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TECHNICAL MEMORANDUM

DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

ROLLING KNOLLS LANDFILL SUPERFUND SITE

CHATHAM, NEW JERSEY

Prepared for

Rolling Knolls Landfill Settling Parties

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EXECUTIVE SUMMARY

This Development and Screening of Remedial Alternatives Technical Memorandum (DSRA Tech Memo) has been prepared for the Rolling Knolls Landfill Superfund Site (the Site) in Chatham, New Jersey. The purpose of this DSRA Tech Memo is to identify and evaluate a range of potential remedial alternatives based upon the remedial action objectives for the Site, to conduct an initial screening of these alternatives based upon effectiveness, implementability and cost, and to select those alternatives that will be carried forward for more detailed evaluation in the Feasibility Study (FS).

The Site includes a 140-acre municipal solid waste landfill with limited industrial waste and a 30-acre Surface Debris Area. Approximately 100 of the 140 acres of the landfill is owned by the Trust created by the Last Will and Testament of Angelo J. Miele (Miele Trust). Approximately 35 acres of the landfill are in the Great Swamp National Wildlife Refuge (GSNWR) and are owned by the United States Fish and Wildlife Service. Five acres of property included within the United States Environmental Protection Agency's (USEPA's) definition of the Site is owned by the Green Village Fire Department. The Surface Debris Area is adjacent to the landfill and has debris scattered on the ground surface but no buried waste, and is owned by the Miele Trust.

The Site is located at the southern end of Britten Road in the Green Village portion of Chatham Township. Green Village is currently a scenic, rural village oriented along Green Village Road. Green Village Road is a 2-lane (one in each direction) county road with residential and limited commercial development on each side. Britten Road intersects Green Village Road and is primarily residential. It is approximately 1.5 lanes wide and is the only road that provides access to the Site. The Site is approximately 5.5 miles from the nearest major road, State Route 24, and is accessible only by driving through residential and commercial areas of Chatham.

Wetlands and flood hazard areas occupy the adjacent areas to the east, south, and west of the Site and portions of the landfill itself. Areas on and adjacent to the landfill provide habitat for native mammals, fish, amphibians, and reptiles, including the endangered bog turtle, Indiana bat, and blue-spotted salamander.

Site conditions and constituent concentrations in soil, sediment, surface water, and groundwater have been characterized through several phases of investigation since 2006. Analytical results indicate that metals, semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs) are present in surface soil at concentrations greater than New Jersey Soil Remediation Standards. Volatile organic compounds (VOCs) are present in groundwater in limited areas of the Site at concentrations above the New Jersey Ground Water Quality Standards, and certain metals are present at concentrations above the New Jersey Ground Water Quality Standards in groundwater below and near the landfill.

Ecological and human health risk assessments have been completed to assess the risks associated with the Site. The results of the ecological risk assessment indicate that exposures to constituents in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robins through exposure to constituents in soil.

The human health risk assessment indicated that, for current exposures and reasonably anticipated future exposures, all estimated cancer risks and the majority of non-cancer health hazard to human receptors are within or less than USEPA target levels. For landscapers that store and maintain equipment in one area of the landfill, the estimated non-cancer hazard is slightly greater than the USEPA target level, but Hazard Indices for individual target organs are all less than or equal to the USEPA target level of 1. Estimated non-cancer health hazard to the adolescent and adult trespassers that currently enter the landfill, or that may reasonably be anticipated to enter the landfill in the future, are greater than the USEPA target level.

Estimated cancer risks and non-cancer health hazards to potential receptors if the Site were to be developed residentially are greater than USEPA target levels, however the human health risk assessment did not characterize residential as a reasonably anticipated future use. Significantly, the Reuse Assessment Report (TRC, 2017) confirms that residential development of the Site is unlikely because:

- the presence of extensive state- and federally-regulated areas on the Site limit any potential development over much of the Site area;
- the environmentally sensitive nature of the surrounding area dictates that habitat preservation is the most appropriate use;
- state, county and local planning documents discourage development away from established centers in environmentally sensitive areas and focus on protection of GSNWR;
- the lack of available infrastructure and the limited Site access issues;
- the continued presence of buried waste at the Site; and
- local opposition to residential development.

Therefore, remedial options relevant to residential development are not considered in the DSRA Tech Memo.

Twenty-nine remedial technologies were evaluated for soil remediation. Of these, 12 were retained for consideration in developing Remedial Alternatives. Five Remedial Alternatives were developed for soil, and were screened to determine whether they should be carried forward into the FS. These five Remedial Alternatives included:

1) No Action;
2) Site Controls (i.e., Institutional Controls and Access Restrictions);
3) Site Controls, Excavation, and Off-Site Disposal of Selected Areas to Reduce Overall Risk;
4) Site Controls and Capping of Selected Areas to Reduce Overall Risk; and
5) Site Controls and Capping of All Landfill Material.

Twenty-nine remedial technologies were evaluated for groundwater remediation. Of these, 19 were retained for consideration in developing Remedial Alternatives. Four Remedial Alternatives were developed for groundwater, and were screened to determine whether they should be carried forward into the FS. These four Remedial Alternatives included:

1) No Action;
2) Monitored Natural Attenuation (MNA);
3) MNA with Source Control; and
4) Biological Treatment and MNA with Source Control.

We recommend that all the Remedial Alternatives noted in the DSRA Tech Memo for soil and groundwater be retained for full evaluation in the FS.

1. INTRODUCTION

On behalf of Chevron Environmental Management Company for itself and on behalf of Kewanee Industries, Alcatel-Lucent USA, Inc., and Novartis Pharmaceuticals Corporation (collectively, the Group), Geosyntec Consultants (Geosyntec) has prepared this Development and Screening of Remedial Alternatives Technical Memorandum (DSRA Tech Memo) for the Rolling Knolls Landfill Superfund Site (the Site) in Chatham, New Jersey. The purpose of this DSRA Tech Memo is to identify and evaluate a range of potential remedial alternatives based upon the remedial action objectives for the Site, to conduct an initial screening of these alternatives based upon effectiveness, implementability and cost, and to select those alternatives that will be carried forward for more detailed evaluation in the Feasibility Study (FS).

The Site location is shown in Figure 1-1, and the Site features are shown in Figure 1-2. The Group began investigations of the Site in 2007, in compliance with the requirements of the Administrative Settlement Agreement and Order on Consent (Agreement) (Index No. II-CERCLA-02-2005-2034) between the United States Environmental Protection Agency (USEPA) and the Group, which was executed in 2005. The work was conducted in accordance with USEPA-approved work plans.

The remainder of this report includes:

- A discussion of Site conditions and results of Site investigations (Section 2);
- The results of human health and ecological risk assessments (Section 3);
- A summary of the constituents of concern (COCs), and presentation of the Applicable or Relevant and Appropriate Requirements (ARARs) and preliminary Remedial Action Objectives (RAOs) (Section 4);
- The development and screening of remedial technologies and process options (Section 5);
- Development and analysis of remedial alternatives (Section 6); and
- Summary and recommendations for the FS (Section 7).

2. SITE BACKGROUND

2.1 Site Location, Topography, and Features

The Site location is shown in Figure 1-1, and the Site features are shown in Figure 1-2. The Site is located at the southern end of Britten Road in the Green Village portion of Chatham Township. Green Village is currently a scenic, rural village oriented along Green Village Road. Green Village Road is a 2-lane (one in each direction) county road with residential and limited commercial development on each side. Britten Road intersects Green Village Road and is primarily residential. It is approximately 1.5 lanes wide and is the only road that provides access to the Site. The Site is approximately 5.5 miles from the nearest major road, State Route 24, and is accessible only by driving through residential and commercial areas of Chatham.

The Site is located within the Piedmont Physiographic Province which is characterized by a low rolling plain that is divided by a series of higher ridges. The topography in the vicinity of the Site is approximately 240 feet above mean sea level (amsl) with minor fluctuation in topographic relief.

The Rolling Knolls Landfill covers approximately 140 acres, with waste materials of varying thickness on top of native soil. Portions of the landfill are covered by a thin layer of soil whereas waste materials are visible on other portions of the Site. Most of the landfill is heavily vegetated. An additional 30 acres adjacent to the western side of the landfill is primarily wooded but includes scattered surface debris and is designated the Surface Debris Area. A large pond is located within the Surface Debris Area, and two ponds are located on or near the northern boundary of the landfill.

Wetlands occupy the adjacent areas to the east, south, and west of the Site. Loantaka Brook and residential properties are located to the west. The Black Brook and Great Swamp National Wildlife Refuge (GSNWR), including a designated Wilderness Area, borders the Site to the south and east. GSNWR includes a portion of the landfill, as discussed in Section 2.2 below.

GSNWR was established in 1960 and encompasses 7,768 acres of varied habitats, including wetlands, uplands, and aquatic areas. The eastern portion of the GSNWR comprises the 3,660-acre Wilderness Area. More than 244 species of birds have been identified at GSNWR, as well as a wide range of native mammals (for example, river otter, mink, red fox, and opossum), fish, amphibians and reptiles. Several endangered species, including Indiana bat, bog turtle, and blue-spotted salamander are also found at the GSNWR (FWS, 2016).

A Baseball Field and a Shooting Range are located north of the landfill. A small building known as the Hunt Club is located in the Surface Debris Area near the western boundary of the landfill; it is generally unoccupied but is used occasionally for social gatherings. Two areas of the Site (Landscape Areas 1 and 2) are leased to landscaping firms for the storage of trucks and equipment.

2.2 Site Ownership

The central and western portions of the landfill, including the Surface Debris Area (shown on Figure 2-1), are owned by the Trust created by the Last Will and Testament of Angelo J. Miele. We have been advised the Paul Miele is the current Trustee of the Trust. The Trust owns approximately 100 acres of the landfill, plus the adjacent Surface Debris Area of approximately 30 acres. The Green Village Fire Department owns the northeastern portion of the property that USEPA includes within the definition of the Site, including approximately 5 acres of the landfill, and areas just north of the landfill that are currently occupied by the Baseball Field and Shooting Range, although there is no evidence that landfilling occurred in these areas. The remainder of the landfill (approximately 35 acres) is owned by the United States Fish and Wildlife Service (USFWS).

2.3 Site History

The Rolling Knolls Landfill reportedly operated from the 1930s until the late 1960s. The landfill was closed in December 1968. Wastes that were disposed of at the landfill during its operation included primarily municipal solid waste as well as a limited amount of industrial wastes and construction and demolition debris generated by the surrounding municipalities (including: Summit, South Orange, Madison, Harding, Chatham Township, Chatham Borough, Berkeley Heights, Warren, Morristown, Millburn, Florham Park, Long Hill, New Providence, Maplewood and the County of Morris). The regulations imposed by the Chatham Township Board of Health (CTBH) during and after the operation of the landfill included requirements for weekly inspections, the application of minimal daily cover (i.e., "swamp muck"), rodent and mosquito control, and drainage of stagnant surface water (Arcadis, 2012). CTBH records also referenced the application of herbicides, oil (as a dust control measure), chemical sprays (for rodent control), the disposal of dead animals, and for a period of time, disposal of septic wastes (Arcadis, 2012).

In 1964, the United States acquired 300 acres of land from the North American Wildlife Federation. A portion of that land was subject to an easement that permitted the Miele Trust to conduct sanitary landfilling operations through December 31, 1968. Landfilling operations appear to have been conducted on approximately 35 acres of this property, which became part of the Great Swamp National Wildlife Refuge (GSNWR). Due to accessibility issues realized during a fire in 1974, the Trust was permitted to construct fire roads at the site, which it did from 1979 to 1982. The fire roads consist of imported material, including construction and demolition debris, and are approximately 4 feet higher than the surrounding landfill surface (Arcadis, 2012).

2.4 Previous Investigations

Contractors to USEPA conducted several investigations at the Site between 1985 and 2003. The work included collection and analysis of soil, sediment, and surface water and fish tissue samples. In addition, these investigations included installation and sampling of seven monitoring wells. Six of these monitoring wells are still in use.

The results of these investigations were used by USEPA in the initial evaluation of the Site. However, they have been superseded by the results of the investigations conducted by the Group since the ACO was executed.

2.5 Implementation of the RI

- The RI was conducted in two major phases. The first phase was implemented from 2007 through 2011, with the general objectives of (1) characterizing the geology and hydrogeology at and in the vicinity of the landfill; (2) characterizing the waste in the landfill including its contents and extent; (3) characterizing COCs in environmental media (soil, sediment, surface water, groundwater, and soil gas) at and in the vicinity of the landfill; and (4) providing a basis for risk assessments and for remedy selection. The results of the first phase of the RI were reported in the SCSR (Arcadis, 2012).

- After the submittal of the SCSR, the USEPA and the Group discussed additional work that might be needed to address data gaps at the Site that were needed to complete the RI. The overall objectives of the additional work were to (1) complete characterization of the nature and extent of COCs associated with the Site; (2) provide additional information to be used in scoping an evaluation of ecological risk; and (3) provide additional information to be used in screening remedial alternatives and selecting a remedy for the Site. The results of the second phase of the RI were reported in the Data Gaps Tech Memo (Geosyntec, 2016a).

- The Group provided a draft RI Report (RIR) to the USEPA in November 2016 (Geosyntec, 2016b). USEPA has reviewed and provided comments to the draft RIR, which the Group is currently addressing. The Group also conducted a supplemental groundwater investigation to evaluate the efficacy of monitored natural attenuation (MNA) as a remedial action to address constituents in groundwater at the Site. The results of this investigation were provided to the USEPA in January 2017 in the Supplemental Groundwater and Baseline Monitored Natural Attenuation Investigation Report (Groundwater MNA Report; Geosyntec, 2017).

- In connection with USEPA's nationwide directive to ensure that remedial action objectives reflect reasonably anticipated future land uses, the Group conducted a reuse assessment to evaluate Site-specific, reuse-related considerations to identify reasonably anticipated future Site uses. The results of this assessment were provided to the USEPA in February 2017 in the Reuse Assessment Report (TRC, 2017).

- The following summary of the RI results is based on information in the draft RIR and in the Groundwater MNA Report.

2.6 RI Results

2.6.1 Soil

Approximately 240 soil samples were collected in shallow soil within and near the landfill footprint. The depths of these samples were generally 0.0 to 1.0 feet below ground surface (bgs), but some were as deep as 1.5 to 2.0 feet bgs if the shallower intervals did not contain enough soil to sample. Most were analyzed for full Target Compound List and Target Analyte List (TCL/TAL) constituents. A subset of the samples was also analyzed for dioxins, furans, and polychlorinated biphenyl (PCB) congeners.

Surface and subsurface soil impacts were identified across the landfill, including SVOCs, polychlorinated biphenyls (PCBs), pesticides and inorganic constituents (i.e. metals, most frequently lead and arsenic). In general, the constituents are widespread and their distribution does not suggest a point source or discrete spills or releases. Few isolated impacts were observed in the Surface Debris Area, in the western portion of the landfill, and along the western and southwestern landfill perimeter. No waste disposal occurred and no landfill-related impacts were observed in soil at the Baseball Field and Shooting Range, which USEPA includes in the definition of the Site but which are located north of the landfill. Constituent levels in soil samples obtained at or adjacent to the edges of the landfill are generally less than applicable residential soil remediation standards, providing horizontal delineation of the constituents. With the exception of one location where a low level of PCBs was detected, subsurface soil samples collected beneath the landfilled materials confirmed that constituents in the landfill are not migrating into the underlying soil.

2.6.2 Sediment and Surface Water

Surface water and sediment sampling was conducted in the on-Site ponds and in Loantaka Brook and Black Brook both upstream and downstream of the Site. Surface water and sediment in the ponds and downstream portions of Loantaka Brook and Black Brook exhibit some constituents that are found at the Site. Many of these constituents are also found in surface water and sediment upstream of the Site. Therefore, their presence in the streams may not be Site-related. With minor exceptions, the constituents are not found in the most downstream surface-water and sediment samples, confirming that the downstream extent of constituents potentially related to the Site, if any, has been defined.

