FLOW)
- PROPOSED LIMIT OF CONSOLIDATION AREA – CAPPED (2FT)
- PROPOSED LIMIT OF 2FT COVER MATERIAL (PROPOSED NEW FLOODPLAIN)
- CONTOUR ELEVATION (FT) 78
- 100 YEAR FLOOD PLAN LIMITS (CURRENT AND PREDICTED)





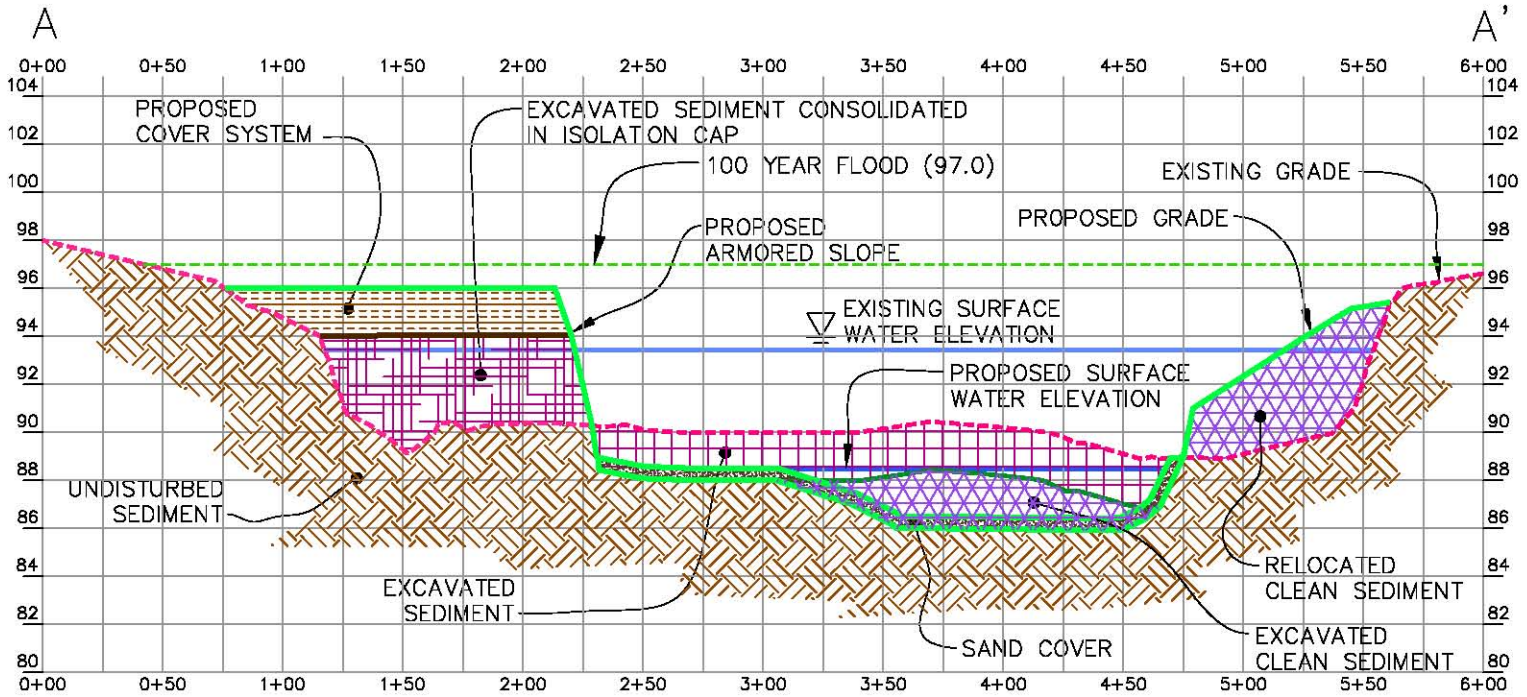
PROFILE
HORIZONTAL SCALE 1" =800'–0"
VERTICAL SCALE 1" = 16'–0"

400 0 400 800 1200
HORIZONTAL SCALE IN FEET

10 0 10 20 30
VERTICAL SCALE IN FEET

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 11f RIVER CHANNEL AND PONDS CONFIGURATION – DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING AND ON–SITE CONSOLIDATION	Document: FIG
			Drawn By: A.C.L.
FIGURE 5–24		Date: 04/08/10	Checked By: D.N.S.
			Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

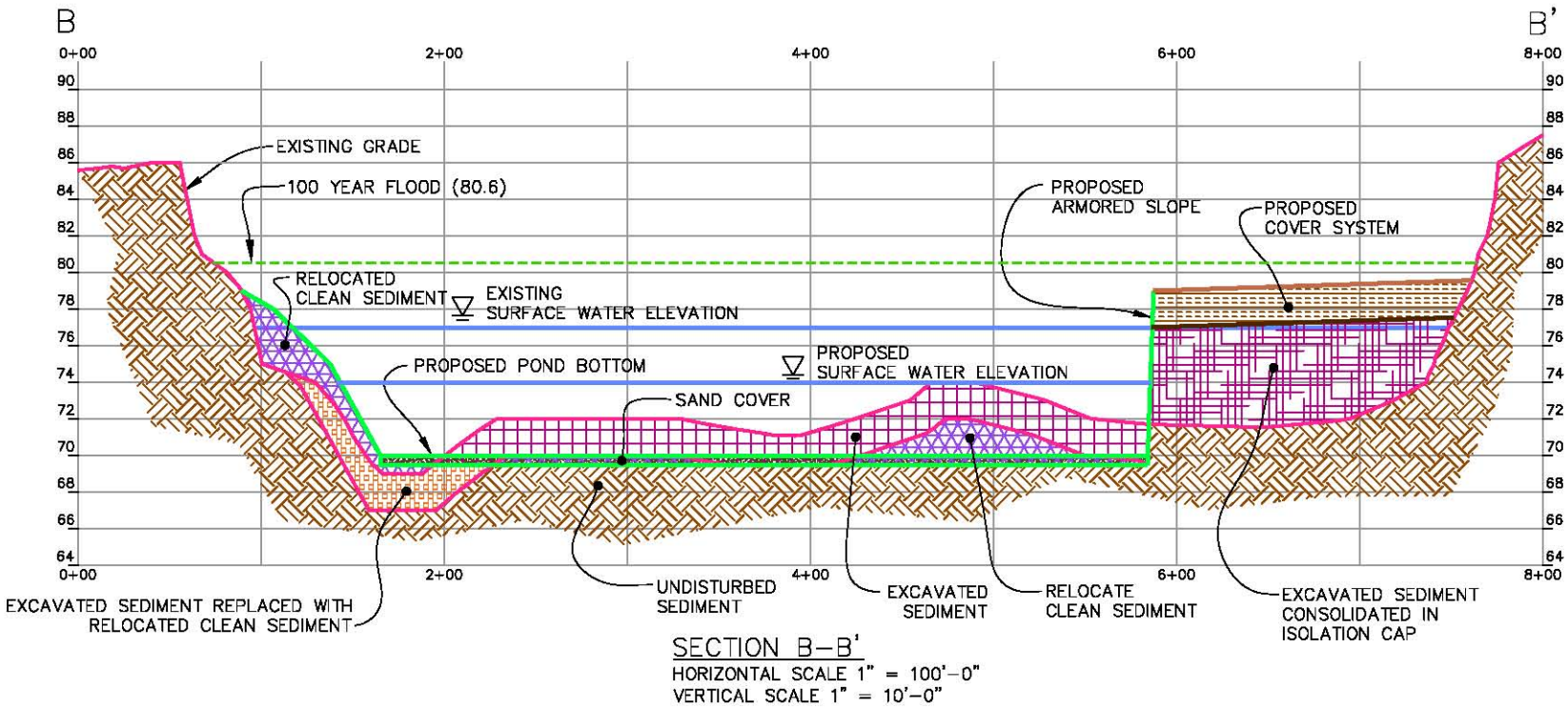
US EPA ARCHIVE DOCUMENT



SECTION A–A'
HORIZONTAL SCALE 1" = 80'–0"
VERTICAL SCALE 1" = 8'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 11f RIVER CHANNEL AND PONDS CONFIGURATION – DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING AND ON-SITE CONSOLIDATION SECTION A–A'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–25a			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

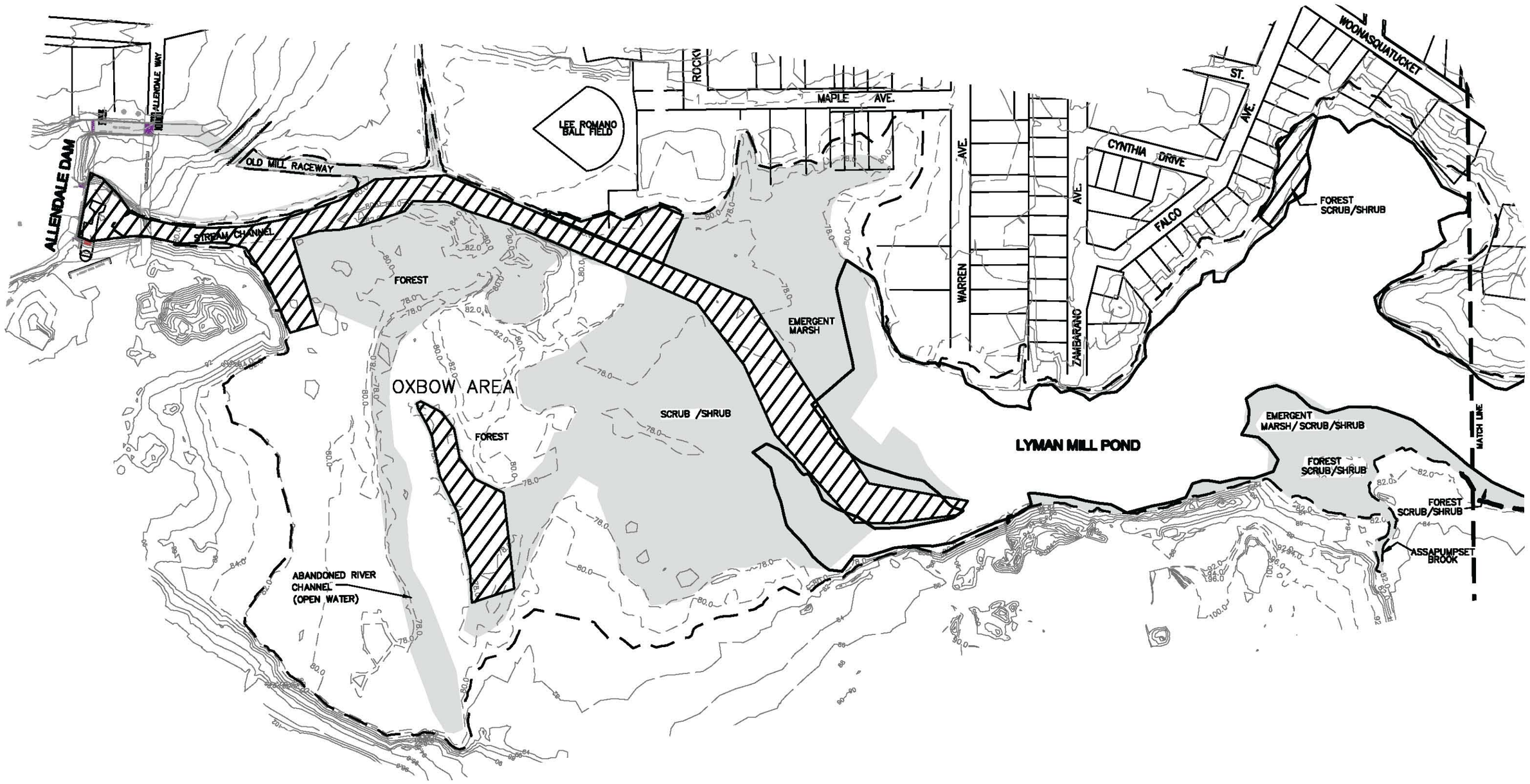
US EPA ARCHIVE DOCUMENT



SECTION B–B'
HORIZONTAL SCALE 1" = 100'–0"
VERTICAL SCALE 1" = 10'–0"

LEA	Scale: AS SHOWN	Explanation: ALTERNATIVE 11f RIVER CHANNEL AND PONDS CONFIGURATION – DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING AND ON-SITE CONSOLIDATION SECTION B–B'		Document: FIG
				Drawn By: A.C.L.
FIGURE 5–25b			Date: 04/08/10	Checked By: D.N.S.
				Projection: R.I. State Plan (NAD 83 feet / NGVD 1929)

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Battelle

Scale: 0 200 400 FEET

Figure 5–26a

Explanation: CONCEPTUAL TARGETED EXCAVATION AND THIN LAYER COVER ALTERNATIVE FOR LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL

- 80.0 EXISTING TOPOGRAPHY
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- THIN LAYER COVER
- EXCAVATE

Date: 04/08/10

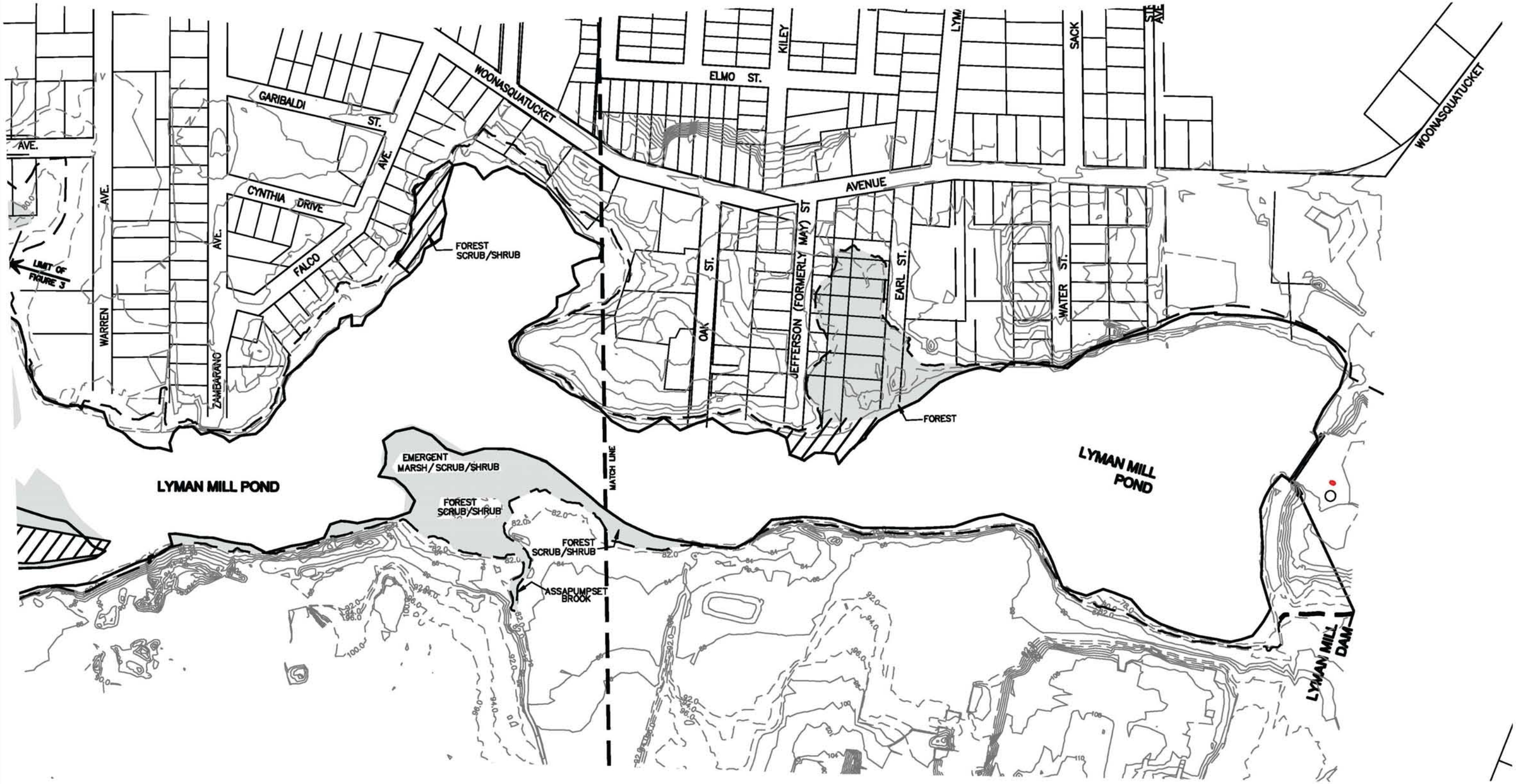
Document: Fig 5–26a&b_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 200 400 FEET

Figure 5–26b

Explanation: CONCEPTUAL TARGETED EXCAVATION AND THIN LAYER COVER ALTERNATIVE FOR LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL

- 80.0 — EXISTING TOPOGRAPHY
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- THIN LAYER COVER
- EXCAVATE

Date: 04/08/10

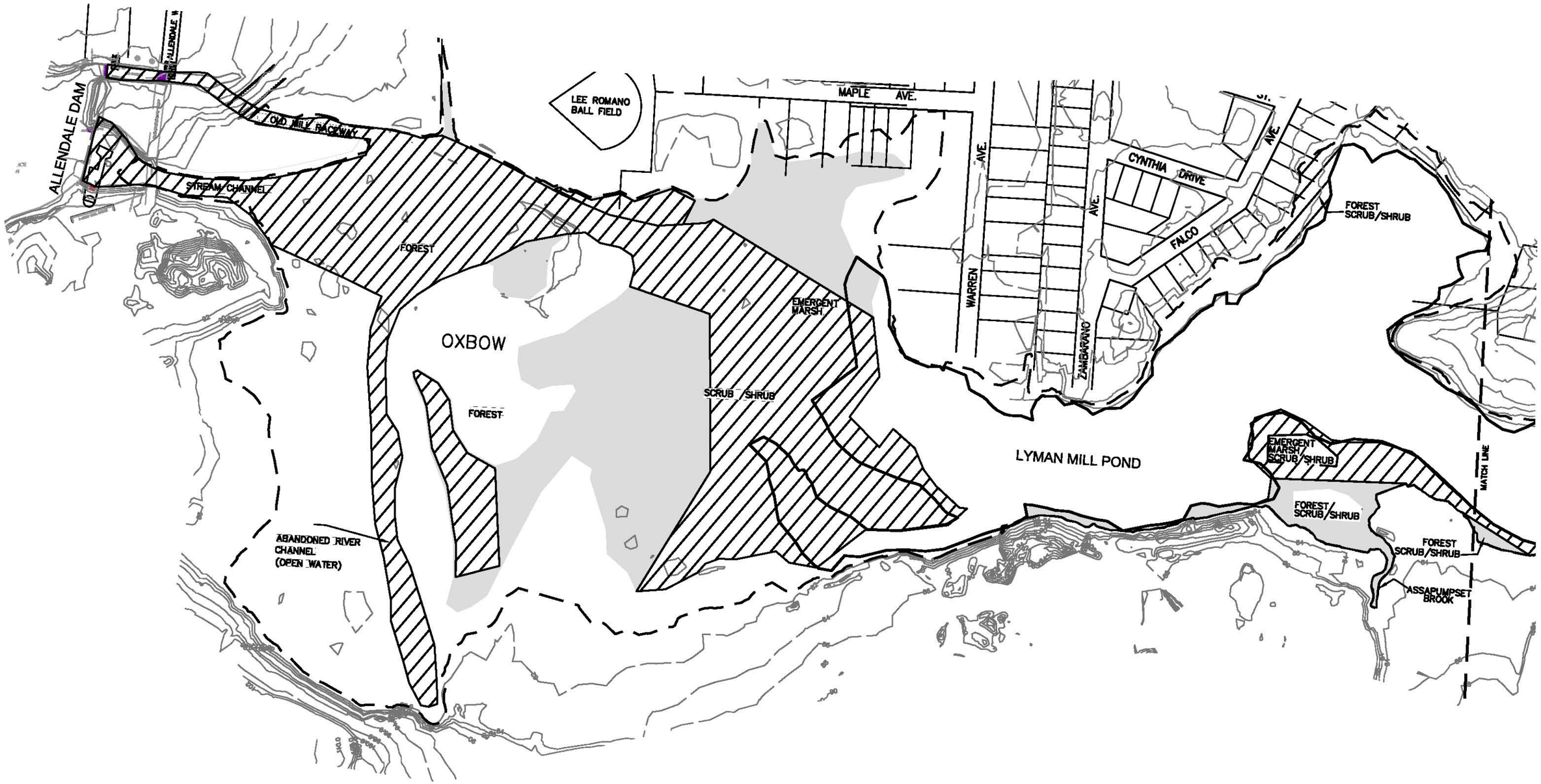
Document: Fig 5–26a&b_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 200 400 FEET

Figure 5–27a

Explanation: CONCEPTUAL PARTIAL EXCAVATION & THIN LAYER COVER ALTERNATIVE FOR LYMAN MILL REACH STREAM SEDIMENT & FLOODPLAIN SOIL

- EXISTING TOPOGRAPHY
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- EXCAVATE
- THIN LAYER COVER
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)

Date: 04/08/10

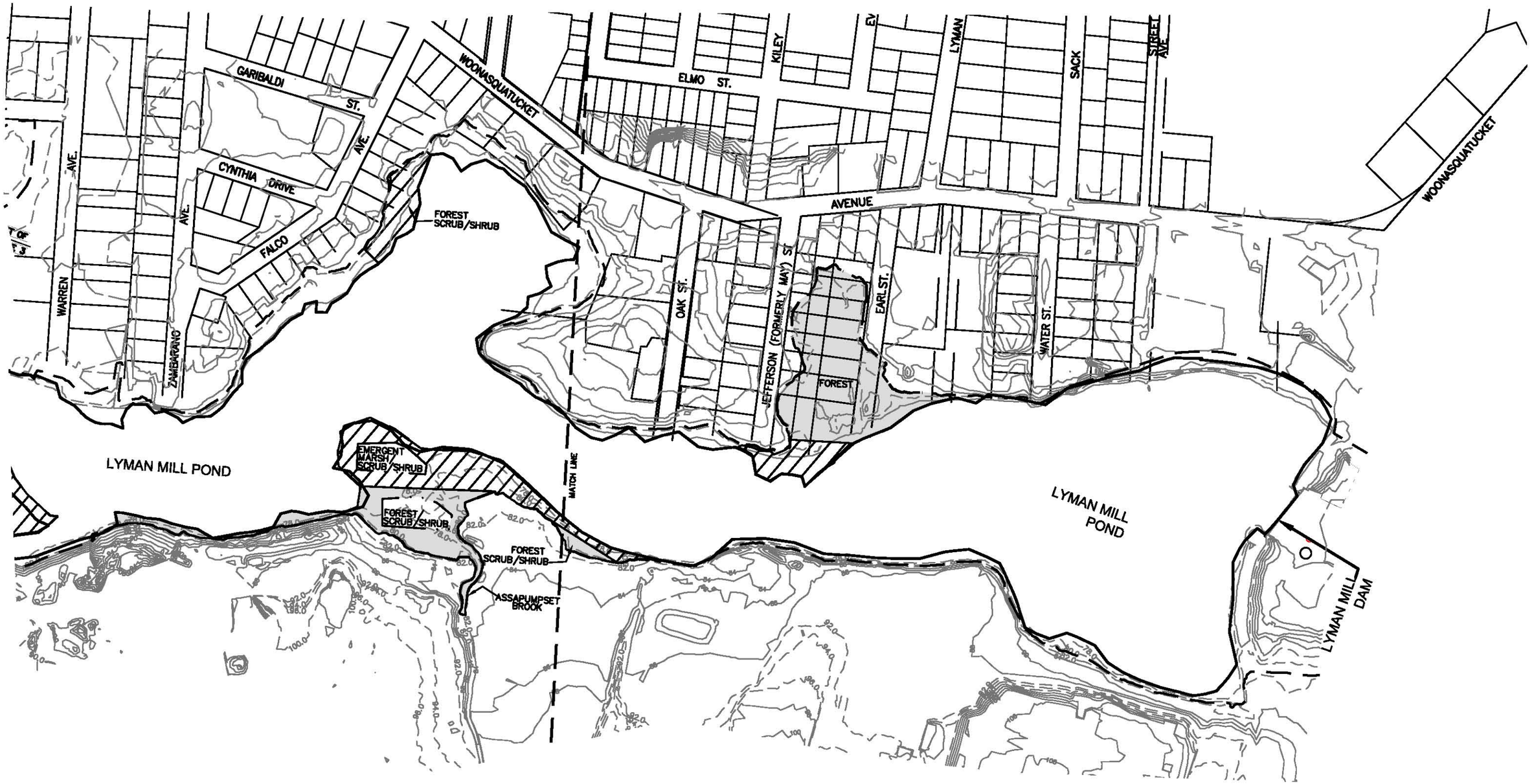
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Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 200 400 FEET

Figure 5–27b

Explanation: CONCEPTUAL PARTIAL EXCAVATION & THIN LAYER COVER ALTERNATIVE FOR LYMAN MILL REACH STREAM SEDIMENT & FLOODPLAIN SOIL

- EXISTING TOPOGRAPHY
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- EXCAVATE
- THIN LAYER COVER
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)

Date: 04/08/10

Document: Fig 5–27a&b_REV0.dwg

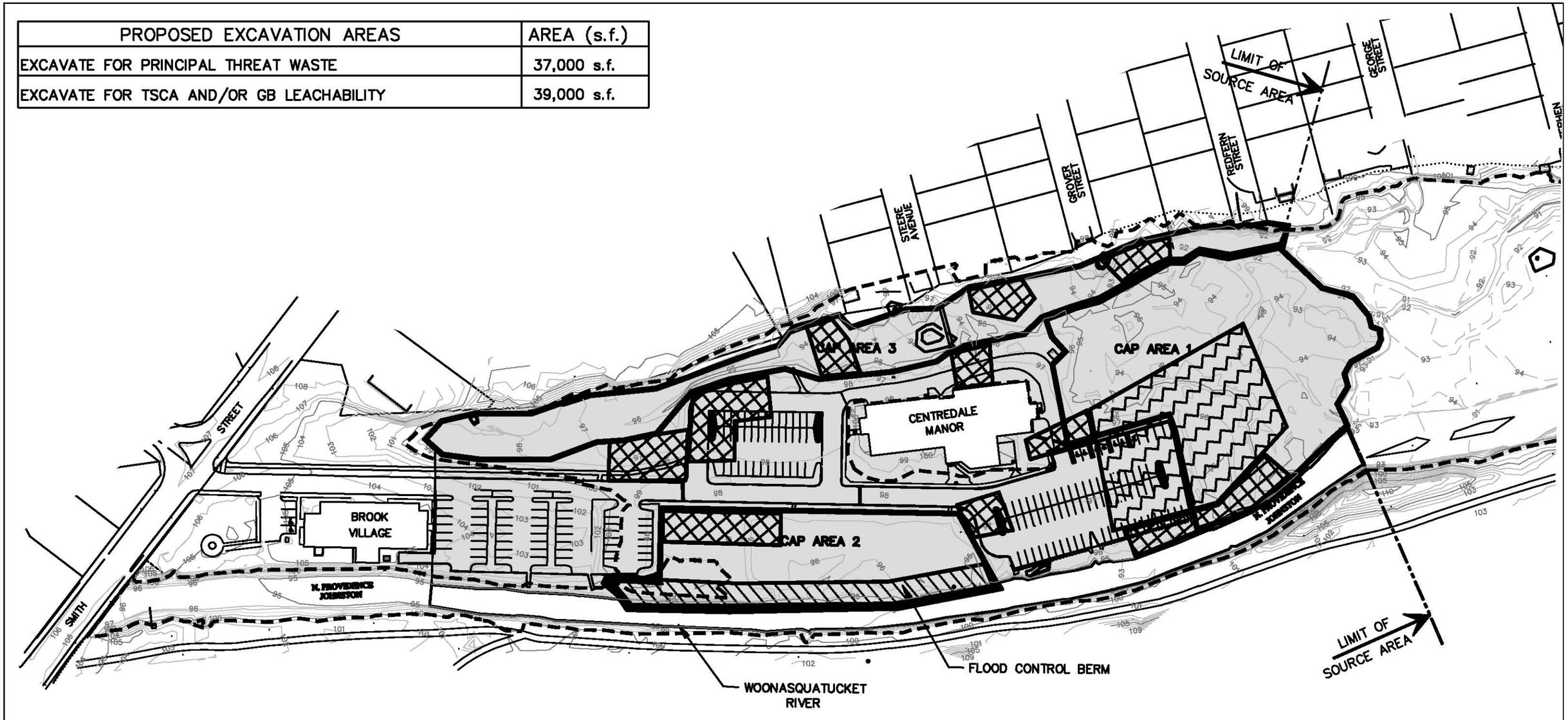
Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT

PROPOSED EXCAVATION AREAS	AREA (s.f.)
EXCAVATE FOR PRINCIPAL THREAT WASTE	37,000 s.f.
EXCAVATE FOR TSCA AND/OR GB LEACHABILITY	39,000 s.f.



Battelle

Scale: 0 120' 240' FEET

Figure 5–28

Explanation: CONCEPTUAL TARGETED EXCAVATION AND UPGRADE CAP ALTERNATIVE FOR SOURCE AREA SOIL

- PROPOSED UPGRADE CAP AREAS
- 100 YR FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT LIMIT OF SOURCE AREA).
- 90 EXISTING GROUND ELEVATION (FT)
- EXCAVATE FOR TSCA AND/OR GB LEACHABILITY
- EXCAVATE FOR PRINCIPAL THREAT WASTE

Date: 02/26/10

Document: Fig 5-28_REV0.dwg

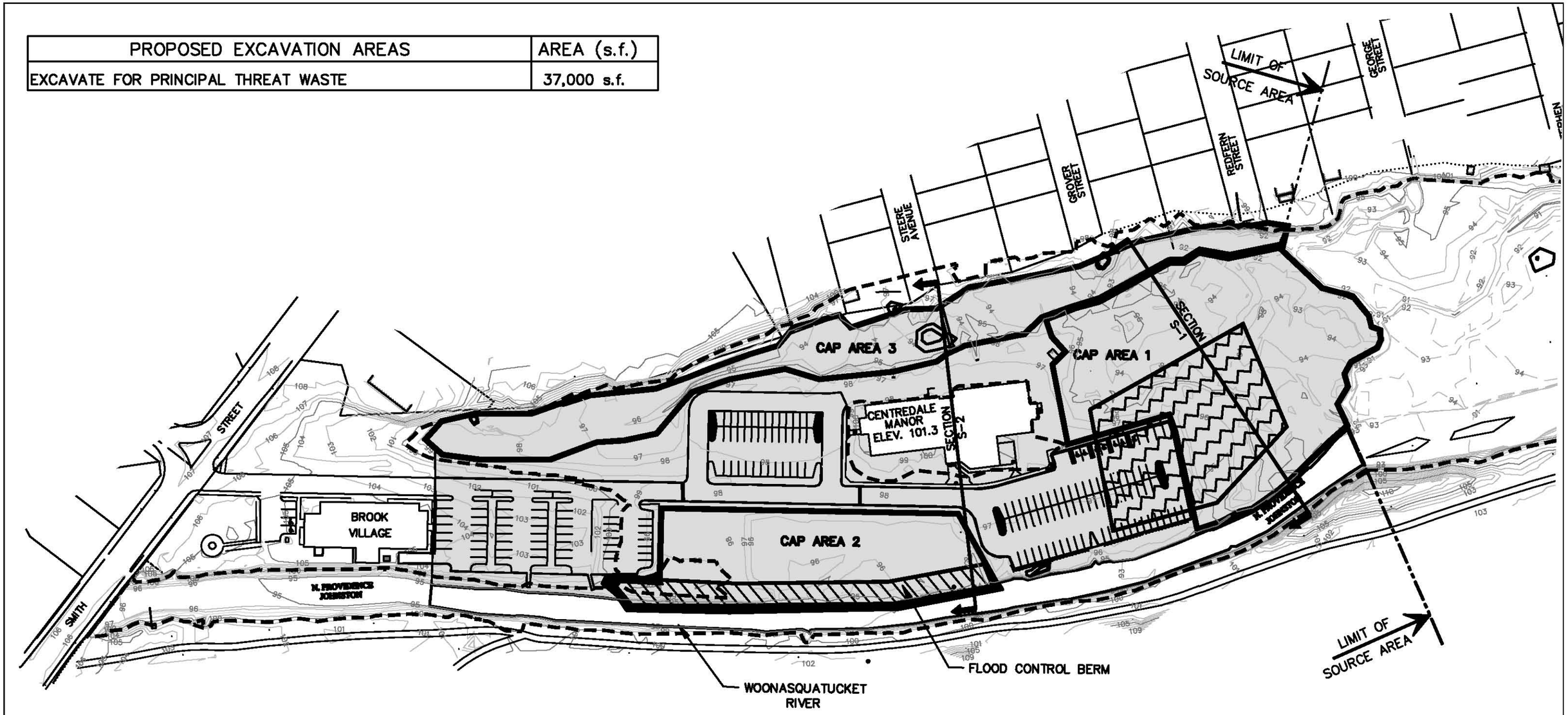
Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT

PROPOSED EXCAVATION AREAS	AREA (s.f.)
EXCAVATE FOR PRINCIPAL THREAT WASTE	37,000 s.f.



Battelle

Scale: 0 120' 240' FEET

Figure 5–29

Explanation: CONCEPTUAL TARGETED EXCAVATION AND RCRA CAP ALTERNATIVE FOR SOURCE AREA SOIL

- 90 EXISTING GROUND ELEVATION (FT)
- PROPOSED RCRA CAP AREAS
- EXCAVATE FOR PRINCIPAL THREAT WASTE
- 100 YR FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT LIMIT OF SOURCE AREA)

RHODE ISLAND STATE PLANE

Date: 02/26/10

Document: Fig 5–29_REV0.dwg

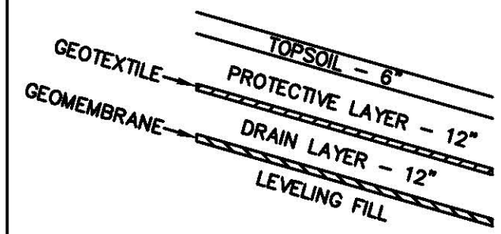
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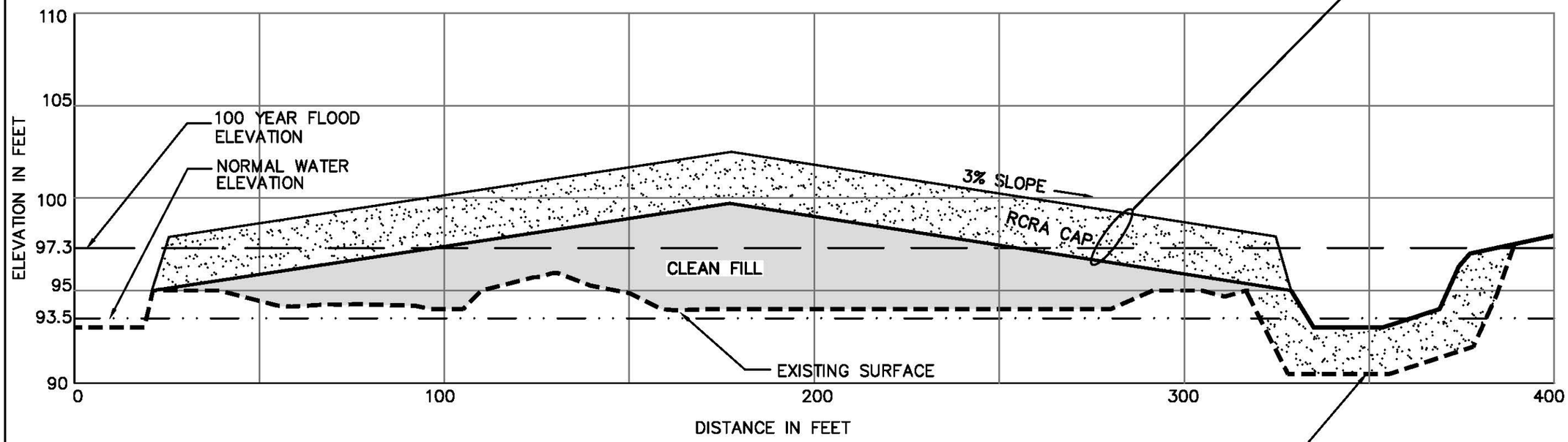
Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT

TYPICAL CROSS SECTION
OF RCRA CAP
NOT TO SCALE

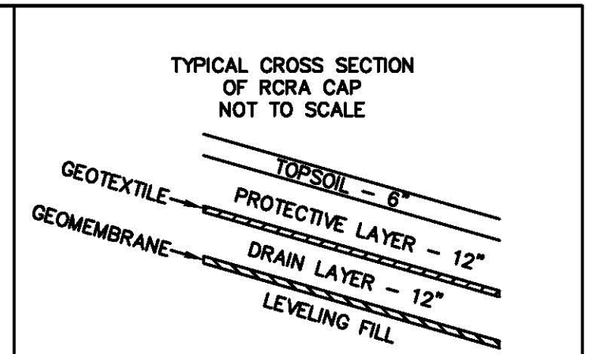


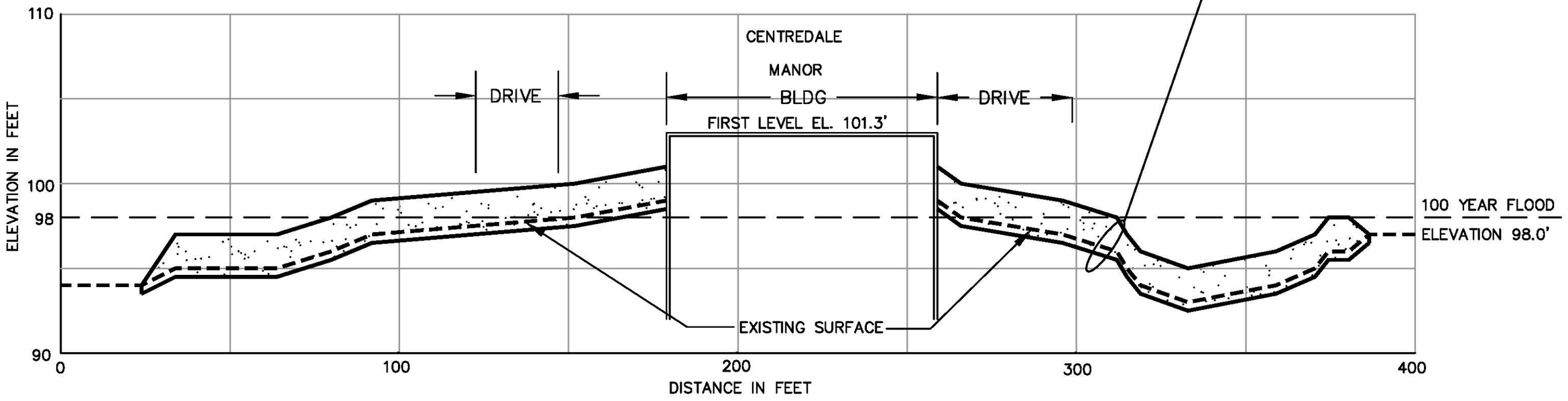


NOTES:
1. IN EXISTING PAVEMENT AREAS, REMOVE ASPHALT AND GRAVEL BASE, THEN INSTALL 2.5 FT CAP. TOP OF RCRA CAP WILL BE 2.0 FT ABOVE EXISTING PAVEMENT.
2. IN EXISTING SOIL CAP AREAS, REMOVE TOPSOIL, PLACE FILL, THEN INSTALL 2.5 FT RCRA CAP.

Battelle	Scale: 1"=30' HORIZONTAL 1"=6' VERTICAL	Explanation: RCRA SECTIONS SECTION S–1		Document: Fig 5–30a&b_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5–30a			Date: 02/26/10	Checked By: D. Dahlen (Battelle)
				Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT

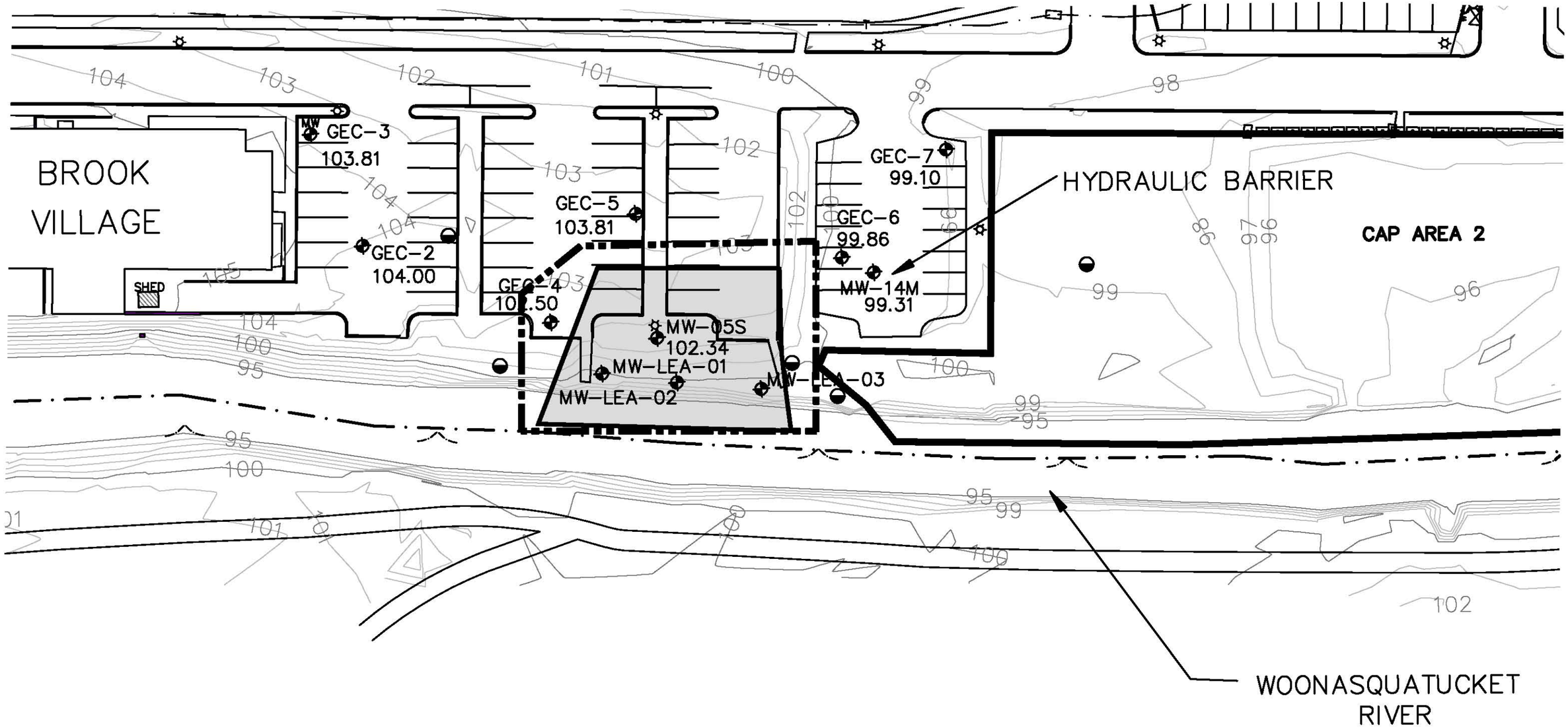




NOTES:
1. IN EXISTING PAVEMENT AREAS, REMOVE ASPHALT AND GRAVEL BASE, THEN INSTALL 2.5 FT CAP. TOP OF RCRA CAP WILL BE 2.0 FT ABOVE EXISTING PAVEMENT.
2. IN EXISTING SOIL CAP AREAS, REMOVE TOPSOIL, PLACE FILL, THEN INSTALL 2.5 FT RCRA CAP.

