Table 6.1-10 D_T Values For Acute and Subchronic Exposure

Contaminant	Acute		Subchronic	
	D_TING (mg/kg-day)	D_TINH (mg/kg-day)	D_TING (mg/kg-day)	D_TINH (mg/kg-day)
Dithiane	NA	NA	NA	NA
Endrin	2.0E-03	2.0E-03	5.0E-04	5.0E-04
Ethylbenzene	3.0E+00	3.0E+00	1.0E+00	2.8E-01
Fluoroacetic acid	NA	NA	NA	NA
HCCPD	NA	NA	7.0E-02	2.0E-04
Isodrin	NA	NA	NA	NA
Isopropylmethyl phosphonic acid	NA	NA	NA	NA
Isopropylmethyl phosphonate	NA	NA	NA	NA
Lead	NA	NA	NA	NA
Lewisite	NA	NA	NA	NA
Lewisite oxide	NA	NA	NA	NA
Malathion	2.0E-02	2.0E-02	2.0E-02	2.0E-02
Mercury(inorganic)	2.0E-01	2.0E-01	3.0E-04	8.5E-05
Methylene chloride	1.0E+00	4.9E+00	6.0E-02	8.5E-01
Methyl isobutyl ketone	NA	NA	5.0E-01	2.0E-01
NDMA	NA	NA	NA	NA
1,4-Oxathiane	NA	NA	NA	NA
Parathion	NA	NA	6.0E-03	6.0E-03
Sarin	NA	NA	NA	5.7E-07
Sulfur mustard	NA	NA	NA	NA
Supona	NA	NA	NA	NA
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA
Tetrachloroethylene	2.0E-01	1.9E+00	1.0E-01	1.7E-01
Thiodiglycol	NA	NA	NA	NA
Toluene	2.0E+00	4.3E+00	2.0E+00	5.7E-01
1,1,1-Trichloroethane	1.0E+01	4.0E-01	9.0E-01	2.8E+00
1,1,2-Trichloroethane	6.0E-02	4.0E-02	4.0E-02	4.0E-02
TCE	2.4E+00	4.3E-01	2.5E+00	2.5E+00
Vapona	NA	NA	NA	NA

Table 6.1-10 D_T Values For Acute and Subchronic Exposure

Contaminant	Acute		Subchronic	
	D_TING (mg/kg-day)	D_TINH (mg/kg-day)	D_TING (mg/kg-day)	D_TINH (mg/kg-day)
M-xylene	4.0E+00	4.0E+00	4.0E+00	1.0E+00
O,p-Xylene	4.0E+00	4.0E+00	4.0E+00	8.5E-02
Zinc	NA	NA	2.0E-01	2.0E-01

NA Dose-response data not available from EPA.
D_TING Allowable dose for ingestion
D_TING Allowable dose for inhalation

Table 6.1-11 Summary of Chronic Cumulative Direct Soil PPLVs for the 5th Percentile[1,2] Page 1 of 1

	Receptor-Specific Soil PPLVs (Units: mg/kg)				
	Open Space Populations			Economic Development Populations	
Chemical	Biological Worker	Regulated/ Casual Visitor	Recreational Visitor	Industrial Worker	Commercial Worker
Aldrin	**7.16E-01**	1.16E+01	3.29E+00	3.02E+00	4.71E+00
Benzene	1.18E+01	5.76E+01	1.30E+01	**1.04E+01**	2.26E+02
Carbon Tetrachloride	2.51E+00	1.32E+01	2.69E+00	**2.33E+00**	5.14E+01
Chlordane	**3.72E+00**	5.39E+01	1.09E+01	7.58E+00	2.66E+01
Chloroacetic Acid*	1.01E+02	8.13E+02	2.34E+02	**7.71E+01**	1.88E+03
Chlorobenzene*	9.66E+02	6.95E+03	2.55E+03	**8.45E+02**	1.68E+04
Chloroform	**4.82E+01**	3.23E+02	8.91E+01	4.84E+01	1.11E+03
DDE	**1.25E+01**	1.77E+02	3.05E+01	1.87E+01	1.26E+02
DDT	**1.35E+01**	1.51E+02	3.60E+01	3.61E+01	9.58E+01
DBCP	**2.01E-01**	1.17E+00	2.52E-01	2.36E-01	4.51E+00
1,2-Dichloroethane	**3.23E+00**	1.74E+01	3.75E+00	3.39E+00	7.07E+01
1,1-Dichloroethylene	**5.16E-01**	2.82E+00	7.33E-01	5.21E-01	1.02E+01
DCPD*	**3.69E+03**	6.11E+04	2.91E+04	6.65E+03	5.83E+04
Dieldrin	**4.14E-01**	6.45E+00	1.96E+00	1.40E+00	2.54E+00
Endrin*	**2.32E+02**	2.99E+03	8.65E+02	3.18E+02	1.12E+03
HCCPD*	**1.06E+03**	1.47E+04	6.16E+03	1.78E+03	1.67E+04
Isodrin*	**5.24E+01**	6.43E+02	2.15E+02	7.39E+01	2.51E+02
Methylene Chloride	**3.53E+01**	2.06E+02	4.58E+01	4.43E+01	7.78E+02
1,1,2,2-Tetrachloroethane	**1.45E+00**	1.94E+00	9.61E+00	1.49E+00	3.31E+01
Tetrachloroethylene	**5.43E+00**	3.57E+01	6.26E+00	5.87E+00	1.30E+02
Toluene*	9.46E+03	6.48E+04	2.11E+04	**7.22E+03**	1.38E+05
TCE	**2.84E+01**	1.78E+02	3.98E+01	2.90E+01	6.27E+02
Metals (Indicator Level[3])					
Arsenic (IL = 10 ppm, >driving PPLV)	**4.17E+00**	7.91E+01	3.68E+01	2.60E+01	2.60E+01
Cadmium (IL = 2.0 ppm)	**5.01E+01**	8.55E+02	2.17E+02	2.12E+02	1.87E+03
Chromium (IL = 40 ppm, >driving PPLV)	**7.52E+00**	1.29E+02	3.28E+01	3.23E+01	2.36E+02
Lead* (IL = 40 ppm)	**2.17E+03**	4.77E+04	2.65E+04	4.46E+03	7.06E+03
Mercury* (IL = 0.1 ppm)	**5.74E+02**	9.85E+03	5.49E+03	1.24E+03	1.35E+03

* Denotes a noncarcinogen. No asterisk denotes PPLV based on carcinogenic slope factors for both oral and inhalation pathways.

1 Cumulative direct PPLVs represent a cancer risk level of 10^{-6} for carcinogens; the PPLV at a 10^{-4} cancer risk is 100 times higher than the values shown in this table. Values in bold face represent the driver PPLVs for the corresponding receptor population.

2 Summaries of dominant exposure pathways comprising the cumulative (5th percentile) direct PPLV are provided in Appendix Section B.4.1 of the IEA/RC report for each receptor population evaluated (Appendix Tables B.4.1-1 through B.4.1-5). As shown in these tables, the majority of PPLVs listed above reflect the carcinogenic endpoint. Also, for most chemicals, dermal absorption was the driver exposure pathway. The only exceptions were certain OCPs (aldrin, DDE, endrin, and isodrin), for which soil ingestion was the driver pathway, and metals, for which ingestion or inhalation pathways were drivers.

3 Indicator level is the assumed background concentration for the inorganic COCs.

Table 6.1-12 Summary of Chronic Cumulative Direct Soil PPLVs for the 50th Percentile[1] Page 1 of 1

	Receptor-Specific Soil PPLVs (Units: mg/kg)				
	Open Space Populations			Economic Development Populations	
Chemical	Biological Worker	Regulated/ Casual Visitor	Recreational Visitor	Industrial Worker	Commercial Worker
Aldrin	**4.27E+00**	1.10E+02	9.43E+01	1.52E+01	3.89E+01
Benzene	**3.43E+01**	6.21E+02	3.26E+02	1.04E+02	1.53E+03
Carbon Tetrachloride	**7.69E+00**	1.28E+02	6.75E+01	1.94E+01	3.05E+02
Chlordane	**1.97E+01**	3.30E+02	2.35E+02	5.03E+01	2.53E+02
Chloroacetic Acid*	2.19E+02	2.84E+03	1.31E+03	**1.67E+02**	2.60E+03
Chlorobenzene*	2.19E+03	2.88E+04	1.28E+04	**1.61E+03**	2.50E+04
Chloroform	**1.91E+02**	3.08E+03	1.66E+03	4.58E+02	7.48E+03
DDE	**7.13E+01**	1.28E+03	8.10E+02	1.95E+02	8.22E+02
DDT	**6.49E+01**	1.29E+03	1.01E+03	2.20E+02	9.01E+02
DBCP	**7.24E-01**	1.24E+01	6.21E+00	1.89E+00	2.89E+01
1,2-Dichloroethane	**1.07E+01**	1.88E+02	9.14E+01	2.99E+01	3.99E+02
1,1-Dichloroethylene	**1.57E+00**	2.94E+01	1.52E+01	4.53E+00	6.83E+01
DCPD*	**8.12E+03**	2.17E+05	2.09E+05	1.66E+04	1.33E+05
Dieldrin	**2.45E+00**	5.73E+01	4.81E+01	8.42E+00	2.27E+01
Endrin*	**6.42E+02**	1.28E+04	6.72E+03	6.81E+02	3.41E+03
HCCPD*	**2.22E+03**	6.12E+04	4.05E+04	6.80E+03	3.32E+04
Isodrin*	**1.48E+02**	2.67E+03	1.56E+03	1.55E+02	7.76E+02
Methylene Chloride	**1.27E+02**	2.04E+03	1.19E+03	3.51E+02	5.32E+03
1,1,2,2-Tetrachloroethane	**5.16E+00**	9.04E+01	4.55E+01	1.32E+01	1.97E+02
Tetrachloroethylene	**1.92E+01**	3.64E+02	1.86E+02	5.33E+01	7.51E+02
Toluene*	2.04E+04	1.74E+05	9.02E+04	**1.46E+04**	1.76E+05
TCE	**1.03E+02**	1.84E+03	8.83E+02	2.79E+02	4.62E+03
Metals (Indicator Level[2])					
Arsenic (IL = 10 ppm, >driving PPLV)	**2.64E+01**	9.38E+02	9.02E+02	1.38E+02	2.44E+02
Cadmium (IL = 2.0 ppm)	**3.10E+02**	1.24E+04	1.36E+04	2.34E+03	2.19E+04
Chromium (IL = 40 ppm, >driving PPLV)	**4.72E+01**	1.89E+03	2.16E+03	3.56E+02	4.21E+03
Lead* (IL = 40 ppm)	**7.22 E+03**	2.37E+05	2.18E+05	1.68E+04	2.40E+04
Mercury* (IL = 0.1 ppm)	**1.80E+03**	6.82E+04	6.81E+04	4.35E+03	5.96E+03

* Denotes a noncarcinogen. No asterisk denotes PPLV based on carcinogenic slope factors for both oral and inhalation pathways.

1 Cumulative direct PPLVs represent a cancer risk level of 10^{-6} for carcinogens; the PPLV at a 10^{-4} cancer risk is 100 times higher than the values shown in this table. Values in bold face represent the driver PPLVs for corresponding receptor population.

2 Indicator level is the assumed background concentration for the inorganic COCs.

Table 6.1-13 Summary of 5th Percentile Direct Single-Pathway PPLVS for the Biological Worker[1]

Chemical Name	Soil Ingestion SPPLV	Soil Inhalation SPPLV	Dermal Absorption SPPLV	Cumulative Direct PPLV-CARC[2]	Cumulative Direct PPLV-NONCARC[2]
Aldrin	**7.64E-01**	9.56E+01	1.30E+01	7.16E-01	7.12E+01
Benzene	1.29E+02	1.02E+04	**1.30E+01**	1.18E+01	NA
Carbon Tetrachloride	8.14E+01	1.20E+04	**2.59E+00**	2.51E+00	3.63E+01
Chlordane	2.71E+01	7.18E+02	**4.34E+00**	3.72E+00	5.51E+01
Chloroacetic Acid	3.98E+03	3.74E+05	**1.04E+02**	NA	1.01E+02
Chlorobenzene	4.12E+04	9.36E+05	**9.91E+02**	NA	9.66E+02
Chloroform	4.58E+03	1.12E+04	**4.90E+01**	4.82E+01	4.41E+02
DDE	**1.96E+01**	1.88E+03	3.53E+01	1.25E+01	NA
DDT	3.02E+01	1.84E+03	**2.47E+01**	1.35E+01	4.09E+02
DBCP	2.96E+00	1.27E+05	**2.16E-01**	2.01E-01	9.75E+00
1,2-Dichloroethane	1.13E+02	6.97E+03	**3.32E+00**	3.23E+00	NA
1,1-Dichloroethylene	1.84E+01	3.61E+03	**5.31E-01**	5.16E-01	4.52E+02
Dicyclopentadiene	3.72E+04	**4.24E+03**	1.20E+05	NA	3.69E+03
Dieldrin	**5.90E-01**	4.02E+01	1.43E+00	4.14E-01	5.77E+01
Endrin	**2.43E+02**	3.76E+04	6.47E+03	NA	2.32E+02
Hexachlorocyclopentadiene	9.74E+03	**1.41E+03**	7.48E+03	NA	1.06E+03
Isodrin	**1.02E+02**	4.42E+03	1.10E+02	NA	5.24E+01
Methylene Chloride	9.51E+02	3.95E+05	**3.66E+01**	3.53E+01	3.11E+03
1,1,2,2-Tetrachloroethane	2.30E+01	1.51E+03	**1.55E+00**	1.45E+00	NA
Tetrachloroethylene	6.05E+02	5.13E+05	**5.48E+00**	5.43E+00	5.47E+02
Toluene	4.69E+05	1.00E+06	**9.75E+03**	NA	9.46E+03
Trichloroethylene	1.41E+03	1.08E+05	**2.90E+01**	2.84E+01	NA
Arsenic	**4.36E+00**	9.56E+01	0.00E+00	4.17E+00	4.76E+02
Cadmium	3.47E+04	**5.01E+01**	0.00E+00	5.01E+01	5.29E+02
Chromium	3.47E+05	**7.52E+00**	0.00E+00	7.52E+00	3.87E+01
Lead	**2.22E+03**	9.28E+04	0.00E+00	NA	2.17E+03
Mercury	**6.24E+02**	7.17E+03	0.00E+00	NA	5.74E+02

1 Values reported as mg/kg. Values are 5th percentile PPLVs, based on a 10^{-6} risk level for carcinogens, and an HI of 1.0 for noncarcinogens. Values in bold face represent the driver exposure pathway.

2 Where a chemical is both a carcinogen (CARC) and noncarcinogen (NONCARC), the single-pathway PPLVs summarized represent the carcinogenic endpoint.

Table 6.1-14 Summary of 5th Percentile Direct Single-Pathway PPLVS for the Recreational Visitor[1]

Chemical Name	Soil Ingestion SPPLV	Soil Inhalation SPPLV	Dermal Absorption SPPLV	Cumulative Direct PPLV-CARC[2]	Cumulative Direct PPLV-NONCARC[2]
Aldrin	**6.36E+00**	4.79E+02	6.93E+00	3.29E+00	4.63E+02
Benzene	5.74E+03	8.62E+04	**1.30E+01**	1.30E+01	NA
Carbon Tetrachloride	3.29E+03	1.91E+05	**2.69E+00**	2.69E+00	8.65E+01
Chlordane	5.14E+01	5.67E+02	**1.41E+01**	1.09E+01	1.59E+02
Chloroacetic Acid	5.30E+04	1.00E+06	**2.35E+02**	NA	2.34E+02
Chlorobenzene	6.36E+05	1.00E+06	**2.56E+03**	NA	2.55E+03
Chloroform	8.26E+04	1.21E+05	**8.39E+01**	8.91E+01	1.17E+03
DDE	4.48E+02	7.35E+03	**3.29E+01**	3.05E+01	NA
DDT	7.98E+02	1.93E+04	**3.78E+01**	3.60E+01	1.62E+03
DBCP	1.50E+02	1.00E+06	**2.52E-01**	2.52E-01	2.32E+01
1,2-Dichloroethane	5.57E+03	1.11E+05	**3.75E+00**	3.75E+00	NA
1,1-Dichloroethylene	5.05E+01	5.65E+03	**7.44E-01**	7.33E-01	1.06E+03
Dicyclopentadiene	3.85E+05	**4.49E+04**	1.05E+05	NA	2.91E+04
Dieldrin	3.48E+01	6.24E+02	**2.08E+00**	1.96E+00	4.70E+02
Endrin	9.83E+03	1.43E+05	**9.55E+02**	NA	8.65E+02
Hexachlorocyclopentadiene	7.88E+04	1.50E+04	**1.21E+04**	NA	6.16E+03
Isodrin	2.02E+03	1.07E+05	**2.41E+02**	NA	2.15E+02
Methylene Chloride	2.17E+04	1.00E+06	**4.59E+01**	4.58E+01	7.30E+03
1,1,2,2-Tetrachloroethane	2.70E+03	5.03E+04	**1.94E+00**	9.61E+00	NA
Tetrachloroethylene	9.93E+03	1.00E+06	**6.27E+00**	6.26E+00	1.28E+03
Toluene	1.00E+06	1.00E+06	**2.21E+04**	NA	2.11E+04
Trichloroethylene	2.06E+04	4.31E+05	**3.99E+01**	3.98E+01	NA
Arsenic	**6.16E+01**	9.15E+01	00.0E+00	3.68E+01	5.84E+03
Cadmium	3.96E+04	**2.19E+02**	00.0E+00	2.17E+02	6.53E+03
Chromium	3.96E+05	**3.28E+01**	00.0E+00	3.28E+01	3.55E+02
Lead	**2.75E+04**	7.08E+05	00.0E+00	NA	2.65E+04
Mercury	**5.91E+03**	7.70E+04	00.0E+00	NA	5.49E+03

1 Values reported as mg/kg. Values are 5th percentile PPLVs, based on a 10^{-6} risk level for carcinogens, and an HI of 1.0 for noncarcinogens. Values in bold face represent the driver exposure pathway.

2 Where a chemical is both a carcinogen (CARC) and noncarcinogen (NONCARC), the single-pathway PPLVs summarized represent the carcinogenic endpoint.