2.6.3 Groundwater

The groundwater zone of interest at the Site is the shallow water-bearing zone comprising silt and sand located below the landfilled materials, with a maximum depth of approximately 25 feet below ground surface. Because it is nearest to the potential sources of contamination in the overlying landfilled materials, the groundwater investigation has been focused on this shallow zone. Although the shallow aquifer is identified by New Jersey as a Class 2A potable aquifer, it is not currently used nor is it practically available for drinking water because under NJDEP regulations (N.J.A.C. 7:9D-2.3) potable wells must have a well casing that is at least 50 feet deep. The clay layer beneath the shallow water-bearing zone is at least 25 feet thick beneath the Site and reportedly more than 100 feet thick in the Site vicinity (Minard, 1967). The clay layer serves as a barrier to the vertical migration of contamination.

Other than inorganic constituents, the RI concluded that concentrations of COCs above their New Jersey Groundwater Quality Standards (GWQS) are localized with no overall dissolved groundwater plume. Four areas of impacted groundwater were identified in the shallow water-bearing zone. These include:

- Benzene and 1,4-dioxane in the southwestern part of the landfill. These constituents were found in monitoring well MW-3 and certain of the nearby temporary well points, and are located downgradient of test pit TP-09, where evidence of potential industrial waste was observed. The downgradient extent of benzene is defined by monitoring well MW-15, which did not contain benzene. 1,4-Dioxane is present in monitoring well MW-15, but at a much lower level than in well MW-3. The decreases in benzene and 1,4-dioxane concentrations from well MW-3 to downgradient well MW-15 indicates natural attenuation of these constituents.
- Freon compounds in the northwestern portion of the landfill and the Surface Debris Area. These constituents were found in monitoring wells MW-10, MW-18, and certain of the nearby temporary well points, and are located near POI-10, where refrigerators were observed on the ground surface. This area is directly adjacent to wetlands. The downgradient extent of the Freon compounds is defined by two pore-water samples collected in the wetlands.
- PCBs detected historically at monitoring well MW-7 in the east-central portion of the landfill. PCBs were not detected in nearby and downgradient monitoring wells so these impacts are confined to this specific area the area in the immediate vicinity of MW-7. In addition, PCBs were not detected in the most recent sample at this well, collected in September 2016.
- Benzene at monitoring well MW-19 near the southeastern boundary of the landfill. The benzene concentration at MW-19 only marginally exceeds the applicable standard. The extent of benzene in this well is defined by two downgradient pore-water samples obtained in the wetlands, which did not contain benzene.

Inorganic constituents were ubiquitous in the monitoring wells. Inorganic constituents are common in groundwater within this region of New Jersey. Although some inorganic constituents are present in groundwater at concentrations above their GWQS, their occurrence is widespread and does not suggest a distinctive source or release.

Metals are mostly not detected in filtered groundwater samples, indicating that metals concentrations are present in colloidal fractions, which are not readily transported with groundwater. The concentration of metals in the aquifer underneath the landfill decreases as groundwater flows to downgradient areas. This is related to the geochemical conditions in the aquifer: strongly reducing beneath the landfill, leading to the formation of sulfide minerals, and oxidizing outside the landfill, leading to immobilization of metals in oxidized forms.

2.6.4 Indoor Air

Sub-slab soil gas was collected from beneath the Hunt Club building, a small generally unoccupied building that is used occasionally for social gatherings. The small number of volatile compounds detected in soil gas and their low concentrations below regulatory action levels confirm that soil gas beneath the Hunt Club building is not a potential indoor air threat.

3. EXPOSURE SETTING

3.1 Baseline Human Health Risk Assessment

A Baseline Human Health Risk Assessment (BHHRA; CDM, 2014) was prepared for the Site based on the results in the SCSR. USEPA subsequently evaluated the results of the BHHRA during 2016 to determine the impact of the sampling results obtained after the SCSR, and confirmed that the conclusions of the 2014 BHHRA were still valid. The results discussed herein are from the 2014 BHHRA.

The focus of the assessment was to characterize potential exposure, cancer risks and non-cancer health hazards to potential human receptors at the Site if no remedial actions are taken to address environmental impacts that are present. The objective of the BHHRA is to provide information to support Site-specific risk management decisions when evaluating and selecting remedial action approaches and options. The BHHRA is supported by information included in a *Revised Technical Memorandum on Exposure Scenarios and Assumptions* (MESA) and a *Pathway Analysis Report* (PAR), both of which were approved by the USEPA (Arcadis, 2008 and 2013). The MESA detailed exposure scenarios, potential receptors and receptor-specific exposure assumptions that were used to evaluate potential human health cancer risk and/or non-cancer health hazards. The subsequent PAR identified chemicals of potential concern (COPCs), Site-specific exposure assumptions, and toxicological data used in the evaluation of potential risks and hazards to receptors at the Site. The resulting BHHRA incorporates Site setting characteristics, exposure scenarios, potential receptors, and receptor-specific exposure assumptions as well as the COPC, Site-specific exposure assumptions, and toxicological data when presenting the characterization of exposure, risk, and possible hazards to potential receptors at the Site. The reader should refer to the BHHRA itself for a complete description of methods and results.

3.1.1 Exposure Assessment

The BHHRA evaluated two exposure scenarios: the Current and Reasonably Anticipated Future Exposure Scenario, and the Future On-Site Residential Exposure Scenario.

Current and Reasonably Anticipated Future Use Scenario

Receptors in the current and reasonably anticipated future exposure scenario with potentially complete exposure pathways include:

- A landscaper in Landscape Area 1
- A landscaper in the Hunt Club Area and Landscape Area 2
- A Hunt Club user at the Hunt Club and Landscape Area 2
- An adolescent and/or adult shooting range user at the Shooting Range
- A ball player on the Baseball Field
- An adolescent and/or adult trespasser on the Landfill

Future On-Site Residential Development Scenario

Receptors in the future on-Site residential development exposure scenario with potentially complete exposure pathways include:

- A child and/or adult resident in the potentially developable area (defined as areas outside the GSNWR, potential bog turtle habitat, potential wetlands and related transition area, and potential flood hazard area)
- A construction worker in the potentially developable area

3.1.2 BHHRA Results

Potential health risks to receptors in each exposure scenario were quantified for cancer risk, non-cancer health hazard and lead exposure. The risk characterization results are as follows:

Current and Reasonably Anticipated Future Exposure Scenario

Receptors	Cumulative Cancer Risk		Cumulative Non-Cancer Health Hazard			
	RME	CTE	RME	Target Organ HIs > 1	CTE	Target Organ HIs > 1
Landscaper (Landscape Area 1)	$6x10^{-5}$	$1x10^{-5}$	**2**	None	1	None
Landscaper (Hunt Club & Landscape Area 2)	$5x10^{-6}$	$1x10^{-6}$	0.1	None	0.09	None
Hunt Club User (Hunt Club & Landscape Area 2)	$2x10^{-6}$	$3x10^{-7}$	0.04	None	0.02	None
Adolescent Shooting Range User (Shooting Range)	$5x10^{-8}$	$4x10^{-8}$	0.002	None	0.002	None

Receptors	Cumulative Cancer Risk		Cumulative Non-Cancer Health Hazard			
	RME	CTE	RME	Target Organ HIs > 1	CTE	Target Organ HIs > 1
Adult Shooting Range User (Shooting Range)	$1x10^{-7}$	$3x10^{-8}$	0.003	None	0.003	None
Ball Player (Baseball Field)	$2x10^{-7}$	$5x10^{-8}$	0.002	None	0.002	None
Adolescent Trespasser (Landfill)	$8x10^{-5}$	$1x10^{-5}$	**6**	Eye, Immune System, Nails	0.9	None
Adult Trespasser (Landfill)	$1x10^{-4}$	$6x10^{-6}$	**4**	Eye, Immune System, Nails	0.7	None
Adolescent Hunter (Landfill)	$4x10^{-6}$	$3x10^{-6}$	0.4	None	0.3	None
Adult Hunter (Landfill)	$9x10^{-6}$	$2x10^{-6}$	0.3	None	0.2	None

Individual constituent and cumulative RME and CTE cancer risk and non-cancer health hazard estimates for adolescent and adult shooting range users at the Shooting Range and the ball player at the Baseball Field are less than USEPA target values (cancer risk of $1x10^{-4}$ to $1x10^{-6}$ and non-cancer health hazard of unity [1]), and therefore, are considered negligible.

Individual constituent and cumulative RME and CTE cancer risk estimates for the landscaper in the Hunt Club/Landscape Area 2, the Hunt Club user in the Hunt Club/Landscape Area 2, and adolescent and adult hunters on the landfill are within or less than the USEPA range of acceptable risks. Individual constituent and cumulative RME and CTE non-cancer health hazard estimates for these receptors are less than the USEPA target value of 1, and therefore, are considered negligible.

Individual constituent and cumulative RME and CTE cancer risk estimates for the landscaper in Landscape Area 1 are within the USEPA range of acceptable risks. The cumulative RME non-cancer health hazard estimate for the landscaper in Landscape Area 1 (2) is slightly greater than the target value of 1; however, individual target organ hazard indices (HIs) for this receptor are each less than or equal to 1. Therefore, potential hazards to this receptor are likely negligible. In addition, individual and cumulative CTE non-cancer health hazard estimates for this receptor are less than the target value of 1.

Individual constituent and cumulative RME and CTE cancer risk estimates for the adolescent and adult trespassers are within the USEPA range of acceptable risks. Individual and cumulative RME and CTE non-cancer health hazard estimates for the adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. PCBs are the primary non-cancer health hazard drivers for these receptors.

Potential exposure of receptors in the Current and Reasonably Anticipated Future Exposure Scenario to lead was evaluated using the USEPA Adult Lead Methodology (ALM).

Exposure Scenarios and PbB Receptors µg/dl	Lead Model	Probability of Exceeding 10
Landscaper (Landscape Area 1)	ALM	0.5%
Adolescent Trespasser (Landfill)	ALM	3%
Adult Trespasser (Landfill)	ALM	3%

The estimated probability of fetal blood lead concentration (PbB) exceeding the target PbB is less than 5 percent for the landscaper in Landscape Area 1 and adolescent and adult trespassers on the landfill. Potential adverse health effects associated with exposure to lead for these receptors are thus not expected.

Lead was not identified as a COPC at the Hunt Club Area and Landscape Area 2, the Shooting Range or Baseball Field, so receptors in these human use areas were not evaluated for potential lead exposure. Furthermore, exposures to adolescent and adult hunters on the landfill are assumed to occur for only a 1-week period during hunting season in December of each year. Therefore, it is assumed that PbB in these receptors do not reach steady state (i.e., lead is cleared from the blood following brief exposure). Potential adverse health effects associated with exposure of lead to adolescent and adult shooting range users, ball player and adolescent and adult hunters is not expected.

Future On-Site Residential Development Exposure Scenario

Exposure Scenarios and Receptors	Cumulative Cancer Risk		Cumulative Non-Cancer Health Hazard			
	RME	CTE	RME	Target Organ HIs >1	CTE	Target Organ HIs > 1
Child Resident (Potentially Developable Area)	**$2x10^{-3}$**	**$1x10^{-3}$**	**200**	Blood, Cardiovascular, CNS, Developmental, Endocrine, Eye, GI System, Hair, Hematopoietic, Immune System, Kidney, Liver, Lung, Nails, Reproductive, Respiratory, Skin, Vascular, Whole Body	**100**	Blood, Cardiovascular, CNS, Developmental, Endocrine, Eye, GI System, Hair, Hematopoietic, Immune System, Liver, Lung, Nails, Reproductive, Respiratory, Skin, Vascular, Whole Body
Adult Resident (Potentially Developable Area)	**$1x10^{-3}$**	**$2x10^{-4}$**	**30**	Blood, CNS, Developmental, Endocrine, Eye, GI System, Hair, Hematopoietic, Immune System, Liver, Lung, Nails, Reproductive, Respiratory, Skin, Whole Body	**20**	Blood, CNS, Developmental, Endocrine, Eye, Hair, Hematopoietic, Immune System, Liver, Nails, Reproductive, Respiratory, Skin, Whole Body
Construction Worker (Potentially Developable Area)	$3x10^{-5}$	$8x10^{-6}$	**30**	Kidney, Neurological, Skeletal	**10**	Kidney, Neurological, Skeletal

Individual and cumulative RME and CTE cancer risk estimates for the child resident are greater than the upper end of the USEPA range of acceptable risks ($1x10^{-6}$ to $1x10^{-4}$), and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value of 1. Cancer risk and non-cancer health hazard drivers are PAHs, dieldrin, PCBs, dioxins and furans, and inorganics (antimony, arsenic, iron, thallium, and vanadium) in soil and benzene, dichlorodifluoromethane, 1,4-

dioxane, vinyl chloride, PAHs, bis(2-chloroethyl)ether, pentachlorophenol, and inorganics (arsenic, iron, manganese, and thallium) in groundwater.

Individual and cumulative RME and CTE cancer risk estimates for the adult resident are greater than the upper end of the USEPA range of acceptable risks ($1x10^{-6}$ to $1x10^{-4}$), and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value. Cancer risk and non-cancer health hazard drivers are PAHs, PCBs, dioxins and furans, and arsenic in soil and benzene, dichlorofluoromethane, 1,4-dioxane, vinyl chloride, PAHs, bis(2-chloroethyl)ether, pentachlorophenol, and inorganic (arsenic and thallium) in groundwater.

Residential exposure can be expressed as a lifetime exposure of 30 years. When adult residential exposures (estimated for 24 years) and child residential exposures (estimated for 6 years) are summed together to evaluate a potential residential lifetime exposure, the estimated cumulative residential lifetime RME excess lifetime carcinogenic risk (ELCR) is $3x10^{-3}$, which is greater than the upper end of the USEPA range of acceptable risks. When summed, the estimated cumulative residential lifetime CTE ELCR is $1x10^{-3}$.

Inhalation of volatile emissions from groundwater to indoor air (i.e., vapor intrusion) in potential future residences was identified as a potential exposure pathway. If future redevelopment occurs on the landfill, additional vapor intrusion investigation is warranted.

Individual and cumulative RME and CTE cancer risk estimates for the construction worker in the Potentially Developable Area are within the USEPA range of acceptable risks, and individual and cumulative RME and CTE non-cancer health hazard estimates for this receptor are greater than the USEPA target value. Non-cancer health hazard drivers are PCBs and cadmium in surface and subsurface soil.

Potential exposure of a future child resident in the Future On-Site Residential Development Exposure Scenario to lead was evaluated using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) model, and potential exposure of a construction worker in the Future On-Site Residential Development Exposure Scenario to lead was evaluated using the USEPA ALM.

Exposure Scenarios and Receptors	Lead Model	Probability of PbB Exceeding 10 µg/dl
Child Resident (Potentially Developable Area)	IEUBK	**81%**
Construction Worker (Potentially Developable Area)	ALM	**17%**

The IEUBK model was used to estimate a probability distribution for modeled PbB of a future child resident in the Potentially Developable Area. Approximately 81 percent of the probability distribution is greater than the PbB threshold of 10 micrograms per deciliter (µg/dL), which may be interpreted as an 81 percent probability of exceeding the PbB threshold for a future child resident in the Potentially Developable Area. This percent exceeds the USEPA risk reduction goal of 5 percent for Comprehensive Environmental Response, Cleanup, and Liability Act (CERCLA) sites.

The ALM was used to estimate a probability of a fetal PbB of a future construction worker in the Potentially Developable Area exceeding the target PbB. The estimated probability of the construction worker's fetal PbB exceeding the target PbB is 17 percent, which is greater than the USEPA risk reduction goal of 5 percent for CERCLA sites.

3.1.3 BHHRA Summary

Estimated cancer risks to all receptors and non-cancer health hazard to the majority of receptors in the Current and Reasonably Anticipated Future Exposure Scenario are within or less than USEPA target levels. Estimated non-cancer hazard to the landscaper in Landscape Area 1 is slightly greater than the USEPA target level, but HIs for individual target organs are all less than or equal to the USEPA target level of 1. Estimated non-cancer health hazard to the adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. Estimated cancer risks and non-cancer health hazards to receptors in the Future On-Site Residential Development Exposure Scenario are greater than USEPA target levels.

Overall, carcinogenic ELCRs and non-carcinogenic HIs presented in this BHHRA are based upon conservative assumptions that are intended to be protective of human health by overestimating exposure to account for parameter uncertainty. Therefore, overall confidence in this risk assessment is high.

3.2 Baseline Ecological Risk Assessment

A Baseline Ecological Risk Assessment (BERA; Integral, 2016) was prepared for the Site and is based on results available through August 2016. The draft BERA report was submitted to USEPA in September 2016 and revised in accordance with USEPA comments, and resubmitted to USEPA on December 28, 2016. USEPA approved the BERA by email dated December 29, 2016. The remainder of this subsection summarizes the results of the BERA (Integral, 2016).