Battelle	Scale: 1"=30' HORIZONTAL 1"=6' VERTICAL	Explanation: RCRA SECTIONS		Document: Fig 5-30a&b_REV0.dwg
				Drawn By: L. Bouchard (Watermark)
Figure 5-30b		SECTION S-2	Date: 02/26/10	Checked By: D. Dahlen (Battelle)
				Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: SCALE: 1"=40'
0 40' 80'

Figure 5-28

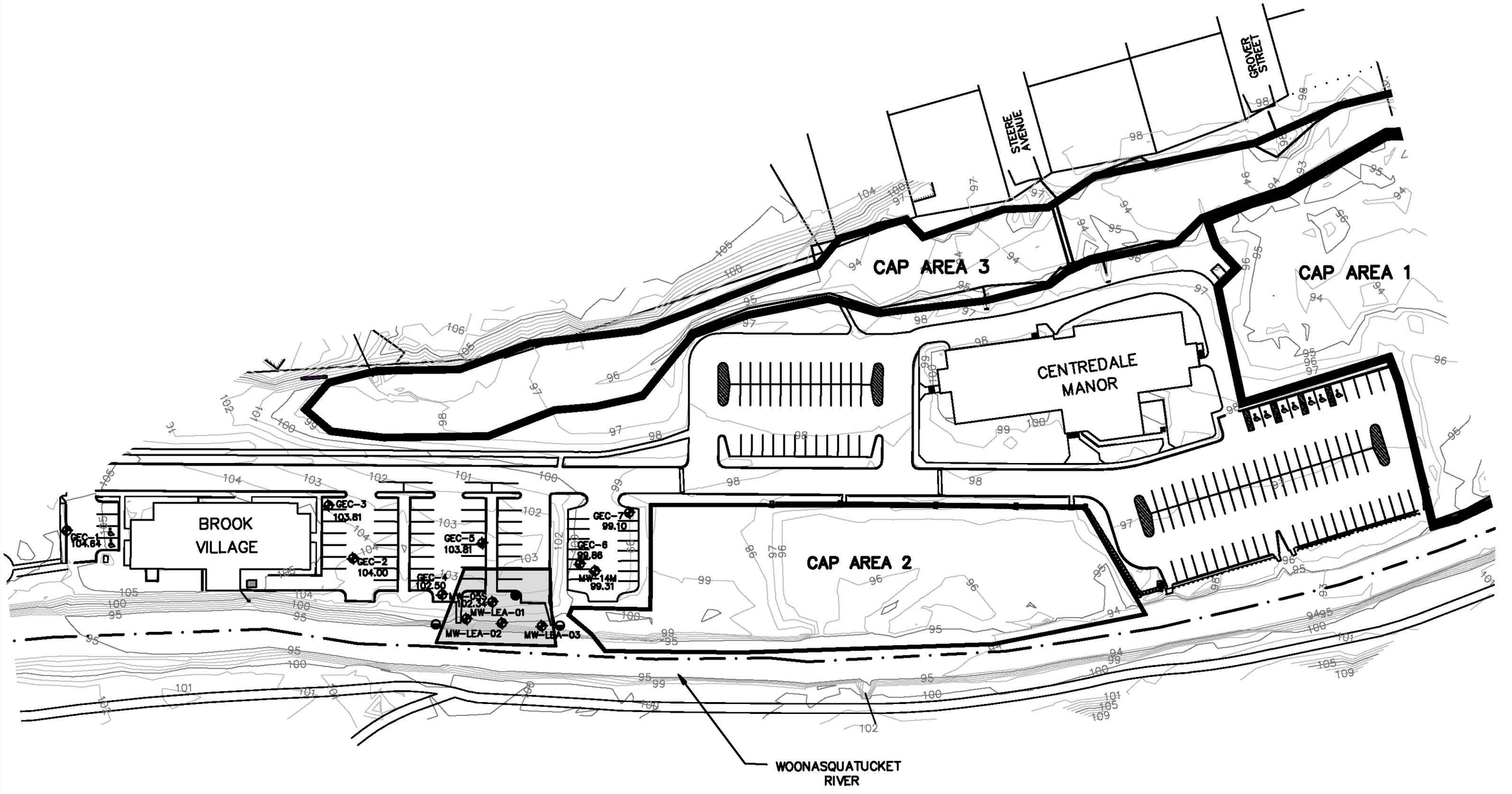
Explanation: CONCEPTUAL HYDRAULIC CONTAINMENT BARRIER

90 EXISTING POND BOTTOM OR GROUND ELEVATION
EXISTING GROUNDWATER MONITORING WELL
PROPOSED GROUNDWATER MONITORING WELL
GROUNDWATER CLEANUP AREA

Date: 5/20/09

Document: Fig 5-28.dwg
Drawn By: S. Brown (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: SCALE: 1"=80'
0 80 160

Figure 5-29

Explanation: CONCEPTUAL HYDRAULIC CONTROL THROUGH PUMP AND TREAT

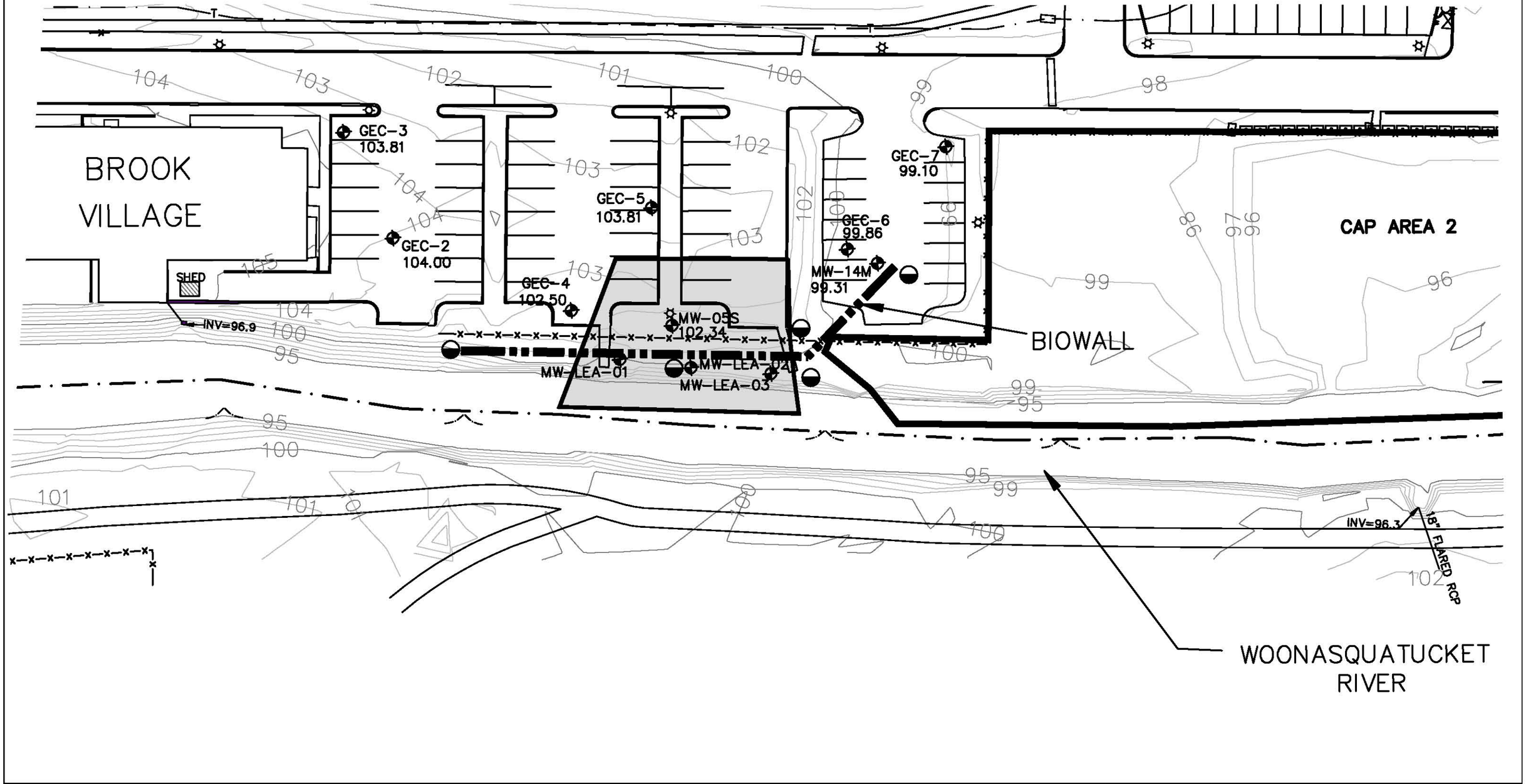
- 90 EXISTING GROUND ELEVATION (ft)
- GROUNDWATER MONITORING WELL
- PROPOSED CLEANUP AREA
- NEW EXTRACTION WELL
- NEW MONITORING WELL

RHODE ISLAND STATE PLANE

Date: 5/20/09

Document: Fig 5-29.dwg
Drawn By: S. Brown (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: SCALE: 1"=40'
0 40' 80'

Figure 5-30

Explanation: CONCEPTUAL
PASSIVE REACTIVE BARRIER (BIOWALL)

90 EXISTING POND BOTTOM OR GROUND ELEVATION
EXISTING GROUNDWATER MONITORING WELL
PROPOSED GROUNDWATER MONITORING WELL
GROUNDWATER CLEANUP AREA

RHODE ISLAND STATE PLANE

Date: 5/20/09

Document: Fig 5-30.dwg
Drawn By: S. Brown (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 500 1000 FEET

Figure 6–1

Explanation: ALLENDALE AND LYMAN MILL REACH SEDIMENT CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 7

- NORMAL WATER ELEVATION
- 100 YR. FLOOD ELEVATION
- AQUATIC – BENTHIC HABITAT, FISH RESTOCKING, TEMPORARY FISH/ INVERTEBRATE NURSERY HABITAT/JUVENILE REFUGIA.
- AQUATIC (POTENTIAL SCOUR AREAS)– BENTHIC HABITAT, FISH RESTOCKING, TEMPORARY FISH/INVERTEBRATE NURSERY HABITAT/JUVENILE REFUGIA.
- NEARSHORE CDF (OPTION B) – COMPENSATORY MITIGATION REQUIRED FOR LOST OPEN WATER/RIPARIAN HABITAT/WETLAND/FLOOD STORAGE CAPACITY.

RHODE ISLAND STATE PLANE

Date: 03/24/10

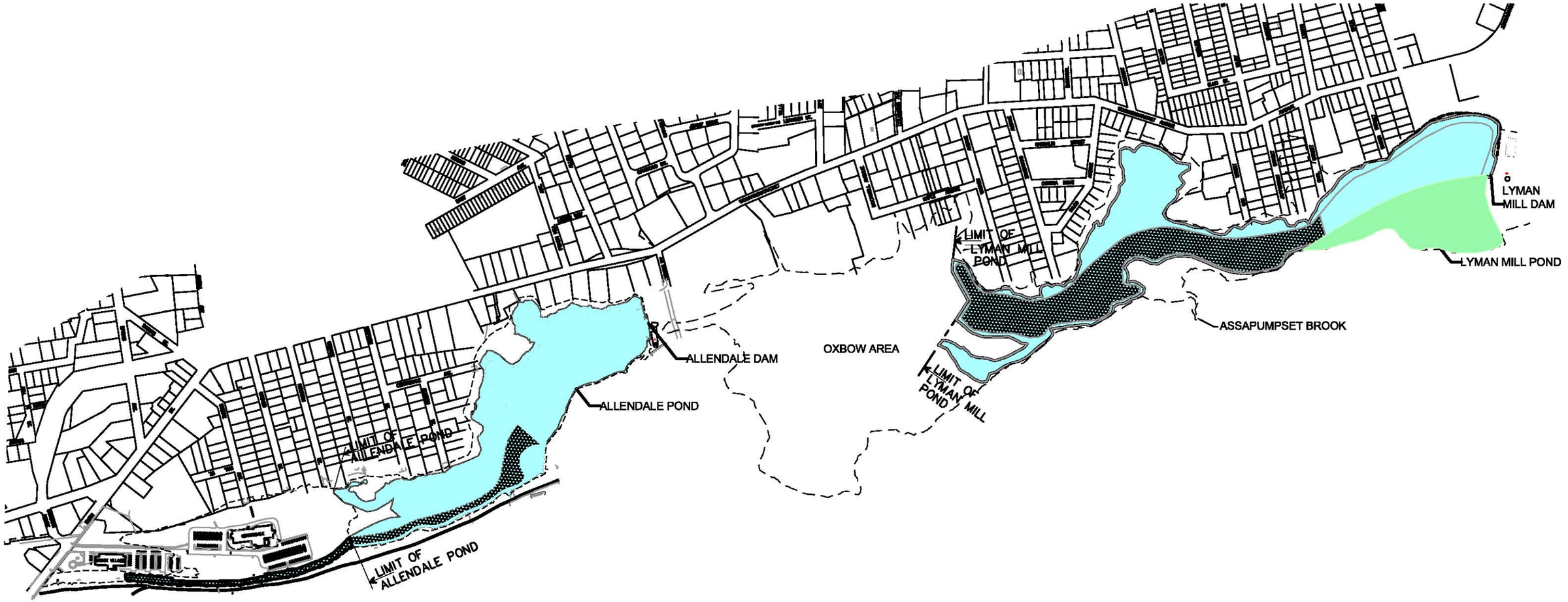
Document: Fig 6–1_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



Battelle

Scale: 0 500 1000 FEET

Figure 6–2

Explanation: ALLENDALE AND LYMAN MILL REACH SEDIMENT CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 8

- NORMAL WATER ELEVATION
- 100 YR. FLOOD ELEVATION
- AQUATIC – BENTHIC HABITAT, FISH RESTOCKING, TEMPORARY FISH/ INVERTEBRATE NURSERY HABITAT/JUVENILE REFUGIA.
- AQUATIC (POTENTIAL SCOUR AREAS)– BENTHIC HABITAT, FISH RESTOCKING, TEMPORARY FISH/INVERTEBRATE NURSERY HABITAT/JUVENILE REFUGIA.
- NEARSHORE CDF (OPTION B) – COMPENSATORY MITIGATION REQUIRED FOR LOST OPEN WATER/RIPARIAN HABITAT/WETLAND/FLOOD STORAGE CAPACITY.

RHODE ISLAND STATE PLANE

Date: 03/24/10

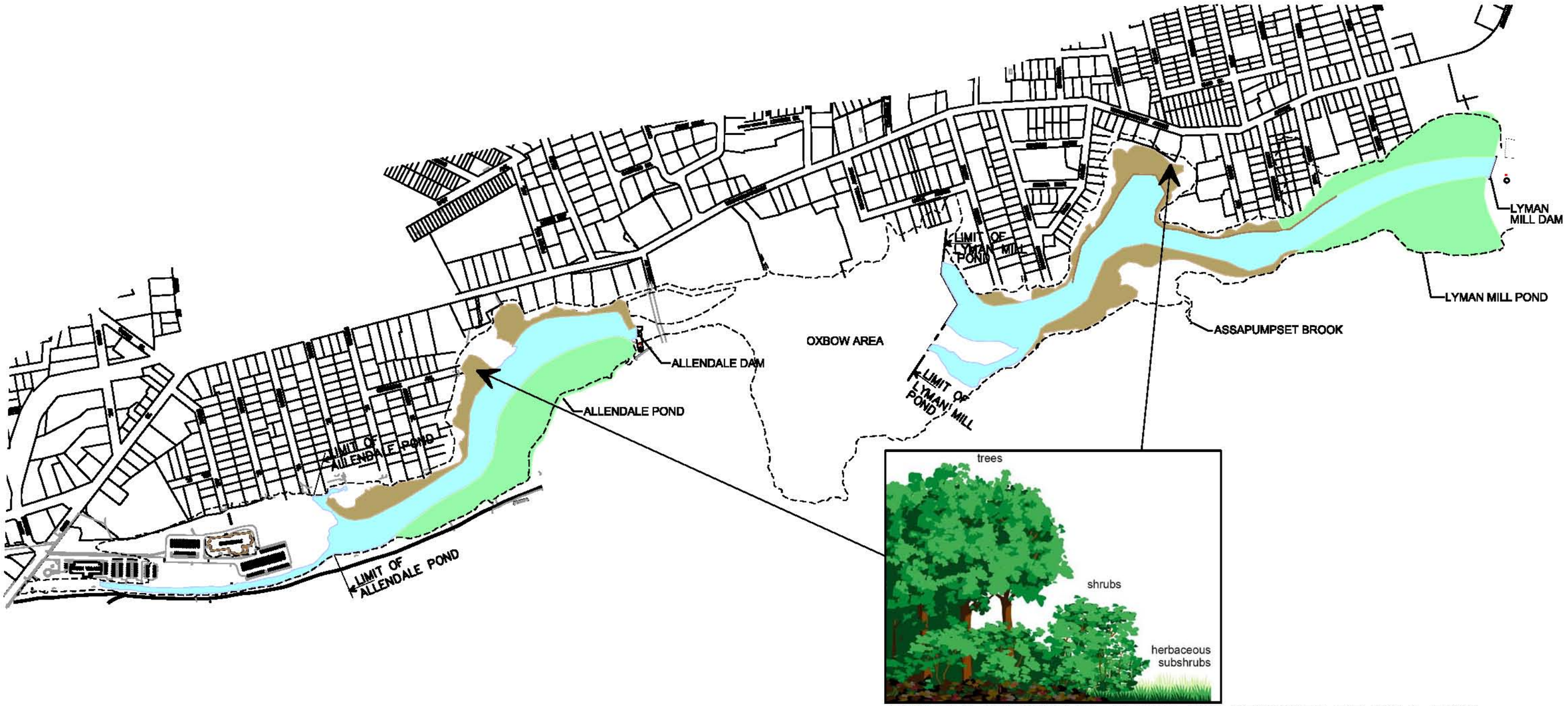
Document: Fig 6–2_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

US EPA ARCHIVE DOCUMENT



EXAMPLE CONCEPTUAL DESIGN FOR RESTORED RIPARIAN ZONE
ADAPTED FROM FISRWG (2001)

Battelle

Figure 6–3

Scale: 0 500 1000 FEET

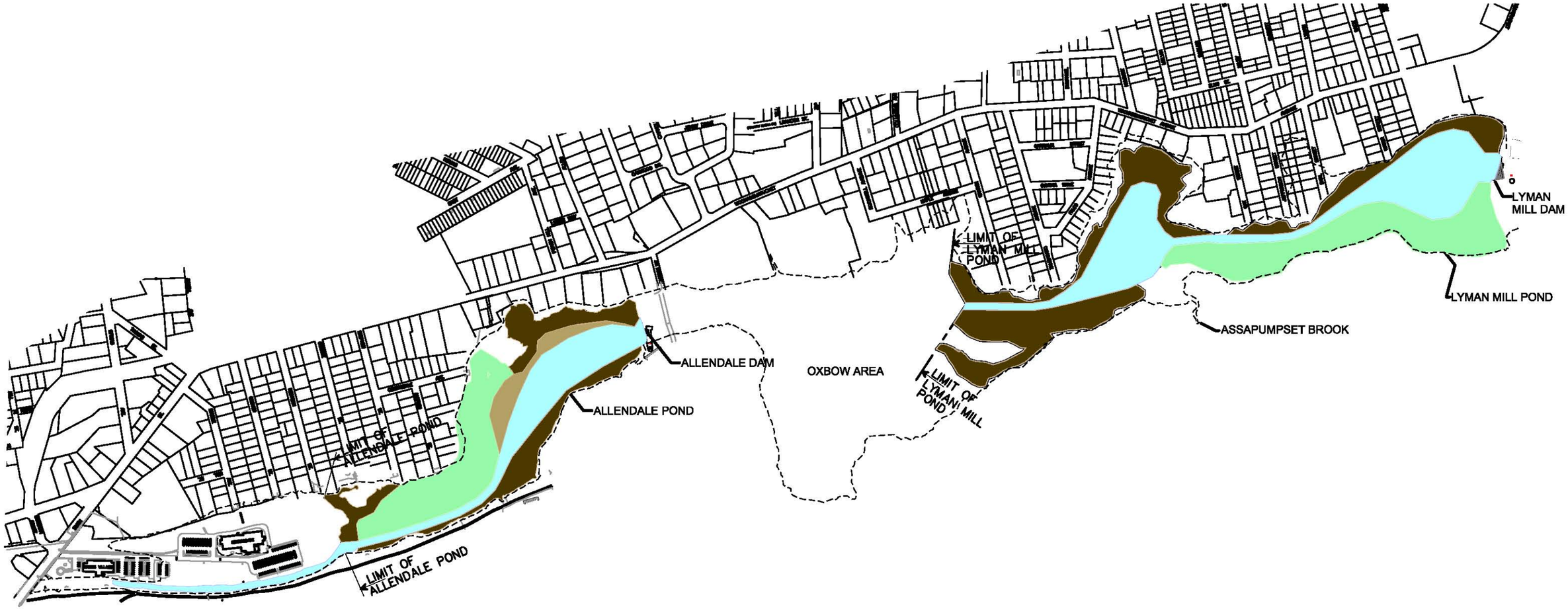
Explanation: ALLENDALE AND LYMAN MILL REACH SEDIMENT CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 10

- AQUATIC – BENTHIC HABITAT, FISH RESTOCKING, TEMPORARY FISH/INVERTEBRATE NURSERY HABITAT/JUVENILE REFUGIA.
- PROPOSED NEW FLOODPLAIN – PLANT RIPARIAN VEGETATION INCLUDING BALLED TREE/SHRUB AND SEED MIX
- NEARSHORE CDF (OPTION B) – COMPENSATORY MITIGATION REQUIRED FOR LOST OPEN WATER/RIPARIAN HABITAT/WETLAND/FLOOD STORAGE CAPACITY.
- NORMAL WATER ELEVATION
- 100 YR. FLOOD ELEVATION

Date: 03/24/10

Document: Fig 6-3_REV0.dwg
Drawn By: L. Bouchard (Watermark)
Checked By: D. Dahlen (Battelle)
Projection: Rhode Island State Plane (NAD 83 Feet)

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Battelle

Scale: 0 500 1000 FEET

Figure 6–4

Explanation: ALLENDALE AND LYMAN MILL REACH SEDIMENT CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 11

- AQUATIC – BENTHIC HABITAT, FISH RESTOCKING, TEMPORARY FISH/ INVERTEBRATE NURSERY HABITAT/JUVENILE REFUGIA.
- PROPOSED NEW FLOODPLAIN – PLANT RIPARIAN VEGETATION INCLUDING BALLED TREE/SHRUB AND SEED MIX
- PROPOSED NEW FLOODPLAIN – COMPENSATORY MITIGATION MAY BE REQUIRED FOR LOST OPEN WATER/RIPARIAN HABITAT/WETLAND/FLOOD STORAGE CAPACITY.
- CONSOLIDATION AREA (OPTION F) – COMPENSATORY MITIGATION REQUIRED FOR LOST OPEN WATER/RIPARIAN HABITAT/WETLAND/FLOOD STORAGE CAPACITY.
- NORMAL WATER ELEVATION
- 100 YR. FLOOD ELEVATION

RHODE ISLAND STATE PLANE

Date: 03/24/10

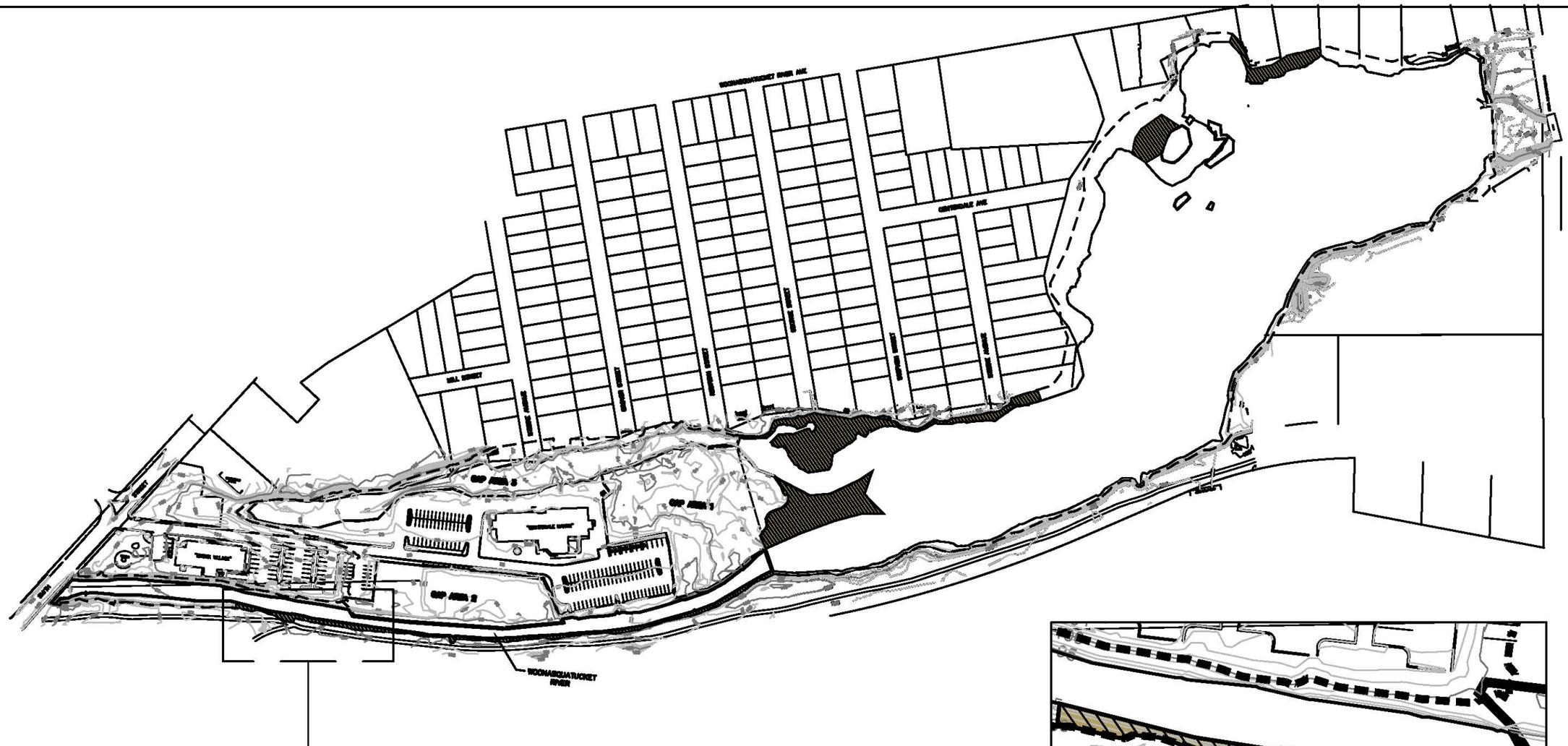
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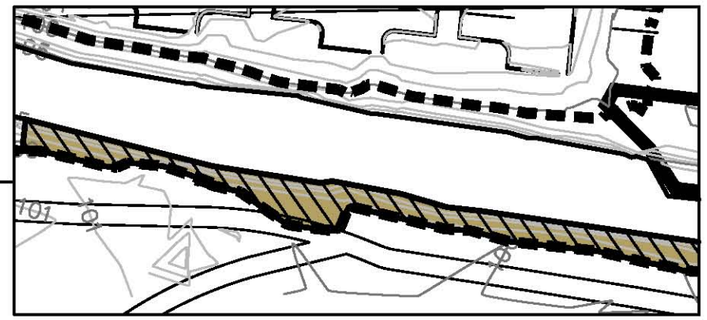
Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

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EXPANDED VIEW OF CLEAN–UP AREA ALONG WESTERN BANK OF WOONASQUATUCKET RIVER

Battelle

Scale: 0 240' 480' FEET

Figure 6–5

Explanation: ALLENDALE REACH FLOODPLAIN SOIL CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 5

- NORMAL WATER ELEVATION (EL=93.5')
- 100 YR. FLOOD ELEVATION (GRADIENT OF 101.2' AT SMITH ST TO 97' AT ALLENDALE DAM)
- FLOODPLAIN (EXCAVATION AREAS) – BACKFILL WITH APPROPRIATE LOAM TO ENCOURAGE RAPID RE–ESTABLISHMENT OF SOIL INFAUNA AND PLANT FLOODPLAIN TREES/SHRUBS ALONG WITH WETLAND HERBACEOUS SEED MIX.

Date: 3/17/10

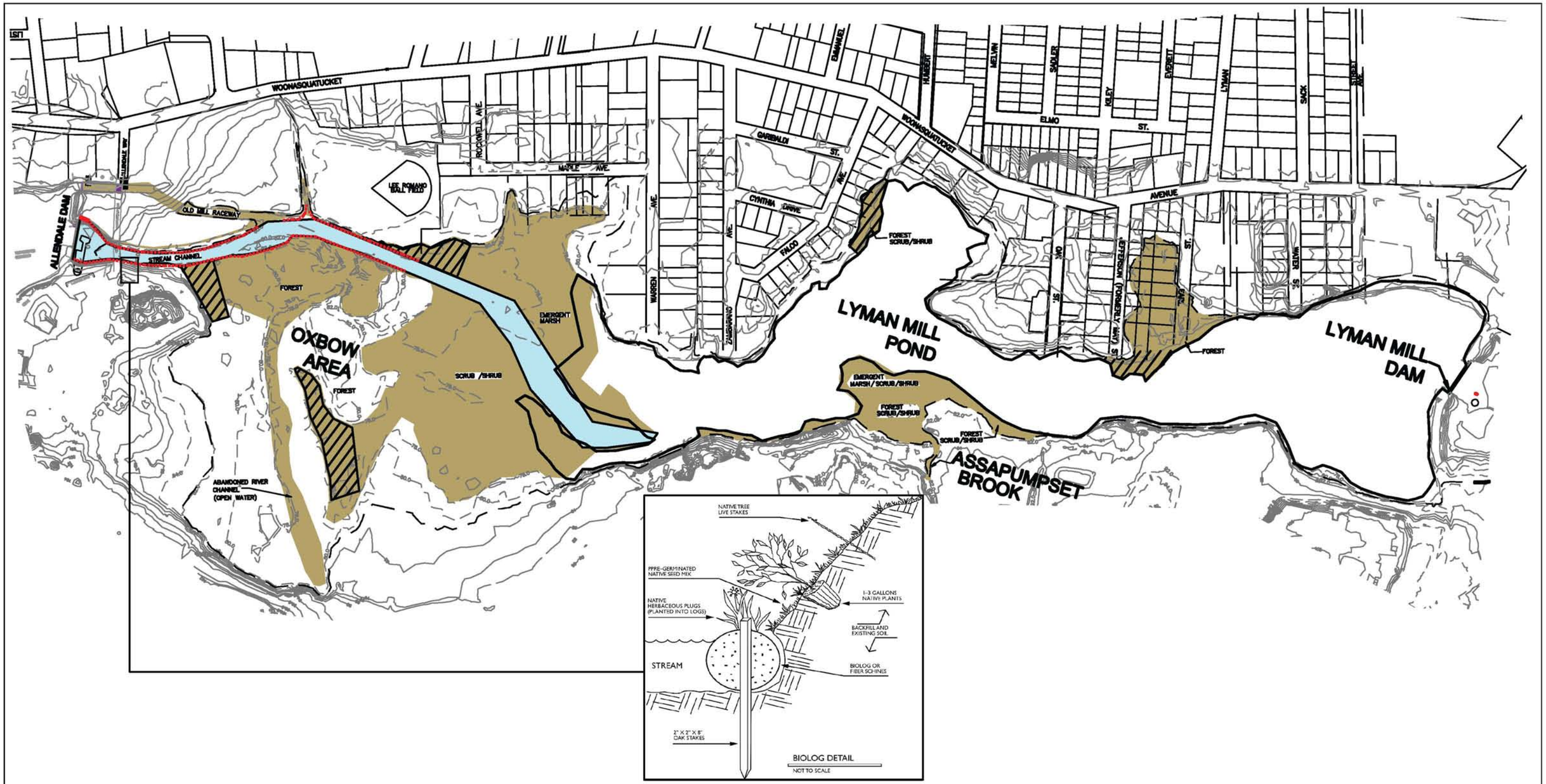
Document: Fig 6–5_REV0.dwg

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Projection: Rhode Island State Plane (NAD 83 Feet)

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EXAMPLE STREAMBANK RESTORATION DESIGN FEATURES
FROM THE USDA NATURAL RESOURCE CONSERVATION SERVICE WATERSHED TECHNOLOGY ELECTRONIC CATALOG

Battelle

Scale: 0 300 600 FEET

Figure 6–6

Explanation: LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 3

- 80.0 EXISTING TOPOGRAPHY
- NORMAL WATER ELEVATION (EL.=77.0' AT LYMAN MILL DAM)
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.6' AT LYMAN MILL DAM)
- INSTALL BIOLOG PARALLEL TO STREAM CHANNEL AND EROSION CONTROL MATTING. (SEE INSET DETAIL).
- AQUATIC (STREAM CHANNEL EXCAVATION AREA)– BACKFILL WITH SIMILARLY SIZED ROCK/GRAVEL TO RE-ESTABLISH EXISTING BENTHIC HABITAT STRUCTURE
- FLOODPLAIN (EXCAVATION AREAS) – BACKFILL WITH APPROPRIATE LOAM TO ENCOURAGE RAPID RE-ESTABLISHMENT OF SOIL INFAUNA, PLANT APPROPRIATE FLOODPLAIN TREES/SHRUBS ALONG WITH WETLAND HERBACEOUS SEED MIX.
- FLOODPLAIN (THIN COVER AREAS) – APPLY WETLAND SEED MIX TO STABILIZE SOILS

RHODE ISLAND STATE PLANE

Date: 03/17/10

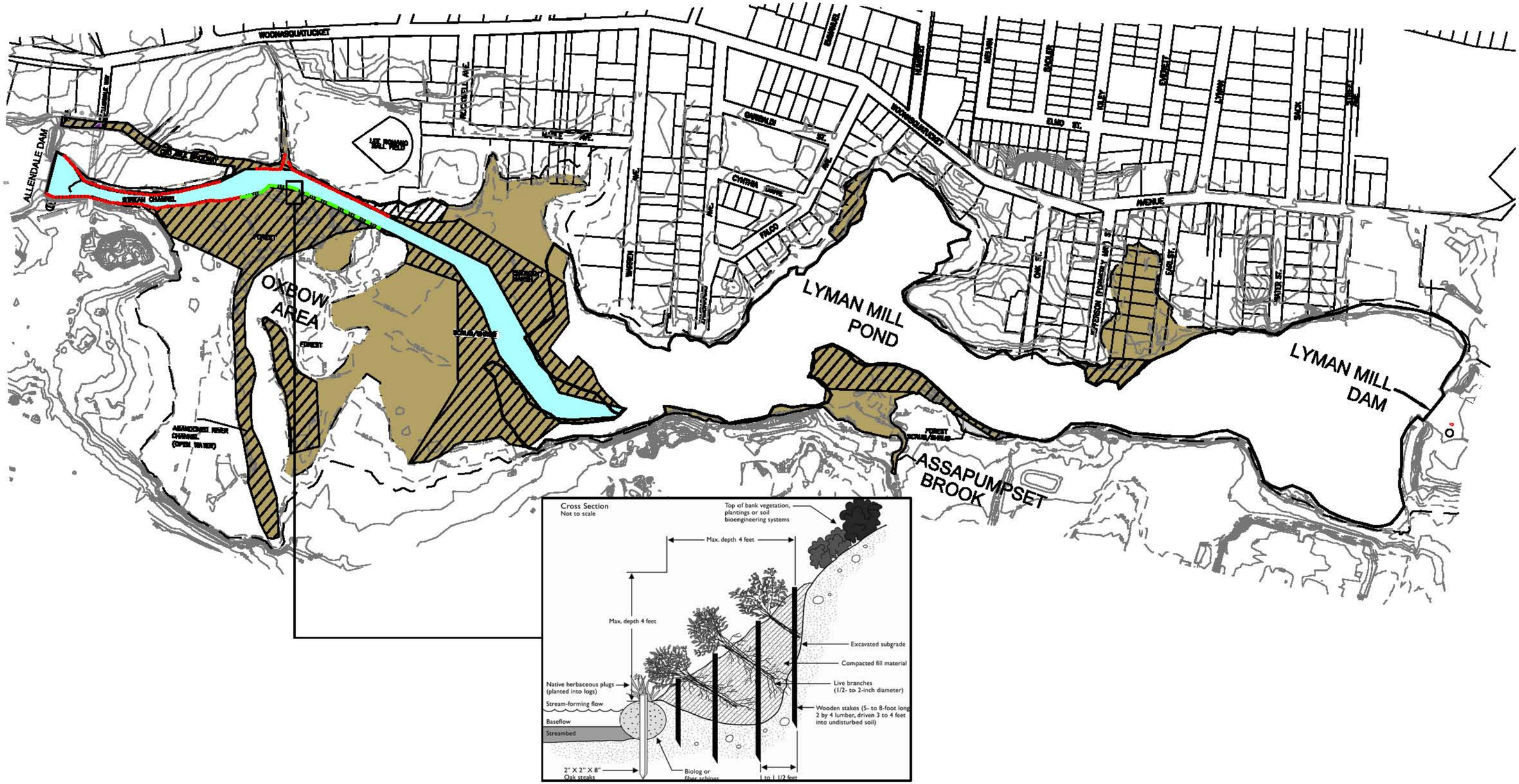
Document: Fig 6–6_REV0.dwg

Drawn By: L. Bouchard (Watermark)

Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

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EXAMPLE STREAMBANK RESTORATION DESIGN FEATURES
FROM THE USDA NATURAL RESOURCE CONSERVATION SERVICE ENGINEERING FIELD HANDBOOK

Battelle

Scale: 0 300 600 FEET

Figure 6–7

Explanation: LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL CONCEPTUAL MITIGATION AREAS FOR ALTERNATIVE 5

- EXISTING TOPOGRAPHY
- 100 YR. FLOOD ELEVATION (GRADIENT OF 82.1' AT STREAM BELOW ALLENDALE DAM TO 80.8' AT LYMAN MILL DAM)
- INSTALL BIOLOG PARALLEL TO STREAM CHANNEL AND EROSION CONTROL MATTING.
- AQUATIC (STREAM CHANNEL EXCAVATION AREA)– BACKFILL WITH SIMILARLY SIZED ROCK/GRAVEL TO RE-ESTABLISH EXISTING BENTHIC HABITAT STRUCTURE
- FLOODPLAIN (EXCAVATION AREAS) – BACKFILL WITH APPROPRIATE LOAM TO ENCOURAGE RAPID RE-ESTABLISHMENT OF SOIL INFAUNA, PLANT APPROPRIATE FLOODPLAIN TREES/SHRUBS ALONG WITH WETLAND HERBACEOUS SEED MIX.
- FLOODPLAIN (THIN COVER AREAS) – APPLY WETLAND SEED MIX TO STABILIZE SOILS
- BANK RESTORATION (SEE INSET) – STABILIZE STREAMSIDE BANK, PLANT APPROPRIATE FLOODPLAIN TREES/SHRUBS

Date: 03/17/10

Document: Fig 6–7_REV0.dwg

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Checked By: D. Dahlen (Battelle)

Projection: Rhode Island State Plane (NAD 83 Feet)

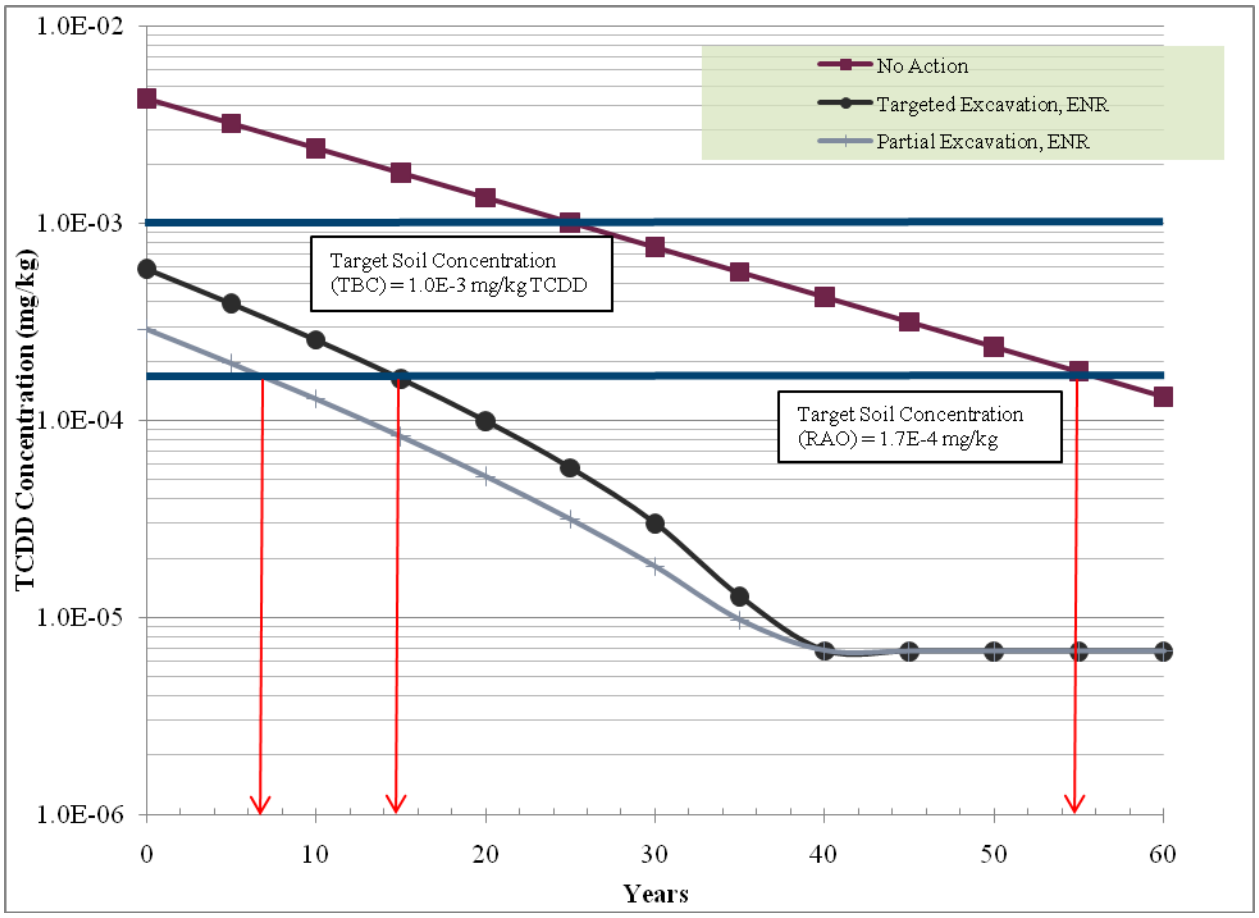


Figure 6-8. Anticipated Time Course for Reduction of Residual 2,3,7,8-TCDD Concentrations in Oxbow Floodplain Soil Following Remedy Implementation

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Table 2-1. Actions Taken at the CMRP Site

Date	Action	Legal Authority	Who Undertook	Results	Related Documents
1999–2000	Fencing constructed in source area and in residential areas adjoining Allendale Pond (repairs to the fence were performed in 2005); Construction of two interim protective caps and a flood control berm in the source area; Placement of riprap along eastern bank of the Woonasquatucket River in the source area	EPA, Region I	Combination of fund-lead and PRP-lead	Restrict access to potentially contaminated media; Isolate contaminated soils to minimize human exposure; Reduce/prevent erosion and runoff of contaminated soils to the river	EPA Region I Action Memorandum, dated May 4, 1999, as amended September 13, 1999 and June 1, 2000
2000–2003	EE/CA; Reconstruction of the Allendale Dam and restoration of Allendale Pond in 2002; Excavation and remediation of contaminated floodplain soils in eleven action areas on residential properties and recreational access points along Allendale and Lyman Mill Ponds	EPA, Region I	PRP-lead	Mitigate unacceptable human health risk from exposure to contaminated soils on residential and recreational use properties on the Woonasquatucket River floodplain between Route 44 and the Lyman Mill Dam; Prevent further downstream migration of sediment-bound contaminants; Minimize exposure to site-related contaminants	TTNUS, 2000a; EPA OSWER Directive 9200.4-26 (*Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites*, April 13, 1998); Action Memorandum dated January 18, 2001 (EPA, 2001c); and Completion of Work Report (LEA, 2005)
2003–2004	Construction of permeable protective cap in former tailrace, installation of a precast modular stormwater control structure at the north end of the tailrace, and construction of a drainage swale along the capped area	EPA, Region I	PRP-lead	Minimize potential erosion and downstream transport of contaminated soils and sediments in the former tailrace on the east side of the source area	Completion of Work Report (LEA, 2004)

Key:
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act of 1980; EE/CA - Engineering Evaluation/Cost Analysis; LEA - Loureiro Engineering Associates; OSWER - Office of Solid Waste and Emergency Response; PRP - Potentially Responsible Party; RCRA - Resource Conservation and Recovery Act; TTNUS - Tetra Tech NUS, Inc.; EPA – United States Environmental Protection Agency

Table 2-2. Land Uses[1]

	Current On-site Use	Current Adjacent Use	Reasonable Potential Beneficial Use	Basis for Potential Beneficial Use
Land	Mixed residential, with some commercial and light industrial	Mixed residential, with some commercial and light industrial	Recreational/ Residential	Rhode Island Statewide Planning Program, Rivers Policy and Classification Plan
	Undeveloped woods and wetland	Mixed residential, with some commercial and light industrial	Recreational	Rhode Island Statewide Planning Program, Rivers Policy and Classification Plan; Oxbow Wetland Analysis (USACE, 2008); Watershed Initiatives[2]
Shallow Groundwater	None[3]	None[3]	None[3]	Not applicable
Deep Groundwater	None	Yacht Club Flavored Seltzer & Soda bottling plant	None	Not applicable
Surface Water	Recreational[4]	Recreational	Recreational	Rhode Island Statewide Planning Program, Rivers Policy and Classification Plan; Watershed Initiatives[2]

Notes:
[1] Land use assumes that the Allendale and Lyman Mill Dams will remain in place. Land use would need to be re-evaluated if the remedy selected includes dam removal and/or replacement.
[2] Remediation at the CMRP site will contribute to achieving the long-term goal to improve conditions in the watershed. The Narragansett Bay and Watershed Planning Commission identified that "By 2015, make the Blackstone, Woonasquatucket and Wood-Pawcatuck Rivers, and Greenwich Bay fishable and swimmable". Local urban revitalization and watershed restoration efforts also promote the development of areas for recreational activities.
[3] Groundwater at the site is federally classified as Class III: Not a Potential Source of Drinking Water and/or of Limited Beneficial Use. Under state groundwater regulations, this aquifer part is also classified as GB (defined as "may not be suitable for public or private drinking water use without treatment due to known or presumed degradation" [RIDEM, 2005a]). The proposed groundwater alternatives assume that institutional controls will be implemented to prevent the use of groundwater.
[4] Surface water at the site is classified as Class B1 (see Section 2.3.1).

