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Table 4

Characterization Summary - Carcinogens

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk		
				Ingestion	Dermal	Exposure Routes Total
		Aquifer - Tap Water	chloroform	2.9×10^{-8}	2.9×10^{-9}	3.2×10^{-8}
		Aquifer - Tap Water	chloromethane	3.1×10^{-7}	9.1×10^{-9}	3.2×10^{-7}
		Aquifer - Tap Water	dibromochloro-methane	7.9×10^{-7}	6.1×10^{-8}	8.5×10^{-7}
		Aquifer - Tap Water	methylene chloride	9.9×10^{-6}	3.8×10^{-7}	1.0×10^{-5}
		Aquifer - Tap Water	trichloroethene	5.3×10^{-7}	9.0×10^{-8}	6.2×10^{-7}
		Aquifer - Tap Water	vinyl chloride	4.3×10^{-5}	2.3×10^{-6}	4.5×10^{-5}
		Aquifer - Tap Water	bis(2ethyl hexyl) phthalate	1.1×10^{-5}	1.8×10^{-5}	2.9×10^{-5}
					groundwater risk total=	5.0×10^{-4}
					Total Risk =	5.0×10^{-4}

Key
— : Toxicity criteria are not available to quantitatively address this route of exposure.

Risk Characterization

This table provides risk estimates for the significant routes of exposure. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a child's exposure to groundwater, as well as the toxicity of the COCs (arsenic, 1,4-dichlorobenzene, benzene, 1,2-Dichloroethane, 1,2-dichloropropane, Chloroethane, chloroform, chloromethane, dibromochloromethane, methylene chloride, trichloroethene, vinyl chloride, bis(2ethyl hexyl) phthalate). The total risk from direct exposure to contaminated groundwater at this Site to a current child resident is estimated to be 5.04×10^{-4}. The COC contributing most to this risk level is arsenic.

Table 5

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient		
					Ingestion	Dermal	Exposure Routes Total
Ground-water	Ground-water	Aquifer - Tap water	arsenic	Skin	2.0	$1.1x10^{-2}$	2.0
Ground-water	Ground-water	Aquifer - Tap water	chromium	---	2.0	$2.1x10^{-3}$	2.0
Ground-water	Ground-water	Aquifer - Tap water	manganese	CNS	9.1	$1.3x10^{-3}$	9.1
Ground-water	Ground-water	Aquifer - Tap water	acetone	Liver/Kidney	4.9	$2.4x10^{-2}$	4.9
Ground-water	Ground-water	Aquifer - Tap water	benzene	---	$1.5x10^{-1}$	$2.4x10^{-2}$	$1.8x10^{-1}$
Ground-water	Ground-water	Aquifer - Tap water	2-butanone	Developmen-tal	1.7	$1.6x10^{-2}$	1.7
Ground-water	Ground-water	Aquifer - Tap water	1,2-dichloroethane	---	$3.6x10^{-3}$	$1.8x10^{-4}$	$3.8x10^{-3}$
Ground-water	Ground-water	Aquifer - Tap water	1,2-dichloropropane	Respiratory	$4.9x10^{-2}$	$5.1x10^{-3}$	$5.4x10^{-2}$
Ground-water	Ground-water	Aquifer - Tap water	chloroethane	—	$1.1x10^{-3}$	$6.6x10^{-5}$	$1.2x10^{-3}$
Ground-water	Ground-water	Aquifer - Tap water	chloroform	Liver	$1.1x10^{-3}$	$1.1x10^{-4}$	$1.2x10^{-3}$
Ground-water	Ground-water	Aquifer - Tap water	dibromochlorom ethane	Kidney	$1.1x10^{-3}$	$8.5x10^{-5}$	$1.1x10^{-3}$
Ground-water	Ground-water	Aquifer - Tap water	4-methyl-2-pentanone	Liver/Kidney	$7.4x10^{-1}$	$2.2x10^{-2}$	$7.7x10^{-1}$
Ground-water	Ground-water	Aquifer - Tap water	methylene chloride	Liver	$5.0x10^{-2}$	$2.0x10^{-3}$	$5.2x10^{-2}$
Ground-water	Ground-water	Aquifer - Tap water	toluene	Liver/Kidney	3.1	1.1	4.2
Ground-water	Ground-water	Aquifer - Tap water	trichloroethene	Liver/Kidney	$1.8x10^{-2}$	$3.2x10^{-3}$	$2.1x10^{-2}$
Ground-water	Ground-water	Aquifer - Tap water	bis(2-ethylhexyl) phthalate	Liver	$8.8x10^{-2}$	$1.5x10^{-1}$	$2.4x10^{-1}$
Ground-water	Ground-water	Aquifer - Tap water	1,4-dichlorobenzene	---	$3.6x10^{-3}$	$2.6x10^{-3}$	$6.2x10^{-3}$

Table 5

Risk Characterization Summary - Non-Carcinogens

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Non-Carcinogenic Hazard Quotient		
					Ingestion	Dermal	Exposure Routes Total
Ground-water	Ground-water	Aquifer - Tap water	2,4-dimethylphenol	Blood	3.0	4.2×10^{-1}	3.4
Ground-water	Ground-water	Aquifer - Tap water	4-methylphenol	CNS	275	27	302
						GW Hazard Index Total =	**331**
						Hazard Index Total =	**331**
						Skin Hazard Index =	**2.0**
						Blood Hazard Index =	**3.4**
						Respiratory Hazard Index =	**0.054**
						Developmental Hazard Index =	**1.7**
						CNS Hazard Index =	**311**
						Liver/Kidney Hazard Index =	**9.9**

Key

— : Toxicity criteria are not available to quantitatively address this route of exposure.
N/A: Route of exposure is not applicable to this medium.

Risk Characterization

This table provides hazard quotients (HQs) for each route of exposure and the hazard index (sum of hazard quotients) for all routes of exposure. The Risk Assessment Guidance (RAGS) for Superfund states that, generally, a hazard index (HI) greater than 1 indicates the potential for adverse noncancer effects. The estimated HI of 327 indicates that the potential for adverse noncancer effects could occur from exposure to contaminated groundwater containing chromium, manganese, acetone, 2-butanone, toluene, 2,4-dimethylphenol, and 4-methylphenol.

The only medium which poses an unacceptable risk is groundwater. The total cancer risk from dermal and oral exposures via a drinking water scenario is 5×10^{-4}. Eighty percent of the cancer risk is due to arsenic at the maximum concentration of 22 μg/L. This cancer risk estimate is conservative because it assumes that groundwater containing the maximum concentration is actually consumed. If groundwater were to be consumed, it is much more likely that the concentration would be closer to the average concentration. Groundwater in the area is not consumed presently because municipal drinking water is provided. In addition, institutional controls will be instituted to prevent installation of drinking water wells in the future.

According to Review Comments on the "Geochemical Modeling for Assessing Natural Attenuation of Arsenic at the Barkhamstead New Hartford Landfill" Superfund Site, Barkhamstead, CT by Ann Keeley, Ph.D. on March 22, 2001, concentrations of arsenic will decrease over time to 5 μg/L. The cancer risk associated with 22 μg/L arsenic is 4×10^{-4}. The cancer risk associated with the other carcinogenic chemicals is 1×10^{-4}. Since the modeled future arsenic concentration (5 μg/L) is 4.4 times lower, the future cancer risk of arsenic would be 9.1×10^{-5}. If the concentrations of the other carcinogenic chemicals remain the same (which is unlikely and perhaps over represents their exposure), the total future cancer risk would be 1.93×10^{-4}. The RI/FS found that the concentrations of these chemicals should reach background levels in about 15 years. Since it is likely that the concentrations of the other carcinogenic chemicals will decrease due to natural attenuation, it is probable that the future cancer risk would be below 1×10^{-4}, within USEPA's acceptable risk range of 1×10^{-4} to 1×10^{-6}. As a result, it is concluded that the future cancer risk will be acceptable even if groundwater was used for drinking water.

The current risks of non-carcinogenic chemicals exceed USEPA's hazard quotients of concern. The hazard indices (HI) which may exceed USEPA's hazard quotient of concern occur for the target endpoints of skin (HI=2.0), blood (HI=3.4), developmental effects (HI=1.7), liver/kidney effects (HI=9.1)and CNS (HI=311). The greatest contributor by far to noncancer risk is 4-methylphenol which is responsible for a HQ of 302 for central nervous system (CNS) effects (Table 5).

Lead in groundwater also exceeds its action level and would exceed USEPA's goal for lead in children's blood. The USEPA's Integrated Exposure and Uptake Biokinetic model was used to evaluate the hazard potential posed by exposure of young children less than 7 years of age as the most sensitive receptor group. This model evaluates exposures to lead from multiple media (i.e. soil/dust, drinking water, diet and air). Model defaults for media concentrations were assumed for all media except for drinking water. The model defaults are based on national background levels of lead in diet, air, dust and soil. The outcome of the model revealed that at the maximum average concentration of lead in any well (42 μg/L), 15.5% of children in the population would have blood lead levels that exceed 10 μg/dL. It is USEPA policy to protect 95% of the sensitive population against blood lead levels in excess of 10 ug/dL blood.

Uncertainty

There is always some imprecision, inaccuracy, and unrepresentativeness in the environmental data used to characterize site risks. The extent to which the data are incomplete is usually quantifiable, but precision, accuracy, and representativeness can only be estimated or described qualitatively. Below is a brief discussion of the major uncertainties associated with the risk assessment for the Site. A more complete discussion can be found in Section 5 of the Baseline Human Health Risk Assessment.

- The data include many measurements flagged with a "J", indicating that the measurement is approximate, or with a "UJ", indicating that the detection limit is approximate. These

measurements contribute to the overall uncertainty in the estimate of risks.

- Many contaminants were measured near their detection limits, where the measurement precision is low. Also, with the typical incidence of low-level laboratory contaminants, measured concentrations of many samples were flagged "J" (estimated" wherever observed concentrations were less than the detection limits).

- Some of the low measurements of acetone and 2-butanone may have been either laboratory or sampling contaminants and/or Site contaminants. Due to the presence of related compounds at the Site, this assessment conservatively assumes that detected quantities represent actual Site contamination, not laboratory or sampling artifacts.

- Nitrate, a common landfill contaminant, was not analyzed for in the RI. It is associated with sewage, fertilizer, and general household waste, not specifically with hazardous waste. Non-Contract Laboratory Program (CLP) analyses indicated that nitrates were present above levels of potential health concern, but the quantitative risk assessment did not address risks from nitrate. Therefore, risks may be underestimated for consumption of groundwater directly downgradient of the landfill.