The objective of the BERA was to assess potential risks to ecological receptors from exposure to Site-related COCs present in environmental media at the Site. The BERA relied on the analytical results of the previous investigations. Supplemental sampling designed to support the BERA was conducted in May and June 2016. This 2016 sampling included collecting sediment sampling for bioavailability evaluation and acute toxicity testing, collecting biota representative of forage or prey items for the evaluated receptors, ad collection of environmental media from an off-Site reference pond. An ecological habitat assessment was also performed at representative portions of the Site.

The BERA is the final three steps of the eight-step process defined in the *Ecological Risk Assessment Guidance for Superfund* (ERAGS). This phased approach includes increasingly sophisticated levels of data collection and analysis. The BERA builds on two prior documents: the *Screening Level Ecological Risk Assessment* (SLERA; Arcadis 2013) which provided ERAGS Steps 1 and 2, and the *BERA Work Plan* (Integral, 2016), which addresses ERAGS Steps 3 through 5.

3.2.1 BERA Methods

The chemical of potential ecological concern (COPECs) were identified as part of ERAGS Step 3 in the *BERA Work Plan*. Media were screened independently, and an aggregated collection of COPECs across all sampled media was developed. These included several SVOCs (e.g., PAHs, phthalates), PCBs, dioxins and furans, and several inorganics. The COPECs include chemical related to Site use and others that are present naturally in the environment (e.g., metals).

Thirteen assessment endpoints were evaluated in the BERA, including:

- Terrestrial vegetation;
- Benthic invertebrates;
- Amphibians and reptiles;
- Herbivorous birds;
- Piscivorous birds;
- Herbivorous mammals;
- Vermivorous mammals;
- Vermivorous birds;
- Carnivorous mammals;
- Insectivorous mammals;
- Insectivorous birds;
- Carnivorous birds; and
- Piscivorous mammals.

Empirical data for the COPECs from on-Site sampling were available for surface water, sediments, soil, soil invertebrates (earthworms and centipedes/millipedes), forage fish, tadpoles and aquatic vegetation. COPEC concentrations were estimated using literature uptake factors (sediment or soil to biota) for aquatic invertebrates, emergent insects, and terrestrial vegetation. The use of uptake factors from literature sources is conservative and overestimates the potential exposure (and calculated risk) because it does not reflect Site-specific bioavailability from the soil or sediment. Risks were evaluated on a Site-wide basis, by basic habitat types (terrestrial, wetland, or aquatic) and by sub-habitat areas (e.g., West Pond #1, southern wetland).

3.2.2 BERA Results

The BERA results for each receptor are discussed below. The hazard quotient (HQ) was calculated based on Toxicity Reference Values (TRVs) used to assess potential risks for all receptors other than terrestrial vegetation, benthic invertebrates, and amphibians and reptiles. The approach taken for each of these receptors is explained with their results.

Terrestrial Vegetation: The SLERA showed that plant toxicity-based soil benchmarks were exceeded throughout the Site. However, the BERA established that the SLERA may have overestimated the potential risks to plants, since there was little apparent impact to vegetation that can be related to soil COPEC concentrations based on the ecological habitat survey results. The more relevant factors affecting the presence of terrestrial vegetation were (1) the thickness of the soil layer and (2) whether solid waste was present on the surface. There were several areas of the Site, predominantly within the perimeter wetlands, that are high value habitats, such as those associated with potential bog turtle habitats. *Phragmites* stands were noted at several locations within and adjacent to the Site and appear to be invading some of the potential bog turtle habitats. Based on the results of the BERA there is no unacceptable risk to terrestrial vegetation from COPECs.

Benthic Invertebrates: There is a potential risk to benthic invertebrates based on the comparison of the measured sediment concentrations to conservative sediment benchmarks at some of the locations sampled in 2016. This was highly variable; for example, at one of the West Pond #1 locations total DDx and nine metals had HQ_{sed} values greater than one, but the remaining two samples had only one COPEC (selenium) with an HQ_{sed} greater than one. The COPEC metal risks may be overestimated based on the assessment of the sediment bioavailability using the measured [SEM-AVS]/TOC. This showed that potential for sediment toxicity is unlikely at the Site, except for one location at the eastern landfill perimeter at sample SED007. This sample also had the largest mean HQ_{sed} of the evaluated sediments. This sample was not evaluated for acute toxicity using *Hyalella* and chironomid bioassays, so the potential for toxicity at this location cannot be verified empirically.

For all tested locations, acute toxicity using *Hyalella* and chironomid bioassays showed no impacts on survival and only a slight potential impact on *Hyalella* and chironomid growth in one of the three samples from West Pond #1 and in both North Ponds. The difference in *Hyalella* growth relative to the Reference Pond was less than 20%, which is not considered to be significant. There was no correlation between the *Hyalella* and chironomid growth results (absolute values) to the COPEC concentrations, which implies that these affects are likely unrelated to the COPEC concentrations. Thus there are no unacceptable risks to these receptors.

Amphibians and Reptiles: The potential risks to amphibians were evaluated by comparing observed results to sediment benchmarks, similar to one of the measurement endpoints used to evaluate benthic invertebrates. Risks are unlikely, however, since tadpoles were abundant at many of the sampling locations.

The risk characterization for the amphibians and reptiles also included a comparison to studies that evaluate the potential linkage(s) between sediment PCB concentrations and amphibian population effects. Generally, there is no conclusive linkage between sediment PCB concentrations and amphibian population effects, except possibly at sites with far greater average PCB concentrations in their sediments than what is observed at the Site. Based on this comparison, in conjunction with the lack of correlation between sediment toxicity (generally regarded as a more sensitive receptor than amphibians) and PCB levels in sediments, it is concluded PCBs present in the sediments at the Site do not present an unacceptable risk to amphibians and reptiles.

Vermivorous Birds and Mammals: The BERA indicates that there were HQ_{LOAEL} (HQ for the lowest observable adverse effect limit) values greater than one for vermivorous birds (e.g., American robins) and mammals (e.g., short-tailed shrew) that consume soil invertebrates at the Site. This risk was due chiefly to the measured metals and PCB concentrations in the soil invertebrates. The Site total PCB concentrations in soils were lower than those reported from field studies that showed no dose-response relationship between the soil (and prey) total PCBs and population metrics. This suggests that the total PCBs in the Site media may not be causing significant risks to these receptors.

Use of field-collected prey items reduces the potential to overestimate potential exposures and risks to these receptor groups. In addition, conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

Piscivorous Birds and Mammals: The BERA indicates that there is no risk to piscivorous birds (e.g., great blue heron) and a potential minimal risk to piscivorous mammals (e.g., mink) that consume the forage fish or tadpoles from the On-Site Ponds (the HQ_{LOAEL} values were less than one for the individual ponds).

Use of field-collected prey items reduces the potential to overestimate potential exposures and risks to these receptor groups. In addition, conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

Herbivorous Birds and Mammals: There is no potential risk to herbivorous birds (e.g., mallard ducks) and minimal risk to herbivorous mammals (e.g. meadow vole) based on the exposure assumptions and media concentrations that have been used for this assessment. The potential risk to the meadow vole was due chiefly to the mercury, selenium and PCDD/F-TEQ concentrations in prey items of vole. However, the selenium risks are unlikely to be site related because all of the Site HQ values were comparable to or less than those calculated for the reference areas.

Empirical data on aquatic vegetation and estimated concentrations in aquatic invertebrates were used to assess the potential risks to the Mallard ducks. Empirical data on soil invertebrates and estimated concentrations in terrestrial vegetation were used to assess the potential risks to the meadow voles and thus the risk is likely overestimated.

Insectivorous Birds and Mammals: There is no potential risk to insectivorous birds (e.g., tree swallow) and minimal potential risk to mammals (e.g., bats) at the Site. Exposure was predominantly from the consumption of emergent insects, whose tissue levels were estimated using bioaccumulation models. The models assume 100% bioavailability from the sediments, which is unlikely based on the elevated TOC (for organics) and reduced bioavailability for metals based on the [SEM-AVS]/TOC results.

HQ_{LOAEL} values for little brown bat were less than one across most of the Site areas, except for arsenic, barium, and methyl mercury in Wetland-east, and copper on a Site-wide and wetland-combined basis (the individual subareas were all below one). Selenium risks do not appear to be Site-related because larger HQ_{LOAEL} values were calculated in the reference areas than on-Site.

The evaluation of these receptors is the most uncertain relative to the other receptors evaluated in this BERA because of the lack of available empirical data on the principal prey group, and the assumption of 100% bioavailability from Site media in the bioaccumulation models used to estimate prey COPEC concentrations.

Carnivorous Birds and Mammals: There is no potential risk to carnivorous birds (e.g., red-tailed hawk) and mammals (e.g., red fox) at the Site. Exposure was predominantly from the consumption of small mammals, whose tissue levels were measured.

The spatial analysis of the soil analytical data showed that the COPEC concentrations were generally higher in the terrestrial portions of the Site compared to the wetland areas. The biota data were also variable from both the terrestrial and wetland areas (fewer samples were collected from the latter) but on average there were no significant differences between the mean biota concentrations across these habitats for most of the COPECs.

3.2.3 BERA Summary

The results of the BERA indicate that exposures to COPECs in the environmental media at the Site do not pose an ecological concern for most of the evaluated receptors, and that there is a low potential risk for short-tailed shrews and American robins. The exposure assumptions and uptake factors used to estimate aquatic invertebrate and emergent insect COPEC concentrations, and the TRVs used to assess the potential ecological risks, include some degree of uncertainty. Uncertainties are inherent for any BERA; however, the nature and magnitude of the uncertainties depend upon knowledge regarding the use of the Site by receptors, the amount and quality of data available and assumptions used in exposure potentials and benchmarks used to assess the potential risks. Here, multiple conservative assumptions were intentionally used to take uncertainties into account. The more conservative the assumptions, the less likelihood that a hazard quotient greater than 1.0 indicates an unacceptable risk. Accordingly, any uncertainty in this analysis would overestimate rather than underestimate potential risks, given that conservative assumptions were employed where applicable to minimize the potential for risk underestimation.

4. PRELIMINARY REMEDIAL ACTION OBJECTIVES

4.1 Constituents of Concern

For this analysis, chemical constituents were considered COCs if (1) they were present at concentrations above an applicable remediation standard; or (2) they were present at a concentration that was associated with unacceptable risk in the BHHRA or in the BERA. COCs were identified in soil and groundwater, but the risk assessments did not identify any potential risks in surface water and sediments, so no COCs have been identified for them.

4.1.1 Soil

For several reasons, analytical results in soil were compared to the New Jersey Non-Residential Direct Contact Soil Remediation Standards (NRDCSRSs). First, though the portion of the Site that is outside the GSNWR is currently zoned residential, residential use is not the reasonably anticipated future land use for the Site. While zoning is always subject to change, USEPA is empowered to require institutional controls to eliminate the possibility of future residential development, as an element of the remedy where such controls are consistent with reasonably anticipated future uses (USEPA, 2000; p. 5 and USEPA, 2006; p. 3 and 4). Institutional controls are particularly appropriate here, since the USEPA has found in the BHHRA that residential development is not a reasonably anticipated future use. Moreover, this finding is fully consistent with USEPA guidance, which states that "[a] landfill site is an example where it is highly likely that future land use will remain unchanged" (USEPA, 1995; p. 7). See also USEPA, 1993 which states "[F]uture residential use of the landfill source area itself is not considered appropriate." Finally, the Reuse Assessment Report (TRC, 2017) concluded that "development of the Site for residential use is considered extremely unlikely" for the following reasons:

- the presence of extensive state- and federally-regulated areas on the Site that limit development over much of the Site area;
- the environmentally sensitive nature of the surrounding area;
- state, county and local planning documents that discourage development away from established centers in environmentally sensitive areas and focus on protection of GSNWR;
- the lack of available infrastructure and associated Site accessibility issues;
- the presence of buried waste at the Site; and
- local opposition to residential development.

The use of NRDCSRSs is, thus, appropriate and consistent with USEPA guidance.

The following COCs have been identified. Analytical results in soil were compared to the New Jersey NRDCSRSs. The following COCs have been identified.

Area	COCs	Potential Exposure Pathways
Landfill surface	Metals, PCBs, PAHs, pesticides	Direct contact (human and ecological)
Soil west of Surface Debris Area	Lead	Direct contact (human)

Metals, PCBs, PAHs, and pesticides were found at concentrations above the NRDCSRS in surface soil samples (generally collected at no deeper than 1.0 feet bgs) on the landfill. The metals found most frequently at concentrations above their NRDCSRSs were lead and arsenic. The soil COCs are present over most of the landfill but are generally not found in the adjacent soil off the landfill.

Risks for adolescent and adult trespassers on the landfill in the Current and Reasonably Anticipated Future Exposure Scenario are greater than the USEPA target level. In addition, risks for landscapers in Landscape Area 1 are slightly above the USEPA target level.

Because future residential development is not a reasonably anticipated future use, and indeed, as demonstrated above, is highly unlikely, risks associated with the Future On-Site Residential Development Exposure Scenario in the BHHRA were not considered in this analysis.

As indicated above, COCs are generally not found in soil samples collected off the landfill. The exception is lead, which is found in several wetlands soil and sediment samples west of the landfill, in the Surface Debris Area and between the Surface Debris Area and Loantaka Brook. Although the lead concentrations exceed its NRDCSRS, no unacceptable risks were found related to lead in either the BHHRA Current or Reasonably Anticipated Future Use Scenario, or in the BERA.

4.1.2 Groundwater

Analytical results in groundwater from the shallow water-bearing zone were compared to the GWQS. The following COCs have been identified.

Area	COCs	Potential Exposure Pathways
MW-3 area (southwest portion of landfill)	Benzene, 1,4-dioxane	No current risk of exposure.
MW-6 area (central portion of landfill)	1,4-dioxane	No current risk of exposure.
MW-7 area (east-central portion of landfill)	PCBs	No current risk of exposure.
MW-10 and MW-18 area (northwest portion of landfill)	Dichlorodifluoromethane, trichlorofluoromethane, benzene, 1,4-dioxane	No current risk of exposure.
MW-19 (adjacent to southeast portion of landfill)	Benzene	No current risk of exposure.
All areas of landfill	Metals	No current risk of exposure.

There are no potable supply wells at or near the Site. The Hunt Club supply well (designated HC-1) is screened well below the clay layer that mitigates migration from the shallow groundwater that is of interest at the Site, and is not used for drinking water (i.e., non-potable). Therefore, there is no current risk of exposure to impacted groundwater at or near the Site. Any future use of the groundwater is unlikely, and not reasonably anticipated, since New Jersey regulations require drinking water wells to have casings that are at least 50 feet deep (N.J.A.C. 7:9D-2.3).

Other than metals, the other COCs in groundwater appear to be in separate, relatively restricted areas. Certain of the COCs are present at levels that only marginally exceed their GWQS; including:

- bis(2-chloroethyl)ether at wells MW-3;
- 1,4-dioxane at wells MW-6 and MW-10; and
- indeno(1,2,3-cd)pyrene at well MW-7.

Based on the observed concentrations, the extent of these COCs is likely limited.

Metals in groundwater are site-wide. As discussed in Section 2.6.3 and in the Groundwater MNA Report (Geosyntec, 2017), metals are not detected in most of the filtered groundwater samples, indicating that metals concentrations are present in colloidal fractions, which are not readily transported with groundwater. The concentration of metals in the aquifer underneath the landfill decreases as groundwater flows to downgradient areas. This is related to the geochemical conditions in the aquifer: strongly reducing beneath the landfill, leading to the formation of sulfide minerals, and oxidizing outside the landfill, leading to immobilization of metals in oxidized forms.

4.2 Applicable or Relevant and Appropriate Requirements

ARARs are summarized in Table 4-1. ARARs are defined as follows:

> "Applicable requirements are federal or state requirements that 'specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site' (NCP Sec 300.5). Relevant and appropriate requirements are federal or state laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site, 'address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to a particular site' (NCP Sec. 300.5)." (USEPA 1991).