Key:
USACE - United States Army Corps of Engineers

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Table 2-3. Summary of Aquifer Characteristics[1]

Aquifer/Aquitard Formation/Confined	Flow Direction, Quantity	Source Contaminants	Discharges To	NAPLs	Dissolved VOCs
Shallow Overburden, silty sands and gravel (0-14 feet bgs)	South/0.21 feet/day average groundwater velocity	Chemicals released directly to the ground and/or buried; soil is a secondary source	Woonasquatucket River[2]; the source area is bounded to the west by the river (see Figure 1-2)	Yes (in soils)	Yes, PCE and TCE
Deep Overburden, sand and gravel, possible till (23-70 feet bgs)	South-southeast/ 0.55 feet/day average groundwater velocity	Shallow Overburden	Shallow Overburden	No	Yes, PCE and chloroethane
Bedrock	South-southeast/27 feet/day average groundwater velocity	Overburden	Deep Overburden	No	Yes, PCE and chloroethane

Notes:
[1] Data source: Battelle, 2005a.
[2] Under low-flow conditions the aquifer recharges the river except in the southern portion of the source area where the river still loses water to the aquifer; under high-flow conditions the river recharges the aquifer except in the vicinity of the small groundwater mound located beneath the Brook Village parking lot.

Key:
bgs - below ground surface; NAPL - non-aqueous phase liquid; PCE - tetrachloroethylene; TCE - trichloroethylene; VOCs - volatile organic compounds

Table 2-4. Flood Frequency Data[1]

Flood Return Period (yr)	Percent Probability of Occurring in 10-yr	Flow Rate (cfs)
5	89	893
10	65	1,150
25	34	1,550
50	18	1,900
100	10	2,300
200	5	2,760
500	2	3,480
1000	1	4,140

Notes:
[1] Data source: USACE/ERDC, 2006. The flood frequency analysis was conducted using the Log Pearson Type III distribution as described in Bulletin 17B of the Hydrology Subcommittee, *Guidelines for Determining Flood Fre*quency, and accepted by federal agencies as the standard to conduct this type of analysis. Reported flow rates are based on average regional skew, expected probability peak.

Key:
cfs - cubic feet per second; yr - year

Table 2-5. Community and Acreage Estimates at Lyman Mill Pond and the Oxbow Area[1]

Community Type	Area (acres)
Lacustrine	
Open Water[2]	20.9
Palustrine	
Open Water	0.9
Emergent vegetation, persistent	5.4
Scrub-shrub, broad-leaved deciduous	0.9
Forest, broad-leaved deciduous	11.1
Mixed open water, persistent emergent	0.5
Mixed persistent emergent, scrub-shrub	2.2
Mixed scrub-shrub, forested	3.8
Riverine	
Open Water	1.5
Intermittent Stream	<0.1
Upland	
Forest	10.6
Shrub	1.5
Grassland	3.0
Other	
Vernal Pool or Potential Vernal Pool	0.1
Sediment Retention Basin	1.0
Total[3]	63.4

Notes:

[1] Data source: USACE, 2008.

[2] Acreage estimate for Lyman Mill Pond (i.e., 20.9 acres) is slightly lower compared to the estimate reported in Section 2.3.8.2 (i.e., 23.5 acres); the difference in estimates is associated with the persistent emergent vegetation in the transition zone between the Oxbow and Lyman Mill Pond areas.

[3] Total acreage estimate (i.e., 63.4 acres) includes upland areas (forest, shrub, and sediment retention basin), which are not included in acreage estimates reported in Section 2.3.8.2 (i.e., approximately 50.5 acres including 27 acres Oxbow and 23.5 acres Lyman Mill Pond).

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Table 2-6a. Sources, Nature and Extent of Contamination at the CMRP site

(Summary statistics reported in Table 2-6b)

Suspected Contamination Source	Contaminant	Medium Affected	Release Mechanisms	Contamination Volume or Areal Extent	Sampling Activities
Chemical manufacturing and drum reconditioning operations (1940s to 1970s)	Dioxins (primarily 2,3,7,8-TCDD), furans, HCX, PCBs, VOCs, SVOCs, and metals	Soil, groundwater, sediment, surface water, and biota	Chemicals released directly to the ground, buried, and possibly discharged directly to the Woonasquatucket River	Study area evaluated in the RI includes the 3-mile reach of the river from the Route 44 Bridge immediately upstream of the Brook Village apartment complex, downstream to the former Dyerville Dam; *Area evaluated in the FS includes the 1.5-mile reach of the River from the Route 44 Bridge to Lyman Mill Dam*	Approximately 40 investigations conducted from 1997 to 2006; approximately 1,000 soils, 450 sediments, 100 groundwater, and 60 surface water chemically analyzed (see Tables 1-2, 2-1, 4-1 of RI [Battelle, 2005a])

Key:
FS – feasibility study; HCX - hexachloroxanthene; PCB - polychlorinated biphenyl; RI - Remedial Investigation report; SVOC - semi-volatile organic compound; VOC - volatile organic compound

Table 2-6b. Sources, Nature and Extent of Contamination at the CMRP Site, Summary Statistics

Affected Medium[1]	Contaminant[1]	Concentration Range[2]	Concentration Average[3]	Mobility	Toxicity[4]
Source Area, Soil	Dioxin TEQ	0.000079–140000 ng/kg	118 ng/kg	Low	B2[5]
	PCBs (total Aroclors)	0.0074–1300 mg/kg	0.29 mg/kg	Low	B2[6]
	Dieldrin	0.0002–9.9 mg/kg	0.0009 mg/kg	Low	B2
	Technical chlordane	0.0009-10.6 mg/kg	-	Low	B2
	Benzo(a)anthracene	0.006–8.5 mg/kg	0.22 mg/kg	Low	B2
	Benzo(a)pyrene	0.006–8.9 mg/kg	0.25 mg/kg	Low	B2
	Benzo(b)fluoranthene	0.0235–10 mg/kg	0.30 mg/kg	Low	B2
	Benzo(g,h,i)perylene	0.0041–5.3 mg/kg	-	Low	D
	Benzo(k)fluoranthene	0.0099–8.8 mg/kg	-	Low	B2
	Biphenyl	0.041-1.61 mg/kg	-	Low	B2
	Bis(2-ethyhexyl)phthalate	0.042-460 mg/kg	0.18 mg/kg	Low	B2
	Chrysene	0.0045–11 mg/kg	0.27 mg/kg	Low	B2
	Dibenzo(a,h)anthracene	0.0048–2.2 mg/kg	-	Low	B2
	Fluoranthene	0.0235–24 mg/kg	0.46 mg/kg	Low	D
	Indeno(1,2,3-c,d)pyrene	0.0055–5.3 mg/kg	-	Low	B2
	Naphthalene	0.0021–84 mg/kg	-	Low	D
	Pentachlorophenol	0.011–18 mg/kg	-	Low	B2
	Pyrene	0.0235–23 mg/kg	0.47 mg/kg	Low	D
	Antimony	0.08–27.8 mg/kg	-	Low	ND
	Arsenic	0.27–49.3 mg/kg	3.40 mg/kg	Low	A
	Beryllium	0.03–3.90 mg/kg	0.41 mg/kg	Low	B2
	Cadmium	0.03–180 mg/kg	0.32 mg/kg	Low	B1
	Lead	2.2–3160 mg/kg	53.8 mg/kg	Low	B2
	Manganese	35.7–6420 mg/kg	194 mg/kg	Low	D
	Thallium	0.16–13.4 mg/kg	-	Low	D
	Benzene	0.0003–480 mg/kg	-	High	A
	Chlorobenzene	0.0004–1000 mg/kg	-	Moderate to Very High	D
	Dichloroethane (1,2-)	0.0002–1.7 mg/kg	-	High to Very High	B2
	Dichloroethene (cis-1,2)	0.0005-500 mg/kg	-	High to Very High	D
	Ethyl benzene	0.0003–81 mg/kg	-	Moderate	D
	Tetrachloroethene (PCE)	0.0002–1700 mg/kg	-	High	B2
	Toluene	0.0003–430 mg/kg	-	Very High to Moderate	D
	Trichloroethene (TCE)	0.0002–2400 mg/kg	-	Moderate to High	B2
	Vinyl chloride	0.0006–2.3 mg/kg	-	High	A
	Xylenes (Total)	0.0009–380 mg/kg	-	Moderate	D
Source Area, Ground-water	2,3,7,8-TCDD	0.95–6154 pg/L	-	Low	B2
	Dibromochloropropane (DBCP)	0.4-7 µg/L	-	High	B2
	Tetrachloroethene (PCE)	0.1–61000 µg/L	-	High	B2
	Trichloroethene (TCE)	0.0435–2500 µg/L	-	Moderate	B2

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Table 2-6b. (continued)

Affected Medium[1]	Contaminant[1]	Concentration Range[2]	Concentration Average[3]	Mobility	Toxicity[4]
Allendale, Sediment	2,3,7,8-TCDD	0.2–110000 ng/kg[8]	879 ng/kg[8]	Low	B2
	Dioxin TEQ	0.52–110000 ng/kg	972 ng/kg	Low	B2[5]
	PCB TEQ	147–147 ng/kg	*147* ng/kg	Low	B2[6]
	Total Aroclors	0.0006–28 mg/kg	0.27 mg/kg	Low	B2[6]
	Aroclor 1254	0.0006–28 mg/kg	0.27 mg/kg	Low	B2
	Aroclor 1268	0.034–0.16 mg/kg	0.067 mg/kg	Low	B2
	Dieldrin	0.0001–0.17 mg/kg	-	Low	B2
	Technical Chlordane	0.0005–0.97 mg/kg	*0.028* mg/kg	Low	B2
	Benzo(a)pyrene	0.012–9.62 mg/kg	0.72 mg/kg	Low	B2
	Dibenzo(a,h)anthracene	0.016–2.6 mg/kg	-	Low	B2
	Arsenic	0.31–18 mg/kg	3.03 mg/kg	Low	A
	Selenium	0.30–4.7 mg/kg	-	Low	D
	Zinc	0.26–2088 mg/kg	**299** mg/kg	Low	D
Lyman Mill, Sediment	2,3,7,8-TCDD	0.035–49421 ng/kg	433 ng/kg	Low	B2
	Dioxin TEQ	0.2–49737 ng/kg	533 ng/kg	Low	B2[5]
	PCB TEQ	17–64.9 ng/kg	*18.6* ng/kg	Low	B2[6]
	Total Aroclors	0.0006–3.26 mg/kg	0.135 mg/kg	Low	B2[5]
	Aroclor 1254	0.0006–2.6 mg/kg	0.13 mg/kg	Low	B2
	Aroclor 1268	0.012–0.31 mg/kg	-	Low	B2
	4,4'-DDD	0.00015–0.05 mg/kg	-	Low	B2
	4,4'-DDE	0.000067–0.046 mg/kg	-	Low	B2
	Dieldrin	0.0001–0.027 mg/kg	-	Low	B2
	Technical Chlordane	0.017–2.21 mg/kg	0.4 mg/kg	Low	B2
	Benzo(a)pyrene	0.012–7.04 mg/kg	0.67 mg/kg	Low	B2
	Dibenzo(a,h)anthracene	0.016–1.24 mg/kg	-	Low	B2
	N-nitroso-di-n-propylamine	0.008–2.1 mg/kg[7]	-	Low	B2
	Aluminum	1690–27773 mg/kg	8075 mg/kg	Low	D
	Arsenic	0.031–14.8 mg/kg	**3.95** mg/kg	Low	A
	Barium	10–380 mg/kg	92.2 mg/kg	Low	Not classified
	Selenium	0.027–4.5 mg/kg	-	Low	D
	Vanadium	4.0–91.7 mg/kg	27.2 mg/kg	Low	Not classified
	Zinc	15.4–2060 mg/kg	256 mg/kg	Low	D
Allendale, Floodplain Soil	Dioxin TEQ	Not detected–1939 ng/kg	44.1 ng/kg	Low	B2[5]
	2,3,7,8-TCDD	0.2405–1510 ng/kg	22.4 ng/kg	Low	B2
Lyman Mill, Floodplain Soil	Dioxin TEQ	0.68–1291 ng/kg	20.4 ng/kg	Low	B2[5]
	2,3,7,8-TCDD	0.0948–1130 ng/kg	8.58 ng/kg	Low	B2
	Total Aroclors	0.030–0.859 mg/kg	-	Low	B2[6]
	Aroclor 1254	0.00506–0.938 mg/kg	-	Low	B2
	4,4-DDE	0.00175–1.0 mg/kg	*0.0052* mg/kg	Low	B2
	Dieldrin	0.000745–0.015 mg/kg	-	Low	B2
	Antimony	0.04–38.2 mg/kg	-	Low	ND
	Arsenic	0.8–55.6 mg/kg	5.94 mg/kg	Low	A

Table 2-6b. (continued)

Affected Medium[1]	Contaminant[1]	Concentration Range[2]	Concentration Average[3]	Mobility	Toxicity[4]
Lyman Mill, Floodplain Soil	Cadmium	0.035–5.2 mg/kg	*0.203* mg/kg	Low	B1
	Lead	8.1–2460 mg/kg	164 mg/kg	Low	B2
	Selenium	0.25–2.4 mg/kg	-	Low	D
	Zinc	17.9–2190 mg/kg	189 mg/kg	Low	D
Oxbow, Floodplain Soil	Dioxin TEQ	347–4291 ng/kg	995 ng/kg	Low	B2[5]
	2,3,7,8-TCDD	12.2–4270 ng/kg	**1409** ng/kg	Low	B2
	Total Aroclors	0.103–3.58 mg/kg	*0.412* mg/kg	Low	B2[6]
	Aroclor 1254	0.00848–3.58 mg/kg	*0.412* mg/kg	Low	B2
	4,4-DDE	0.00251–0.0424 mg/kg	*0.00618* mg/kg	Low	B2
	Dieldrin	0.00008–0.0634 mg/kg	*0.00297* mg/kg	Low	B2
	Antimony	0.922–7.01 mg/kg	2.31 mg/kg	Low	D
	Arsenic	0.181–12.8 mg/kg	2.91 mg/kg	Low	A
	Cadmium	0.0075–8.25 mg/kg	**2.61** mg/kg	Low	B1
	Lead	44.4–1835 mg/kg	275 mg/kg	Low	B2
	Selenium	0.205–2.22 mg/kg	**1.52** mg/kg	Low	D
	Zinc	58.3–1867 mg/kg	240 mg/kg	Low	D
Allendale, Surface Water	2,3,7,8-TCDD	0.145 – 4000 pg/L	-	Low	B2
Lyman Mill, Surface Water	2,3,7,8-TCDD	1.75 – 853 pg/L	*3.65* pg/L	Low	B2

Notes:

[1] Summary statistics are provided for affected medium and contaminants for which cleanup goals are developed (as described in Section 3.4), as follows:

- Source Area Soils - contaminants detected in soil samples at concentrations in excess of the RIDEM residential direct exposure or GB leachability criteria (RIDEM, 2004; applicable to vadose zone), or EPA's recommended residential level for dioxin (EPA, 1998b; applicable to surface soil);
- Source Area Groundwater – contaminants detected in groundwater at concentrations in excess of the RIDEM GB groundwater objectives (RIDEM, 2004) as well as dioxin;
- Allendale and Lyman Mill Reach Sediment - contaminants for which there are risk-based (human health and ecological) PRGs (MACTEC, 2005b);
- Allendale and Lyman Mill Reach Floodplain Soil - contaminants for which there are risk-based (human health and ecological) PRGs (MACTEC, 2005b and Appendix D), as well as contaminants detected in floodplain soils at concentrations in excess of the RIDEM residential direct exposure criteria (RIDEM, 2004; applicable to vadose zone; there were no exceedances of the GB leachability criteria) or EPA's recommended residential level for dioxin (EPA, 1998b); and
- Allendale and Lyman Mill Reach Surface Water – cleanup goals developed for dioxin to serve as a useful benchmark that will be monitored during remedy implementation.

[2] The minimum concentration is based on the minimum detected concentration or ½ the method detection limit for non-detects, whichever is smaller. The maximum concentration is based on the maximum detected value, unless otherwise indicated. Data source is the RI (Battelle, 2005a) for source area soil, Allendale sediment and floodplain soil, Lyman Mill floodplain soil and Oxbow floodplain soil; data source is RI (Battelle, 2005a), Appendix A, and LEA (2008) for source area groundwater; and data source is Appendix B for Lyman Mill sediment.

[3] Average concentrations are only reported where the detection frequency is 50% or higher; reported as '-' where the detection frequency is less than 50%. The geometric mean is reported for data that are lognormally distributed; the median data (*italics*) is reported for data that are not lognormally or normally distributed; the arithmetic mean (**bold**) is reported for data that are normally distributed. Data source is the RI (Battelle, 2005a) for source area soil, Allendale sediment and floodplain soil, Lyman Mill floodplain soil and Oxbow floodplain soil; data source is RI (Battelle, 2005a) and LEA (2008) for source area groundwater; and data source is Appendix B for Lyman Mill sediment.

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Table 2-6b. (continued)

Notes: (cont)

[4] Toxicity based on Weight of Evidence/Cancer Guideline Descriptions (http://rais.ornl.gov/tox/rap_toxp.shtml), including:

A – human carcinogen
B1 – probable human carcinogen, indicates that limited human data are available
B2 – probable human carcinogen, indicates that sufficient evidence in animals and inadequate or no evidence in humans
C – possible human carcinogen
D – not classifiable as a human carcinogen
E – evidence of noncarcinogeniety
ND – no data available

[5] Based on toxicity profile for 2,3,7,8-TCDD.
[6] Based on toxicity profile for Aroclor 1254.
[7] Maximum concentration based on detection limit.
[8] Concentration range and average do not include sediment data from 2005 SPMD investigation (Appendix A); however, concentrations of 2,3,7,8-TCDD in surface sediments from the 2005 SPMD investigation are within the concentration range reported here.

Key:
mg/kg - milligrams per kilogram; ng/kg - nanograms per kilogram; PCB - polychlorinated biphenyl; TEQ - toxic equivalency

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Table 2-7a. Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Receptor: Resident Living Along the River / Visiting Recreational Angler
Medium: Biota
Exposure Medium: Biota

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection			Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum							
Allendale Pond	Aroclor 1254	0.43	3.2	mg/kg	18	/	20	1.9	mg/kg	Avg (1)
	Aroclor 1268	0.018	0.077	mg/kg	11	/	20	0.027	mg/kg	Avg (1)
	Dieldrin	0.0017	0.014	mg/kg	19	/	20	0.0089	mg/kg	Avg (1)
	Technical Chlordane	0.10	1.2	mg/kg	20	/	20	0.47	mg/kg	Avg (1)
	Toxicity Equivalency (PCB Congeners) - Mammals	0.000018	0.000042	mg/kg	6	/	6	0.000032	mg/kg	Avg (1)
	Toxicity Equivalency (Dioxins/Furans) - Mammals	0.0000096	0.00080	mg/kg	20	/	20	0.00030	mg/kg	Avg (1)

Notes:
(1) – Exposure point concentration is the average of the exposure point concentrations for American eel and white sucker.

Key:
mg/kg - milligrams per kilogram
PCB - Polychlorinated Biphenyl

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Table 2-7b. Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Receptor: Resident Living Along the River
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum					
Allendale Pond	Benzo(a)pyrene	0.064	9.2	mg/kg	45 / 48	4.0	mg/kg	95% UCL-T
	Dibenzo(a,h)anthracene	0.077	2.6	mg/kg	26 / 47	2.0	mg/kg	95% UCL-T
	Arsenic	1	18	mg/kg	48 / 51	5.8	mg/kg	95% UCL-NP
	Toxicity Equivalency (Dioxins/Furans) - Mammals	0.0000012	0.0730	mg/kg	149 / 149	0.0057	mg/kg	95% UCL-NP

Key
95% UCL-T: 95% Upper Concentration Limit on the mean, lognormal distribution
95% UCL-NP: 95% Upper Concentration Limit on the mean, nonparametric distribution. Arithmetic mean used to approximate the 95% UCL for nonparametric data.
mg/kg - milligrams per kilogram

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Table 2-7c. Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Receptor: Resident Living Along the River / Visiting Recreational Angler
Medium: Biota
Exposure Medium: Biota

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum					
Lyman Mill Pond	Benzo(a)pyrene	0.00014	0.01469	mg/kg	18 / 30	0.0055	mg/kg	Avg (1)
	4,4'-DDE	0.02045	0.28651	mg/kg	30 / 30	0.089	mg/kg	Avg (1)
	Aroclor 1254	0.089	7.1	mg/kg	30 / 30	2.1	mg/kg	Avg (1)
	Aroclor 1268	0.007	0.1	mg/kg	20 / 30	0.021	mg/kg	Avg (1)
	Dieldrin	0.001	0.01	mg/kg	30 / 30	0.0057	mg/kg	Avg (1)
	Technical Chlordane	0.073	2.6	mg/kg	30 / 30	1.0	mg/kg	Avg (1)
	Toxicity Equivalency (PCB Congeners) - Mammals	0.0000014	0.000060	mg/kg	11 / 11	0.000041	mg/kg	Avg (1)
	Toxicity Equivalency (Dioxins/Furans) - Mammals	0.0000099	0.0014	mg/kg	30 / 30	0.00037	mg/kg	Avg (1)

Notes:
(1) - Exposure point concentration is the average of the exposure point concentrations for American eel, largemouth bass and white sucker.

Key:
mg/kg - milligrams per kilogram
PCB - Polychlorinated Biphenyl

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Table 2-7d. Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Receptor: Resident Living Along the River
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum					
Lyman Mill Pond	Benzo(a)pyrene	0.045	6.2	mg/kg	34 / 40	2.9	mg/kg	95% UCL-T
	Dibenzo(a,h)anthracene	0.078	1.1	mg/kg	17 / 40	1.1	mg/kg	Maximum
	N-nitroso-di-n-propylamine	1.4	1.4	mg/kg	1 / 33	1.3	mg/kg	95% UCL-N (1)
	Arsenic	1.2	13.2	mg/kg	37 / 39	6.4	mg/kg	95% UCL-T
	Toxicity Equivalency (Dioxins/Furans) - Mammals	0.00000089	0.0080	mg/kg	46 / 46	0.0080	mg/kg	Maximum

Notes:
(1) – Statistic calculated using an earlier version of EPA ProUCL software (circa 2004) with non-detected values replaced with one-half the reported analytical detected level.

Key
95% UCL-T: 95% Upper Concentration Limit on the mean, lognormal distribution
95% UCL-N: 95% Upper Concentration Limit on the mean, normal distribution

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Table 2-7e. Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Current
Receptor: Passive Recreational Visitor
Medium: Soil
Exposure Medium: Flood Plain Soil

Exposure Point	Chemical of Concern	Concentration Detected		Units	Frequency of Detection	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
		Minimum	Maximum					
Oxbow Area	Aroclor 1254	0.64	3.6	mg/kg	2 / 3	3.6	mg/kg	Maximum
	Arsenic	2.6	12.8	mg/kg	4 / 4	12.8	mg/kg	Maximum
	Toxicity Equivalency (Dioxins/Furans) - Mammals	0.00035	0.0043	mg/kg	7 / 7	0.0043	mg/kg	Maximum

Key
mg/kg - milligrams per kilogram

Table 2-8a. Principal and Low-level Threats at the CMRP Site

(source media, affected media, contaminant data, and affected receptors summarized in Table 2-8b)

Principal Threats	Medium	Contaminant(s)[1]	Action To Be Taken
Buried waste material	Soil/Liquid	Chemicals that were potentially used on site were identified based on drum labels and included caustics, halogenated solvents, PCBs, and inks	Preferred remedy not selected yet. Potential remedial alternatives include no action, or targeted excavation in combination with either upgrading the existing caps and parking lots or converting the existing surfaces to RCRA caps.
Leaching	Soil (west side of Brook Village parking lot)	Dioxin and VOCs	Preferred remedy not selected yet. Potential remedial alternatives include no action, excavation of contaminated soils for groundwater protection, or in-situ chemical treatment.
Low-level Threats	**Medium**	**Contaminant(s)**	**Action To Be Taken**
Resuspension and Transport	Sediment and floodplain soil	Dioxin; PCBs; Pesticides; SVOCs, and metals	Preferred remedy not selected yet. Potential remedial alternatives for sediment include no action, excavation, or partial excavation with isolation capping. Potential remedial alternatives for floodplain soil include no action, excavation, targeted excavation with enhanced natural recovery (thin-layer cover), or partial excavation with enhanced natural recovery.
Fish Consumption and Dermal Contact	Biota, sediment, floodplain soil, and surface water	Dioxin; PCBs, Pesticides, SVOCs, and metals	As above
Leaching	Source area soil	PCB and VOCs	Preferred remedy not selected yet. Potential remedial alternatives include no action, or targeted excavation in combination with either upgrading the existing caps and parking lots or converting the existing surfaces to RCRA caps.
Groundwater discharge to Woonasquatucket River	Groundwater (in vicinity of Brook Village parking lot)	Dioxin[2] and VOCs	Preferred remedy not selected yet. Potential remedial alternatives include no action, excavation of contaminated soils for groundwater protection, or in-situ chemical treatment.

Notes:

[1] See Table 2-8b for detailed contaminant data.

[2] Groundwater is not a source of drinking water, and VOCs in surface water do not pose unacceptable risk to ecological receptors. However, dioxin appears to be mobilized in groundwater and discharging to the river in the vicinity of the Brook Village parking lot.

Key:

PCB - polychlorinated biphenyl; RCRA - Resource Conservation and Recovery Act; SVOCs - semi-volatile organic compounds; TEQ - toxic equivalency; VOCs - volatile organic compounds

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Table 2-8b. Principal and Low-level Threats: Source Media, Affected Media, Contaminants, Reasons, Concentrations, and Impacted Receptors

Principal Threats					
Source Media	**Affected Media**	**Contaminant(s)**	**Reason(s)**	**Concentration(s)[1]**	**Receptors**
Buried waste material	Source area soil and groundwater	Chemicals that were potentially used on site were identified based on drum labels and included caustics, halogenated solvents, PCBs, and inks	Buried waste may leach into soil and groundwater and migrate to surface water	Unknown	Residents living along the river and ecological receptors
Soil	Source area soil at west side of Brook Village parking lot	Dioxin and VOCs	Contaminants may leach into groundwater and migrate to surface water	140,000 ng/kg (2,3,7,8-TCDD); 1,700 mg/kg (PCE); 2,400 mg/kg (TCE)	Residents living along the river and ecological receptors
Low-level Threats					
Source Media	**Affected Media**	**Contaminant(s)**	**Reason(s)**	**Concentration(s)[1]**	**Receptors**
Sediment	Biota, sediment, floodplain soil, and surface water	Dioxin; PCBs; Pesticides; SVOCs; metals *(PCB concentrations are below TSCA criteria)*	Resuspension and transport, bioaccumulation hazard and toxicity	110,000 ng/kg (2,3,7,8-TCDD and dioxin TEQ); 147 ng/kg (coplanar PCB TEQ); 28 mg/kg (total Aroclors); 28 mg/kg (Aroclor 1254); 0.31 mg/kg (Aroclor 1268); 0.046 mg/kg (4,4'-DDE); 0.050 mg/kg (4,4'-DDD); 0.17 mg/kg (dieldrin); 2.2 mg/kg (technical chlordane); 9.6 mg/kg (benzo(a)pyrene); 2.6 mg/kg (dibenzo(a,h)anthracene); 2.1 mg/kg (N-nitroso-di-n-propylamine)[2]; 27,773 mg/kg (aluminum); 18 mg/kg (arsenic); 380 mg/kg (barium); 4.7 mg/kg (selenium); 91.7 mg/kg (vanadium); 2,088 mg/kg (zinc)	Residents living along the river, visiting recreational anglers, and ecological receptors

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Table 2-8b. (continued)

Low-level Threats					
Source Media	**Affected Media**	**Contaminant(s)**	**Reason(s)**	**Concentration(s)[1]**	**Receptors**
Floodplain Soil	Biota, sediment, and surface water	Dioxin; PCBs; Pesticides**;** and metals *(PCB concentrations are below TSCA criteria)*	Resuspension and transport, bioaccumulation hazard and toxicity Exceeds RIDEM criteria and EPA's recommended residential level for dioxin	4,291 ng/kg (dioxin TEQ) 4,270 ng/kg (2,3,7,8-TCDD) 3.58 mg/kg (total Aroclors); 3.58 mg/kg (Aroclor 1254); 1 mg/kg (4,4'-DDE); 0.063 mg/kg (dieldrin); 38.2 mg/kg (antimony); 55.6 mg/kg (arsenic); 8.25 mg/kg (cadmium); 2,460 mg/kg (lead): 2.4 mg/kg (selenium) 2,190 mg/kg (zinc)	Passive recreational visitor and ecological receptors
Source area soil	Soil (surface and subsurface), groundwater, surface water, and sediment	Dioxin; PCBs; Pesticides; VOCs; SVOCs; metals	Exceeds RIDEM criteria, EPA's recommended residential level for dioxin, and TSCA criteria	140,000 ng/kg (dioxin TEQ); 1,300 mg/kg (total Aroclors); 9.9 mg/kg (dieldrin); 10.6 mg/kg (technical chlordane); 8.5 mg/kg (benzo(a)anthracene); 8.9 mg/kg (benzo(a)pyrene); 10 mg/kg (benzo(b)fluoranthene); 5.3 mg/kg (benzo(g,h,i)perylene); 8.8 mg/kg (benzo(k)fluoranthene); 1.61 mg/kg (biphenyl); 460 mg/kg (bis(2-ethylhexyl)phthalate); 11 mg/kg (chrysene); 2.2 mg/kg (dibenzo(a,h)anthracene); 24 mg/kg (fluoranthene); 5.3 mg/kg (indeno(1,2,3-c,d)pyrene); 84 mg/kg (naphthalene); 18 mg/kg (pentachlorophenol); 23 mg/kg (pyrene); 27.8 mg/kg (antimony); 49.3 mg/kg (arsenic); 3.9 mg/kg (beryllium);	Residents living along the river and ecological receptors

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Table 2-8b. (continued)

Low-level Threats					
Source Media	**Affected Media**	**Contaminant(s)**	**Reason(s)**	**Concentration(s)[1]**	**Receptors**
Source area soil (cont)	Soil (surface and subsurface), groundwater, surface water, and sediment	Dioxin; PCBs; Pesticides; VOCs; SVOCs; metals	Exceeds RIDEM criteria, EPA's recommended residential level for dioxin, and TSCA criteria	180 mg/kg (cadmium); 3,160 mg/kg (lead); 6,420 mg/kg (manganese); 13.4 mg/kg (thallium); 480 mg/kg (benzene); 1,000 mg/kg (chlorobenzene); 1.7 mg/kg (1,2-dichloroethane); 500 mg/kg (dichloroethene (cis-1,2); 81 mg/kg (ethyl benzene); 1,700 mg/kg (PCE); 430 mg/kg (toluene); 2,400 mg/kg (TCE); 2.3 mg/kg (vinyl chloride); 380 mg/kg (total xylenes);	Residents living along the river and ecological receptors
Groundwater (non source material)	Surface water and sediment	Dioxin[3] and VOCs	Exceeds RIDEM criteria; Contaminated groundwater likely migration pathway from source area to river for dioxin	6,154 pg/L (2,3,7,8-TCDD); 61,000 µg/L (PCE); 2,500 µg/L (TCE)	Residents living along the river, visiting recreational anglers, and ecological receptors

Notes:
[1] Maximum detected concentration reported, by media and across all exposure areas (see Table 2-6 for additional statistical data). Data source is the RI (Battelle, 2005a) for source area soil and floodplain soil; data source is the RI (Battelle, 2005a) and Appendix B for sediment; and data source is the RI (Battelle, 2005a), Appendix A, and LEA (2008) for groundwater.
[2] Contaminant not detected in site samples; value reported is based on laboratory detection limit.
[3] Groundwater is not a source of drinking water, and VOCs in surface water do not pose unacceptable risk to ecological receptors. However, dioxin appears to be mobilized in groundwater and discharging to the river in the vicinity of the Brook Village parking lot.

Key:
mg/kg - milligrams per kilogram; ng/kg - nanograms per kilogram; PCB - polychlorinated biphenyl; PCE - tetrachloroethylene; RIDEM - Rhode Island Department of Environmental Management; SVOCs - semi-volatile organic compounds; TCE - trichloroethylene; TEQ - toxic equivalency

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Table 2-9. Cancer Toxicity Data Summary

Pathway: Ingestion, Dermal

Chemical of Concern	Oral Cancer Slope Factor		Absorbed Cancer Slope Factor for Dermal		Weight of Evidence / Cancer Guideline Description	Source	Date[1]	Date of Last IRIS Revision[2]
	Value	Units	Value	Units				
Benzo(a)pyrene	7.3	$(mg/kg/day)^{-1}$	7.3	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	11/1/1994
Dibenzo(a,h)anthracene[3]	7.3	$(mg/kg/day)^{-1}$	7.3	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	3/1/1994
N-nitroso-di-n-propylamine	7.0	$(mg/kg/day)^{-1}$	7	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	7/1/1993
4,4'-DDE	0.34	$(mg/kg/day)^{-1}$	0.34	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	8/22/1988
Aroclor-1254[4]	2.0	$(mg/kg/day)^{-1}$	2	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	6/1/1997
Aroclor-1268	2.0	$(mg/kg/day)^{-1}$	2	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	6/1/1997
Dieldrin	16	$(mg/kg/day)^{-1}$	16	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	7/1/1993
Technical Chlordane	0.35	$(mg/kg/day)^{-1}$	0.35	$(mg/kg/day)^{-1}$	B2	IRIS	2/25/2010	2/7/1998
Arsenic	1.5	$(mg/kg/day)^{-1}$	1.5	$(mg/kg/day)^{-1}$	A	IRIS	2/25/2010	4/10/1998
Toxicity Equivalency (PCB Congeners) – Mammals[5]	150000	$(mg/kg/day)^{-1}$	150000	$(mg/kg/day)^{-1}$	B2	HEAST (1997)	—	NA
Toxicity Equivalency (Dioxins/Furans) - Mammals[5]	150000	$(mg/kg/day)^{-1}$	150000	$(mg/kg/day)^{-1}$	B2	HEAST (1997)	—	NA

Notes:
[1] Date value was obtained from IRIS.
[2] Indicates most recent revisions to the IRIS carcinogenicity assessments.
[3] As indicated in the EPA Region 1 Risk Updates (EPA, 1994b), the following interim peer-reviewed policy can be used to assign cancer potency values to different PAHs (EPA, July 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*; EPA/600/R-93/069) until a national standard is adopted. Following this policy, the oral cancer slope factor for dibenzo(a,h)anthracene (with a compound relative potency value of 1.0) is the same as that of benzo(a)pyrene.
[4]The oral cancer slope factors presented in this table are for a mixture of PCBs. EPA IRIS files currently do not identify oral cancer slope factors for individual Aroclors. The values shown are "high-risk and persistence; upper bound slope factors".
[5]Both cancer slope factors (HEAST, 1997. *FY-1997 Update*, EPA 540/R-97-036, July) and toxicity equivalence factors (WHO. 2006. "The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds," *Toxicological Sciences* 93(2), 223-241) are used to calculate risk for dioxin and furan congeners.

EPA Group
A - Human carcinogen
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans

Key:
mg/kg/day - milligrams per kilogram per day; IRIS - Integrated Risk Information System; HEAST - Health Effects Assessment Summary Tables; PCB - Polychlorinated Biphenyl; NA - Not applicable

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Table 2-10. Non-Cancer Toxicity Data Summary									
Pathway: Ingestion, Dermal									
Chemical of Concern	Chronic / Subchronic	Oral RfD Value	Oral RfD Units	Dermal RfD	Dermal RfD Units	Primary Target Organ	Combined Uncertainty Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ
Aroclor 1254	chronic	0.00002	mg/kg/day	0.00002	mg/kg/day	Immune system/Immunotoxicity	300	IRIS	February, 2003

Key:
mg/kg/day - milligrams per kilogram per day
IRIS - Integrated Risk Information System
RfD - Reference Dose

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Table 2-11a. Risk Characterization Summary – Carcinogens

Scenario Timeframe: Current/Future
Receptor Population: Resident Living Along the River
Receptor Age: Young Child/Adult (Ages 0-30)

				Carcinogenic Risk				
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Biota	Biota	Allendale Pond	Aroclor 1254	3.5E-04	--	--	--	3.5E-04
			Aroclor 1268	5.0E-06	--	--	--	5.0E-06
			Dieldrin	1.3E-05	--	--	--	1.3E-05
			Technical Chlordane	1.5E-05	--	--	--	1.5E-05
			Toxicity Equivalency (PCB Congeners) - Mammals	4.4E-04	--	--	--	4.4E-04
			Toxicity Equivalency (Dioxins/Furans) - Mammals	4.2E-03	--	--	--	4.2E-03
							Biota Risk Total:	5E-03
Sediment	Sediment	Allendale Pond	Benzo(a)pyrene	6.7E-06	--	3.2E-06	--	9.9E-06
			Dibenzo(a,h)anthracene	3.4E-06	--	1.6E-06	--	4.9E-06
			Arsenic	2.0E-06	--	2.2E-07	--	2.2E-06
			Toxicity Equivalency (Dioxins/Furans) - Mammals	2.0E-04	--	2.1E-05	--	2.2E-04
							Sediment Risk Total:	2E-04
							Total Risk:	**5E-03**

Key:
PCB - Polychlorinated Biphenyl

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Table 2-11b. Risk Characterization Summary - Carcinogens

Scenario Timeframe: Current/Future
Receptor Population: Resident Living Along the River
Receptor Age: Young Child/Adult (Ages 0-30)

				Carcinogenic Risk				
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Biota	Biota	Lyman Mill Pond	Benzo(a)pyrene	3.7E-06	--	--	--	3.7E-06
			4,4'-DDE	2.8E-06	--	--	--	2.8E-06
			Aroclor 1254	3.9E-04	--	--	--	3.9E-04
			Aroclor 1268	4.0E-06	--	--	--	4.0E-06
			Dieldrin	8.4E-06	--	--	--	8.4E-06
			Technical Chlordane	3.3E-05	--	--	--	3.3E-05
			Toxicity Equivalency (PCB Congeners) - Mammals	5.6E-04	--	--	--	5.6E-04
			Toxicity Equivalency (Dioxins/Furans) - Mammals	5.1E-03	--	--	--	5.1E-03
							Biota Risk Total:	6E-03
Sediment	Sediment	Lyman Mill Pond	Benzo(a)pyrene	4.9E-06	--	2.3E-06	--	7.2E-06
			Dibenzo(a,h)anthracene	1.8E-06	--	8.5E-07	--	2.6E-06
			N-nitroso-di-n-propylamine	2.1E-06	--	7.6E-07	--	2.9E-06
			Arsenic	2.2E-06	--	2.4E-07	--	2.4E-06
			Toxicity Equivalency (Dioxins/Furans) - Mammals	2.8E-04	--	3.0E-05	--	3.1E-04
							Sediment Risk Total:	3E-04
							Total Risk:	**6E-03**

Key:
PCB - Polychlorinated Biphenyl

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Table 2-11c. Risk Characterization Summary - Carcinogens

Scenario Timeframe:
Current/Future
Receptor Population: Visiting Recreational Angler
Receptor Age: Young Child/Adult (Ages 0-30)

				Carcinogenic Risk				
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Biota	Biota	Allendale Pond	Aroclor 1254	3.5E-04	--	--	--	3.5E-04
			Aroclor 1268	5.0E-06	--	--	--	5.0E-06
			Dieldrin	1.3E-05	--	--	--	1.3E-05
			Technical Chlordane	1.5E-05	--	--	--	1.5E-05
			Toxicity Equivalency (PCB Congeners) - Mammals	4.4E-04	--	--	--	4.4E-04
			Toxicity Equivalency (Dioxins/Furans) - Mammals	4.2E-03	--	--	--	4.2E-03
							Biota Risk Total:	5E-03
							Total Risk:	**5E-03**

Key:
PCB - Polychlorinated Biphenyl

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Table 2-11d. Risk Characterization Summary - Carcinogens

Scenario Timeframe:
Current/Future
Receptor Population: Visiting Recreational Angler
Receptor Age: Young Child/Adult (Ages 0-30)

				Carcinogenic Risk				
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Biota	Biota	Lyman Mill Pond	Benzo(a)pyrene	3.7E-06	--	--	--	3.7E-06
			4,4'-DDE	2.8E-06	--	--	--	2.8E-06
			Aroclor 1254	3.9E-04	--	--	--	3.9E-04
			Aroclor 1268	4.0E-06	--	--	--	4.0E-06
			Dieldrin	8.4E-06	--	--	--	8.4E-06
			Technical Chlordane	3.3E-05	--	--	--	3.3E-05
			Toxicity Equivalency (PCB Congeners) - Mammals	5.6E-04	--	--	--	5.6E-04
			Toxicity Equivalency (Dioxins/Furans) - Mammals	5.1E-03	--	--	--	5.1E-03
							Biota Risk Total:	6E-03
							Total Risk:	**6E-03**

Key:
PCB - Polychlorinated Biphenyl

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Table 2-11e. Risk Characterization Summary - Carcinogens

Scenario Timeframe: Current/Future
Receptor Population: Passive Recreational Visitor
Receptor Age: Young Child/Adult (Ages 0-30)

				Carcinogenic Risk				
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Ingestion	Inhalation	Dermal	External (Radiation)	Exposure Routes Total
Soil	Floodplain Soil	Oxbow Area	Aroclor 1254	2.7E-06	--	1.7E-06	--	4.4E-06
			Arsenic	7.3E-06	--	9.6E-07	--	8.2E-06
			Toxicity Equivalency (Dioxins/Furans) - Mammals	2.4E-04	--	3.2E-05	--	2.8E-04
							Soil Risk Total:	3E-04
							Total Risk:	**3E-04**

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Table 2-12a. Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe:
Current/Future
Receptor Population: Resident Living Along the River
Receptor Age: Child

					Non-Carcinogenic Hazard Quotient			
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Biota	Biota	Allendale Pond	Aroclor 1254	Immune system	2.8E+01	--	--	2.8E+01
							Biota Hazard Index Total:	3E+01
							Immune System Hazard Index:	3E+01

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Table 2-12b. Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current/Future
Receptor Population: Resident Living Along the River
Receptor Age: Child

					Non-Carcinogenic Hazard Quotient			
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Biota	Biota	Lyman Mill Pond	Aroclor 1254	Immune system	3.2E+01	--	--	3.2E+01
							Biota Hazard Index Total:	3E+01
							Immune System Hazard Index:	3E+01

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Table 2-12c. Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current/Future
Receptor Population: Visiting Recreational Angler
Receptor Age: Child

					Non-Carcinogenic Hazard Quotient			
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Biota	Biota	Allendale Pond	Aroclor 1254	Immune system	2.8E+01	--	--	2.8E+01
							Biota Hazard Index Total:	3E+01
							Immune System Hazard Index:	3E+01

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Table 2-12d. Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current/Future
Receptor Population: Visiting Recreational Angler
Receptor Age: Child

					Non-Carcinogenic Hazard Quotient			
Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Biota	Biota	Lyman Mill Pond	Aroclor 1254	Immune system	3.2E+01	--	--	3.2E+01
							Biota Hazard Index Total:	3E+01
							Immune System Hazard Index:	3E+01

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Table 2-13a. Occurrence, Distribution, and Selection of Chemicals of Concern (COCs)

Exposure Medium: Allendale Sediment

Chemical of Concern[1]	Min Conc.[2] (ppm)	Max Conc.[3] (ppm)	Mean Conc.[3] (ppm)	RME Conc.[3] (ppm)	Statistical Measure[3,4]	Background conc.[5] (ppm)	Screening Toxicity Value[3] (ppm)	Screening Toxicity Value Source[3]	HQ[6]
Dioxins and furans (TEQ-Bird)	8.96E-08	0.073	0.0058	0.027	95% UCL-T	0.000034	2.6E-06	Wildlife PCL	2.8E+04
Aroclor 1254	0.011	27	1.5	2.4	95% UCL-T	0.15	0.055	Wildlife PCL	4.9E+02
Total Aroclors	0.011	27	1.53	2.3	95% UCL-T	0.21	0.023	NOAA ER-L	1.2E+03
Technical chlordane	0.06385	0.85181	0.515	0.651	95% UCL-N	0.4	0.0005	NOAA ER-L	1.7E+03
Selenium	0.58	3.8	1.1	1.4	95% UCL-T	1.1	0.52	Wildlife PCL	7.3E+00
Zinc	23	2088	354	482.4	95% UCL-T	221	0.37	Wildlife PCL	5.6E+03

Notes:

[1] The Chemicals of Concern listed in this table are a subset of those that were identified as resulting in actionable risks to one or more ecological receptor in the BERA (MACTEC, 2004). Specifically, remediation goals were not developed for macroinvertebrates due to the lack of appropriate site-specific effects information and those chemicals posing an actionable risk to this receptor group only are not listed. Consideration of the spatial distribution and magnitude of the risk estimates for vertebrate receptors supports the use of fish- and wildlife-based values as protective surrogates for invertebrate receptors.