- Use of unfiltered groundwater samples for chemical analysis during the RI may overstate exposures that would actually occur in the event that groundwater directly downgradient of the landfill were to be used as drinking water. Actual water supplies from groundwater are typically less turbid than samples from monitoring wells and would probably have lower concentrations of most metals.

- An important assumption in this assessment is that environmental concentrations of chemicals will remain constant for the foreseeable future. This assumption is made when estimated exposure rates are extended a number of years. A more detailed model might predict the dispersion of contamination and degradation of organic compounds expected to occur with natural attenuation. Unfortunately, this kind of modeling is not very reliable. Uncertainty about the extent of contamination and movement of contaminants toward the nearby residences means that risks to neighborhood residents could be underestimated or overestimated by this assessment.

- Use of maximum values for an upper estimate of exposure is conservative, and may result in overestimation of the risk for the maximally exposed individual. On the other hand, average concentrations are also subject to statistical uncertainty, and may overestimate or underestimate realistic or exposure point concentrations.

Human Health Risk Summary

All human health risks other than those associated with groundwater were addressed as a result of the NTCRA because all exposure pathways except groundwater ingestion were either

eliminated or ameliorated to acceptable risk levels by the NTCRA. The only medium that poses an unacceptable human health risk is exposure to groundwater. The total elevated cancer risk from dermal and oral exposures via a drinking water scenario is 5×10^{-4} (e.g. 5 in 10,000 chance of cancer above the normal lifetime chance of cancer of 1 in 3 or 4). Most (80%) of this elevated risk is due to arsenic at a maximum concentration of 22 μg/l. The hazard indices (HI) of contaminants in groundwater which may exceed the hazard quotient of concern (HI=1) occur for non-carcinogenic effects to skin, blood, kidney, fetal development, and the central nervous system. The greatest contributor by far to non-cancer risk is 4-methylphenol which is responsible for a hazard quotient (HQ) of 302 for central nervous system effects. Lead in groundwater also exceeds its action level and would exceed the USEPA's health goal for lead in children's blood under the conservative assumption that children would ingest lead at the maximum average concentration of lead in any well (42 μg/l).

2. Ecological Risk Assessment

RI Baseline Ecological Risk Assessment

The baseline ecological risk assessment in the RI (Metcalf & Eddy, 1996) evaluated ecological risk of chemicals of potential concern (COPCs) in sediment and surface water of the Unnamed Brook and Unnamed Pond, as well as soil in seeps. The ecological risk assessment was limited to locations outside the projected landfill cap using the assumption that seeps would dry out and become soil areas. COPCs are chemicals that have been detected at least once during chemical analysis of samples from a site. There were 59 COPCs in sediment, 32 COPCs in surface water, and 60 COPCs in seep soil, many of which were common to all three media. The maximum concentration of each COPC in each medium was screened against conservative ecological risk-based screening levels for the same medium (surface water, sediment and soil), and those COPCs that exceeded screening levels were selected as Chemicals of Concern (COCs) for further ecological risk assessment. The COCs selected for each medium were presented in Table 3-5 of the baseline ecological risk assessment (Metcalf & Eddy, 1996). The COCs included inorganics, pesticides and PAHs.

The risks of the COCs were evaluated by calculating average and maximum hazard quotients (HQ) for each receptor. The HQ is calculated by dividing the COC concentration or dose at the site by the no-effect or low-effect concentration or dose derived from the scientific literature. The representative receptors included fish, benthic invertebrates, amphibians, mammals (beaver, muskrat, mink, woodchuck, rodents), birds (robin), and soil invertebrates (earthworms). The average and maximum HQs for fish were calculated by dividing the average and maximum COC concentrations in surface water by the USEPA Ambient Water Quality Criteria. The HQ values for benthic invertebrates were calculated by dividing average and maximum COC concentrations in sediment by Lowest Effect Levels (LELs) from the Ontario Ministry of Energy and Environment or other conservative benchmarks. HQ values for mammals and birds were calculated by dividing the estimated dose due to ingestion of soil, sediment or tissue by no-effect or low-effect benchmark doses from the scientific literature.

The baseline ecological risk assessment concluded that: 1) aquatic invertebrate communities in the unnamed brook were at risk from metals, specifically aluminum, manganese, and iron; 2) mink and other semi-aquatic animals were at risk from pesticides in sediment (primarily DDT); and 3) small terrestrial mammals that consume animal tissue (e.g. earthworms) are at risk from the ingestion of chromium in seep soil.

Post-NTCRA Ecological Risk Assessment

Since the completion of the RI and the Baseline Ecological Risk Assessment, RRDD#1 has completed landfill closure under the NTCRA, which included capping of the landfill and installation of a leachate collection system, completed in 1998. During the performance of the NTCRA, an approximate 340-ft reach of the Unnamed Brook on the west side of the landfill (in the vicinity of Leachate Seeps 8 and 13) was relocated, with the former section of the brook being filled and covered with soil. Moreover, sediments were excavated from an approximate 70-ft reach of the brook near the northwest corner of the landfill (roughly between Leachate Seeps 5 and 6), and placed beneath the cap during the NTCRA construction. That excavation was conducted after coordinating with CTDEP to remove the most visually contaminated (iron stained) sediment from the brook.

Monitoring of water in the seeps and surface water of the Unnamed Brook was conducted in November/December, 2000 and February, 2000. In April, 2000 USEPA updated the ecological risk assessment with data from 1999/2000 by estimating risks associated with surface water and seeps. The surface water and seep water data are presented in Tables 6 and 7, respectively.

Post-NTCRA Surface Water

The more recent surface water monitoring data (Table 6) indicates that none of the inorganics that had driven the risk to aquatic organisms prior to the NTCRA exceeded surface water benchmarks after the NTCRA. However, bis(2-ethylhexyl) phthalate and carbon disulfide were detected in surface waters in December, 1999 at concentrations exceeding surface water quality benchmarks, but these were not detected in February, 2000. The concentrations of contaminants detected in surface water in December, 1999 and February, 2000 are compared with benchmark concentrations for aquatic organisms in Table 6. The results show that carbon disulfide and bis(2-ethylhexyl) phthalate exceeded their benchmarks in December, 1999 but not in February, 2000. These results indicate that at the last sampling period in February, 2000 there were no exceedances of surface water benchmarks in the Unnamed Brook, indicating that there is no significant risk of COCs in surface water to aquatic organisms.

Table 6
Chemical Concentrations in Surface Water of Unnamed Brook Before and After NTCRA-Barkhamsted Landfill

Chemical of Concern of Concern	Benchmark (ug/l)	Benchmark Source	Maximum Concentration (ug/l)			
			Pre-NTCRA		Post-NTCRA	
			August, 1995	April, 1997	December, 1999	February, 2000
Acetone	1500	(2)	10J	NA	ND	ND
Carbon disulfide	0.92	(2)	NA	NA	**13**	ND
Methylene chloride	2200	(2)	2J	NA	0.67J	ND
2,4-Dimethylphenol	2.4	(5)	**8**	NA	ND	ND
4-Methylphenol	--	--	**16**	NA	ND	ND
Bis(2-ethylhexyl) phthalate	3	(2)	ND	NA	**3.9J**	ND
Aluminum	87	(3)	**700**	**500**	ND	ND
Barium	3.9	(1)	ND	ND	ND	ND
Copper	2.7	(4)	ND	ND	ND	ND
Iron	1000	(3)	**8800**	**2100**	1.2	1.9
Lead	0.4	(4)	**3**	ND	ND	ND
Manganese	120	(2)	**250**	**230**	0.25	0.29
Zinc	36.5	(4)	ND	10	ND	ND

1) USEPA, 1996
(2) Suter and Tsao, 1996
(3) National Recommended Ambient Water Quality Criteria (USEPA, 1999)
(4) National Recommended Ambient Water Quality Criteria-adjusted to 25 mg/l hardness (USEPA, 1999)
(5) Rhode Island Ambient Water Quality Criteria (as used in the baseline risk assessment)
NA = Not Analyzed
ND = Not Detected
J = Estimated concentration
-- = Not Available
Values in bold exceed benchmark
Data from Table 3 (USEPA, 2000)

Post-NTCRA Seep Water

Seeps are expected to gradually diminish with the implementation of the NTCRA, until all seeps have been eliminated. As shown in Table 7, chemical concentrations in seep water have decreased since the NTCRA and do not exceed surface water benchmarks in the latest sampling round (February, 2000), except possibly for 2,4-dimethylphenol which had an estimated concentration greater than the benchmark. Nevertheless, 2,4-dimethylphenol was not detectable in surface water of the Unnamed Brook (see Table 6), indicating that seep water is not causing exceedances of aquatic benchmarks in the Unnamed Brook itself where aquatic organisms occur. Aquatic organisms do not occur in the seeps themselves. These trends are expected to continue over time due to the landfill cap and continuing leachate collection. The seeps are expected to become drier as less precipitation infiltrates into the landfill. The ecological risks of seep soil to terrestrial mammals were minimal prior to the NTCRA and will decrease as vegetation becomes

established in the seep areas. The results of these analyses will be used to assess the ecological risk over time and determine the need for any future remedial action. In particular, the monitoring data will be addressed as part of the 5-year review for the site.