Table 6.1-15 Summary of 5th Percentile Direct Single-Pathway PPLVS for the Regulated/Casual Visitor[1]

Chemical Name	Soil Ingestion SPPLV	Soil Inhalation SPPLV	Dermal Absorption SPPLV	Cumulative Direct PPLV-CARC[2]	Cumulative Direct PPLV-NONCARC[2]
Aldrin	**2.32E+01**	3.68E+02	2.48E+01	1.16E+01	1.09E+03
Benzene	4.05E+03	1.36E+05	**5.85E+01**	5.76E+01	NA
Carbon Tetrachloride	1.17E+03	9.73E+04	**1.34E+01**	1.32E+01	2.86E+02
Chlordane	2.91E+02	5.99E+03	**6.69E+01**	5.39E+01	5.82E+02
Chloroacetic Acid	5.62E+04	1.00E+06	**8.25E+02**	NA	8.13E+02
Chlorobenzene	7.37E+05	1.00E+06	**7.07E+03**	NA	6.95E+03
Chloroform	2.34E+04	7.49E+04	**3.29E+02**	3.23E+02	4.41E+03
DDE	3.66E+02	1.16E+04	**3.52E+02**	1.77E+02	NA
DDT	1.11E+03	1.56E+04	**1.77E+02**	1.51E+02	5.89E+03
DBCP	7.20E+01	1.00E+06	**1.19E+00**	1.17E+00	7.76E+01
1,2-Dichloroethane	1.24E+03	4.40E+04	**1.77E+01**	1.74E+01	NA
1,1-Dichloroethylene	2.05E+02	2.28E+04	**2.86E+00**	2.82E+00	3.49E+03
Dicyclopentadiene	1.00E+06	**7.81E+04**	3.91E+05	NA	6.11E+04
Dieldrin	**9.24E+00**	3.17E+02	2.28E+01	6.45E+00	9.39E+02
Endrin	1.15E+04	3.43E+05	**4.09E+03**	NA	2.99E+03
Hexachlorocyclopentadiene	2.48E+05	**2.24E+04**	5.18E+04	NA	1.47E+04
Isodrin	3.04E+03	3.27E+05	**8.17E+02**	NA	6.43E+02
Methylene Chloride	1.33E+04	1.00E+06	**2.09E+02**	2.06E+02	2.37E+04
1,1,2,2-Tetrachloroethane	5.74E+02	2.00E+04	**9.78E+00**	1.94E+00	NA
Tetrachloroethylene	2.52E+03	1.00E+06	**3.62E+01**	3.57E+01	3.82E+03
Toluene	1.00E+06	1.00E+06	**7.44E+04**	NA	6.48E+04
Trichloroethylene	1.25E+04	6.80E+05	**1.80E+02**	1.78E+02	NA
Arsenic	**1.03E+02**	3.43E+02	0.00E+00	7.91E+01	9.97E+03
Cadmium	2.90E+04	**8.80E+02**	0.00E+00	8.55E+02	1.30E+04
Chromium	1.00E+06	**1.29E+02**	0.00E+00	1.29E+02	7.38E+02
Lead	**5.01E+04**	1.00E+06	0.00E+00	NA	4.77E+04
Mercury	**1.05E+04**	1.58E+05	0.00E+00	NA	9.85E+03

1 Values reported as mg/kg. Values are 5th percentile PPLVs, based on a 10^{-6} risk level for carcinogens, and an HI of 1.0 for noncarcinogens. Values in bold face represent the driver exposure pathway.

2 Where a chemical is both a carcinogen (CARC) and noncarcinogen (NONCARC), the single-pathway PPLVs summarized represent the carcinogenic endpoint.

Table 6.1-16 Summary of 5th Percentile Direct Single-Pathway PPLVS for the Industrial Worker[1]

Chemical Name	Soil Ingestion SPPLV	Soil Inhalation SPPLV	Dermal Absorption SPPLV	Cumulative Direct PPLV-CARC[2]	Cumulative Direct PPLV-NONCARC[2]
Aldrin	9.96E+00	1.29E+02	**4.50E+00**	3.02E+00	1.19E+02
Benzene	3.25E+03	7.59E+04	**1.04E+01**	1.04E+01	NA
Carbon Tetrachloride	8.19E+02	2.18E+04	**2.33E+00**	2.33E+00	2.96E+01
Chlordane	1.04E+02	3.06E+03	**8.20E+00**	7.58E+00	6.23E+01
Chloroacetic Acid	5.99E+04	6.82E+005	**7.72E+01**	NA	7.71E+01
Chlorobenzene	5.77E+04	1.00E+06	**8.58E+02**	NA	8.45E+02
Chloroform	1.52E+04	2.68E+04	**4.87E+01**	4.84E+01	3.73E+02
DDE	6.58E+01	3.57E+03	**2.64E+01**	1.87E+01	NA
DDT	3.49E+02	6.48E+03	**4.06E+01**	3.61E+01	4.70E+02
DBCP	6.98E+01	4.81E+05	**2.37E-01**	2.36E-01	7.99E+00
1,2-Dichloroethane	1.12E+03	1.26E+04	**3.40E+00**	3.39E+00	NA
1,1-Dichloroethylene	1.10E+02	1.25E+04	**5.23E+01**	5.21E-01	3.28E+02
Dicyclopentadiene	3.60E+05	**7.84E+03**	4.95E+04	NA	6.65E+03
Dieldrin	8.94E+00	9.10E+01	**1.69E+00**	1.40E+00	1.06E+02
Endrin	4.78E+03	2.22E+05	**3.41E+02**	NA	3.18E+02
Hexachlorocyclopentadiene	1.71E+05	**2.38E+03**	7.44E+03	NA	1.78E+03
Isodrin	1.62E+03	8.32E+03	**7.82E+01**	NA	7.39E+01
Methylene Chloride	1.53E+04	6.99E+05	**4.44E+01**	4.43E+01	2.25E+03
1,1,2,2-Tetrachloroethane	5.42E+02	1.12E+04	**1.49E+00**	1.49E+00	NA
Tetrachloroethylene	2.39E+03	6.30E+05	**5.88E+00**	5.87E+00	4.05E+02
Toluene	1.00E+06	1.00E+06	**7.32E+03**	NA	7.22E+03
Trichloroethylene	2.19E+03	2.09E+05	**2.94E+01**	2.90E+01	NA
Arsenic	**3.03E+01**	1.83E+02	0.00E+00	2.60E+01	8.67E+02
Cadmium	1.28E+04	**2.15E+02**	0.00E+00	2.12E+02	1.05E+03
Chromium	1.28E+05	**3.23E+01**	0.00E+00	3.23E+01	7.30E+01
Lead	**4.60E+03**	1.52E+05	0.00E+00	NA	4.46E+03
Mercury	**1.43E+03**	8.95E+03	0.00E+00	NA	1.24E+03

1 Values reported as mg/kg. Values are 5th percentile PPLVs, based on a 10^{-6} risk level for carcinogens, and an HI of 1.0 for noncarcinogens. Values in bold face represent the driver exposure pathway.

2 Where a chemical is both a carcinogen (CARC) and noncarcinogen (NONCARC), the single-pathway PPLVs summarized represent the carcinogenic endpoint.

Table 6.1-17 Summary of 5th Percentile Direct Single-Pathway PPLVS for the Commercial Worker[1]

Chemical Name	Soil Ingestion SPPLV	Soil Inhalation SPPLV	Dermal Absorption SPPLV	Cumulative Direct PPLV-CARC[2]	Cumulative Direct PPLV-NONCARC[2]
Aldrin	**4.81E+00**	5.76E+03	2.43E+02	4.71E+00	2.04E+02
Benzene	9.47E+02	2.36E+05	**2.97E+02**	2.26E+02	NA
Carbon Tetrachloride	1.11E+03	2.30E+05	**5.40E+01**	5.14E+01	6.24E+02
Chlordane	**4.96E+01**	1.77E+04	5.75E+01	2.66E+01	2.16E+02
Chloroacetic Acid	1.38E+04	1.00E+06	**2.19E+03**	NA	1.88E+03
Chlorobenzene	8.24E+04	1.00E+06	**2.15E+04**	NA	1.68E+04
Chloroform	1.33E+04	9.56E+04	**1.23E+03**	1.11E+03	8.93E+03
DDE	**1.43E+02**	2.83E+05	1.07E+03	1.26E+02	NA
DDT	**1.06E+02**	2.83E+05	9.87E+02	9.58E+01	1.92E+03
DBCP	4.72E+01	1.00E+06	**4.98E+00**	4.51E+00	1.84E+02
1,2-Dichloroethane	5.78E+02	8.76E+04	**8.06E+01**	7.07E+01	NA
1,1-Dichloroethylene	8.66E+01	4.36E+04	**1.16E+01**	1.02E+01	7.74E+03
Dicyclopentadiene	**9.55E+04**	1.79E+05	9.20E+05	NA	5.83E+04
Dieldrin	**2.58E+00**	7.75E+03	1.75E+02	2.54E+00	2.26E+02
Endrin	**1.16E+03**	1.00E+06	2.96E+04	NA	1.12E+03
Hexachlorocyclopentadiene	2.02E+05	**2.08E+04**	1.47E+05	NA	1.67E+04
Isodrin	**2.57E+02**	4.75E+05	1.09E+04	NA	2.51E+02
Methylene Chloride	6.51E+03	1.00E+06	**8.84E+02**	7.78E+02	5.06E+04
1,1,2,2-Tetrachloroethane	3.20E+02	3.83E+04	**3.69E+01**	3.31E+01	NA
Tetrachloroethylene	1.32E+03	1.00E+06	**1.44E+02**	1.30E+02	8.75E+03
Toluene	1.00E+06	1.00E+06	**1.91E+05**	NA	1.38E+05
Trichloroethylene	1.18E+04	1.00E+06	**6.63E+02**	6.27E+02	NA
Arsenic	**2.61E+01**	8.38E+03	0.00E+00	2.60E+01	1.30E+03
Cadmium	5.56E+04	**1.93E+03**	0.00E+00	1.87E+03	1.70E+03
Chromium	6.15E+04	**3.28E+02**	0.00E+00	3.26E+02	7.82E+02
Lead	**7.11E+03**	1.00E+06	0.00E+00	NA	7.06E+03
Mercury	**1.36E+03**	2.39E+05	0.00E+00	NA	1.35E+03E

1 Values reported as mg/kg. Values are 5th percentile PPLVs, based on a 10^{-6} risk level for carcinogens, and an HI of 1.0 for noncarcinogens. Values in bold face represent the driver exposure pathway.

2 Where a chemical is both a carcinogen (CARC) and noncarcinogen (NONCARC), the single-pathway PPLVs summarized represent the carcinogenic endpoint.

Table 6.1-18 Summary of Sites with C_{rep} Values Exceeding 5th Percentile PPLVs in Horizon 0

Chemical[1, 2]	Number of Sites with Chemical-Specific $C_{rep,upper}$ Concentrations Exceeding 5th Percentile PPLVs				
	Biological Worker	Regulated/ Casual Visitor	Recreational Visitor	Industrial Visitor	Commercial Worker
Aldrin	**10**	**1**	**3**	**7**	**5**
Benzene	0	0	0	0	0
Carbon Tetrachloride	0	0	0	0	0
Chlordane	4	2	2	4	2
Chloroacetic Acid	**1**	0	**1**	**1**	0
Chlorobenzene	0	0	0	0	0
Chloroform	0	0	0	0	0
DBCP	**1**	**1**	**1**	**1**	**1**
DCPD	0	0	0	0	0
DDE	0	0	0	0	0
DDT	0	0	0	0	0
1,2-Dichloroethane	0	0	0	0	0
1,1-Dichloroethylene	0	0	0	0	0
Dieldrin	**9**	2	4	5	4
Endrin	2	0	0	2	0
HCCPD	0	0	0	0	0
Isodrin	**3**	0	0	**2**	0
Methylene Chloride	0	0	0	0	0
1,1,2,2-Tetrachloroethane	0	0	0	0	0
Tetrachloroethylene	0	0	0	0	0
Toluene	0	0	0	0	0
Trichloroethylene	0	0	0	0	0
Arsenic	**5**	**1**	**1**	**4**	**3**
Cadmium	0	0	0	0	0
Chromium	5	0	1	2	0
Lead	0	0	0	0	0
Mercury	0	0	0	0	0

1 Boldface type indicates exceedances of 10^{-4} cancer risk or HIs of 1.0.

2 For carcinogens, exceedances of 1×10^{-4} risk levels are noted. For noncarcinogens, exceedances of a target HI of 1.0 are given.

Table 6.1-19 Summary of Acute RME PPLVs for Cumulative Direct Soil Exposure Pathway[1]

Chemical	Receptor-Specific Soil PPLVs (Units: mg/kg)			
	Biological/ Industrial Worker	Regulated/ Casual Visitor	Recreational Visitor	Commercial Visitor
Aldrin[2]	5.6E+01	**3.8E+00**	**3.8E+00**	6.9E+01
Benzene	ND	ND	ND	ND
Carbon Tetrachloride	4.8E+04	**1.1E+04**	**1.1E+04**	2.5E+05
Chlordane	7.2E+02	**1.7E+02**	**1.7E+02**	3.7E+03
Chloroacetic Acid	ND	ND	ND	ND
Chlorobenzene	2.4E+04	**5.6E+03**	**5.6E+03**	1.2E+05
Chloroform	2.2E+04	**5.0E+03**	**5.0E+03**	1.1E+05
DDE	ND	ND	ND	ND
DDT	6.0E+01	**1.4E+01**	**1.4E+01**	3.1E+02
DBCP	6.0E+02	**1.4E+02**	**1.4E+02**	3.1E+03
1,2-Dichloroethane	ND	ND	ND	ND
1,1-Dichloroethylene	2.4E+04	**5.6E+03**	**5.6E+03**	1.2E+05
Dicyclopentadiene	ND	ND	ND	ND
Dieldrin[2]	4.7E+01	**3.7E+00**	**3.7E+00**	6.9E+01
Endrin	2.4E+02	**5.6E+01**	**5.6E+01**	1.2E+03
Hexachlorocyclopentadiene	ND	ND	ND	ND
Isodrin	ND	ND	ND	ND
Methylene Chloride	1.2E+05	**2.8E+04**	**2.8E+04**	6.2E+05
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND
Tetrachloroethylene	2.4E+04	**5.6E+03**	**5.6E+03**	1.2E+05
Toluene	2.4E+05	**5.6E+04**	**5.6E+04**	[3]
TCE	2.9E+05	**6.7E+04**	**6.7E+04**	[3]
Metals				
Arsenic	3.4E+03	**3.0E+02**	**3.0E+02**	5.4E+03
Cadmium	1.9E+03	**1.5E+02**	**1.5E+02**	2.8E+03
Chromium	4.7E+04	**3.8E+03**	**3.8E+03**	6.9E+04
Lead	ND	ND	ND	ND
Mercury	9.4E+04	**7.7E+03**	**7.7E+03**	1.4E+05

[1] Based on an HI of 1.0, and using the exposure assumptions listed in Appendix Table B.6-1 of the IEA/RC report. Values in bold face represent the driver PPLVs for the corresponding receptor population.

[2] RME PPLVs for aldrin and dieldrin were recalculated using an RfD recently updated by EPA (OHEA-EPA 1992) (1.0×10^{-4} mg/kg-day; see Appendix Table B.6-3 in the IEA/RC); this criterion supersedes the value used in the HHEA Addendum. These recalculated PPLVs also reflect the following: (1) dermal RAFs for aldrin and dieldrin were revised to equal 0.0052 and 0.1, respectively, consistent with the assumptions used in the IEA/RC; and (2) concomitant with this revision of the aldrin/dieldrin dermal RAFs, the soil covering assumed for recreational and regulated/casual visitor populations was revised to equal 1.0 mg/cm^2, consistent with recent EPA dermal exposure assessment guidance.

[3] PPLV is greater than 1×10^6 mg/kg, indicating that the allowable soil concentrations are equivalent to exposure to pure compound over all direct soil pathways at the soil intake rates assumed for this analysis.

ND Not Developed; EPA dose-response information not available.

Table 6.1-20 Summary of Subchronic RME PPLVs for Cumulative Direct Soil Exposure Pathway[1]

Chemical	Receptor-Specific Soil PPLVs (Units: mg/kg)			
	Biological/ Industrial Worker	Regulated/ Casual Visitor	Recreational Visitor	Commercial Visitor
Aldrin[2]	8.0E+01	**2.7E+01**	**2.7E+01**	1.0E+02
Benzene	ND	ND	ND	ND
Carbon Tetrachloride	1.2E+03	**1.4E+03**	**1.4E+03**	6.3E+03
Chlordane	1.0E+01	**1.2E+01**	**1.2E+01**	5.4E+01
Chloroacetic Acid	3.5E+03	**3.9E+03**	**3.9E+03**	1.8E+04
Chlorobenzene	3.5E+04	**3.9E+04**	**3.9E+04**	1.8E+05
Chloroform	1.7E+03	**2.0E+03**	**2.0E+03**	9.0E+03
DDE	ND	ND	ND	ND
DDT	8.7E+01	**9.8E+01**	**9.8E+01**	4.5E+02
DBCP	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND
1,1-Dichloroethylene	1.6E+03	**1.8E+03**	**1.8E+03**	8.1E+03
Dicyclopentadiene	3.4E+04	**5.4E+04**	**5.4E+04**	2.0E+05
Dieldrin[2]	6.8E+01	**2.6E+01**	**2.6E+01**	1.0E+02
Endrin	8.7E+01	**9.8E+01**	**9.8E+01**	4.5E+02
Hexachlorocyclopentadiene	8.8E+03	**1.3E+04**	**1.3E+04**	5.1E+04
Isodrin	ND	ND	ND	ND
Methylene Chloride	1.0E+04	**1.2E+04**	**1.2E+04**	5.4E+04
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND
Tetrachloroethylene	1.7E+04	**2.0E+04**	**2.0E+04**	9.0E+04
Toluene	3.5E+05	**3.9E+05**	**3.9E+05**	[3]
TCE	4.3E+05	**4.9E+05**	**4.9E+05**	[3]
Metals				
Arsenic	6.7E+02	**2.7E+02**	**2.7E+02**	9.9E+02
Cadmium	3.4E+02	**1.4E+02**	**1.4E+02**	5.0E+02
Chromium	**7.2E+02**	2.4E+03	2.4E+03	5.3E+03
Lead	ND	ND	ND	ND
Mercury	2.0E+02	**8.2E+01**	**8.2E+01**	3.0E+02

1 Based on an HI of 1.0. Values in bold face represent the driver PPLVs for the corresponding receptor population.

2 RME PPLVs for aldrin and dieldrin were recalculated using an RfD recently updated by EPA (OHEA-EPA 1992) (1.0×10^{-4} mg/kg-day; see Appendix Table B.6-3 in the IEA/RC report); this criterion supersedes the value used in the HHEA Addendum. These recalculated PPLVs also reflect the following: (1) dermal RAFs for aldrin and dieldrin were revised to equal 0.0052 and 0.1, respectively, consistent with the assumptions used in the IEA/RC; and (2) concomitant with this revision of the aldrin/dieldrin dermal RAFs, the soil covering assumed for recreational and regulated/casual visitor populations was revised to equal 1.0 mg/cm^2, consistent with recent EPA dermal exposure assessment guidance.

3 PPLV is greater than 1×10^6 mg/kg, indicating that the allowable soil concentrations are equivalent to exposure to pure compound over all direct soil pathways at the soil intake rates assumed for this analysis.

ND Not Developed; EPA dose-response information not available.