The three types of ARARs are: chemical-specific, location-specific, and action-specific. These designations are noted for each ARAR in Table 4-1. As described in a letter from Walter Mugdan of USEPA to Irene Kropp of NJDEP, dated 12 May 2010, New Jersey's Soil Remediation Standards (SRS) for direct contact (i.e., ingestion/dermal exposure) are potential ARARs, but will not be considered as ARARs if those standards are not generally applicable, but rather, can change on a site-by-site basis. For example, the standard for lead, or when future site use will be limited to recreation, for inhalation pathways and impact to groundwater soil remediation goals are not ARARs.

Table 4-1 also identifies certain guidance or other documents that "may provide useful information or recommend procedures if (1) no ARAR addresses a particular situation, or (2) if existing ARARs do not provide protection" (USEPA 1991). These documents are designated To Be Considered (TBCs) in Table 4-1.

4.3 Preliminary Remedial Action Objectives

Based on the considerations of Site conditions, results of the risk assessments, the reuse assessment and ARARs described in this section, the following preliminary RAOs have been developed for the Site.

- Control exposure of human and ecological receptors to COCs to address unacceptable risks based on reasonably anticipated future uses;
- Control future impacts to groundwater from source areas; and
- Control human exposure to COCs in groundwater based on reasonably anticipated future uses.

5. IDENTIFICATION AND PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

5.1 Introduction

This section describes the general response actions, remedial technologies, and process options that may apply to the COCs found in Site soil and groundwater. This section also includes a summary of the criteria and methodology used to evaluate the identified process options and perform preliminary screening of the process options and remedial technologies.

USEPA has recognized that large municipal landfills are the type of site where the use of treatment technologies and the development of a wide range of remedial options may not be practicable. Recognizing that treatment at municipal landfill sites may be prohibitively expensive or difficult to implement, USEPA has identified a presumptive remedy for such sites (USEPA, 1993). These sites typically pose a low-level threat, rather than a principal threat, and the volume and heterogeneity of waste contained within the landfill often makes treatment impracticable. The presumptive remedy for CERCLA municipal landfill sites is containment.

Based upon the information generated in the RI, BHHRA, and BERA, the Site presents many of the characteristics typical of landfills – it poses a low-level threat and the volume and heterogeneity of waste make treatment impracticable. Another consideration in the identification of general response actions is that the Site is located within an environmentally sensitive area within the Great Swamp. The Site is also characterized by the presence of wetland areas, flood hazard areas, and habitat areas for endangered species (the bog turtle and blue-spotted salamander). Also, Green Village is currently a scenic, rural village oriented along Green Village Road, but its rural character could be adversely impacted if development of the Site occurs (Chatham Township Planning Board, 2011).

5.2 Identification of Process Options

General response actions, remedial technologies, and process options considered as part of this DSRA Technical Memorandum were identified from Tables 2 through 5 of the *Technical Memorandum on Candidate Technologies* (TMCT; Arcadis, 2015). Additional technologies, which were either not considered in the TMCT or screened out by the TMCT, were included the DSRA process in response to (i) a 20 May 2015 letter sent by USEPA regarding Comments on the Technical Memorandum on Candidate Technologies and (ii) comments provided by USEPA during a project meeting in Edison, New Jersey on 14 September 2016 regarding those specific technologies.

The process options identified and evaluated for the soil and groundwater media as part of the DSRA process are presented in Tables 5-1 and 5-2, respectively. Process options presented in Tables 5-1 and 5-2 are grouped by general response action and remedial technology.

5.3 Screening Criteria

The remedial technologies and process options identified as being potentially applicable to the Site were evaluated in two phases: preliminary screening of remedial technologies and process options screening. The screening criteria and results of the two screening phases are described in more detail in Sections 5.4 and 5.5 below. Each process option was reviewed with respect to the screening criteria, Site COCs, and other Site-specific factors.

The following Site-specific factors strongly influenced the evaluation and screening of the identified process options:

- Human health risks to trespassers are present in the Site soil[1];
- As discussed in Section 4.1.1, residential development of the Site is not a reasonably anticipated future use;
- Minor ecological risks to shrews and robins exist in terrestrial habitat on the landfill;
- No risks for human or ecological receptors in sediment or surface water were identified in the BHHRA or BERA;
- The areal extent of the Site is large, which, limits the feasibility of certain process options due to cost and/or implementability;
- Site access for trucks and equipment is limited to Britten Road and other Chatham Township roads, which limits the feasibility/implementability of certain process options requiring a high volume of vehicle traffic;
- The Site soil is mixed with a significant amount of municipal waste, which may make some process options ineffective and/or difficult to implement;

[1] Human health risks to future adult and child residents were not considered because residential development is not a reasonably anticipated future use.

- Metals present in the Site groundwater are widespread but may be a result of geochemical conditions associated with the municipal waste present in the soil or naturally occurring conditions;
- Non-metals groundwater impacts are localized and are limited to areas within and close to the boundaries of the landfill;
- The thick clay layer beneath the Site prevents vertical migration of COCs; and
- Site groundwater is not a current or reasonably anticipated future source of drinking water.

Process options were not evaluated in isolation, we considered the implementation of process options in conjunction with other process options. This allowed certain options to be retained, even if not applicable to all media or all COCs, provided they could be implemented in conjunction with other process options to provide an effective remedy.

5.4 Initial (Preliminary) Screening of Remedial Technologies and Process Options

5.4.1 Overview

Remedial technologies and process options were initially evaluated on a preliminary basis based on their technical implementability considering general applicability to the Site COCs and conditions. Preliminary screening was performed in consideration of guidance from Section 4.1.2.4 and Figure 4-4 of *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988) and previous preliminary screening results presented in Tables 2 and 3 of the TMCT.

5.4.2 Soil

Twenty-nine process options for soil are presented in Columns 1 through 3 of Table 5-1. The process options are grouped into twelve remedial technologies, which are further grouped into nine general response actions. The process options were evaluated based on their potential applicability to address risks associated with Site soil based on reasonably anticipated future uses of the Site. Preliminary screening of the process options was conducted, and based on their technical implementability (Columns 4 and 5), three process options were not retained for further consideration. The reasons for not retaining these process options are explained below.

- In-situ biological treatments bioventing and enhanced bioremediation were not retained for further consideration because they are not established technologies for treating a significant portion of the Site COCs (e.g., PCBs, metals).

- The effectiveness of bioventing is limited by shallow groundwater at the site and the effectiveness of enhanced bioremediation is limited by heterogeneous media (e.g., soil mixed with varying types of waste) on Site.

- Treatment and reuse of contaminated soil was not retained for further consideration based on its technical implementability. To be reused on the Site, soil (actually a soil-waste mix) would require ex-situ treatment. None of the ex-situ treatments were expected to be applicable to the waste-soil mixture present on the Site.

The remaining process options were retained for the evaluation phase of screening because they were considered both applicable to the Site COCs and potentially technically feasible.

5.4.3 Groundwater

Twenty-nine process options for groundwater are presented in Columns 1 through 3 of Table 5-2. The process options are grouped into thirteen remedial technologies and further grouped into eight general response actions. The process options were evaluated based on their potential applicability to address risks associated with Site groundwater based on reasonably anticipated future uses. Preliminary screening of the process options was performed, and based on their technical implementability (Columns 4 and 5), all process options were retained for further consideration.

5.5 <u>Remedial Technology and Process Option Evaluation/Screening</u>

5.5.1 Overview

A second round of evaluation/screening was conducted for the process options that were retained from the preliminary screening of technologies. The evaluation/screening was based on three criteria: effectiveness, implementability, and cost. Process options were assigned ratings ranging from low to high for each category. Screening criteria for this stage of evaluation were based on guidance on the evaluation of process options presented in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under*

CERCLA (USEPA, 1988) and previous evaluation results presented in Tables 4 and 5 of the TMCT.

During the process options evaluation screening phase, the decision to retain a process option was based on the relative favorability of the evaluation ratings for each evaluation criterion and the relative benefit of a process option over a similar process option. In other words, a process option may receive favorable ratings for all three criteria, but ultimately provide less effective treatment or be less economical for similar results when compared to a similar process option.

5.5.2 Soil

Columns 6 through 8 of Table 5-1 present the evaluation criteria ratings assigned to each process option considered for the remediation of Site soil impacts. The results of the evaluation (i.e., whether or not the process option was retained) and the rationale for the results are presented in Column 9. Fourteen additional process options were not retained for further consideration as a result of the evaluation screening phase. The reasons for not retaining these process options are explained below.

- The asphalt cap process option was not retained due to its higher cost relative to other low-permeability cap process options that offer the same effectiveness. Additionally, the asphalt cap process option would not allow for the preservation or restoration of natural habitat, further reducing its effectiveness.
- Slurry phase biological treatment was not retained because its implementation would offer little benefit over the off-site disposal process option. Similarly, incineration was not retained because the inclusion of incineration prior to off-site disposal would offer no increase in benefit as incineration is not applicable to inorganic COCs, the presence of which would still necessitate off-site disposal of the incinerated soil.
- In-situ treatments oxidation/reduction and precipitations/co-precipitation were not retained because they are expected to be less effective than containment options and would still require containment to prevent direct contact. As such, in-situ oxidation/reduction and precipitation/co-precipitation offer no benefit over other containment process options.
- In-situ treatments including thermal treatment, cementation and/or solidification and/or stabilization, and soil vapor extraction and ex-situ treatment options including thermal treatment, chemical extraction, chemical reduction/oxidation, separation and solidification/stabilization were not retained because of anticipated

low effectiveness and/or low implementability due to the heterogeneous nature of the soil-waste mixture present at the Site.

- Biopiles was not retained because of the long treatment time relative to other ex-situ biological treatments.
- Landfarming was not retained because it is not anticipated to be feasible for the large area and volume of soil requiring treatment, and because the soil is mixed with waste.

The remaining process options were retained for consideration during the development of remedial alternatives.

5.5.3 Groundwater

Columns 6 through 8 of Table 5-2 present the evaluation criteria ratings assigned to each process option considered for the remediation of Site groundwater impacts. The results of the evaluation (i.e., whether or not the process option was retained) and the rationale for the results are presented in Column 9. Ten process options were not retained for further consideration as a result of the evaluation screening phase. The reasons for not retaining these process options are explained below.

- Trenched cutoff wall, sheet piling, permeable reactive wall, and passive/reactive treatment walls were not retained for further consideration because they are not effective options for mitigating onsite impacts, only controlling off-site migration of constituents, which is not an issue for the Site.

- Groundwater recovery trenches, chemical treatments with ozone, and Fenton's Reagent/hydrogen peroxide were not retained for further consideration for the Site because they were considered less effective or offer no significant benefits over, other technologies evaluated.

- Soil vapor extraction and air sparging were not retained for further consideration because they are not expected to be effective in treating the low VOC concentrations and are expected to be difficult to implement given the heterogeneous nature of the Site soil conditions.

- Advanced oxidative processes were not retained for further consideration because energy requirements, and therefore costs, of implementation are expected to be higher than comparable process options.

The remaining process options were retained for further consideration during development of remedial alternatives as discussed in Section 6.

6. REMEDIAL ALTERNATIVE DEVELOPMENT AND ANALYSIS

6.1 Introduction

This section presents Remedial Alternatives for soil and groundwater at the Site. The Remedial Alternatives were developed from process options identified and evaluated as described in Section 5 and address the preliminary RAOs presented in Section 4.

6.2 Identification of Remedial Alternatives

Remedial alternatives considered as part of this DSRA Tech Memo were compiled from the process options summarized in Tables 5.1 and 5.2. Separate remedial alternatives were developed for soil and for groundwater as summarized below. The remedial alternatives and an evaluation of effectiveness, implementability, and estimated relative cost are summarized in Table 6-1 for soil and Table 6-2 for groundwater.

The BHHRA and BERA indicate that environmental media, including surface soil, groundwater, surface water, and sediment at the Site do not pose unacceptable risks that would require remediation under current and reasonably anticipated future Site uses except to protect adult and adolescent trespassers. The BHHRA evaluated a potential residential future use scenario, but did not characterize residential as a reasonably anticipated future use. In this regard, the BHHRA is consistent with the Reuse Assessment Report (TRC, 2017), and the USEPA guidance documents identified in Section 4.1.1 of this Report, all of which demonstrate that residential development is not a reasonably anticipated future use.

That the portion of the Site outside the GSNWR sits in an area that is zoned residential does not alter the conclusion that residential is not a reasonably anticipated future use. As indicated in USEPA 2000 and USEPA 2006, the USEPA is empowered to impose institutional controls through the enforcement mechanisms that CERCLA provides it. The current version of the USEPA/Department of Justice Model Consent Decree for Remedial Design and Remedial Action contemplates as much when it provides that where settling defendants are unable to secure institutional controls despite use of “best efforts,” the United States may assist the settling defendants or “take independent action” in obtaining such controls (Model Consent Decree at Para. 22).

The most common end uses of CERCLA landfill sites are as open space, wildlife enhancement areas, or passive recreational use areas. Given the Site’s location in an environmentally sensitive area, the reasonably anticipated future Site use is as open space or ecological habitat, with passive recreational use a possible but less likely option. In fact, these future use scenarios are the only options that can comply with existing federal, state and local statutory and regulatory constraints on significant portions of the Site while meeting the intent of local, county and state planning documents for the area.

Based upon these factors, a future residential use of the Site is not likely or probable and therefore will not be considered further for purposes of developing and screening remedial alternatives or for remedy selection.

6.2.1 Soil

Based on the results of the preliminary screening of remedial technologies and evaluation/screening of remedial technology and process options described in Section 5, five remedial alternatives for soil were evaluated. The remedial alternatives for soil include the following:

1. No Action (as required in USEPA 1988);
2. Site Controls (i.e., Institutional Controls and Access Restrictions);
3. Site Controls, Excavation, and Off-Site Disposal of Selected Areas to Reduce Overall Risk;
4. Site Controls and Capping of Selected Areas to Reduce Overall Risk; and
5. Site Controls and Capping of All Landfill Material.

A description and a summary of the evaluation of effectiveness, implementability, and relative cost of each soil alternative is presented in Table 6-1.

<u>Soil Alternative 1: No Action</u> – The No Action alternative provides a baseline for comparing other alternatives. No remedial activities would be implemented with the No Action alternative, so long-term human health and environmental risks for the Site will remain similar to those identified in the baseline risk assessments. There would be no additional risks posed to human health or the environment as a result of this alternative being implemented, for example, no truck traffic to increase risks of accidents or cause emissions to the atmosphere, and no impacts to the existing habitat at the Site. There are no implementability issues or concerns and no costs associated with this remedial action.

<u>Soil Alternative 2: Site Controls</u> – The Site Controls option will include institutional controls and access restrictions. Institutional controls (e.g., deed restrictions) would be used to control land use by imposing site restrictions. Access restrictions (e.g., physical barriers such as a fence or living fence, signage, security, etc.) would be used to restrict

entry to the Site by trespassers. Site controls reduce the long-term human health risks and prevent exposure to contaminated soil by restricting land use and site access usage that could negatively impact long-term human health risks.

There are few to no implementability issues or concerns with this alternative; USEPA has enforcement authority to require institutional controls (USEPA, 2000). Access restrictions are readily implementable. Site Controls are a sustainable approach because they do not require removal of the existing habitat, and do not result in emission of carbon dioxide or other air pollutants associated with remedies that rely on trucking to haul materials to and from the Site. The relative cost for implementation of institutional controls and installation and maintenance of access restrictions is anticipated to be low.

Soil Alternative 3: Site Controls, Excavation, and Off-Site Disposal of Selected Areas to Reduce Overall Risk – This alternative addresses the areas of the Site where COCs in surface soil contribute the majority of the risk to trespassers (adult and adolescent) in the Current and Reasonably Anticipated Future Use Scenario in the BHHRA. Using the data and calculations in the BHHRA, areas to be remediated are identified such that when those areas are remediated, risk on the entire Site is acceptable. The definition of these areas will be based on the risk drivers identified in the BHHRA and will be determined during the FS; specific areas will be selected and illustrated on figures for USEPA review with accompanying calculations of the Site risks after remediation.

Site Controls are described above. Used in conjunction with site controls, excavation and off-site disposal of the selected areas would further reduce exposure to contaminated soil.

Excavation can be performed with standard construction equipment, but implementability is greatly reduced by limited access to the Site, the need for potentially thousands of truck trips to haul materials through residential areas on narrow streets not built for heavy truck traffic, large truck traffic over soft soil conditions, and the need to characterize all the material being transported off site (e.g., hazardous or non-hazardous) and identifying an appropriate disposal facility. Furthermore, the use of trucks to haul materials to and from the Site will result in the emission of carbon dioxide and other air pollutants. Excavation will result in the destruction of the existing on-Site habitat. The relative cost of this alternative is high, due to the high cost of exporting materials, the potential cost of characterization, and the cost of importing material to backfill the excavations.