Table 7
Chemical Concentrations in Surface Water of Seeps Before and After NTCRA-Barkhamsted Landfill

			Maximum Concentration (ug/l)			
	Benchmark	**Benchmark**	**Pre-NTCRA**		**Post-NTCRA**	
Chemical of Concern	(ug/l)	Source	August, 1995	August, 1998	December, 1999	February, 2000
Acetone	1500	(2)	26	NA	1.2J	ND
1,1-Dichloroethane	47	(2)	ND	NA	0.47J	0.64
1,2-Dichloroethane	910	(2)	ND	NA	0.26J	ND
1,2-Dichloropropane	--	--	ND	NA	0.29J	ND
4-Methyl-2-pentanone (MIBK)	170	(2)	ND	NA	0.62J	ND
Benzene	130	(2)	2.1	NA	1.9	1.8
Bromodichloromethane	--	--	ND	NA	0.28J	ND
Carbon disulfide	0.92	(2)	ND	NA	**54J**	ND
Chlorobenzene	54	(2)	2.8	NA	1.3	0.96
Chloroethane	--	--	4.7	NA	1.5J	1.3
Chloroform	28	(2)	ND	NA	1	ND
Chloromethane	--	--	ND	NA	ND	0.43J
Dibromochloromethane	--	--	ND	NA	0.15J	ND
Ethylbenzene	7.3	(2)	0.58	NA	ND	ND
Methylene chloride	2200	(2)	ND	NA	0.36J	ND
Toluene	9.8	(2)	ND	NA	0.21J	0.16J
Xylenes	13	(2)	3.4	NA	2.2	0.79
cis-1,2-Dichloroethene	590	(6)	ND	NA	0.12J	ND
Diethyl phthalate	210	(2)	7.1J	NA	2.6J	ND
2,4-Dimethylphenol	2.4	(5)	**21**	NA	**24**	**5.4J**
Phenol	110	(7)	ND	NA	ND	13
Aluminum	87	(3)	**900**	ND	3.6J	52
Arsenic	150	(3)	5	ND	0.005	0.007
Barium	3.9	(1)	**500**	**300**	0.4	0.4
Cadmium	0.8	(4)	ND	ND	ND	0.001
Chromium	23.8	(3)	20	10	0.01	0.05
Copper	29	(4)	10	ND	ND	0.09
Iron	1000	(3)	**80000**	**42000J**	76	150
Lead	14.7	(4)	ND	ND	ND	0.058
Manganese	120	(2)	**4800**	**5600**	0.25	0.29
Zinc	382	(4)	ND	ND	0.02	0.17

Data from Table 4 (USEPA, 2000)
(1) USEPA, 1996
(2) Suter and Tsao, 1996
(3) National Recommended Ambient Water Quality Criteria (USEPA, 1999)
(4) National Recommended Ambient Water Quality Criteria-adjusted to 25 mg/l hardness (USEPA, 1999)
(5) Rhode Island Ambient Water Quality Criteria (as used in the baseline risk assessment)
(6) Tier II value for 1,3-Dichloropropane used based on structural similarity
(7) AWQC chronic value calculated by the Great Lakes Water Quality Initiative as cited in Suter and Tsao, 1996
NA = Not Analyzed
ND = Not Detected
J = Estimated concentration
-- = Not Available
Values in bold exceed benchmark

Post-NTCRA Sediment

Sediments have not been analyzed in the Unnamed Brook after the completion of the NTCRA. Estimated post-NTCRA average and maximum COC concentrations were calculated by removing the RI data for the samples from areas of the Unnamed Brook that were relocated (SED-5) or excavated (SED-15), followed by re-calculation of the maximum and average concentrations. These re-calculated average and maximum concentrations were compared with updated sediment benchmarks for benthic invertebrates. The results of this comparison are presented in Table 8.

Table 8.
Comparison of Pre- and Post-NTCRA Sediment Concentrations With Benchmarks

	Sediment Concentration (ug/kg)				Sediment Benchmark Concentration (ug/kg)	
	Pre-NTCRA (1)		Post-NTCRA (2)		TEC	PEC
Chemical	Maximum	Average	Maximum	Average	(ug/kg)	(ug/kg)
Benzo(a)pyrene	850	268	850	251	150	1,450
Phenanthrene	730	243	730	255	204	1,170
Pyrene	2,300	402	2,300	436	195	1,520
4,4'-DDE	9.6	3.3	9.6	3.4	3.16	31.3
4,4'-DDT	11	3.4	11	3.3	4.16	62.9
Endosulfan	8.9	3.2	8.9	3.2	5.4(3)	5.4(3)
Endrin	3.8	2.9	3.8	2.8	20 (3)	20(3)
Chlordane	11	2.2	11	2.3	3.24	17.6
Barium	204,000	80,642	204,000	73,190	40,000(4)	40,000(4)
Chromium	66,900	23,952	55,700	22,093	43,400	111,000
Copper	47,900	16,252	47,900	15,988	31,600	149,000
Iron	79,400,000	21,608,750	79,400,000	20,320,500	20,000,000(5)	40,000,000 (6)
Lead	73,700	21,394	73,700	21,838	35,800	128,000
Manganese	9,450,000	1,221,279	9,450,000	1,105,035	460,000 (5)	1,100,000 (6)

Table 8.
Comparison of Pre- and Post-NTCRA Sediment Concentrations With Benchmarks

	Sediment Concentration (ug/kg)				Sediment Benchmark Concentration (ug/kg)	
	Pre-NTCRA (1)		Post-NTCRA (2)		TEC	PEC
Chemical	Maximum	Average	Maximum	Average	(ug/kg)	(ug/kg)
Nickel	35,500	12,208	35,500	11,780	22,800	48,600
Zinc	183,000	48,170	183,000	47,414	121,000	459,000

NA = Not Available
TEC = Threshold Effects Concentration from MacDonald et al (2000)
PEC = Probable Effects Concentration from MacDonald et al (2000)
(1) Data from RI Report (Metcalf & Eddy, 1996)
(2) Concentrations estimated by recalculation after removal of SED-5 and SED-15 from RI database
(3) Sediment Quality Benchmark from USEPA (1996) Ecotox Thresholds. ECO Update. USEPA 540/F-95/038
(4) Benchmark from Table 5-1 in RI Report (Metcalf & Eddy, 1996)
(5) Lowest Effect Level from Ontario Ministry of the Environment
(6) Severe Effect Level from Ontario Ministry of the Environment

Updated sediment benchmarks for aquatic organisms were taken from more recent studies (MacDonald et al 2000; USEPA, 1996). The original RI benchmarks (Table 5-1 of Metcalf & Eddy, 1996) were used if updated benchmarks were unavailable. Two types of benchmarks are represented; no-effect concentrations and probable effect concentrations. No-effect benchmarks include the Threshold Effect Concentration (TEC) from MacDonald et al (2000), the Lowest Effect Level (LEL) from the Ontario Ministry of Environment and Energy (OMEE), and the Sediment Quality Benchmark (SQB) from USEPA (1996). These benchmarks represent concentrations below which adverse effects are unlikely. These benchmarks are compared with maximum contaminant concentrations in screening level ecological risk assessments to screen out chemicals from further concern. It can be concluded that a chemical will not have adverse effects if it does not exceed these type of benchmarks.

The probable effect benchmarks include Probable Effect Concentrations (PEC) from MacDonald et al (2000) and Severe Effect Levels (SELs) from OMEE. These benchmarks represent concentrations above which adverse effects are likely. These benchmarks can be used in a baseline ecological risk assessment to conclude that effects are likely, unless rebutted by more site-specific data such as toxicity tests or benthic population surveys. Generally, the baseline ecological risk assessment concludes that adverse effects are likely only if the average concentration exceeds this type of benchmark.

The results of this analysis (Table 8) indicate that the estimated maximum post-NTCRA sediment concentration of many of the COCs exceeds the no-effect benchmarks, but the average concentrations of only two COCs (barium and manganese) exceed the probable effect benchmarks. As a result, it is concluded that some level of risk might still exist for benthic invertebrates in the Unnamed Brook.

It is likely that the contaminant concentrations in the biotic zone of the Unnamed Brook will decrease in the future due to biodegradation of some of the organic COCs, decreased inputs due to the NTCRA, and covering of stream sediment by natural sedimentation. Over time, these processes should ameliorate the possible risks to benthic invertebrates. As part of the site remedy, the seeps and sediment will be monitored in the future. The results of these analyses can be used to assess the ecological risk during the monitoring period and at the five-year review period.

Post-NTCRA Seep Soils

The primary risk of contaminants in seep soil was associated with ingestion by deer mice of chromium in prey tissue. This risk was calculated based on a food web model that conservatively assumed that the deer mouse diet is 50% animal tissue, that the chromium concentration in tissue was equal to that in soil, that 100% of the diet was obtained from seep areas, and that the reference dose was 2.5 mg/kg/day. Hazard Quotients for the average and maximum exposure cases were 44 and 1128, respectively, for the consumption of chromium in animal tissue. The average exposure case is likely more reflective of actual exposure than the maximum exposure case, and this risk is likely overestimated by one or more orders of magnitude because of the conservative exposure assumptions used in the food web model. In addition, the reference dose used in the model was highly conservative because it assumed that all of the chromium in seep soil was in the more toxic hexavalent form. Since it is likely that most of the chromium in seep soils would be in the less toxic trivalent form, a more appropriate reference dose would be 5466 mg/kg/day, which is the estimated reference dose for white footed mice (Sample et al, 1996) for trivalent chromium. This reference dose is about 2000 times higher so it is probable that the hazard quotient is overestimated by at least 3 orders of magnitude due to this factor alone. Combined with the probability that the mice would probably forage beyond the seep areas for much more of their diet than assumed, it is concluded that the actual risk of seep soil to mice is negligible.

Uncertainty

As discussed previously with human health risk assessment there is always some imprecision, inaccuracy, and unrepresentativeness in the environmental data used to characterize site risks. Many of the human health risk uncertainties described previously apply to ecological risk assessment as well. Conservative assumptions with high levels of uncertainty include the use of estimated data (J values) in the calculation of average concentrations, the assumption that environmental concentrations will remain the same over time, and the use of maximum concentrations as an upper estimate of exposure. In addition, there is great uncertainty concerning the toxicity factors used to estimate risks to the representative receptor organisms. The toxic effects of COCs have not been tested in laboratory studies with the selected receptors, rather, the no-effect doses have been estimated based on laboratory studies with other laboratory species. Additional uncertainty factors associated with ecological risk assessment include uncertainty concerning the assumptions made in food web modeling, including soil-to-prey bioaccumulation factors, foraging areas relative to site exposure areas, proportion of time spent by a receptor

species at the site, body weights, ingestion rates, and diet composition.

Ecological Risk Summary

The baseline ecological risk assessment in the RI concluded that: 1) aquatic invertebrate communities in the Unnamed Brook were at risk from metals, specifically aluminum, manganese and iron; 2) mink and other semi-aquatic animals were at risk from pesticides in sediment (primarily DDT); and 3) small mammals that consume animal tissue (e.g. earthworms) are at risk from the ingestion of chromium from organisms that grow in seep soil.

Evaluation of the available post-NTCRA chemical data indicate that the concentrations have decreased significantly in surface water of the Unnamed Brook and in seep water. Risks of chemicals in surface water to aquatic organisms are now acceptable as shown by the absence of benchmark exceedances during the latest monitoring round in February, 2000. Chemical concentrations in seep water have decreased, and are not causing exceedances of aquatic benchmarks in the Unnamed Brook. These trends are expected to continue over time due to the landfill cap and continuing leachate collection. The seeps are expected to become drier as less precipitation infiltrates into the landfill.