Table 6.2-1 Mean BMF Calculated by Alternate Methods[1]

Trophic Box	BMF by the Army Calibration Procedure Mean BMF	BMF_{obs} by the Shell Collocated Distributions Approach Mean BMF	BMF_{obs} by the (EPA) Modified Paired Data Approach Mean BMF
Aldrin/Dieldrin			
Soil	1	1	1
Terrestrial Plant	1.6E-02	6.0E-02	1.8E-01
Worm	2.3E-01	1.0E+00	2.5E+00
Insect	7.4E-02	9.7E-02	4.2E-01
Small Bird	2.1E-01	2.7E-01	6.8E-01
Small Mammal	2.7E-01	5.9E-01	3.0E+00
Medium Mammal	3.8E-01	2.7E-01	1.9E+00
Herptile	2.4E+00	2.4E+00	7.7E+00
Kestrel	2.6E+00	4.9E+00	2.3E+01
Owl	8.0E+00	6.9E+00	4.1E+01
Shorebird	3.6E+00	2.3E+00	6.2E+00
Heron	2.9E+00	3.0E+00	8.6E+00
Eagle	6.1E+00	4.4E+00	2.8E+01
DDE/DDT			
Soil	1	1	1
Terrestrial Plant	6.6E-01	9.2E-01	5.2E+00
Worm	1.4E+00	1.1E+00	7.8E+00
Insect	7.5E-01	9.9E-01	3.9E+01
Small Bird	5.4E-01	8.1E-01	3.3E+00
Small Mammal	4.6E-01	6.5E-01	2.8E+00
Medium Mammal	4.9E-01	3.1E+00	6.0E+00
Herptile	1.3E+00	2.5E+00	6.3E+00
Kestrel	9.9E+00	1.4E+01	5.5E+01
Owl	3.2E+01	1.7E+02	3.4E+02
Shorebird	4.8E+01	6.0E+01	1.5E+02
Heron	1.1E+01	1.8E+01	4.2E+01
Eagle	1.9E+01	1.2E+02	2.2E+02

Table 6.2-1 Mean BMF Calculated by Alternate Methods[1]

Trophic Box	BMF by the Army Calibration Procedure	BMF_{obs} by the Shell Collocated Distributions Approach	BMF_{obs} by the (EPA) Modified Paired Data Approach
	Mean BMF	Mean BMF	Mean BMF
Endrin			
Soil	1	1	1
Terrestrial Plant	1.4E-01	2.1E-01	1.3E+00
Worm	4.0E-01	2.4E-01	1.1E+00
Insect	1.0E-01	5.3E-02	3.6E-01
Small Bird	1.1E-01	1.3E-01	9.1E-01
Small Mammal	1.7E-01	2.7E-01	1.5E+00
Medium Mammal	3.3E-02	3.6E-01	1.2E+00
Herptile	1.0E+00	9.0E-01	1.5E+00
Kestrel	1.9E-01	2.6E-01	1.3E+00
Owl	8.8E-02	4.0E-01	1.4E+00
Shorebird	9.9E-01	6.0E-01	1.1E+00
Heron	1.1E-01	1.0E-01	1.6E-01
Eagle	6.7E-02	4.0E-01	1.3E+00
Mercury			
Soil	1	1	1
Terrestrial Plant	3.5E-02	1.6E-01	3.1E-01
Worm	6.2E-01	4.0E-01	8.1E-00
Insect	1.1E-02	1.3E-01	2.7E-01
Small Bird	1.1E-01	1.9E-01	3.4E-01
Small Mammal	5.5E-01	1.5E-02	1.7E-01
Medium Mammal	2.8E-01	3.3E-01	7.3E+00
Herptile	6.0E-01	7.8E-01	8.2E-01
Kestrel	3.2E-01	6.8E-02	1.8E-01
Owl	2.6E-01	2.4E-01	4.8E+00
Shorebird	1.2E+0	1.6E-01	1.8E-02
Heron	6.8E-01	7.2E-01	7.6E-01
Eagle	2.3E-01	2.6E-01	5.4E+00

[1] For the three BMF_{obs} methods, kestrel, owl, heron, and eagle BMFs were calculated with the food-web model because there are no available field data. For these four trophic boxes:

$BMF_{obs(k)} = BAF_{lit(k)} * SUM_{(j)(FR(k,j)} * BMF_{obs(j)}$

where:
$BMF_{obs(k)}$ is the BMF for predator trophic box k
$BAF_{lit(k)}$ is the literature-derived BAF distribution for trophic box k
$SUM_{(j)}$ is the summation function over the argument j
$FR_{(k,j)}$ is the mass fraction of predator k's food from prey trophic box j
$BMF_{obs(j)}$ is the BMF for prey trophic box j

Biota	Chemical	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.	End Point
Parameter = Bioaccumulation Factor (BAF)							
Small Bird	Aldrin/Dieldrin	Normal	6.6	1.8			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Small Mammal	Aldrin/Dieldrin	Uniform	NA	NA			0.64, 1.6
	Endrin	Lognormal	0.08	1.0	-2.526	0.001	
	DDE/DDT	Uniform	NA	NA			0.44, 0.98
	Arsenic	Lognormal	0.19	4.7	-1.684	1.543	
	Mercury	Triangular	22.5	NA			0.001, 50
Medium Mammal	Aldrin/Dieldrin	Uniform	NA	NA			0.64, 3.2
	Endrin	Lognormal	0.16	1.1	-1.833	0.095	
	DDE/DDT	Uniform	NA	NA			0.44, 0.98
	Arsenic	Lognormal	0.19	4.7	-1.684	1.543	
	Mercury	Triangular	22.5	NA			0.001, 50
Water Bird	Aldrin/Dieldrin	Normal	16	5.1			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Normal	96	26.2			
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Lognormal	4.1	3.4	1.411	1.224	
Kestrel	Aldrin/Dieldrin	Normal	10.5	1.2			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Owl	Aldrin/Dieldrin	Normal	21.1	3.4			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Lognormal	43.7	2.4	3.777	0.875	
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Shorebird	Aldrin/Dieldrin	Normal	13.3	4.2			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Heron	Aldrin/Dieldrin	Normal	16	5.1			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Normal	93.5	20			
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Lognormal	4.1	3.4	1.411	1.224	

Biota	Chemical	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.	End Point
Parameter = Bioaccumulation Factor (BAF)							
Bald Eagle	Aldrin/Dieldrin	Normal	15.9	3.9			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Lognormal	27.1	2.4	3.300	0.875	
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2

* Mean = arithmetic mean for normal distribution, geometric mean for lognormal distribution, and apex for triangular distribribution

Predator	Prey Item	Biomass Fraction*
Parameter = Dietary Fractions (FR)		
Terrestrial Food Chain		
Small Birds	Soil	0.057
	Terrestrial Plants	0.113
	Earthworm	0.116
	Insect	0.714
Small Mammals	Soil	0.020
	Terrestrial Plants	0.866
	Earthworm	0.008
	Insect	0.106
Medium Mammal	Soil	0.074
	Terrestrial Plants	0.926
	Insect	0.000
Kestrel	Soil	0.029
	Insect	0.184
	Small Mammal	0.665
	Small Bird	0.122
Owl	Soil	0.029
	Small Mammal	0.121
	Medium Mammal	0.830
	Small Bird	0.020
Heron	Soil	0.036
	Reptile	0.060
	Small Mammal	0.013
	Water	0.071
	Aquatic Plant	0.000
	Aquatic Invertebrates	0.024
	Small Fish	0.186
	Large Fish	0.604
	Amphibian	0.006
Bald Eagle	Soil	0.029
	Small Mammal	0.000
	Medium Mammal	0.936
	Small Bird	0.003
	Waterbird	0.030
	Large Fish	0.002
Aquatic Food Chain		
Water bird	Water	0.019
	Sediment	0.038
	Aquatic Plant	0.942
	Aquatic Invertebrates	0.001

Predator	Prey Item	Biomass Fraction*
Shorebird	Terrestrial Plants	0.007
	Insect	0.728
	Sediment	0.160
	Aquatic Invertebrates	0.105

* Fractions reported as zero are pathways considered to be relatively inconsequential to model output due to their small values.

Biota	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.
Parameter = Feed Rate (R)	kg/kg body weight/day				
Water Bird	Normal	0.07602	0.0245		
Small Bird	Fixed	0.0879			
Small Mammal	Fixed	0.12			
Medium Mammal	Fixed	0.096			
Shorebird	Lognormal	0.0879	1.652	-2.4315	0.50189
Kestrel	Normal	0.08913	0.02689		
Owl	Normal	0.08913	0.02689		
Heron	Normal	0.08913	0.02689		
Bald Eagle	Normal	0.08913	0.02689		

* Mean = Arithmetic mean for normal distribution, geometric mean for lognormal distribution, and apex for triangular distribribution.

Biota	Chemical	Distribution	Value
Parameter = Maximum Allowable Tissue Concentration (MATC)			
Small Bird	Aldrin/Dieldrin	Fixed	0.15
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	0.14
	Mercury	Fixed	0.017
Small Mammal	Aldrin/Dieldrin	Fixed	0.19
	Endrin	Fixed	NA
	DDE/DDT	Fixed	0.22
	Mercury	Fixed	NA
Medium Mammal	Aldrin/Dieldrin	Fixed	0.19
	Endrin	Fixed	NA
	DDE/DDT	Fixed	0.22
	Mercury	Fixed	NA
Reptile	Aldrin/Dieldrin	Fixed	NA
	Endrin	Fixed	NA
	DDE/DDT	Fixed	NA
	Mercury	Fixed	NA
Kestrel	Aldrin/Dieldrin	Fixed	0.73
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	4.3
	Mercury	Fixed	0.017
Owl	Aldrin/Dieldrin	Fixed	0.76
	Endrin	Fixed	0.087
	DDE/DDT	Fixed	0.53
	Mercury	Fixed	0.017
Water bird	Aldrin/Dieldrin	Fixed	0.24
	Endrin	Fixed	0.09
	DDE/DDT	Fixed	0.18
	Mercury	Fixed	0.01
Shorebird	Aldrin/Dieldrin	Fixed	0.15
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	1.4
	Mercury	Fixed	0.011
Heron	Aldrin/Dieldrin	Fixed	0.87
	Endrin	Fixed	0.043
	DDE/DDT	Fixed	15
	Mercury	Fixed	0.011
Bald Eagle	Aldrin/Dieldrin	Fixed	0.41
	Endrin	Fixed	0.031
	DDE/DDT	Fixed	2.2
	Mercury	Fixed	0.0083

Biota	Chemical	Distribution	Value
Parameter = Toxicity Reference Values (TRV)			
Terrestrial Plant	Arsenic	Fixed	1.9
Small Bird	Aldrin/Dieldrin	Fixed	0.028
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.003
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Small Mammal	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.010
	DDE/DDT	Fixed	0.029
	Mercury	Fixed	0.0014
	Arsenic	Fixed	0.038
	Copper	Fixed	0.75
	Cadmium	Fixed	0.045
	DCPD	Fixed	2.8
	Chlordane	Fixed	0.10
	CPMS	Fixed	0.24
	$CPMSO_2$	Fixed	0.27
	DBCP	Fixed	0.05
Medium Mammal	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.010
	DDE/DDT	Fixed	0.029
	Mercury	Fixed	0.0014
	Arsenic	Fixed	0.038
	Copper	Fixed	0.75
	Cadmium	Fixed	0.045
	DCPD	Fixed	2.8
	Chlordane	Fixed	0.10
	CPMS	Fixed	0.24
	$CPMSO_2$	Fixed	0.27
	DBCP	Fixed	0.05

NA Data not available to calculate a TRV.

Biota	Chemical	Distribution	Value
Kestrel	Aldrin/Dieldrin	Fixed	0.01
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.04
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Owl	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.008
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Water brid	Aldrin/Dieldrin	Fixed	0.027
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.004
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	3.2
	Chlordane	Fixed	3.1
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Shorebird	Aldrin/Dieldrin	Fixed	0.022
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.008
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA

Biota	Chemical	Distribution	Value
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Heron	Aldrin/Dieldrin	Fixed	0.03
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.004
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Bald Eagle	Aldrin/Dieldrin	Fixed	0.002
	Endrin	Fixed	0.001
	DDE/DDT	Fixed	0.005
	Mercury	Fixed	0.00063
	Arsenic	Fixed	0.19
	Copper	Fixed	0.48
	Cadmium	Fixed	0.10
	DCPD	Fixed	5.3
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17

NA Data not available to calculate a TRV.

Table 6.2-3 Uncertainty Factor Protocol

Basis for Uncertainty	Uncertainty Value Assigned	
Intertaxon Variability Extrapolation Category—		
Same species	1	
Same genus, different species	2	
Same family, different genus	3	
Same order, different family	4	
Same class, different order	5	
Study Duration Extrapolation Category—		
Chronic studies where contaminants attained equilibrium	1	
Chronic studies where equilibrium not attained or possibly not attained, including subchronic studies	5	
Acute studies	20	
Study Endpoint Extrapolation Category—		
	Nonlethal	Lethal
No observed effects level	NOEL: 1	NOEL: 3
No observed adverse effects level	NOAEL: 1	NOAEL: 3
Lowest observed effects level	LOEL: 3	LOEL: 10
Lowest observed adverse effects level	LOAEL: 5	LOAEL: 10
Frank effects level	FEL: 10	FEL: 15
Modifying Factor Category—		
Threatened and endangered species	0 or 2	
Relevance of endpoint to ecological health	-1 to 0	
Extrapolating lab to field	0 to 2	
Study had co-contaminants	-1 to +1	
Endpoint was unclear	-2 to +2	
Study species was obviously highly sensitive	-2 to +2	
Ratios used to get from organ or egg to whole body	0 to 2[1]	
Intraspecific variability	0 to 2	

[1] Used only for MATC (not TRV) uncertainty factor development.

Table 6.2-4 Toxicity Threshold Values Selected for Representative Receptors (Trophic Boxes)[1, 2, 3]

Chemical	American Kestrel MATC	American Kestrel TRV	Bald Eagle MATC	Bald Eagle TRV	Great Horned Owl MATC	Great Horned Owl TRV	Great Blue Heron MATC	Great Blue Heron TRV	Shorebird MATC	Shorebird TRV	Water Bird MATC	Water Bird TRV	Small Bird MATC	Small Bird TRV	Small Mammal MATC	Small Mammal TRV	Medium Mammal MATC	Medium Mammal TRV	Reptile MATC	Reptile TRV	Terrestrial Plant MATC	Terrestrial Plant TRV
Aldrin/ Dieldrin	0.73	**0.01**	0.41	**0.002**	0.76	**0.004**	**0.87**	0.027	0.15	**0.022**	**0.24**	0.027	0.15	**0.028**	0.19	**0.004**	0.19	**0.004**		NA		
DDT/DDE	**4.27**	0.04	**2.17**	0.005	**0.53**	0.008	**15**	0.004	**1.38**	0.008	**0.18**	0.004	0.14	**0.003**	0.22	**0.029**	0.22	**0.029**		NA		
Endrin	**0.05**	0.002	**0.03**	0.001	**0.09**	0.003	**0.09**	0.003	**0.05**	0.002	0.09	**0.003**	**0.05**	0.002	NA	**0.01**	NA	**0.01**		NA		
Mercury	0.02	**0.002**	0.01	**0.001**	0.02	**0.002**	0.01	**0.001**	0.01	**0.001**	**0.01**	0.001	0.02	**0.002**	NA	**0.001**		**0.001**		NA		
Arsenic		0.378		0.189		0.378		0.378		0.378		0.378		0.378		0.038		0.038		NA		1.9
Copper		0.96		0.48		0.96		0.96		0.96		0.96		0.96		0.75		0.75		NA		
Cadmium		0.24		0.103		0.24		0.24		0.24		0.24		0.24		0.045		0.045		NA		
DCPD		8.889		5.333		8.889		8.889		8.889		3.2		8.889		2.833		2.833		NA		
Chlordane		0.035		0.035		0.035		0.035		0.035		3.125		0.035		0.1		0.1		NA		
CPMS		ND		ND		ND		ND		ND		ND		ND		0.235		0.235		NA		
$CPMSO_2$		ND		ND		ND		ND		ND		ND		ND		0.272		0.272		NA		
DBCP		0.167		0.167		0.167		0.167		0.167		0.167		0.167		0.05		0.05		NA		

[1] Values shown in bold face were selected for use in the estimation of potential risk based on their total uncertainty and whether or not use of a BAF was necessary.

[2] Tissue-based approach was used for calculation of risk from mercury to shorebird from aquatic food chains; other trophic boxes with mixed food chains (bald eagle and great blue heron) used the same approach for aquatic and terrestrial food chains.

[3] MATC values are presented in mg/kg, and TRVs are presented in mg/kg-bw-day.

Table 6.2-5 Toxicity Reference Value (Post-UF)[1]

Aldrin/Dieldrin	Critical Value	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor[2] (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	0.04	1	1	1	4			1		2		1
Bald Eagle	0.05	5	1	1	6	2		1	0	2		1
Great Horned Owl	0.06	4	1	1	4			1	0	2		1
Great Blue Heron	0.4	5	1	3	1		-1	1				1
Shorebird	0.22	5	1	1	2			1				1
Waterbird	0.4	5	1	3	1		-1	1				1
Small Bird	0.28	5	1	1	2			1				1
Sm. Mammal	0.06	4	1	1	4			2		1		1
Med. Mammal	0.06	4	1	1	4			2		1		1
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	4	0.010
Bald Eagle	30	0.002
Great Horned Owl	16	0.004
Great Blue Heron	15	0.027
Shorebird	10	0.022
Waterbird	15	0.027
Small Bird	10	0.028
Sm. Mammal	16	0.004
Med. Mammal	16	0.004
Reptile	NA	NA

1 Values reported as mg/kg bw.
2 If $0 \leq U < 1$, it was replaced with 1; if $U < 0$, it was replaced with 0.5.
Final TRV Critical value/total UF
NA Not Available
Total UF 1*Q2*Q3*U
TRV Toxicity Reference Value
U Sum of factors to right
UF Uncertainty Factor

Table 6.2-6 Post-Uncertainty MATC[1]

Aldrin/Dieldrin	Critical Value	Intertaxon (1)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor[2] (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Tissue to Whole-Body Ratio	Intraspecific Variability
American Kestrel	2.9	1	1	1	4			1		2			1
Bald Eagle	12.2	5	1	1	6	2		1		2			1
Great Horned Owl	12.2	4	1	1	4			1		2			1
Great Blue Heron	1.3	1	1	3	0.5			0	-1				0
Shorebird	2.9	5	1	1	4			1		2			1
Waterbird	7.1	5	1	3	2		-1	1				1	1
Small Bird	2.9	5	1	1	4			1		2			1
Mammal	4.5	4	1	1	6			2		2		1	1

Trophic Box	Total UF	Final MATC
American Kestrel	4	0.73
Bald Eagle	30	0.41
Great Horned Owl	16	0.76
Great Blue Heron	1.5	0.87
Shorebird	20	0.15
Waterbird	30	0.24
Small Bird	20	0.15
Mammal	24	0.19

[1] Values reported as mg/kg bw.
[2] If $0 \leq U < 1$, it was replaced with 1; if $U < 0$, it was replaced with 0.5.
Total UF 1*Q2*Q3*U
U Sum of factors to right
Final TRV Critical value/total UF

Table 6.2-7 HQs and HIs for Exposure through Aquatic Food Chains

Trophic Box	Hazard Quotients for Aldrin/Dieldrin	Hazard Quotients for DDT/DDE	Hazard Quotients for Endrin	Hazard Quotients for Mercury	Hazard Index
Water bird	2.87	1.66	0.63	6.75	11.91
Shorebird	0.19	2.60	1.17	8.30	12.26
Great Blue Heron	2.28	1.06	0.63	15.63	19.60
Bald Eagle	0.93	0.17	0.03	0.21	1.34

Table 6.3-1 Uncertainties Potentially Influencing Assigned Distributions for Soil Intake Parameters

Soil Covering		Soil Ingestion		Dust Loading	
Population and Age Class	Uncertainties	Population and Age Class	Uncertainties	Population and Age Class	Uncertainties
Regulated/Casual Visitor 0 to < 1	• Judgment distribution	Regulated/Casual Visitor 0 to < 1	• Assumed minimal (1 mg/day)	Regulated/Casual and Recreational Visitor All Ages	• Assumed outdoor ambient exposure • Representation of activities by ambient outdoor dust loading conditions • Data measurement error
1 to < 7	• Data measurement error • Extrapolation of sample patch to entire surface area • Data representation of age distribution and activities	1 to < 7	• Judgment 95th percentile (EPA default) • Data median (literature) • Data measurement error • Data representation of age and activities		
7 to < 18	• Data measurement error • Extrapolation of sample patch to entire surface area • Data representation of age and activities	7 to < 75	• Judgment 95th percentile (EPA default) • Shape extrapolated from literature distribution for child		

Table 6.3-1 Uncertainties Potentially Influencing Assigned Distributions for Soil Intake Parameters

Soil Covering		Soil Ingestion		Dust Loading	
Population and Age Class	Uncertainties	Population and Age Class	Uncertainties	Population and Age Class	Uncertainties
18 to < 75	• Data measurement error • Extrapolation of sample patch to entire surface area • Data representation of age and activities				
Recreational Visitor 0 to < 1	• Judgment distribution	0 to < 1	• Assumed minimal (1 mg/day)		
1 to < 7	• Data measurement error • Extrapolation of sample patch to entire surface area • Data representation of age and activities	1 to < 7	• Judgment 95th percentile (EPA default) • Data median (literature) • Data measurement error • Data representation of age and activities		

Table 6.3-1 Uncertainties Potentially Influencing Assigned Distributions for Soil Intake Parameters