Soil Alternative 4: Site Controls and Capping of Selected Areas to Reduce Overall Risk– This alternative would address the same areas as those addressed by Soil Alternative 3.

Site Controls are described above. Capping (e.g., vegetative capping, low permeable cover, etc.) of the selected areas of the Site would be used to prevent direct contact with impacted soil material by humans and animals and reduce future impacts to the groundwater. Used in conjunction with site controls, capping would further reduce risk of exposure to contaminated soil by preventing direct contact with the impacted soil and waste.

Capping can be performed with standard construction equipment. However, implementability is greatly reduced by the need for potentially thousands of truck trips to haul a significant amount of material (e.g., soil cover materials, geosynthetics, etc.) through residential areas over narrow streets not built for heavy truck traffic, and the potential difficulty in accessing areas of the Site with large delivery truck traffic over soft soil conditions. Furthermore, the use of trucks to haul materials to and from the Site will result in the emission of carbon dioxide and other air pollutants. Capping will replace the existing on-Site habitat with vegetation and habitat that is not consistent with the native conditions (i.e., grasses rather than trees and shrubs). The relative cost of this alternative is moderate to high, due to the high cost of importing capping materials and the need to clear areas of the Site of vegetation, trees and other habitat prior to capping.

<u>Soil Alternative 5: Site Controls and Capping of All Landfill Material</u> – Site Controls and capping are described above. For this alternative, capping would include the entire landfill area of the Site. Implementability of this scenario is reduced by the need to haul a significant amount of material (i.e., more material than in Soil Alternative 4) to the Site, requiring tens of thousands of truck trips through residential areas over narrow streets not built for heavy truck traffic. Furthermore, the use of trucks to haul materials to and from the Site will result in the emission of carbon dioxide. Capping will replace the existing on-Site habitat with vegetation and habitat that is not consistent with the native conditions (i.e., grasses rather than trees and shrubs). The impact of the carbon dioxide and air pollutant emissions, and habitat loss, are proportional to the size of the area capped, and therefore are greater for Soil Alternative 5 than for Soil Alternatives 3 or 4. The relative cost of this alternative is high, due to the high cost of importing capping materials and the need to clear the Site of vegetation prior to capping.

6.2.2 Groundwater

Based on the results of the preliminary screening of remedial technologies and evaluation/screening of remedial technology and process options described in Section 5, four remedial alternatives for groundwater were evaluated. The remedial alternatives for groundwater include the following:

1. No Action (as required in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, USEPA 1988);
2. MNA;
3. MNA with Source Control;
4. Biological Treatment and MNA with Source Control; and.

A description and a summary of the evaluation of effectiveness, implementability, and relative cost of each groundwater alternative is presented in Table 6-2.

<u>Groundwater Alternative 1: No Action</u> – The No Action alternative provides a baseline for comparing other alternatives. No remedial activities would be implemented with the No Action alternative, so long-term human health and environmental risks for the site will remain similar to those identified in the baseline risk assessment. There would be no additional risks posed to the community, the workers, or the environment as a result of this alternative being implemented, for example, no truck traffic to increase risks of accidents or produce carbon dioxide emissions, and no impacts to the existing habitat at the Site. There are no implementability issues or concerns and no costs associated with this remedial action.

<u>Groundwater Alternative 2: Monitored Natural Attenuation</u> – MNA would include institutional controls. Institutional controls (a Classification Exception Area (CEA) and a Well Restriction Area (WRA)) would be used to prohibit groundwater use. Institutional controls reduce the long-term human health risks due to contaminated groundwater by prohibiting usage that could negatively impact long-term human health. Periodic groundwater quality monitoring would be performed to evaluate the natural attenuation and extent of groundwater impacts.

This alternative relies on natural processes to achieve a reduction of COCs. There are little to no implementability issues or concerns with this alternative; New Jersey has a regulatory process for establishing CEAs and WRAs. Also, the relative costs of this alternative would be low because monitoring could be performed using existing infrastructure.

<u>Groundwater Alternative 3: MNA with Source Control</u> – MNA (with institutional controls) is described above in Groundwater Alternative 2. Source control can be used to supplement an MNA remedy where source materials continue to contribute COCs to

groundwater, leading to better effectiveness for MNA. Source control measures may include containment, in-situ treatment, removal, or disposal/discharge (these are described in Table 5-1, Screening of Remedial Technologies for Soil).

Source control is effective for the Site COCs. Implementability should be moderate to high. The relative cost of source control will depend on the area and/or volume of the source to be treated and its properties (for example, whether liquids are present, and whether the material is classified as hazardous under the Resource Conservation and Recovery Act after it is removed), and so can range from low to high.

Groundwater Alternative 4: Biological Treatment and MNA with Source Control – MNA (with institutional controls) and source control is described above in Groundwater Alternative 3. Biological treatment (e.g., enhanced reductive dechlorination, aerobic bioremediation, phytoremediation) would include injection of material to degrade compounds or using plants to remove, stabilize, or destroy constituents. Used in conjunction with MNA and institutional controls, biological treatment could further reduce the long-term human health and environmental risks due to contaminated groundwater by increasing the rate of degradation or removal of COCs.

Biological treatments are effective for the Site COCs. Implementability is moderate to high with standard equipment and materials. The relative cost of this alternative is low to moderate, with the total cost being a function of the size of the area and volume of groundwater to be treated, and of the aquifer properties (e.g., permeability).

7. SUMMARY AND RECOMMENDATIONS

This DSRA Tech Memo presents the basis for the remedy selection for the Rolling Knolls Landfill Site, screens potential remedial technologies, and assembles selected remedial technologies into Remedial Alternatives for initial evaluation. Based on the results of the RI, BHHRA, and BERA, remediation will be needed to address specific soil and groundwater impacts. Remediation is not required for sediment, surface water, or indoor air.

Twenty-nine remedial technology process options were evaluated for soil remediation. Of these, 12 were retained for consideration in developing Remedial Alternatives. Five Remedial Alternatives were developed for soil, and were screened to determine whether they should be carried forward into the FS.

Twenty-nine remedial technology process options were evaluated for groundwater remediation. Of these, 19 were retained for consideration in developing Remedial Alternatives. Four Remedial Alternatives were developed for groundwater, and were screened to determine whether they should be carried forward into the FS.

Based on the information and screening presented herein, we recommend that all the Remedial Alternatives noted in the DSRA for soil and groundwater be retained for full evaluation in the FS.

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TABLES

FIGURES

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Action-Specific	New Jersey Air Pollution Control Rules (N.J.A.C 7:27)	Potentially Applicable- to remedial activities generating certain air emissions	Establishes standards for the emissions of contaminants into [the ambient atmosphere] air.
Action-Specific	Clean Air Act (42 U.S.C subsections 7401 et seq)	Potentially Applicable- to remedial activities generating certain air emissions	Establishes standards for the emissions of contaminants into [the ambient atmosphere] air.
Action-Specific	RCRA Generation, Transportation and Disposal of Hazardous waste (40 CFR 260-270)	Potentially Applicable – to the management of waste streams for off-site disposal	Establishes responsibilities and standards for the management of hazardous and non-hazardous waste.
Action-Specific	49 C.F.R. Hazardous Materials Transportation	Potentially Applicable – to waste streams transported offsite for disposal	Regulates transportation of hazardous materials in the United States under the Department of Transportation (49 CFR).
Action-Specific	New Jersey Hazardous Waste Rules (N.J.A.C 7:26G)	Potentially Applicable – to waste streams transported offsite for disposal	Identifies the standards for the acceptable management of hazardous waste in New Jersey.

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Action-Specific	Plant Protection Act (7 U.S.C. Section 2814)	Potentially Applicable - if remedy requires introducing vegetation to any portion of the site	Requires the use of integrated management systems to control or contain undesirable plant species. Applicable to on-site remedial activities to control, eradicate, or prevent or retard the spread of such weeds.
Action-Specific	New Jersey Brownfield and	Relevant and Appropriate	Enabling legislation for development of remediation standards necessary to protect public health and safety and the environment from discharged hazardous substances and for mandating cleanup of contaminated sites.
Action-Specific	RCRA Subtitle D Landfills (40 CFR Parts 239 - 259)	Relevant and Appropriate	These regulations apply to non-hazardous waste landfills, including municipal solid waste landfills.
Action-Specific	Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712; 50 CFR 10.13)	Relevant and Appropriate	This Act makes it unlawful to “take, capture, kill,” or otherwise impact a migratory bird or any nest or egg of a migratory bird.
Action-Specific	Occupation Safety and Health Standards and Safety and Health Regulations for Construction (29 CFR 1910 and 1926)	Relevant and Appropriate	Establishes occupational safety and health standards.
Action-Specific	New Jersey Storm Water Management Rules (N.J.A.C 7:8)	Relevant and Appropriate	Establishes stormwater management requirements to prevent contamination of waterways via stormwater discharge.
Action-Specific	New Jersey Water Pollution Control Act Regulations (N.J.A.C 7:14)	Relevant and Appropriate	Prohibits the discharge of any pollutant into the waters of the State without a valid permit.

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Action-Specific	New Jersey Pollutant Discharge Elimination System Rules (N.J.A.C 7:14A)	Relevant and Appropriate	Establishes the framework under which NJDEP regulates the discharge of pollutants to the surface and groundwater's of the State.
Action-Specific	New Jersey Noise Control Rules (N.J.A.C 7:29).	Relevant and Appropriate	Prohibits the generation of certain types of noise at specific times and establishes methods to determine compliance.
Action-Specific	Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups (OSWER Publication 9355.0-74FS-P).	To Be Considered	Empowers USEPA to require institutional controls to eliminate the possibility of future residential development, as an element of the remedy where such controls are consistent with reasonably anticipated future uses .
Action-Specific	New Jersey Field Sampling Procedures Manual, Appendix 6.1, New Jersey Well Standards	To Be Considered	Establishes standards for the construction, maintenance, and sampling of monitoring wells.
Action-Specific	Additional, Specific Disposal Regulation for Sanitary Landfills (N.J.A.C. 7:26-2A)	To Be Considered	State regulations that include the requirements for closure and post-closure of sanitary landfills.
Action-Specific	New Jersey Solid Waste Rules (N.J.A.C 7:26)	To Be Considered	Governs the registration, operation, maintenance, and closure of sanitary landfills, other solid waste facilities, and solid waste transportation operations in the State of New Jersey.
Action-Specific	New Jersey Technical Requirements for Site Remediation (N.J.A.C 7:26E)	To Be Considered	Establishes the technical requirements for the remediation of contaminated sites.

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Action-Specific	NJDEP "Ecological Evaluation Technical Guidance." Version 1.3, February 2015.	To Be Considered	Provides guidance on conducting ecological evaluations and implementing Risk Management Decisions for ecologically sensitive natural resources.
Action-Specific	Administrative Requirements for the Remediation of Contaminated Sites (N.J.A.C 7:26C)	To Be Considered	Requirements related to New Jersey's site remediation process.
Action-Specific	New Jersey Department of Transportation (NJDOT) Standard Specifications – Soil Erosion and Sediment Control Measures (1996) (N.J.A.C. 16:25A-2.1 et seq.)	To Be Considered	NJDOT standards are typically used to develop the appropriate plans for sediment and soil erosion control required under New Jersey Soil Conservation Act.
Action-Specific	Presumptive Remedy for CERCLA Municipal Landfills (OSWER Directive No. 9355.0-49F)	To Be Considered	This guidance outlines a streamlined approach to the scoping (planning) stages of the RI/FS in the process of closing municipal landfills under CERCLA, with containment as the presumptive remedy. This directive also provides guidance regarding the appropriate level of detail appropriate for risk assessment of source areas and characterization of hot spots.
Action-Specific	Guide to Management of Investigation-Derived Wastes (OSWER Publication 9345.3-03FS)	To Be Considered	Present regulatory background and options for managing investigation-derived waste at Superfund sites.

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Action-Specific	Green Remediation: Incorporating Sustainable Environmental Practices in Remediation of Contaminated Sites (OSWER Publication EPA 542-R-08-002)	To Be Considered	Outlines the principals of green remediation and describes opportunities to reduce the footprint of cleanup activities throughout the life of a project. Identifies new strategies and alternatives to improve sustainability of cleanup activities, and helps decision-makers balance the alternatives within existing regulatory frameworks.
Chemical-Specific	Remediation Standards (N.J.A.C 7:26D; 7:9B; 7:9C)	Relevant and Appropriate	Establishes the minimum standards for the remediation of soil, groundwater, and surface water.
Chemical-Specific	Federal Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (40 CFR 141.11-.16, and .60-.63)	To Be Considered	Defines the quality criteria for public drinking water supplies.
Chemical-Specific	New Jersey Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (N.J.S.A. 58:12A-1 et seq.)	To Be Considered	Defines the quality criteria for public drinking water supplies.
Chemical-Specific	NJDEP "NJDEP Ecological Screening Criteria." March 2009.	To Be Considered	Provides Ecological Screening Criteria to be used as screening values in ecological assessments.
Chemical-Specific	NJDEP Site Remediation Program, Technical Guidance for the Attainment of Remediation Standards and Site- Specific Criteria September 24, 2012, Version 1.0.	To Be Considered	Guidance on alternate methods to achieve compliance with applicable remediation standards.

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Chemical-Specific	EPA Human Health Assessment Cancer Slope Factors (CSFs)	To Be Considered	CSFs are developed by EPA for health effects assessments or evaluation by the Human Health Assessment Group. These values present the most up-to-date cancer risk potency information and are used to compute the individual incremental cancer risk resulting from exposure to carcinogens.
Location-Specific	Establishment of a Classification Exception Area/Well Restriction Area (N.J.A.C. 7:9-6.6)	Relevant and Appropriate	Promulgated state regulations that include requirements for establishing a classification exception area/well restriction area where groundwater quality does not meet New Jersey groundwater quality criteria.
Location-Specific	Ground Water Quality and Surface Water Standards (N.J.A.C 7:9).	Relevent and Appropriate	Regulates activities respecting protection and enhancement of ground water and surface water resources.
Location-Specific	Endangered Species Act (16 USC 1531 et seq.)	Relevent and Appropriate	Requires that action be performed to conserve endangered species or threatened species.
Location-Specific	Fish and Wildlife Coordination Act (16 USC 661 et seq	Relevent and Appropriate	Requires actions to protect fish or wildlife when diverting, channeling, or modifying a stream.
Location-Specific	Federal Water Pollution Control Act (FWPCA) (33 USC 1521 et seq.)	Relevent and Appropriate	Requires a permit from USACE and consideration by both the EPA and the USFWS before an application to dredge and fill may be enacted.
Location-Specific	New Jersey Freshwater Wetlands Protection Act Rules (N.J.A.C 7:7A)	Relevent and Appropriate	Requires permit for regulated activity disturbing freshwater wetlands.
Location-Specific	New Jersey Flood Hazard Area Control (N.J.A.C 7:13)	Relevent and Appropriate	Sets forth the requirements governing activities in the flood hazard area or riparian zone of a regulated water.
Location-Specific	New Jersey Endangered Plant Species Program (N.J.A.C 7:5C)	Relevent and Appropriate	Identifies the official list of endangered plant species and establishes the program for maintaining and updating the list.

Table 4-1
Applicable or Relevant and Appropriate Requirements
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

ARAR Type	Requirement	Status	Summary of Requirement
Location-Specific	New Jersey Division of Fish, Game, and Wildlife Rules (N.J.A.C 7:25)	Relevent and Appropriate	Supplements the statutes governing fish and game laws in the State of New Jersey.
Location-Specific	Land Use in the CERCLA Remedy Selection Process (OSWER Directive No. 9355.7-04).	To Be Considered	Indicates that landfill site is an example where future land use will likely remain unchnaged
Location-Specific	EPA's 1985 "Policy on Floodplains and Wetlands Assessments for CERCLA Actions".	To Be Considered	Requires that CERCLA actions meet the substantive requirements of Floodplain Management Executive Order (EO 11988) and Protection of Wetlands Executive Order (EO 1990).
Location-Specific	Fish and Wildlife Coordination Act Advisories.	To Be Considered	Advisories on the effects of pollutants and other activities on wildlife, including migratory birds and fish, and wildlife habitat authorized under the Fish and Wildlife Coordination Act.
Location-Specific	Section 404 - Clean Water Act, as it pertains to wetlands	To Be Considered	Prohibits discharge of dredged or fill material into wetlands adjacent to navigable waters without a permit.
Location-Specific	Executive Order 11988 Floodplain Management	To Be Considered	Requires federal agencies to avoid to the extent possible long- and short-term adverse impacts associated with the occupancy and modification of flood plains, and avoid support of floodplain development wherever there is a practicable alternative.
Location-Specific	Executive Order 11990 Protection of Wetlands	To Be Considered	Requires federal agencies to provide leadership and take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.