[2] Minimum concentration detected in Allendale, Lyman Mill, Manton and Dyerville exposure areas; data from the BERA (MACTEC, 2004).

[3] Maximum, mean concentrations, statistical measures, and toxicity data from the BERA (MACTEC, 2004).

[4] Statistical measures for the RME EPC are:

95% UCL – T: 95% upper confidence on the mean, lognormal distribution
95% UCL – N: 95% upper confidence on the mean, normal distribution
95% UCL – NP: 95% upper confidence on the mean, nonparametric distribution; arithmetic mean used to approximate the 95% UCL.
Max: Maximum detection concentration, applied if fewer than 10 samples or if the 95% UCL is greater than the maximum concentration.

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Table 2-13a. (continued)

Notes: (cont)

[5] Background concentrations from Table 5-1, Interim Final PRG Report Part II (MACTEC, 2005b).
[6] HQ is defined as the Maximum Concentration/Screening Toxicity Value.

Key:
EPC - Exposure Point Concentration; RME - Reasonable Maximum Exposure; NOAA ER-L - National Oceanic and Atmospheric Administration Effects Range-Low; PCL - Protective Concentration Level; protective of semi-aquatic wildlife exposure to sediment via incidental sediment ingestion and consumption of contaminated prey; value is minimum of selected receptor species; ppm – parts per million (equivalent to mg/kg or milligrams per kilogram)

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Table 2-13b. Occurrence, Distribution, and Selection of Chemicals of Concern (COCs)

Exposure Medium: Lyman Mill Sediment

Chemical of Concern[1]	Min Conc.[2] (ppm)	Max Conc.[3] (ppm)	Mean Conc.[3] (ppm)	RME Conc.[3] (ppm)	Statistical Measure[3,4]	Back-ground Conc.[5] (ppm)	Screening Toxicity Value[3] (ppm)	Screening Toxicity Value Source[3]	HQ[6]
Dioxins and furans (TEQ-Bird)[7]	8.96E-08	0.00808	0.0018	0.00808	Max	0.000034	2.6E-06	Wildlife PCL	3.1E+03
Coplanar PCBs (TEQ-Bird)[7]	1.27E-05	0.00021	0.00015	0.00021	Max	0.000045	2.6E-06	Wildlife PCL	8.1E+01
Aroclor 1254	0.011	2.2	0.27	0.49	95% UCL-T	0.15	0.055	Wildlife PCL	4.0E+01
Total Aroclors	0.011	2.2	0.2629	0.39	95% UCL-T	0.21	0.023	NOAA ER-L	9.6E+01
4,4'-DDD	0.00002	0.052	0.0093	0.0093	95% UCL-NP	0.0049	0.002	NOAA ER-L	2.6E+01
4,4'-DDE	0.00031	0.048	0.0083	0.011	95% UCL-T	0.006	0.0021	Wildlife PCL	2.3E+01
Technical chlordane	0.06385	2.2	1.3	2.21273	Max	0.4	0.0005	NOAA ER-L	4.4E+03
Aluminum	1640	27773	10181	13069	95% UCL-T	8210	44	Wildlife PCL	6.3E+02
Barium	7.6	380	130	207	95% UCL-T	134	54	Wildlife PCL	7.0E+00
Selenium	0.58	2.9	0.96	1.2	95% UCL-T	1.1	0.52	Wildlife PCL	5.6E+00
Vanadium[8]	4	91.7	35.5	91.7	Max	37.6	9.6	Wildlife PCL	9.6E+00
Zinc	23	1662	391	758	95% UCL-T	221	0.37	Wildlife PCL	4.5E+03

Notes:
[1] The Chemicals of Concern listed in this table are a subset of those that were identified as resulting in actionable risks to one or more ecological receptor in the BERA (MACTEC, 2004). Specifically, remediation goals were not developed for macroinvertebrates due to the lack of appropriate site-specific effects information and those chemicals posing an actionable risk to this receptor group only are not listed. Consideration of the spatial distribution and magnitude of the risk estimates for vertebrate receptors supports the use of fish- and wildlife-based values as protective surrogates for invertebrate receptors.
[2] Minimum concentration detected in Allendale, Lyman Mill, Manton and Dyerville exposure areas; data from the BERA (MACTEC, 2004).
[3] Maximum, mean concentrations, statistical measures, and toxicity data from the BERA (MACTEC, 2004).

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Table 2-13b. (continued)

Notes: (cont)

[4] Statistical measures for the RME EPC are:

95% UCL – T: 95% upper confidence on the mean, lognormal distribution.
95% UCL – NP: 95% upper confidence on the mean, nonparametric distribution; arithmetic mean used to approximate the 95% UCL.
Max: Maximum detection concentration, applied if fewer than 10 samples or if the 95% UCL is greater than the maximum concentration.

[5] Background concentrations from Table 5-1, Interim Final PRG Report Part II (MACTEC, 2005b).
[6] HQ is defined as the Maximum Concentration/Screening Toxicity Value.
[7] The BERA (MACTEC, 2004) determined that exposure to dioxin and furans and coplanar PCBs would result in actionable risks to mammalian wildlife as well as bird and fish receptors; however, of these groups, mammals were determined to be the least sensitive and they thus would be protected by actions taken to eliminate risks to these other receptor categories.
[8] Minimum, maximum and statistical measures for vanadium from RI because, in the BERA, it was screened out as a COPEC in sediment but retained as a COPEC for fish tissue.

Key:
EPC - Exposure Point Concentration; RME - Reasonable Maximum Exposure; NOAA ER-L - National Oceanic and Atmospheric Administration Effects Range-Low;
PCL - Protective Concentration Level; protective of semi-aquatic wildlife exposure to sediment via incidental sediment ingestion and consumption of contaminated prey; value is minimum of selected receptor species; ppm – parts per million (equivalent to mg/kg or milligrams per kilogram)

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Table 2-13c. Occurrence, Distribution, and Selection of Chemicals of Concern (COCs)									
Exposure Medium: Allendale Soil									
Chemical of Concern[1]	**Min Conc.[2] (ppm)**	**Max Conc.[3] (ppm)**	**Mean Conc.[3] (ppm)**	**RME Conc.[3] (ppm)**	**Statistical Measure[3,4]**	**Background Conc.[5] (ppm)**	**Screening Toxicity Value[3] (ppm)**	**Screening Toxicity Value Source[3]**	**HQ[6]**
Dioxins and furans (TEQ-mammal)[7]	8.5E-07	0.0281	0.00083	0.0024	95% UCL-T	0.000050	8.9E-07	Wildlife PCL	3.2E+04

Notes:
[1] The Chemical of Concern listed in this table is a subset of those that were identified as resulting in actionable risks to one or more ecological receptor in the BERA (MACTEC, 2004). Specifically, remediation goals were not developed for macroinvertebrates due to the lack of appropriate site-specific effects information and those chemicals posing an actionable risk to this receptor group only are not listed. Consideration of the spatial distribution and magnitude of the risk estimates for vertebrate receptors supports the use of wildlife-based values as protective surrogates for invertebrate receptors.
[2] Minimum concentration detected in Allendale and Lyman Mill exposure areas; data from the BERA (MACTEC, 2004).
[3] Maximum, mean concentrations, statistical measures, and toxicity data from the BERA (MACTEC, 2004).
[4] Statistical measures for the RME EPC are:

95% UCL – T: 95% upper confidence on the mean, lognormal distribution.
Max: Maximum detection concentration, applied if fewer than 10 samples or if the 95% UCL is greater than the maximum concentration.

[5] Background concentrations from Table 5-2, Interim Final PRG Report Part II (MACTEC, 2005b).
[6] HQ is defined as the Maximum Concentration/Screening Toxicity Value.
[7]The BERA (MACTEC, 2004) determined that exposure to dioxin and furans would result in actionable risks to avian wildlife as well as mammals; however, birds were determined to be less sensitive and they thus would be protected by actions taken to eliminate risks to mammals that forage in floodplain soils at the site.

Key:
EPC - Exposure Point Concentration; RME - Reasonable Maximum Exposure; PCL - Protective Concentration Level; protective of semi-aquatic wildlife exposure to sediment via incidental sediment ingestion and consumption of contaminated prey; value is minimum of selected receptor species; ppm – parts per million (equivalent to mg/kg or milligrams per kilogram)

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Table 2-13d. Occurrence, Distribution, and Selection of Chemicals of Concern (COCs)

Exposure Medium: Lyman Mill Floodplain Soil (Including Oxbow)

Chemical of Concern[1]	Min Conc.[2] (ppm)	Max Conc.[2] (ppm)	Mean Conc.[2] (ppm)	RME Conc.[2] (ppm)	Statistical Measure[2,3]	Background Conc.[4] (ppm)	Screening Toxicity Value[2] (ppm)	Screening Toxicity Value Source[2]	HQ[5]
2,3,7,8-TCDD	1.2E-05	0.00427	0.001745	0.0043	Max	0.000017	8.9E-07	Wildlife PCL	4.8E+03
Dioxins and furans (TEQ-mammal)[6]	0.000347	0.00429	0.00181	0.00429	Max	0.000050	8.9E-07	Wildlife PCL	4.8E+03
4,4'-DDE	0.006	0.042	0.018	0.04236	Max	0.013	0.0025	EPA Region IV	1.7E+01
Antimony	0.92	7.0	3.03	7.0	Max	0.62	0.045	Wildlife PCL	1.6E+02
Aroclor 1254	0.0085	3.58	1.41	3.583	Max	0.52	0.092	Wildlife PCL	3.9E+01
Cadmium	1.2	8.3	4.0	8.3	Max	1.6	1.7	Wildlife PCL	4.9E+00
Dieldrin	0.0025	0.063	0.0231	0.06338	Max	0.0063	0.0005	EPA Region IV	1.3E+02
Lead	44	1835	575.0	1835	Max	450	20	Wildlife PCL	9.2E+01
Total Aroclors	0.103	3.583	1.441	3.583	Max	NA	1.7	Wildlife PCL	2.1E+00
Zinc	109	1867	645	1867	Max	288	76	Wildlife PCL	2.5E+01
Arsenic[7]	0.181	7.42	5.5	7.42	Max	7.7	0.22	Wildlife PCL	3.4E+01
Selenium[7]	0.205	0.779	0.43	0.779	Max	0.7	0.34	Wildlife PCL	2.3E+00

Notes:
[1] The Chemical of Concern listed in this table is a subset of those that were identified as resulting in actionable risks to one or more ecological receptor in the BERA (MACTEC, 2004) and the Addendum to the BERA (MACTEC, Inc. and Battelle. 2006). Specifically, remediation goals were not developed for macroinvertebrates due to the lack of appropriate site-specific effects information and those chemicals posing an actionable risk to this receptor group only are not listed. Consideration of the spatial distribution and magnitude of the risk estimates for vertebrate receptors supports the use of wildlife-based values as protective surrogates for invertebrate receptors.
[2] Minimum, maximum, mean concentrations, statistical measures, and toxicity data from the Oxbow Area Addendum to the BERA (MACTEC, Inc. and Battelle. 2006); the Oxbow is where the most significant ecological exposures will occur.

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Table 2-13d. (continued)

Notes: (cont)

[3] Statistical measures for the RME EPC are:

Max: Maximum detection concentration, applied if fewer than 10 samples or if the 95% UCL is greater than the maximum concentration.

[4] Background concentrations from Oxbow Area PRGs (Appendix D).
[5] HQ is defined as the Maximum Concentration/Screening Toxicity Value.
[6] The Oxbow Area Addendum to the BERA ((MACTEC, Inc. and Battelle. 2006) determined that exposure to dioxin and furans would result in actionable risks to avian wildlife as well as mammals; however, birds were determined to be less sensitive and they thus would be protected by actions taken to eliminate risks to mammals that forage in floodplain soils at the site.
[7] COC identified for Lyman Mill floodplain soil in BERA (MACTEC, 2004); Minimum concentration from the site RI (Battelle, 2005a) for Oxbow and other statistical measures as reported in BERA (MACTEC, 2004).

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Table 2-14. Ecological Exposure Pathways of Concern

Exposure Medium	Sensitive Environment Flag Y or N	Receptor[1]	Endangered/ Threatened Species Flag Y or N	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Sediment	N	Benthic organisms	N	Ingestion, respiration, and direct contact with chemicals in sediment	Protection and Maintenance (i.e., survival, growth, reproduction) of aquatic invertebrate communities, which are a forage base for fish and wildlife populations	Comparison of surface water COPC concentrations to criteria/guidelines
						Comparison of sediment COPC concentrations to benchmarks/guidelines
						Site-specific whole sediment laboratory bioassays
						Comparison of measured COPC concentrations in aquatic macroinvertebrates to Critical Body Residues (CBRs)
						Site-specific study of aquatic macroinvertebrate community structure/function
						Site-specific study of emerging aquatic macroinvertebrate productivity
Surface Water	N	Fish	N	Ingestion, respiration, and direct contact with chemicals in surface water	Protection and maintenance of demersal, omnivorous fish populations as a forage base or sport fishery	Fish length-weight relationships and condition indices relative to habitat characterization
						Percent gross lesions in individual fish
						Demographic structure analysis of dominant species
						Species richness and relative abundance of ichthyoplankton
						Comparison of measured concentrations or toxic equivalencies in fish tissue to literature derived CBRs
						Comparison of modeled concentrations or toxic equivalencies in eggs and fish tissue to site-specific CBRs
						Partial life cycle laboratory bioassay using channel catfish eggs, embryos, and fry

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Table 2-14. (continued)

Exposure Medium	Sensitive Environment Flag Y or N	Receptor[1]	Endangered /Threatened Species Flag Y or N	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Surface Water	N	Fish	N	Ingestion, respiration, and direct contact with chemicals in surface water	Protection and maintenance of pelagic, piscivorous or semi-piscivorous fish populations as a forage base or sport fishery	Fish length-weight relationships and condition indices relative to habitat characterization
						Percent gross lesions in individual fish
						Demographic structure analysis of dominant species
						Species richness and relative abundance of ichthyoplankton
						Comparison of measured concentrations or toxic equivalencies in fish tissue to literature-derived CBRs
						Comparison of modeled concentrations or toxic equivalencies in eggs and fish tissue to site-specific CBRs
Soil	N	Terrestrial invertebrates	N	Ingestion and direct contact with chemicals in wetland soils	Protection and maintenance (i.e., survival, growth, reproduction) of floodplain invertebrate communities, which are a forage base for wildlife populations	Comparison of floodplain soil COPC concentrations to benchmarks/guidelines
						Comparison of measured site-specific COPC concentrations in floodplain soil invertebrates to CBRs
						Site-specific study of floodplain soil invertebrate community structure/function

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Table 2-14. (continued)

Exposure Medium	Sensitive Environment Flag Y or N	Receptor[1]	Endangered/ Threatened Species Flag Y or N	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Biological Tissue	N	Wildlife	N	Ingestion and direct contact with chemicals in wetland soils, sediment, and surface water	Protection and maintenance of piscivorous mammal and bird populations	Comparison of estimated ingestion doses in piscivorous wildlife with TRVs and toxic equivalencies
						Comparison of estimated piscivorous wildlife residues with CBRs
					Protection and maintenance of omnivorous mammal and bird populations	Comparison of estimated ingestion doses in omnivorous wildlife with TRVs and TEQs
					Protection and maintenance of insectivorous mammal and bird populations	Comparison of estimated ingestion doses in insectivorous wildlife with TRVs and toxic equivalencies
						Comparison of measured insectivorous wildlife tissue and/or egg residues with CBR data
						Comparison of estimated insectivorous wildlife tissue and/or egg residues with site-specific CBR data
						Site-specific measurement of reproductive effects in local tree swallow populations
						Site-specific survey of calling amphibians
						Elevated MFO activity in tree swallow nestling liver tissue

Note:
[1] The indicated receptor for each exposure medium was determined to be the most sensitive to contaminants associated with this medium although it should be recognized that other receptor categories could also be exposed.

Key:
COPC – chemical of potential concern; CBR – critical body residue; MFO – mixed function oxidase; TEQ – toxic equivalency;
TRV – toxicity reference value

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Table 2-15. Summary of Toxicity and Field Studies

Environmental Media	Study Name	Endpoints	Results
Sediment	Chronic life-cycle test with *Chironomus dilutus* (formerly known as *C. tentans*)	• Survival • Growth • Reproduction	• Significant reduction in survival in all treatment samples • Growth significantly reduced in one test sample • Reproduction similar in all treatments and control, but number of egg cases lower in one sample
	Chronic life-cycle test with *Hyalella azteca*	• Survival • Growth • Reproduction	• Significant reduction in survival in six treatment samples • Growth significantly reduced in three samples • Reproduction similar in all treatments and control samples
	Benthic macroinvertebrate community study	• Taxa richness • Biotic index • Ratio of scrapers to filterers • Ratio of EPT to Chironomidae abundance • Percent contribution of the dominant family • EPT richness index • Community loss index	Taxa richness was high at all stations with none of the stations having numerical dominance by a single taxon greater than 27.2% and most below 20%. EPT to Chironomidae abundance ratio and EPT richness metrics received an optimal score of 6 at all stations except one. Analysis of benthic data from six of the eight stations indicated no impairment when compared to background station. Overall, good to excellent habitats for supporting benthic communities were found and the communities downstream of the source area did not appear to be substantially impaired.
Soil	Floodplain soil invertebrate community study	• Abundance of organisms • Species diversity • Overlap of shared fauna	A total of 19 invertebrate taxa were collected. Earthworms numerically dominated the taxonomic community samples, representing approximately 73% of the overall fauna collected. *Aporrectoda rosea* dominated the upstream background stations and *Lumbriculus*

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Table 2-15. Summary of Toxicity and Field Studies			
Environmental Media	**Study Name**	**Endpoints**	**Results**
			rubellus was dominant in the sampling stations. Other invertebrates collected were arthropods, gastropods, and nematodes. Conclusions indicate that there were no adverse effects evident in the floodplain communities relative to the upstream background locations.
Tissue	Fish population and community study	Index of Biotic Integrity (IBI) metrics	Overall, the fish assemblage within the study area appeared to be in relatively good condition. Two samples appeared to be the most affected. The relatively high abundance of generalist feeders, such as sunfish, bullheads, and white sucker, suggest that these areas are low to moderate quality habitats.
	Ichthyoplankton survey	Abundance, diversity, and pathological measurements	Ichthyoplankton from the study area appeared to be developing normally with only a few gross abnormalities observed.
	Partial life-cycle (ELS) bioassay	Evaluation of the lethal and sublethal effects of TCDD, PCB congeners, and HCX on fish embryos and larvae, including: • Days to hatch • Hatching success • Fry survival • Fry growth • Developmental malformations	Waterborne exposure of channel catfish eggs to increasing concentrations of TCDD, PCB-77, and PCB-126, with and without HCX added at approximately 5-times the concentration of TCDD, were negatively correlated with hatching success and fry survival 32 days post-hatch. Estimated EC10 and EC25 values for fry survival across exposures in channel catfish eggs to TCDD and PCBs, with and without HCX, are 319 and 510 pg TEC/g egg wet weight, respectively.

Key:
EPT - Ephemeroptera, Plecoptera, and Trichoptera; ELS - early life stage; HCX - hexachloroxanthene; IBI - Index of Biotic Integrity; MFO - Mixed Function Oxidase; PCB - polychlorinated biphenyl; TCDD - Tetrachlorodibenzo-p-dioxin; TEQ - toxic equivalency; TRV - toxicity reference value

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Table 2-16. COC Concentrations Expected to Provide Adequate Protection to Ecological Receptors					
Habitat Type/ Name	**Exposure Medium**	**COC**	**Protective Level (ppm)**	**Basis**	**Assessment Endpoint**
Allendale	Sediment	Dioxins and furans (TEQ)	0.00029	Middle risk range value (i.e., Hazard Index of 1) for the most sensitive ecological exposure pathway - bird	Protection and maintenance of insectivorous mammal and bird populations
		Coplanar PCBs (TEQ)	0.000025	Background	
		Aroclor 1254	0.15	Background	
		Total Aroclors	0.21	Background	
		Technical chlordane	0.4	Background	
		Selenium	1.1	Background	
		Zinc	220	Background	
	Soil	Arsenic	7.7	Background	
		Cadmium	1.6	Background	
		Selenium	0.7	Background	
		Dioxin/furan TEQ	0.000055	Background	
Lyman Mill	Sediment	Dioxins and furans (TEQ)	0.00029	Middle risk range value (i.e., Hazard Index of 1) for the most sensitive ecological exposure pathway - bird	Protection and maintenance of insectivorous mammal and bird populations
		Coplanar PCBs (TEQ)	0.000025	Background	
		Aroclor 1254	0.15	Background	
		Total Aroclors	0.21	Background	
		4,4'-DDD	0.0084	Middle risk range value (i.e., Hazard Index of 1) for the most sensitive ecological exposure pathway - bird	Protection and maintenance of piscivorous mammal and bird populations
		4,4'-DDE	0.006	Background	

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Table 2-16. (continued)

Habitat Type/ Name	Exposure Medium	COC	Protective Level (ppm)	Basis	Assessment Endpoint
Lyman Mill	Sediment	4,4'-DDE	0.006	Background	
		Technical chlordane	0.4	Background	
		Aluminum	8200	Background	
		Barium	130	Background	
		Selenium	1.1	Background	
		Vanadium	38	Background	
		Zinc	220	Background	
Oxbow Area/Lyman Mill	Soil	2,3,7,8-TCDD	0.000017	Background	
		4,4'-DDD	0.0082	Background	
		4,4'-DDE	0.013	Background	
		Antimony	0.62	Background	
		Beryllium	3.1	Background	
		Cadmium	1.6	Background	
		Dieldrin	0.0063	Background	
		Lead	450	Background	
		Lindane	0.00005	Middle risk range value (i.e., Hazard Index of 1) for the most sensitive ecological exposure pathway - invertebrate	Protection and maintenance (i.e., survival, growth, reproduction) of floodplain invertebrate communities, which are a forage base for wildlife populations
		Total Aroclors	1.7	Middle risk range value (i.e., Hazard Index of 1) for the most sensitive ecological exposure pathway - bird	Protection and maintenance of insectivorous mammal and bird populations
		Zinc	288	Background	

Key:

PCB – polychlorinated biphenyl; ppm – parts per million (or mg/kg, milligrams per kilogram); TEQ – toxic equivalency

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Table 3-1. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for the CMRP Site

Requirement	Status	Synopsis	Potential Application
Chemical-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Exceedances of AWQC are present in Woonasquatucket River.
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	One part per billion (ppb, or 1000 ng/kg) dioxin (as TEQ) is to be generally used as a starting point for setting cleanup levels for CERCLA removal sites and as a Preliminary Remediation Goal (PRG) for remedial sites for dioxin in surface soil involving residential exposure scenarios. A cleanup range of 5 to 20 ppb of dioxin (as TEQ) has been established for commercial and industrial exposure scenarios.	Soil at the site contains dioxin at levels above the PRG.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	This provides guidance on assessing risk to children from carcinogens.	Guidance used to evaluate all risk to children from carcinogens.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	EPA may use Health Advisories to establish criteria in the absence of other criteria.

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Table 3-1. (continued)

Requirement	Status	Synopsis	Potential Application
Chemical-Specific ARARs (cont)			
Federal Requirements (cont)			
Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 40 CFR 141.11-141.13	Not Applicable	The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to Maximum Contaminant Levels Goals (MCLGs) as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.	MCLs are not relevant and appropriate as the groundwater at the site is not a potential drinking water source.
Safe Drinking Water Act Maximum Contaminant Levels Goals (MCLGs), 40 CFR 141.50-141.51	Not Applicable	The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.	MCLGs are not relevant and appropriate as the groundwater at the site is not a potential drinking water source.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives). Similarly, groundwater objectives established in Rule 8.03 shall be applied to contaminated sites.	Soil at the site contains contaminants subject to the Rule 8.02B soil objectives. Groundwater at the site contains contaminants subject to the Rule 8.03 GB groundwater objectives.
RIDEM Rules and Regulations for Groundwater Quality, 5/06	Not Applicable	Establishes MCLs, limits, and requirements for current and future public water supply systems.	MCLs are not relevant and appropriate as the groundwater at the site is not a potential drinking water source.
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency involved in actions that will result in the control or structural modification of any stream or water body to take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	On-site remediation activities may include modifications to the Woonasquatucket River.
Clean Water Act, Section 404(b)(1) Guidelines for specification of disposal sites for dredged or fill material, 40 CFR Part 230, 231 and 33 CFR Parts 320-323 and Guidelines for Compensatory Mitigation for Losses of Aquatic Resources, 33 CFR Part 332	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	On-site remediation activities may include discharge of dredged or fill material into the Woonasquatucket River.

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Table 3-1. (continued)

Requirement	Status	Synopsis	Potential Application
***Location-Specific ARARs* (cont)**			
Federal Requirements (cont)			
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Prohibits unauthorized obstruction or alteration of navigable waters of the U.S.	Remediation activities may involve obstruction or alteration of the Woonasquatucket River.
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Some wetlands are located within the site boundaries. Any activities in wetland areas will need to comply with this order.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid occupancy and modification of a floodplain unless there is no practicable alternative and avoid support of floodplain development wherever there is a practicable alternative.	The site is located in a 100-yr floodplain. If no practicable alternative, any activity will be designed to minimize such impacts.
Endangered Species Act of 1973, 16 USC 1531 et seq. 50 CFR 402	Potentially Applicable	Establishes requirements to protect species threatened by extinction and habitats critical to their survival.	Site includes part of the Woonasquatucket River and some wetlands. There are no known habitats for threatened or endangered species at Allendale and Lyman Mill Ponds, but transient bald eagles may occasionally occur within the Woonasquatucket River watershed.
Archaeological and Historical Preservation Act of 1974 Public Law 93-291	Not applicable	Requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.	There are presently no known areas with potential to contain significant archaeological or historical artifacts.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	Potentially Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Treatment, disposal, and storage of hazardous materials may take place at the site, which is located within the 100-yr floodplain.

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Table 3-1. (continued)

Requirement	Status	Synopsis	Potential Application
***Location-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Some wetlands are located within the site boundaries.
RIDEM Rules and Regulations for Groundwater Quality, 5/06	Not Applicable	Sets forth policy to protect future and present sources of drinking water by protection of the groundwater, aquifers, recharge areas, and watersheds.	Groundwater and surface water at and near the site are not currently a source of drinking water.
Action-Specific ARARs			
Federal Requirements			
TSCA PCB regulations (40 CFR 761, Subparts B and C)	Applicable	Establishes requirements for addressing PCB-contaminated remediation waste.	PCBs are present in source area soil.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions that may be taken in the river, wetlands and/or floodplains could result in the introduction of invasive species.
RCRA (40 CFR 264, Subpart AA)	Potentially Applicable	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Potentially Applicable	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
RCRA (40 CFR 264, Subpart CC)	Potentially Applicable	Air emission standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have more than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste have more than 500 ppmw of volatile organics, then these requirements will be met.

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Table 3-1. (continued)

Requirement	Status	Synopsis	Potential Application
***Action-Specific ARARs* (cont)**			
Federal Requirements (cont)			
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Potentially Applicable	Applicable to major sources of hazardous air pollutants.	If site remediation activities result in emissions or potential to emit hazardous air pollutants that qualify as a major source, then these requirements will be met.
RCRA Land Disposal Restrictions (40 CFR 268)	Potentially Applicable	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDFs must be treated to meet these requirements.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	R & A	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and State of Rhode Island (Rule 5.08) definitions.	Solid waste generated by excavation of soils or sediments at the site will undergo hazardous waste determination. The standard is 'relevant and appropriate' because wastes that may be classified as hazardous waste were disposed of prior to 1980.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Potentially Applicable	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	If remediation at the site includes some of these activities, substantive requirements must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Potentially Applicable	Outlines design, operational, and closure requirements for land disposal facilities.	Requirements must be met for CDFs constructed on site as well as other activities.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Potentially Applicable	Outlines design, operational, and closure requirements for incinerator facilities.	If remediation at the site includes on-site thermal treatment, substantive requirements must be met.

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Table 3-1. (continued)

Requirement	Status	Synopsis	Potential Application
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media (soil and groundwater only) at contaminated sites and sets minimum risk standards under state law. (1×10^{-5}).	This section was used to develop cleanup goals for the site.
RIDEM Rules and Regulations for Dredging and the Management of Dredged Material (2/03)	Not Applicable	Sets standards for any remedial action or removal action including dredging of sediments in marine waters.	Applies only to marine waters of the state and freshwater upland disposal sites.
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Remediation activities may affect water quality.
RIDEM Regulations for the Rhode Island Pollutant Discharge Elimination System (RIPDES) (2/03)	Potentially Applicable	Sets requirements for discharges to surface waters and to protect waters from discharges of pollutants.	Remediation activities may require discharge of water to the Woonasquatucket River; these regulations are applicable to discharges as a result of extracting groundwater or dewatering an excavation area.
RIDEM Rules and Regulations for Groundwater Quality, 5/06	Applicable	Establishes construction standards for permanent monitoring wells and abandonment procedures (Appendix 1)	The site contains approximately 33 monitoring wells.
RIDEM Oil Pollution Control Regulations (1/91, Refiled 12/01)	Not Applicable	Establishes guidelines for the prevention of discharge, escape or release of oil into the waters of the state	No oil will be discharged during the remedial action.
RIDEM Underground Injection Control Program (5/05)	Potentially Applicable	Establishes rules for remedial actions that include subsurface discharge or underground injection of treated or untreated groundwater.	May be applicable to subsurface injection of chemical oxidants.
RIDEM Solid Waste Regulation No. 1, Rules and Regulations for Solid Waste Management (10/05)	Potentially Applicable	Applicable for the minimization of environmental hazards associated with the operation of solid waste facilities.	CDFs containing non-hazardous waste would need to be constructed in accordance with substantive provisions.
RIDEM Solid Waste Regulation No. 2 (2/97)	Potentially Applicable	Establishes standards for construction of final covers, leachate collection systems and monitoring plans that result from on-site remedial actions.	CDFs containing non-hazardous waste would need to be constructed in accordance with substantive provisions.

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Table 3-1. (continued)

Requirement	Status	Synopsis	Potential Application
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Pretreatment Regulations (7/84)	Not Applicable	Applicable for any remedial action where treated or untreated liquids are discharged to a Publically Owned Treatment Works (POTW) facility.	No liquids will be discharged to a POTW.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation activities could potentially result in visible emissions. If these standards are exceeded, emissions would need to be managed through engineering controls.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable	Requires that reasonable measures be taken to prevent particulate matter from becoming airborne.	Remediation activities could potentially result in fugitive dust. Appropriate measures would need to be taken to prevent particulate matter from becoming airborne.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Remediation activities may result in emissions
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Potentially Applicable	Limits the amount of organic solvents emitted to the atmosphere	Remediation activities could result in emission of organic solvents to the atmosphere.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Potentially Applicable	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation activities could result in emission of toxics to the atmosphere.

Key
R & A - relevant and appropriate; TBC - to be considered

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Table 3-2. Off-Site Waste Disposal Options at the CMRP Site

Waste Classification	Waste Concentration	Disposal Requirement	Comment
F020	Do not meet treatment standards of 40 CFR 268.40 (e.g., Dioxins > 1 µg/kg or > 0.001 mg/kg)	Incineration	Within U.S., based on F-listing (40 CFR 261.31), accompanying Land Disposal Restrictions (LDRs) for dioxins (40 CFR 268.31), and treatment standards for hazardous waste (40 CFR 268.40)
		Hazardous landfill	For soil, constituents must meet 10 times the Universal Treatment Standards (UTS) (40 CFR 268.48) (LDR alternative treatment standards do not apply to sediment) Landfill disposal may be possible in Canada (Quebec) for dioxins < 5 µg/kg
	Meet treatment standards of 40 CFR 268.40 (e.g., Dioxins < 1 µg/kg or < 0.001 mg/kg)	Hazardous landfill	Within U.S. 40 CFR 261.31(d)(1) allows exception to LDR if concentrations meet Subpart D (40 CFR 268.40 Treatment Standards for Hazardous Waste)
Non-listed	> TCLP concentration	Incineration	For soil, constituents that exceed 10 times the UTS (40 CFR 268.48) For sediment, constituents that exceed treatment standards (40 CFR 268.40)
		Hazardous landfill	For soil, constituents must meet 10 times the UTS (40 CFR 268.48) For sediment, constituents must meet the treatment standards (40 CFR 268.40)
	< TCLP concentrations	Local non-hazardous landfill	Waste that is neither listed nor characteristic (40 CFR 261.24)

Key:
LDR – land disposal restrictions; TCLP - toxicity characteristic leaching procedure; UTS – universal treatment standard; µg/kg - micrograms per kilogram; mg/kg – milligrams per kilogram

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Table 3-3. Proposed Cleanup Goals for Allendale and Lyman Mill Reach Sediment[1]

Contaminant	Sediment Cleanup Goal	Basis	Explanation (Receptor/Exposure Pathway)
Dioxin and Dioxin-like Polychlorinated Biphenyls (ng/kg)			
2,3,7,8-TCDD[2]	14.7	Background	Human health risk-based PRG (combined fish diet, 10^{-6}) value of 0.5 ng/kg is below upstream background value of 14.7 ng/kg.
Coplanar PCB TEQ	24.9	Background	Human health risk based PRG (combined fish diet, 10^{-6}) value of 0.0058 ng/kg is below upstream background value of 24.9 ng/kg
Pesticides and Polychlorinated Biphenyls (mg/kg)			
Total Aroclors (total PCB)	0.21	Background	Ecological risk based PRG (Belted Kingfisher diet, hazard index of 1) value of 0.124 mg/kg is below upstream background value of 0.21 mg/kg
Aroclor 1254	0.15	Background	Human health risk based PRG (combined fish diet, 10^{-6}) value of 0.00374 mg/kg is below upstream background value of 0.15 mg/kg
Aroclor 1268	0.14	Background	Human health risk based PRG (combined fish diet, 10^{-6}) value of 0.0137 mg/kg is below upstream background value of 0.14 mg/kg
4,4'-DDD[3]	0.0084	Ecological risk-based PRG	Belted Kingfisher diet, hazard index of 1
4,4'-DDE[3]	0.006	Background	Ecological risk based PRG (Belted Kingfisher diet, hazard index of 1) value of 0.0034 mg/kg is below upstream background value of 0.006 mg/kg (Human health risk-based PRG [combined fish diet, 10^{-6}] value is 0.0096 mg/kg)
Dieldrin	0.0026	Background	Human health risk based PRG (combined fish diet, 10^{-6}) value of 0.0015 mg/kg is below upstream background value of 0.0026 mg/kg
Technical Chlordane	0.4	Background	Ecological risk based PRG (White Sucker CBR, hazard index of 1) value of 0.014 mg/kg is below upstream background value of 0.4 mg/kg (Human health risk-based PRG [combined fish diet, 10^{-6}] value is 0.05 mg/kg)
Semi-volatile organic compounds (mg/kg)			
Benzo(a)pyrene	1.4	Background	Human health risk based PRG (Resident Living Along the River, direct contact, 10^{-6}) value of 0.4 mg/kg is below upstream background value of 1.4 mg/kg
Dibenzo(a,h)anthracene	0.97	Background	Human health risk based PRG (Resident Living Along the River, direct contact, 10^{-6}) value of 0.4 mg/kg is below upstream background value of 0.97 mg/kg
N-nitroso-di-n-propylamine[3]	0.456	Human health risk-based PRG	Resident Living Along the River, Direct contact, 10^{-6} (not detected in upstream background)

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Table 3-3. (continued)

Contaminant	Sediment Cleanup Goal	Basis	Explanation (Receptor/Exposure Pathway)
Metals (mg/kg)			
Aluminum[3]	8210	Background	Ecological risk based PRG (Largemouth Bass CBR, hazard index of 1) value of 973 mg/kg is below upstream background value of 8210 mg/kg
Arsenic	3.9	Background	Human health risk based PRG (direct contact, 10^{-6}) value of 2.62 mg/kg is below upstream background value of 3.9 mg/kg
Barium[3]	134	Background	Ecological risk based PRG (White Sucker CBR, hazard index of 1) value of 45.5 mg/kg is below upstream background value of 134 mg/kg
Selenium	1.1	Background	Ecological risk based PRG (White Sucker CBR, hazard index of 1) value of 0.444 mg/kg is below upstream background value of 1.1 mg/kg
Vanadium[3]	37.6	Background	Ecological risk based PRG (Largemouth Bass CBR, hazard index of 1) value of 22.2 mg/kg is below upstream background value of 37.6 mg/kg
Zinc	221	Background	Ecological risk based PRG (Largemouth Bass CBR, hazard index of 1) value of 36.2 mg/kg is below upstream background value of 221 mg/kg

Notes:
[1] Proposed cleanup goals are based on the PRGs developed for the most sensitive receptor and/or exposure pathway, or background, whichever value is higher. See Appendix F (Table F-1) for additional detail regarding comparison of PRGs to background data. Appendix F (Attachment F-1, Table 7) summarizes the fish tissue concentrations (target tissue concentrations) anticipated following attainment of sediment cleanup goals presented in this table.
[2] This cleanup goal is also protective of ecological receptors. As shown in Appendix F, Table F-1, a sediment cleanup goal for dioxin/furan TEQ of 289 ng/kg is protective of the most sensitive ecological receptor (tree swallow CBR, hazard index of 1).
[3] Applicable to Lyman Mill reach sediment only.

Key:

CBR - critical body residue; PCB - polychlorinated biphenyl; PRG - preliminary remediation goal; TEQ - toxic equivalency; mg/kg - milligram per kilogram; and ng/kg - nanograms per kilogram

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Table 3-4. Proposed Cleanup Goals for Allendale and Lyman Mill Reach Floodplain Soil[1]

Contaminant	Cleanup Goal	Basis	Explanation (Receptor/Exposure Pathway)
Dioxin (ng/kg)			
2,3,7,8-TCDD	17	Background	Ecological risk-based PRG (Short-tailed Shrew CBR, hazard index of 1) value of 10 ng/kg is below upstream background value of 17 ng/kg. (Human health risk-based PRG [Passive Recreational Visitor, direct contact 10^{-6}) value of 16 ng/kg dioxin TEQ is below upstream background value of 50 ng/kg)
Pesticides/PCBs (mg/kg)			
Total Aroclors[2] (total PCB)	1.7	Ecological risk-based PRG	American Woodcock diet, hazard index of 1
Aroclor 1254[2]	0.82	Human health risk-based PRG	Passive Recreational Visitor, Direct Contact, 10^{-6}
4,4'-DDE[2]	0.016	Ecological risk-based PRG	American Woodcock CBR, hazard index of 1
Dieldrin[2]	0.04	ARAR	RIDEM residential direct exposure (Ecological risk-based PRG [American Woodcock CBR, hazard index of 1] value is 0.041 mg/kg)
Metals (mg/kg)			
Antimony[2]	0.62	Background	Ecological risk based PRG (Short-tailed Shrew diet, hazard index of 1) value of 0.47 mg/kg is below upstream background value of 0.62 mg/kg
Arsenic[2]	7.7	Background	Human health risk PRG (Passive Recreational Visitor, direct contact 10^{-6}) value of 1.6 mg/kg is below upstream background value of 7.7 mg/kg.
Cadmium[2]	3.8	Ecological risk-based PRG	Short-tailed Shrew diet, hazard index of 1
Lead[2]	450	Background	Ecological risk based PRG (American Woodcock diet, hazard index of 1) value of 160 mg/kg is below upstream background value of 450 mg/kg
Selenium[2]	0.7	Background	Ecological risk based PRG (Short-tailed Shrew diet, hazard index of 1) value of 0.16 mg/kg is below upstream background value of 0.7 mg/kg
Zinc[2]	320	Ecological risk-based PRG	American Woodcock diet, hazard index of 1

Notes:

[1] Proposed cleanup goals are based on an evaluation of risk-based PRGs (developed for the most sensitive receptor and/or exposure pathway), potential ARARs, TBCs, and site background data, as described in Section 3.4 and Appendix F. Contaminants detected in excess of ARARs but found to be consistent with, or less than background conditions were not retained for cleanup goal determination unless a risk-based PRG was available for the contaminant (Appendix F). Cleanup goals were not developed for undetected contaminants where the laboratory detection limits were in excess of ARARs. Additional sampling will be performed during the design phase to verify background conditions and the statistical comparisons, and verify undetected contaminants using analytical methods capable of measuring concentrations at levels below the ARARs. These data will be evaluated to assess impacts, if any, to the proposed cleanup goals. However, all numeric criteria for all contaminants listed as ARARs must be met regardless of whether or not they are identified above as proposed cleanup goals except where background is an issue.

[2] Applicable to Lyman Mill reach floodplain soil only (including Oxbow).

Key:

ARAR - Applicable or Relevant and Appropriate Requirement; CBR - critical body residue; PCB - polychlorinated biphenyl; PRG - preliminary remediation goal; TBC - to be considered; TEQ - toxic equivalency; mg/kg - milligram per kilogram; and ng/kg - nanograms per kilogram

Table 3-5. Proposed Cleanup Goals for Surface Water[1]

Contaminant	Cleanup Goal	Basis	Explanation
Dioxin (pg/L)			
2,3,7,8-TCDD	0.5	ARAR	Federal and state WQC based on human health scenario including drinking water and fish consumption, as modified based on site specific bioaccumulation factors (see Appendix F); undetected at upstream background.

Notes:
[1] Proposed cleanup goals for surface water are based on an evaluation of potential ARARs and site background data, as described in Section 3.4 and Appendix F. Potential ARARs include the State of Rhode Island standards and federal WQC: chronic ambient freshwater and human health criteria for consumption of water + organism (RIDEM, 2006 and EPA, 2006). Contaminants detected in excess of ARARs but found to be consistent with, or less than background conditions were not retained for cleanup goal determination (Appendix F). Cleanup goals were not developed for undetected contaminants where the laboratory detection limits were in excess of ARARs. Additional sampling will be performed during the design phase to verify background conditions and the statistical comparisons, and verify undetected contaminants using analytical methods capable of measuring concentrations at levels below the ARARs. These data will be evaluated to assess impacts, if any, to the proposed cleanup goals. However, all numeric criteria for all contaminants listed as ARARs must be met regardless of whether or not they are identified above as proposed cleanup goals except where background is an issue.