Soil Covering		Soil Ingestion		Dust Loading	
Population and Age Class	Uncertainties	Population and Age Class	Uncertainties	Population and Age Class	Uncertainties
7 to < 18	• Data measurement error • Extrapolation of sample patch to entire surface area (data representativeness) • Representation of age and activities (study representativeness)	7 to < 75	• Judgment 95th percentile (EPA default) • Shape extrapolated from literature distribution (child)		
18 to < 75	• Data measurement error • Extrapolation of sample patch to entire surface area (data representativeness) • Representation of age and activities (study representativeness)				

Table 6.3-1 Uncertainties Potentially Influencing Assigned Distributions for Soil Intake Parameters

Soil Covering		Soil Ingestion		Dust Loading	
Population and Age Class	Uncertainties	Population and Age Class	Uncertainties	Population and Age Class	Uncertainties
Commercial Worker	• Theoretical estimate of mean, judgment range	Commercial Worker	• Judgment 50th and 95th percentile	Commercial Worker	• Assumed indoor exposure • Dust loading data measurement error • Outdoor/indoor attenuation data measurement error
Industrial Worker	• Judgment 95th percentile (EPA default) • Distribution shape extrapolated from biological/ maintenance worker	Industrial Worker	• Judgment 95th percentile • Shape extrapolated from literature distribution (child)	Industrial Worker	• Assumed ambient outdoor exposure • Representation of activities by ambient conditions • Data measurement error
Biological/ Maintenance Worker	• Data representation of time spent in activities • Data representation of soil covering to projected activities • Judgment estimate of indoor soil covering distribution	Biological Worker	• Data representation of time spent in activities • Judgment based activity specific distributions	Biological Worker	• Data representation of time spent in activities

Table 6.3-2 Uncertainties Potentially Influencing Assigned Distributions for Time-Dependent Exposure Parameters

Population	TM (Hours/Day)	DW (Days/Year)	TE (Years/Lifetime)
Regulated/Casual Visitor	• Representativeness of chosen activities for neighborhood population • Representativeness of data-based mean for activity-specific distributions • Judgment-based distribution shape • Representativeness of participation rate in multiple daily activities • Representativeness of national means for percent participation in each activity and duration of each activity	• No data specific to visitation of RMA neighborhood subpopulation • Intentional conservative estimation bias • Judgment-based distribution for number of activity days/year • Judgment-based distribution for fraction of activity days occurring at RMA	• Representativeness of PSCo data for neighborhood subpopulation (PSCo 1989) • Positive bias (overestimation) due to analysis method, which under-represents low TE values in population • Negative bias (underestimation) due to moves within same county
Recreational Visitor	• Representativeness of chosen activities for neighborhood population • Representativeness of data-based mean for activity-specific distributions • Judgment-based distribution shape • Representativeness of participation rate in multiple daily activities • Representativeness of national means for percent participation in each activity and duration of each activity	• Intentional conservative estimation bias • Representativeness of chosen activities for neighborhood subpopulation • Representativeness of western region and national means for percent participation in activity • Representativeness of national distribution of number of jogging days per week and assumption of 52 weeks per year for neighborhood subpopulation • Judgment-based distribution for number of activity days/year for some activity-specific distributions • Judgment-based distribution for fraction of activity days occurring at RMA	• Representativeness of PSCo data for neighborhood subpopulation (PSCo 1989) • Positive bias (overestimation) due to analysis method, which under-represents low TE values in subpopulation • Negative bias (underestimation) due to moves within same county
Commercial/Industrial Worker	• Representativeness of national data on hours spent at work	• Incorporation of judgment estimates for vacation time and holidays • Representativeness of western region data on job absence rates (BNA 1974–90)	• Representativeness of Mountain States Employer's Council mean job turnover data used to obtain distribution mean (MSEC 1981–90) • Representativeness of national data on occupational turnover used to obtain distribution shape

Table 6.3-2 Uncertainties Potentially Influencing Assigned Distributions for Time-Dependent Exposure Parameters

Population	TM (Hours/Day)	DW (Days/Year)	TE (Years/Lifetime)
Biological Worker	• Representativeness of on-site work schedule of interviewed personnel at three refuges	• Representativeness of on-site work schedule of interviewed personnel at three refuges	• Representativeness of job tenure history of interviewed personnel at three refuges (Bureau of the Census 1987) • Censored data (current tenure was longer than reported at time of survey)

Table 6.3-3 Uncertainties Potentially Influencing Assigned Distributions for Chemical-Specific Parameters[1]

Henry's Law Constant (K_H)[2]		Soil to Water Partition Coefficient Normalized to Organic Carbon K_{oc} (Kd)[3]		Vapor Pressure (V_P)[2]	
Chemical Group	Uncertainties	Chemical Group	Uncertainties	Chemical Group	Uncertainties
Aldrin Endrin 1,1,2,2-Tetrachloroethane DDT DDE Chlordane HCCPD	• Representation of RMA temperature regime • Experimental measurement error • $\leq$ 6 data points	Aldrin Endrin 1,2-Dichloroethane Methylene Chloride	• Experimental measurement error • $\leq$ 6 data points	Endrin Chlorobenzene Chlordane	• Experimental measurement error • Representation of RMA temperature regime • $\leq$ 6 data points
Isodrin	• Representation of RMA temperature regime • Experimental measurement error • No data, extrapolation across chemicals	Isodrin 1,1-Dichloroethylene HCCPD DCPD DBCP	• Experimental measurement error • $\leq$ 2 data points • Extrapolation across chemicals	1,1-Dichloroethylene 1,1,2,2-Tetrachloroethane DDE HCCPD	• Experimental measurement error • Representation of RMA temperature regime • $\leq$ 6 data points • Intentional conservative bias in estimation of SD
DCPD DBCP Chloroacetic Acid	• Representation of RMA temperature regime • Experimental measurement error • No data, extrapolation based on vapor pressure and solubility	Chloroacetic Acid	• $\leq$ 2 data points • Extrapolation from other partitioning information	Isodrin Chloroacetic DCPD DBCP	• Experimental measurement error • Representation of RMA temperature regime • 2 data points • Judgment range

Table 6.3-3 Uncertainties Potentially Influencing Assigned Distributions for Chemical-Specific Parameters[1]

Henry's Law Constant (K_H)[2]		Soil to Water Partition Coefficient Normalized to Organic Carbon K_{oc} (Kd)[3]		Vapor Pressure (V_P)[2]	
Chemical Group	Uncertainties	Chemical Group	Uncertainties	Chemical Group	Uncertainties
Dieldrin Toluene Benzene Chloroform 1,2-Dichloroethane 1,1-Dichloroethylene Methylene Chloride Carbon Tetrachloride Tetrachloroethylene Chlorobenzene TCE	• Representation of RMA temperature regime • Experimental measurement error	Dieldrin Toluene Benzene Chloroform Carbon Tetrachloride 1,1,2,2-Tetrachloroethane Tetrachloroethylene Chlorobenzene TCE DDT DDE Chlordane Arsenic* Cadmium* Chromium* Lead* Mercury*	• Experimental measurement error	Aldrin Dieldrin Toluene Benzene Chloroform 1,2-Dichloroethane Methylene Chloride Carbon Tetrachloride Tetrachloroethylene TCE DDT	• Experimental measurement error • Representation of RMA temperature regime

[1] See IEA/RC report (Appendix E) for discussion of types of uncertainties.
[2] K_H^2 and V_P^2 not defined for metals.
[3] Kd (distribution coefficient) used for organic COCs lacking K_{oc} data.

7.0 Description of the Feasibility Study Process and the Remedial Alternatives Developed

7.1 Summary of the Feasibility Study Process

The FS process involved two major phases: the Development and Screening of Alternatives and the Detailed Analysis of Alternatives. Each contaminated environment at RMA (water, structures, and soil) was subdivided into several medium groups of similarly contaminated groundwater plumes, structures, or soil sites to organize and streamline the FS process.

At the outset of the Development and Screening of Alternatives, Remedial Action Objectives (RAOs) were identified. These goals provide general guidance for the FS by identifying the contaminants and media of interest, potential exposure pathways, and preliminary remediation goals. For the On-Post Operable Unit, RAOs were developed for water, structures, and soil based on the results of the IEA/RC, an evaluation of ARARs specified in federal and state environmental laws and regulations, and the provisions of the FFA. (ARARs are listed in Appendix A.) The human health and biota remediation goals are to achieve appropriate remediation such that the selected remedy is protective of both humans and biota.

During the Development and Screening of Alternatives, a wide range of alternatives was evaluated for each medium group with respect to effectiveness, implementability, and cost. Those alternatives retained for further consideration were evaluated during the Detailed Analysis of Alternatives against a set of threshold and primary balancing criteria defined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (see Section 8). Also taken into account were RMA-specific considerations such as Army safety procedures and USFWS guidance regarding the future use of the site as a national wildlife refuge.

A range of alternatives including no action, institutional controls, containment, and treatment options was developed for each of the water, structures, and soil medium groups. The No Action alternative (as required by EPA) and the No Additional Action alternative were also developed and used as a baseline against which other alternatives were evaluated. The No Action alternative represents current site conditions with no remedial actions undertaken, ongoing, or planned and IRAs discontinued. The No Additional Action alternative involves no action beyond the IRAs currently being implemented on post.

Once the alternatives for each group were evaluated with respect to the seven threshold and primary balancing criteria, the comparative performance of each alternative was evaluated and a range of alternatives was retained for each medium group/subgroup to use in the development of sitewide alternatives. Tables 7.1-1, 7.1-2, and 7.1-3 present descriptions of all individual technologies used to develop the respective sitewide alternatives for the water, structures, and soil medium groups. It should be noted that the No Action and No Additional Action alternatives

were developed for each contaminated medium, but were eliminated from consideration during the comparative analysis conducted for sitewide alternatives because they were not sufficiently protective.

All of the alternatives that were identified have several features in common as follows:

- Land-Use Restrictions – The Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 restricts current and future land use, specifies that the U.S. government shall retain ownership of RMA, and prohibits certain activities such as agriculture, use of on-post groundwater as a drinking source, and consumption of fish and game taken at RMA. Continued restriction on land use or access are included as an integral component of all on-post alternatives. Long-term management includes access restrictions to capped and covered areas to ensure the integrity of the containment systems.
- Five-Year Review – In accordance with CERCLA, a review will be performed a minimum of every 5 years after initiation of remedial action to ensure that the various remedial actions where contamination continues to exist, such as the capped areas or the hazardous waste landfill, remain protective of human health and the environment and comply with ARARs.
- Site Monitoring – The Army will continue to conduct air, groundwater, and surface water monitoring programs at RMA, and will continue to fund USFWS to conduct on-post wildlife monitoring programs. Samples will be collected periodically to assess the effectiveness of the remedy for protection of human health and the environment. The actual compliance monitoring program for each of the environmental media will be finalized during the remedial design.
- Revegetation – Any time vegetation is disturbed during remedial construction, the disturbed areas will be revegetated consistent with a USFWS refuge management plan.
- Long-Term Operation and Maintenance – Areas that are remediated will be operated and maintained as required. Management activities may include maintaining capped and covered areas or operating the on-post hazardous waste landfill or groundwater treatment systems.
- On-Post Water Supply – A sufficient on-post water supply will be maintained to support remedial actions (revegetation, habitat enhancement, maintenance of lake levels).

7.1.1 Area of Contamination

An AOC is defined by EPA (OSWER-EPA 1989b) as the areal extent (or boundary) of contiguous contamination. Such contamination must be continuous, but may contain varying types and concentrations of hazardous substances. For on-site disposal, placement occurs when wastes are moved from one AOC into another AOC. Placement does not occur when wastes are left in place or moved within a single AOC.

Placement does not occur when wastes are:

- Treated in situ
- Capped in place
- Consolidated within the AOC
- Processed within the AOC (but not in a separate unit, such as a tank) to improve its structural stability (e.g., for capping or to support heavy machinery

Placement does occur when wastes are:

- Consolidated from different AOCs into a single AOC

- Moved outside of an AOC (e.g., for treatment or storage) and returned to the same or a different AOC
- Excavated from an AOC, placed in a separate unit, such as an incinerator or tank that is within the AOC, and redeposited into the same AOC

If placement does not occur, land disposal restrictions (LDRs) are not applicable to the Superfund action. Correspondingly, if placement on site does occur, LDRs would be applicable to the Superfund action.

At RMA, an AOC was defined that encompasses all principal threat exceedance areas, the majority of human health exceedance areas, and wildlife risk areas defined by the study area that is the subject of the SFS. The boundaries of the AOC are shown on Figure 7.1-1.

7.1.2 Corrective Action Management Unit

Several of the proposed alternatives for the On-Post Operable Unit include the construction and operation of a new on-post hazardous waste landfill for disposal of principal threat and human health exceedance soil and debris as defined in the Detailed Analysis of Alternatives report. Some of this material is RCRA-listed or potentially RCRA-characteristic hazardous waste (based on TCLP). Therefore, during the development of the Detailed Analysis of Alternatives, it was determined that a Corrective Action Management Unit (CAMU) would be required (EPA 1993). The CAMU will incorporate a future hazardous waste landfill, a Basin F Wastepile drying unit, and an appropriate waste staging and/or management area(s). The CAMU was designated by CDPHE under authority of and in accordance with CHWMA. The CAMU designation provides for landfilling of hazardous wastes and movement of waste into the CAMU from anywhere on post, within or outside the AOC, including treatment units. This ROD also provides for use of the CAMU rule as an ARAR for several remedial alternatives (see Appendix A).

The basis for designation of a CAMU and the requirements for the CAMU that are to be specified as part of the designation are provided in 6 CCR 1007-3, Section 264.552. In addition, Section 264.552(a)(3) specifies that where remediation waste placed into a CAMU is hazardous waste, the CAMU shall comply with Part 265, Subparts B, C, D, and E of 6 CCR 1007-3 (Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities [TSDFs]). When such remediation wastes are to remain in place after closure, Section 264.552(a)(3) also requires compliance with the siting requirements for hazardous waste disposal sites (6 CCR 1007-2, Part 2). The new hazardous waste landfill is the only facility within the CAMU to which these siting requirements apply; however, the CAMU may include additional areas as necessary to implement other actions.

A draft CAMU Designation Document (CDD) was submitted to CDPHE on January 12, 1996. It was resubmitted with additional information on March 15, 1996 and was followed by a public comment period. A public hearing was held April 17, 1996, and the comment period closed May 20, 1996. The CDD contains a discussion of the

guidelines to be used for the designation of the RMA CAMU as well as a discussion of the operational, monitoring, closure, and post-closure guidelines that will be implemented following designation of the CAMU.

The following decision-making criteria were addressed in designating the CAMU:

- Facilitation of the remedy
- Risks to human health and the environment
- Justification of inclusion of uncontaminated area
- Containment of remediation waste remaining after closure
- Expeditious timing of remedial activity implementation
- Application of treatment technologies
- Minimization of land area where wastes remain in place

CDPHE designated the CAMU by way of the final CDD (Harding Lawson Associates 1996) and a Corrective Action Order. The CAMU boundaries are shown in Figure 7.1-1.

7.1.3 Development of Criteria for Evaluating Soil Contamination

The NCP (EPA 1990a) indicates that acceptable exposure levels for suspected carcinogens are "generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}" and that the 10^{-6} level shall be used as the point of departure for determining remediation goals. EPA (OSWER-EPA 1991b) indicates that action generally is not warranted for sites with additive excess cancer risks less than 10^{-4} and an HI less than 1.0 for noncarcinogenic contaminants. Therefore, the human health SEC for contaminated soil were defined as the additive excess cancer risks of COCs equal to 10^{-4} and/or additive noncarcinogenic HIs equal to 1.0. The boring-by-boring analysis was used to identify the areas of each site, if any, that exceeded the human health SEC and were therefore candidates for remediation. Sites with contaminant concentrations that result in exceedances of these criteria are termed exceedance sites, and their contaminants and resultant volumes are referred to as exceedance COCs and exceedance volumes. Table 7.1-4 presents the human health SEC, which are based on a 10^{-4} cumulative excess cancer risk and noncarcinogenic HI of 1.0 (the criteria ultimately selected in the Detailed Analysis of Alternatives). The human health SEC are based on the lower of the industrial or biological worker PPLVs for each COC. Acute risk criteria were used as human health SEC where they were lower than the corresponding chronic risk human health SEC.

The NCP (EPA 1990a) and EPA guidance documents also develop the concept of a principal threat. Although EPA guidance allows for considerable interpretation in identifying specific sites or areas as principal threats, the EPA fact sheet "Guide to Principal Threat and Low-Level Threat Wastes" (OERR-EPA 1991) provides the following general definition of principal threats:

> ...those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. They include

> liquids or other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat." However, where toxicity and mobility of source material combine to pose a potential [excess] cancer risk of 10^{-3} or greater, generally treatment alternatives should be evaluated.

In addition, the guidance includes a determination as to whether a source material is a principal threat waste:

> ...should be based on the inherent toxicity as well as a consideration of the physical state of the material (e.g., liquid), the potential mobility of the wastes in the particular environmental setting, and the liability and degradation products of the material. However, this concept of principal threat waste should not necessarily be equated with risks posed by site contaminants via various exposure pathways.

Principal threats, as defined in EPA's "Guide to Selecting Superfund Remedial Actions" (1990b), include the following:

- Areas contaminated with relatively high concentrations of toxic compounds
- Liquids and other highly mobile materials
- Contaminated media (e.g., sediment or soil) that pose a significant risk of excessive exposure
- Media containing contaminants several orders of magnitude above health-based levels

The objective of identifying the principal threat wastes is to focus the remediation on the areas of highest risk to human health and the environment. This focused approach is especially appropriate to RMA because many sites combine large areas of minimal or low-level contamination with small areas of high-level contamination that fall within the definition of principal threats being several orders of magnitude above health-based levels. Because 10^{-4} was set as the human health SEC, the principal threat criteria for RMA soil were established at a 10^{-3} excess cancer risk and a noncarcinogenic HI of 1,000. These criteria are listed by COC in Table 7.1-4. It should be noted and emphasized that the principal threat criteria are risk-management endpoints for use in directing and prioritizing remedial activities; only the SEC denote protective boundaries based on risks (with varying uncertainties) to health. The areas of RMA that exceed the human health SEC and principal threat criteria are shown in Figure 7.1-1.

7.1.4 Soil Volume Modeling and Estimation

Most of the soil alternatives that were evaluated make use of a volume or area estimate to accurately analyze the proposed remedial actions and to develop costs. These volume or area estimates were developed based on the above-described exceedance criteria.

Human health exceedance volume estimates were generated by one of two methods. The distribution of contaminants in some sites was modeled using a commercial software package (TECHBASE). A three-dimensional model, represented by an array of blocks, was created for each site and was bounded vertically by the ground-surface elevation at the time of sampling and depth of the water table (or to a maximum 10-ft depth based on the exposure assessment performed as part of the IEA/RC) and laterally by the site boundary as defined in the Remedial Investigation Summary Report. The modeling routine then searched within a defined volume (based on sample

distribution within the site) around each block and used a three-dimensional inverse distance squared algorithm to estimate contaminant concentrations in each block.

Modeled soil concentrations were compared to the human health SEC to identify blocks to be included in the human health exceedance volume for each site. Similarly, soil concentrations were compared to the principal threat criteria to identify blocks to be included in **principal threat exceedance** volume. Concentrations were evaluated to account for potential cumulative effects of multiple contaminants, and all soil located between ground surface and the deepest exceedance block was counted in the exceedance volume. Areas were estimated by projecting all exceedance blocks to the surface and contouring around the surface projection. Perimeters were also estimated from these projections.