Most of the ecological risk of seep soil to terrestrial mammals was associated with chromium in the food web of mice that might eat earthworms in seep soils. Due to the use of highly conservative food web assumptions and toxicity factors, it is probable that the actual risk in seep soils is negligible. The RI ecological risk assessment assumed that all of the chromium was in the more toxic hexavalent form and that the mice would feed only in the seep soil areas. Use of more realistic exposure and toxicity assumptions would result in calculated risks at least three orders of magnitude lower than those estimated in the RI. Any other potential risks of seep soil will decrease as the seeps dry out and vegetation becomes established in the seep areas.

Although sediment in the Unnamed Brook has not been sampled since the NTCRA, it is probable that risks to benthic organisms have decreased due to NTCRA activities (stream relocation and selected excavation, capping and leachate collection), as well as natural sedimentation and attenuation of organic COCs. A comparison of sediment COC concentrations measured prior to the NTCRA with updated sediment benchmarks indicates that there may be limited risk to benthic organisms due to barium and manganese in sediment.

With the completion of the NTCRA cap and leachate collection system, it is anticipated that the sources of contaminants to the Unnamed Brook-leachate seeps and landfill runoff-have been or will be mitigated. Results of sampling conducted in November/December 1999 and February 2000 showed that none of the previously detected COCs (pesticides, metals, SVOCs) were detected. Monitoring of seeps and sediment will be conducted as part of the NTCRA consent order between Connecticut and the PRP group. These data can be used to confirm that ecological risks are continuing to decrease.

With the completion of the NTCRA cap and leachate collection system, it is anticipated that the sources of contaminants to the Unnamed Brook – leachate seeps and landfill runoff – have been or will be mitigated. Results of sampling conducted in November/December 1999 and February 2000 showed that neither of the pesticide contaminants of potential concern (DDE or DDT) were detected in any of the surface water or leachate seep samples collected.

3. Basis for Response Action

The only medium that poses an unacceptable post-NTCRA risk to human health is groundwater. The baseline human health risk assessment revealed that potential exposure of residents to compounds of concern in groundwater via ingestion and dermal exposure may present an unacceptable human health risk. The total cancer risk from dermal and oral exposures via a drinking water scenario is 5×10^{-4}. Eighty percent of the cancer risk is due to arsenic at the maximum concentration of 22 μg/L. The hazard indices (HI) which may exceed EPA's hazard quotient of concern occur for the target endpoints of skin (HI = 2.0), blood (HI = 3.4), developmental effects (HI = 1.7), liver/kidney effects (HI = 9.1), and central nervous system (HI = 311). The greatest contributor by far to noncancer risk is 4-methylphenol which is responsible for a HQ of 302 for central nervous system effects. Lead in groundwater also exceeds its action level and would exceed EPA's maximum blood lead goal for children.

The only medium that potentially poses an unacceptable post-NTCRA risk to the environment is sediment. The baseline ecological risk assessment indicated that no-effect screening level benchmarks for benthic invertebrates were exceeded by many chemicals. However, probable post-NTCRA average concentrations exceeded more realistic effects-based benchmarks only for barium and manganese, suggesting that there may remain some level of risk to benthic invertebrates in the Unnamed Brook. Although the actual risk is uncertain, it is likely that decreased leachate, biodegradation of organic contaminants, and natural sedimentation will ameliorate these possible risks.

Based in the findings of the baseline human health and ecological risk assessments and post-NTCRA risk assessment screening, only groundwater was found to pose a definite future Site risk. Therefore, groundwater is the only focus of this remedial action.

H. REMEDIATION OBJECTIVES

Based on preliminary information relating to types of contaminants, environmental media of concern, and potential exposure pathways, response action objectives (RAOs) were developed to aid in the development and screening of alternatives. These RAOs were developed to mitigate prevent existing and future potential threats to human health and the environment. The RAOs for the selected remedy for Barkhamsted New-Hartford Superfund Site are:

Sediment

The RAOs for sediment for environmental protection are as follows:

- Protect benthic invertebrates and mammals ingesting contaminated prey from direct contact with, or ingestion of, sediment having constituent concentrations exceeding a hazard index of 1.

- Prevent releases of constituents from sediments that would result in surface water levels exceeding federal Ambient Water Quality Criteria, CT Water Quality Standards, or in their absence, a hazard index of 1.

Groundwater

Human Health

The RAOs for groundwater identified by USEPA for human health are as follows:

- Prevent the ingestion or dermal contact with groundwater having constituent concentrations exceeding USEPA Safe Drinking Water Act Maximum Contaminant Levels (MCLs), or in their absence, the more stringent of an excess cancer risk of 1×10^{-6} for each substance or a hazard quotient of 1 for each non-carcinogenic substance.

- Restore groundwater beyond the compliance boundary (limits of the landfill) to MCLs or any more stringent CT Remediation Standards (background concentrations), or in their absence, the more stringent of an excess cancer risk of 1×10^{-6} for each substance or a hazard quotient of 1 for each non-carcinogenic substance.

I. DEVELOPMENT AND SCREENING OF ALTERNATIVES

1. Statutory Requirements/Response Objectives

Under its legal authorities, USEPA's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences, including: a requirement that USEPA's remedial action, when complete, must comply with all federal and more stringent state environmental and facility siting standards, requirements, criteria or limitations, unless a waiver is invoked; a requirement that USEPA select a remedial action that is cost-effective and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and a preference for remedies in which treatment which permanently and significantly reduces the volume, toxicity or

mobility of the hazardous substances is a principal element over remedies not involving such treatment. Response alternatives were developed to be consistent with these Congressional mandates.

2. Technology and Alternative Development and Screening

CERCLA and the National Contingency Plan (NCP) set forth the process by which remedial actions are evaluated and selected. In accordance with these requirements, a range of alternatives were developed for the Site.

The RI/FS developed a limited number of remedial alternatives that attain Site specific remediation levels for Site groundwater within different time frames using different technologies; and a no action alternative.

As discussed in Section 2.4 of the FS, groundwater treatment technology options were identified, assessed and screened based on implementability, effectiveness, and cost. These technologies were combined into management of migration (MM) alternatives. Section 3 of the FS presented the remedial alternatives developed by combining the technologies identified in the previous screening process in the categories identified in Section 300.430(e)(3) of the NCP. The purpose of the initial screening was to narrow the number of potential remedial actions for further detailed analysis while preserving a range of options. Each alternative was then evaluated in detail in Sections 4 and 5 of the FS. Four management of migration alternatives were selected for detailed analysis.

J. DESCRIPTION OF ALTERNATIVES

This Section provides a narrative summary of each management of migration alternative evaluated.

Management of migration (MM) alternatives address contaminants that have migrated into and with the groundwater from the original source of contamination. At the Site, contaminants have migrated from landfill wastes and contaminated soils into groundwater prior to implementation of the NTCRA. The MM alternatives analyzed for the Site include:

- MM-1 No Action
- MM-2 Management/Natural Attenuation
- MM-3A Collection, Treatment, and Discharge of Groundwater
- MM-3B Collection, Treatment, and Discharge of Groundwater

Each of the four MM alternatives is summarized below. A more complete, detailed presentation of each alternative is found in Section 3 of the FS.

MM-1: No Action

The key component of MM-1: No Action is monitoring of groundwater, surface water (including seeps), and sediment for 5-year reviews.

A No-Action alternative is included in the MM alternatives as required by the NCP (40 C.F.R. § 300.430(e)(6)). The No-Action alternative would include an environmental monitoring program for groundwater, surface water and sediment, to be performed for at least 30 years. Monitoring is part of the No Action alternative as it is necessary to perform the 5-year reviews as required by the NCP (40 C.F.R. § 300.430(f)(ii)). The No Action alternative would not, in and of itself, treat, remove, or actively reduce the potential exposure risk to contaminated groundwater, soil, and/or sediments on-site. This alternative would not include environmental land use restrictions or public education.

Estimated annual O&M cost (monitoring): $16,900
Estimated Present Worth: $242,080 (assuming 30 years at 7% discount rate)

MM-2: Management/Natural Attenuation

The key components of MM-2: Management/Natural Attenuation include:

- Long-term monitoring of groundwater, surface water (including seeps), and sediment
- Restoration of contaminated groundwater via natural attenuation
- Environmental land use restrictions
- Public education program

Long-term monitoring would include the installation of additional monitoring wells and periodic sampling and analysis of the groundwater, surface water, seeps, and sediment to evaluate changes over time. USEPA will determine the location, magnitude, frequency, and extent of all environmental sampling and analysis as necessary. Groundwater sampling would generally be conducted quarterly, although certain wells would be sampled only semiannually or annually. The samples would be analyzed generally for TCL Organics (VOCs and SVOCs) and TAL metals (dissolved and total) and any other compound as necessary. Surface water samples would also generally be collected at the same frequency as groundwater and analyzed for the same parameters as the groundwater plus pesticides. Seeps would be sampled quarterly for the first year and analyzed for the same parameters as the surface water samples. The seep sampling program would then be reviewed and adjusted, if necessary, based on the results from the first year. Sediment sampling and analysis will generally occur on an annual basis for TCL Organics (PCBs/Pesticides, VOCs, SVOCs) and TAL metals. Air sampling would be conducted during the first sampling round. Air samples would be taken from the landfill vents and from four stations, including one at a downwind residence and two at the recycling/maintenance facility work area.

The air samples would be analyzed for VOCs and compared to applicable Federal and state standards. Based on the results of this single air sampling event, recommendations for additional sampling or actions, if necessary, would be made.

Environmental land use restrictions involve placing legal restrictions on present and future uses. Land use restrictions would include use of groundwater for drinking or any other purpose, disturbances of soil on the Site, and construction of buildings on the Site. In general, these land use restrictions would prevent residential use of the Site, prevent contaminated groundwater from being extracted for use, and avoid disturbance of the landfill cap installed under the NTCRA. Additional environmental land use restrictions of down-gradient properties would prohibit the installation of any wells and the use of groundwater for any purpose. Any owner of property interests on the Site shall be required to create binding land use restrictions on their property needed to implement the remedy under applicable federal, state and local standards. On any property outside of the Site where the remedy calls for institutional controls to be implemented, any and all property rights needed to implement legally binding, land use restrictions for the remedy shall be acquired under applicable federal, state, and local standards.

A public education program would be implemented. Informational meetings would be held to inform the community of imminent or completed remedial activities. Mailings would also be used to provide updates on the progress of the cleanup or, if necessary, to discuss potential Site hazards.

The groundwater cleanup levels would be achieved via natural attenuation under this alternative. Natural attenuation processes include advection, dispersion, sorption, dilution, volatilization, geochemical precipitation, bio-degradation, radioactive decay, and chemical or biological stabilization, transformation, or destruction. Groundwater modeling conducted during the FS showed that natural attenuation will achieve the groundwater cleanup levels, in the overburden in approximately 15.6 years and in the bedrock aquifer in approximately 6 years.