Key:
ARAR - Applicable or Relevant and Appropriate Requirement; pg/L - picograms per liter; WQC – water quality criteria

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Table 3-6. Proposed Cleanup Goals for Source Area Soils[1]

Contaminant[2]	Cleanup Goal	Basis	Explanation
Dioxin (ng/kg)			
Dioxin TEQ	1000	TBC	EPA's recommended residential level for dioxin (EPA, 1998b)
Pesticides/PCBs (mg/kg)			
Total Aroclors (total PCB)	10	ARAR	RIDEM residential direct exposure criteria
Dieldrin	0.04	ARAR	RIDEM residential direct exposure criteria
Technical Chlordane	0.5	ARAR	RIDEM residential direct exposure criteria
Semi-volatile Organic Compounds (mg/kg)			
Benzo(a)anthracene	0.9	ARAR	RIDEM residential direct exposure criteria
Benzo(a)pyrene	0.4	ARAR	RIDEM residential direct exposure criteria
Benzo(b)fluoranthene	0.9	ARAR	RIDEM residential direct exposure criteria
Benzo(g,h,i)perylene	0.8	ARAR	RIDEM residential direct exposure criteria
Benzo(k)fluoranthene	0.9	ARAR	RIDEM residential direct exposure criteria
Biphenyl, 1,1-	0.8	ARAR	RIDEM residential direct exposure criteria
Bis(2-ethylhexyl)phthalate	46	ARAR	RIDEM residential direct exposure criteria
Chrysene	0.4	ARAR	RIDEM residential direct exposure criteria
Dibenzo(a,h)anthracene	0.4	ARAR	RIDEM residential direct exposure criteria
Fluoranthene	20	ARAR	RIDEM residential direct exposure criteria
Indeno(1,2,3-cd)pyrene	0.9	ARAR	RIDEM residential direct exposure criteria
Naphthalene	54	ARAR	RIDEM residential direct exposure criteria
Pentachlorophenol	5.3	ARAR	RIDEM residential direct exposure criteria
Pyrene	13	ARAR	RIDEM residential direct exposure criteria
Metals (mg/kg)			
Antimony	10	ARAR	RIDEM residential direct exposure criteria
Arsenic	7	ARAR	RIDEM residential direct exposure criteria
Beryllium	0.4	ARAR	RIDEM residential direct exposure criteria
Cadmium	39	ARAR	RIDEM residential direct exposure criteria
Lead	150	ARAR	RIDEM residential direct exposure criteria
Manganese	390	ARAR	RIDEM residential direct exposure criteria
Thallium	5.5	ARAR	RIDEM residential direct exposure criteria

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Table 3-6. (continued)

Contaminant[2]	Cleanup Goal	Basis	Explanation
Volatile organic compounds (mg/kg)			
Benzene	2.5	ARAR	RIDEM residential direct exposure criteria
Chlorobenzene	100	ARAR	RIDEM GB leachability criteria
Dichloroethane (1,2-)	0.9	ARAR	RIDEM residential direct exposure criteria
Dichloroethene (cis-1,2-)	60	ARAR	RIDEM GB leachability criteria
Ethyl benzene	62	ARAR	RIDEM GB leachability criteria
Tetrachloroethene (PCE)	4.2	ARAR	RIDEM GB leachability criteria
Toluene	54	ARAR	RIDEM GB leachability criteria
Trichloroethene (TCE)	13	ARAR	RIDEM residential direct exposure criteria
Vinyl chloride	0.02	ARAR	RIDEM residential direct exposure criteria
Xylenes (Total)	110	ARAR	RIDEM residential direct exposure criteria

Notes:
[1] Cleanup goals applicable to vadose zone soils at the Source Area, except dioxin TEQ applicable to surface soils (0 to 1 ft bgs). However, all numeric criteria for all contaminants listed as ARARs must be met regardless of whether or not they are identified above as proposed cleanup goals except where background is an issue.
[2] Contaminants are identified based on those chemicals detected in vadose zone samples at concentrations in excess of the potential ARARs (RIDEM residential direct exposure and GB leachability criteria, RIDEM, 2004) or detected in surface samples at concentrations in excess of EPA's recommended residential level for dioxin (EPA, 1998b) as described in Appendix F.

Key:
ARAR - Applicable or Relevant and Appropriate Requirement; PCB - polychlorinated biphenyl; RIDEM – Rhode Island Department of Environmental Management; TBC - to be considered; TEQ, toxic equivalency; mg/kg - milligram per kilogram; and ng/kg - nanograms per kilogram

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Table 3-7. Proposed Cleanup Goals for Protection of Source Area Groundwater

Contaminant[1]	Cleanup Goals based on Groundwater/Surface Water Mixing Model [2]		Cleanup Goals based on ARARs RIDEM GB Criteria	
	Soil (ng/kg)	Groundwater (pg/L)	Soil Leachability Criteria[3] (mg/kg)	Groundwater Objectives[3] (µg/L)
2,3,7,8-TCDD	8,600	1,768	NA	NA
Total PCB	NA	NA	10	NA
Benzene	NA	NA	4.3	– [4]
Chlorobenzene	NA	NA	100	– [4]
Dibromochloropropane (DBCP)	NA	NA	NA	2
Dichloroethene (cis-1,2-)	NA	NA	60	– [4]
Ethyl benzene	NA	NA	62	– [4]
Tetrachloroethene (PCE)	NA	NA	4.2	150
Toluene	NA	NA	54	– [4]
Trichloroethene (TCE)	NA	NA	20	540

Notes:
[1] Contaminants are identified based on those chemicals detected in source area soil (vadose zone) or groundwater samples at concentrations in excess of the potential ARARs (RIDEM GB soil leachability criteria and groundwater objectives) as described in Appendix F. However, all numeric criteria for all contaminants listed as ARARs must be met regardless of whether or not they are identified above as proposed cleanup goals except where background is an issue.
[2] Cleanup goals developed in support of RAO to prevent migration of contaminants (dioxin) in groundwater discharging to river that would result in surface water concentrations in excess of ARARs (ambient water quality criteria for dioxin modified based on site-specific bioaccumulation factors as described in Appendix F).
[3] GB soil leachability and groundwater criteria promulgated in the RIDEM Remediation Regulations (RIDEM, 2004).
[4] RIDEM GB groundwater objectives promulgated for this contaminant, however cleanup goals were not developed because it was not detected in source area groundwater at concentrations in excess of the ARAR (see footnote 1).

Key:
ARAR - Applicable or Relevant and Appropriate Requirement; PCB - polychlorinated biphenyl; RIDEM – Rhode Island Department of Environmental Management; NA - not applicable; mg/kg - milligram per kilogram; ng/kg - nanograms per kilogram; pg/L – picograms per liter; and µg/L – micrograms per liter

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Table 3-8. Area and Volume Estimates for Proposed Cleanup Areas

Action Area/Media	Cleanup Area		In-Situ Removal Volume[1] (cy)
	(sq ft)	(ac)	
Allendale Reach/Sediment	673,600	15.5	48,200
Lyman Mill Reach/Sediment	1,022,000	23.5	91,000
Allendale Reach/Floodplain Soil	64,600	1.5	2,400
Lyman Mill Reach/Stream Sediment and Floodplain Soil[2]	940,000	21.6	34,800
Source Area/Soil[3]	339,500	7.8[3]	62,900
Source Area/Groundwater	5,500	0.13	1,300[4]

Notes:

[1] In-situ removal volumes do not include any allowance for over-excavation or over-dredging which is needed to perform the remediation. The volumes described in the alternative descriptions and cost estimates in subsequent sections of this FS are higher because they include an over-dredge or over-excavation allowance.
[2] Action area includes the Oxbow area located southwest of Allendale Dam.
[3] Majority of cleanup area is comprised of existing interim caps and paved surfaces (6.4 acres), and the remaining area is comprised of landscape areas, walkways, and rip rap.
[4] The volume of material, either source area soil or groundwater, removed is variable and dependent upon the specific alternative. The specific volume of groundwater to be removed (i.e. in the case of a pump and treatment alternative) is not able to be calculated; the treatment would be considered complete when confirmation testing indicated that the levels of dissolved parameters had dropped below the clean up goals.

Key:
sq ft – square feet; ac – acres; cy – cubic yards

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Table 4-1. Screening Evaluation of General Response Actions, Technologies and Process Options for Sediment

General Response Action		Screening Criteria			Retained for Detailed Analysis
Technologies	**Process Options**	**Effectiveness**	**Implement-ability**	**Cost**	
NO ACTION					
—	—	Not Effective	Easily	Low	Yes
INSTITUITIONAL CONTROLS					
Covenants and easements Local ordinances and zoning Informational devices	Deed restrictions on excavation and future use; No dredge zones in public waterway; No anchor zones; Swimming restrictions; Fish consumption or health advisory	Low to Moderate	Easily	Low	Yes
ENGINEERING CONTROLS					
Physical barriers	Perimeter fence; Warning buoys of restricted zones	Low to Moderate	Easily	Low	Yes
Dam maintenance and/or removal	Maintenance of dams, replacement with smaller structures, and/or dam removal to minimize risk of structural breaches	High	Moderate	Low	Yes
MONITORED NATURAL RECOVERY					
Natural deposition of native sediment	Natural physical deposition	Low to Moderate	Easily	Low	Yes
Natural biological degradation	Natural biological activity	Not Effective	Easily	Low	No
CONTAINMENT					
Isolation cap	Sand/silt cap; Geosynthetic membrane cap; Bentonite blanket cap	Moderate	Moderate	Moderate	Yes
Reactive cap	Treatment cap: such as organic soil or sediment, activated carbon	Moderate	Moderate	Moderate	Yes
Wetland cap	Thick cap to raise ground elevation; Wetland soil for plant growth; Biodegradable fabric; Wetland planting	Moderate	Moderate	Moderate	Yes
Habitat enhancement cap or thin layer cover	Thin-layer cover to improve habitat and accelerate natural recovery	Low	Moderate	Moderate	Yes
Shoreline stabilization cap	Rock rip-rap; Biodegradable fabric; Vegetation	Moderate	Moderate	Moderate	Yes

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Table 4-1. (continued)

General Response Action		Screening Criteria			Retained for Detailed Analysis
Technologies	**Process Options**	**Effectiveness**	**Implement-ability**	**Cost**	
SEDIMENT REMOVAL					
Dredging (subaqueous excavation)	Mechanical; Hydraulic; Hybrid; Pneumatic	Moderate	Moderate	Moderate	Yes
Excavation (after lowering water level)	Cofferdam dewatering (either circular or double-wall earth filled); Single sheet pile wall; Fabric dam; Earth dam	High	Moderate	Moderate	Yes
TRANSPORTATION					
Mechanical transport	Floating barge; Amphibious vehicle; Wheeled vehicle; Rail; Conveyor	High	Easily	Moderate	Yes
Hydraulic transport	Pipeline slurry direct from dredge; Pipeline slurry from hybrid dredge or mixing basin	High	Easily	Moderate	Yes
DEWATERING					
Passive dewatering	Gravity separation; Air drying	High	Infeasible	Low	No
Solidification	Mix with cement, lime or fly ash	High	Moderate	Moderate	Yes
Mechanical dewatering	Belt filter press; Plate and frame press; Centrifuge	High	Moderate	Moderate	Yes
SEDIMENT DISPOSAL					
On- or off-site confined aquatic disposal	Excavate subaqueous pit; place material in natural depression	Moderate	Infeasible	Moderate	No
On-site nearshore confined disposal facility	Permeable dikes and cap; Impermeable dike and/or cap; Base liner and leachate collection; Soil gas collection system	Moderate	Moderate	Low	Yes
On-site consolidation	Move dredged/excavated sediment into consolidation area and cover with isolation cap and an armored slope	Moderate	Moderate	Low	Yes
On- or off-site upland confined disposal facility	Monofill for dredged material; Multiuser facility; Hazardous waste landfill	High	Easily to Moderate[1]	Low[2]	Yes
EX-SITU TREATMENT					
Stabilization	Mix with cement, lime or fly ash; Mix with custom-designed stabilization agents	Low	Moderate	Moderate	No
Thermal treatment	Incineration (high-temperature destruction); Thermal desorption (low-temperature separation)	High	Moderate to Complex/Difficult[3]	Very High	Yes

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Table 4-1. (continued)

General Response Action		Screening Criteria			Retained for Detailed Analysis
Technologies	**Process Options**	**Effectiveness**	**Implement-ability**	**Cost**	
EX-SITU TREATMENT (continued)					
Biological treatment	Aerobic degradation; Anaerobic degradation	Low	Infeasible	High	No
Chemical treatment	Solvent extraction; Chemical reaction	Low	Infeasible	Very High	No

Notes:
[1] On-site disposal at an upland facility would be moderate; disposal off site at permitted facility would be easy to implement.
[2] Costs for disposal off site at a permitted facility could be very high if treatment is required.
[3] On-site thermal treatment would be complex/difficult and off-site disposal by incineration at a permitted facility would be moderate.

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Table 4-2. Screening Evaluation of General Response Actions, Technologies and Process Options for Source Area Soil and Floodplain Soil

General Response Action		Screening Criteria			Retained for Detailed Analysis
Technologies	**Process Options**	**Effectiveness**	**Implement-ability**	**Cost**	
NO ACTION					
—	—	Not Effective	Easily	Low	Yes
INSTITUITIONAL CONTROLS					
Covenants and easements; Land or water use restrictions; Local ordinances and zoning	Land use restrictions on excavation and future use; Restrict actions such as building, utility, and other construction activities; Zoning ordinances to require walkways or boardwalks	Low	Easily	Low	Yes
ENGINEERING CONTROLS					
Physical barriers	Perimeter fence	Low to Moderate	Easily	Low	Yes
MONITORED NATURAL RECOVERY					
Natural deposition of new soil	Natural physical deposition	Not Effective	Easily	Low	No
Natural biological degradation	Natural biological activity	Not Effective	Easily	Low	No
CONTAINMENT					
Isolation cap	Clay, asphalt or concrete cap; Geosynthetic membrane cap; Bentonite blanket cap	Moderate	Moderate	Moderate	Yes
Shoreline stabilization cap	Rock rip-rap; Biodegradable fabric; Vegetation	Moderate	Moderate	Moderate	Yes
SOIL REMOVAL					
Excavation	Mechanical	High	Moderate to Complex/Difficult	Moderate	Yes
Dredging inside flooded excavation	Mechanical; Hydraulic	High	Complex/Difficult	High	Yes
TRANSPORTATION					
Mechanical transport	Amphibious vehicle; Wheeled vehicle; Rail; Conveyor	High	Easily	Moderate	Yes

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Table 4-2. (continued)

General Response Action		Screening Criteria			Retained for Detailed Analysis
Technologies	**Process Options**	**Effectiveness**	**Implement-ability**	**Cost**	
DEWATERING					
Passive dewatering	Gravity separation; Air drying	High	Infeasible	Low	No
Solidification	Mix with cement, lime or fly ash with deep soil mixing	High	Moderate	Moderate	Yes
Mechanical dewatering	Belt filter press; Plate and frame press; Centrifuge	High	Complex/Difficult	High	No
SOIL DISPOSAL					
On-site nearshore confined disposal facility	Combined disposal with CDF for sediment	Moderate	Moderate	Moderate	Yes
On- or off-site upland confined disposal facility	Monofill for soil; Hazardous waste landfill	High	Easily to Moderate[1]	Moderate[2]	Yes
EX-SITU TREATMENT					
Stabilization	Mix with cement, lime or fly ash; Mix with custom-designed stabilization agents	Low	Moderate	Moderate	No
Thermal treatment	Incineration (high-temperature destruction); Thermal desorption (low-temperature separation)	High	Moderate to Complex/Difficult[3]	Very High	Yes
Biological treatment	Aerobic degradation	Low	Infeasible	High	No
Chemical treatment	Solvent extraction; Chemical reaction	Low	Infeasible	Very High	No
IN-SITU TREATMENT					
Solidification/Stabilization	Mix with cement, lime or fly ash; Mix with custom-designed stabilization agents	Low	Complex/Difficult	High	No
Thermal treatment	In-situ thermal desorption; Electrical resistance heating; Stream stripping	High	Complex/Difficult	High	No
Biological treatment	Anaerobic degradation; Phytoremediation	Low	Infeasible	Moderate	No

Notes:
[1] On-site disposal at an upland facility would be moderate; disposal off site at permitted facility would be easy to implement.
[2] Costs for disposal off site at a permitted facility could be very high if treatment is required.
[3] On-site thermal treatment would be complex/difficult and off-site disposal by incineration at a permitted facility would be moderate.

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Table 4-3. Screening Evaluation of General Response Actions, Technologies and Process Options for Groundwater

General Response Action		Screening Criteria			Retained for Detailed Analysis
Technologies	**Process Options**	**Effectiveness**	**Implement-ability**	**Cost**	
NO ACTION					
—	—	Not Effective	Easily	Low	Yes
INSTITUITIONAL CONTROLS					
Land and water use restrictions	Deed restrictions on groundwater use	Low	Easily	Low	Yes
MONITORED NATURAL ATTENUATION					
Natural degradation	Natural biological activity	Not Effective[1]	Easily	Low	No
CONTAINMENT					
Subterranean hydraulic barrier	Slurry wall; Steel sheet pile wall; Cement or chemical grout injection	Moderate	Moderate	Moderate	Yes
Hydraulic control	Pump to lower groundwater table; Aboveground treatment	Moderate	Moderate	Moderate	Yes
EXCAVATION/DEWATERING					
Short-term pumping	Dewatering in conjunction with mechanical soil excavation below groundwater table	Moderate	Easily	Low	Yes
PUMP AND TREATMENT					
Physical treatment	Precipitation/coagulation/flocculation; Filtration; Air stripping; Activated carbon adsorption	Moderate	Moderate	Moderate	Yes
Biological treatment	Anaerobic degradation	Low	Infeasible	High	No
Chemical treatment	Chemical reactions	Moderate	Moderate	High	Yes
IN-SITU TREATMENT					
Physical treatment	Air sparging; Thermal	Moderate	Complex/Difficult	High	No
Biological treatment	Anaerobic degradation; Passive/reactive treatment walls; Phytoremediation	Moderate[2]	Easily	Moderate	Yes
Chemical treatment	Chemical reactions	Moderate[2]	Easily	Moderate	Yes

Notes:
[1] Not effective for dioxins, but effective for VOCs.
[2] Effectiveness for dioxins would need to be evaluated.

Table 6-1. Detailed Analysis of Allendale and Lyman Mill Sediment Alternative 1, No Action

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-1: NO ACTION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and Environment	Contaminated sediment would remain on site unaddressed and continue to present a risk to human health and the environment. The existing controls (perimeter fence at Allendale Pond and fishing advisories) would not effectively limit exposure to human and ecological receptors.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	See Table 6-2.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Existing risk will remain because no action would be taken to isolate or destroy the contaminated sediment or prevent the erosion and migration of contaminated sediment downstream. Migration of contaminated sediment downstream may increase future risk in these areas. Natural recovery processes may decrease risk from contaminated sediment in the very long term.
Adequacy and Reliability of Controls	This alternative does not include measures to maintain and enforce access restrictions or control physical disturbance of the sediment to minimize exposure to contaminants in the long term. There are no controls to require maintenance of the privately owned dams along the river, and downstream transport of contaminated sediment could occur in the event of a dam breach.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	None proposed for this alternative.
Amount Destroyed or Treated	None anticipated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	No reductions in toxicity, mobility, or volume of contamination is anticipated for this alternative.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	There would be no residuals because no treatment is planned for this alternative.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.

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Table 6-1. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-1: NO ACTION
SHORT-TERM EFFECTIVENESS	
Protection of Workers During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Environmental Impacts	Not applicable, as no remedial actions are proposed for this alternative
Time Until Remedial Action Objectives are Achieved	While some reduction in risk is possible due to natural deposition, it is unknown if or when cleanup objectives would be reached. (Based on estimated rates, it would take 40 to 60 years for a one foot thick layer of new sediment to be deposited in the ponds and not all areas may be covered.)
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Reliability of the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative does not preclude future remedial activities.
Ability to Monitor the Effectiveness of Remedy	Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. Periodic monitoring would include routine testing and could be easily implemented.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable, as no activities requiring approval are planned for this alternative.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Not applicable for this alternative.
Availability of Technology	Not applicable for this alternative.
COST[1]	
Capital Cost	$0
Present Worth of Long-term Monitoring and Maintenance	$450,000 (includes costs for periodic monitoring and five-year reviews)
Total Present Worth Cost	$450,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale and Lyman Mill Sediment Alternative 1, No Action[1]

Requirement	Status	Synopsis	Action to be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contributions of contaminants from sediment that exceed AWQC in the Woonasquatucket River will not be minimized to the maximum extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Alternative would not prevent exposure to contaminants considered under this guidance.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Alternative would not prevent exposure to contaminants potentially considered under this guidance.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	Alternative would not prevent exposure to contaminants potentially considered under this guidance.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Alternative would not prevent exposure to contaminants potentially considered under this assessment.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Alternative would not prevent exposure to contaminants potentially considered under this assessment.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Alternative would not prevent exposure to contaminants potentially considered under these advisories.

Notes:
[1] With no action, there are no location- or action-specific ARARs.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-3. Estimated On-site CDF Capacities[1]

On-site CDF Areas	Average length (ft)	Average Width (ft)	Top of Berm Elevation (ft)	Top of Cover (ft)	Capacity (cy)
North Oxbow Area					
Option 1[2] 370		600	93	104	74,000
Option 2[3] 370		600	93	104	52,000
South Oxbow Area					
Option 1[2] 300		340	86	94	62,000
Option 2[3] 300		340	86	94	42,000
Combined North and South Oxbow					**94,000 to 136,000**
Cap Area #1 and Southern Peninsula					
Option 1[4] 520		200	100	104	35,200
Option 2[4] 520		200	106	110	59,600
Allendale Pond Nearshore CDF[4]	1,200 150		94	97	42,900
Lyman Mill Pond Nearshore CDF[4]					
East CDF	700	180	78	80	34,900
West CDF	700	280	78	80	47,400
Combined Allendale and Lyman Mill Pond CDFs					125,200[5]
Concrete Plant					
Option 1	600	580	100	110	115,000
Option 2	600	580	102.5	112.5	133,000

Notes:
[1] Excavated material from other areas of the site (e.g., floodplain soil) could be utilized to regrade the source area under Source Area Soil Alternative 4, should this be implement, which would provide additional CDF capacity.
[2]Assumes that the existing soil is removed down to the ground surface elevation at the downhill dike prior to CDF construction.
[3]Same as note 1, except that perimeter berms would be built 50 feet upland from edge of floodplain.
[4] Capacity varies depending on the height of the dike. Maximum capacity under Option 2 based on a higher dike compared to Option 1.
[5] Raising the final height of the CDFs by approximately 1.5 ft would increase capacity sufficiently to also contain excavated floodplain soil.

Key:
CDF – confined disposal facility; cy – cubic yards; ft – feet

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Table 6-4. Detailed Analysis of Allendale and Lyman Mill Sediment Alternative 7, Excavation and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-7: EXCAVATION AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and Environment	The excavation and removal of sediments would provide high overall protection to human health and the environment by quickly reducing human health and ecological risk to acceptable levels. In addition, the removal of resident fish from the ponds would effectively reduce the fish consumption risks to humans and piscivorous wildlife. Removal of the sediment would prevent contaminant migration downstream due to erosion for Options 7a (upland CDF), 7d (on-site thermal treatment) and 7e (off-site disposal and/or treatment). However, contamination would remain in the floodplain for Option 7b (nearshore CDF) which would reduce its overall protection.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 7 are summarized in Table 6-5. Assuming that excavation involves more than a *deminimis*/ incidental discharge to surface water, Clean Water Act Section 404 requirements are triggered by excavation. In addition, the thin cover (all options), dewatering (all options except 7b), nearshore CDF (Option 7b), and possibly the upland CDF (Option 7a) also trigger Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under Option 7a (upland CDF), selection of the CDF that contains low-quality wetlands would result in the destruction of the wetlands. Option 7b (nearshore CDF) would impact wetlands and floodplains and include a discharge of dredged and/or fill material to waters of the US. In addition, a portion of the nearshore CDF would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Flood storage capacity would be reduced under Option 7b. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 7a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 7b) that is within the area of contamination.

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Table 6-4. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-7: EXCAVATION AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Excavation would remove contaminated sediment from the river/ponds to provide a very high level of risk reduction and low residual risk. In order to meet the RAOs, a thin-layer cover would be placed on top of the sediment if post-excavation contaminant concentrations exceeded the cleanup goals in some locations. Inherent hazard would be further reduced for Options 7d and 7e because sediment would be incinerated on site or taken off site for disposal or treatment. Inherent hazard would be somewhat higher for Option 7a (upland CDF) because the contamination would remain on site, although in a secure upland disposal facility. The highest inherent hazard will remain for Option 7b (nearshore CDF) because the contamination would remain in the floodplain, adjacent to the river, although also in a controlled disposal facility.
Adequacy and Reliability of Controls	Excavation would be effective in the long term because the contaminated sediment would be removed and either contained on site, destroyed, or shipped off site for disposal or treatment. This alternative can be reliable as long as long-term monitoring, maintenance and ICs are implemented for any type of on-site disposal facility (Options 7a and 7b). Maintenance, monitoring, and ICs are particularly important for Option 7b (nearshore CDF) because the inherent hazard remains in the floodplain adjacent to the river. Dam maintenance would also be critical for the effectiveness of Alternative 7 for any options where inherent hazard remains in the river or floodplain.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Options 7a and 7e assume some material will require treatment to meet LDRs. Option 7d includes on-site incineration.
Amount Destroyed or Treated	Under Option 7a, approximately 9,800 cy of dewatered sediment would be treated (10% of the total dewatered volume). Under Option 7d, approximately 155,800 cy of sediment would be excavated, dewatered, and treated. Under Option 7e, approximately 49,000 cy (50% of the total dewatered volume) would be treated.

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Table 6-4. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-7: EXCAVATION AND DISPOSAL AND/OR TREATMENT
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination from incineration under Options 7a, 7d, and 7e. There would be no treatment under Option 7b, although the mobility of the contaminated sediment particles would be reduced by the disposal facility.
Degree to Which Treatment is Irreversible	For sediments that undergo thermal treatment (Options 7a, 7d, and 7e), the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. Air emissions of contaminants or additional by-products produced during on- or off-site thermal treatment (Options 7a, 7d, and 7e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment particles would be nearly the same as the pre-treatment volume, but concentrations of chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	All of the options would result in limited impacts to the community from construction. Access to the work zone during construction activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 7d would result in air emissions which would be monitored to ensure that they are below regulatory standards.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during site activities, mitigating risks to workers.
Environmental Impacts	Excavation would result in destruction of the existing benthic habitat in both ponds and the elimination of the fish communities. In addition, aquatic-dependent wildlife populations would be adversely affected until primary and secondary productivity in the ponds becomes re-established, which could take two to five years. During pond lowering, there is the potential for downstream migration of contaminated sediment. Up to an acre of floodplain habitat would be impacted during the remedial construction phase.
Time Until Remedial Action Objectives are Achieved	RAOs are achieved immediately upon completion of remedy implementation, which is estimated to take approximately two years.

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Table 6-4. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-7: EXCAVATION AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	For all options, the very soft surface sediments would require the use of low-ground pressure equipment and hydraulic excavators. Temporary haul roads would need to be constructed to provide access. For Options 7a, 7d and 7e, an upland land area is required for sediment dewatering. For Option 7a, additional land is needed for a disposal facility and Option 7d requires land for an incinerator. This property may need to be acquired from private parties. Increased monitoring would be needed for Options 7a, 7b and 7d relative to Option 7e.
Reliability of the Technology	Excavation of soft sediments after lowering over-lying surface water is a proven technology and has been successfully implemented at other contaminated sediment sites. CDFs are widely used and CDF construction and thermal treatment are proven technologies. However, a nearshore CDF under Option 7b could present additional reliability concerns given that it would be located partially in the river.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. Confirmation sampling would be performed at the completion of construction activities to determine if the cleanup goals were achieved. A thin-layer cover would be placed over areas where contamination is above the cleanup goals, even after excavation. Long-term monitoring would be required to assess recovery of biological communities, assess the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. Increased monitoring would be needed for the on-site containment (Options 7a and 7b) and on-site treatment (Option 7d) options. However, these monitoring programs would not present any unusual issues.

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Table 6-4. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT-7: EXCAVATION AND DISPOSAL AND/OR TREATMENT	
IMPLEMENTABILITY		
Ability to Obtain Approvals and Coordinate with Other Agencies	For those components with wetlands/404 impacts, these actions must be evaluated to determine the least damaging practicable alternative. For Option 7a, some low-value wetlands could be destroyed depending on the location of the CDF and a treatability variance may need to be obtained. For Option 7b, a portion of the CDF would require the permanent occupancy and modification of the floodplain, and a determination would need to be made concluding that there is no other practicable alternative before selecting this option. Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs.	
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. Samples of dewatered sediment could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.	
Availability of Necessary Equipment and Specialists	Excavation and CDF construction contractors and equipment are readily available. Thermal treatment equipment is commercially available.	
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.	
COST[1]		
Capital Cost	Option 7a, On-site Upland CDF	$58,000,000
	Option 7b, On-site Nearshore CDF	$44,000,000
	Option 7d, On-site Thermal Treatment	$115,000,000
	Option 7e, Off-site Disposal and/or Treatment	$114,000,000
Present Worth of Long-term Monitoring and Maintenance	Option 7a, On-site Upland CDF	$2,800,000
	Option 7b, On-site Nearshore CDF	$2,900,000
	Option 7d, On-site Thermal Treatment	$2,700,000
	Option 7e, Off-site Disposal and/or Treatment	$2,500,000
Total Present Worth Cost	Option 7a, On-site Upland CDF	$61,000,000
	Option 7b, On-site Nearshore CDF	$47,000,000
	Option 7d, On-site Thermal Treatment	$118,000,000
	Option 7e, Off-site Disposal and/or Treatment	$116,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-5. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale and Lyman Mill Sediment Alternative 7, Excavation and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to be Taken to Attain Requirement
Chemical-Specific ARARs (there are no applicable State Requirements)			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants that exceed AWQC in the Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Health Advisories used to establish criteria in the absence of other standards.
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in the Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.

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Table 6-5. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation, thin cover, dewatering, and nearshore CDF (and potentially upland CDF) subject to these requirements. Activities must be conducted in accordance with these requirements including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Thin cover and nearshore CDF subject to these requirements. Activities must be conducted in accordance with these requirements.
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	An upland CDF containing wetlands can only be selected if there is no practicable alternative to destruction of wetlands.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	Nearshore CDF can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A: Nearshore CDF	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Nearshore CDF must be constructed in accordance with these requirements.

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Table 6-5. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
***Location-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.
Action-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation, dewatering, thin cover, and nearshore CDF must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
RCRA (40 CFR 264, Subpart CC)	Applicable: Upland CDF On-site Incineration Off-site Disposal	Air emission standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics then these requirements will be met.

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Table 6-5. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Action-Specific ARARs (cont)			
Federal Requirements (cont)			
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site thermal treatment must meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF On-site Incineration Off-site Disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Used to determine appropriate disposal for contaminated sediment.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable: Upland CDF On-site incineration R & A: Nearshore CDF	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal or on-site incineration must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable: Upland CDF R & A Nearshore CDF	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements related to land disposal must be met for CDFs constructed on site.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site Incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site incineration must be conducted to meet these substantive requirements.
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation, thin cover, dewatering (discharge of dredged return water) and nearshore CDF must be conducted so that there are no exceedances of water quality standards.

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Table 6-5. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions.	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable Prohibits	emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-6. Typical Root Penetration Depths for Freshwater Emergent Plants

Taxon	Root Penetration (ft)	References
Common reed	1 ½ to 2	Gersberg *et al*., 1985 as cited in EPA, 1988, 1993; Crites and Middlebrooks, 1995 as cited in Korkusuz 2005
Cattail 1		
Bulrush	2 to 2 ½	

Key:
ft – feet

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Table 6-7. Detailed Analysis of Allendale and Lyman Mill Sediment Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 8: PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and Environment	The removal of sediment from shallow areas and areas with high erosion potential would provide some protection by reducing concentrations in areas where exposure is most likely and reducing the risk of potential cap erosion. Capping sediments would isolate the remaining contaminants from the environment and restrict potential contaminant migration. The removal of resident fish from the ponds would effectively reduce the fish consumption risks to humans and piscivorous wildlife.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 8 are summarized in Table 6-8. Assuming that excavation involves more than a *deminimis*/ incidental discharge to surface water, Section 404 requirements are triggered by excavation. In addition, the isolation cap (all options), the nearshore CDF (Option 8b) and possibly the upland CDF (Option 8a) also trigger Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. In addition, isolation capping and the nearshore CDF (Option 8b) would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 8a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 8b) that is within the area of contamination.

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Table 6-7. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 8: PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Residual risk after the contaminated sediment is excavated and a cap is installed will be reduced, provided the cap is designed, constructed and maintained to provide long-term isolation of contaminants. Where contamination remains under the cap in the river and contained on site in a controlled disposal facility (Options 8a and 8b), inherent hazard of waste also remains. Partial excavation would provide some risk reduction because sediment in the areas most susceptible to erosion or sediment with highest contamination would be removed and either contained in an engineered facility or treated by incineration.
Adequacy and Reliability of Controls	Reliability of a cap over contaminated sediment would be dependent upon monitoring, maintenance and ICs. In addition, the cap is in a relatively stable depositional area and would provide reliable chemical isolation with the top layer of the cap designed to withstand erosion, although there are some reliability concerns because contamination is still located in the river/ponds. Long-term monitoring, maintenance, including maintenance of the dams, and ICs would be critical to control physical disturbances and protect the integrity of the cap or any type of on-site disposal facility (Options 8a and 8b) for the long-term effectiveness of this alternative.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Options 8a and 8e assume some material will require treatment to meet LDRs. Option 8d includes on-site incineration.
Amount Destroyed or Treated	Under Option 8a, approximately 4,100 cy of dewatered sediment would be treated (10% of the total dewatered volume). Under Option 8d, approximately 64,400 cy of sediment would be excavated, dewatered, and treated. Under Option 8e, approximately 21,000 cy of dewatered sediment would be treated (50% of the total dewatered volume)
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination by incineration under Options 8a (upland CDF), 8d (on-site thermal treatment), and Option 8e (off-site disposal and/or treatment). There would be no reduction of toxicity, mobility, or volume of contamination through treatment under Option 8b, although the mobility of the contaminated sediment particles would be reduced by the isolation cap in both ponds and the disposal facility.
Degree to Which Treatment is Irreversible	For sediments that undergo thermal treatment (Options 8a, 8d, and 8e), the process is irreversible.

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Table 6-7. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 8: PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. For sediments that remain on site under the cap, there would be no residuals. Air emissions of contaminants or additional by-products produced during on- or off-site thermal treatment (Options 8a, 8d and 8e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment particles would be nearly the same as the pre-treatment volume, but concentrations of chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	All of the options would present limited impacts to the community from construction. Access to the work zone during excavation and capping activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 8d would result in air emissions which would be monitored to ensure that they are below regulatory standards.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during construction activities, mitigating risks to workers.
Environmental Impacts	Excavation and capping would result in destruction of the existing benthic habitat in both ponds and the elimination of the fish communities. In addition, aquatic-dependent wildlife populations would be adversely affected until primary and secondary productivity in the ponds had become re-established which could take two to five years. During pond lowering, there is the potential for downstream migration of contaminated sediment. Cap placement could increase non-contaminated suspending solids.
Time Until Remedial Action Objectives are Achieved	RAOs are achieved immediately upon completion of remedy implementation, which is estimated to take approximately two years.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	For all options, the very soft surface sediments would require the use of low-ground pressure equipment and hydraulic excavators. Temporary haul roads would need to be constructed to provide access. For Options 8a, 8d and 8e, an upland land area is required for sediment dewatering and water treatment. Additional land is needed for a disposal facility under Option 8a. Option 8d requires land for an incinerator. These properties may need to be acquired from private parties.

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Table 6-7. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 8: PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Reliability of the Technology	Excavation and capping technologies are field proven technologies. Sand caps have been successfully placed over soft sediment similar to those found at this site. However, habitat restoration activities have historically had variable success rates. CDFs are widely used and CDF construction and thermal treatment are proven technologies although they have greater reliability when located outside of floodplain areas.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. A physical survey would be conducted at the completion of construction activities to confirm that the isolation cap was placed over the entire pond bottom and meets the design thickness. Long-term monitoring would be required to assess cap performance and recovery of biological communities, assess the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. It can be more difficult to monitor in a subaqueous environment. The implementation of a long-term monitoring program and enforcement of ICs are critical to the success of this alternative. Increased monitoring programs would be needed for the on-site containment (Options 8a and 8b) and treatment (Option 8d) options.
Ability to Obtain Approvals and Coordinate with Other Agencies	For those components with wetlands/404 impacts, these actions must be evaluated to determine the least damaging practicable alternative. In addition, capping (all options) and the nearshore CDF (Option 8b) would take place in the waterway and would require the permanent occupancy and modification of the floodplain. Thus, a determination must first be made concluding that there is no other practicable alternative. For Option 8a, some low-value wetlands could be destroyed depending on the location of the CDF and a treatability variance may need to be obtained. Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available Samples of dewatered sediment could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.
Availability of Necessary Equipment and Specialists	Construction equipment and personnel are readily available. Thermal treatment equipment is commercially available.

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Table 6-7. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 8: PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT	
IMPLEMENTABILITY		
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.	
COST[1]		
Capital Cost	Option 8a, On-site Upland CDF	$41,000,000
	Option 8b, On-site Nearshore CDF	$32,000,000
	Option 8d, On-site Thermal Treatment	$63,000,000
	Option 8e, Off-site Disposal and/or Treatment	$62,000,000
Present Worth of Long-term Monitoring and Maintenance	Option 8a, On-site Upland CDF	$4,500,000
	Option 8b, On-site Nearshore CDF	$4,600,000
	Option 8d, On-site Thermal Treatment	$4,100,000
	Option 8e, Off-site Disposal and/or Treatment	$3,900,000
Total Present Worth Cost	Option 8a, On-site Upland CDF	$45,000,000
	Option 8b, On-site Nearshore CDF	$36,000,000
	Option 8d, On-site Thermal Treatment	$67,000,000
	Option 8e, Off-site Disposal and/or Treatment	$66,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-8. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale and Lyman Mill Sediment Alternative 8, Partial Excavation, Isolation Capping and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to be Taken to Attain Requirement
Chemical-Specific ARARs (there are no applicable State Requirements)			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants that exceed AWQC in the Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Used to establish criteria in the absence of other standards..
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.

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Table 6-8. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation, isolation capping, dewatering and nearshore CDF (and potentially upland CDF) subject to these requirements. Activities must be conducted in accordance with these requirements including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Isolation capping and nearshore CDF subject to these requirements. Activities must be conducted in accordance with these requirements
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	An upland CDF containing wetlands can only be selected if there is no practicable alternative to destruction of wetlands.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	Nearshore CDF can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.

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Table 6-8. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Location-Specific ARARs (cont)			
State Requirements (cont)			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Isolation cap and nearshore CDF must be constructed in accordance with these requirements
Action-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation, placement of cap, dewatering, and nearshore CDF must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
RCRA (40 CFR 264, Subpart CC)	Applicable: Upland CDF On-site Incineration Off-site Disposal	Air emission standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics then these requirements will be met.

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Table 6-8. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Action-Specific ARARs (cont)			
Federal Requirements (cont)			
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site thermal treatment must meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF On-site incineration Off-site disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Used to determine appropriate treatment and or disposal.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable: Upland CDF On-site incineration R & A: Nearshore CDF	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal or incineration must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable: Upland CDF R & A: Nearshore CDF	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements related to land disposal must be met for CDFs constructed on site.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site thermal treatment must meet these substantive requirements.

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Table 6-8. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation, placement of cap, dewatering (discharge of dredged return water) and nearshore CDF must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions.	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable Prohibits	emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-9. Detailed Analysis of Allendale and Lyman Mill Sediment Alternative 10, Dam Replacement, Excavation and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 10: DAM REPLACEMENT, EXCAVATION, AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and Environment	The excavation and removal of sediments would provide high overall protection to human health and the environment by quickly reducing human health and ecological risk to acceptable levels. In addition, the removal of resident fish from the ponds would effectively reduce the fish consumption risks to humans and piscivorous wildlife. Removal of the sediment would prevent contaminant migration downstream due to erosion for Options 10a (upland CDF), 10d (on-site thermal treatment) and 10e (off-site disposal and/or treatment). However, contamination would remain in the floodplain for Option 10b (nearshore CDF) which would reduce its overall protection.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 10 are summarized in Table 6-10. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Section 404 requirements are triggered by excavation. In addition, the nearshore CDF (Option 10a) and possibly upland CDF (Option 10b), dam replacement and thin cover (all options) also trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under Option 10b (on-site confinement in a nearshore CDF) a portion of the nearshore CDF would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 10a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 10b) that is within the area of contamination.

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Table 6-9. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 10: DAM REPLACEMENT, EXCAVATION, AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Excavation would remove contaminated sediment from the river to provide a very high level of risk reduction. In order to meet the RAOs, a thin-layer cover may be placed on top of the sediment if post-excavation contaminant concentrations exceed the cleanup goals in some locations. Inherent hazards would be further reduced for Options 10d and 10e because sediment would be incinerated on site or taken off site for disposal or treatment. Inherent hazard would be somewhat higher for Option 10a because the contamination would remain on site, although in a secure upland disposal facility. The inherent hazard would be highest for Option 10b because the contamination would remain in the floodplain, adjacent to the river, although also in a controlled disposal facility.
Adequacy and Reliability of Controls	Excavation would be effective in the long term because the contaminated sediment would be removed and either contained on site, destroyed, or shipped off site for disposal or treatment. This alternative can be reliable as long as long-term monitoring, maintenance and ICs are implemented for any type of on-site disposal facility (Options 10a and 10b). Maintenance, monitoring, and ICs are particularly important for Option 10b because the inherent hazard remains in the floodplain adjacent to the river. Inspections and long-term maintenance of the weir structure would also be required for Alternative 10 for any options where inherent hazard remains in the river or floodplain.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Options 10a and 10e assume some material will require treatment to meet LDRs. Option 10d includes an on-site incineration option.
Amount Destroyed or Treated	Under Option 10a, approximately 9,800 cy of dewatered sediment would be treated (10% of the total dewatered volume). Under Option 10d, approximately 155,800 cy of sediment would be excavated, dewatered, and treated. Under Option 10e, approximately 49,000 cy of dewatered sediment would be treated (50% of the total dewatered volume).
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction in the toxicity, mobility, or volume of contamination from incineration under Options 10a, 10d, and 10e. There would no treatment under Option 10b, although the mobility of the contaminated sediment particles would be reduced by the disposal facility.
Degree to Which Treatment is Irreversible	For sediments that undergo thermal treatment (Options 10a, 10d and 10e), the process is irreversible.

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Table 6-9. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 10: DAM REPLACEMENT, EXCAVATION, AND DISPOSAL AND/OR TREATMENT
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. Air emissions of contaminants or additional by-products produced during on-site or off-site thermal treatment (Options 10a, 10d and 10e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment particles would be nearly the same as the pre-treatment volume, but concentrations of chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative would permanently reduce the size of the waterbodies bordering adjacent property owners along the eastern shore of both ponds. Depending on the specific disposal option selected, open water habitat would be replaced with either floodplain or an engineered containment structure. All of the options would present limited impacts to the community from construction. Access to the work zone during excavation activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 10d would result in air emissions which would be monitored to ensure that they are below regulatory standards.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during construction activities, mitigating risks to workers.
Environmental Impacts	Excavation would result in destruction of the existing benthic habitat in both ponds and the elimination of the fish communities. In addition, aquatic-dependent wildlife populations would be adversely affected until primary and secondary productivity in the ponds becomes re-established which could take two to five years. During pond lowering and dam replacement, there is the potential for downstream migration of contaminated sediment. Replacing the dams with a smaller weir structure would permanently reduce the size of the lacustrine (i.e., lake) habitat, increase the river riparian habitat and convert some aquatic habitat to floodplain habitat. It may be difficult to predict fully the impact of replacement of the dams.
Time Until Remedial Action Objectives are Achieved	RAOs are achieved immediately upon completion of remedy implementation, which is estimated to take approximately two years.

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Table 6-9. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 10: DAM REPLACEMENT, EXCAVATION, AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Replacement of the dams with weir structures involves standard construction equipment and civil engineering considerations. However, public opposition would have to be addressed. For all options, the very soft surface sediments would require the use of low-ground pressure equipment and hydraulic excavators. Temporary haul roads would need to be constructed to provide access. For Options 10a, 10d and 10e, an upland land area is required for sediment dewatering. For Option 10a, additional land is needed for a disposal facility and Option 10d requires land for an incinerator. This property may need to be acquired from private parties. Increased monitoring would be needed for Options 10a, 10b and 10d relative to Option 10e.
Reliability of the Technology	Dam construction, excavation, and CDF construction technologies are field proven. Excavation of soft sediments after lowering over-lying surface water has been successfully implemented at other contaminated sediment sites. CDFs are widely used and CDF construction and thermal treatment are proven technologies. However, a nearshore CDF under Option 10b could present additional reliability concerns given that it would be located partially in the river.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. Confirmation sampling would be performed at the completion of construction activities to determine if the cleanup goals were achieved. A thin-layer cover would be placed over areas where contamination is above the cleanup goals, even after excavation. Long-term monitoring would be required to assess recovery of biological communities, assess the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. Increased monitoring would be needed for the on-site containment options (Options 10a and 10b) and on-site treatment (Option 10d). However, these monitoring programs would not present any unusual issues.