Additional volumes and areas were calculated for sites not considered amenable to modeling. In general, if modeling was subject to great uncertainty due to the physical characteristics of a site, highly heterogeneous or uneven spatial contamination, or limited data availability, information from the Study Area Reports (as summarized in the Remedial Investigation Summary Report) was used for volume and area calculations. A boring-by-boring analysis was performed to identify individual sample exceedances, and depth and lateral extents were projected halfway to the next nonexceedance sample. Volumes and areas were calculated using physical dimensions as listed in the Study Area Reports and measured distances between exceedance and nonexceedance samples.

Biota exceedance volumes were developed based on the potential biota risk areas as identified through the risk assessment process described in Section 6.2. The volume was calculated by multiplying the potential risk area by 1 ft (depth). The potential risk area for a site is defined as the entire biota exceedance area within the boundaries of a site, less any human health exceedance area, to avoid double-counting of the volume.

Potential agent and UXO areas were determined from boundaries presented in the Remedial Investigation Summary Report. Potential volume was calculated using these areas and the depths presented in the Detailed Analysis of Alternatives report. The expected agent or UXO volume of soil reflects a 0.1 percent factor to estimate actual agent or UXO occurrence within the potential volume. In addition, UXO surface debris volume was calculated by multiplying the potential UXO area by 1 ft (depth); the result is considered the maximum potential debris volume. For each site, overlap between agent, UXO, or UXO debris volume and human health or biota volume was calculated. Exceedance volumes were adjusted to prevent double-counting of soil volumes. UXO debris volume may include human health and/or biota exceedance volume. Actual human health exceedance volume or biota exceedance volume would increase to the previously unadjusted volume if less than the maximum potential debris volume is encountered.

The volume and area estimates that resulted from these calculations represent the soil quantities used for all soil alternative detailing. Volume increases due to commonly used excavation practices (such as sidesloping, bottom leveling, and perimeter rounding), although expected to be small, were not included in these calculations. Table 7.1-5 lists human health, principal threat, excess biota, agent, UXO, and UXO debris volumes for each soil medium group, and Table 7.1-6 lists the corresponding areas for each soil medium group.

7.2 Remedial Alternatives for Groundwater

7.2.1 Description of Medium

As described in Section 5, contaminated groundwater plumes were detected primarily in the vicinity of the basins, North and South Plants, and the northern and western sections of RMA (Figure 5.4-3). Plumes are generally moving to the north and northwest. Groundwater contaminant plumes predominantly consist of organic compounds (solvents, chloroform, dieldrin, DIMP, DCPD, DBCP, and organosulfur compounds) and fluoride and chloride salts (Tables 5.4-1 through 5.4-5). The overall concentrations and configurations of the plumes suggest that the greatest contaminant releases to the UFS have occurred from Basin A and the Lime Settling Basins, the South Plants chemical sewer, South Plants Tank Farm and production area, the Army and Shell Trenches in Section 36, and the Former Basin F. Plumes emanating from the Motor Pool/Rail Yard and North Plants areas are other sources of contaminant releases to the UFS.

Four groundwater alternatives were developed based on the contaminant concentrations in the individual plumes and evaluated against the remedial alternative screening criteria (see Section 8). A range of alternatives was developed and analyzed for each plume group. These alternatives included no action, continued operation of existing systems, and groundwater extraction and treatment approaches. Alternatives selected for each plume group were combined into four sitewide alternatives that were evaluated and compared against the screening criteria. Groundwater flow modeling utilizing commercially available software (MODFLOW), as summarized in the South Plants/Basin A groundwater flow model report (Foster Wheeler Environmental 1995c), was conducted to assess flow patterns and estimate flow and extraction rates in the South Plants and Basin A areas.

7.2.2 Remedial Action Objectives

The following RAOs were established for on-post groundwater at RMA:

Human Health

- Ensure that the boundary containment and treatment systems protect groundwater quality off post by treating groundwater flowing off RMA to the specific remediation goals identified for each of the boundary systems.
- Develop on-post groundwater extraction/treatment alternatives that establish hydrologic conditions consistent with the preferred soil alternatives and also provide long-term improvement in the performance of the boundary control systems.

Ecological Protection

- Ensure that biota are not exposed to biota COCs in surface water in concentrations capable of causing acute or chronic toxicity.

7.2.3 Description of Sitewide Remedial Alternatives for Groundwater

Flow of surface water at RMA occurs through a network of streams, lakes, and canals, and flow of groundwater occurs within the alluvium and the uppermost weathered portion of the Denver Formation (UFS). Deeper water-bearing units within the Denver Formation (CFS) are separated from the UFS by low-permeability confining units. Depending on site-specific hydrological characteristics, varying degrees of hydraulic interchange are possible between surface water and groundwater and between the UFS and CFS. In general, analytical and hydraulic data indicate little hydraulic interchange between the UFS and CFS.

The following are considerations for all water alternatives:

- Chloride is expected to attenuate naturally at the NBCS, where it currently exceeds the remediation goal of 250 mg/l. It has been estimated that chloride concentrations will attenuate to concentrations less than the remediation goal at the north boundary within 30 years (MK 1996). Assessment of chloride concentrations will occur during the 5-year site reviews.
- The remediation goal of 540 mg/l for sulfate at the NBCS represents the natural background concentration. It is estimated that sulfate will attenuate to the remediation goal within approximately 25 years (MK 1996). Assessment of sulfate concentrations will occur during the 5-year site reviews.
- NDMA has been detected in the North Boundary Plume Group and at the NBCS. Monitoring for NDMA using a method detection limit of 20 parts per trillion (ppt) is ongoing. If the current monitoring program identifies an NDMA problem, potential design modifications (both on post and at the boundary or adjacent to the boundary) required to achieve the remediation goal at the RMA boundary will be prepared during the remedial design. Any upgrades required for existing treatment systems to address the remediation goal will be incorporated into the remedial actions.

7.2.3.1 Alternative 1 – Boundary Systems

Under Alternative 1, the three **boundary systems** all continue to operate and the systems installed as IRAs are discontinued. The boundary systems are the following:

- Northwest Boundary Containment System (NWBCS)
- North Boundary Containment System (NBCS)
- Irondale Containment System (ICS)

Each of the boundary systems includes groundwater extraction and reinjection systems and a treatment system that removes organic contaminants through carbon adsorption; the NWBCS and NBCS include **slurry walls** for containment and control of groundwater flow. The total amount of water currently treated at the boundary systems is about 1 billion gallons per year. Boundary systems will continue to operate as necessary to achieve remedial action objectives until remediation is complete, and the CERCLA Wastewater Treatment Plant continues to operate as needed to support remedial activities.

Under Alternative 1, the following IRAs are discontinued: the Basin F extraction system, the Basin A Neck extraction and treatment system (including breaching of the slurry wall to allow groundwater flow), the Rail Yard extraction system, and the Motor Pool extraction system. Monitoring of boundary system influent and effluent concentrations and groundwater monitoring continue. In addition, caps or covers installed in South Plants and Basin A as part of the soil remedy minimize infiltration of precipitation, thereby reducing contaminant migration through lowering of the water table (passive dewatering).

The components of this alternative are summarized in Table 7.2-1. The total estimated cost for this alternative (in 1995 dollars) is $111 million (present worth cost of $80 million). A breakdown of capital and operations and maintenance (O&M) costs is presented in Table 7.2-2. Operations are assumed to continue for at least 30 years.

The operation of each of the boundary systems is detailed below.

Northwest Boundary Containment System

Under Alternative 1, operation of the NWBCS for the Northwest Boundary Plume Group continues. The NWBCS is designed to capture and treat organic contaminants, primarily dieldrin, in groundwater approaching the northwest boundary. The NWBCS includes extraction wells, a slurry wall, reinjection wells, and a GAC adsorption system. When the system was constructed, a slurry wall was installed along the northwest boundary to minimize migration of the contaminated groundwater flowing across that boundary. This wall, constructed of soil/bentonite and originally measuring 1,425 ft long by 3 ft wide by approximately 30 ft deep, was subsequently extended by an additional 665 ft in the northeast direction to intercept groundwater flowing through the alluvial channel to the northeast. The slurry wall extension was keyed a minimum of 10 ft into the existing slurry wall and the extension ranged from 28 to 35 ft deep.

Five extraction wells were also added to the original system, two along the slurry wall, and three southwest of the system. Four reinjection wells were installed to the southeast of the newly installed extraction wells to maintain a separation between contaminants migrating to the north versus contaminants migrating to the northwest and to push groundwater toward the NWBCS along a small, localized groundwater divide. One additional extraction well was added to the southwest extension in early 1996 in response to hydrological changes associated with increased pumping rates in off-post SACWSD water supply wells and decreased infiltration rates at the Havana Ponds (south of Lake Mary and Lake Ladora in Section 11). The southwest extension currently extracts 425 gpm and reinjects approximately 230 gpm; the balance (195 gpm) is reinjected at the original NWBCS system. The rest of the NWBCS extracts and reinjects approximately 600 gpm and 795 gpm, respectively, for a total system flow of approximately 1,025 gpm.

Groundwater is pumped from the extraction wells to the influent sump adjacent to the treatment building. The treatment system consists of three identical GAC vessels, two of which are operated in parallel; the third is used as a

backup unit. Each vessel contains 40,000 lbs (1,400 cubic ft) of GAC, is operated in an upflow mode, and has a design capacity of 500 gpm and a residence time of 22 minutes. Treated water is currently discharged into an effluent sump from which the water is pumped (using two 500-gpm pumps) through a recharge header pipe to the reinjection (recharge) wells. The system includes two 500-gpm backup pumps. There are 25 recharge wells that range in depth from approximately 40 ft to 60 ft below the ground surface.

The NWBCS generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The spent carbon in the adsorbers is removed and regenerated at an off-post facility. The filter solids are drummed and disposed in a landfill regulated by RCRA and CHWMA.

North Boundary Containment System

Under Alternative 1, operation of the NBCS for the North Boundary Plume Group continues, but the operation of the extraction well that is currently part of the Basin F Groundwater IRA is discontinued. The NBCS is a pump-and-treat system that consists of 35 extraction wells approximately 35 ft deep, 12 of which are currently operating, and a soil/bentonite slurry wall 6,740 ft long, 3 ft wide, and 30 ft deep. The extracted water is treated at the treatment plant with GAC and recharged through 15 reinjection trenches. The NBCS was upgraded as part of the IRA for this system. The upgraded system has an improved treatment system, 5 new recharge trenches installed in 1990, and 10 recharge trenches installed in 1988. The trenches parallel the line of extraction wells and are located about 45 ft north of the existing soil/bentonite slurry wall. The existing 38 recharge wells are not in operation, but can be used as backups if needed. The trenches were installed close to the slurry wall to better maintain a reverse gradient.

The NBCS treatment system originally included prefiltration units, three 30,000-lb GAC adsorbers operated in parallel, and a combination of cartridge and bag postfilters. Treated effluent is discharged to a sump for groundwater recharge. The treatment plant has undergone minor operational changes (associated mostly with carbon handling) and now has two 20,000-lb GAC adsorbers operated in series; a third unit is available as a backup. The GAC units operate in downflow mode, and the carbon usage is approximately 100,000 lbs per year. The total capacity of the modified extraction/treatment system is estimated to be 450 gpm. Flow through the treatment plant currently averages 270 gpm.

The NBCS generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The spent carbon in the adsorbers is removed and regenerated at an off-post facility. The filter solids are drummed and disposed in a landfill regulated by RCRA and CHWMA.

Water levels in the Former Basin F area have been declining for years. The new cap and soil covers in this area will cause the water level to drop further.

Irondale Containment System

Originally, the ICS consisted of two rows of extraction wells and one row of recharge wells. A number of modifications to the ICS system configuration were completed by 1991. The extraction systems have changed as some wells have reached cleanup goals and more contaminated wells have been added to the system. Six of the original extraction wells are currently operating as extraction wells and three of the original extraction wells have been converted to injection wells. Nine new recharge wells, which reduce the water table depression caused by heavy SACWSD pumping rates and which enlarge the zone of captured groundwater on the south edge of the ICS, were installed south of the original system. Additionally, four new extraction wells, three of which are currently operating, were installed 2,000 ft upgradient of the original ICS in an area of greater saturated thickness than the original ICS extraction wells.

Under Alternative 1, all groundwater extracted from the Western Plume Group is treated at the ICS. The water is collected in an influent sump and is treated with GAC adsorption before being reinjected into the aquifer. The treatment plant has three existing treatment trains, each capable of treating a maximum of 700 gpm, although historically only two of the trains have been run simultaneously. The treatment system consists of three identical GAC vessels, two of which are operated in parallel; the third is used as a backup unit. Each vessel contains 40,000 lbs of GAC, is operated in an upflow mode, and has a design capacity of 700 gpm and a corresponding residence time of 15 minutes. Alternative 1 does not include the operation of the two IRA systems (Motor Pool and Rail Yard) that feed into the ICS.

The ICS generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The spent carbon in the adsorbers is removed and regenerated at an off-post facility. The filter solids are drummed and disposed in a landfill regulated by RCRA and CHWMA.

7.2.3.2 Alternative 2 – Boundary Systems/IRAs

Under Alternative 2, all boundary systems continue to operate as for Alternative 1. Passive dewatering is accomplished through installation of the soil caps and covers. In addition, all the IRAs continue to operate as follows:

- The systems in the Motor Pool and Rail Yard areas continue to extract groundwater and pipe it to the ICS for treatment.
- The Basin F Groundwater IRA continues to extract water north of Basin F for treatment at the Basin A Neck IRA System.
- Under the Basin A Neck IRA, water migrating from Basin A continues to be extracted at Basin A Neck and treated by carbon adsorption. A slurry wall helps control contaminant migration. Water from north of Basin F (Basin F Groundwater IRA) is treated by air stripping and carbon adsorption at Basin A Neck.
- The CERCLA Wastewater Treatment Plant continues to operate as needed to support remedial activities.

Operation of the internal groundwater extraction IRA systems continue as necessary until remedial action objectives are met. The other systems operate as necessary to achieve remedial action objectives until remediation is complete. Groundwater and system influent and effluent monitoring continue under this alternative.

The Rail Yard and Motor Pool IRA systems include seven extraction wells to intercept DBCP contamination and two extraction wells to intercept a TCE plume, respectively. These wells became operational in September 1991. Five of the seven wells in the Rail Yard IRA are currently pumping at a total rate of approximately 230 gpm; the two other wells are backup extraction wells and have not been used. The two wells in the Motor Pool area are currently pumping approximately 100 gpm. The groundwater that is extracted from the Motor Pool Area and Rail Yard extraction wells is pumped from the wells through a metering station to a manifold and then flows via an 8-inch-pipeline to the ICS.

To allow for the additional flow at the ICS, the capacity of this system was increased by bringing the third GAC bed on line, although this option has not been required with present flow rates (the ICS is treating approximately 1,030 gpm as of August 1995). With all three trains operating in parallel, the ICS has a maximum design capacity of 2,100 gpm.

The Basin F Groundwater IRA was implemented to capture contamination moving north out of the Basin F Area. Water is extracted using one well at a rate of 1 to 4 gpm and is then piped to the Basin A Neck IRA system where it is treated prior to reinjection into the Basin A Neck recharge trenches.

The Basin A Neck IRA is a pump-and-treat system that intercepts and treats contamination in groundwater as it moves northwest from Basin A. The extraction system consists of seven alluvial wells that currently pump a total flow of approximately 20 gpm. Three gravel-filled recharge trenches (160 ft, 170 ft, and 180 ft in length) are located across the more permeable, deeper portions of the Basin A Neck. A soil/bentonite slurry wall extends 830 ft across the Basin A Neck between the extraction wells and the recharge trenches to limit recirculation of water between the two systems and inhibit any flow of contaminants not captured by the extraction wells. Treated water from the CERCLA Wastewater Treatment Plant is conveyed to the Basin A Neck treatment plant by an underground pipeline, combined with effluent from the plant at a maximum rate of 5 gpm, and reinjected in the Basin A Neck reinjection trenches. The CERCLA Wastewater Treatment Plant treats water in a semibatch mode on an as-needed basis.

Groundwater extracted from both the Basin A Neck and the Basin F Groundwater IRAs is treated at the Basin A Neck IRA treatment facility. Approximately 1 to 4 gpm of groundwater from the Basin F Groundwater IRA is filtered and then treated in an air stripper. The vapor emissions from the air stripper are treated by two vapor-phase GAC vessels operated in series and an additional backup unit. The effluent from the air stripper is combined with the Basin A Neck IRA influent and treated by pre-filtration through a multimedia filter followed by adsorption in two 2,000-lb carbon vessels in series (one backup vessel is on standby). The GAC effluent is filtered through multimedia filters and

discharged to a 3,000-gallon effluent tank. Water from the tank is then filtered through 5-micron bag filters and pumped to the recharge trenches.

The Basin A Neck IRA treatment system generates two sidestreams requiring treatment or disposal, spent carbon and filter solids. The spent carbon in the adsorbers is removed and regenerated at an off-post facility. The filter solids are disposed in a landfill regulated by RCRA and CHWMA.

The components of this alternative are summarized in Table 7.2-1. The total estimated cost for this alternative (in 1995 dollars) is $139 million (present worth cost of $98 million). A breakdown of capital and O&M costs is presented in Table 7.2-2. Operations under this alternative are assumed to continue for at least 30 years.

7.2.3.3 Alternative 3 – Boundary Systems/IRAs/On-Post Dewatering

Alternative 3 includes all components described for Alternative 2. In addition, the water table in the Basin A and South Plants areas is lowered by installing a network of dewatering wells (**active dewatering**) in the central areas of South Plants and Basin A and by installing caps or soil covers in the same area as part of the soil remedy (passive dewatering). Extracted water is treated in a new treatment system by air stripping and GAC adsorption and is then reinjected. Concurrently, groundwater in the South Tank Farm Plume is treated by active **in situ biological treatment**. The South Tank Farm Plume is monitored for the presence of LANPL and, if freely drainable product accumulates to a sufficient thickness, this product is separated and treated. Treatment system and groundwater monitoring is conducted.

Alternative 3 involves removing the most contaminated portions of the Basin A Plume Group, lowering and maintaining future groundwater levels beneath Basin A, and dewatering the South Plants groundwater mound, including the South Plants North Source and South Plants Southeast Plumes. Based on modeling results (see Foster Wheeler Environmental 1995c) for the proposed well layout in Basin A and South Plants, an initial pumping rate of approximately 80 gpm will be used for the first 10 years to reduce the groundwater mound. After 10 years, a pumping rate of 35 gpm will be used to maintain groundwater elevations. Dewatering is accomplished using a system of **horizontal wells** that are installed prior to the initiation of structures medium remedial activities. The caps are installed as part of the soil remedy. The successful operation of the alternative relies on the active extraction/dewatering of the aquifer to reverse horizontal gradients and induce inward flow to the dewatering well system.

The operational goal under Alternative 3 for Basin A is to actively dewater contaminated portions of the soil and the alluvial aquifer. During the first decade (Phase I), the extraction system removes an estimated 60 gpm and the water table is artificially lowered 20 ft or more in the center of Section 36, and to a lesser degree in other areas beneath

Basin A. It is estimated that the long-term pumping rate sufficient to maintain this depressed water level is approximately 20 gpm in Basin A once the soil cap or cover is in place (Phase II). The Basin A Neck IRA intercept system continues to operate and extracts contaminants that are downgradient and beyond the influence of the dewatering system. The dewatering systems are expected to be installed prior to installation of the Basin A and South Plants soil covers, which are to be completed as part of the soil remedy.

Under Alternative 3, dewatering and in situ biotreatment occur concurrently in the South Plants area. Because horizontal wells are used, dewatering under the South Plants Central Processing Area can be initiated before or during demolition or capping activities. The water table is lowered approximately 20 ft through extraction of 20 gpm during the first 10 years (Phase I). The water level is then maintained through extraction of 15 gpm in Phase II. The use of horizontal wells provides flexibility in the overall cleanup of South Plants because the wells can be installed from outside the other construction and demolition areas. The concurrent treatment for the South Tank Farm Plume involves in situ biodegradation of benzene. Water is extracted from the South Tank Farm Plume source area at a rate of 10 gpm. The extracted groundwater is transferred to a collection tank and then reinjected after the appropriate amounts of hydrogen peroxide and nutrients have been added; reinjecting the water flushes the plume as it enhances biological growth and degradation of contaminants in the subsurface. When the northernmost cell (Cell I) of the in situ biotreatment system becomes inefficient after several years due to dewatering of the South Plants area, three of the injection wells in Cell 1 are converted to extraction wells and become part of the overall dewatering system. The remainder of the in situ system continues to operate for an estimated 10 years.