Table 5-1
Screening of Remedial Technologies for Soil
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option [1]	Preliminary Screening of Remedial Technologies: Description	Retained/Rationale		Remedial Technology and Process Options Screening Criteria [2]: Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation		Retained	
No Action	No Action	No Action	No Remedial Action	Yes	As required by NCP and USEPA as a baseline for other process options.	Low	Does not result in a decreased residual risk; baseline conditions	High	Readily implementable	Low	Capital - None O&M - Low (for monitoring)	Yes	As required by NCP and USEPA as a baseline for other process options.
Monitoring	Monitoring	Monitor containment technologies/cover integrity	Monitoring of containment technologies/cover integrity	Yes	To supplement containment technologies/cover integrity	High	Effective to evaluate other technologies (e.g., containment) and ensure the technologies are functioning properly	High	Readily implementable	Low - Moderate	Capital - Low O&M - Low to Moderate	Yes	Standard practice for containment and capping technologies; implemented with other containment options
Institutional Controls (3)	Institutional Controls	Proprietary Controls, Enforcement Tools, Deed Restrictions, and Information Devices	Administrative actions taken to minimize the potential for human exposure to constituents present by controlling land use and guiding human behavior.	Yes	Discourage non-applicable land use by imposing site restrictions and providing notification of constituents in media.	High	Effective in limiting future Site use; five-year review process ensures long-term effectiveness	Moderate - High	New Jersey has regulatory process for establishing land use restrictions; Requires coordination with property owner and regulatory authorities	Low	Capital - Low O&M - Low	Yes	Standard practice for landfill management; may be implemented with additional process options
Access Restrictions	Access Restrictions	Physical Barriers, Signage, and Security	Using physical barriers, signage, and security to prevent or discourage entry	Yes	To be used in conjunction with other remedial technologies	Moderate	Effectiveness may require monitoring	High	Readily implementable	Low - Moderate	Capital - Low to moderate O&M - Low to moderate	Yes	Standard practice for landfill management; implemented with additional process options
Containment	Soil Capping	Asphalt Cover	Prevent infiltration and direct contact with surface soil constituents.	Yes	Impermeable barrier that prevents contact with surface soil constituents and reduces infiltration.	Moderate	Prevents direct contact with contaminated soils and debris. Requires clearing of Site vegetation/destruction of habitat and placement of asphalt. Long-term success dependent on maintenance of cover.	Moderate	Standard technology but implementability reduced by limited truck access to site. Typically used in developed areas (e.g., parking lots).	Moderate	Capital - Moderate O&M - Moderate	No	Other low permeability covers offer same effectiveness and implementability at lower cost; no habitat will remain in asphalt-paved areas.
		Vegetative Cover	Prevent direct contact with a vegetative cover.	Yes	Prevents direct contact with surface soil constituents and reduces erosion and transport of constituents.	Moderate	Prevents direct contact with contaminated soils and debris. Requires clearing of Site vegetation/destruction of habitat and placement of clean soil. Long-term success dependent on maintenance of cover.	Moderate	Standard technology but implementability reduced by limited truck access to site.	Low - Moderate	Capital - Moderate O&M - Low	Yes	Standard containment process option; can be applied to portions of the site.
		Low-permeability Cover	Minimize infiltration and prevent direct contact.	Yes	Prevents direct contact with surface soil constituents and reduces infiltration.	Moderate	Prevents direct contact with contaminated soils and debris. Requires clearing of Site vegetation/destruction of habitat and placement of clean soil. Long-term success dependent on maintenance of cover.	Moderate	Standard technology but implementability reduced by limited truck access to site.	Moderate	Capital - Moderate O&M - Low	Yes	Standard containment process option; can be applied to portions of the site.
	Subsurface Source Controls	Low-permeability Liner	Minimize infiltration/leaching into subsurface	Yes	Reduces infiltration/leaching into subsurface	High	Minimizes infiltration of leachate into subsurface; may be used in areas where waste has been relocated	Low	Standard construction equipment, but may be limited by site conditions in some areas of the site and total volume of impacted material	High	Capital - High O&M - Low to Moderate	Yes	Standard containment process option; can be applied to portions of the site.

Table 5-1
Screening of Remedial Technologies for Soil
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option (1)	Preliminary Screening of Remedial Technologies			Remedial Technology and Process Options Screening Criteria (2)						Retained	
			Description	Retained/Rationale		Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation			
In-Situ Treatment	Physical/Chemical	Cementation Solidification/Stabilization	Use cementitious material (or similar) to immobilize constituents.	Yes	Immobilizes constituents thereby reducing concerns associated with direct contact and infiltration	Low	Constituents are incorporated into a dense structure that reduces mobility, limited effectiveness for VOCs, SVOCs, PAHs, and pesticides	Low	Standard construction equipment, but may be limited by site conditions (presence of municipal waste) and would require significant mixing of additives	Moderate	Capital - High O&M - Low to None	No	Implementability reduced by presence of municipal waste in soil. Unlikely to have degree of mixing and contact of cementitious material and soil needed to bind constituents.
		Oxidation/Reduction	Chemically transform hazardous constituents to non-hazardous or less toxic constituents	Yes	Stabilizes, immobilizes, or makes inert constituents thereby reducing concerns associated with direct contact and infiltration	Moderate	Treats inorganics; less effective for some VOCs, SVOCs, and pesticides	Moderate	Potentially requires handling of large quantities of hazardous oxidizing chemicals, appropriate training, and treatability studies	Moderate	Capital - Moderate O&M - Moderate	No	Established technology for preventing mobilization of constituents; may be implemented on a portion of the site with additional process options
		Precipitation/Co-precipitation	Convert soluble constituents into insoluble solids for precipitation and removal	Yes	Reduces infiltration/leaching into subsurface	Low	Not applicable to majority of constituents present; constituents remain in soil	Low	Not readily deployable to soil mixed with waste	Low - Moderate	Capital - Moderate O&M - Low to None	No	Less effective than other immobilization/containment options; requires additional containment to control direct contact
		Soil Vapor Extraction	Vacuum applied to extraction wells to facilitate volatilization of groundwater constituents such as VOCs	Yes	Combined with other technologies for enhancing constituent extraction and ex-situ treatment	Low	Removes VOCs from the subsurface for ex-situ treatment; effectiveness is low in areas where VOC concentrations are low	Low - Moderate	Potential limitations due to presence of waste (installation of wells and piping is difficult; heterogeneity not favorable to uniform air flow in the subsurface)	Moderate	Capital - Moderate (well installation and equipment) O&M - Low to Moderate	No	Unlikely to be effective given the low VOC concentrations at the site, and difficult to implement due to presence of waste.
		Thermal Treatment	Application of heat through various methods increases volatilization of SVOCs to facilitate extraction	Yes	Removes constituents for ex-situ treatment	Moderate	Treats some constituents (VOCs, SVOCs, pesticides); requires additional air stream treatment	Low	Debris in media likely to cause operating difficulties and potentially safety issues; extraction rates varies; high moisture content limits effectiveness; power needs can be high	Moderate - High	Capital - Moderate to High (no adequate exisiting power available for most of site) O&M - Moderate	No	Implementability reduced by presence of municipal waste in soil. Costs potentially high.
	Biological	Bioventing	Oxygen is delivered to soil to facilitate biodegradation	No	Not an established technology to treat many of the constituents present	-	-	-	-	-	-	-	-
		Enhanced Bioremediation	Water-based solutions circulated through media to stimulate natural microbial activity	No	Not an established technology to treat many of the constituents present	-	-	-	-	-	-	-	-
		Phytoremediation	Plants used to remove, stabilize, or destroy constituents	Yes	Removes or immobilizes constituents thereby reducing concerns associated with direct contact and infiltration	Moderate	Effective for some constituents, but not all (e.g. PCBs); does not prevent direct contact without other process options	High	Readily implementable	Low - Moderate	Capital - Moderate O&M - Low	Yes	Can be combined with other process options to provide treatment of constituents present

Table 5-1
Screening of Remedial Technologies for Soil
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option [1]	Preliminary Screening of Remedial Technologies: Description	Retained/Rationale		Remedial Technology and Process Options Screening Criteria [2]: Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation		Retained	
Ex-Situ Treatment	Biological	Biopiles	Soils are excavated, mixed with amendments, and actively aerated to remove volatile constituents	Yes	Removes constituents for ex-situ treatment	Moderate	Treats some constituents (VOCs, SVOCs, pesticides); requires additional air stream treatment	Low	Implementability reduced by presence of waste mixed in soil	Moderate	Capital - Moderate O&M - Moderate	No	Longer treatment times than other ex-situ biological treatments
		Landfarming	Soils are excavated, placed in containment and tilled to remove volatile constituents	Yes	Removes constituents for ex-situ treatment	Low	Does not treat inorganics; volatile constituents require pretreatment	Low	Requires large area	Moderate	Capital - Moderate O&M - Moderate	No	No feasible for volume of soil and number of constituents requiring treatment
		Slurry Phase Biological Treatment	Soils are mixed with water and admixtures to facilitate biodegradation	Yes	Removes constituents from impacted soil	High	Effective treatment for majority of constituents present	Low	Implementability reduced by presence of waste mixed in soil; dewatering and disposal of treated material and wastewater required	High	Capital - High O&M - High	No	Offers minimal benefit to off-site disposal
	Physical/Chemical	Chemical Extraction	Excavated soil is mixed with chemical extractant to dissolve constituents, which are then separated from extractant	Yes	Removes constituents from impacted soil	Moderate	Effective for some constituents (i.e., PCBs, VOCs, pesticides)	Low	May not be implementable for potential large volume of soil requiring treatment; presence of municipal waste will reduce make mixing/contact very difficult. Reactions between waste and chemicals cannot be predicted.	High	Capital - High O&M - Low to Moderate	No	Presence of waste reduces implementability of this technology
		Chemical Reduction/Oxidation	Chemically transform hazardous constituents to non-hazardous or less toxic constituents	Yes	Stabilizes, immobilizes or makes inert constituents thereby reducing concerns associated with direct contact and infiltration	Moderate	Treats inorganics; less effective for some VOCs, SVOCs, and pesticides	Low	May not be implementable for potential large volume of soil requiring treatment; presence of municipal waste will reduce make mixing/contact very difficult. Reactions between waste and chemicals cannot be predicted.	Moderate	Capital - Moderate O&M - Moderate	No	Presence of waste reduces implementability of this technology
		Separation	Constituents concentrated by physically or chemically separating constituents from the medium	Yes	Removes constituents from impacted soil	Moderate	Applicable to some constituents present (i.e., VOCs, SVOCs, pesticides and inorganics)	Low	May not be implementable for potential large volume of soil requiring treatment; presence of municipal waste will reduce make mixing and separation very difficult.	Moderate	Capital - Moderate O&M - Low/moderate	No	Presence of waste reduces implementability of this technology
		Solidification/Stabilization	Stabilizing agents added to excavated soil to physically bind or enclose constituents in a mass	Yes	Immobilizes constituents thereby reducing concerns associated with direct contact and infiltration	Low	Applicable to inorganics; low effectiveness with pesticides and organics	Low	Not likely implementable for large volumes as treatment increases volume further; presence of waste makes mixing and contact more difficult	Low - Moderate	Capital - Moderate O&M - Low	No	Not feasible for volume of soil requiring treatment
Removal	Excavation	Excavation	Physically remove impacted soil	Yes	Well established technology for removing impacted soil.	High	Requires clearing of site vegetation and destruction of habitat. Removal of constituents from site reduces toxicity and volume of constituents	Low - Moderate	Standard construction equipment, but implementability may be reduced by limited truck access to site and by site conditions	High	Capital - High O&M - Low to None	Yes	Standard process option applicable to all constituents; implemented in conjunction with disposal

Table 5-1
Screening of Remedial Technologies for Soil
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option (1)	Preliminary Screening of Remedial Technologies			Remedial Technology and Process Options Screening Criteria (2)						Retained	
			Description	Retained/Rationale		Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation			
Disposal/Discharge	Disposal	Off-Site Landfill	Off-site disposal of excavated soil at an approved landfill	Yes	Well established technology for disposal of impacted soil	Moderate - High	Removal of constituents from site reduces toxicity and volume of constituents	Moderate	Standard construction equipment, but characterization required to find appropriate disposal facility; potentially difficult to find a facility that can receive such a large volume of impacted material; implementability reduced by limited truck access to site	Moderate - High	Capital - Dependent on volume and waste characterization (hazardous/non-hazardous) O&M - Low to None	Yes	Standard disposal method applicable to all constituents
		Off-Site Incineration	Incineration of excavated soil or remedial process residuals in an approved incineration facility.	Yes	Technology is applicable for most site constituents except inorganics, which would require disposal.	Moderate - High	Removal of constituents from site reduces toxicity and volume of constituents	Moderate	Standard construction equipment, but characterization required to find appropriate disposal facility; implementability reduced by limited truck access to site	Moderate - High	Capital - Dependent on volume and waste characterization (hazardous/non-hazardous) O&M - Low to None	No	Technology is not applicable for inorganics, which would still require off-site disposal. Therefore, incineration offers no benefit over simple off-site disposal.
		On-Site Consolidation	Excavate and relocate soil on-site for further, long-term management (e.g., containment).	Yes	Well-established technology for management of impacted soil	Moderate	Reduction of extent/area of impacted material; may be combined with other soil treatment or containment technologies	Moderate - High	Standard construction equipment; liner may be required under impacted materials to prevent migration of constituents to groundwater	Moderate	Capital - High O&M - Low to None	Yes	Standard, proven disposal method; implemented with containment
		Backfilling Excavation	Backfilling with clean fill	Yes	Well-established technology for restoring excavated area; combine with excavation or other disposal technologies	Moderate	May be combined with other soil treatment or containment technologies	Low - Moderate	Potentially unfeasible due to site size/volume of soil required; implementability reduced by limited truck access to site	Moderate	Capital - Moderate (soil sampling and handling) O&M - Low to None	Yes	Less feasible than other disposal options
		Soil Reuse	Reuse of treated soils as fill or cover material in a landfill	No	Ex-situ treatments required to allow soil reuse are not applicable to the site because material is a mixture of waste and soil	-	-	-	-	-	-	-	-

Notes
(1) Remedial Technology/Process Options list developed from Tables 4 and 5 of *Rolling Knolls Landfill Superfund Site Technical Memorandum on Candidate Technologies and based on USEPA comments provided 20 May 2015.*
(2) Per USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* , October 1988.
(3) Institutional controls for soil may include easements, covenants, or deed notices.