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Table 6-9. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 10: DAM REPLACEMENT, EXCAVATION, AND DISPOSAL AND/OR TREATMENT	
IMPLEMENTABILITY		
Ability to Obtain Approvals and Coordinate with Other Agencies	Potential public opposition to replacing the dams with smaller weir structures would need to be addressed. Local residents that live along the river may express concerns regarding replacing the dams, especially if it would result in a reduction of open water area (Option 10b). For those components with wetlands/404 impacts, these actions must be evaluated to determine the least damaging practicable alternative. For Option 10a, some low-value wetlands could be destroyed depending on the location of the CDF and a treatability variance may need to be obtained. For Option 10b, a portion of the CDF would require the permanent occupancy and modification of the floodplain, and a determination would need to be made concluding that there is no other practicable alternative before selecting this option. Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs.	
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. Samples of the dewatered sediment could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.	
Availability of Necessary Equipment and Specialists	Excavation and CDF construction contractors and equipment are readily available. Thermal treatment equipment is commercially available.	
Availability of Technology	All materials, equipment, personnel, and services required to construct and operate this alternative are readily available.	
COST[1]		
Capital Cost	Option 10a, On-site Upland CDF	$59,000,000
	Option 10b, On-site Nearshore CDF	$47,000,000
	Option 10d, On-site Thermal Treatment	$116,000,000
	Option 10e, Off-site Disposal and/or Treatment	$115,000,000
Present Worth of Long-term Monitoring and Maintenance	Option 10a, On-site Upland CDF	$2,800,000
	Option 10b, On-site Nearshore CDF	$3,000,000
	Option 10d, On-site Thermal Treatment	$2,700,000
	Option 10e, Off-site Disposal and/or Treatment	$2,500,000
Total Present Worth Cost	Option 10a, On-site Upland CDF	$62,000,000
	Option 10b, On-site Nearshore CDF	$50,000,000
	Option 10d, On-site Thermal Treatment	$119,000,000
	Option 10e, Off-site Disposal and/or Treatment	$117,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-10. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale and Lyman Mill Sediment Alternative 10, Dam Replacement, Excavation and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to be Taken to Attain Requirement
Chemical-Specific ARARs (there are no applicable State Requirements)			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants that exceed AWQC in the Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Health Advisories used to establish criteria in the absence of other standards.
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in the Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.

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Table 6-10. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Dam replacement, excavation, thin cover, dewatering, and nearshore CDF (and potentially upland CDF) are subject to these requirements. Activities must be conducted in accordance with these requirements including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Dam replacement, thin cover and nearshore CDF subject to these requirements. Activities must be conducted in accordance with these requirements.
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	This alternative can only be selected if there is no practicable alternative to destruction of wetlands.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	Nearshore CDF can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A: Nearshore CDF	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Nearshore CDF must be constructed in accordance with these requirements.

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Table 6-10. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
***Location-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.
Action-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Dam replacement, excavation, dewatering, thin cover, and nearshore CDF must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
RCRA (40 CFR 264, Subpart CC)	Applicable: Upland CDF On-site Incineration Off-site Disposal	Air emission standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics then these requirements will be met.

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Table 6-10. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Action-Specific ARARs (cont)			
Federal Requirements (cont)			
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site thermal treatment must meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF On-site Incineration Off-site Disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Used to determine appropriate disposal for contaminated sediment.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable: Upland CDF On-site incineration R & A: Nearshore CDF	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal or on-site incineration must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable: Upland CDF R & A: Nearshore CDF	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements related to land disposal must be met for CDFs constructed on site.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site Incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site incineration must be conducted to meet these substantive requirements.

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Table 6-10. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Dam replacement, excavation, thin cover, dewatering (discharge of dredged return water) and nearshore CDF must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-11. Detailed Analysis of Allendale and Lyman Mill Sediment Alternative 11, Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 11: DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection (and Environment)	The partial excavation of sediment from areas that would form the new smaller ponds and areas with high erosion potential would provide some protection by reducing concentrations in areas where erosion is more likely. Capping sediments would isolate the remaining contaminants from the environment and reduce potential contaminant migration. Option 11f would be less protective overall because contamination would be capped in place. In addition, the removal of resident fish from the ponds would effectively reduce the fish consumption risks to humans and piscivorous wildlife.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 11 are summarized in Table 6-12. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Section 404 requirements are triggered by excavation. In addition, dam replacement, the isolation cap, the nearshore CDF (Option 11b), consolidation (Option 11f) and possibly the upland CDF (Option 11) also trigger Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. In addition, isolation capping (all options), the nearshore CDF (Option 11b) and consolidation (Option 11f) would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed under Option 11a. As long as the sediment is not dewatered first, or otherwise treated ex-situ, the sediment does not need to meet the treatment standards in the LDRs prior to disposal in a nearshore CDF (Option 11b) that is within the area of contamination. The same would be true for the on-site consolidation option (Option 11f).

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Table 6-11. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 11: DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Residual risk after the contaminated sediment is partially excavated and a cap is installed will be low, provided the cap is designed, constructed and maintained to provide long-term isolation of contaminants. Sediment would be removed from areas with the highest potential for erosion and the cap would provide chemical isolation. However, the inherent hazard would remain because most of the sediment would remain in the river and newly formed floodplain areas under the cap. Partial excavation would provide some risk reduction because sediment in the areas most susceptible to erosion would be removed and either contained in an engineered facility or treated by incineration.
Adequacy and Reliability of Controls	Reliability of a cap over contaminated sediment would be dependent upon monitoring, maintenance and ICs. In addition, the cap is in a relatively stable depositional area and would provide reliable chemical isolation with the top layer of the cap designed to withstand erosion, although there are some reliability concerns because contamination is still located in the floodplain. Long-term monitoring, maintenance and ICs would be required to protect integrity of the cap, maintain any type of on-site disposal facility, and prevent other activities that could result in a release of contamination that remains in-place. Inspections and long-term maintenance of the weir structure would also be required for Alternative 11.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Options 11a and 11e assume some material will require treatment to meet LDRs. Option 11d includes on-site incineration.
Amount Destroyed or Treated	Under Option 11a, approximately 3,800 cy of dewatered sediment would be treated (10% of the total dewatered volume). Under Option 11d, approximately 59,800 cy of sediment would be excavated, dewatered, and treated. Under Option 11e, approximately 19,000 cy of dewatered sediment would be treated (50% of the total dewatered volume).
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination by incineration under Options 11a, 11d, and 11e. There would be no reduction of toxicity, mobility, or volume of contamination through treatment for Options 11b and 11f; however, the mobility of the contaminated sediment particles would be reduced by the isolation cap (all options) and disposal facility.

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Table 6-11. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 11: DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Degree to Which Treatment is Irreversible	For sediments that undergo thermal treatment (Options 11a, 11d and 11e), the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. For sediments that remain on site under the cap, there would be no residuals. Air emissions of contaminants or additional by-products produced during on-site or off-site thermal treatment (Options 11a, 11d and 11e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment particles would be nearly the same as the pre-treatment volume, but concentrations of chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	This alternative would permanently reduce the size of the waterbodies bordering adjacent property owners along the eastern shore of both ponds. Depending on the specific disposal option selected, open water habitat would be replaced with either floodplain or an engineered containment structure. All of the options would present limited impacts to the community from construction. Access to the work zone during excavation and capping activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 11d would result in air emissions which would be monitored to ensure that they are below regulatory standards.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during construction activities, mitigating risks to workers.
Environmental Impacts	Excavation would result in destruction of the existing benthic habitat in both ponds and the elimination of the fish communities. In addition, aquatic-dependent wildlife populations would be adversely affected until primary and secondary productivity in the ponds has become re-established which could take two to five years. During dam replacement and pond lowering, there is the potential for downstream migration of contaminated sediment. Replacing the dams with a smaller weir structure would permanently reduce the size of the lacustrine (i.e., lake) habitat, increase the river riparian habitat and convert some aquatic habitat to floodplain habitat. It may be difficult to predict fully the impact of replacement of the dams.

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Table 6-11. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 11: DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
SHORT-TERM EFFECTIVENESS	
Time Until Remedial Action Objectives are Achieved	RAOs are achieved immediately upon completion of remedy implementation, which is estimated to take approximately one year for Option 11f (on-site consolidation) and upwards of two years for Options 11a, 11b, 11d, and 11e.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Replacement of the dams with weir structures involves standard construction equipment and civil engineering considerations. However, public opposition would have to be addressed. For all options, the very soft surface sediments would require the use of low-ground pressure equipment and hydraulic excavators. Temporary haul roads would need to be constructed to provide access. For Options 11a, 11d and 11e, an upland land area is required for the sediment dewatering. For Option 11a, additional land is needed for a disposal facility and Option 11d requires land for an incinerator. These properties may need to be acquired from private parties. Increased monitoring would be needed for Options 11a, 11b, 11d, and 11f relative to Option 11e.
Reliability of the Technology	Dam construction, excavation and capping technologies are field proven. Sand caps have been successfully placed over soft sediment similar to those found at this site. However, habitat restoration activities have historically had variable success rates. CDFs are widely used and CDF construction and thermal treatment are proven technologies. However, a nearshore CDF (Option 11b) and on-site consolidation (Option 11f) could present additional reliability concerns given that it would be located partially in the river/floodplain.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.

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Table 6-11. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 11: DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. A physical survey would be conducted at the completion of construction activities to confirm that the isolation cap was placed over the entire pond bottom and meets the design thickness. Long-term monitoring would be required to assess cap performance and recovery of biological communities, monitor the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. It can be more difficult to monitor in a subaqueous environment. The implementation of a long-term monitoring program and enforcement of ICs are critical to the success of this alternative but should not present any unusual issues. Increased monitoring programs would be needed for the on-site containment (Options 11a, 11b and 11f) and treatment (Option 11d) options.
Ability to Obtain Approvals and Coordinate with Other Agencies	Potential public opposition to replacing the dams with smaller weir structures would need to be addressed. Local residents that live along the river may express concerns regarding replacing the dams, especially because this would result in a reduction of open water area. For those components with wetlands/404 impacts, these actions must be evaluated to determine the least damaging practicable alternative. In addition, capping (all options) and the nearshore CDF and consolidation options (Options 11b and 11f) would constitute a permanent occupancy of the floodplain, and thus a determination must first be made concluding that there is no other practicable alternative. For Option 11a, some low-value wetlands could be destroyed depending on the location of the CDF and a treatability variance may need to be obtained. Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. It is assumed that the dewatered sediment could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.
Availability of Necessary Equipment and Specialists	Construction equipment and personnel are readily available. Thermal treatment equipment is commercially available.
Availability of Technology	All materials, equipment, personnel, and services required to construct and operate this alternative are readily available.

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Table 6-11. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE AND LYMAN MILL SEDIMENT- 11: DAM REPLACEMENT, PARTIAL EXCAVATION, ISOLATION CAPPING, AND DISPOSAL AND/OR TREATMENT	
COST[1]		
Capital Cost	Option 11a, On-site Upland CDF	$38,000,000
	Option 11b, On-site Nearshore CDF	$32,000,000
	Option 11d, On-site Thermal Treatment	$60,000,000
	Option 11e, Off-site Disposal and/or Treatment	$59,000,000
	Option 11f, On-site Consolidation	$30,000,000
Present Worth of Long-term Monitoring and Maintenance	Option 11a, On-site Upland CDF	$4,500,000
	Option 11b, On-site Nearshore CDF	$4,600,000
	Option 11d, On-site Thermal Treatment	$4,100,000
	Option 11e, Off-site Disposal and/or Treatment	$3,900,000
	Option 11f, On-site Consolidation	$4,500,000
Total Present Worth Cost	Option 11a, On-site Upland CDF	$42,000,000
	Option 11b, On-site Nearshore CDF	$37,000,000
	Option 11d, On-site Thermal Treatment	$64,000,000
	Option 11e, Off-site Disposal and/or Treatment	$63,000,000
	Option 11f, On-site Consolidation	$35,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-12. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale and Lyman Mill Sediment Alternative 11, Dam Replacement, Partial Excavation, Isolation Capping and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to be Taken to Attain Requirement
Chemical-Specific ARARs (there are no applicable State Requirements)			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants that exceed AWQC in the Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Used to establish criteria in the absence of other standards..
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.

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Table 6-12. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Dam replacement, excavation, isolation capping, dewatering, nearshore CDF (and potentially upland CDF), and consolidation subject to these requirements. Activities must be conducted in accordance with these requirements including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Dam replacement, isolation capping, and nearshore CDF subject to these requirements. Activities must be conducted in accordance with these requirements
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	This alternative can only be selected if there is no practicable alternative to destruction of wetlands.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	This alternative and nearshore CDF can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.

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Table 6-12. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Location-Specific ARARs (cont)			
State Requirements (cont)			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Isolation cap and nearshore CDF must be constructed in accordance with these requirements.
Action-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Dam replacement, excavation, placement of cap, nearshore CDF, and consolidation must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
RCRA (40 CFR 264, Subpart CC)	Applicable: Upland CDF On-site Incineration Off-site Disposal	Air emission standards for tanks, surface impoundments, and containers used to manage hazardous waste. Emission controls required if tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics.	If tanks, surface impoundments, and containers used to manage hazardous waste have greater than 500 ppmw of volatile organics then these requirements will be met.

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Table 6-12. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Action-Specific ARARs (cont)			
Federal Requirements (cont)			
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site thermal treatment must meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF On-site incineration Off-site disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Used to determine appropriate treatment and or disposal
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable: Upland CDF On-site incineration R & A: Nearshore CDF Consolidation Isolation Capping	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal, incineration, or closure must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable: Upland CDF R & A: Nearshore CDF Consolidation Isolation Capping	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements related to land disposal, incineration, or closure must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site thermal treatment must meet these substantive requirements.

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Table 6-12. (continued)

Requirement Status		Synopsis	Action to be Taken to Attain Requirement
Action-Specific ARARs **(cont)**			
State Requirements (cont)			
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Dam replacement, excavation, placement of cap, dewatering (discharge of dredged return water), nearshore CDF, and consolidation must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-13. Key Features of the Allendale and Lyman Mill Reach Sediment Alternatives

Alternative		Present Worth Cost	Remediation Area (acres)	Excavation Volume (cy)	Difference in Habitat (acres)	Residual Risk[1]			Estimated Time to RAOs
						RME Cancer[2]	HI Immune[2,3]	HI Ecological[4]	
1 - No Action		$450K	—	—	—	5.E-03 (Allendale) 6.E-03 (Lyman Mill)	30 (Allendale) 30 (Lyman Mill)	20-70 (Allendale) 10-100 (Lyman Mill)	Unknown
7 - Excavation and Disposal and/or Treatment	Option 7a	$61M	Excavate: 39 Total: 39	155,800	—	5.E-05 (Allendale) 6.E-05 (Lyman Mill)	0.8 (Allendale) 0.8 (Lyman Mill)	0.04-30 (Allendale) 0.5-60 (Lyman Mill)	2 years
	Option 7b	$47M	Excavate: 28 CDF: 11 Total: 39	123,500	-11 AQ; +11UP				
	Option 7d	$118M	Excavate: 39 Total: 39	155,800	—				
	Option 7e	$116M			—				
8 - Partial Excavation, Isolation Capping and Disposal and/or Treatment	Option 8a	$45M	Excavate: 26 Isolation Cap: 39 Total: 39	64,400	—				2 years
	Option 8b	$36M	Excavate: 23 Isolation Cap: 34 CDF: 5 Total: 39	56,500	-5 AQ; +5 UP				
	Option 8d	$67M	Excavate: 26 Isolation Cap: 39 Total: 39	64,400	—				
	Option 8e	$66M			—				

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Table 6-13. (continued)

Alternative		Present Worth Cost	Remediation Area (acres)	Excavation Volume (cy)	Difference in Habitat (acres)	Residual Risk[1]			Estimated Time to RAOs
						RME Cancer[2]	HI Immune[2,3]	HI Ecological[4]	
10 - Dam Replacement, Excavation and Disposal and/or Treatment	Option 10a	$62M	Excavate: 39 Total: 39	155,800	-5 AQ; +5 FP/ WET	5.E-05 (Allendale) 6.E-05 (Lyman Mill)	0.8 (Allendale) 0.8 (Lyman Mill)	0.04-30 (Allendale) 0.5-60 (Lyman Mill)	2 years
	Option 10b	$50M	Excavate: 26 CDF: 13 Total: 39	111,800	-18 AQ; +5 FP/ WET, +13 UP				
	Option 10d	$119M	Excavate: 39 Total: 39	155,800	-5 AQ; +5 FP/ WET				
	Option 10e	$117M							
11 - Dam Replacement, Partial Excavation, Isolation Capping and Disposal and /or Treatment	Option 11a	$42M	Excavate:16 Isolation Cap: 23 Total: 39	59,800	-23 AQ; +23 FP/ WET				1 year (Option 11f) 2 years (all other options)
	Option 11b	$37M	Excavate:16 Isolation Cap/ CDF: 23 Total: 39		-23 AQ; + 11 FP/ WET, +12 UP				
	Option 11d	$64M	Excavate:16 Isolation Cap:23 Total: 39		-23 AQ; +23 FP/ WET				
	Option 11e	$63M							
	Option 11f	$35M	Excavate: 16 Isolation Cap: 23 Total: 39		-23 AQ; + 11 FP/ WET, +12 UP				

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives; residual risks for No Action are based on current conditions.
[2]Based on receptor at highest risk, i.e., Resident Living Along the River; summary of information in Tables 6-14 and 6-15 and in Appendix K.
[3] Residual risk for action-based alternatives calculated using estimated regional background values derived by excluding elevated upriver background results collected between the Smithfield Wastewater Treatment Plant and Route 44.
[4]Summary of information presented in Tables 6-14 and 6-15.

Key
AQ – Aquatic; FP/WET – Floodplain/Wetland; UP – Upland; CDF – Confined Disposal Facility; Option a – On-site Containment in Upland CDF; Option b – On-site Containment in Nearshore CDF; Option d – On-site Thermal Treatment; Option e – Off-site Disposal and/or Treatment; Option f – On-site Consolidation

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Table 6-14a. Summary of Residual Risks[1] for Human Health, Allendale Reach Sediment Alternative 1-No Action[2]

Sediment Contact and Sediment Associated Fish Consumption for a Resident Living Along the River

Carcinogenic Contaminant	Cancer Classification	Basis	No Action RME Risk	
Benzo(a)pyrene	B2	Risk	1.E-05	A
Dibenz(a,h)anthracene B	2	Risk	5.E-06	A
Dieldrin B2		Risk	1.E-05	B
Technical Chlordane	B2	Risk	2.E-05	B
Aroclor 1254	B2	Risk	3.E-04	B
Aroclor 1268	B2	Risk	5.E-06	B
Arsenic A		Risk	2.E-06	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin B	2	Risk	4.E-03	C
Coplanar PCBs (TEQ)	B2	Risk	4.E-04	C
	Sum of Carcinogenic Risk		**5.E-03**	
Non-Carcinogenic Contaminant	**Target Endpoint**	**Basis**	**No Action RME Hazard Index**	
Benzo(a)pyrene	Kidney	Risk	0.0003	A
Dibenz(a,h)anthracene K	idney	Risk	0.0002	A
Dieldrin Li	ver	Risk	0.05	B
Technical Chlordane	Liver	Risk	0.3	B
Aroclor 1254	Immune system	Risk	28	B
Aroclor 1268	Immune system	Risk	0.4	B
Arsenic Ski	n	Risk	0.04	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin --		Risk	--	D
Coplanar PCBs (TEQ)	--	Risk	--	D
		HI Kidney	**0.0005**	
		HI Liver	**0.4**	
		HI Immune System	**30**	
		HI Skin	**0.04**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks.

Key:
A - No action cancer risk and/or hazard index for direct contact.
B - No action cancer risk and/or hazard index for fish consumption.
C - No action cancer risk and/or hazard index for fish consumption and direct contact.
D - RME no action Hazard Index not calculated for this compound due to lack of noncarcinogenic toxicity data.
HI - Hazard Index
RME - Reasonable Maximum Exposure
PCB - polychlorinated biphenyl
TEQ - toxic equivalent

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Table 6-14b. Summary of Residual Risks[1] for Human Health, Allendale Reach Sediment Action-Based Alternatives (Alternatives 7, 8, 10, and 11)

Sediment and Sediment Associated Fish Consumption for a Resident Living Along the River

Carcinogenic Contaminant	Cancer Classification	Sediment Cleanup Goal (mg/Kg)	Basis	RME Residual Cancer Risk	
Benzo(a)pyrene	B2	1.4	Background	4.E-06	A
Dibenz(a,h)anthracene B	2	0.97	Background	2.E-06	A
Dieldrin B2		0.0026	Background	2.E-06	B
Technical Chlordane	B2	0.4	Background	8.E-06	B
Aroclor 1254	B2	0.031	Background[2] 8	.E-06	B
Aroclor 1268	B2	0.023	Background[2] 2	.E-06	B
Arsenic	A	3.9	Background	1.E-06	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin B	2	0.000015	Background	3.E-05	C
Coplanar PCBs (TEQ)	B2	0.000025	Background	--	D
			Sum of Carcinogenic Risk	**5.E-05**	
Non-Carcinogenic Contaminant	**Target Endpoint**	**Sediment Cleanup Goal (mg/Kg)**	**Basis**	**RME Residual Hazard Index**	
Benzo(a)pyrene	Kidney	1.4	Background	0.0001	A
Dibenz(a,h)anthracene Ki	dney	0.97	Background	0.00008	A
Dieldrin Liv	er	0.0026	Background	0.007	B
Technical Chlordane	Liver	0.4	Background	0.1	B
Aroclor 1254	Immune system	0.031	Background[2] 0.	7	B
Aroclor 1268	Immune system	0.023	Background[2] 0.	1	B
Arsenic	Skin	3.9	Background	0.03	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin --		0.000015	Background	--	E
Coplanar PCBs (TEQ)	--	0.000025	Background	--	E
			HI Kidney	**0.00008**	
			HI Liver	**0.2**	
			HI Immune System	**0.8**	
			HI Skin	**0.03**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Estimated regional background values derived by excluding elevated upriver background results collected between the Smithfield Wastewater Treatment Plant and Route 44.

Key:
A - Residual cancer risk and/or hazard index for direct contact.
B - Residual cancer risk and/or hazard index for fish consumption.
C - Residual cancer risk and/or hazard index for fish consumption and direct contact.
D – Residual cancer risk and/or hazard index not calculated for Coplanar PCBs due to highly uncertain BSAFs. Use of this Cleanup Goal with the existing BSAFs would be inconsistent with the previously calculated risk at Greystone Mill Pond (the background area).
E – RME Residual Hazard Index not calculated for this compound due to lack of noncarcinogenic toxicity data.
HI - Hazard Index
RME - Reasonable Maximum Exposure
mg/kg - milligrams/kilogram
PCB - polychlorinated biphenyl
TEQ - toxic equivalent

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Table 6-14c. Summary of Residual Risks[1] for Ecological Health, Allendale Reach Sediment Alternative 1-No Action[2]

Sediment Contact and Sediment Associated Prey Consumption by Ecological Receptors

Contaminant[a]	Current Conditions[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]					
			Demersal Fish[d]		Pelagic Fish[d]	Piscivorous Wildlife[e]		Insectivorous Wildlife[f]	
2.3.7.8-TCDD	0.0058	Risk	15	A	N/A	19	C	15	D
Aroclor 1254	1.5	Risk	6.8	A	N/A	4.7	C	-	
Total Aroclors	1.53	Risk	-		N/A	14	C	-	
Technical Chlordane	0.515	Risk	34	A	N/A	-		-	
Selenium	1.1	Risk	2.6	A	N/A	-		-	
Zinc	354	Risk	7.3	A	N/A	-		-	
		HI	**70**		**-**	**40**		**20**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks.

a. Comprehensive list of all sediment contaminants identified for ecological receptors; see Table 1-1 in the Interim Final PRG (Part II) report (MACTEC, 2005).

b. Sediment Exposure Point Concentrations (EPCs) obtained from Table 27 in the BERA (MACTEC, 2004).

c. Calculated by dividing the remediation goal by the PRG for the most sensitive measurement endpoint for each receptor category.

d. Sediment concentrations protective of demersal and pelagic fish were derived using: (A) literature-derived CBR and (B) site-specific ELS thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The white sucker and large-mouth bass are representative receptor species for these two assessment endpoints, respectively.

e. Sediment concentrations protective of piscivorous wildlife were derived using: (C) dietary exposure modeling. The belted kingfisher is the representative receptor species for this assessment endpoint.

f. Sediment concentrations protective of insectivorous wildlife were derived using: (D) literature-derived CBR and (E) site-specific percent hatchability thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The tree swallow is the representative receptor species for this assessment endpoint.

Key:
HI - Hazard Index
mg/Kg - milligrams/kilogram
PCB - polychlorinated biphenyl
TEQ - Toxic Equivalent
N/A - not applicable

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**Table 6-14d. Summary of Residual Risks[1] for Ecological Health,
Allendale Reach Action-Based Sediment Alternatives (Alternatives 7, 8, 10, and 11)**

Sediment Contact and Sediment Associated Prey Consumption by Ecological Receptors

Contaminant[a]	Sediment Cleanup Goal[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]			
			Demersal Fish[d]	Pelagic Fish[d]	Piscivorous Wildlife[e]	Insectivorous Wildlife[f]
2,3,7,8-TCDD	0.0000147	Background	0.038 A	N/A	0.049 C	0.039 D
Aroclor 1254	0.031	Background[g]	0.14 A	N/A	0.10 C	-
Total Aroclors	0.060	Background[g]	-	N/A	0.55 C	-
Technical Chlordane	0.4	Background	27 A	N/A	-	-
Selenium	1.1	Background	2.6 A	N/A	-	-
Zinc	221	Background	4.5 A	N/A	-	-
		HI	**30**		**0.7**	**0.04**

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.

a. Comprehensive list of all sediment contaminants identified for ecological receptors; see Table 1-1 in the Interim Final PRG (Part II) report (MACTEC, 2005).

b. Sediment remediation goals are summarized in Table 3-3 of the FS report.

c. Calculated by dividing the remediation goal by the PRG for the most sensitive measurement endpoint for each receptor category.

d. Sediment concentrations protective of demersal and pelagic fish were derived using: (A) literature-derived CBR and (B) site-specific ELS thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The white sucker and large-mouth bass are representative receptor species for these two assessment endpoints, respectively.

e. Sediment concentrations protective of piscivorous wildlife were derived using: (C) dietary exposure modeling. The belted kingfisher is the representative receptor species for this assessment endpoint.

f. Sediment concentrations protective of insectivorous wildlife were derived using: (D) literature-derived CBR and (E) site-specific percent hatchability thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The tree swallow is the representative receptor species for this assessment endpoint.

g. Estimated regional background values derived by excluding elevated upriver background results collected between the Smithfield Wastewater Treatment Plant and Route 44.

Key:
HI - Hazard Index
mg/Kg - milligrams/kilogram
PCB - polychlorinated biphenyl
TEQ - Toxic Equivalent
N/A - not applicable

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Table 6-15a. Summary of Residual Risks[1] for Human Health, Lyman Mill Reach Sediment Alternative 1-No Action[2]

Sediment and Sediment Associated Fish Consumption for a Resident Living Along the River

Carcinogenic Contaminants[3]	Cancer Classification	Basis	No Action RME Risk	
Benzo(a)pyrene	B2	Risk	1.E-05	C
Dibenz(a,h)anthracene B	2	Risk	3.E-06	A
N-nitroso-di-n-propylamine	B2	Risk	3.E-06	A
Dieldrin B2		Risk	8.E-06	B
Technical Chlordane	B2	Risk	3.E-05	B
Aroclor 1254	B2	Risk	4.E-04	B
Aroclor 1268	B2	Risk	4.E-06	B
Arsenic A		Risk	2.E-06	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin B	2	Risk	5.E-03	C
Coplanar PCBs (TEQ)	B2	Risk	6.E-04	C
		Sum of Carcinogenic Risk	**6.E-03**	
Non-Carcinogenic Contaminants	**Target Endpoint**	**Basis**	**No Action RME Hazard Index**	
Benzo(a)pyrene	Kidney	Risk	0.0004	C
Dibenz(a,h)anthracene Ki	dney	Risk	0.00009	A
N-Nitroso-di-n-propylamine	--	Risk	--	E
Dieldrin Li	ver	Risk	0.03	B
Technical Chlordane	Liver	Risk	0.6	B
Aroclor 1254	Immune system	Risk	32	B
Aroclor 1268	Immune system	Risk	0.3	B
Arsenic Ski	n	Risk	0.04	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin --		Risk	--	D
Coplanar PCBs (TEQ)	--	Risk	--	D
		HI Kidney	**0.0004**	
		HI Liver	**0.6**	
		HI Immune System	**30**	
		HI Skin	**0.04**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks
[3]Comprehensive list of all sediment contaminants identified for human receptors; see Table 1-3 in the Interim Final PRG (Part I) report (MACTEC, 2005).

Key:
A - No action cancer risk and/or hazard index for direct contact.
B - No action cancer risk and/or hazard index for fish consumption.
C -No action cancer risk and/or hazard index for fish consumption and direct contact.
D - RME no action Hazard Index not calculated for this compound due to lack of noncarcinogenic toxicity data.
HI - Hazard Index
RME - Reasonable Maximum Exposure
PCB - polychlorinated biphenyl
TEQ - toxic equivalent

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**Table 6-15b. Summary of Residual Risks[1] for Human Health,
Lyman Mill Reach Sediment Action-Based Alternatives (Alternatives 7, 8, 10, and 11)
Sediment and Sediment Associated Fish Consumption
for a Resident Living Along the River**

Carcinogenic Contaminant[3]	Cancer Classification	Sediment Cleanup Goal (mg/Kg)	Basis	RME Residual Cancer Risk	
Benzo(a)pyrene	B2	1.4	Background	4.E-06	C
Dibenz(a,h)anthracene B	2	0.97	Background	2.E-06	A
N-Nitroso-di-n-propylamine	B2	0.46	Risk	1.E-06	A
Dieldrin B2		0.0026	Background	2.E-06	B
Technical Chlordane	B2	0.40	Background	8.E-06	B
Aroclor 1254	B2	0.031	Background[2] 8	.E-06	B
Aroclor 1268	B2	0.023	Background[2] 2	.E-06	B
Arsenic	A	3.9	Background	1.E-06	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin B	2	0.000015	Background	3.E-05	C
Coplanar PCBs (TEQ)	B2	0.000025	Background	--	D
			Sum of Carcinogenic Risk	**6.E-05**	
Non-Carcinogenic Contaminant	**Target Endpoint**	**Sediment Cleanup Goal (mg/Kg)**	**Basis**	**RME Residual Hazard Index**	
Benzo(a)pyrene	Kidney	1.4	Background	0.0001	C
Dibenz(a,h)anthracene Ki	dney	0.97	Background	0.00008	A
N-Nitroso-di-n-propylamine	--	0.46	Risk	--	E
Dieldrin Liv	er	0.0026	Background	0.007	B
Technical Chlordane	Liver	0.40	Background	0.1	B
Aroclor 1254	Immune system	0.031	Background[2] 0.	7	B
Aroclor 1268	Immune system	0.023	Background[2] 0.	1	B
Arsenic	Skin	3.9	Background	0.03	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin --		0.000015	Background	--	E
Coplanar PCBs (TEQ)	--	0.000025	Background	--	E
			HI Kidney	**0.0002**	
			HI Liver	**0.2**	
			HI Immune System	**0.8**	
			HI Skin	**0.03**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Estimated regional background values derived by excluding elevated upriver background results collected between the Smithfield Wastewater Treatment Plant and Route 44.
[3]Comprehensive list of all sediment contaminants identified for human receptors; see Table 1-3 in the Interim Final PRG (Part I) report (MACTEC, 2005).

Key:
A - Residual cancer risk and/or hazard index for direct contact.
B - Residual cancer risk and/or hazard index for fish consumption.
C - Residual cancer risk and/or hazard index for fish consumption and direct contact.
D - Residual cancer risk and/or hazard index not calculated for Coplanar PCBs due to highly uncertain BSAFs. Use of this Remedial Goal with the existing BSAFs would be inconsistent with the previously calculated risk at Greystone Mill Pond (the background area).
E - RME Residual Hazard Index not calculated for this compound due to lack of noncarcinogenic toxicity data.
HI - Hazard Index
RME - Reasonable Maximum Exposure
mg/kg - milligrams/kilogram
PCB - polychlorinated biphenyl
TEQ - toxic equivalent

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Table 6-15c. Summary of Residual Risks[1] for Ecological Health, Lyman Mill Reach Sediment Alternative 1-No Action[2]

Sediment Contact and Sediment Associated Prey Consumption by Ecological Receptors

Contaminant[a]	Current Conditions[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]							
			Demersal Fish[d]		Pelagic Fish[d]		Piscivorous Wildlife[e]		Insectivorous Wildlife[f]	
2,3,7,8-TCDD	0.0018	Risk	3.5	A	1.5	A	5.1	C	8.2	D
Coplanar PCBs (TEQ)	0.00015	Risk	0.29	B	-		1.3	C	2.8	D
Aroclor 1254	0.27	Risk	0.96	A	-		0.66	C	-	
Total Aroclors	0.2629	Risk	-		-		1.9	C	-	
Technical Chlordane	1.3	Risk	91	A	43	A	0.37	C	-	
4.4'-DDE	0.0083	Risk	0.59	A	-		2.4	C	-	
4,4'-DDD	0.0093	Risk	0.44	A	-		1.1	C	-	
Aluminum	10181	Risk	9.4	A	11	A	-		-	
Barium	130	Risk	9.0	A	16	A	-		-	
Selenium	0.96	Risk	2.0	A	-		-		-	
Vanadium[g]	27.2	Risk	0.9	A	1.2	A	-		-	
Zinc	391	Risk	11	A	11	A	-		-	
		HI	**100**		**80**		**10**		**10**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks.
a. Comprehensive list of all sediment contaminants identified for ecological receptors; see Table 1-1 in the Interim Final PRG (Part II) report (MACTEC, 2005).
b. Sediment Exposure Point Concentrations (EPCs) obtained from Table 27 in the BERA (MACTEC, 2004) except where noted.
c. Calculated by dividing the remediation goal by the PRG for the most sensitive measurement endpoint for each receptor category.
d. Sediment concentrations protective of demersal and pelagic fish were derived using: (A) literature-derived CBR and (B) site-specific ELS thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The white sucker and large-mouth bass are representative receptor species for these two assessment endpoints, respectively.
e. Sediment concentrations protective of piscivorous wildlife were derived using: (C) dietary exposure modeling. The belted kingfisher is the representative receptor species for this assessment endpoint.
f. Sediment concentrations protective of insectivorous wildlife were derived using: (D) literature-derived CBR and (E) site-specific percent hatchability thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The tree swallow is the representative receptor species for this assessment endpoint.
g. Analytical data for vanadium not available in BERA data set; reported value obtained from RI sample data (Appendix B, Table B-3).

Key:
HI - Hazard Index; mg/Kg - milligrams/kilogram; PCB - polychlorinated biphenyl; TEQ - Toxic Equivalent; N/A - not applicable

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**Table 6-15d. Summary of Residual Risks[1] for Ecological Health,
Lyman Mill Reach Action-Based Sediment Alternatives (Alternatives 7, 8, 10, and 11)**

Sediment Contact and Sediment Associated Prey Consumption by Ecological Receptors

Contaminant[a]	Sediment Cleanup Goal[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]							
			Demersal Fish[d]		Pelagic Fish[d]		Piscivorous Wildlife[e]		Insectivorous Wildlife[f]	
2,3,7,8-TCDD	0.0000147	Background	0.028	A	0.012	A	0.042	C	0.067	D
Coplanar PCBs (TEQ)	0.0000249	Background	0.049	B	-		0.21	C	0.46	D
Aroclor 1254	0.031	Background[g]	0.11	A	-		0.076	C	-	
Total Aroclors	0.060	Background[g]	-		-		0.43	C	-	
Technical Chlordane	0.4	Background	29	A	13	A	0.11	C	-	
4.4'-DDE	0.006	Background	0.43	A	-		1.8	C	-	
4,4'-DDD	0.0084	Kingfisher diet	0.40	A	-		1.0	C	-	
Aluminum	8210	Background	7.6	A	8.4	A	-		-	
Barium	134	Background	9.3	A	16	A	-		-	
Selenium	1.1	Background	2.3	A	-		-		-	
Vanadium	37.6	Background	1.3	A	1.7	A	-		-	
Zinc	221	Background	6.1	A	6.1	A	-		-	
		HI	**60**		**50**		**4**		**0.5**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
a. Comprehensive list of all sediment contaminants identified for ecological receptors; see Table 1-1 in the Interim Final PRG (Part II) report (MACTEC, 2005).
b. Sediment remediation goals are summarized in Table 3-3.
c. Calculated by dividing the remediation goal by the PRG for the most sensitive measurement endpoint for each receptor category.
d. Sediment concentrations protective of demersal and pelagic fish were derived using: (A) literature-derived CBR and (B) site-specific ELS thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The white sucker and large-mouth bass are representative receptor species for these two assessment endpoints, respectively.
e. Sediment concentrations protective of piscivorous wildlife were derived using: (C) dietary exposure modeling. The belted kingfisher is the representative receptor species for this assessment endpoint.
f. Sediment concentrations protective of insectivorous wildlife were derived using: (D) literature-derived CBR and (E) site-specific percent hatchability thresholds; the basis (*i.e.*, most protective of available PRGs) for the residual hazard calculation indicated. The tree swallow is the representative receptor species for this assessment endpoint.
g. Estimated regional background values derived by excluding elevated upriver background results collected between the Smithfield Wastewater Treatment Plant and Route 44.

Key:
HI - Hazard Index; mg/Kg - milligrams/kilogram; PCB - polychlorinated biphenyl; TEQ - Toxic Equivalent; N/A - not applicable

Table 6-16. Detailed Analysis of Allendale Reach Floodplain Soil Alternative 1, No Action

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE REACH FLOODPLAIN SOIL-1: NO ACTION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	Direct contact with contaminated floodplain soil does not present an actionable risk to human health. However, under this alternative, the contaminated floodplain soil would remain in place and could be transported downstream, especially during flooding or high flow events. Contaminated soil would remain on site unaddressed and continue to pose an exposure hazard to ecological receptors. The existing controls (perimeter fence at Allendale Pond) would not effectively limit exposure to human and ecological receptors.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	See Table 6-17. This alternative will not comply with ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b).
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	The residual risk is high because no actions are taken to address the contaminated floodplain soil or reduce the risk of erosion and migration downstream.
Adequacy and Reliability of Controls	There would be no controls in place to adequately and/or reliably prevent exposure in the long term.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	None proposed for this alternative.
Amount Destroyed or Treated	None anticipated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	No reductions in toxicity, mobility, or volume of contamination are anticipated for this alternative.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	There would be no residuals because treatment is not planned for this alternative.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Protection of Workers During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Environmental Impacts	Not applicable, as no remedial actions are proposed for this alternative

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Table 6-16. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE REACH FLOODPLAIN SOIL-1: NO ACTION
SHORT-TERM EFFECTIVENESS	
Time Until Remedial Action Objectives are Achieved	While some reduction in risk is possible due to natural deposition, it is unknown if or when cleanup objectives would be achieved. (Based on estimated rates, it could take 50 – 100 years for a one foot thick layer of new sediment to be deposited on top of existing soil.)
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Reliability of the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative does not preclude future remedial activities.
Ability to Monitor the Effectiveness of Remedy	Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. Periodic monitoring would include routine testing and could be easily implemented.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable, as no activities requiring approval are planned for this alternative.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Not applicable for this alternative.
Availability of Technology	Not applicable for this alternative.
COST[1]	
Capital Cost	$0
Present Worth of Long-term Monitoring and Maintenance	$0 (costs for periodic monitoring and five-year reviews are covered under the sediment No Action alternative, Table 6-1)
Total Present Worth Cost	$0

Notes:
[1]Detailed costs estimates provided in Appendix J.

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Table 6-17. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale Reach Floodplain Soil Alternative 1, No Action[1]

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Some residential use soils at the site contains dioxin at levels above the PRG and will not be addressed by this alternative.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contributions of contaminants from floodplain soil that exceed AWQC in the Woonasquatucket River will not be minimized to the maximum extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Alternative would not prevent exposure to contaminants considered under this guidance.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Alternative would not prevent exposure to contaminants considered under this guidance.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	Alternative would not prevent exposure to contaminants considered under this guidance.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Alternative would not prevent exposure to contaminants considered under this guidance.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Alternative would not prevent exposure to contaminants considered under this guidance.

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Table 6-17. (continued)

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs (cont)			
Federal Requirements (cont)			
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Alternative would not prevent exposure to contaminants potentially considered under these advisories.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives).	Some residential use soils at the site contain contaminants subject to the Rule 8.02B soil objectives and would not be addressed by this alternative.

Notes:
[1] With no action, there are no location- or action-specific ARARs.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-18. Detailed Analysis of Allendale Reach Floodplain Soil Alternative 5, Excavation and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE REACH FLOODPLAIN SOIL-5: EXCAVATION AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	The removal of the top one foot (or deeper within the vadose zone to meet ARARs) of floodplain soil and backfill with clean material would achieve high overall protection because all of the soil with contaminant concentrations above cleanup goals would be removed.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 5 are summarized in Table 6-19. Placement of backfill in wetland areas, the nearshore CDF (Option 5b), and possibly the upland CDF (Option 5a) trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under Option 5b, a portion of the nearshore CDF would require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. Under Options 5a and 5e, some of the floodplain soil could require treatment if it exceeds the alternative treatment standards for contaminated soil set forth in the LDRs (40 CFR § 268.49); however this is unlikely based on the existing data. Floodplain soil excavated and contained in a nearshore CDF (Option 5b) would not need to meet the treatment standards set forth in the LDRs because it would be consolidated in an area of contamination and would not require any dewatering or other ex-situ activities. Alternative 5 will comply with ARARs for residential direct exposure and EPA's recommended residential level for dioxin (EPA, 1998b), as well as Subtitle C closure requirements under RCRA.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Excavation would be effective in the long term because the contaminated soil would be removed and either contained on site, destroyed, or shipped off site for disposal and/or treatment thereby greatly reducing the residual risk.
Adequacy and Reliability of Controls	Because this alternative relies on excavation to remove contaminated soil, there is little reliance on controls. However, long-term monitoring, maintenance and ICs would be required to maintain any type of on-site disposal facility (Options 5a and 5b).

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Table 6-18. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE REACH FLOODPLAIN SOIL-5: EXCAVATION AND DISPOSAL AND/OR TREATMENT
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Option 5d includes on-site incineration.
Amount Destroyed or Treated	Under Option 5d, approximately 2,400 cy of soil would be excavated and treated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination through incineration under Option 5d. There would be no reduction of toxicity, mobility, or volume of contamination through treatment for the containment options (Options 5a and 5e [assuming concentrations are below the alternative treatment standards for soil] and 5b), although the mobility of the contaminated soil particles would be reduced by the disposal facility.
Degree to Which Treatment is Irreversible	For soils that undergo thermal treatment (Option 5d), the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. Air emissions of contaminants or additional by-products produced during on-site thermal treatment (Option 5d) would be at levels below regulatory standards. After incineration, the volume of inorganic soil particles would be nearly the same as the pre-treatment volume, but concentrations of organic chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	All of the options would present limited impacts to the community from construction. Access to the work zone during construction activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 5d would result in air emissions which would be monitored to ensure that they were below regulatory standards.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during site activities, mitigating risks to workers.

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Table 6-18. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE REACH FLOODPLAIN SOIL-5: EXCAVATION AND DISPOSAL AND/OR TREATMENT
SHORT-TERM EFFECTIVENESS	
Environmental Impacts	Excavation would result in the temporary destruction of the existing habitat, the elimination of floodplain soil infauna and riparian vegetation, and collateral impacts to wildlife that rely on this habitat for shelter and food. At least several years would be required for the remediated areas to recover sufficiently to provide the environmental services that this habitat typically provides. Habitat enhancement during construction will help facilitate ecological recovery.
Time Until Remedial Action Objectives are Achieved	RAOs are achieved immediately upon completion of remedy implementation, which is estimated to take approximately one month.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	For all options, the soft soils would require the use of low-ground pressure equipment and hydraulic excavators. Temporary work areas would need to be set up and the areas cleared of vegetation. Temporary haul roads would need to be constructed to provide access. Upland land is required for the temporary work areas and soil processing areas (all options except Option 5b). Additional land is needed for a disposal facility (Option 5a) and Option 5d requires land for an incinerator. This property may need to be acquired from private parties. Increased monitoring would be needed for Options 5a, 5b, and 5d relative to Option 5e.
Reliability of the Technology	Excavation, CDF construction and thermal treatment technologies have been successfully implemented at other contaminated soil sites, although the nearshore CDF (Option 5b) could present additional reliability concerns because it is located in the floodplain/river. Habitat restoration activities have historically had variable success rates.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. Confirmation sampling would be performed at the completion of construction activities to determine if the cleanup goals were achieved. Long-term monitoring would be required to assess the rate of recovery and degree of functioning of riparian vegetation (including the tree, shrub, and herbaceous cover strata), assess the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. Additional monitoring would be needed for the nearshore CDF (Option 5b) and on-site treatment (Option 5d) options.