An evaluation of natural attenuation was conducted in accordance with USEPA protocols (Wiedemeier, et. al. 1998). Lines of evidence indicate that the organic contaminant plumes in the overburden and shallow bedrock are attenuating naturally. The first line of evidence was applied through evaluation of the historic groundwater analytical data that established decreasing trends in COCs and documented plume stability. The second line of evidence was documented through the collection and analysis of geochemical parameters during the December 1998, November/December 1999, and February 2000 sampling events, and examining those data trends and relationships between the supplies of electron donors and electron acceptors, and the presence of metabolic by-products.

A review of historical groundwater quality data indicates that the concentrations of Site-related constituents are either remaining stable or decreasing over time. Elimination of the source of groundwater contaminants by completion of the NTCRA in November 1998 shows

further decreases in contaminant concentrations. Evidence of microbial mediated degradation is supported by the presence of daughter products. Geochemical evidence that indicates subsurface conditions amenable for microbially mediated degradation include the following:

- an abundance of dissolved organic carbon that can be utilized as a carbon source (electron donor) by microbes;
- anaerobic conditions that sustain reductive dechlorination;
- presence of organic compounds that can undergo fermentation reactions (BTEX, ketones) that produce hydrogen, which can be utilized by microbes during reductive dechlorination;
- low concentrations of nitrate that will not suppress the reductive dechlorination pathway;
- low sulfate concentrations within the plume as compared to background suggesting utilization as an electron acceptor;
- some degree of increased chloride concentration in the plume compared to background suggesting dechlorination is occurring;
- some degree of increased alkalinity in the plume compared to background suggesting that the plume is biologically active;
- decreases in oxidation-reduction potential in the plume as compared to background suggesting the plume is biologically active;
- the presence of methane that suggests highly reducing conditions and microbial degradation; and
- groundwater pH ranges that are suitable for microbial populations.

In addition to the lines of evidence, completion of the bioattenuation screening process provides further evidence supporting natural attenuation. The screening process completed for the December 1998, November/December 1999, and February 2000 data consistently indicates that there is adequate to strong evidence that geochemical conditions are amenable to natural attenuation. Natural attenuation is discussed in detail in Section 4.2.2.2. of the FS.

Site conditions with implementation of MM-2 would eventually be consistent with applicable federal and state chemical-specific ARARs once natural attenuation of the ground water in the overburden is achieved in approximately 15.6 years and in the bedrock aquifer in approximately 6 years. The remedy is also consistent with all identified action-specific ARARs listed in Table 4-3B. No location-specific ARARs were identified.

Estimated Capital Cost: $147,000
Estimated Annual O&M Costs: $82,000
Estimated Present Worth: $945,392 to $1,196909 (assuming a range of 16 to 30 years at a discount rate of 7%)
Estimated Time to Reach Remediation Goals: 15.6 years

MM-3A: Collection, Treatment (including air stripping and carbon adsorption) and Discharge of Groundwater

The key components of MM-3A: Collection, Treatment (including air stripping and carbon adsorption) and Discharge of Groundwater include:

- Long-term monitoring of groundwater, surface water (including seeps), and sediment
- Environmental land use restrictions
- Public education program
- Groundwater extraction
- Filtration
- Chemical precipitation
- Neutralization
- Air stripping
- Carbon adsorption
- Discharge of treated groundwater to the Unnamed Brook

The treatment technologies are described in detail in Section 2.4.1. of the FS and are summarized below.

Alternative MM-3A builds upon MM-1 and MM-2 (as it includes the same monitoring, environmental land use restrictions, and public education elements) and also consists of installation of extraction wells; on-site treatment of groundwater collected in the wells via filtration, chemical precipitation, neutralization, air stripping, and carbon adsorption; and discharge of treated groundwater to the Unnamed Brook.

As summarized in Section E of this ROD, Site Characteristics, the nature and extent of contamination in groundwater suggests that VOCs, SVOCs, and metals are the primary COCs. The distribution of impact appears to be primarily in the overburden and shallow bedrock aquifers. However, groundwater in various depths of the overburden and bedrock aquifers has been impacted. Extraction wells (recovery wells) are suitable for extraction of groundwater from shallow and deep overburden or bedrock aquifers. Groundwater modeling (presented in Section 1.2.4 of the FS) was used to evaluate the number, location, and pumping rate of the extraction wells necessary to prevent further migration of the groundwater plume. The modeling showed that installation of seven wells in the overburden zone and seven wells in the shallow bedrock zone will effectively capture the plume. A combined pumping rate of 15.4 gpm would create a sufficient capture zone to intercept the contaminants. Aquifer performance testing would be required to evaluate the actual placement and flow rate of the recovery wells.

The treatment technologies would address the COCs. Filtration would remove precipitated metals and suspended solids. Chemical precipitation involves oxidation and reduction reactions to change the chemical form of a hazardous material to render it less toxic or to change its solubility, stability, or separability, or otherwise change it for handling or disposal purposes. Neutralization is used to eliminate or reduce the reactivity and corrosiveness of contaminated water and/or treated water. The process of pH adjustment is a partial neutralization process which makes the waste stream either more acidic or more alkaline to enhance chemical,

biochemical reactions and precipitation. Air stripping is a mass transfer process in which volatile organic contaminants in groundwater are transferred to the gaseous (vapor) phase. Carbon adsorption is a physical treatment process involving adsorption of chemical contaminants onto activated carbon. It involves contacting a liquid or vapor waste stream with the carbon, usually by flow, through a series of packed-bed reactors. The treated water would be discharged to the Unnamed Brook in accordance with the criteria established by state and federal regulations.

This alternative would eventually be consistent with Federal and State ARARs. For MM-3A, groundwater will achieve the cleanup levels in the overburden in approximately 13.2 years and in the bedrock in approximately 4.9 years.

Estimated Capital Cost: $1,514,080
Estimated Annual O&M Costs: $244,800
Estimated Present Worth: $3,673,291 - $4,584,181 (assuming a range of 14 to 30 years at a discount rate of 7%)
Estimated Implementation Time Frame: one year
Estimated Time to Reach Remediation Goals: 14.2 years

MM-3B: Collection, Treatment (including UV oxidation) and Discharge of Groundwater

The key components of MM-3B: Collection, Treatment (including UV oxidation) and Discharge of Groundwater include:

- Long-term monitoring of groundwater, surface water (including seeps), and sediment
- Environmental land use restrictions
- Public education program
- Groundwater extraction
- Filtration
- Chemical precipitation
- Neutralization
- UV oxidation
- Discharge of treated groundwater to the Unnamed Brook

The treatment technologies are described in detail in Section 2.4.1 of the FS and are summarized below.

Alternative MM-3B builds upon MM-1 and MM-2 (as it includes the same monitoring, environmental land use restrictions, and public education elements) and is very similar to MM-3A, with the exception of the use of UV oxidation in lieu of air stripping and carbon adsorption. Ultraviolet (UV) oxidation is a process which utilizes UV radiation in combination with an oxidizer such as hydrogen peroxide or ozone to destroy hazardous chemicals in aqueous solution. The combination of the UV radiation and oxidizer produces a synergistic effect and acts to promote the oxidation of many contaminants into nontoxic forms. This treatment process is most

amenable to dissolved organic compounds including halogenated organic and aromatic compounds and has been successful in treating many of the COCs associated with this Site. The treated water would be discharged to the Unnamed Brook in accordance with the criteria established by state and federal regulations.

This alternative would eventually be consistent with Federal and State ARARs. For MM-3B, groundwater will achieve the cleanup levels in the overburden in approximately 13.2 years and in the bedrock in approximately 4.9 years.

Estimated Capital Cost: $1,572,880
Estimated Annual O&M Costs: $245,800
Estimated Present Worth: $3,819,545 - $4,767,071 (assuming a range of 14 to 30 years at a discount rate of 7%)
Estimated Implementation Time Frame: one year
Estimated Time to Reach Remediation Goals: 14.2 years

K. SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

Section 121(b)(1) of CERCLA presents several factors that at a minimum USEPA is required to consider in its assessment of alternatives. Building upon these specific statutory mandates, the NCP articulates nine evaluation criteria to be used in assessing the individual remedial alternatives.

A detailed analysis was performed on the alternatives using the nine evaluation criteria in order to select a Site remedy. The following is a summary of the comparison of each alternative's strength and weakness with respect to the nine evaluation criteria. These criteria are summarized as follows:

Threshold Criteria

The two threshold criteria described below must be met in order for the alternatives to be eligible for selection in accordance with the NCP:

1. **Overall protection of human health and the environment** addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced or controlled through treatment, engineering controls, or institutional controls.

2. **Compliance with applicable or relevant and appropriate requirements (ARARs)** addresses whether or not a remedy will meet all Federal environmental and more stringent State environmental and facility siting standards, requirements, criteria or limitations, unless a waiver is invoked.

Primary Balancing Criteria

The following five criteria are utilized to compare and evaluate the elements of one alternative to another that meet the threshold criteria:

3. **Long-term effectiveness and permanence** addresses the criteria that are utilized to assess alternatives for the long-term effectiveness and permanence they afford, along with the degree of certainty that they will prove successful.

4. **Reduction of toxicity, mobility, or volume through treatment** addresses the degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume, including how treatment is used to address the principal threats posed by the Site.

5. **Short term effectiveness** addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until cleanup goals are achieved.

6. **Implementability** addresses the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. **Cost** includes estimated capital and Operation Maintenance (O&M) costs, as well as present-worth costs.

Modifying Criteria

The modifying criteria are used as the final evaluation of remedial alternatives, generally after USEPA has received public comment on the RI/FS and Proposed Plan:

8. **State acceptance** addresses the State's position and key concerns related to the preferred alternative and other alternatives, and the State's comments on ARARs or the proposed use of waivers.

9. **Community acceptance** addresses the public's general response to the alternatives described in the Proposed Plan and RI/FS report.

Following the detailed analysis of each individual alternative, a comparative analysis, focusing on the relative performance of each alternative against the nine criteria, was conducted. This comparative analysis can be found in Tables 4-4a through 4-4g of the FS.

A summary of the comparative analysis is presented below in Table 10. This table presents the nine criteria and a brief narrative summary of the alternatives and the strengths and weaknesses according to the detailed and comparative analysis. Only those alternatives which satisfied the first two threshold criteria were balanced and modified using the remaining seven criteria.