Table 5-2
Screening of Remedial Technologies for Groundwater
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option (1)	Preliminary Screening of Remedial Technologies			Remedial Technology and Process Options Screening Criteria (2)						Retained	
			Description	Retained/Rationale		Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation			
No Action	No Action	No Action	No Remedial Action	Yes	As required by NCP and USEPA as a baseline for other process options.	Low	Does not result in a decreased residual risk; baseline conditions	High	Readily implementable	Low	Capital - None O&M - Low (for monitoring)	Yes	As required by NCP and USEPA as a baseline for other process options.
Monitoring	Monitoring	Groundwater Monitoring	Sampling and testing of groundwater	Yes	To supplement other technologies and monitor groundwater quality	High	Effective to evaluate other technologies and evaluate effectiveness of technologies	High	Readily implementable	Low - Moderate	Capital - Low O&M - Low to Moderate Can use existing infrastructure for groundwater monitoring	Yes	Standard practice for evaluating effectiveness of technologies; implemented with other containment options
Institutional Controls	Institutional Controls	Classification Exception Area and Well Restriction Area	Administrative actions taken to minimize the potential for human exposure to constituents present by controlling land use, guiding human behavior, and using groundwater use restrictions	Yes	Provides notification of constituents in media and prevents installation of wells.	High	Effective in providing notification of areas of contamination	Moderate - High	New Jersey has regulatory process for establishing Classification Exception Area and Well Restriction Area; requires coordination with regulatory authorities	Low	Capital - Low O&M - Low	Yes	Standard practice for landfill management; implemented with additional process options
Monitored Natural Attenuation	Monitored Natural Attenuation	Monitored Natural Attenuation	Periodic groundwater quality monitoring to evaluate the natural attenuation and extent of groundwater impacts	Yes	Established technology for groundwater constituents	Moderate	Relies on natural processes to achieve a reduction of contaminants of concern	High	Readily implementable	Low	Capital - Low O&M - Low Can use existing infrastructure for groundwater monitoring	Yes	Conventional technology that can be supplemented with other technologies. Can be combined with control of source areas if needed to reduce migration of constituents to groundwater and improve effectiveness.
Containment	Infiltration Control	Low Permeability Cover	Reduce infiltration to impacted areas and minimize potential for direct contact with groundwater	Yes	Reduces further leaching of constituents to groundwater	Moderate	Prevents direct contact with subsurface; long-term maintenance dependent on site use and maintenance of cover	Moderate	Limited truck access to site reduces implementability	Moderate	Capital - Moderate O&M - Low	Yes	Conventional technology that can be supplemented with other technologies
	Barriers	Trenched Cutoff Wall	Low-permeability material placed in a trench to prevent horizontal migration of impacted groundwater	Yes	Established technology for containment of impacted groundwater	Low	Effective in controlling off-site migration, but off-site migration not observed at site	Moderate	Moderately implementable--potential limitations due to site geology and presence of waste materials	High	Capital - High (based on depth and nature of impacted groundwater)	No	Not effective other than to control off-site migration.
		Sheet Piling	Sheet pile installed to prevent horizontal migration of impacted groundwater; often requires groundwater extraction to reduce groundwater pooling upgradient of sheet piling	Yes	Established technology for containment of impacted groundwater	Low	Effective in controlling off-site migration, but off-site migration not observed at site	Moderate	Moderately implementable--potential limitations due to site geology and presence of waste materials.	Moderate - High	Capital - Moderate to High; costs increased if groundwater extraction is required	No	Not effective other than to control off-site migration.
		Permeable Reactive Wall	Passive treatment wall constructed to intercept flow path of and treat passing impacted groundwater	Yes	Established technology for treatment of groundwater constituents	Low	Effective in controlling off-site migration, but off-site migration not observed at site	Moderate	Moderately implementable--potential limitations due to site geology and presence of waste materials.	High	Capital - High	No	Not effective other than to control off-site migration.
		Groundwater Extraction	Extract groundwater to control horizontal migration of impacted groundwater and potentially control contaminant plume	Yes	Established technology that provides groundwater constituent removal	Moderate	Moderately effective at controlling constituent migration, reduces volume of constituents	Moderate	Moderately implementable--potential limitations due to site geology and presence of waste materials	Moderate - High	Capital - Moderate to High O&M - Moderate to High	Yes	Conventional technology that can be supplemented with other technologies
		Groundwater Recovery Trenches	Trenches and associated piping used to passively collect groundwater and potentially provide hydraulic control of impacted groundwater	Yes	Established technology that facilitates subsequent pumping and groundwater constituent removal	Moderate	Moderately effective at controlling constituent migration	Moderate	Moderately implementable--potential limitations due to site geology and presence of waste materials; requires treatment and disposal of recovered water	High	Capital - High (based on depth and nature of impacted groundwater)	No	Less effective than other technologies

Table 5-2
Screening of Remedial Technologies for Groundwater
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option (1)	Preliminary Screening of Remedial Technologies			Remedial Technology and Process Options Screening Criteria (2)						Retained	
			Description	Retained/Rationale		Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation			
In-Situ Treatment	Physical	Soil Vapor Extraction	Vacuum applied to extraction wells to facilitate volatilization of groundwater constituents such as VOCs	Yes	Combined with other technologies for enhancing extraction and treatment	Low - Moderate	Removes VOCs from the vadose zone for ex-situ treatment but effectiveness is low in areas where VOC concentrations are low; geology (vadose zone thickness/depth to groundwater table) will influence effectiveness	Moderate	Potential limitations due to site geology and presence of waste	Moderate	Capital - Moderate (well installation and equipment) O&M - Low to Moderate	No	Unlikely to be effective given the low VOC concentrations at the site, and difficult to implement due to presence of waste.
		Air Sparging	Air injection wells used to strip groundwater constituents in-situ	Yes	Established technology combined with other technologies for treatment of extracted vapors	Low - Moderate	Removes VOCs from the subsurface for ex-situ treatment but effectiveness is low in areas where VOC levels are low; geology/depth to groundwater table will influence effectiveness	Moderate	Potential limitations due to site geology and presence of waste	Moderate	Capital - Moderate (well installation and equipment) O&M - Low to Moderate	No	Unlikely to be effective given the low VOC concentrations at the site, and difficult to implement due to presence of waste.
	Chemical	Passive/Reactive Treatment Walls	Iron treatment wall to degrade chlorinated compounds	Yes	VOCs, SVOCs, inorganics, and some fuel hydrocarbons	Moderate	Effective in controlling off-site migration, but off-site migration not observed at site	Moderate	Moderately implementable--potential limitations due to site geology and presence of waste materials. May be implementable if only applied to limited areas of the site.	Moderate - High	Capital - Moderate to High (installation and treatment medium) O&M - Low to Moderate (dependent on whether reactive medium must be replaced)	No	Not effective other than to control off-site migration.
		Ozone (combined with collection of vapors)	Use ozone to oxidize constituents in situ	Yes	Established technology for groundwater constituents	Moderate	Moderately effective for destruction of susceptible constituents; presence of waste materials will likely consume oxidant	Low	Ozone distribution will likely be difficult in the subsurface	High	Capital - High O&M - High	No	Difficult to implement, no significant benefits over other technologies
		Fenton's Reagent/Hydrogen Peroxide	Use hydroxyl radical through Fenton's reagent for in-situ oxidation of groundwater constituents or increasing dissolved oxygen	Yes	Established technology for groundwater constituents	Moderate	Moderately effective for destruction of susceptible constituents; presence of waste materials will likely consume oxidant	Low	Site conditions and depth of groundwater would be challenging; Health and safety concerns during implementation	High	Capital - High O&M - High	No	Difficult to implement, no significant benefits over other technologies
		Persulfate	Use persulfate for in-situ oxidation of groundwater constituents	Yes	Established technology for groundwater constituents	Moderate - High	Effective for VOCs; presence of waste materials will likely consume oxidant	Moderate	Moderately implementable with standard equipment and materials	Moderate - High	Capital - Moderate to High O&M - Moderate to High	Yes	Conventional technology that can be supplemented with other technologies
		Permanganate	Use sodium or potassium permanganate for in-situ oxidation of groundwater constituents	Yes	Established technology for groundwater constituents	Moderate - High	Effective for VOCs; presence of waste materials will likely consume oxidant	Moderate	Moderately implementable with standard equipment and materials	Moderate - High	Capital - Moderate to High O&M - Moderate to High	Yes	Conventional technology that can be supplemented with other technologies
	Biological	Enhanced Reductive Dechlorination	Inject a degradable substrate to enhance biodegradation of chlorinated compounds by microorganisms present in groundwater; bioaugmentation may be used if sufficient native microorganisms are not present	Yes	Established technology for groundwater constituents	Moderate - High	Effective for chlorinated VOCs	Moderate	Moderately implementable with standard equipment and materials	Moderate	Capital - Moderate O&M - Moderate	Yes	Conventional technology that can be supplemented with other technologies
		Aerobic Bioremediation	Inject oxygen source to facilitate aerobic degradation of constituents or precipitate metals	Yes	Established technology for groundwater constituents	Moderate - High	Effective for VOCs and certain metals	Moderate	Moderately implementable with standard equipment and materials	Moderate	Capital - Moderate O&M - Moderate	Yes	Conventional technology that can be supplemented with other technologies
		Phytoremediation	Plants used to remove, stabilize, or destroy constituents	Yes	Removes constituents from groundwater	Moderate - High	Effective for VOCs, SVOCs, pesticides, and metals	High	Readily implementable, well understood	Low - Moderate	Capital - Moderate O&M - Low	Yes	Can be combined with other process options to provide treatment of constituents in groundwater

Table 5-2
Screening of Remedial Technologies for Groundwater
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1	2	3	4	5		6		7		8		9	
General Response Action	Remedial Technology	Process Option [(1)]	Preliminary Screening of Remedial Technologies			Remedial Technology and Process Options Screening Criteria [(2)]						Retained	
			Description	Retained/Rationale		Effectiveness Evaluation		Implementability Evaluation		Cost Evaluation			
Ex-Situ Treatment	Physical	Air Stripping	Transfer groundwater constituents from liquid phase to vapor phase and possibly provide off-gas treatment.	Yes	Established technology for treating groundwater and vapor process stream and is frequently combined with carbon adsorption to provide treatment	Moderate - High	Effective for removal of VOCs from aqueous waste; requires air treatment/discharge	High	Readily implementable	Moderate	Capital - Moderate O&M - Moderate	Yes	Effective for relatively high concentrations of VOCs
Ex-Situ Treatment	Physical	Carbon Adsorption	Move contaminants from aqueous or vapor phases onto activated carbon	Yes	Established technology for treating groundwater and vapor process stream and is frequently combined with air stripping to provide treatment	Moderate - High	Effective for removal of VOCs from aqueous or vapor waste stream; not as effective for some VOCs such as vinyl chloride	High	Readily implementable	Low - Moderate	Capital - Low to Moderate O&M - Low to Moderate	Yes	Effective for VOCs
Ex-Situ Treatment	Chemical	Ion Exchange	Use engineered media to preferentially sorb ionic species from an aqueous stream	Yes	Established technology that may be required as pre-treatment of metals along with other process options	Moderate	Effective for ex-situ treatment of metals; less effective for other constituents	High	Readily implementable	Moderate	Capital - Moderate O&M - Moderate	Yes	Conventional technology that can be supplemented with other technologies
Ex-Situ Treatment	Chemical	Precipitation	Precipitate metals through the conversion of soluble heavy metals salts to soluble salts, coagulation, and/or flocculation	Yes	Established technology that may be required as pre-treatment of metals along with other process options	Low - Moderate	Presence of multiple metals species may be difficult to treat	Low - Moderate	Requires sampling and disposal of sludge; sludge characterization required to find appropriate disposal facility	High	Capital - High O&M - High	Yes	Conventional technology that can be supplemented with other technologies
Ex-Situ Treatment	Chemical	Advanced Oxidation Processes	UV oxidation of organic constituents through addition of strong oxidizers and UV light	Yes	Organic contaminants that are reactive with the hydroxyl radical	Moderate	Effective for organics such as petroleum and chlorinated hydrocarbons	Low - Moderate	May require pretreatment; dependent on water chemistry and turbidity	Moderate - High	Capital - High (energy) O&M - Low	No	Costs may be higer than competing technologies because of energy requirements
Disposal/Discharge	Disposal	Off-Site landfill	Off-site disposal of treatment media at an approved landfill	Yes	Spent groundwater treatment media will require off-site disposal	High	Effective for treatment media associated with ex-situ groundwater treatment	Moderate - High	Standard construction equipment, but characterization required to find appropriate disposal facility	Moderate - High	Capital - Dependent on volume and waste characterization (hazardous/non-hazardous) O&M - Low to None	Yes	Conventional technology
Disposal/Discharge	Discharge	POTW	Off-site surcharge to a publicly owned treatment works with appropriate permits	Yes	POTWs often accept remediation discharges, though discharges may require on-site pre-treatment	High	Effective for disposal of aqueous waste stream	Moderate	Moderately implementable; pretreatment of groundwater and a permit may be required; most POTWs in northern New Jersey do not accept treated water from Superfund remedial actions	Low - Moderate	Capital - Low to Moderate O&M - Low to Moderate	Yes	Supplement with other technologies
Disposal/Discharge	Discharge	Reinjection	Reinject treated groundwater meeting applicable discharge limits outside of the areas of contamination	Yes	Established technology used following collection and ex-situ treatment	Moderate	Effective for treated groundwater	Low	Geology may limit implementability (difficulty in finding area where water can be reinjected without impacting surface water conditions and wetland hydrology); permitting and pretreatment will be necessary	Moderate	Capital - Moderate O&M - Moderate	Yes	Low implementability; better options available than injection wells, but reinjection trenches may be incorporated to supplement other technologies
Disposal/Discharge	Discharge	Surface Water Discharge	Reinject treated groundwater meeting applicable discharge limits to a receiving surface water body	Yes	Established technology used following collection and ex-situ treatment	High	Effective for treated groundwater (with permit)	Moderate	Moderately implementable, may require permitting and testing	Moderate - High	Capital - Moderate to High O&M - Moderate to High	Yes	Supplement with other technologies

Notes

(1) Remedial Technology/Process Options list developed from Tables 4 and 5 of *Rolling Knolls Landfill Superfund Site Technical Memorandum on Candidate Technologie:* and based on USEPA comments provided 20 May 2015.

(2) Per USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCL/*, October 1988.

Table 6-1
Screening of Remedial Alternatives for Soil
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1		2	3		4		5	
Alternative		Process Options	Remedial Alternative Screening Criteria: Effectiveness		Implementability		Relative Cost	
1	No Action [1]	No Action	Low	Does not result in a decreased residual risk.	High	Readily Implementable.	Low	No Cost
2	Site Controls	Institutional Controls [2] and Access Restrictions	Low - Moderate	Institutional controls are effective in limiting future Site use; five-year review process ensures long-term effectiveness. Physical barriers/signage/security are effective at preventing/discouraging entry.	High	USEPA has enforcement authority to require institutional controls. Access restrictions/physical barriers are readily implementable.	Low	Minimal cost for institutional controls, likely low to moderate capital and O&M costs for access restrictions.
3	Site Controls, Excavation, and Off-Site Disposal of Selected Areas to Reduce Overall Risk	Institutional Controls, Access Restrictions, and Excavation with Off-Site Disposal	High	Institutional controls are effective in limiting future Site use; five-year review process ensures long-term effectiveness. Physical barriers/signage/security are effective at preventing/discouraging entry. Excavation and off-site disposal will physically remove impacted soil from the Site.	Low	USEPA has enforcement authority to require institutional controls. Access restrictions/physical barriers are readily implementable, but excavation and transport off-site may be limited by truck access to the Site through residential area on narrow roads, and Site conditions. Also, the material must be characterized to locate an appropriate disposal facility. Finding a facility that can handle the material may be challenging. Truck usage results in carbon emissions and excavation results in habitat loss, leading to lower implementability.	High	Minimal cost for institutional controls, likely low to moderate capital and O&M costs for access restrictions. However, excavation and off-site disposal costs anticipated to be high and dependent on total volume and waste characterization.
4	Site Controls and Capping of Selected Areas to Reduce Overall Risk	Institutional Controls, Access Restrictions, and Vegetative or Low-Permeability Cover (in selected areas of the site)	High	Institutional controls are effective in limiting future Site use; five-year review process ensures long-term effectiveness. Physical barriers/signage/security are effective at preventing/discouraging entry. Capping prevents direct contact with contaminated soils and debris, but requires clearing of Site vegetation/destruction of habitat. Long-term success depends on maintenance of cover.	Moderate	USEPA has enforcement authority to require institutional controls. Access restrictions/physical barriers are readily implementable. Implementability affected by access to the Site (only access is through residential areas on narrow road) since cap materials will be hauled in by truck. Truck usage results in carbon dioxide emissions and capping results in habitat loss, leading to lower implementability.	Moderate - High	Minimal cost for institutional controls, likely low to moderate capital and O&M costs for access restrictions. Capital costs for capping high, but O&M costs should be low to moderate (proportional to area of cap).
5	Site Controls and Capping of All Landfill Material	Institutional Controls, Access Restrictions, and Vegetative or Low-Permeability Cover (entire landfill area)	High	Institutional controls are effective in limiting future Site use; five-year review process ensures long-term effectiveness. Physical barriers/signage/security are effective at preventing/discouraging entry. Capping prevents direct contact with contaminated soils and debris, but requires clearing of Site vegetation/destruction of habitat. Long-term success depends on maintenance of cover.	Moderate-Low	USEPA has enforcement authority to require institutional controls. Access restrictions/physical barriers are readily implementable. Implementability affected by access to the Site (only access is through residential areas on narrow road) since cap materials will be hauled in by truck. Truck usage results in carbon dioxide emissions and capping results in habitat loss, leading to lower implementability. Alternative 5 may require a significantly greater volume of hauling traffic, and more habitat loss, than Alternative 4.	High	Minimal cost for institutional controls, likely low to moderate capital and O&M costs for access restrictions. Capital costs for capping high, O&M costs moderate to high (proportional to area of cap).