Each of the proposed extraction systems under Alternative 3 requires installation of performance monitoring wells. Groundwater-quality and water-level data from the newly installed performance monitoring wells are used to evaluate the effectiveness and operation of the extraction/dewatering system. The final location of the wells is based upon review of existing well locations and screened intervals. Where appropriate, existing wells are utilized in place of construction of new monitoring wells.

The components of this alternative are summarized in Table 7.2-1. The total estimated cost for this alternative (in 1995 dollars) is $179 million (present worth cost of $130 million). A breakdown of capital and O&M costs is presented in Table 7.2-2. Operations under this alternative are assumed to continue for at least 30 years.

7.2.3.4 Alternative 4 – Boundary Systems/IRAs/Intercept Systems

Alternative 4 includes all components of Alternative 2 as well as groundwater extraction from the Section 36 Bedrock Ridge Plume in an interceptor configuration followed by treatment at the existing Basin A Neck IRA (which includes air stripping and GAC adsorption). Treated water is reinjected to the aquifer through the existing recharge trenches. The interceptor configuration is designed to prevent further migration of the Section 36 Bedrock Ridge Plume northeast

out of the Basin A area towards the First Creek drainage. Alternative 4 is accomplished in conjunction with the soil remedy, which includes caps or soil covers over the Basin A and South Plants areas, and caps and slurry walls associated with the Shell Trenches and the Army Complex Trenches.

Groundwater-quality and water-level data are collected and used to evaluate the effectiveness and operation of the Bedrock Ridge and Basin A Neck systems. It is assumed that there are sufficient existing wells in both areas to be used for performance monitoring, so no new wells are installed. Wells closed during the implementation of the soil remedy will be replaced if required to maintain adequate performance monitoring. Further evaluation of the hydraulic control provided by the entire system (wells, caps, and slurry walls) will be performed during the remedial design.

Alternative 4 also includes groundwater monitoring of the CFS. Monitoring of the CFS is to be conducted in the South Plants area, the Basin A area, and close to Basin F. Data from these wells are assessed to determine whether contaminant levels within the CFS are increasing or migrating significantly with time. Due to poor construction or documentation of well-installation techniques, screened intervals, and bentonite-seal locations, approximately 30 to 40 CFS wells are closed and abandoned. Both groundwater and system monitoring continues.

Water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems. The biological health of the ecosystems will continue to be monitored. Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance.

The components of this alternative are summarized in Table 7.2-1. The total estimated cost for this alternative is $146 million (present worth cost of $104 million). A breakdown of capital and O&M costs is presented in Table 7.2-2. Operations under this alternative are assumed to continue for at least 30 years.

7.3 Description of Sitewide Remedial Alternatives for Structures

7.3.1 Description of Medium

As described in Section 5 and detailed in the structures inventory tables (Tables 5.4-6 through 5.4-9), approximately 94 percent of the remaining 798 structures at RMA were identified as potentially contaminated based on previous use or location in manufacturing areas. To date, 525 structures at RMA have been demolished. The debris has been disposed off post or is awaiting disposal.

7.3.2 Remedial Action Objectives

The RAOs for structures were developed based on potential risks, both physical and chemical, to human and ecological receptors through the potential exposure pathways of inhalation, dermal contact, or ingestion of contaminants potentially present in, or emanating from, structures at RMA. They were also based on the potential for the movement of contaminants through soil, air, or water from structures. The RAOs for the structures medium are as follows:

Human Health

- Prevent contact with the physical hazards and contaminant exposure associated with structures.
- Limit inhalation of asbestos fibers to applicable regulatory standards.
- Limit releases or migration of COCs from structures to soil or water in excess of remediation goals for those media or to air in excess of risk-based criteria for inhalation as developed in the HHRC.

Ecological Protection

- Prevent contact with the physical hazards associated with structures.
- Prevent biota from entering structures that are potentially contaminated.

7.3.3 Description of Sitewide Remedial Alternatives for Structures

Before any structures remedial alternatives can be implemented, each structure must be visually examined to determine the structural integrity of the building. The decontamination status of each structure is also determined with respect to ACM and PCBs.

The scope of the ongoing Asbestos IRA is to remove and dispose all ACM from RMA structures, piping, and tanks. The Asbestos IRA continues as part of the structures remediation, so any asbestos remaining in the structures will be removed as an integral part of the remediation process and disposed in the on-post hazardous waste landfill.

Agent-related and nonagent-related process equipment and piping located in the North Plants and South Plants is being sampled, decontaminated, and dismantled under the Chemical Process-Related Activities IRA. Although much of the equipment in these areas has already been removed, process-related equipment not remediated as part of this IRA will be disposed in the new on-post TSCA-compliant hazardous waste landfill as part of the final remedy.

Army structures have been subject to a comprehensive sampling program under the PCB IRA to identify all PCB-contaminated equipment and structural materials. The results of this program are to be presented in the PCB IRA completion report. PCB-contaminated materials will be disposed in the on-post hazardous waste landfill, which will meet Toxic Substances Control Act (TSCA) requirements. The results of the PCB IRA completion report for Army structures will be incorporated into remediation activities as discussed below.

Equipment and structures for which the Army has responsibility will be handled as follows:

- Equipment – PCB fluids will be drained and sent off post for disposal in compliance with applicable TSCA regulations. PCB-contaminated equipment will be disposed in the new on-post hazardous waste landfill that meets TSCA requirements. The equipment will be disposed under one of three possible scenarios:
  - Identified and disposed as part of the ongoing PCB IRA.
  - Identified under the PCB IRA but disposed under the final structures cleanup.
  - Agent-decontaminated materials to be disposed under the final structures cleanup.
- Structures – The PCB contamination in No Future Use structural materials will be identified in the PCB IRA completion report. Based on a 50 parts per million (ppm) action level, structural materials will be addressed in one of two ways:
  - Structural materials with PCB concentrations of 50 ppm or above that exist above the ground elevation, as well as contaminated parts of ground floor slabs and foundations that will be removed, will be identified prior to demolition, segregated during demolition, and disposed in the on-post TSCA-compliant hazardous waste landfill. Similar materials with PCB concentrations less than 50 ppm will be disposed according to use history as described in the alternative detailing.
  - PCB-contaminated sections of ground floor slabs or foundations at or below grade that are not required to be demolished as part of the remediation and with PCB concentrations of less than 50 ppm will be left in place. However, slabs or foundation materials with PCB concentrations of 50 ppm or greater will be removed during demolition and disposed in the new TSCA-compliant hazardous waste landfill.

Army Future Use structures have been managed for occupancy under current environmental and worker protection regulations. There is no evidence of PCB contamination in this medium group.

Potential PCB contamination in Shell structures are to be identified through visual evidence, and will be disposed in accordance with TSCA requirements and guidance. Structures and equipment for which Shell has responsibility are so indicated in Tables 5.4-6 through 5.4-9 and will be handled as follows:

- All Shell buildings to be demolished during the final remedy will be inspected for equipment containing fluids potentially contaminated with PCBs prior to demolition. Potentially contaminated fluids will be drained and sent off post for disposal in compliance with applicable TSCA regulations. Equipment that contained these fluids, as well as all other equipment, will be disposed in the on-post TSCA-compliant hazardous waste landfill. Significant Contamination History structures will be demolished and the resulting debris will be placed in the new on-post TSCA-compliant hazardous waste landfill. Other Contamination History structures will be evaluated by Shell and EPA for any visual evidence of leaks or spills. If observed in areas where potential PCB releases may be reasonably expected to occur, the affected debris will be disposed in the on-post TSCA-compliant hazardous waste landfill. Examples of this type of visual evidence would include stains near equipment potentially containing PCB fluids or stains in buildings where there are numerous instances of equipment potentially containing PCB-contaminated fluids. Further details of this work will be addressed at the remedial design stage.
- All fluorescent-light ballasts will be disposed at an off post-disposal facility in accordance with applicable TSCA regulations.

Shell does not have responsibility for any structures within the Future Use or Agent History Groups.

Most of the demolition at RMA will consist of dismantling (i.e., reducing a standing building to a pile of debris), using a combination of demolition techniques and equipment such as a backhoe with a thumb attachment, a wrecking ball and crane, or a crane and clamshell, or by performing piece-by-piece disassembly, sawing, or crushing. Additional techniques, such as structural undermining or explosives demolition, may be appropriate in some cases. Standard dust-suppression measures consistent with the remediation goals are used throughout the demolition process to meet state and federal requirements.

As the structural debris is removed, materials are segregated for purposes of recycling and waste classification. Economically recyclable materials, such as scrap metals, are collected for salvage. Structural materials not salvaged are placed in a bermed dirt or concrete staging area. The debris is segregated into potentially hazardous and nonhazardous waste as the structure is dismantled and placed in separate containment areas. The debris is sized for disposal concurrent with stockpiling to limit the amount of settling in the landfill or consolidation area. Due to the potential hazards, these handling activities are limited for Agent History structures.

The debris is then transported by truck to the disposal site. Debris from Agent History structures is monitored for the presence of agent and treated, as necessary, before disposal in the hazardous waste landfill. Agent-contaminated structures will be handled in compliance with AR 385-61, AR 50-6, and Department of Defense regulations in effect at the time of remediation. Action must be taken to treat the agent contamination within the structure or debris to a level consistent with Army regulations (3X or 5X) so it may be properly disposed. Debris from the Significant Contamination and Other Contamination History structures are taken directly to the hazardous waste landfill, depending on the remedial alternative. Floor slabs and foundations at or below grade for the Other Contamination History and Significant Contamination History Groups are left in place unless they must be removed to provide access to underlying contaminated soil (i.e., the slabs and foundations of structures located in the South Plants Central Processing Area within principal threat or human health soil exceedance areas, which are removed to a depth of 5 ft along with the contaminated soil). Floor slabs not removed are broken in place to prevent water ponding and are contained beneath the soil covers specified for the specific areas in which they occur (see Section 7.4).

7.3.3.1 Alternative 1 – Landfill/Cap In Place

Alternative 1 addresses each of the three No Future Use medium groups as follows:

- No Future Use, Significant Contamination History – The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill.
- No Future Use, Other Contamination History – The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris consolidated and capped in one of three places: the Rail Yard, North Plants, or the South Plants Central Processing Area. Multilayer caps are used for containment of the debris.

- No Future Use, Agent History – The structures are dismantled using dust controls and air monitoring, the debris monitored for the presence of Army chemical agent and caustic washed as necessary, and the resulting debris disposed in the on-post hazardous waste landfill. Spent caustic wash is treated in an evaporator/crystallizer; the resulting waste salts are drummed and disposed in the on-post hazardous waste landfill.

The components of this alternative are summarized in Table 7.3-1. The total estimated cost of this alternative (in 1995 dollars) is $114 million (present worth cost of $106 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.3-2. This alternative requires approximately 2 years for implementation.

7.3.3.2 Alternative 2 – Landfill/Consolidate

Alternative 2 addresses each of the three No Future Use medium groups as follows:

- No Future Use, Significant Contamination History – The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill.
- No Future Use, Other Contamination History – The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris transported to the Basin A consolidation area for use as gradefill.
- No Future Use, Agent History – The structures are dismantled using dust controls and air monitoring, the debris monitored for the presence of Army chemical agent and caustic washed as necessary, and the resulting debris disposed in the on-post hazardous waste landfill. Spent caustic wash is treated in an evaporator/crystallizer; the resulting waste salts are drummed and disposed in the on-post hazardous waste landfill.

The components of this alternative are summarized in Table 7.3-1. The total estimated cost of this alternative (in 1995 dollars) is $112 million (present worth cost of $104 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.3-2. This alternative requires approximately 2 years for implementation.

7.3.3.3 Alternative 3 – Landfill

Alternative 3 addresses each of the three No Future Use medium groups as follows:

- No Future Use, Significant Contamination History – The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill.
- No Future Use, Other Contamination History – The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill.
- No Future Use, Agent History – The structures are dismantled using dust controls and air monitoring, the debris monitored for the presence of Army chemical agent and caustic washed as necessary, and the resulting debris disposed in the on-post hazardous waste landfill. Spent caustic wash is treated in an evaporator/crystallizer; the resulting waste salts are drummed and disposed in the on-post hazardous waste landfill.

The components of this alternative are summarized in Table 7.3-1. The total estimated cost of this alternative (in 1995 dollars) is $118 million (present worth cost of $109 million). A breakdown of capital and operating and maintenance costs for each component of this alternative is presented in Table 7.3-2. This alternative requires approximately 2 years for implementation.

7.4 Description of Sitewide Remedial Alternatives for Soil

7.4.1 Description of Medium

As described in Section 5, the majority of contamination is present in the trenches, disposal basins, and the South Plants manufacturing area, covering approximately half of the central six sections of RMA (Figure 5.4-1 and Tables 5.4-11 and 5.4-12). The highest contaminant concentrations tend to occur in soil within 5 ft of the ground surface, although exceptions are noted, particularly at sites where burial trenches, disposal basins, or manufacturing complexes are located. In general, contaminant distribution is significantly influenced most by the physical and chemical properties of the contaminants, the environmental media through which they are transported, and the characteristics of the sources (i.e., former manufacturing and disposal practices).

7.4.2 Remedial Action Objectives

The RAOs identified for the soil medium are the following:

Human Health

- Prevent ingestion of, inhalation of, or dermal contact with soil or sediments containing COCs at concentrations that generate risks in excess of 1×10^{-4} (carcinogenic) or an HI greater than 1.0 (noncarcinogenic) based on the lowest calculated reasonable maximum exposure (5th percentile) PPLV values (which generally represent the on-site biological worker population).
- Prevent inhalation of COC vapors emanating from soil or sediments in excess of acceptable levels, as established in the HHRC.
- Prevent migration of COCs from soil or sediment that may result in off-post groundwater, surface water, or windblown particulate contamination in excess of off-post remediation goals.
- Prevent contact with physical hazards such as UXO.
- Prevent ingestion of, inhalation of, or dermal contact with acute chemical agent hazards.

Ecological Protection

- Ensure that biota are not exposed to COCs in surface water, due to migration from soil or sediment, at concentrations capable of causing acute or chronic toxicity via direct exposure or bioaccumulation.
- Ensure that biota are not exposed to COCs in soil and sediments at toxic concentrations via direct exposure or bioaccumulation.

7.4.3 Description of Sitewide Remedial Alternatives for Soil

The implementation of any soil alternative is tied to structures remediation because most of the structures at RMA are located in areas of soil contamination. In such areas, structures must be demolished before components of the soil remedy, such as excavation or the construction of containment systems, can be implemented.

PCB-contaminated soil at RMA was identified under the PCB IRA program. The remedial activities for PCB-contaminated soil are dependent on the concentration and location as follows:

- The three PCB-contaminated soil areas identified by the PCB IRA with concentrations of 250 ppm or greater will be removed. The limits of contamination will be determined based on visual evidence with immunoassay field confirmation sampling (SW-846).
- There are five PCB-contaminated soil areas identified by the PCB IRA with concentrations from 50 ppm to below 250 ppm. These areas will receive a minimum of 3 ft of soil cover, and the PCB-contaminated soil there will be left in place. The soil cover will be maintained as part of the wildlife refuge and is subject to the institutional controls of the FFA.
- No remaining areas of PCB-contaminated soil with concentrations above 50 ppm have been identified by the PCB IRA. If necessary, any suspected PCB soil contamination areas will be characterized further during the remedial design. If additional PCB-contaminated soil is found in concentrations of 50 ppm or above, the Army will determine any necessary remedial action in consultation with EPA.
- PCB-contaminated soil that is excavated under any soil alternative is disposed in the on-post TSCA-compliant landfill.

7.4.3.1 Alternative 1 – Caps/Covers

Alternative 1 involves the **containment** of 1,200 acres through the installation of a cap and the landfilling of 290,000 bank cubic yards (BCY) of contaminated soil. Under this alternative, **multilayer caps** are installed to contain contaminated soil. The capped areas are located in the central portions of RMA (Figure 7.4-1). The existing cover for the Former Basin F Subgroup is augmented to improve performance and meet EPA guidance governing caps and covers. A composite cap is constructed over the existing cover for the Basin F Wastepile. Approximately 17.8 million BCY of borrow materials are required as backfill and gradefill to achieve the design grades for capping, and an additional 11.3 million BCY of borrow (clay and common fill) are required for construction of the caps.

In addition to capping, all sewer manholes are plugged with cement. Slurry walls are used in conjunction with caps for the Complex Trenches, Shell Trenches, Hex Pit, and Buried M-1 Pits Subgroups to augment the containment of these sites. The groundwater inside the contained area is pumped and treated if necessary.

Areas outside the central portions of RMA that are suspected to have potential chemical agent or UXO presence are screened and cleared. Any **excavated** agent-contaminated soil identified during **agent monitoring** is treated by caustic washing and then landfilled. In addition, any identified HE-filled (high explosive) or agent-filled UXO is excavated, packaged, and **transported** off post to an existing Army facility for detonation and disposal (unless the UXO is unstable and must be detonated on post) or other demilitarization process. The 200,000 BCY of contaminated soil and debris from several sites in the eastern and western portions of RMA are excavated and placed in the on-post hazardous waste landfill along with debris from **munitions screening** operations. The

110,000 BCY of human health exceedances from the Surficial Soil, Lake Sediments, and Agent Storage Medium Groups are also landfilled.

Soil posing risk to biota is generally capped as discussed above. No action is undertaken for soil that potentially poses risks to biota that is located outside of the capped area including Upper Derby Lake and the Surficial Soil, Ditches/Drainage Areas, and Agent Storage Medium Groups. The soil in these areas is sampled periodically. No action (other than monitoring) is conducted for the aquatic lake sediments. Ongoing monitoring of biota in these areas will be conducted in support of design refinement/design characterization.

The components of this alternative are summarized in Table 7.4-1. The total estimated cost for this alternative (in 1995 dollars) is $542 million (present worth cost of $386 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.4-2. This alternative requires approximately 17 years for implementation.

7.4.3.2 Alternative 2 – Landfill/Caps

Alternative 2 involves containment of approximately 490 acres through the installation of multilayer caps and the landfilling of 2 million BCY of contaminated soil. The areas outside the central portion of RMA are excavated and landfilled. The 110,000 BCY of human health exceedances from the Lake Sediments, Surficial Soil, and Agent Storage Medium Groups are landfilled. Any excavated agent-contaminated soil identified during monitoring is treated by caustic washing and then landfilled. In addition, any HE-filled or agent-filled UXO identified through geophysical surveys or other screening methods are excavated, packaged, and transported off-post to an existing Army facility for detonation and disposal (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Chemical sewer lines in the central portion of the South Plants complex and within the Complex Trenches are plugged with cement and the sanitary sewer manholes are plugged. The remaining chemical sewers and associated contaminated soil are excavated and placed in the on-post hazardous waste landfill.

A 390-acre area in the central portion of RMA is covered with multilayer caps. The capped areas consist of human health exceedance areas and areas with residual contamination in Section 36, the South Plants Central Processing Area, and the Former Basin F (Figure 7.4-2). The existing cover for the Former Basin F Subgroup is augmented to improve performance and meet EPA guidance governing caps and covers. A composite cap is constructed over the existing cover for the Basin F Wastepile. Approximately 8.8 million BCY of borrow materials are required as backfill and gradefill to achieve the design grades for capping, and an additional 3.9 million BCY of borrow (clay and common fill) are required for construction of the caps.