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Table 6-18. (continued)

EVALUATION CRITERIA	ALTERNATIVE ALLENDALE REACH FLOODPLAIN SOIL-5: EXCAVATION AND DISPOSAL AND/OR TREATMENT	
IMPLEMENTABILITY		
Ability to Monitor the Effectiveness of Remedy (cont)	However, these monitoring programs would not present any unusual issues.	
Ability to Obtain Approvals and Coordinate with Other Agencies	Because this alternative constitutes the placement of fill in waters of the US, a determination must first be made that this is the least damaging practicable alternative to the aquatic environment. In addition, this alternative would require the permanent occupancy and modification of the floodplain, and a determination would first need to be made concluding that there is no other practicable alternative before selecting this option as the preferred remedy. For Option 5a, some low-value wetlands could be destroyed depending on the location of the CDF. Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs. Access from property owners may be required.	
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. Samples of the excavated soil could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.	
Availability of Necessary Equipment and Specialists	Excavation and CDF construction contractors and equipment are readily available. Thermal treatment equipment is commercially available.	
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.	
COST[1]		
Capital Cost	Option 5a, On-site Upland CDF	$1,300,000
	Option 5b, On-site Nearshore CDF	$1,300,000
	Option 5d, On-site Thermal Treatment	$4,200,000
	Option 5e, Off-site Disposal and/or Treatment	$3,100,000
Present Worth of Long-term Monitoring and Maintenance	Option 5a, On-site Upland CDF	$100,000
	Option 5b, On-site Nearshore CDF	$100,000
	Option 5d, On-site Thermal Treatment	$100,000
	Option 5e, Off-site Disposal and/or Treatment	$100,000
Total Present Worth Cost	Option 5a, On-site Upland CDF	$1,400,000
	Option 5b, On-site Nearshore CDF	$1,400,000
	Option 5d, On-site Thermal Treatment	$4,300,000
	Option 5e, Off-site Disposal and/or Treatment	$3,200,000

Notes:
[1]Detailed costs estimates provided in Appendix J.

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Table 6-19. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Allendale Reach Floodplain Soil Alternative 5, Excavation and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Soil at the site that contains dioxin at levels above that recommended in this guidance would be addressed under this alternative.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants from floodplain soil that contribute to exceedances of AWQC in Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.

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Table 6-19. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs (cont)			
Federal Requirements (cont)			
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Used to establish criteria in the absence of other standards..
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives).	Some residential use soils at the site contain contaminants subject to the Rule 8.02B soil objectives and would be addressed under this alternative consistent with state requirements.
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in the Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation, placement of backfill, and nearshore CDF (and potentially upland CDF) subject to these requirements. Activities must be conducted in accordance with these requirements, including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Nearshore CDF subject to these requirements. Activities must be conducted in accordance with these requirements.

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Table 6-19. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Excavation, placement of backfill, and the nearshore CDF (and potentially the upland CDF) are subject to these requirements. Activities must be conducted in accordance with these requirements.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	Nearshore CDF alternative can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A: Nearshore CDF	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Nearshore CDF must meet these requirements.
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.

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Table 6-19. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation, placement of backfill, and nearshore CDF must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site incineration must be conducted to meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.

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Table 6-19. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
***Action-Specific ARARs* (cont)**			
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF Incineration Off-site Disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Will be used to determine appropriate treatment and disposal.
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative meets this requirement.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable and R & A	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal, on-site incineration, or closure must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable: Upland CDF R & A: Nearshore CDF Floodplain	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements for land disposal must be met for CDFs constructed on site. Substantive requirements related to closure must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site incineration must be conducted to meet these substantive requirements.
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation, placement of backfill, and nearshore CDF must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.

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Table 6-19. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-20. Key Features of the Allendale Reach Floodplain Soil Alternatives

		Alternative				
			5 – Excavation and Disposal and/or Treatment			
		1 – No Action	Option 5a, On-site Containment in Upland CDF	Option 5b, On-site Containment in Nearshore CDF	Option 5d, On-site Thermal Treatment	Option 5e, Off-site Disposal and/or Treatment
Present Worth Cost		$0[4] $1	.4M	$1.4M	$4.3M	$3.2M
Remediation Area (acres)		—	Excavate: 1.5 Total: 1.5			
Excavation Volume (cy)		—	2,400			
Difference in Habitat (acres)		—	—			
Residual Risk[1]	**RME Cancer[2]**	2E-05	NA (no actionable risk for human health)			
	HI Immune[2]	—	NA (no actionable risk for human health)			
	HI Ecological[3]	20 0.	5			
Estimated Time to Achieve RAOs		Unknown	1 month			

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives; residual risks for No Action are based on current conditions.
[2]Based on receptor at highest risk, i.e., Resident Living Along the River (MACTEC, 2005a).
[3]Summary of information presented in Table 6-21.
[4] Costs for periodic monitoring and five-year reviews are covered under the Allendale and Lyman Mill Sediment Alternative 1, No Action.

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Table 6-21a. Summary of Residual Risks[1] for Ecological Health, Allendale Reach Floodplain Soil Alternative 1-No Action[2]

Floodplain Soil Contact and Prey Consumption by Ecological Receptors

Contaminant[a]	Current Conditions[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]	
			Insectivorous wildlife[d]	
2,3,7,8-TCDD 0.	00083	Central Tendency	22	A
		HI	**20**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks.
a. Comprehensive list of all floodplain soil contaminants identified for ecological receptors; see Table 1-1 in the Interim Final PRG report (MACTEC, 2005).
b. Floodplain soil Exposure Point Concentrations (EPCs) obtained from Table 67 in the BERA (MACTEC, 2004).
c. Calculated by dividing the existing conditions by the PRG for the most sensitive measurement endpoint for each receptor category.
d. Floodplain soil concentrations protective of insectivorous wildlife were derived using: (A) dietary exposure modeling. The short-tailed shrew is the representative receptor species for this assessment endpoint.

Key:
HI - Hazard Index
mg/Kg - milligrams/kilogram
TEQ - Toxic Equivalent

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Table 6-21b. Summary of Residual Risks[1] for Ecological Health, Allendale Reach Floodplain Soil Alternative 5-Excavation and Disposal and/or Treatment

Floodplain Soil Contact and Prey Consumption by Ecological Receptors

Contaminant[a]	Floodplain Soil Cleanup Goal[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]	
			Insectivorous wildlife[d]	
2,3,7,8-TCDD 0.	000017	Background	0.46	A
		HI	**0.5**	

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
a. Comprehensive list of all floodplain soil contaminants identified for ecological receptors; see Table 1-1 in the Interim Final PRG report (MACTEC, 2005).
b. Floodplain soil remediation goals are summarized in Table 3-4 of the FS report.
c. Calculated by dividing the remediation goal by the PRG for the most sensitive measurement endpoint for each receptor category.
d. Floodplain soil concentrations protective of insectivorous wildlife were derived using: (A) dietary exposure modeling. The short-tailed shrew is the representative receptor species for this assessment endpoint.

Key:
HI - Hazard Index
mg/Kg - milligrams/kilogram
TEQ - Toxic Equivalent

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Table 6-22. Detailed Analysis of Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 1, No Action

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -1: NO ACTION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	Contaminated sediment and floodplain soil would remain on site unaddressed and continue to present a risk to human health and the environment.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	See Table 6-23. This alternative will not comply with ARARs for residential direct exposure or EPA's recommended residential level for dioxin (EPA, 1998b).
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	The residual risk is high because no actions are taken to address contaminated sediment and floodplain soil or reduce the risk of erosion and migration downstream.
Adequacy and Reliability of Controls	There would be no controls in place to adequately and/or reliably prevent exposure in the long term. In addition, there would be no controls to ensure maintenance of the privately owned dams which could lead to downstream transport of contaminated sediment in the event of a dam breach.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	None proposed for this alternative.
Amount Destroyed or Treated	None anticipated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	No reductions in toxicity, mobility, or volume of contamination anticipated for this alternative.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	There would be no residuals because no treatment is planned for this alternative.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Protection of Workers During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Environmental Impacts	Not applicable, as no remedial actions are proposed for this alternative

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Table 6-22. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -1: NO ACTION
SHORT-TERM EFFECTIVENESS	
Time Until Remedial Action Objectives are Achieved	The time to achieve RAOs may be on the order of several decades to well over a century depending on the deposition and chemical decay rates. Overall, the time to reach the cleanup goals for the most sensitive ecological receptor (short-tailed shrew) varies from 40 to greater than 250 years, best estimate is approximately 105 years. The time to reach the cleanup goals for the passive recreational visitor is expected to be reached in about 55 years.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Reliability of the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative does not preclude future remedial activities.
Ability to Monitor the Effectiveness of Remedy	Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. Periodic monitoring would include routine testing and could be easily implemented.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable, as no activities requiring approval are planned for this alternative.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Not applicable for this alternative.
Availability of Technology	Not applicable for this alternative.
COST[1]	
Capital Cost	$0
Present Worth of Long-term Monitoring and Maintenance	$250,000 (includes costs for periodic monitoring and five-year reviews)
Total Present Worth Cost	$250,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-23. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 1, No Action[1]

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Some residential use soils at the site contains dioxin at levels above the PRG and will not be addressed by this alternative.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contributions of contaminants from sediment/floodplain soil that exceed AWQC in the Woonasquatucket River will not be minimized to the maximum extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Alternative would not prevent exposure to contaminants considered under this guidance.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Alternative would not prevent exposure to contaminants considered under this guidance.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	Alternative would not prevent exposure to contaminants considered under this guidance.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	Alternative would not prevent exposure to contaminants considered under this guidance.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Alternative would not prevent exposure to contaminants considered under this guidance.

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Table 6-23. (continued)

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs (cont)			
Federal Requirements (cont)			
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Alternative would not prevent exposure to contaminants potentially considered under these advisories.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives).	Some residential use soils at the site contain contaminants subject to the Rule 8.02B soil objectives and would not be addressed by this alternative.

Notes:
[1] With no action, there are no location- or action-specific ARARs.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-24. Detailed Analysis of Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	The combination of targeted excavation and removal of contaminated sediment/soil and placement of a thin-layer cover would provide some protection to human health and the environment. Removal of the sediment from the stream channel would reduce contaminant migration downstream due to erosion. In addition, removal of contaminated soil that exceeds ARARs or EPA's dioxin requirements in combination with a thin cover would reduce exposure to contamination and accelerate the natural recovery processes. Flow control structures to divert stream flow into the Oxbow would also accelerate the natural recovery processes. However, because some contamination would remain in place, ICs restricting site access and use would be required to prevent the disturbance of the CDFs (Options 3a and 3b) and thin-layer cover (all options). In addition, ICs (such as boardwalks and fencing) could be used to enhance remedy effectiveness by further reducing human exposure. Potential risks to ecological receptors would be reduced, but not eliminated because contaminated sediment/soil under the thin-layer cover could continue to present an exposure hazard to burrowing aquatic and floodplain organisms over an extended period of time until the cleanup objectives are met. In addition, the bioaccumulation hazard to wildlife would be reduced but not eliminated over an extended period of time until cleanup objectives are met.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 3 are summarized in Table 6-25. Assuming that excavation involves more than a *deminimis*/incidental discharge to surface water, Clean Water Act Section 404 requirements are triggered by excavation. In addition, placement of backfill in wetland areas, the nearshore CDF (Option 3b), and possibly the upland CDF (Option 3a) also trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. The thin-layer cover (all options) and nearshore CDF (Option 3b) would also require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.

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Table 6-24. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific (continued)	In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 3a. The Subtitle C requirements under RCRA would have to be waived for this alternative. The waiver would be based on the determination that the placement of a RCRA-compliant cap would result in greater risk to the environment. Specifically, the cover proposed under this alternative would allow for preservation of a majority of the existing forested wetland that provides a regionally-important habitat to a variety of birds and animals (including potential threatened/endangered vernal pool species). However, requiring a thicker, impermeable cap would permanently eliminate one of the largest areas of forested riparian habitat remaining along the Woonasquatucket River downstream of the Smithfield town line.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Targeted excavation would be somewhat effective in the long term because some contaminated sediment/soil would be removed and either contained on site, destroyed, or shipped off site for disposal and treatment. Targeted excavation will remove floodplain soil from areas where contaminant concentrations are in excess of ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b), and provide a higher level of risk reduction for human receptors. Although post-construction ecological residual risk would remain elevated as a result of leaving contamination in place under the thin-layer cover, targeted excavation would remove some of the contamination from areas with the highest likelihood of downstream migration. ICs and ECs would be used to further minimize human exposure. The risks to ecological receptors would be further reduced over time, as clean material was deposited within the area. However, the overall implementation period for this alternative is expected to be long (e.g., several decades to well over a century) even with the inclusion of river flow-diversion structures to increase sedimentation rates in the Oxbow. As a result, ecological receptors would continue to be at risk of harm from exposure to contaminants where contamination remains in place in the area where enhanced natural recovery occurs. This alternative does not involve significant destruction of ecological habitat which would be balanced against the benefits of a more intrusive excavation.

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Table 6-24. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Adequacy and Reliability of Controls	Long-term monitoring, maintenance, including maintenance of the dam, and ICs would be necessary to assure the long-term protectiveness of this alternative, including the soil cover and any on-site disposal facility under Options 3a and 3b. Although not necessary to achieve RAOs, implementation of ICs would provide further protection to human health by lowering the potential for human exposure; ICs are only effective if adequately monitored, enforced, and maintained. ICs are not reliable or effective in addressing ecological risk.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Option 3d includes on-site incineration. Option 3e assumes some material will require treatment to meet LDRs.
Amount Destroyed or Treated	Under Option 3d, approximately 9,700 cy of sediment/soil would be excavated and treated. Under Option 3e, approximately 1,200 cy of sediment would be treated (50% of the total volume).
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination by incineration under Options 3d and 3e. There would be no reduction of toxicity, mobility, or volume of contamination through treatment for Options 3a and 3b; however, the mobility of the contaminated sediment particles would be reduced by the disposal facility, if used.
Degree to Which Treatment is Irreversible	For sediment/soil that undergo thermal treatment (Options 3d and 3e), the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. Air emissions of contaminants or additional by-products produced during on-site or off-site thermal treatment (Options 3d and 3e) would be at levels below regulatory standards. After incineration, the volume of inorganic soil particles would be nearly the same as the pre-treatment volume, but concentrations of organic chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	All of the options would result in limited impacts to the community from construction. Access to the work zone during construction activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 3d would result in air emissions which would be monitored to ensure that they are below regulatory standards.

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Table 6-24. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT
SHORT-TERM EFFECTIVENESS	
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during site activities, mitigating risks to workers.
Environmental Impacts	Excavation would temporarily destroy existing habitat, which may take at least a decade to become reestablished in areas of emergent marsh. Application of cover material may have deleterious effects to the trees within the Oxbow. However, using a hydraulic slurry method and performing the work during the dormant season (e.g., late fall or early winter) would minimize damage to vegetation. Non-mobile animals, such as soil invertebrates, would be buried by the cover; however, it is expected that they would quickly colonize the newly applied cap material. Some short-term air emissions from truck traffic and petroleum powered engines and generators are associated with this alternative.
Time Until Remedial Action Objectives are Achieved	The time to achieve RAOs may be on the order of several decades to well over a century depending on the deposition and chemical decay rates. Overall, the time to reach the cleanup goals for the most sensitive ecological receptor (short-tailed shrew) varies from 30 to a couple hundred years, best estimate is approximately 60 years. The time to reach the cleanup goals for the passive recreational visitor is expected to be in about 15 years (based on meeting the Rhode Island carcinogenic risk range of 10^{-6} to 10^{-5}; post-construction residual risk estimates would be within EPA's risk range, see Appendix M). Flow control structures will be incorporated into the design to direct flood flows over the entire area, which will increase the rate of clean sediment deposition.

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Table 6-24. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	For all options, the soft soils would require the use of low-ground pressure equipment and hydraulic excavators. Temporary work areas would need to be set up and the areas cleared of vegetation. Temporary haul roads would need to be constructed to provide access. Obtaining property access is expected to be difficult. Use of a hydraulic slurry method for placement of a wetland cover is not routine, but such a broadcast method has been successfully demonstrated at other sites. The soft surface sediment/soil would require the use of low-ground pressure equipment and hydraulic excavators but should not present any significant issues. Upland land is required for the temporary work areas and sediment/soil processing areas (all options except Option 3b). Additional land is needed for a disposal facility (Option 3a) and Option 3d requires land for an incinerator. This property may need to be acquired from private parties. Increased monitoring would be needed for Options 3a, 3b, and 3d relative to Option 3e.
Reliability of the Technology	Excavation, CDF construction and thermal treatment technologies have been successfully implemented at other contaminated soil sites, although the nearshore CDF (Option 3b) could present additional reliability concerns because it is located in the floodplain/river. Although the concept of pumping soils slurries has been used for placing aquatic caps and is used in the mining industry, use of this technology for placing wetland covers is an innovative application. Habitat restoration activities have historically had variable success rates. Because contamination remains in place, technical problems could arise in the future.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.

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Table 6-24. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. Confirmational sampling would be performed at the completion of construction activities to verify that the cleanup goals were achieved. A physical survey would also be conducted at the completion of construction activities to confirm that the cover was placed over the entire remedial footprint and meets the design thickness. Long-term monitoring would be required to assess cover performance and the rate at which recovery is occurring, assess the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. Increased monitoring would be needed for the on-site containment (Options 3a and 3b) and treatment (Option 3d) options. However, these monitoring programs would not present any unusual issues. The implementation of a long-term monitoring program and enforcement of institutional controls are critical to the success of this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Because this alternative constitutes the placement of fill in waters of the US, a determination must first be made that this is the least damaging practicable alternative to the aquatic environment. In addition, this alternative would require the permanent occupancy and modification the floodplain, and a determination would first need to be made concluding that there is no other practicable alternative before selecting this option as the preferred remedy. For Option 3a, some low-value wetlands could be destroyed depending on the location of the CDF and a treatability variance may need to be obtained for sediment depending on contaminant concentrations.
Ability to Obtain Approvals and Coordinate with Other Agencies (cont)	Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs. Access from property owners would be required to obtain access to the site and to maintain Allendale Dam.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. Samples of excavated sediment/floodplain soil could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.
Availability of Necessary Equipment and Specialists	Construction equipment and personnel are readily available.
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.

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Table 6-24. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -3: TARGETED EXCAVATION, ENHANCED NATURAL RECOVERY AND DISPOSAL AND/OR TREATMENT	
COST[1]		
Capital Cost	Option 3a, On-site Upland CDF	$7,000,000
	Option 3b, On-site Nearshore CDF	$7,000,000
	Option 3d, On-site Thermal Treatment	$16,000,000
	Option 3e, Off-site Disposal and/or Treatment	$13,000,000
Present Worth of Long-term Monitoring and Maintenance	Option 3a, On-site Upland CDF	$2,700,000
	Option 3b, On-site Nearshore CDF	$2,700,000
	Option 3d, On-site Thermal Treatment	$2,400,000
	Option 3e, Off-site Disposal and/or Treatment	$2,400,000
Total Present Worth Cost	Option 3a, On-site Upland CDF	$9,700,000
	Option 3b, On-site Nearshore CDF	$9,700,000
	Option 3d, On-site Thermal Treatment	$19,000,000
	Option 3e, Off-site Disposal and/or Treatment	$16,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-25. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 3, Targeted Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Soil at the site that contains dioxin at levels above that recommended in this guidance would be addressed under this alternative.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants from sediment/floodplain soil that exceed AWQC in Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Used to establish criteria in the absence of other standards..

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Table 6-25. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs (cont)			
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives).	Some residential use soils at the site contain contaminants subject to the Rule 8.02B soil objectives and would be addressed under this alternative consistent with state requirements.
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in the Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation/backfill, placement of thin cover, and nearshore CDF (and potentially upland CDF) subject to these requirements. Activities must be conducted in accordance with these requirements, including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Backfill/thin cover, nearshore CDF, and flow control structures subject to these requirements. Activities must be conducted in accordance with these requirements.

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Table 6-25. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Excavation/backfill, placement of thin cover, and nearshore CDF (and potentially upland CDF) are subject to these requirements. Activities must be conducted in accordance with these requirements.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	This alternative and nearshore CDF alternative can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Nearshore CDF must meet these requirements. The Subtitle C requirements under RCRA would have to be waived for this alternative (see Table 6-24).
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.

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Table 6-25. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill, placement of thin cover, and nearshore CDF must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site incineration must be conducted to meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.

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Table 6-25. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs (cont)			
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF Incineration Off-site Disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Will be used to determine appropriate treatment and disposal
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative meets this requirement.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable and R & A	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal, on-site incineration, or closure must be met. The Subtitle C requirements under RCRA would have to be waived for this alternative (see Table 6-24).
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable and R & A	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements for land disposal must be met for CDFs constructed on site. Substantive requirements for closure must be met. The Subtitle C requirements under RCRA would have to be waived for this alternative (see Table 6-24).
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site incineration must be conducted to meet these substantive requirements.

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Table 6-25. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
***Action-Specific ARARs* (cont)**			
State Requirements (cont)			
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation/backfill, placement of thin cover, and nearshore CDF must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable Prohibits	emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-26. Detailed Analysis of Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -5: PARTIAL EXCAVATION, ENHANCED NATURAL RECOVERY, AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	This alternative would provide some overall protection of human health and the environment, and would help balance the long-term benefits of sediment/soil removal with the short-term benefit of protecting valuable existing wetland habitat. Targeted excavation and removal of contaminated soil from areas where contaminant concentrations are in excess of ARARs or EPA's dioxin requirements, as well as removal of contaminated sediment and soil from areas with the highest potential human exposure and areas with higher potential for downstream transport of contaminated sediment/floodplain soil would minimize human and ecological exposure to contamination. Placement of a thin cover would further reduce exposure to contamination, and used in combination with flow control structures to divert stream flow into the Oxbow would also accelerate the natural recovery processes. Potential risks to ecological receptors would be reduced, but not eliminated because contaminated sediment/soil under the thin-layer cover could continue to present an exposure hazard to burrowing aquatic and floodplain organisms over an extended period of time until the cleanup objectives are met. In addition, the bioaccumulation hazard to wildlife would be reduced but not eliminated over an extended period of time until cleanup objectives are met.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 5 are summarized in Table 6-27. Excavation, placement of backfill/cover material in wetland areas, the nearshore CDF (Option 5b), and possibly the upland CDF (Option 5a) will trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. The thin-layer cover (all options) and nearshore CDF (Option 5b) would also require the permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy. In addition, some of the sediment could require treatment if it exceeds the treatment standards set forth in the LDRs. A treatability variance could be obtained to reduce the amount of treatment needed for sediment under Option 5a.

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Table 6-26. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -5: PARTIAL EXCAVATION, ENHANCED NATURAL RECOVERY, AND DISPOSAL AND/OR TREATMENT
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific (continued)	The Subtitle C requirements under RCRA would have to be waived for this alternative. The waiver would be based on the determination that the placement of a RCRA-compliant cap would result in greater risk to the environment. Specifically, the cap proposed under this alternative would allow for preservation of a majority of the existing forested wetland that provides a regionally-important habitat to a variety of birds and animals (including potential threatened/endangered vernal pool species). However, requiring a thicker, impermeable cap would permanently eliminate one of the largest areas of remaining forested riparian habitat remaining along the Woonasquatucket River downstream of the Smithfield town line.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Partial excavation would be somewhat effective in the long term because the contaminated sediment/soil would be removed and either contained on site, destroyed, or shipped off-site for disposal and treatment. In addition, placement of a thin-layer cover would facilitate risk reduction through natural recovery. All sediment and floodplain soil will be excavated from areas where contaminant concentrations are in excess of ARARs for residential direct exposure or EPA's recommended residential level for dioxin in soil (EPA, 1998b), as well as from areas of highest potential for future erosion, from low-lying channels where contaminated sediment has accumulated, and from areas with potential for frequent human exposure; therefore the residual risk would be significantly reduced particularly for human receptors. The elevated post-construction ecological residual risk from contamination remaining in place under the thin-layer cover would be further reduced over time as clean material was deposited within the area, although this process will be fairly slow even with the inclusion of river flow-diversion structures to increase sedimentation rates in the Oxbow.
Adequacy and Reliability of Controls	Long-term monitoring, maintenance, including maintenance of the dam, and ICs would be critical to ensure the long-term protectiveness of the thin-layer cover and any type of on-site disposal facility (Options 5a and 5b). Although not necessary to achieve RAOs, implementation of ICs would provide further protection to human health by lowering the potential for human exposure; ICs are only effective if adequately monitored, enforced, and maintained. ICs are not reliable or effective in addressing ecological risk.

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Table 6-26. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -5: PARTIAL EXCAVATION, ENHANCED NATURAL RECOVERY, AND DISPOSAL AND/OR TREATMENT
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Option 5d includes on-site incineration. Option 5e assumes some sediment would require treatment to meet LDRs.
Amount Destroyed or Treated	Under Option 5d, approximately 27,300 cy of sediment/soil would be excavated and treated. Under Option 5e, approximately 1,200 cy of sediment would be excavated and treated (50% of the sediment volume).
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination by incineration under Options 5d and 5e. There would not be a reduction of toxicity, mobility, or volume of contamination through treatment for the on-site containment options (Options 5a and 5b), although the mobility of the contaminated sediment/soil particles would be reduced by the disposal facility and thin-layer cover.
Degree to Which Treatment is Irreversible	For sediment/soil that undergoes thermal treatment (Options 5d and 5e), the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. Air emissions of contaminants or additional by-products produced during on- or off-site thermal treatment (Options 5d and 5e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment/soil particles would be nearly the same as the pre-treatment volume, but the concentrations of organic chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	All of the options would present limited impacts to the community from construction. Access to the work zone during construction activities would be prohibited, and engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring will mitigate risks to the community. An on-site incinerator under Option 5d would result in air emissions which would be monitored to ensure that they are below regulatory standards.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during site activities, mitigating risks to workers.
Environmental Impacts	Excavation would temporarily destroy existing habitat, which may take at least a decade to become reestablished in areas of emergent marsh, and a considerably longer time (on the order of several decades) in areas with a well-developed tree canopy.

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Table 6-26. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -5: PARTIAL EXCAVATION, ENHANCED NATURAL RECOVERY, AND DISPOSAL AND/OR TREATMENT
SHORT-TERM EFFECTIVENESS	
Time Until Remedial Action Objectives are Achieved	The time to achieve RAOs may be on the order of several decades to well over a century depending on the deposition and chemical decay rates. Overall, the time to reach the cleanup goals for the most sensitive ecological receptor (short-tailed shrew) varies from 30 to over 250 years, best estimate is approximately 55 years. The time to reach the cleanup goals for the passive recreational visitor is expected to be reached in slightly less than 8 years (based on meeting the Rhode Island carcinogenic risk range of 10^{-6} to 10^{-5}; post-construction residual risk estimates would be within EPA's risk range, see Appendix M). Flow control structures will be incorporated into the design to direct flood flows over the entire area, which will increase the rate of clean sediment deposition.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Use of a hydraulic slurry method for placement of a wetland cover is not routine; however, the relevant technologies have been successfully utilized in other situations to meet similar objectives. The soft surface sediment/floodplain soil would require the use of low-ground pressure equipment and hydraulic excavators but should not present any significant issues. Temporary haul roads would need to be constructed to provide access. Obtaining property access is expected to be difficult. Upland land is required for the temporary work areas and sediment/soil processing areas (all options except Option 5b). Additional land is needed for a disposal facility (Option 5a) and Option 5d requires land for an incinerator. This property may need to be acquired from private parties. Increased monitoring would be needed for Options 5a, 5b, and 5d relative to Option 5e.
Reliability of the Technology	Excavation and CDF construction are proven technologies and has been successfully implemented at other contaminated sediment/soil sites. Although the concept of pumping soils slurries has been used for placing aquatic caps and is used in the mining industry, use of this technology for placing wetland covers is an innovative application. In addition, habitat restoration activities have historically had variable success rates.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.

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Table 6-26. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -5: PARTIAL EXCAVATION, ENHANCED NATURAL RECOVERY, AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and water quality protection measures could be monitored with routine testing. Confirmational sampling would be performed at the completion of construction activities to verify that the cleanup goals were achieved. A physical survey would also be conducted at the completion of construction activities to confirm that the cover was placed over the entire remedial footprint and meets the design thickness. Long-term monitoring would be required to assess cover performance and the rate at which recovery is occurring, assess the impact of the remedial action on downstream areas, and determine if additional evaluations or clean-ups are warranted. Increased monitoring would be needed for the on-site containment (Options 5a and 5b) and treatment (Option 5d) options. However, these monitoring programs would not present any unusual issues. The implementation of a long-term monitoring program and enforcement of institutional controls are critical to the success of this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Because this alternative constitutes the placement of fill in waters of the US, a determination must first be made that this is the least damaging practicable alternative to the aquatic environment. In addition, this alternative would require the permanent occupancy and modification of the floodplain, and a determination would first need to be made concluding that there is no other practicable alternative before selecting this option as the preferred remedy. For Option 5a, some low-value wetlands could be destroyed depending on the location of the CDF and a treatability variance may need to be obtained. Coordination with adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs. Access from property owners would be required to obtain access to the site and to maintain Allendale Dam.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available Samples of excavated sediment/soil could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.
Availability of Necessary Equipment and Specialists	Excavation, cover placement, and CDF construction contractors and equipment are readily available.
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.

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Table 6-26. (continued)

EVALUATION CRITERIA	ALTERNATIVE LYMAN MILL REACH STREAM SEDIMENT AND FLOODPLAIN SOIL -5: PARTIAL EXCAVATION, ENHANCED NATURAL RECOVERY, AND DISPOSAL AND/OR TREATMENT	
COST[1]		
Capital Cost	Option 5a, On-site Upland CDF	$14,000,000
	Option 5b, On-site Nearshore CDF	$13,000,000
	Option 5d, On-site Thermal Treatment	$40,000,000
	Option 5e, Off-site Disposal and/or Treatment	$29,000,000
Present Worth of Long-term Monitoring and Maintenance	Option 5a, On-site Upland CDF	$2,700,000
	Option 5b, On-site Nearshore CDF	$2,700,000
	Option 5d, On-site Thermal Treatment	$2,400,000
	Option 5e, Off-site Disposal and/or Treatment	$2,400,000
Total Present Worth Cost	Option 5a, On-site Upland CDF	$16,000,000
	Option 5b, On-site Nearshore CDF	$16,000,000
	Option 5d, On-site Thermal Treatment	$42,000,000
	Option 5e, Off-site Disposal and/or Treatment	$32,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-27. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 5, Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Soil at the site that contains dioxin at levels above that recommended in this guidance would be addressed under this alternative.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants from sediment/floodplain soil that exceed AWQC in Woonasquatucket River will be minimized to the extent practical.
Guidelines for Carcinogenic Risk Assessment, EPA/630/P-03/001F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens.	Guidelines used to evaluate all risk assessments on carcinogenicity.
Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens, EPA/630/R-03/003F (March 2005)	TBC	These guidelines provide guidance on conducting risk assessments involving carcinogens	Guidelines used to evaluate all risk assessments on carcinogenicity in children.
EPA Risk Reference Doses (RfDs)	TBC	RfDs are estimates of a daily exposure concentration that is likely to be without appreciable risk of deleterious effects during a lifetime exposure.	RfDs used to characterize human health risks due to non-carcinogens in site media.
Human Health Assessment Cancer Slope Factors (CSFs)	TBC	CSFs are estimates of the upper-bound probability of an individual developing cancer as a result of a lifetime exposure to a particular concentration of a potential carcinogen.	CSFs used to compute the individual incremental cancer risk resulting from exposure to carcinogens in site media.
EPA Carcinogenic Assessment Group Potency Factors	TBC	These factors are used to evaluate an acceptable risk from a carcinogen.	Used to evaluate carcinogenicity of dioxin.
EPA Health Advisories	TBC	EPA publishes contaminant-specific health advisories that indicate the non-carcinogenic risks associated with consuming contaminated drinking water.	Used to establish criteria in the absence of other standards..

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Table 6-27. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs (cont)			
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives).	Some residential use soils at the site contain contaminants subject to the Rule 8.02B soil objectives and would be addressed under this alternative consistent with state requirements.
Location-Specific ARARs			
Federal Requirements			
Fish and Wildlife Coordination Act 16 U.S.C. 661, Fish and Wildlife Protection (40 CFR Section 6.302(g))	Applicable	Requires that a federal agency take action to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources. Encourages that any federal agency proposing to modify a body of water to consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and other related state agencies.	Construction activities under this alternative in the Woonasquatucket River are subject to these requirements. Actions will be taken in accordance with these requirements.
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation/backfill, placement of thin cover, and nearshore CDF (and potentially upland CDF) are subject to these requirements. Activities must be conducted in accordance with these requirements, including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Backfill/thin cover, nearshore CDF, and flow control structures subject to these requirements. Activities must be conducted in accordance with these requirements.

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Table 6-27. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Excavation/backfill, placement of thin cover, and nearshore CDF (and potentially upland CDF) are subject to these requirements. Activities must be conducted in accordance with these requirements.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	This alternative and nearshore CDF can only be selected if there is no practicable alternative to occupancy and modification of floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	R & A: Nearshore CDF	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Nearshore CDF must meet these requirements. Contamination from areas prone to erosion is excavated. The Subtitle C requirements under RCRA would have to be waived for this alternative (see Table 6-26).
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.

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Table 6-27. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARAR			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill, placement of thin cover, and nearshore CDF must be conducted so that there are no exceedances of AWQC.
RCRA (40 CFR 264, Subpart AA)	Applicable: On-site Incineration	Air emission standards for process vents apply to process vents that manage hazardous wastes with organic concentrations of at least 10 parts per million by weight (ppmw).	Should incinerator operations manage hazardous wastes with organic concentrations of at least 10 ppm by weight, vents operated as part of the system will comply with these requirements.
RCRA (40 CFR 264, Subpart BB)	Applicable: On-site Incineration	Air emission standards for equipment leaks apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10 percent by weight.	Should equipment used in incineration come into contact with hazardous wastes containing organic concentrations of at least 10 percent by weight, these regulations will be followed.
CAA National Emissions Standards for Hazardous Air Pollutants: Site remediation (40 CFR 63, Subpart GGGGG)	Applicable: On-site Incineration	Applicable to major sources of hazardous air pollutants conducting site remediation.	On-site incineration must be conducted to meet these substantive requirements.
RCRA Land Disposal Restrictions (40 CFR 268)	Applicable: Upland CDF	These regulations identify treatment standards for hazardous wastes and specify requirements that generators, transporters, and owners or operators of treatment, storage, and disposal facilities that manage restricted wastes destined for land disposal must meet.	Material subject to these regulations placed in upland CDF must be treated to meet these requirements.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.

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Table 6-27. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs			
State Requirement			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable: Upland CDF On-site Incineration Off-site Disposal	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Will be used to determine appropriate treatment and disposal.
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative meets this requirement.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable and R & A	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal, on-site incineration, or closure must be met. The Subtitle C requirements under RCRA would have to be waived for this alternative (see Table 6-24).
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	Applicable and R & A	Outlines design, operational, and closure requirements for land disposal facilities.	Substantive requirements for land disposal must be met for CDFs constructed on site. Substantive requirements for closure must be met. The Subtitle C requirements under RCRA would have to be waived for this alternative (see Table 6-24).
RIDEM Rules and Regulations for Hazardous Waste Management, Section 11 (3/07) - Incinerators	Applicable: On-site incineration	Outlines design, operational, and closure requirements for incinerator facilities.	On-site incineration must be conducted to meet these substantive requirements.

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Table 6-27. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs			
State Requirement			
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation/backfill, placement of thin cover, and nearshore CDF must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable Prohibits	emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.
RI Air Pollution Control Regulation #15: Control of Organic Solvent Emissions, 7/19/07	Applicable: On-site incineration	Limits the amount of organic solvents emitted to the atmosphere	Any emissions of organic solvents will be controlled to ensure that the standards are met.
RI Air Pollution Control Regulation #22: Air Toxics (4/04) Air Toxics Guideline, and Air Modeling Guidelines (6/05), 7/19/07	Applicable: On-site incineration	Prohibits the emissions of specified contaminants that result in ground level concentrations greater than ambient level concentrations.	Remediation will be conducted so that these requirements are met.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-28. Key Features of the Lyman Mill Reach Stream Sediment and Floodplain Soil Alternatives[1]

Alternative		Present Worth Cost	Remediation Area (acres)	Excavation Volume (cy)	Difference in Habitat (acres)	Residual Risk[2]				Estimated Time to RAOs[5]
						RME Cancer[3]	HI Immune[3]	HI Skin[3]	HI Ecological[4]	
1 – No Action		$250K	—	—	—	3.E-04	0.7	0.1	50 - 400	Ecological: 45 to over 250 years, best estimate 105 years Human: about 55 years
3 – Targeted Excavation, Enhanced Natural Recovery, and Disposal and/or Treatment	Option 3a	$9.7M	Excavate: 4.8 ENR: 16.8 Total: 21.6	9,700 —		7.E-06	0.2 0.	08	100 (soil inverte-brates) 7 (birds) 5 (mammals)	Ecological: 30 to couple hundred years, best estimate 60 years Human: about 15 years
	Option 3b	$9.7M								
	Option 3d	$19M								
	Option 3e	$16M								
5 – Partial Excavation, Enhanced Natural Recovery and Disposal and/or Treatment	Option 5a	$16M	Excavate: 13.5 ENR: 8.0 Total: 21.6	27,300	—					Ecological: 30 to over 250 years, best estimate 55 years Human: slightly less than 8 years
	Option 5b	$16M								
	Option 5d	$42M								
	Option 5e	$32M								

Notes:
[1]Post-construction risks (i.e., those existing immediately following completion of remedy implementation phase) for each alternative are presented in Appendix M. The exposure estimates are based on projected area-weighted soil concentrations and assumed annual sediment deposition and degradation rates for 2,3,7,8-TCDD. Appendix M provides further details on the model and information regarding the time course of risk reduction for ecological receptors following remedy implementation.
[2]Residual risks are those risks that remain following attainment of the cleanup objectives; residual risks for No Action are based on current conditions.
[3]Based on receptor at highest risk, i.e., Resident Living Along the River; summary of information in Tables 6-29a and 6-29b. Post-construction carcinogenic risks for Alternatives 1, 3 and 5 are 3.E-04, 4.E-05, and 2.E-05, respectively. The non-carcinogenic risks (immune system) are 0.9, 0.3, and 0.2 for Alternatives 1, 3, and 5 respectively, whereas post-construction non-carcinogenic risks (skin) are all 0.1.
[4]Based on receptor at highest risk, i.e., short-tailed shrew; a summary of information presented in Tables 6-29c and 6-29d.
[5] Times estimates are based on a sensitivity analysis conducted to evaluate the predictive floodplain soil contaminant exposure model for ecological receptors presented in Appendix M (Table M-15). The sensitivity analysis assessed the impact of a range of potential values for the two most important determinants of future exposure and risk (i.e., the average annual deposition rate and the chemical half-life of organic contaminants in floodplain soil). Time estimates presented here are based on the contaminant 2,3,7,8-TCDD; time estimates for the ecological receptor are based on the most sensitive ecological receptor (i.e., short-tailed shrew).

Table 6-29a. Summary of Residual Risks[1] for Human Health, Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 1-No Action[2]

Floodplain Soil Contact for a Passive Recreational Visitor

Carcinogenic Contaminant	Cancer Classification	Basis	No Action RME Residual Cancer Risk	
Aroclor 1254	B2	Risk	4.E-06	A
Arsenic A		Risk	8.E-06	A
2,3,7,8-TCDD B	2	Risk	3.E-04	A
		Sum of Carcinogenic Risk	**3.E-04**	
Non-Carcinogenic Contaminant	**Target Endpoint**	**Basis**	**No Action RME Hazard Index**	
Aroclor 1268	Immune system	Risk	0.7	A
Arsenic Skin		Risk	0.1	A
2,3,7,8-TCDD --		Risk	--	B
		HI Kidney	--	
		HI Liver	--	
		HI Immune System	**0.7**	A
		HI Skin	**0.1**	A

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks (i.e., maximum concentrations).

A - Residual cancer risk and/or hazard index for direct contact.
B - RME Residual Hazard Index not calculated for this compound due to lack of noncarcinogenic toxicity data.

HI - Hazard Index
RME - Reasonable Maximum Exposure
mg/Kg - milligrams/kilogram
TEQ - toxic equivalent

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Table 6-29b. Summary of Residual Risks[1] for Human Health, Lyman Mill Reach Stream Sediment and Floodplain Soil Action-Based Alternatives (Alternatives 3 and 5)

Floodplain Soil Contact for a Passive Recreational Visitor

Carcinogenic Contaminant	Cancer Classification	Floodplain Soil Cleanup Goal (mg/Kg)	Basis	RME Residual Cancer Risk	
Aroclor 1254	B2	0.82	HH PRG	1.E-06	A
Arsenic	A	7.7	Background	5.E-06	A
2,3,7,8-TCDD	B2	0.000017	Background	1.E-06	A
			Sum of Carcinogenic Risk	**7.E-06**	
Non-Carcinogenic Contaminant	**Target Endpoint**	**Floodplain Soil Cleanup Goal (mg/Kg)**	**Basis**	**RME Residual Hazard Index**	
Aroclor 1268	Immune system	0.82	HH PRG	0.2	A
Arsenic	Skin	7.7	Background	0.08	A
2,3,7,8-TCDD	--	0.000017	Background	--	B
			HI Kidney	--	
			HI Liver	--	
			HI Immune System	**0.2**	A
			HI Skin	**0.08**	A

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
A - Residual cancer risk and/or hazard index for direct contact.
B - RME Residual Hazard Index not calculated for this compound due to lack of noncarcinogenic toxicity data.

HH PRG - Human Health Risk-based PRG
HI - Hazard Index
RME - Reasonable Maximum Exposure
mg/Kg - milligrams/kilogram
TEQ - toxic equivalent

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Table 6-29c. Summary of Residual Risks[1] for Ecological Health, Lyman Mill Reach Stream Sediment and Floodplain Soil Alternative 1-No Action[2]

Floodplain Soil Contact and Prey Consumption by Ecological Receptors

Contaminant[a]	Current Conditions[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]		
			Soil Invertebrates[d]	Wildlife - Birds[e]	Wildlife - Mammals[f]
2,3,7,8-TCDD	0.0043	Risk	-	22 C	430 E
Aroclor 1254	3.58	Risk	-	-	2 F
Total Aroclors	3.58	Risk	-	2 D	2 F
4.4'-DDE 0.	042	Risk	17 A	3 C	-
Dieldrin 0	.063	Risk	130 A	2 C	-
Antimony 7.	0	Risk	2 A	-	15 F
Cadmium	8.3	Risk	100 B	-	2 F
Lead	1835	Risk	4 A	11 D	-
Zinc 1	867	Risk	73 B	6 D	-
		HI	**300**	**50**	**400**

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
[2]Residual risks for No Action are based on current risks.
a. Includes all floodplain soil contaminants identified for ecological receptors in Table 3-4 of the FS report, with the exception of arsenic and selenium. The BERA (MACTEC, 2004) concluded that exposure to these two contaminants in limited floodplain habitat along the eastern shore of Lyman Mill Pond might present unacceptable risks to ecological receptors; however, the addendum to the BERA (MACTEC and Battelle, 2006), which focused on the much more extensive floodplain habitat associated with the Oxbow and adjoining areas, came to an opposite conclusion. Consequently, arsenic and selenium were not included in this table.
b. Under the NFA alternative, anticipated exposure would remain unchanged; current conditions represented by maximum detected concentration. From Table 2 in the Addendum to the Interim Final Baseline Ecological Risk Assessment: Oxbow Area (Battelle, 2006).
c. Calculated by dividing the current condition exposure concentration by the PRG for the most sensitive measurement endpoint for each receptor category. A dash indicates no unacceptable risk for that particular receptor.
d. Floodplain soil concentrations protective of soil invertebrates were derived using: (A) soil screening benchmarks and (B) literature-derived CBR thresholds.
e. Floodplain soil concentrations protective of vermivorous wildlife (birds) were derived using: (C) literature-derived CBRs and (D) dietary exposure modeling. The American woodcock is the representative receptor species for this assessment endpoint.
f. Floodplain soil concentrations protective of vermivorous wildlife (mammals) were derived using: (E) literature-derived CBRs and (F) dietary exposure modeling. The short-tailed shrew is the representative receptor species for this assessment endpoint.