Notes

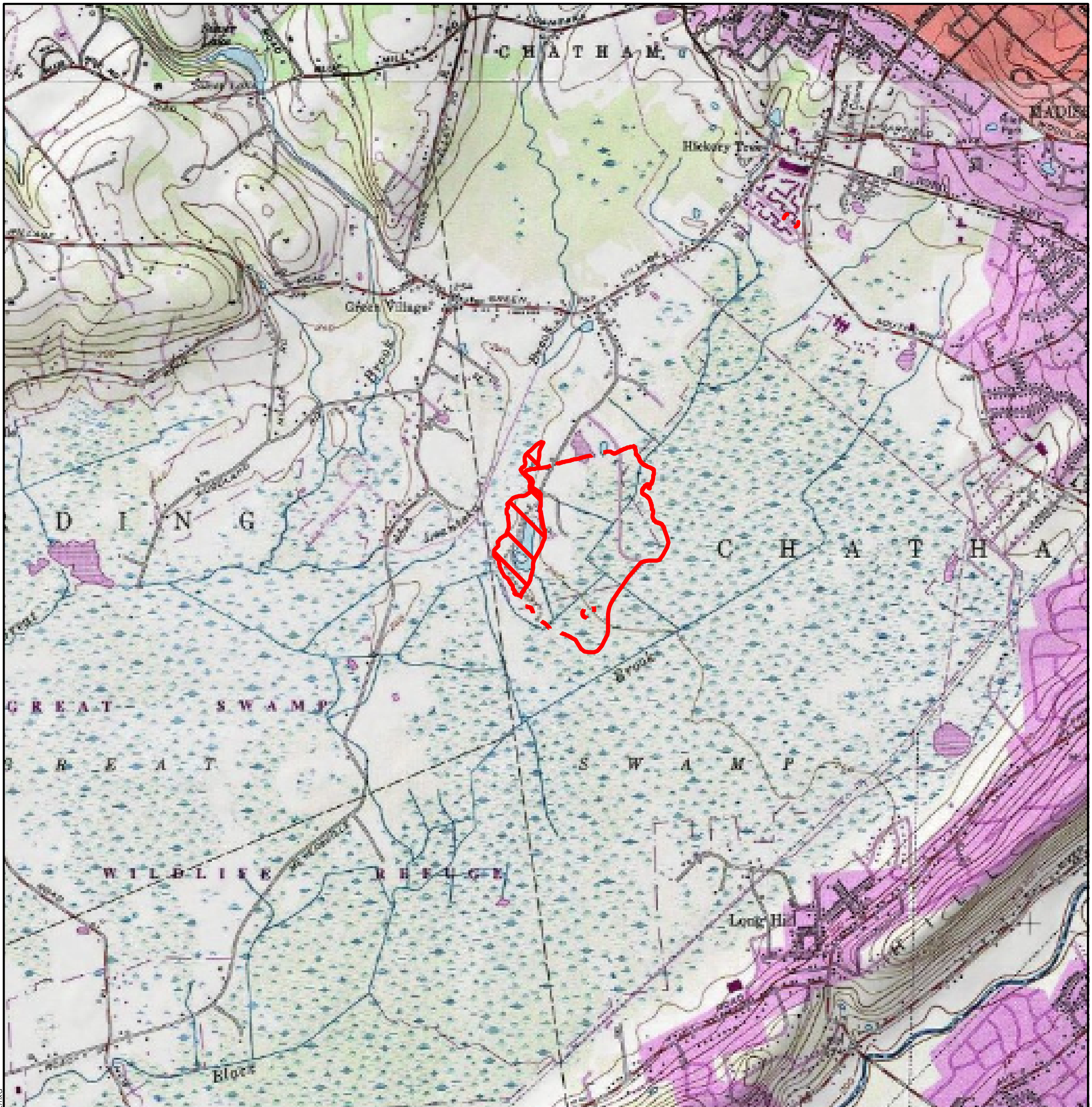
(1) As required by USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, October 1988.
(2) Institutional controls for soil may include easements, covenants, or deed notices.

Prepared by Geosyntec Consultants

Table 6-2
Screening of Remedial Alternatives for Groundwater
Rolling Knolls Landfill Superfund Site
Chatham, New Jersey

1		2	3		4		5	
Alternative		Process Options	Remedial Alternative Screening Criteria					
			Effectiveness		Implementability		Relative Cost	
1	No action (1)	No Action	Low	Does not result in a decreased residual risk.	High	Readily Implementable.	Low	No cost.
2	Monitored Natural Attenuation (MNA)	MNA and Institutional Controls (2)	Moderate	Relies on natural processes to achieve a reduction of contaminants of concern. Duration cannot be estimated at this time.	High	Readily Implementable.	Low	Can use existing infrastructure for groundwater monitoring.
3	MNA with Source Control	Source Control (Containment, In-Situ Treatment, Removal, or Disposal/Discharge) with MNA and Institutional Controls	Moderate - High	MNA relies on natural processes to achieve a reduction of contaminants of concern. Source control can be used to supplement MNA where source materials continue to contribute COCs to groundwater, leading to better effectiveness for MNA.	Moderate - High	MNA is readily implementable. Source control is generally moderately implementable with standard equipment and materials.	Low - Moderate	Can use existing infrastructure for groundwater monitoring. Generally moderate costs to implement source control technologies, depending on area/volume and composition of source.
4	Biological Treatment and MNA with Source Control	Biological Treatment (Enhanced Reductive Dechlorination, Aerobic Bioremediation, or Phytoremediation), Source Control, MNA and Institutional Controls	Moderate - High	MNA relies on natural processes to achieve a reduction of contaminants of concern. Biological treatment effective for various contaminants when treatment is correctly matched to the contaminant and site conditions.	Moderate - High	MNA is readily implementable. Biological in-situ treatment is generally moderately implementable with standard equipment and materials.	Low - Moderate	Can use existing infrastructure for groundwater monitoring. Generally moderate costs to implement in-situ biological technologies.

Notes
(1) As required by USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, October 1988.
(2) Institutional controls for groundwater include a Classification Exception Area and Well Restriction Area.



Site Property created from Arcadis CAD drawings received December 2015.
United States Geological Survey topographic maps accessed via ArcGIS Online and provided by National Geographic Society andi-cubed on 30 September 2016.
Morristown (1982) and Chatham (1982) quadrangles are shown.

2,000 1,000 0 2,000 Feet

Legend

Edge of landfilled wastes (dashed where approximate)

Waste and debris observed on ground surface but not observed or anticipated below ground surface

Site Location

ROLLING KNOLLS LANDFILL SUPERFUND SITE
CHATHAM, NEW JERSEY

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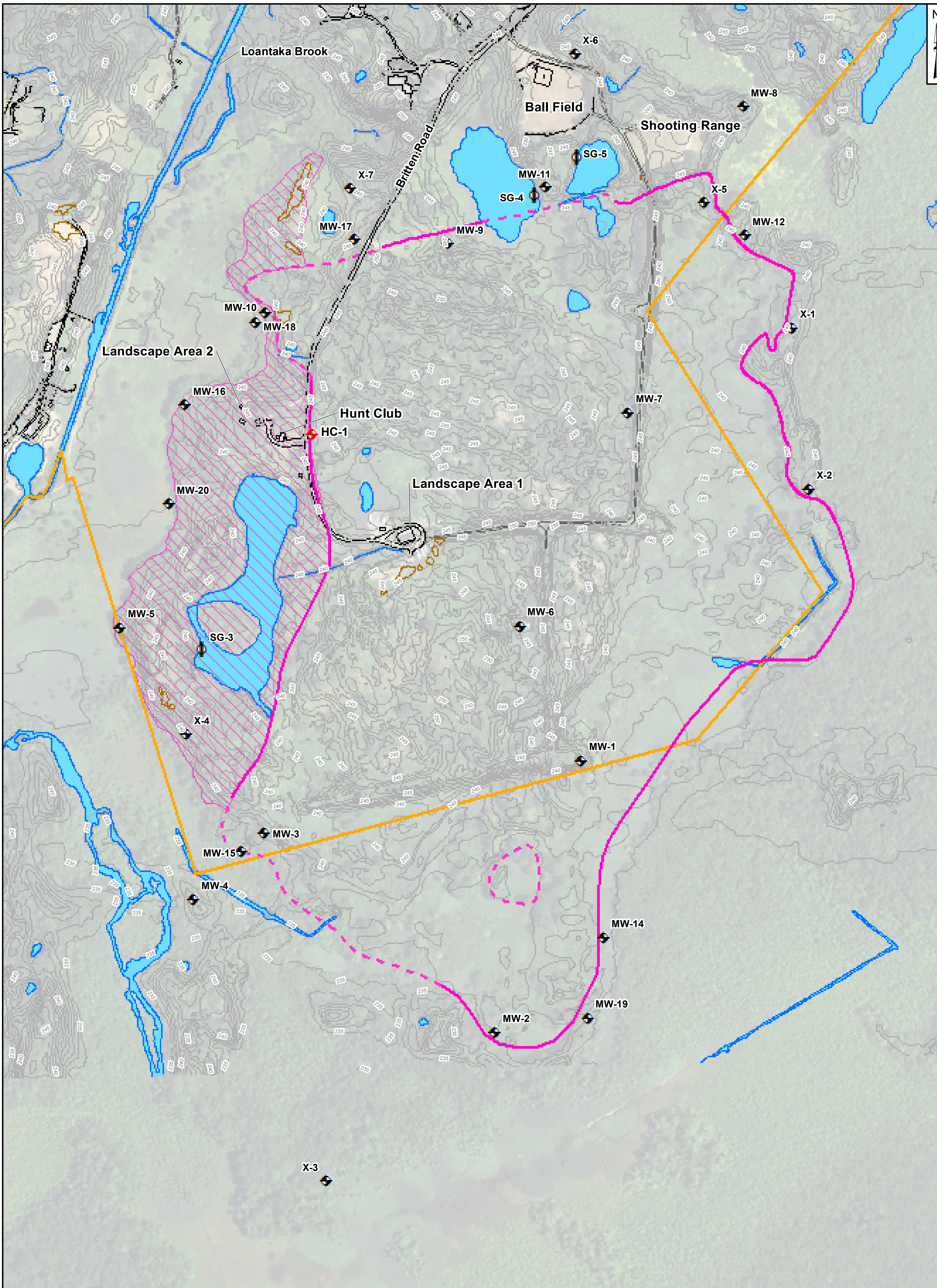
Figure 1-1

\\columbia-01\DATA\GIS\Rolling Knolls\Report 1\Figure 1 Site Location Map 8.5x11.mxd



Site Plan created from Arcadis CAD drawings received December 2015.
Aerial imagery accessed via ArcGIS Online and provided by the United States Department of Agriculture on 30 September 2016. Image is dated 31 July 2015.

400 200 0 400 Feet

Legend

- Monitoring Well Location
- Staff Gauge Location
- Non-Potable Supply Well
- Edge of landfilled wastes (dashed where approximate)
- Great Swamp National Wildlife Refuge property boundary
- Waste and debris observed on ground surface but not observed or anticipated below ground surface
- Open water

Site Plan

ROLLING KNOLLS LANDFILL SUPERFUND SITE
CHATHAM, NEW JERSEY

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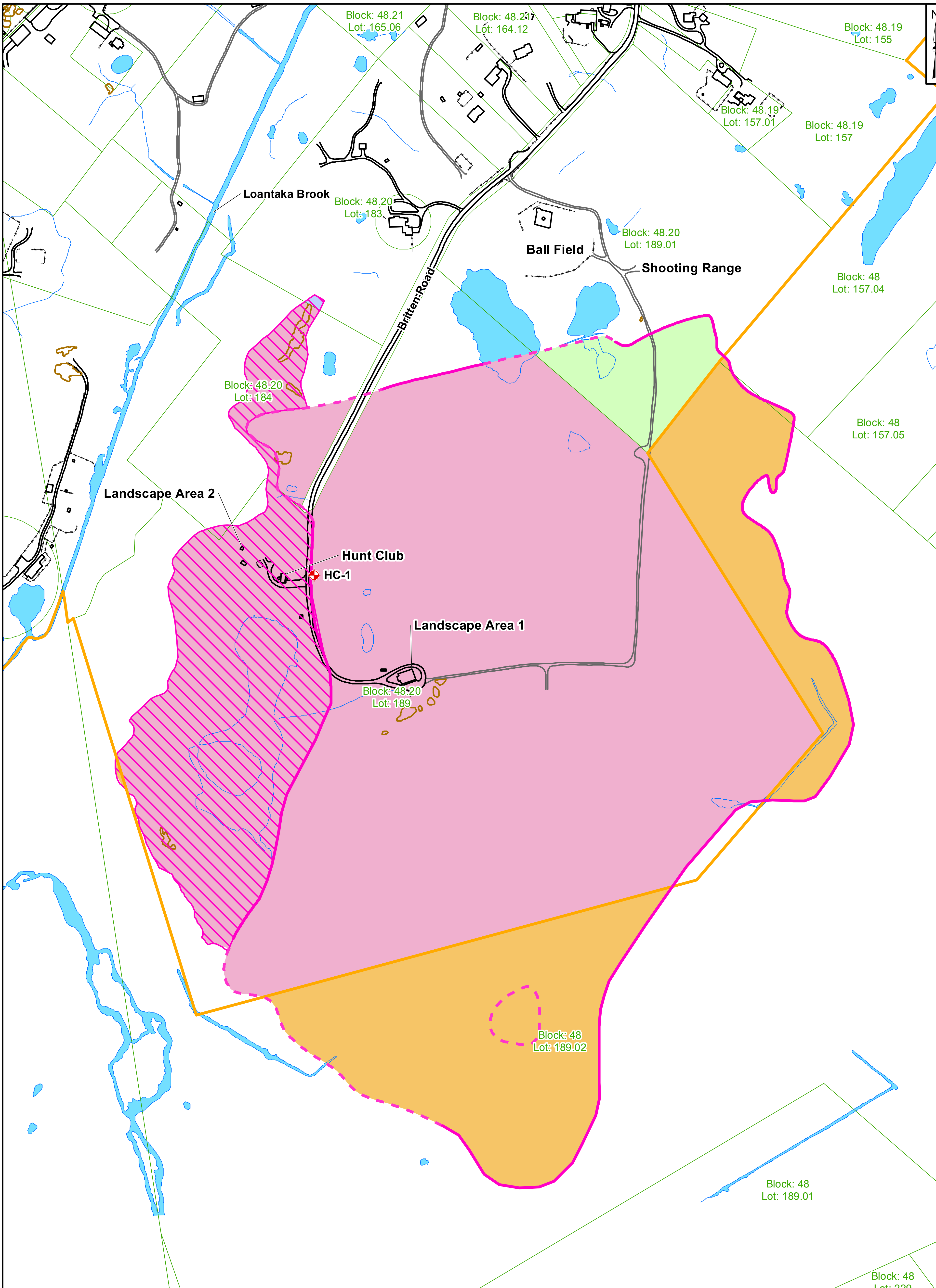
Figure 1-2



Parcel data provided by Morris County, GIS. 2 August 2016. Site Plan created from Arcadis CAD drawings received December 2015.

400 200 0 400 Feet

Legend

- Non-Potable Supply Well
- Edge of landfilled wastes (dashed where approximate)
- Great Swamp National Wildlife Refuge property boundary
- Waste and debris observed on ground surface but not observed or anticipated below ground surface
- Open water
- Property Parcel
- Block 48.20, Lot 183 (Owned by David M. Bakunas [Trustee])
- Block 48.20, Lots 184 and 189 (Owned by Robert J. Miele [Trustee])
- Block 48.20, Lot 189.01 (Owned by Green Village Fire Department)
- Great Swamp National Wildlife Refuge (Owned by the United States Fish and Wildlife Service)

Property Ownership

ROLLING KNOLLS LANDFILL SUPERFUND SITE
CHATHAM, NEW JERSEY

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Figure 2-1

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