Table 10: Summary for the Comparative Analysis of Alternatives

Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

All of the alternatives, except the no-action alternative (MM-1), are protective of human health and the environment by eliminating, reducing, or controlling risks posed by the Site through natural attenuation or treatment of contaminants, engineering controls, and/or institutional controls. For MM-2, the two-dimensional groundwater model shows that natural attenuation will achieve the cleanup levels in the overburden in approximately 15.6 years and in the bedrock aquifer in approximately 6 years. For MM-3A and MM-3B, groundwater will achieve the cleanup levels in the overburden in approximately 13.2 years and in the bedrock in approximately 4.9 years. Alternatives MM-3A and MM-3B provide only a slight advantage over MM-2 in terms of the time to achieve groundwater criteria. There is no difference in the cleanup time frames between MM-3A and MM-3B.

MM-2, MM-3A, and MM-3B provide better protection than MM-1 since they include environmental land use restrictions and public education that would prevent contact with, and ingestion of, groundwater. MM-2, MM-3A, and MM-3B are considered to be equally protective of human health and the environment because cleanup goals will be met.

Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA requires that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address hazardous substances, the remedial action to be implemented at the Site, the location of the Site, or other circumstances present at the Site. Relevant and appropriate requirements are those substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law which, while not applicable to the hazardous materials found at the Site, the remedial action itself, the Site location or other circumstances at the Site, nevertheless address problems or situations sufficiently similar to those encountered at the Site that their use is well-suited to the Site.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

All alternatives had in common the federal and state chemical-specific ARARs. Maximum contaminant levels (MCLs) for several Site contaminants are exceeded in the plume that flows northeast from beneath the landfill in the groundwater system. MM 1 does not meet chemical-specific ARARs because it does not adequately address exceedances of MCLs. Location- and action specific ARARs associated with construction and potential regulatory issues associated with discharge requirements, air emissions, and waste generation, storage and disposal applied to

alternatives MM-3A and MM-3B only.

Alternatives MM-3A and MM-3B provide only a slight advantage over MM-2 in terms of the time to achieve the groundwater cleanup levels. There is no difference in the cleanup time frames between MM-3A and MM-3B. Alternatives MM-2, MM-3A, MM-3B would eventually be compliant with the chemical-specific ARARs.

The activities associated with implementation of MM-2, MM-3A, and MM-3B would be performed in a manner compliant with the action-specific ARARs. Alternative MM-3A and MM-3B will meet all applicable federal and state location-specific ARARs for building discharge pipes and discharging water into wetlands and watercourses. Based on the above, only alternatives MM-2, MM-3A, and MM-3B would be compliant with the applicable ARARs or critical To Be Considered Materials (TBCs) for the Site. TBCs are non-promulgated advisories or guidance issued by the federal or state government that are not legally binding and do not have the status of ARARs.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk and the adequacy and reliability of controls.

Each alternative, except the No Action alternative, provides some degree of long-term protectiveness through environmental land use restrictions and public education. Alternatives MM-3A and MM-3B may provide an additional degree of protection through groundwater extraction and treatment.

There are no controls under MM-1 to manage untreated groundwater. Environmental land use restrictions and public education are adequate and reliable in restricting activities resulting in potential ingestion of, or contact with, groundwater for MM-2, MM-3A, and MM-3B. Monitoring activities associated with all four alternatives are adequate and reliable in terms of evaluating changes in the extent and concentrations of the contaminants. The extraction and treatment technologies associated with both MM-3A and MM-3B have been used extensively and have been proven to provide long-term reliability.

The adequacy and suitability of controls for MM-3A, MM-3B, and MM-2 are better than MM-1, since they include use of environmental land use restrictions and public education. MM-2, MM-3A, and MM-3B are equal with respect to the reliability of the management controls.

Five year reviews would be necessary to evaluate the effectiveness of any of these alternatives because hazardous substances would remain on-site in concentrations above health-based levels.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternatives MM-1 and MM-2 do not include treatment as a component of the remedy. Therefore, these alternatives would not actively reduce the toxicity or volume of contamination at the Site. Over time, however, contaminant levels in the existing areas of contamination are expected to decrease through natural attenuation.

The treatment processes associated with MM-3A and MM-3B would generate treatment residuals, however these would be safely handled and properly disposed of according to Federal, state, and local standards.

Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers and the community during construction and operation of the remedy until cleanup goals are achieved.

Groundwater, surface water and sediment monitoring will not affect the community.

For MM-2, MM-3A, and MM-3B, additional environmental land use restrictions will prohibit installation of wells and use of groundwater. Alternatives MM-3A and MM-3B would pose a minimal increase in potential risk to the community if implemented compared to MM-1 and MM-2. This is due to potential exposure to contaminated fugitive dust and vapors during construction. Risks to samplers of exposure to contaminated groundwater, surface water, and sediment would be associated with the monitoring program for MM-1, MM-2, MM-3A, and MM-3B. Appropriate personal protective equipment would be used during the monitoring activities.

Since alternatives MM-3A and MM-3B involve construction activities, inhalation of dust and vapors, and direct contact with groundwater could cause significantly more risk to workers if MM-3A and MM-3B were implemented than if MM-1 and MM-2 were implemented.

No environmental impacts are identified for implementation of MM-1 and MM-2. Alternatives MM-3A and MM-3B could pose an impact to the environment by contaminant transport during construction. Impacts may be caused by improper off-Site drainage control and dust control measures. There is no expected environmental impact during operation and maintenance of MM-3A and MM-3B.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Groundwater, surface water, and sediment monitoring associated with MM-1, MM-2, MM-3A, and MM-3B is readily implemented and is reliable to evaluate the Site conditions. For all four alternatives, additional remedial actions (if required) would be easily implemented.

For MM-2, MM-3A, and MM-3B, legal coordination with property owners and town officials would be required to implement the environmental land use restrictions and public education program. On any property outside of the Site where the remedy calls for institutional controls to be implemented, property rights needed to implement legally binding, land use restrictions for the remedy need to be acquired under applicable federal, state, and local standards. Environmental land use restrictions, public education, and groundwater, surface water and sediment monitoring are readily implemented and are reliable.

Installation of recovery wells and construction and operation of the treatment technologies associated with MM-3A and MM-3B are readily implemented and reliable. The effectiveness of MM-3A and MM-3B would be easily monitored as part of the groundwater, surface water, and sediment monitoring program.

Although all of the alternatives presented are feasible, there is significant difference in the implementability of MM-1 and MM-2 versus MM-3A and MM-3B, as the latter two require the installation, operation, and maintenance of treatment equipment for a period of approximately 15 years.

Coordination with agencies other than USEPA and CTDEP would not be required for MM-1. Legal coordination with property owners and the town would be necessary to implement the environmental land use restrictions and public education program for MM-2, MM-3A, MM-3B. Environmental land use restrictions, public education, and monitoring are readily implemented. Permits for off-Site disposal of residual materials and treated groundwater for MM-3A and MM-3B would be required and are easily obtainable.

Cost

The estimated present worth costs for each alternative are presented in ranges. The lower present worth cost is based on the estimated number of years that the alternative will achieve the groundwater cleanup levels in both the overburden and bedrock aquifers. The upper end of the range is based on 30 years in accordance with USEPA Guidance on Conducting RI/FS under CERCLA.

MM-1: $183,405 to $242,080
MM-2: $945,382 to $1,196,909
MM-3A: $3,673,291 to $4,584,181
MM-3B: $3,819,545 to $4,767,071

Alternative MM-1 is the least costly alternative. The cost to implement MM-2 is significantly less than the extraction and treatment alternatives (MM-3A and MM-3B) which are similar to each other. The increase in costs of alternatives MM-3A and MM-3B provide only a slight decrease in the time required to reduce toxicity, mobility, and volume than the other alternatives, based on groundwater modeling results.

State / Support Agency Acceptance

The State of Connecticut has accepted and concurred with this remedy decision. CTDEP provided comments on the Proposed Plan. Details of these comments are found in the Responsiveness Summary. The State is supportive of this remedy.

Community Acceptance

The community is supportive of this remedy. There were no comments made during the comment period.

L. THE SELECTED REMEDY

1. Summary of the Rationale for the Selected Remedy

The selected remedy for the Barkhamsted-New Hartford Landfill is alternative number MM-2 Management/Natural Attenuation. This remedy, which addresses management of migration of contaminated Site groundwater, is the final component of a comprehensive remedy for the Site. The selected remedy addresses the low-level risks posed by Site groundwater. The source and all principal risks were addressed in a previous action.

The major components of this remedy include remediation of groundwater to cleanup levels by natural attenuation after approximately 15.6 years; installation of groundwater monitoring wells; institutional controls; a public education program; long term monitoring of groundwater, surface water, and sediment; and five-year reviews.

2. Description of Remedial Components

The key components of the Selected Remedy, Management/Natural Attenuation, include:

- Long-term monitoring of groundwater, surface water (including seeps), and sediment
- Restoration of contaminated groundwater via natural attenuation
- Environmental land use restrictions
- Public education program
- Five year review

Long-term monitoring would include the installation of additional monitoring wells and periodic sampling and analysis of the groundwater, surface water, and sediment to evaluate changes over time. Once cleanup levels have been met, the groundwater monitoring system will be utilized to collect information to ensure that the cleanup levels are maintained and the remedy is protective. The Connecticut Remediation Standard Regulations (RSRs) require that all substances in the groundwater that are part of a release be remediated to background concentrations. For practical purposes, monitoring of the groundwater from under the landfill will be measured at wells located at the boundary of the landfill for compliance. Compliance with background must be demonstrated in accordance with Section 22a-133k-3(g)(3) of the RSRs, therefore long-term monitoring would continue until cleanup has been demonstrated in accordance with these regulations.

The currently listed background concentrations (see Table 11), based on data from the existing up gradient wells, are considered cleanup levels until additional samples from appropriately located background wells can be collected to establish representative background concentrations in a manner consistent with the RSRs. CTDEP and USEPA agreed to the use of these groundwater cleanup levels with the understanding that background concentrations in groundwater would be adjusted during the remedial design phase.

The groundwater cleanup levels would be achieved via natural attenuation under this alternative. Natural attenuation processes include advection, dispersion, sorption, dilution, volatilization, geochemical precipitation, biodegradation, radioactive decay, and chemical or biological stabilization, transformation, or destruction.

To the extent required by policy, USEPA will review the Site at least once every five years after construction completion, if any hazardous substances, pollutants or contaminants remain at the Site, to assure that the remedial action continues to protect human health and the

environment.

The selected remedy may change somewhat as a result of monitoring the remedy. Changes to the remedy described in this ROD will be documented in a technical memorandum in the Administrative Record for the Site, an Explanation of Significant Differences (ESD) or a ROD Amendment, as appropriate.