HI - Hazard Index
mg/Kg - milligrams/kilogram

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Table 6-29d. Summary of Residual Risks[1] for Ecological Health, Lyman Mill Reach Stream Sediment and Floodplain Soil Action-Based Alternatives (Alternatives 3 and 5)

Floodplain Soil Contact and Prey Consumption by Ecological Receptors

Contaminant[a]	Floodplain Soil Cleanup Goal[b] (mg/Kg)	Basis	Residual Hazard Quotients[c]		
			Soil Invertebrates[d]	Wildlife - Birds[e]	Wildlife - Mammals[f]
2,3,7,8-TCDD	0.000017	Background	-	0.089 C	1.7 E
Aroclor 1254	0.82	Human Health PRG	-	-	0.41 F
Total Aroclors	1.7	Avian Dose	-	1.0 D	0.85 F
4.4'-DDE 0.	016	Avian CBR	6.4 A	1.0 C	-
Dieldrin 0.	04	ARAR	82 A	1.0 C	-
Antimony 0.	62	Background	0.18 A	-	1.3 F
Cadmium 3.	8	Mammal Dose	48 B	-	1.0 F
Lead	450	Background	0.90 A	2.8 D	-
Zinc 32	0	Avian Dose	12 B	1.0 D	-
Notes		**HI**	**100**	**7**	**5**

Notes:
[1]Residual risks are those risks that remain following attainment of the cleanup objectives.
a. Includes all floodplain soil contaminants identified for ecological receptors in Table 3-4 of the FS report, with the exception of arsenic and selenium. The BERA (MACTEC, 2004) concluded that exposure to these two contaminants in limited floodplain habitat along the eastern shore of Lyman Mill Pond might present unacceptable risks to ecological receptors; however, the addendum to the BERA (MACTEC and Battelle, 2006), which focused on the much more extensive floodplain habitat associated with the Oxbow and adjoining areas, came to an opposite conclusion. Consequently, arsenic and selenium were not included in this table.
b. Floodplain soil remediation goals are summarized in Table 3-4 of the FS report.
c. Calculated by dividing the current condition exposure concentration by the PRG for the most sensitive measurement endpoint for each receptor category. A dash indicates no unacceptable risk for that particular receptor.
d. Floodplain soil concentrations protective of soil invertebrates were derived using: (A) soil screening benchmarks and (B) literature-derived CBR thresholds.
e. Floodplain soil concentrations protective of vermivorous wildlife (birds) were derived using: (C) literature-derived CBRs and (D) dietary exposure modeling. The American woodcock is the representative receptor species for this assessment endpoint.
f. Floodplain soil concentrations protective of vermivorous wildlife (mammals) were derived using: (E) literature-derived CBRs and (F) dietary exposure modeling. The short-tailed shrew is the representative receptor species for this assessment endpoint.

ARAR – Applicable or Relevant and Appropriate Requirement
HI - Hazard Index
mg/Kg - milligrams/kilogram

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Table 6-30. Existing Surfaces and Excavation Areas at the Source Area

Proposed Cleanup Area	Surface Area	
	(sq ft)	(acres)
Existing Cap Areas		
Cap Area #1	85,000	2.0
Cap Area #2	48,000	1.1
Cap Area #3	53,000	1.2
TOTALS	**186,000**	**4.3**
Parking Lot Areas		
Southwest of Centredale Manor	34,000	0.8
North of Centredale Manor	27,000	0.6
South of Brook Village	32,000	0.7
TOTALS	**93,000**	**2.1**
Landscape, Walkway, Service Road and Rip Rap Areas	**60,500**	**1.4**
Excavation Areas		
Principal Threat Waste	37,000	0.8
TSCA/GB Leachability	39,000	0.9
TOTALS	**76,000**	**1.7**

Key:
sq ft – square feet.

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Table 6-31. Detailed Analysis of Source Area Soil Alternative 1, No Action

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL -1: NO ACTION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	The existing interim caps, parking lots and pavement currently reduce the risk of direct human exposure to contaminated vadose zone soils. However, without additional actions this alternative would not be protective in the long term. This alternative would not prevent precipitation infiltration into the underlying soil and groundwater.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to the No Action alternative are summarized in Table 6-32. This alternative would not comply with ARARs for residential direct exposure, GB leachability, TSCA closure, or EPA's recommended residential level for dioxin in soil (EPA, 1998b).
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Inherent hazard and risk of existing contaminated soil will remain in the floodplain without an applicable RCRA and TSCA closure. In addition, contamination above acceptable levels would remain in areas that are not capped.
Adequacy and Reliability of Controls	There would be no adequate or reliable controls to prevent exposure in the long term or maintain the controls currently in place. Without long-term monitoring and ICs to maintain the integrity of the existing surfaces, there would be risk of future uncontrolled exposure and migration of contaminated soils by erosion and transport to the Woonasquatucket River and Allendale Pond.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	None proposed for this alternative.
Amount Destroyed or Treated	None anticipated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	No reductions of toxicity, mobility, or volume of contamination through treatment is anticipated with this alternative. The mobility of the contaminated soil particles would be reduced by the existing interim caps and paved surfaces.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	There would be no residuals because treatment is not planned for this alternative.

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Table 6-31. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL -1: NO ACTION
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Protection of Workers During Remedial Action	Not applicable, as no remedial actions are proposed for this alternative.
Environmental Impacts	Not applicable, as no remedial actions are proposed for this alternative
Time Until Remedial Action Objectives are Achieved	This alternative would not achieve the RAOs.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Reliability of the Technology	Not applicable, as no remedial technology is implemented under this alternative.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative does not preclude future remedial activities.
Ability to Monitor the Effectiveness of Remedy	Five-year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. Periodic monitoring would include routine testing and could be easily implemented.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable, as no activities requiring approval are planned for this alternative.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Not applicable for this alternative.
Availability of Technology	Not applicable for this alternative.
COST[1]	
Capital Cost	$0
Present Worth of Long-term Monitoring and Maintenance	$170,000 (includes costs for periodic monitoring and five-year reviews)
Total Present Worth Cost	$170,000

Notes
[1]Detailed cost estimates provided in Appendix J.

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Table 6-32. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Source Area Soil Alternative 1, No Action[1]

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Soil at the source area contains dioxin at levels above the PRG established pursuant to this guidance. This alternative will not address soils that exceed the level recommended in this guidance.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
TSCA PCB Regulations (40 CFR 761)	Applicable	Establishes requirements for PCB-remediation waste.	PCBs present in source area soil would not be addressed under this alternative.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contributions of contaminants from source area soil that exceed AWQC in the Woonasquatucket River will not be minimized to the maximum extent practical.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives). Groundwater objectives established in Rule 8.03 provide groundwater cleanup criteria.	Soils at the source area contain contaminants subject to the Rule 8.02B soil objectives and would not be addressed by this alternative. Groundwater at the source area contains contaminants subject to the Rule 8.03 GB groundwater objectives that would not be addressed under this alternative.

Notes:
[1] With no action, there are no location- or action-specific ARARs.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-33. Detailed Analysis of Source Area Soil Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-3: TARGETED EXCAVATION, UPGRADE AND MAINTAIN EXISTING SURFACES AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	Removal of principal threat waste and contaminated soil that exceeds TSCA/GB leachability criteria, in conjunction with upgrading the existing surfaces (existing interim caps, parking lots, landscape areas, and rip rap), would provide moderate protection to human health and the environment. Targeted removal of principal threat waste would remove highly toxic or highly mobile waste that generally cannot be reliably contained and could present a significant risk to human health or the environment should exposure occur. Targeted removal of contaminated soil that exceeds TSCA would prevent exposure to toxic soils. Targeted removal of contaminated soil that exceeds GB leachability criteria, upgrading the existing surfaces, and extending the caps over landscape areas would reduce migration of contaminated soil at the source area to the Woonasquatucket River and Allendale Pond. The risk of exposure to contamination that remains in place would be reduced with ICs restricting site activities.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 3 are summarized in Table 6-34. This alternative would not comply with RCRA closure requirements. In addition, excavation and placement of fill in wetland areas would result in the destruction of existing wetlands and will trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under this alternative, there would be permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Excavation and removal of the principal threat waste and contaminated soil that exceeds TSCA/GB leachability will be effective in the long term. Upgrading the existing surfaces and extending the caps over landscaped areas would increase the effectiveness of this alternative. Some contaminated soil would remain in the floodplain. Inherent hazard of contamination will remain on site under an upgraded cap but without an applicable RCRA closure. Risk reduction will be high as long as the cap is designed, constructed and maintained to provide long-term isolation of contaminants.

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Table 6-33. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-3: TARGETED EXCAVATION, UPGRADE AND MAINTAIN EXISTING SURFACES AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Adequacy and Reliability of Controls	Long-term monitoring and maintenance of the upgraded surfaces would be required to prevent erosion and exposure of the underlying contaminated soils. In addition, ICs would be required to prevent human exposure, and could include restrictions on excavation, access for buried utilities, and construction with pilings or basements. However, these controls are only effective if adequately monitored and enforced. Periodic monitoring would also be performed to verify that contamination left in place remains relatively immobile, and that no future releases occur.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	This alternative assumes principal threat waste and some contaminated soil will be treated off site to meet LDRs.
Amount Destroyed or Treated	Approximately 9,800 cy of contaminated material would be excavated and approximately 5,900 cy would be treated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination through treatment under this alternative. The mobility of the contaminated soil particles that remain in place would be reduced by the upgraded caps and paved surfaces.
Degree to Which Treatment is Irreversible	For contaminated soils that undergo thermal treatment, the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. For soil that remains on site under the cap, there would be no residuals. Air emissions of contaminants or additional by-products produced during off-site thermal treatment (Option 3e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment/soil particles would be nearly the same as the pre-treatment volume, but the concentrations of organic chemical contaminants would be below detection limits.

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Table 6-33. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-3: TARGETED EXCAVATION, UPGRADE AND MAINTAIN EXISTING SURFACES AND DISPOSAL AND/OR TREATMENT
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	There would be some short-term impacts to the community from construction. Access to the work zone during construction activities would be prohibited, but measures would be taken to provide residents access to the buildings and parking areas. There would be potential risk to residents from dust and VOCs generated during excavation activities and installation of asphalt sealants. However, all appropriate measures including engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring would be taken to mitigate risks to the community.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls, and personal protective equipment will be used during construction activities, mitigating risks to workers.
Environmental Impacts	Excavation and placement of fill in wetland areas would result in the destruction of existing wetlands.
Time Until Remedial Action Objectives are Achieved	The RAO to prevent direct human contact with the contaminated vadose zone soil would be achieved at the completion of remedy implementation, which is estimated to take approximately three months. Achieving this RAO, however, is contingent on long-term monitoring and maintenance of the existing surfaces that would continue after construction activities are complete. The time to achieve the RAO to prevent migration or leaching of contaminants to soil and groundwater that would result in contamination above the ARARs is unknown, because some precipitation infiltration to the underlying soil and groundwater could still occur under this alternative. However, contaminated soil that exceeds the GB leachability criteria would be removed and should reduce the potential leaching of contaminants from soil to groundwater.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	The limited space on site for staging areas and the close proximity of the construction zone to residents would present some implementability challenges. However, all construction would be performed in phases, and all work could be performed with conventional earthwork or paving equipment.

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Table 6-33. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-3: TARGETED EXCAVATION, UPGRADE AND MAINTAIN EXISTING SURFACES AND DISPOSAL AND/OR TREATMENT
IMPLEMENTABILITY	
Reliability of the Technology	Excavation and capping are proven technologies and have been successfully implemented at contaminated soil sites. The existing interim caps are made from natural earth materials that are stable and erosion would be controlled by existing rock rip rap and grass over the soil areas. These features would provide effective and reliable prevention of direct contact with vadose zone soils.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and air/water quality protection measures could be monitored with routine testing. A physical survey would also be conducted at the completion of construction activities to confirm that the isolation cap meets the design thickness. Long-term monitoring would be required to assess cap performance and determine if additional actions are warranted. The implementation of a long-term monitoring program and enforcement of ICs are critical to the success of this alternative.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with the management of the Centredale Manor and Brook Village apartment buildings, adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs, develop a traffic control plan, and provide continuous access to residents and building service providers. Because this alternative constitutes the placement of fill in waters of the US, a determination must first be made that this is the least damaging practicable alternative to the aquatic environment. In addition, this alternative would require the permanent occupancy and modification of the floodplain, and a determination would first need to be made concluding that there is no other practicable alternative before selecting this option as the preferred remedy.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. Samples of excavated soil could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.
Availability of Necessary Equipment and Specialists	Excavation and construction equipment and personnel, and monitoring equipment and personnel, are readily available.
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.

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Table 6-33. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-3: TARGETED EXCAVATION, UPGRADE AND MAINTAIN EXISTING SURFACES AND DISPOSAL AND/OR TREATMENT	
COST[1]		
Capital Cost	Option 3e, Off-site Disposal and/or Treatment	$19,100,000
Present Worth of Long-term Monitoring and Maintenance	Option 3e, Off-site Disposal and/or Treatment	$500,000
Total Present Worth Cost	Option 3e, Off-site Disposal and/or Treatment	$19,600,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-34. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Source Area Soil Alternative 3, Targeted Excavation, Upgrade and Maintain Existing Surfaces and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Soils at the source area contains dioxin at levels above the PRG. This soil will be addressed consistent with this guidance.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants from soil that exceed AWQC in Woonasquatucket River will be minimized to the extent practical.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives). Groundwater objectives established in Rule 8.03 provide groundwater cleanup criteria.	Soils at the source area contain contaminants subject to the Rule 8.02B soil objectives and would be addressed under this alternative consistent with state requirements. Groundwater at the source area contains contaminants subject to the Rule 8.03 GB groundwater objectives and would be addressed under this alternative consistent with state requirements.

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Table 6-34. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs			
Federal Requirements			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact.	Excavation/backfill and capping subject to these requirements. Activities must be conducted in accordance with these requirements, including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Excavation/backfill and capping are subject to these requirements. Activities must be conducted in accordance with these requirements.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	This alternative can only be selected if there is no practicable alternative to occupancy and modification of floodplain. Source area soil is located within the 100 year floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Hazardous waste remains in place within the 100-yr floodplain under this alternative. As a result, these requirements must be met. Principal threat waste and contaminated soils from areas prone to migration are excavated. This alternative would not comply with RCRA closure requirements.

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Table 6-34. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs (cont)			
State Requirements (cont)			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.
Action-Specific ARAR			
Federal Requirements			
TSCA PCB Regulations (40 CFR 761)	Applicable	Establishes requirements for PCB-remediation waste.	PCBs present in source area soil will be addressed in accordance with these requirements.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill and capping must be conducted so that there are no exceedances of AWQC.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.
State Requirement			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Will be used to determine appropriate treatment and disposal
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative meets this requirement.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	R & A	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to closure may not be met.

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Table 6-34. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs (cont)			
State Requirement (cont)			
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	R & A	Outlines design, operational, and closure requirements for land disposal facilities.	This alternative will not meet the substantive requirements related to land disposal.
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation/backfill and capping must be conducted so that there are no exceedances of water quality standards.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-35. Detailed Analysis of Source Area Soil Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-4: TARGETED EXCAVATION, CONVERT TO RCRA CAPS AND MAINTAIN AND DISPOSAL AND/OR TREATMENT
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	Removal of principal threat waste and converting the existing surfaces (interim caps, parking lots, pavement, and landscape areas) to RCRA caps would be highly protective of human health and the environment. Targeted removal of principal threat waste would remove highly toxic or highly mobile waste that generally cannot be reliably contained and could present a significant risk to human health or the environment should exposure occur. The RCRA caps would also meet TSCA requirements for capping PCB remediation waste. This alternative would prevent direct contact with soil, prevent erosion and runoff of contaminated soils, and prevent precipitation infiltration into the groundwater.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 4 are summarized in Table 6-36. This alterative will comply with all ARARs, including requirements for TSCA and RCRA closure. Excavation and placement of fill in wetland areas will result in the destruction of existing wetlands and will trigger wetlands/Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. State wetlands requirements will also need to be addressed. Under this alternative, there would be permanent occupancy and modification of the floodplain. According to Executive Order 11988, a determination would need to be made that there was no other practicable alternative before selecting this option as the preferred remedy.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Excavation and off-site disposal or treatment of the principal threat waste will be effective in the long term. Capping contaminated soils with a RCRA and TSCA cap would increase the long-term effectiveness of this alternative by providing highly reliable chemical isolation. Risk reduction will be high as the cap will be designed, constructed and maintained in compliance with RCRA and TSCA closure requirements. Because contaminated soil is only contained and remains under the cap, inherent hazard of waste also remains.

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Table 6-35. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-4: TARGETED EXCAVATION, CONVERT TO RCRA CAPS AND MAINTAIN AND DISPOSAL AND/OR TREATMENT
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Adequacy and Reliability of Controls	Long-term monitoring, maintenance, and ICs would be required to protect integrity of the caps. ICs would also be required to prevent human exposure, and could include restrictions on excavation, access for buried utilities, and construction with pilings or basements. However, these controls are only effective if adequately monitored and enforced.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	This alternative assumes principal threat waste will be shipped off site for treatment.
Amount Destroyed or Treated	Approximately 5,500 cy of principal threat waste would be excavated and treated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	There would be a reduction of toxicity, mobility, or volume of contamination through treatment under this alternative. The mobility of the contaminated soil particles that remain in place would be reduced by the RCRA caps.
Degree to Which Treatment is Irreversible	For contaminated soils that undergo thermal treatment, the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. For soil that remains on site under the cap, there would be no residuals. Air emissions of contaminants or additional by-products produced during off-site thermal treatment (Option 4e) would be at levels below regulatory standards. After incineration, the volume of inorganic sediment/soil particles would be nearly the same as the pre-treatment volume, but the concentrations of organic chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	There would be some short-term impacts to the community from construction. Access to the work zone during construction activities would be prohibited, but measures would be taken to provide residents access to the buildings and parking areas and maintain utilities. Construction of the clean utility corridor would require excavation into contaminated soil and could result in potential exposure. There would also be potential risk to residents from dust and VOCs generated during excavation activities and installation of asphalt sealants. However, all appropriate measures including engineering controls, dust suppression techniques, and site perimeter air (dust) monitoring would be taken to mitigate risks to the community.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during construction activities, mitigating risks to workers.

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Table 6-35. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-4: TARGETED EXCAVATION, CONVERT TO RCRA CAPS AND MAINTAIN AND DISPOSAL AND/OR TREATMENT
SHORT-TERM EFFECTIVENESS	
Environmental Impacts	Excavation and placement of fill in wetland areas would result in the destruction of existing wetlands.
Time Until Remedial Action Objectives are Achieved	The RAOs would be achieved at the completion of remedy implementation, which is estimated to take approximately 8 months. Achieving the RAOs, however, is contingent on long-term monitoring and maintenance of the RCRA caps that would continue after construction activities are complete.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Generally, this alternative could be easily implemented, and all work could be performed in phases with conventional earthwork or paving equipment. Additional steps may need to be taken to address the concern of working near an apartment building for the elderly. Although there is limited space for staging areas, this should not raise significant implementability concerns.
Reliability of the Technology	Excavation and capping are proven technologies that have been successfully implement at soil sites. The RCRA cap would be made from natural earth materials and geosynthetic materials that are proven to be stable in the long term. There may be some additional reliability issues because the cap would be located in the floodplain.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.
Ability to Monitor the Effectiveness of Remedy	The effectiveness of excavation and air/water quality protection measures could be monitored with routine testing. A physical survey would be conducted at the completion of construction activities to confirm that the RCRA cap meets the design specifications. Long-term monitoring would be required to assess cap performance and determine if additional actions are warranted. The implementation of long-term monitoring and enforcement of ICs are critical to the success of this alternative.

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Table 6-35. (continued)

EVALUATION CRITERIA	ALTERNATIVE SOURCE AREA SOIL-4: TARGETED EXCAVATION, CONVERT TO RCRA CAPS AND MAINTAIN AND DISPOSAL AND/OR TREATMENT	
IMPLEMENTABILITY		
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with the management of the Centredale Manor and Brook Village apartment buildings, adjacent property owners, and appropriate federal, state, and local agencies would be required to implement ICs, develop a traffic control plan, and provide continuous access to residents and building service providers. Residents' concerns about disruptions from construction activities would need to be addressed. Because this alternative constitutes the placement of fill in waters of the US, a determination must first be made that this is the least damaging practicable alternative to the aquatic environment. In addition, this alternative would require the permanent occupancy and modification of the floodplain, and a determination would first need to be made concluding that there is no other practicable alternative before selecting this option as the preferred remedy.	
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. This alternative assumes principal threat waste will be shipped off site for treatment.	
Availability of Necessary Equipment and Specialists	Construction equipment and personnel, and monitoring equipment and personnel, are readily available.	
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.	
COST[1]		
Capital Cost	Option 4e, Off-site Disposal and/or Treatment	$20,800,000
Present Worth of Long-term Monitoring and Maintenance	Option 4e, Off-site Disposal and/or Treatment	$500,000
Total Present Worth Cost	Option 4e, Off-site Disposal and/or Treatment	$21,300,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-36. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Source Area Soil Alternative 4, Targeted Excavation, Convert to RCRA Caps and Maintain and Disposal and/or Treatment

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
OSWER Directive 92-4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (April 13, 1998)	TBC	Guidance cleanup levels for CERCLA removal sites and PRGs for remedial sites for dioxin (as TEQ) in surface soil involving residential exposure scenarios. Also establishes a cleanup range for dioxin (as TEQ) for commercial and industrial exposure scenarios.	Soil at the source area contains dioxin at levels above the PRG. This soil will be addressed consistent with this guidance.
Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA Sites (December 30, 2009)	TBC	Draft recommended interim PRGs of 72 parts per trillion (ppt or ng/kg) dioxin (as TEQ) for residential exposure scenarios and 950 ppt dioxin (as TEQ) for commercial and industrial exposure scenarios are recommended as a starting point for setting cleanup levels for CERCLA removal sites.	Soil at the site contains dioxin at levels above the draft recommended interim PRGs.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants from soil that exceed AWQC in Woonasquatucket River will be minimized to the extent practical.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Unless otherwise specified, soil contaminated as a result of a release of hazardous materials shall be remediated in a manner which meets the direct exposure and leachability criteria for each hazardous substance established in Rule 8.02.B (Method 1 Soil Objectives). Groundwater objectives established in Rule 8.03 provide groundwater cleanup criteria.	Soils at the source area contain contaminants subject to the Rule 8.02B soil objectives and would be addressed under this alternative consistent with state requirements. Groundwater at the source area contains contaminants subject to the Rule 8.03 GB groundwater objectives and would be addressed under this alternative consistent with state requirements.

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Table 6-36. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs			
Federal Requirements (cont)			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact.	Excavation/backfill and capping subject to these requirements. Activities must be conducted in accordance with these requirements, including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Excavation/backfill and capping are subject to these requirements. Activities must be conducted in accordance with these requirements.
Floodplain Management (Executive Order 11988)	TBC	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative.	This alternative can only be selected if there is no practicable alternative to occupancy and modification of floodplain. Source area soil is located within the 100 year floodplain.
State Requirements			
RIDEM Rules and Regulations for Hazardous Waste Management, Location Standards for Hazardous Waste Facilities	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR 264.18(b) are incorporated by reference. Facility located in 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by 100-yr flood, unless demonstrate no adverse effects on human health or environment will result from washout.	Hazardous waste remains in place within the 100-yr floodplain under this alternative. As a result, these requirements must be met. Principal threat waste is excavated and disposed off site.
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Activities required by RIDEM for remediation will be conducted in accordance with these requirements.

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Table 6-36. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARAR			
Federal Requirements			
TSCA PCB Regulations (40 CFR 761)	Applicable	Establishes requirements for PCB-remediation waste.	PCBs present in source area soil will be addressed in accordance with these requirements.
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill and capping must be conducted so that there are no exceedances of AWQC.
Invasive Species (Executive Order 13112)	TBC	Federal agencies are directed to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause when requiring actions that impact the environment.	Actions will be taken to address invasive species consistent with the Executive Order.
State Requirement			
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Will be used to determine appropriate treatment and disposal.
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative meets this requirement.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	R & A	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to land disposal must be met.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 10 (3/07) – Land Disposal Facilities	R & A	Outlines design, operational, and closure requirements for land disposal facilities.	This alternative will meet the substantive requirements related to land disposal.
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation and capping must be conducted so that there are no exceedances of water quality standards.

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Table 6-36. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs (cont)			
State Requirement (cont)			
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-37. Key Features of the Source Area Soil Alternatives

Alternati	ve		
	1 – No Action	**3e – Targeted Excavation, Upgrade and Maintain Existing Surfaces, and Off-site Disposal and/or Treatment**	**4e – Targeted Excavation, Convert to RCRA Caps and Maintain, and Off-site Disposal and/or Treatment**
Present Worth Cost	$170K[1] $1	9.6M	$21.3M
Remediation Area (acres)	—	Excavate: 1.7 Isolation Cap: 7.8 Total: 7.8	Excavate: 0.85 Isolation Cap: 7.8 Total: 7.8
Excavation Volume (cy)	—	9,800	5,500
Estimated Time to Achieve RAOs	Unknown	3 months (after construction complete), to achieve RAO to prevent direct contact Unknown for RAO to prevent migration and leaching of contaminants from soil to groundwater	8 months (after construction complete) Achieving the RAOs, contingent on long-term monitoring and maintenance of the RCRA caps.

Notes:
[1] If periodic monitoring is implemented, the annual cost for monitoring would be $14,000 and the present worth costs would be $170,000.

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Table 6-38. Detailed Analysis of Source Area Groundwater Alternative 1, No Action

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE-1: NO ACTION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	Contaminated groundwater would remain on site unaddressed and could continue to migrate and discharge into the Woonasquatucket River. The existing controls (GB groundwater classification) would limit groundwater exposure to human receptors.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	See Table 6-39. This alternative would not comply with ARARs for surface water and groundwater quality.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Existing risk will remain as no action is taken to address the contamination. Contaminants would continue to migrate to the Woonasquatucket River.
Adequacy and Reliability of Controls	There are no actions to reliably and adequately control the contamination and no controls in place to prevent exposure.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	None proposed for this alternative.
Amount Destroyed or Treated	None anticipated.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	No reductions in toxicity, mobility or volume of contamination through groundwater treatment will occur under this alternative. Groundwater concentrations might be naturally attenuated over time, but without rigorous long-term monitoring it would not be possible to assess the rate of recovery.
Degree to Which Treatment is Irreversible	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	There would be no residuals because no treatment is planned for this alternative.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	Not applicable as no remedial actions are proposed for this alternative.
Protection of Workers During Remedial Action	Not applicable as no remedial actions are proposed for this alternative.
Environmental Impacts	Not applicable as no remedial actions are proposed for this alternative.

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Table 6-38. (continued)

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE-1: NO ACTION
SHORT-TERM EFFECTIVENESS	
Time Until Remedial Action Objectives are Achieved	While some reduction in risk is possible due to natural attenuation, it is unknown if or when the cleanup objectives would be reached because groundwater monitoring is not included with this alternative.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Not applicable as no remedial technology is proposed as part of this alternative.
Reliability of the Technology	Not applicable as no remedial technology is proposed for this alternative.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative does not preclude future remedial activities.
Ability to Monitor the Effectiveness of Remedy	Five year reviews and periodic monitoring, triggered by severe weather events, are incorporated into this alternative. It is assumed that there would be one groundwater monitoring event and report to EPA every five years. Periodic monitoring would include routine testing and could be easily implemented.
Ability to Obtain Approvals and Coordinate with Other Agencies	Not applicable as no remedial technology is proposed as part of this alternative.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Not applicable for this alternative.
Availability of Technology	Not applicable for this alternative.
COST[1]	
Capital Cost	$0
Present Worth of Long-term Monitoring and Maintenance	$270,000 (includes periodic monitoring; costs for five-year reviews covered under Source Area soil alternatives)
Total Present Worth Cost	$270,000

Notes:
[2]Detailed cost estimates provided in Appendix J.

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Table 6-39. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Source Area Groundwater Alternative 1, No Action[1]

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Discharges from the action area may cause degradation of surface water quality of the Woonasquatucket River in excess of AWQC. This alternative would not address these exceedances.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Groundwater objectives established in Rule 8.03 provide groundwater cleanup criteria..	Groundwater at the action area contains contaminants subject to the Rule 8.03 GB groundwater objectives that would not be addressed under this alternative.
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances.	Discharges from the action area may cause degradation of surface water quality of Woonasquatucket River in excess of water quality standards. This alternative would not address these exceedances.

Notes:
[1] With no action, there are no location- or action-specific ARARs.

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Table 6-40. Detailed Analysis of Source Area Groundwater Alternative 2, Excavation/Dewatering

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE 2: EXCAVATION/DEWATERING
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection (and the Environment)	The removal of contaminated soil and groundwater would mitigate risks by reducing VOC concentrations in groundwater to levels that meet the ARARs for groundwater quality and preventing future migration of contaminated groundwater to the Woonasquatucket River.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 2 are summarized in Table 6-41. This alternative is expected to comply with ARARs for groundwater and surface water quality. Excavation, dewatering, and placement of the sheet pile wall as a permanent structure in the river would trigger Clean Water Act Section 404 requirements. As a result, these actions must be evaluated to determine the least damaging practicable alternative. Excavation could result in the destruction of some riverbank wetland resource areas and state wetlands requirements will need to be addressed.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	Removal of the contaminant source and off-site disposal and treatment of contaminated soil would provide long-term highly reliable protection from leaching of contaminants from soil to groundwater and from migration of contaminated groundwater to the Woonasquatucket River.
Adequacy and Reliability of Controls	Periodic monitoring of groundwater will be conducted to assess the efficacy of the remedy. ICs would be required to prevent the use of groundwater. However, these controls are only effective if adequately monitored and enforced.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	Extracted groundwater would be treated. Some of the excavated soil will likely require treatment to meet LDRs.
Amount Destroyed or Treated	Approximately 80,000 gallons of extracted groundwater would be treated and returned to the surface water in accordance with ARAR requirements. Approximately 1,300 cubic yards of excavated soil would be shipped off site. Some of this material will likely require treatment to meet LDRs.
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	For excavated soils that are incinerated (up to 1,300 cy), the mobility, toxicity and volume would be reduced.
Degree to Which Treatment is Irreversible	For soils that undergo thermal treatment, the process is irreversible.

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Table 6-40. (continued)

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE 2: EXCAVATION/DEWATERING
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Type and Quantity of Residuals Remaining After Treatment	Excavation would produce no residuals. Air emissions of contaminants or additional by-products produced during off-site thermal treatment would be at levels below regulatory standards. After incineration, the volume of inorganic sediment/soil particles would be nearly the same as the pre-treatment volume, but the concentrations of organic chemical contaminants would be below detection limits.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	There would be some short-term impacts to the community under this alternative. There is the potential for exposure to contaminated soils. However, actions would be taken during construction to minimize such impacts. Access to the work zone during construction activities would be prohibited, and engineering controls, dust suppression techniques, site perimeter air (dust) monitoring, and air and noise monitoring and abatement will mitigate risks to the community. In addition, actions would be taken to minimize disruption to use of the parking lots by the residents.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression), and personal protective equipment will be used during construction activities, mitigating risks to workers.
Environmental Impacts	Excavation would require the temporary occupancy of floodplain areas during construction and temporary work areas would be cleared of vegetation. The floodplain would be restored at the completion of construction.
Time Until Remedial Action Objectives are Achieved	RAOs would be achieved immediately upon completion of remedy implementation, which is estimated to take approximately one month.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	This alternative would be relatively easy to implement, and all work could be performed with conventional earthwork equipment. There is limited space for staging areas, however this should not present any significant implementability issues. In addition, excavation near the river would present an added degree of difficulty but should not raise significant issues.
Reliability of the Technology	Excavation of soils is a highly reliable and proven technology, although excavation near the river and below the groundwater can present some challenges. Groundwater and soil disposal and/or treatment technologies are proven technologies.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.

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Table 6-40. (continued)

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE 2: EXCAVATION/DEWATERING
IMPLEMENTABILITY	
Ability to Monitor the Effectiveness of Remedy	During construction, treated groundwater would be tested on a regular basis to confirm that chemical concentrations were at levels acceptable for return to the surface water in accordance with ARAR requirements. Periodic monitoring would be performed to assess the efficacy of the remedy in support of five year reviews. The implementation of periodic monitoring would not present any unusual issues.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with the management of the Centredale Manor and Brook Village apartment buildings, adjacent property owners, and appropriate federal, state, and local agencies would be required to develop a traffic control plan, and provide continuous access to residents and building service providers. Residents' concerns about disruptions from construction activities would need to be addressed. Impacts to riverbank wetland resource areas would need to be addressed consistent with federal and state requirements.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Off-site landfill and treatment options are readily available. Samples of excavated soil could be tested to determine if the material could be taken to a hazardous waste landfill without treatment.
Availability of Necessary Equipment and Specialists	Excavation and groundwater pumping construction contractors and equipment are readily available. Treatment equipment is also readily available.
Availability of Technology	Technology is common enough that required equipment and materials would be readily available.
COST[1]	
Capital Cost	$2,700,000
Present Worth of Long-term Monitoring and Maintenance	$300,000 (costs for five-year reviews covered under Source Area soil alternatives)
Total Present Worth Cost	$3,000,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-41. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Source Area Groundwater Alternative 2, Excavation/Dewatering

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants that exceed AWQC in Woonasquatucket River will be minimized to the extent practical.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Groundwater objectives established in Rule 8.03 03 provide groundwater cleanup criteria.	Groundwater at the action area contains contaminants subject to the Rule 8.03 GB groundwater objectives and would be addressed under this alternative consistent with state requirements. Contaminated soils that exceed GB leachability criteria in Rule 8.02.B will be addressed under the Source Area Soil remedy.
RIDEM Water Quality Regulations, 7/06	R & A	Provides water classification for surface waters in Rhode Island and sets water quality standards.	Contaminants that exceed water quality standards in Woonasquatucket River will be minimized to the extent practical.
Location-Specific ARARs			
Federal Requirements			
Clean Water Act, Section 404 Guidelines for discharge of dredged or fill material into waters of US (40 CFR Parts 230 and 231, 33 CFR Parts 320-323, and 33 CFR Part 332)	Applicable	Outlines requirements for the discharge of dredged or fill materials into surface waters, including wetlands. Such discharges are not allowed if there are practicable alternatives with less adverse impact. Sets standards for restoration and mitigation required as a result of unavoidable impacts to aquatic resources.	Excavation/backfill, dewatering, capping, and sheet pile wall are subject to these requirements. Activities must be conducted in accordance with these requirements, including but not limited to mitigation and/or restoration. Alternative must be evaluated to determine least damaging practicable alternative before it can be selected.

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Table 6-41. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Location-Specific ARARs (cont)			
Federal Requirements (cont)			
Rivers and Harbors Act Section 10 (33 U.S.C. Section 403)	Applicable	Sets forth criteria for placing dams/structures in navigable waters of the U.S.	Coffer dam and sheet pile wall subject to these requirements. Activities must be conducted in accordance with these requirements.
Protection of Wetlands (Executive Order 11990)	TBC	Federal agencies are required to avoid adversely impacting wetlands unless there is no practicable alternative and the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Excavation/backfill and capping are subject to these requirements. Activities must be conducted in accordance with these requirements.
State Requirement			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Some riverbank wetland resource areas are located within the site boundaries. Activities must be conducted in accordance with Rule 6.08.
Action-Specific ARAR			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	Applicable	Ambient Water Quality Criteria (AWQC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Excavation/backfill, dewatering, and capping must be conducted so that there are no exceedances of AWQC.
State Requirement			
RIDEM Regulations for the Rhode Island Pollutant Discharge Elimination System (RIPDES) (2/03)	Applicable	Contains discharge limitations, monitoring requirements, and best management practices applicable to discharges to navigable waters.	Remediation activities may require discharge of water to the Woonasquatucket River as a result of extracting groundwater or dewatering an excavation. Discharge of treated groundwater to river will meet substantive requirements.

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Table 6-41. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARARs (cont)			
State Requirement (cont)			
RIDEM Water Quality Regulations, 7/06	Applicable	Provides water classification for surface waters in Rhode Island and sets ambient water quality criteria for toxic substances and governs water quality impacts associated with site activities.	Excavation/backfill, dewatering, and capping must be conducted so that there are no exceedances of water quality standards.
RIDEM Rules and Regulations for Groundwater Quality, 5/06	Applicable	Establishes construction standards for permanent monitoring wells and abandonment procedures (Appendix 1)	Monitoring wells will comply with these standards.
RIDEM Rules and Regulations for Hazardous Waste Management Amendment Eff. 2/9/07 Identification and Listing of Hazardous Wastes	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its regulations. The standards of 40 Part 261 of RCRA are incorporated by reference. Sets forth requirements for hazardous waste determination according to federal (40 CFR 262.11) and RI State (Rule 5.08) definitions.	Material generated by excavation will undergo hazardous waste determination to determine appropriate treatment and disposal.
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative will meet these requirements.
RIDEM Rules and Regulations for Hazardous Waste Management, Section 9 (3/07) – Operation Requirements for Treatment, Storage, and Disposal Facilities	Applicable	Outlines operational requirements for all hazardous waste treatment, storage, and disposal facilities, including general waste analyses, security procedures, inspections, safety, etc. Sets design, construction, and operational requirements for hazardous waste containers and tanks, and closure requirements for hazardous waste facilities.	Substantive requirements related to excavated material and closure must be met.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable Requires	that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable Prohibits	emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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Table 6-42. Detailed Analysis of Source Area Groundwater Alternative 5, In-Situ Chemical Oxidation

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	
Human Health Protection and the Environment	This alternative may be protective of human health and the environment because concentrations of PCE and TCE would probably be reduced to acceptable levels and migration of contaminants to the river could be reduced or eliminated.
COMPLIANCE WITH ARARS	
Chemical-, Location-, and Action-Specific	ARARs specific to Alternative 5 are summarized in Table 6-43. This alternative will probably comply with ARARs for groundwater quality. This alternative may not comply with ARARs for surface water quality because the technology is unproven with respect to destruction of low-level dioxin contamination. A non-CERCLA waiver may be required if underground injections of chemical oxidants occur within 50 ft of a river. State wetlands requirements would have to be evaluated for compliance. Monitoring wells would be installed and monitored between the application area and the Woonasquatucket River to ensure that application chemicals do not impact the surface water.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
Magnitude of Residual Risk	In-situ chemical oxidation would effectively destroy chlorinated solvents and possibly dioxins. Bench-scale and pilot testing would be required to confirm the effectiveness for dioxins and site conditions. Risk reduction could be high although there is some uncertainty regarding the technology. The alternative depends on the ability of the reagent to contact and react with the dioxin and solvents. Follow-on treatments would be applied if rebound in contamination levels were observed
Adequacy and Reliability of Controls	Periodic monitoring of groundwater will be conducted to assess the efficacy of the remedy. ICs may be required to prevent exposure to groundwater as a result of excavation, demolition, or other activities. ICs restricting future site groundwater use would be required. However, these controls are only effective if adequately monitored and enforced.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Treatment Process Used and Materials Treated	This alternative involves the injection of an oxidizing agent such as ozone, hydrogen peroxide, or persulfate into the groundwater in the vicinity of Well MW-05S. The oxidizing agent would cause the rapid chemical destruction of the PCE and TCE in the groundwater, and possibly dioxins.
Amount Destroyed or Treated	The area to be treated is estimated as 50 ft by 100 ft and up to 12 ft deep. Injections would be made at approximately 5-foot spacings.

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Table 6-42. (continued)

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	
Degree of Expected Reductions of Toxicity, Mobility, or Volume Through Treatment	This alternative would reduce the toxicity, mobility, and volume of PCE, TCE and dioxin through chemical treatment.
Degree to Which Treatment is Irreversible	For soils and groundwater that undergo chemical treatment, the process is irreversible.
Type and Quantity of Residuals Remaining After Treatment	In-situ chemical treatment would produce no residuals.
SHORT-TERM EFFECTIVENESS	
Protection of Community During Remedial Action	The short-term impacts to the community should be limited because the work would be confined to a small area and actions would be taken during construction to minimize impacts. Access to the work zone during construction activities would be prohibited, and engineering controls (dust and noise control) would mitigate risks to the residents and community.
Protection of Workers During Remedial Action	Health and safety plans, emergency response plans, engineering controls (dust suppression and noise control), and personal protective equipment will be used during construction activities, mitigating risks to workers.
Environmental Impacts	This alternative would require the temporary occupancy of floodplain areas during construction and temporary work areas would be cleared of vegetation. The floodplain would be restored at the completion of construction. Short-term impacts to habitat are a concern due to oxidation within 50 feet of the river, though these impacts would likely be minimized through the use of a fast-acting reagent focused on in-situ application within areas of groundwater contamination.
Time Until Remedial Action Objectives are Achieved	The RAOs are expected to be achieved immediately upon completion of remedy implementation, which is estimated to take approximately one month.
IMPLEMENTABILITY	
Ability to Construct and Operate the Technology	Obtaining the specialized equipment and experienced crew may require mobilization from outside the region.
Reliability of the Technology	There is some question regarding the reliability of this technology to reduce contaminant concentrations. In-situ chemical treatment is a proven technology for the destruction of chlorinated solvents, but bench-scale testing and a field demonstration with adequate monitoring may be desired to confirm the safety and effectiveness of the in-situ chemical oxidation alternative.
Ease of Undertaking Additional Remedial Actions, If Necessary	This alternative would not preclude additional future remedial actions.

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Table 6-42. (continued)

EVALUATION CRITERIA	GROUNDWATER ALTERNATIVE 5: IN-SITU CHEMICAL OXIDATION
IMPLEMENTABILITY	
Ability to Monitor the Effectiveness of Remedy	Soil and groundwater monitoring would be performed during construction activities to measure the removal of VOCs and dioxin in groundwater and soil at the impacted area. Periodic monitoring would be required to assess the long-term effectiveness of the remedy. Monitoring would require routine testing and could be easily implemented.
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination with the management of the Centredale Manor and Brook Village apartment buildings, adjacent property owners, and appropriate federal, state, and local agencies would be required to develop a traffic control plan, and provide continuous access to residents and building service providers. Residents' concerns about disruptions from construction activities would need to be addressed. Impacts to riverbank wetland resource areas would need to be addressed consistent with federal and state requirements.
Availability of Off-Site Treatment, Storage, and Disposal Services and Capacity	Not applicable for this alternative.
Availability of Necessary Equipment and Specialists	Obtaining the specialized equipment and an experienced crew may require a mobilization from outside the region, but such equipment and staff are commercially available.
Availability of Technology	Technology is common enough that the required equipment and materials would be commercially available.
COST[1]	
Capital Cost	$880,000
Present Worth of Long-term Monitoring and Maintenance	$330,000 (costs for five-year reviews covered under Source Area soil alternatives)
Total Present Worth Cost	$1,200,000

Notes:
[1]Detailed cost estimates provided in Appendix J.

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Table 6-43. Potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Criteria for Source Area Groundwater Alternative 5, In-Situ Chemical Oxidation

Requirement	Status	Synopsis	Action to Be Taken to Attain Requirement
Chemical-Specific ARARs			
Federal Requirements			
Clean Water Act Federal Water Quality Criteria, Section 304(a) 40 CFR 131.11 1976, 1980, and 1986.	R & A	Ambient Water Quality Criteria (AWOC) are provided by EPA for chemicals for both the protection of human health and the protection of aquatic life.	Contaminants that exceed AWQC in Woonasquatucket River will be minimized to the extent practical but surface water requirements may not be met.
State Requirements			
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), 2/04	Applicable	Groundwater objectives established in Rule 8.03 03 provide groundwater cleanup criteria.	Groundwater at the action area contains contaminants subject to the Rule 8.03 GB groundwater objectives and would be addressed under this alternative consistent with state requirements. Contaminated soils that exceed GB leachability criteria in Rule 8.02.B will be addressed under the Source Area Soil remedy.
RIDEM Water Quality Regulations, 7/06	R & A	Provides water classification for surface waters in Rhode Island and sets water quality standards.	Contaminants that exceed water quality standards in Woonasquatucket River will be minimized to the extent practical but surface water requirements may not be met.
Location-Specific ARARs (there are no Federal requirements)			
State Requirements			
RIDEM Rules and Regulations Governing the Enforcement of the Freshwater Wetlands Act (December 2009)	Applicable	Sets requirements to prevent the undesirable drainage, excavation, filling, alteration, encroachment, or any other form of disturbance or destruction to a wetland.	Some riverbank wetland resource areas are located within the site boundaries. Activities required by RIDEM for remediation are permitted provided site plans are submitted to the Freshwater Wetland Program for review and activities are conducted in accordance with Rule 6.08.

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Table 6-43. (continued)

Requirement Status		Synopsis	Action to Be Taken to Attain Requirement
Action-Specific ARAR (there are no Federal requirements)			
State Requirement			
RIDEM Rules and Regulations for Groundwater Quality, 5/06	Applicable	Establishes construction standards for permanent monitoring wells and abandonment procedures (Appendix 1)	Monitoring wells will comply with these standards.
RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (i.e., Remediation Regulations), (2/04) DEM-DSR-01-93 Section 8.0 (Risk Management)	Applicable	This section regulates impacted media at contaminated sites.	This section was used to develop cleanup goals for the site. This alternative will meet these requirements.
RIDEM Underground Injection Control Program (5/05)	Applicable	Establishes rules for remedial actions that include subsurface discharge or underground injection of treated or untreated groundwater.	Subsurface injections of chemical oxidants must meet these requirements.
RI Air Pollution Control Regulation #1: Visible Emissions (8/67, Amended 7/07)	Applicable	Establishes opacity limitations for contaminant emissions	Remediation will be conducted to meet the standards for visible emissions.
RI Air Pollution Control Regulation #5: Fugitive Dust, 7/19/07	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Actions will be taken to prevent particulate matter from becoming airborne in accordance with these regulations.
RI Air Pollution Control Regulation #7: Emissions Detrimental to Persons or Property, 7/19/07	Applicable	Prohibits emissions of contaminants which may be injurious to human, plant, or animal life or cause damage to property or which unreasonably interfere with the enjoyment of life and property.	Any potential emissions subject to these requirements will meet these standards.

Key:
R & A – Relevant and Appropriate; TBC – To Be Considered

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