Slurry walls are used in conjunction with caps for the Complex Trenches, Shell Trenches, Hex Pit, and Buried M-1 Pits Subgroups to augment the containment of these sites. The groundwater inside the contained area is pumped and treated if necessary to maintain lowered water table elevations.

Soil posing risk to biota within the central six sections of RMA is generally excavated and landfilled as discussed above. No action is undertaken for soil that potentially poses risks to biota that is located outside of the capped area including Upper Derby Lake and the Surficial Soil, Ditches/Drainage Areas, and Agent Storage Medium Groups. Although a residual risk to biota exists outside the capped area, the magnitude of the residual risk is comparatively low (see Section 6.2.4.3) and the short-term destruction of habitat is minimized. The soil in these areas is sampled periodically. No additional action other than monitoring is conducted for the aquatic lake sediments. Ongoing monitoring of biota in these areas will be conducted in support of design refinement/design characterization.

The components of this alternative are summarized in Table 7.4-1. The total estimated cost for this alternative (in 1995 dollars) is $383 million (present worth cost of $276 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.4-2. This alternative requires approximately 16 years for implementation.

7.4.3.3 Alternative 3 – Landfill

Alternative 3 involves the containment of 3.4 million BCY of contaminated soil in an on-post hazardous waste landfill. Approximately 100 acres of principal threat or human health exceedance soil areas are contained with a multilayer cap instead of being landfilled, and 300 acres are capped (multilayer cap), after removing the human health exceedance volume and landfilling, to address residual contamination (Figure 7.4-3).

Contaminated soil from nearly all of the sites (3.4 million BCY total) is excavated and landfilled. Chemical sewers and associated contaminated soil are excavated and placed in the on-post hazardous waste landfill. The 87,000 BCY of human health exceedance volume from the Surficial Soil Medium Group, soil with human health exceedances in the Agent Storage Medium Group (2,900 BCY), and human health exceedances and soil that may pose a risk to biota from the Lake Sediments (including portions of Upper Derby Lake) and Ditches/Drainage Areas Medium Groups (58,000 BCY) are also excavated and landfilled. Any excavated agent-contaminated soil identified during monitoring is treated by caustic washing and then landfilled. The excavation of the Former Basin F, Buried M-1 Pits, Shell Trenches, and Hex Pit Subgroups requires the use of **vapor- and odor-suppression measures** such as foam, liners, or a transportable structure.

The sanitary sewer manholes are plugged. Any HE-filled (high explosive) and agent-filled UXO identified through geophysical surveys or other screening methods are excavated, packaged, and transported off post to an existing

Army facility for detonation and disposal (unless the UXO is unstable and must be detonated on post) or other demilitarization process.

The Basin F Wastepile and the Complex Trenches Subgroups are left in place and capped. A composite cap is constructed over the existing cover for the Basin F Wastepile. Following the excavation and landfilling of human health exceedances, 390 acres in Section 36, South Plants Central Processing Area, and the Former Basin F are capped (multilayer caps). Approximately 10.1 million BCY of borrow materials are required as backfill and gradefill to achieve the design grades for capping, and an additional 3.86 million BCY of borrow are required for construction of the cap.

Slurry walls are used in conjunction with the caps for the Complex Trenches Subgroup to augment the containment of this site. The groundwater inside the contained area is pumped and treated.

Soil posing risk to biota within the central six sections of RMA is generally excavated and landfilled as discussed above. No action is undertaken for soil that potentially poses risks to biota in the Surficial Soil Medium Group, but the soil in this area is sampled periodically. Although a residual risk to biota exists in this medium group, the magnitude of the residual risk is comparatively low (see Section 6.2.4.3) and the short-term destruction of habitat is minimized. No action other than monitoring is conducted for the aquatic lake sediments. Ongoing monitoring of the biota in these areas will be conducted in support of design refinement/design characterization.

The components of this alternative are summarized in Table 7.4-1. The total estimated cost for this alternative (in 1995 dollars) is $576 million (present worth cost of $384 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.4-2. This alternative requires approximately 22 years for implementation.

7.4.3.4 Alternative 4 – Consolidation/Caps/Treatment/Landfill

Alternative 4 involves consolidation of 1.5 million BCY of soil with low levels of contamination into Basin A, Former Basin F, and the South Plants Central Processing Area; capping or covering of 1,100 acres of contaminated soil; landfilling of 1.7 million BCY of soil and debris; and treatment of 217,000 BCY of soil by solidification/ stabilization (Figure 7.4-4). This alternative also includes a contingent soil volume of 150,000 BCY that may be landfilled. The locations of the contingent volume will be based on visual field observations such as soil stains, presence of barrels, or newly discovered evidence of contamination. In addition, 14 samples from North Plants, Toxic Storage Yards, Lake Sediments, Sand Creek Lateral, and Burial Trenches Medium Groups and up to 1,000 additional confirmatory samples may be used to identify the contingent soil volume requiring landfilling.

Approximately 190,000 BCY of principal threat soil in the Former Basin F are treated by in situ solidification/stabilization, and 26,000 BCY of principal threat and human health exceedance soil from the Buried M-1 Pits are excavated, solidified, and placed in the on-post landfill. Excavation of the Buried M-1 Pits will be conducted using vapor- and odor-suppression measures.

Approximately 1,000 BCY of principal threat material from the Hex Pit are treated using an innovative thermal technology. The remaining 2,300 BCY are excavated and disposed in the on-post hazardous waste landfill. Remediation activities will be conducted using vapor- and odor-suppression measures as required. Treatability testing will be performed during remedial design to verify the effectiveness of the innovative thermal process and establish operating parameters for the design of the full-scale operation. The innovative thermal technology must meet the treatability study technology evaluation criteria as described in the dispute resolution agreement (PMRMA 1996). Treatment will be revised to a solidification/stabilization technology if all evaluation criteria for the innovative thermal technology are not met. Treatability testing for solidification will be performed to verify the effectiveness of the solidification process and determine appropriate solidification/stabilization agents. Treatability testing and technology evaluation will be conducted in accordance with EPA guidance (OSWER-EPA 1989a) and EPA's "Guide for Conducting Treatability Studies Under CERCLA" (1992).

The approximately 650,000 BCY of highly contaminated soil from the Basin F Wastepile and the Section 36 Lime Basins Subgroups is excavated (using vapor- and odor-suppression measures) and disposed in triple-lined cells within the on-post hazardous waste landfill. Soil from the Basin F Wastepile not passing the **EPA paint filter test** (SW-846, Method 9095) will be reduced to acceptable moisture-content levels by using a dryer in an enclosed structure. Any contaminants released from the soil during drying will be captured and treated.

Approximately 1 million BCY of human health exceedance soil from other sites throughout RMA, as well as debris from UXO clearance operations, are landfilled under this alternative. Any excavated agent-contaminated soil identified during monitoring is treated by caustic washing and then landfilled. In addition, any identified HE-filled and agent-filled UXO are excavated, packaged, and transported off post to an existing Army facility for detonation and disposal (unless the UXO is unstable and must be detonated on post) or other demilitarization process.

Slurry walls are used in conjunction with the caps for the Shell Trenches and Complex Trenches Subgroups to augment the containment of these sites. For the purposes of conceptual design and costing during the FS, it was assumed that the groundwater inside the contained area is pumped and treated at the Basin A Neck treatment system (this assumption will be reevaluated during the remedial design). The Shell Trenches and Complex Trenches caps are designed to be **RCRA-equivalent caps**. The complex trenches cap includes a 6-inch-thick formed concrete layer. The sanitary sewer manholes and the chemical sewers located in the South Plants Central Processing Area

and Complex Trenches are plugged. The remaining human health exceedance soil and chemical sewer debris are excavated and placed in the landfill.

Soil posing a potential risk to biota within the Secondary Basins as well as the North Plants Manufacturing Area is contained in place using 2-ft-thick soil covers. Soil posing a potential risk to biota within the Ditches/Drainage Areas, Sanitary Landfills, Section 36 Balance of Areas, Sand Creek Lateral, South Plants, and some of the Lake Sediments and Surficial Soil Medium Groups/Subgroups are consolidated as gradefill soil within Basin A, South Plants Central Processing Area, or Former Basin F and are contained beneath the cap or soil covers for those sites. The construction of the cap and covers of these three areas requires approximately 5.7 million BCY of gradefill to provide sufficient slope for proper drainage. Other sites require an additional 3.1 million BCY of backfill and gradefill to achieve design grades for caps/covers. An additional 5.1 million BCY of borrow material are required for construction of all caps/covers. The Former Basin F cap is designed to be RCRA-equivalent. Basin A and the South Plants Central Processing Area are contained with a 4-ft-thick soil cover and, respectively, a 6-inch-thick formed concrete layer and 1-ft-thick crushed concrete layer for prevention of biota intrusion.

The South Plants Balance of Areas is covered with a variable-thickness soil cover. The former human health exceedance area is covered with a 3-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to ensure that the soil under the 1-ft-thick soil cover does not exceed human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft-thick cover will be extended over these areas or the exceedance soil will be excavated and landfilled. The top 1 ft of the entire soil cover area will be constructed using uncontaminated soil from the on-post borrow areas.

The Section 36 Balance of Areas will also be covered with a variable-thickness soil cover. The former human health exceedance area is covered with a 2-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover.

Soil posing risk to biota is generally excavated and consolidated within the Basin A and South Plants Central Area covers or placed beneath the Basin F cap. No action is undertaken for soil that potentially poses risks to biota that is located outside of this area, i.e., soil within the Lake Sediments or Surficial Soil Medium Groups. Although a residual risk to biota exists in these areas, the magnitude of the residual risk is comparatively low (see Section 6.2.4.3) and the short-term destruction of habitat is minimized. These areas are sampled periodically. No action (other than monitoring) is conducted for the aquatic lake sediments. Ongoing monitoring of the biota in these areas will be conducted in support of design refinement/design characterization.

The components of this alternative are summarized in Table 7.4-1. The total estimated cost for this alternative (in 1995 dollars) is $566 million (present worth cost of $401 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.4-2. This alternative requires approximately 17 years for implementation.

7.4.3.5 Alternative 5 – Caps/Treatment/Landfill

Alternative 5 is composed of the following features: capping of 530 acres of contaminated soil, landfilling of 4 million BCY of soil and debris, and treatment of 1.1 million BCY of contaminated soil (Figure 7.4-5).

Approximately 1.1 million BCY of principal threat soil are treated by **thermal desorption, incineration**, or **solidification/stabilization**. The majority of the soil treated by thermal desorption is from the Basin F Wastepile, Former Basin F and South Plants Central Processing Area Subgroups. The excavation of soil from both the Basin F Wastepile and Former Basin F for treatment may require use of vapor- and odor- suppression measures. Soil in the Shell Trenches and Hex Pit Subgroups (103,000 BCY) is excavated and treated by incineration. The excavation of both the Shell Trenches and Hex Pit also requires use of vapor- and odor-suppression measures. All soil treated by thermal desorption or incineration is placed in the on-post hazardous waste landfill.

A total of 27,000 BCY of soil contaminated with inorganic contaminants are treated by solidification. The majority of the soil to be solidified is excavated from the Buried M-1 Pits Subgroup, which requires vapor- and odor-suppression measures during excavation.

The Complex Trenches Subgroup is left in place and contained with a multilayer cap and slurry walls. The groundwater inside the contained area is pumped and treated as necessary.

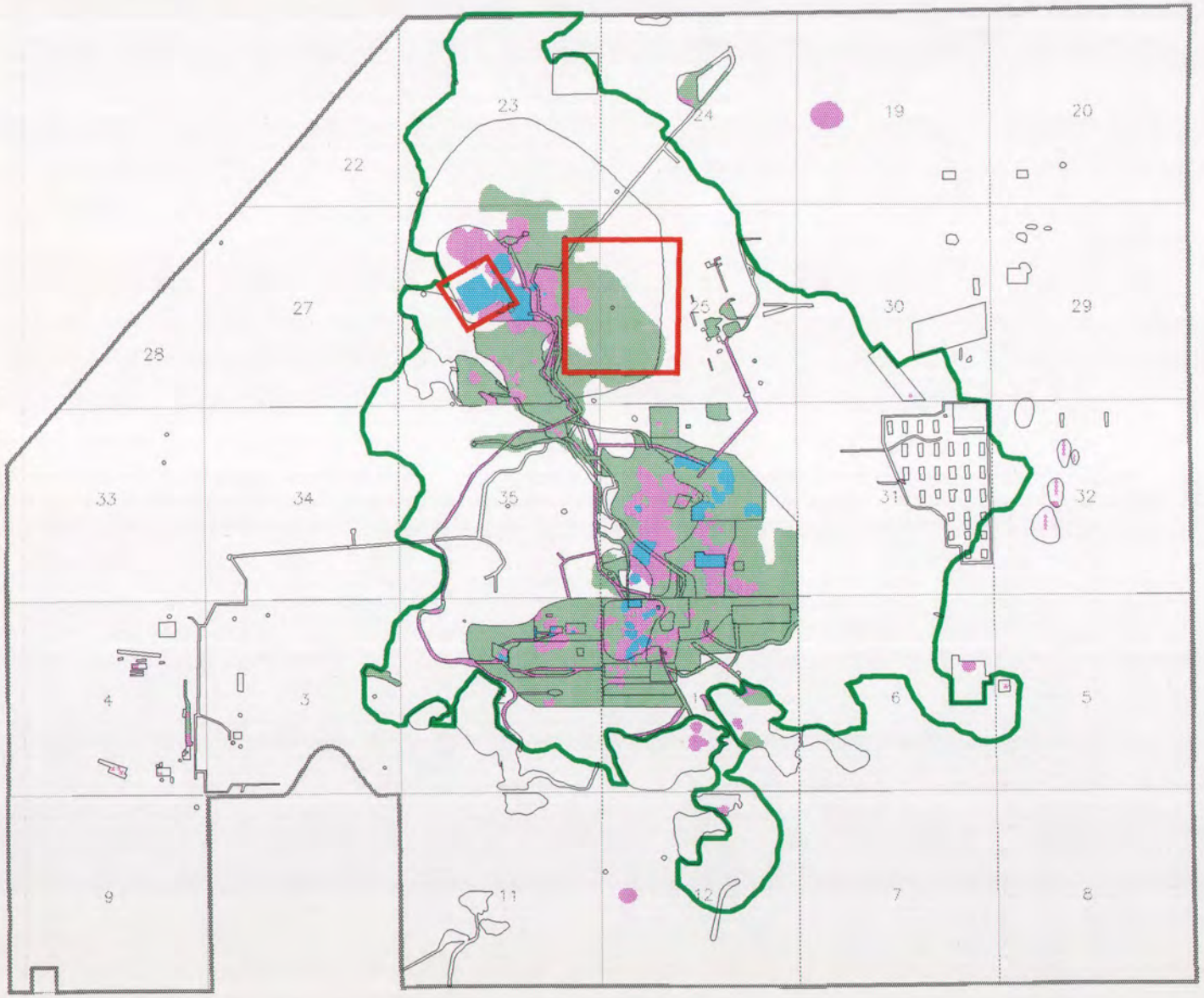
Following the excavation of human health exceedance volumes for treatment or disposal, 530 acres in Section 36, the South Plants Central Processing Area, and the Former Basin F are capped (multilayer caps). Approximately 10.5 million BCY of borrow materials are required as gradefill to achieve the design grade for the caps, and an additional 3.9 million BCY of borrow are required for construction of the caps.

Approximately 4 million BCY of contaminated soil, primarily from sites outside of the central portions of RMA, as well as debris from UXO clearance operations, are landfilled under this alternative. The incinerated soil and debris and the thermally desorbed soil are also placed in the on-post hazardous waste landfill. Any agent-contaminated soil identified during screening is treated by caustic washing and then landfilled. In addition, any identified HE-filled and agent-filled UXO is excavated, packaged, and transported off post to an existing Army facility for detonation and disposal (unless the UXO is unstable and must be detonated on post) or other demilitarization

process. The sanitary sewer manholes are plugged. The chemical sewers and any associated contaminated soil are excavated and placed in the on-post hazardous waste landfill. The 87,000 BCY of human health exceedance volume from the Surficial Soil Medium Group are also landfilled.

Soil posing risk to biota within the central six sections of RMA is generally excavated and landfilled. An additional 1,600 acres of soil representing a potential risk to the great horned owl are addressed through agricultural practices, which reduces the level of contamination in near-surface soil. No action other than monitoring is conducted for the aquatic lake sediments. Ongoing monitoring of biota in these areas will be conducted in support of design refinement/design characterization.

The components of this alternative are summarized in Table 7.4-1. The total estimated cost for this alternative (in 1995 dollars) is $1.01 billion (present worth cost of $542 million). A breakdown of capital and O&M costs for each component of this alternative is presented in Table 7.4-2. This alternative requires approximately 28 years for implementation.



Legend

- RMA Boundary
- SAR Site Boundary[1]
- Principal Threat Exceedance Area Cancer Risk ≥ 10E−3 or HI ≥ 1000
- Human Health Exceedance Area Cancer Risk ≥ 10E−4, Chronic HI ≥ 1.0, or Acute HI ≥ 1.0
- Biota Risk Area
- 5 Section Number
- Area of Contamination Boundary
- CAMU Boundary

[1]Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a).

[2]Based on RME exposure parameters and C_{max} on boring by boring basis for 0−ft to 10−ft depth interval.

-N-

1500 0 1500 3000 Feet

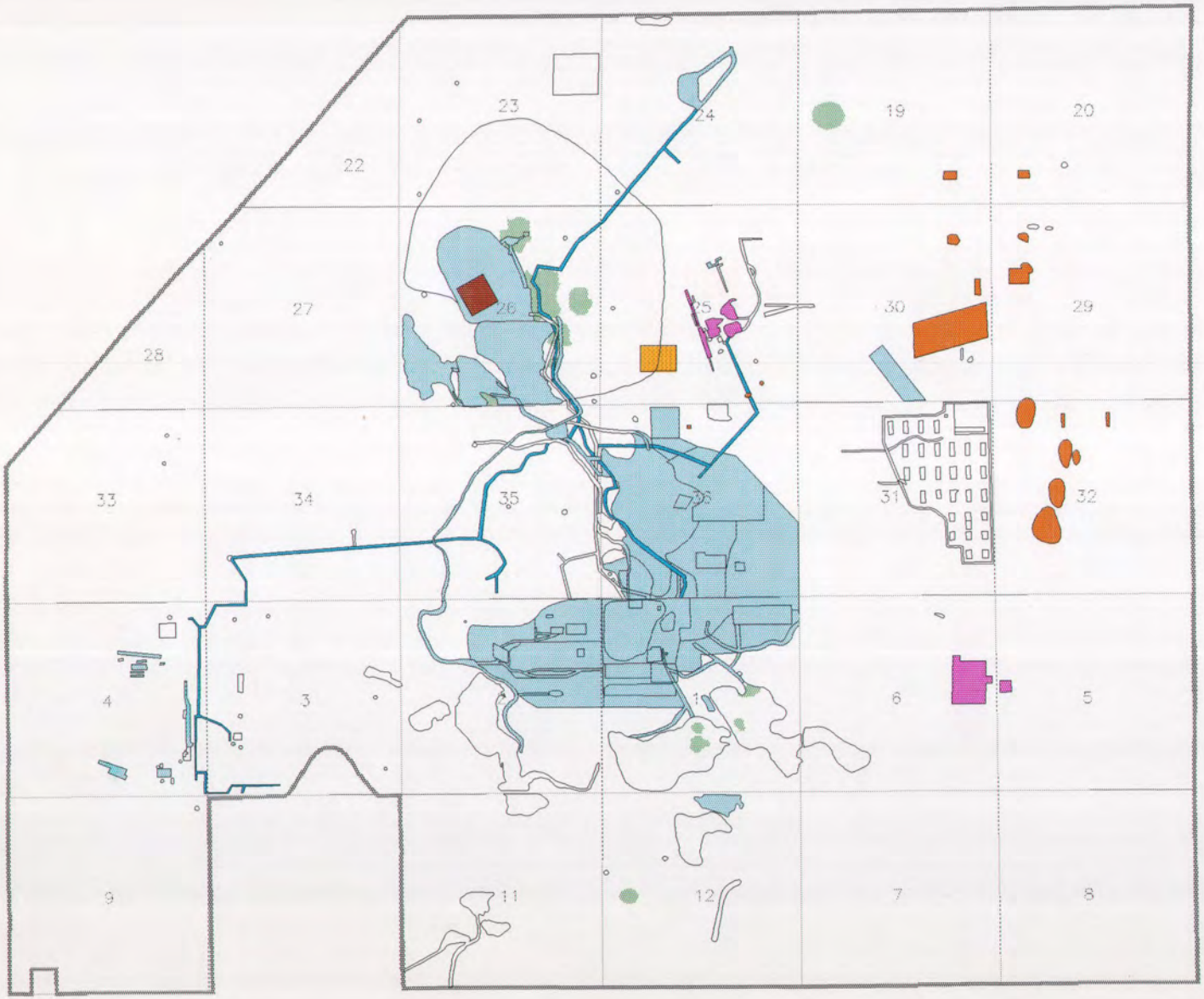
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 7.1−1

Human Health Exceedance Areas and Biota Risk Area[2]

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOIL\S\FOD\FIG711
Date 6/06/96
Drawn by XG
Checked by SA



Legend

- RMA Boundary
- SAR Site Boundary[1]
- Capped Areas
- Landfill Site
- Areas to be Landfilled
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Basin F Wastepile Cap
- Access Restrictions
- 5 Section Number

[1]Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a).