3. Summary of the Estimated Remedy Costs

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the Monitored Natural Attenuation remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an ESD, or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost.

ITEM	TOTAL COST
Direct Capital Costs	
Monitoring Wells Installation - Overburden	$20,000
Monitoring Wells Installation - Shallow Bedrock	$30,000
Environmental Land Use Restrictions	$5,000
Public Education Program	$20,000
Engineering (20%)	$36,000
Contingency (20%)	$36,000
Total Direct Capital Costs	**$147,000**

Annual Operation & Maintenance Costs		
Sampling Labor/Directs		$30,000
Groundwater, Surface Water & Sediment Analyses		
- Natural attenuation analysis		$8,000
- VOC analysis		$10,000
- SVOC analysis		$12,000
- Metals analysis		$12,000
Groundwater, Surface Water & Sediment Reports		$6,000
Miscellaneous		$1,500
Public Education Program		$2,500
	Total Annual O&M Costs	**$82,000**
Five-Year Review (one-time cost every 5 yrs)	$15,000	$15,000
	Present Worth of Annual O&M Costs for 16 Years (i=7%)	**$798,382**
	Present Worth of Annual O&M Costs for 30 Years (i=7%)	**$1,049,909**
	TOTAL ESTIMATED COST FOR 16 YEARS	**$945,382**
	TOTAL ESTIMATED COST FOR 30 YEARS	**$1,196,909**

4. Expected Outcomes of the Selected Remedy

The primary expected outcome of the selected remedy is that the area downgradient of the landfill will no longer present an unacceptable risk to humans via groundwater and will be suitable for unrestricted use. Approximately 16 years are estimated as the amount of time necessary to achieve the goals consistent with residential use. The expected outcome of the Site itself is to remain as a refuse / recycling / disposal facility, with restricted use of land and groundwater at the landfill itself, unrestricted use in all other areas.

Groundwater Cleanup Levels

Cleanup levels have been established in groundwater for all chemicals of concern

identified in the Baseline Risk Assessment found to pose an unacceptable risk to either public health or the environment. Cleanup levels have been set based on the ARARs (e.g., non-zero Drinking Water Maximum Contaminant Level Goals (MCLGs), MCLs, and more stringent State Remediation Standard Regulations) as available, or other suitable criteria described below. Periodic assessments of the protection afforded by remedial actions will be made as the remedy is being implemented and at the completion of the remedial action. At the time that Groundwater Cleanup Levels identified in the ROD and newly promulgated ARARs and modified ARARs which call into question the protectiveness of the remedy have been achieved and have not been exceeded for a period of three consecutive years, and as demonstrated in accordance with Section 22a-133k-3(g)(3) of the Connecticut RSRs, a risk assessment shall be performed on all residual groundwater contamination to determine whether the remedial action is protective. This risk assessment of the residual groundwater contamination shall follow USEPA procedures and will assess the cumulative carcinogenic and non-carcinogenic risks posed by all chemicals of concern (including but not limited to the chemicals of concern) via ingestion and dermal contact with groundwater. If, after review of the risk assessment, the remedial action is not determined to be protective by USEPA, the remedial action shall continue until either protective levels are achieved, and are not exceeded for a period of three consecutive years, or until the remedy is otherwise deemed protective or is modified. These protective residual levels shall constitute the final cleanup levels for this ROD and shall be considered performance standards for this remedial action.

Because the aquifer at and beyond the compliance boundary for the landfill is a Class IIB aquifer (GA) which is a potential source of drinking water, MCLs and non-zero MCLGs established under the Safe Drinking Water Act and more stringent State standards are ARARs. For practical purposes, a compliance boundary has been established as the wells around the perimeter of the landfill.

In situations where a promulgated State standard is more stringent than values established under the Safe Drinking Water Act, the State standard was used as the cleanup level.

Table 11 summarizes the Cleanup Levels for carcinogenic and non-carcinogenic chemicals of concern identified in groundwater.

Table 11: Groundwater Cleanup Levels*

Carcinogenic Chemical of Concern	Cancer Classification	Cleanup Level (ug/l)	Basis	RME Risk
arsenic	A	5.0	Background Conc.	9.1×10^{-5}
1,4-dichlorobenzene	C	<10.0	Background Conc.	5.0×10^{-6}
Benzene	A	<0.5	Background Conc.	2.0×10^{-7}

1,2-dichloroethane	B2	<0.5	Background Conc.	$5.8x10^{-7}$
1,2-dichloropropane	B2	<0.5	Background Conc.	$4.4x10^{-7}$
chloroethane	B2	<1.0	Background Conc.	$3.7x10^{-8}$
chloroform	B2	<0.5	Background Conc.	$4.0x10^{-8}$
chloromethane	C	<1.0	Background Conc.	$1.6x10^{-7}$
dibromochloromethane	C	<0.5	Background Conc.	$5.5x10^{-7}$
methylene chloride	B2	<2.0	Background Conc.	$1.9x10^{-7}$
Trichloroethene	B2	<0.5	Background Conc.	$7.8x10^{-8}$
vinyl chloride	A	<1.0	Background Conc.	$2.4x10^{-5}$
bis(2-ethyl hexyl) phthalate	B2	<2.0	Background Conc.	$8.9x10^{-7}$
Sum of Carcinogenic Risk				$1.2x10^{-4}$

Noncarcinogenic Chemicals of Concern Class D & E	Target Endpoint	Cleanup Level (ug/l)	Basis	RME Hazard Quotient
arsenic	Skin	5.0	Background Conc.	$4.5x10^{-1}$
chromium	---	50.0	Background Conc.	$4.5x10^{-1}$
lead	---	3.0	Background Conc.	----
manganese	CNS	50.0	Background Conc.	$5.6x10^{-2}$
acetone	Liver/Kidney	<10.0	Background Conc.	$2.7x10^{-3}$
benzene	---	<0.5	Background Conc.	$5.2x10^{-3}$
2-butanone	Developmental	<10.0	Background Conc.	$4.6x10^{-4}$
1,2-dichloroethane	—	<0.5	Background Conc.	$4.7x10^{-4}$
1,2-dichloropropane	Respiratory	<0.5	Background Conc.	$1.4x10^{-2}$
chloroethane	—	<1.0	Background Conc.	$7.2x10^{-5}$
chloroform	Liver	<0.5	Background Conc.	$1.5x10^{-3}$
chloromethane	—	<1.0	Background Conc.	----
dibromochloromethane	Kidney	<0.5	Background Conc.	$7.3x10^{-4}$
4-methyl-2-pentanone	Liver/Kidney	<5.0	Background Conc.	$1.7x10^{-3}$
methylene chloride	Liver	<2.0	Background Conc.	$9.4x10^{-4}$
toluene	Liver/Kidney	<0.5	Background Conc.	$9.2x10^{-5}$
trichloroethene	Liver/Kidney	<0.5	Background Conc.	$2.7x10^{-3}$

Noncarcinogenic Chemicals of Concern Class D & E	Target Endpoint	Cleanup Level (ug/l)	Basis	RME Hazard Quotient
vinyl chloride	---	<1.0	Background Conc.	----
bis(2-ethylhexyl)phthalate	Liver	<2.0	Background Conc.	7.3×10^{-3}
1,4-dichlorobenzene	---	<10.0	Background Conc.	1.6×10^{-2}
2,4-dimethylphenol	Blood	<10.0	Background Conc.	1.5×10^{-2}
4-methylphenol	CNS	<10.0	Background Conc.	5.9×10^{-2}
			Skin Hazard Index =	4.5×10^{-1}
			Blood Hazard Index =	1.5×10^{-2}
			Developmental Hazard Index =	4.6×10^{-4}
			CNS Hazard Index =	1.2×10^{-1}
			Respiratory Hazard Index =	1.4×10^{-2}
			Liver/Kidney Hazard Index =	2.6×10^{-2}

* The cleanup level established for each chemical is the background concentration, per Connecticut RSRs, Section 22a-133k-3(a). During the RA Phase, USEPA in consultation with CTDEP will determine whether these concentrations represent background for this Site and will change these values, if necessary, through an ESD.

All Groundwater Cleanup Levels identified in the ROD and newly promulgated ARARs and modified ARARs which call into question the protectiveness of the remedy and the protective levels determined as a consequence of the risk assessment of residual contamination, must be met at the completion of the remedial action at the points of compliance. At this Site, Cleanup Levels must be met for the entire Site, as measured at the compliance boundary (edge of the landfill) USEPA has estimated that the Cleanup Levels will be obtained within 16 years of issuance of this ROD.

M. STATUTORY DETERMINATIONS

The remedial action selected for implementation at the Barkhamsted-New Hartford Site is consistent with CERCLA and, to the extent practicable, the NCP. The selected remedy is protective of human health and the environment, will comply with ARARs and is cost effective. In addition, the selected remedy utilizes permanent solutions to the maximum extent practicable. Practicable alternate treatment technologies or resource recovery technologies were not identified for this remedy. The selected remedy does not satisfy the statutory preference for treatment that permanently and significantly reduces the mobility, toxicity or volume of hazardous substances as a principal element. In balancing the nine criteria, the lack of treatment is outweighed by modeling that shows that the contaminates of concern will be effectively reduced in toxicity

through natural attenuation processes after a slightly longer period than would be needed to achieve clean-up requirements through available treatment technologies, at significantly less cost.

1. The Selected Remedy is Protective of Human Health and the Environment

The remedy at this Site will adequately protect human health and the environment by eliminating, reducing or controlling exposures to human and environmental receptors through monitored natural reductions in toxicity, engineering controls and institutional controls. More specifically, groundwater cleanup levels will be achieved through natural attenuation processes. Environmental land use restrictions would prohibit residential use of the Site, use of groundwater for drinking or any other purpose, and avoid disturbance of the landfill cap installed under the NTCRA. Environmental land use restrictions of downgradient properties would prohibit the installation of any wells and use of groundwater for any purpose. Any owner of property interests on the Site shall be required to create binding land use restrictions on their property needed to implement the remedy under applicable Federal, state, and local standards. On any property outside of the Site where the remedy calls for institutional controls to be implemented, any and all property rights needed to implement legally binding, land use restrictions for the remedy shall be acquired under applicable Federal, State, and local standards. A public education program would be implemented to provide the community with information regarding the Site.

The selected remedy will reduce potential human health risk levels such that they do not exceed USEPA's acceptable risk range of 10^{-4} to 10^{-6} for incremental carcinogenic risk and such that the non-carcinogenic hazard is below a level of concern (HI will not exceed 1). It will reduce potential human health risk levels to protective ARARs levels, i.e., the remedy will comply with ARARs and To Be Considered criteria. Implementation of the selected remedy will not pose any unacceptable short-term risks or cause any cross-media impacts.

Groundwater monitoring will be used to determine when the ARAR-based Groundwater Cleanup Levels identified in the ROD, as well as newly promulgated ARARs and modified ARARs that call into question the protectiveness of the remedy, have been achieved and have not been exceeded for a period of three consecutive years. At that time, a risk assessment shall be performed on the residual groundwater contamination to determine whether the remedy is protective. This risk assessment of the residual groundwater contamination shall follow USEPA procedures and will assess the cumulative carcinogenic and non-carcinogenic risks posed by ingestion and dermal contact with groundwater. If, after review of the risk assessment, the remedy is not determined to be protective by USEPA, the remedial action shall continue until protective levels are achieved and have not been exceeded for a period of three consecutive years, or until the remedy is otherwise deemed protective. These protective residual levels shall constitute the final cleanup levels for this Record of Decision and shall be considered

performance standards for any remedial action.

2. The Selected Remedy Complies With ARARs

The selected remedy will comply with all federal and any more stringent state ARARs that pertain to the Site. In particular, this remedy will comply with the following federal ARARs:

- Safe Drinking Water Act

Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), 40 CFR 141.11-141.16. The SDWA MCLs and non-zero MCLGs are relevant and appropriate because they are the basis for the Cleanup Levels for the Site groundwater, which is a potential future drinking water source.

Safe Drinking Water Act (SDWA) Maximum Contaminant Level Goals (MCLGs), 40 CFR 141.50-141.51. The SDWA MCLG are relevant and appropriate because they are health-based criteria to be considered for drinking water sources. Non-zero MCLGs are to be used as goals when MCLs have not been established.

In addition, the selected remedy will comply with the following more stringent state ARARs:

- State groundwater and surface water standards
- State drinking water standards
- State groundwater remediation regulations

Connecticut Water Quality Standards (C.G.S. Section 22a-426): These standards are applicable because the groundwater classification of the Site is GA, and the state's goal is to restore the groundwater to a quality consistent with its use for drinking water without treatment.

Connecticut Standards for Quality and Adequacy of Public Drinking Water (RCSA Section 19-13-B101 through B102): These regulations are relevant and appropriate because, similar to the federal Safe Drinking Water Act, the regulations have established standards for water quality in private water supply systems and standards for quality of public drinking water.

Connecticut Remediation Standard Regulations (RCSA Section 22a-133K 1 through 3): These regulations are applicable because any substance that is part of a release at a Site must be remediated. Depending on the contaminant of concern, the cleanup standards vary from cleaning up to background concentrations to specific numeric cleanup criteria described in Section 22a-

133k-3(d)(1) and (2).

A discussion of why these requirements are applicable or relevant and appropriate may be found in the FS Report in Tables 4-1, 4-2, and 4-3 of the ROD.

3. The Selected Remedy is Cost-Effective

In the USEPA's judgment, the selected remedy is cost-effective because the remedy's costs are proportional to its overall effectiveness (see 40 CFR 300.430(f)(1)(ii)(D)). This determination was made by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (i.e., that are protective of human health and the environment and comply with all federal and any more stringent ARARs, or as appropriate, waive ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria -- long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness, in combination. The overall effectiveness of each alternative then was compared to the alternative's costs to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence represents a reasonable value for the money to be spent.

MATRIX OF COST AND EFFECTIVENESS DATA FOR THE BARKHAMSTED-NEW HARTFORD LANDFILL SUPERFUND SITE

RELEVANT CONSIDERATION FOR COST-EFFECTIVENESS DETERMINATION: (Site characteristics relate to cost-effectiveness criteria)

Alternative	Present Work Cost[1]	Incremental Cost[1]	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
1) MM-1: No Action □	$183,400 to $242,000	———	• No reduction in long-term risk to human health and the environment	• No, reduction of toxicity and volume through natural attenuation	• Small short-term risk to workers implementing site monitoring • Short-term risk to community from potential exposure to contaminated groundwater
2) MM-2: Management/ Natural Attenuation, including institutional controls ■	$945,400 to $1,196,900	+762,000 to +954,900	• Reduction in long-term risk to human health through public education and land use restrictions	• No, reduction of toxicity and volume through natural attenuation	• Small short-term risk to workers implementing site monitoring • Reduction in short-term risk to community from potential exposure to contaminated groundwater through public education and land use restrictions
3) MM-3A: Collection Treatment (including air stripping and carbon adsorption) and Discharge of Groundwater ■	$3,673,300 to $4,584,200	+3,027,900 to +3,387,300	• Reduction in long-term risk to human health through public education and land use restrictions	• Reduction in toxicity, mobility, and volume through collection and treatment • Generation of treatment residuals	• Some additional short-term risk to workers, environment, and community due to construction activities • Reduction in short-term risk to community from potential exposure to contaminated groundwater through public education and land use restrictions • Slightly shorter time to achieve remedial goals for groundwater
4) MM-3B: Collection, Treatment (including UV oxidation) and Discharge of Groundwater ■	$3,819,500 to $4,767,000	+146,200 to +182,800	• Reduction in long-term risk to human health through public education and land use restrictions	• Reduction in toxicity, mobility, and volume through collection and treatment • Generation of treatment residuals	• Some additional short-term risk to workers, environment, and community due to construction activities • Reduction in short-term risk to community from potential exposure to contaminated groundwater through public education and land use restrictions • Slightly shorter time to achieve remedial goals for groundwater

COST-EFFECTIVENESS SUMMARY: *(Summary of individual cost-effectiveness evaluations and relative cost-effectiveness determinations)*

- Alternative 1 is not considered to be cost-effective.
- While Alternatives 2, 3 and 4 are considered to be cost-effective, Alternative 2 provides a potentially greater return on investment.

Key: [1] The estimated present worth costs are presented in ranges. The lower end of the range is based on the estimated cleanup time for that alternative. The high end of the range is based on 30 years, in accordance with USEPA Guidance on Conducting RI/FS under CERCLA

4. The Selected Remedy Utilizes Permanent Solutions and Alternative Treatment or Resource Recovery Technologies to the Maximum Extent Practicable

Once the Agency identified those alternatives that attain or, as appropriate, waive ARARs and that are protective of human health and the environment, USEPA identified which alternative utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. This determination was made by deciding which one of the identified alternatives provides the best balance of trade-offs among alternatives in terms of: 1) long-term effectiveness and permanence; 2) reduction of toxicity, mobility or volume through treatment; 3) short-term effectiveness; 4) implementability; and 5) cost. The balancing test emphasized long-term effectiveness and permanence and the reduction of toxicity, mobility and volume through treatment; and considered the preference for treatment as a principal element, the bias against off-Site land disposal of untreated waste, and community and state acceptance. The selected remedy provides the best balance of trade-offs among the alternatives.

All of the alternatives, except No Action (MM-1), provide some degree of long-term protectiveness through environmental land use restrictions and public education. Alternatives MM-3A and MM-3B may provide an additional degree of protection through groundwater extraction and treatment. All of the alternatives would address the contaminants of concern by reducing concentrations in the groundwater to the cleanup levels. Although the selected remedy, MM-2, would not employ treatment as a component of the remedy, cleanup levels would be achieved within a reasonable time-frame without generating treatment residuals. Reduction of toxicity, mobility, or volume would be equal for each of the alternatives. While the natural attenuation process in alternative MM-2 does not meet the criteria for reduction of toxicity, mobility, or volume, functionally at this site natural processes are expected to equal or exceed clean-up levels achieved by either of the treatment technologies proposed in alternatives MM-3A or MM-3B. The selected remedy does not involve construction, thereby resulting in no environmental impacts during the implementation of this alternative. Risk to workers during implementation of this remedy would be less than for those alternatives involving construction. All four alternative are easily implemented. The selected remedy was found to be the most cost-effective of the alternatives, except No Action.

5. The Selected Remedy Satisfies the Preference for Treatment Which Permanently and Significantly Reduces the Toxicity, Mobility or Volume of the Hazardous Substances as a Principal Element

While the MM-2 natural attenuation alternative does not meet this criteria, modeling shows that natural attenuation is expected to address the primary threat at the Site, contamination of groundwater, as defined by chemical concentrations in excess of drinking water standards and State groundwater remediation standards and groundwater quality criteria. Although active groundwater treatment is not being employed, it has been determined that remediation of the Site groundwater via natural processes, including advection, dispersion, sorption, dilution, volatilization, geochemical precipitation, and biodegradation, will effectively

achieve cleanup levels within a time frame similar to other alternatives.

6. Five-Year Reviews of the Selected Remedy are Required.

Upon completion of this remedy, hazardous substances will remain on-site under the landfill cap and will limit use of the property. For all other areas of the site, upon completion of this remedy to clean up groundwater, no hazardous substances will remain on-site above levels that prevent unlimited use or unrestricted exposure. However, prior to reaching the groundwater clean up goals, groundwater and / or land use restrictions are necessary. This remedy will require greater than five years to achieve its clean up goals; therefore, pursuant to CERCLA section 121(c) and as provided in the current guidance on Five Year Reviews (OSWER Directive 9355.7-03B-P, Comprehensive Five-Year Review Guidance, June 2001), USEPA must conduct policy five-year reviews. Therefore, the first five-year review will be completed five years from the date of the Preliminary Close Out Report (PCOR) and subsequent review will be conducted in five year intervals until cleanup levels are achieved.

N. DOCUMENTATION OF NO SIGNIFICANT CHANGES

USEPA presented a proposed plan for monitored natural attenuation for remediation of the Site on June 20, 2001. The source control was addressed by the NTCRA. The management of migration portion of the preferred alternative included:

- Long-term monitoring of groundwater, surface water (including seeps), and sediment
- Restoration of contaminated groundwater via natural attenuation
- Environmental land use restrictions
- Public education program
- Five year review

USEPA reviewed all written and verbal comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the proposed plan, were necessary.

O. STATE ROLE

The Connecticut Department of Environmental Protection (CTDEP) has reviewed the various alternatives and has indicated its support for the selected remedy. The State has also reviewed the Remedial Investigation, Risk Assessment and Feasibility Study to determine if the selected remedy is in compliance with applicable or relevant and appropriate State environmental and facility siting laws and regulations. The State of Connecticut concurs with the selected remedy for the Barkhamsted-New Hartford Landfill Superfund Site. A copy of the declaration of concurrence is attached as Appendix A.