N

1500 0 1500 3000 Feet

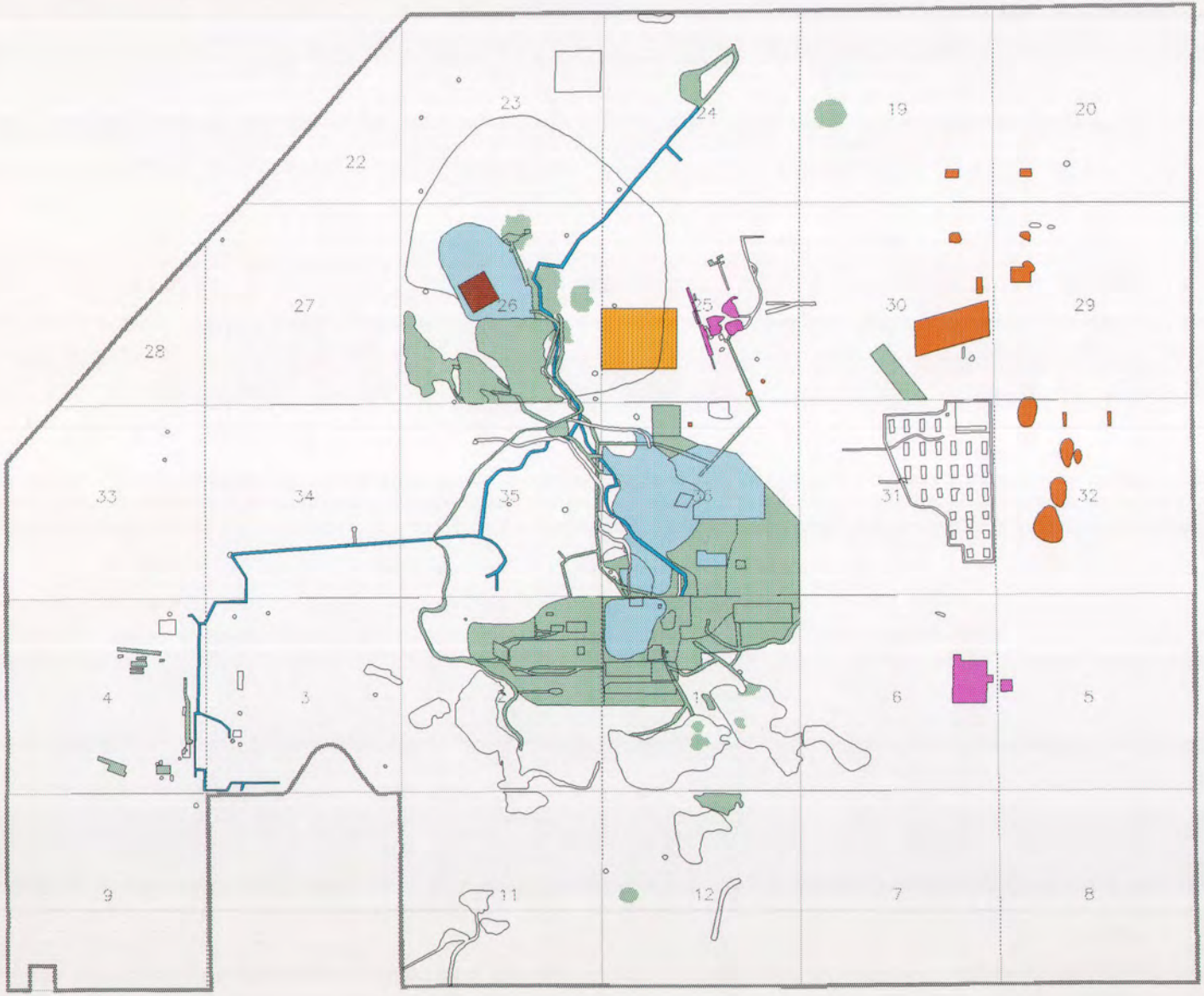
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 7.4-1

Caps/Covers Alternative

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOILS\ROD\SOIL_ES1
Date 6/06/96
Drawn by XG
Checked by SA



Legend

- RMA Boundary
- SAR Site Boundary[1]
- Capped Areas
- Landfill Site
- Areas to be Landfilled
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Basin F Wastepile Cap
- Access Restrictions
- 5 Section Number

[1]Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a).

-N-

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 7.4-2

Landfill/Caps Alternative

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOILS\ROD\SOIL_ES2
Date 6/06/96
Drawn by XG
Checked by SA

Legend

- RMA Boundary
- SAR Site Boundary[1]
- Capped Areas following Landfill
- Landfill Site
- Areas to be Landfilled
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Basin F Wastepile Cap
- 5 Section Number

[1]Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a).

-N-

1500 0 1500 3000 Feet

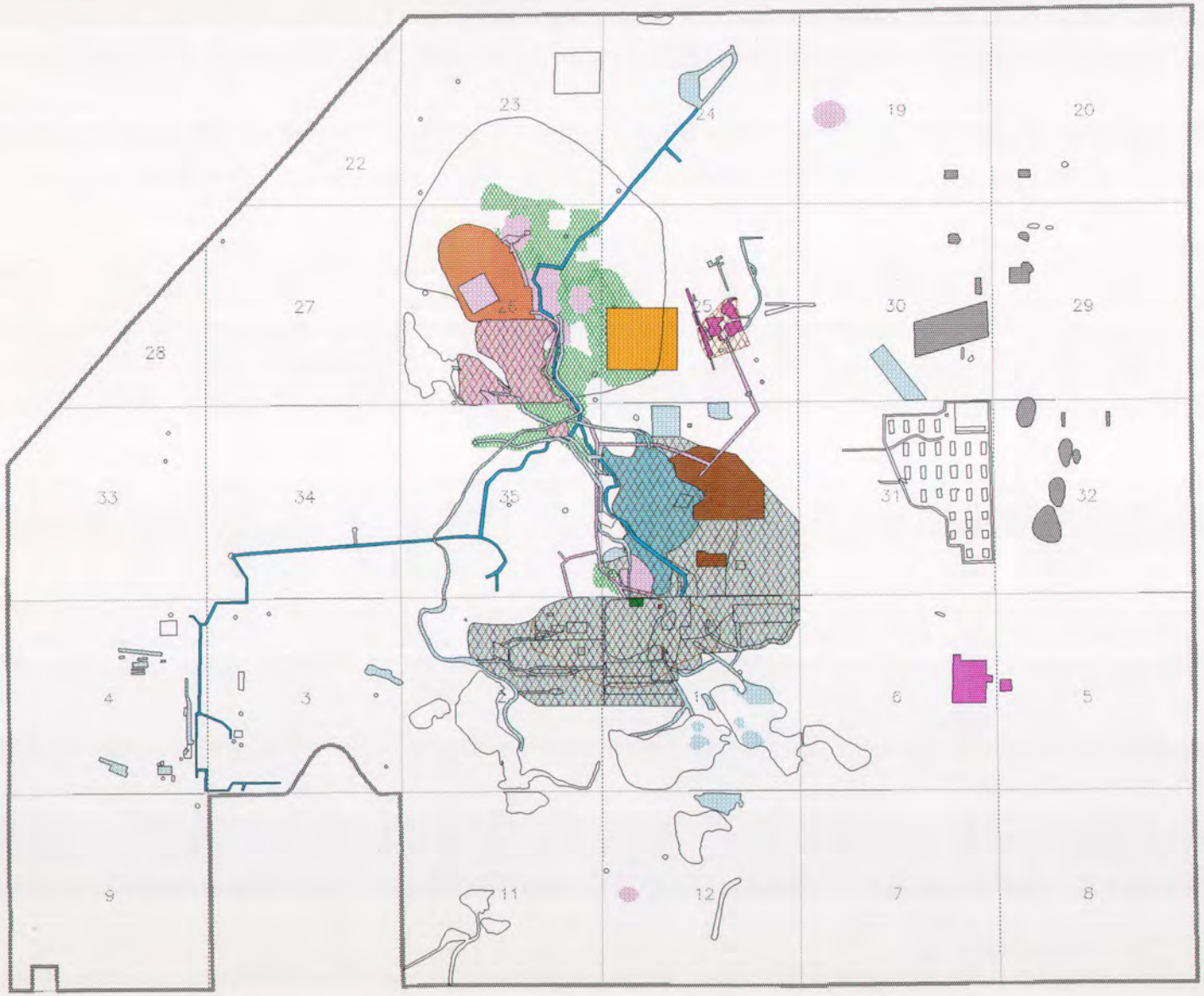
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 7.4-3

Landfill Alternative

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOILS\ROD\SOIL_ES3
Date 6/06/96
Drawn by XG
Checked by SA



Legend

- RMA Boundary
- SAR Site Boundary[1]
- In-situ Solidification of Principal Threat Volume; RCRA-Equivalent Cap
- RCRA-Equivalent Caps
- Direct Solidification/Stabilization
- Innovative Thermal Treatment (Hex Pit)
- Basin A Consolidation Area
- Landfill Human Health Soil,[2] Consolidation of Biota Soil
- Landfill Human Health Soil[3]
- Landfill Site
- Soil Covers
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Surficial Soil Consolidation
- Access Restrictions
- 5 Section Number

[1] Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a)

[2] Debris from the Sanitary Landfills Medium Group will be consolidated.

[3] Wastepile material will be dried prior to landfilling, if necessary, to pass EPA paint filter test.

-N-

1500 0 1500 3000 Feet

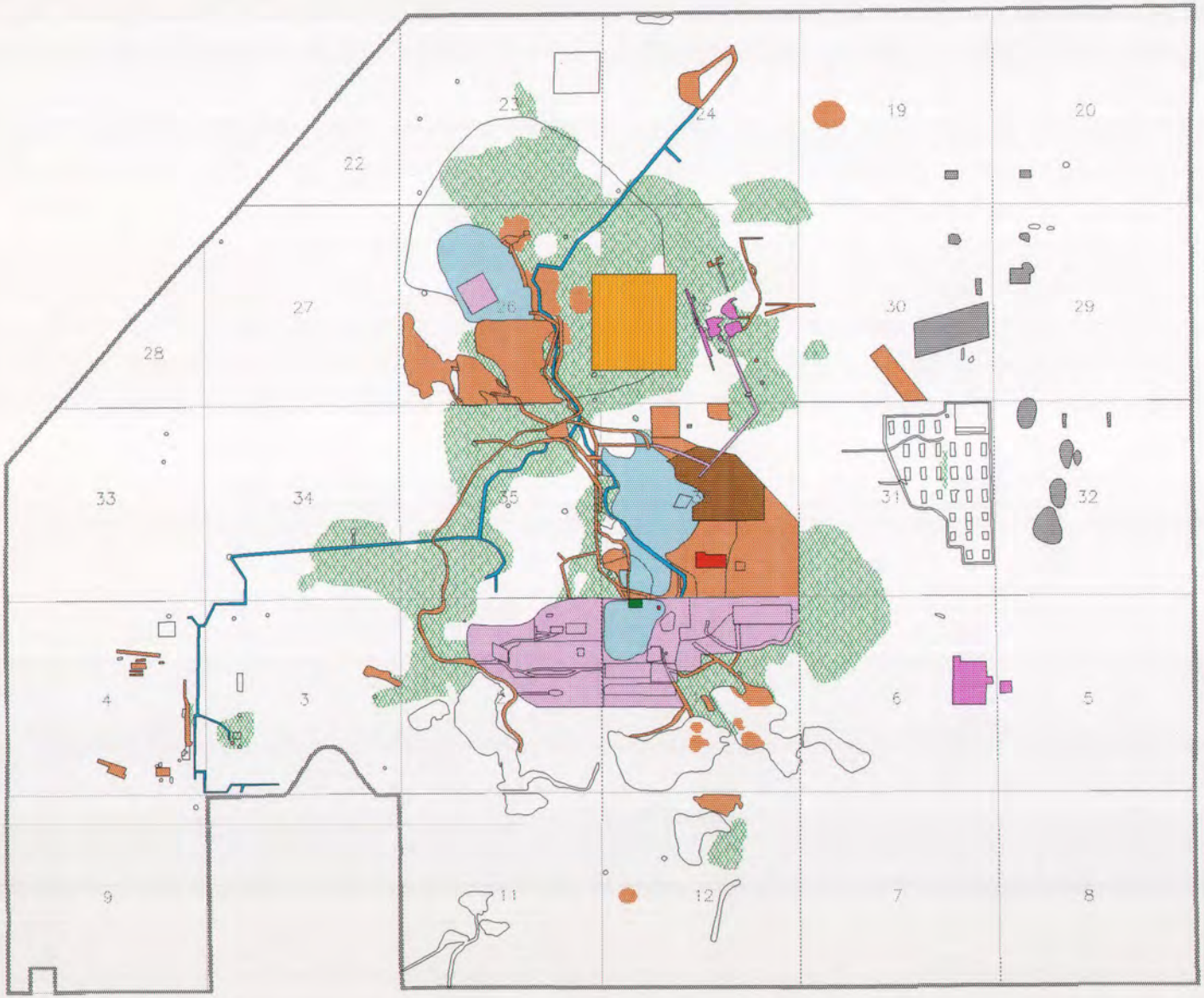
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 7.4-4

Consolidation/Caps/Treatment/ Landfill Alternative

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOILS\ROD\SOIL_ES4
Date 6/06/96
Drawn by XG
Checked by SA



Legend

- RMA Boundary
- SAR Site Boundary[1]
- Landfill and Cap following[2] Thermal Desorption of Principal Threat Volumes in Basin A, Former Basin F, South Plants Central Processing
- Thermal Desorption of Wastepile or Principal Threat Volume; Landfill
- Incineration
- Landfill Site
- Areas to be Landfilled
- Cap
- Direct Solidification/Stabilization
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- In Situ Agricultural Practices
- Access Restrictions
- 5 Section Number

[1]Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a).

[2]Solidification/Stabilization of Principal Threat Volume with inorganic exceedance for South Plants Central Processing Area.

-N-

1500 0 1500 3000 Feet

Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 7.4-5

Caps/Treatment/Landfill Alternative

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOILS\ROD\SOIL_ES5
Date 6/06/96
Drawn by XG
Checked by SA

Table 7.1-1 Description of Water Technologies[1]

Technology	Description
Dewatering	Dewatering involves the withdrawal of groundwater from an underground water-bearing zone, effectively lowering the water table in an area. A lower water table separates contamination in soil near the surface from groundwater. Prior to dewatering, groundwater levels are close to the ground surface. In areas of shallow groundwater, it is relatively easy for chemical spills or contaminants in soil near the surface to migrate down to the groundwater. Following dewatering, contaminated soil and groundwater are separated from each other and further contamination of groundwater is reduced. Dewatering is also used in construction and demolition activities in areas of shallow groundwater to stabilize subsurface soil. For example, before an old building and its basement can be demolished, the ground around it is dewatered. Once an area is dewatered, heavy equipment can be used and water is prevented from filling up the excavation. Dewatering also reduces the chances that the underground walls will cave in on workers.
Granular-Activated Carbon Adsorption	GAC adsorption refers to the removal of dissolved contaminants from an aqueous stream, although it may also be applied to gaseous streams. In the GAC process, water containing dissolved organic compounds is brought into contact with GAC, onto which the organic compounds preferentially adsorb. The attraction of organic molecules in solution to the surface of the carbon is dependent on the strength of the molecular attraction between the carbon and the organic contaminant, the molecular weight of the contaminant, the type and characteristics of the carbon, the surface area of the carbon, and the pH and temperature of the solution. The GAC process option can be used as a single treatment technology or as one of a series of treatments designed to optimally address a contaminant mixture in a treatment process train.
Air Stripping	Air stripping is an effective and proven method for removal of volatile organic compounds from water. The process involves the removal of the volatiles from an aqueous stream by mass transfer through countercurrent contact of the stream with air. Air stripping is a means for transferring the contamination from the liquid phase to gas (vapor). The gases are collected and require additional treatment.

Table 7.1-1 Description of Water Technologies[1]

Technology	Description
In Situ Biological Treatment	In situ biodegradation, or biological treatment, takes advantage of naturally occurring microorganisms in the aquifer that are capable of breaking down and destroying contaminants. In situ means "in place;" the term is appended to the name of this technology because the degradation occurs underground in the aquifer. The microorganisms that make this treatment technology work are already present in the aquifer, but they are not plentiful enough to significantly decrease the concentration of contaminants in the aquifer. To encourage their growth, oxygen and nutrients containing nitrogen are added to the aquifer. This is done by extracting some of the groundwater, adding chemicals to the water, and then reinjecting it into the aquifer. The microorganism population increases after the nutrients are added. The contaminants serve as a source of food for the microorganisms, with the result that the contaminants are destroyed.
Groundwater Extraction/Reinjection	Groundwater extraction methods may be used to collect contaminated groundwater from aquifers for surface treatment and reinjection, to dewater excavations in areas with a shallow water table, and/or to contain a plume of contaminated groundwater. The design of the extraction system is determined by site-specific conditions and the intended purpose of the system. For example, an intercept system may be designed to capture either the leading edge of a plume or the most contaminated portion of the plume. Under a mass-reduction approach, an extraction system is designed to capture the central mass or most contaminated portion of the plume. In addition to removing the mass of contamination, a mass reduction or dewatering approach eliminates contact between overlying contaminated soil and groundwater by lowering the water table. The layout, pumping rates, well spacing, etc., all differ for each of these examples depending on the desired effect. The groundwater extraction technology under consideration is extraction wells, with provisions for trenches/drains if needed. The reinjection method under consideration is a recharge trench. Extracted water is pumped to a treatment facility and the effluent from treatment is reinjected. Recharge trenches are excavated to a depth sufficient to convey water to the water table and may use any type of buried conduit used to convey liquids by gravity flow.

[1] Detailed discussion of all water remediation technologies considered is presented in the Detailed Analysis of Alternatives report.

Table 7.1-2 Description of Structures Technologies[1]

Technology	Description
Structures Demolition	Structures demolition involves the physical dismantling of structures, sizing of debris, and separation of salvageable materials. Dismantling requires the use of medium to heavy equipment to demolish a structure, i.e., to take it apart piece by piece. The structure is broken up using bulldozers, backhoes, wrecking balls, clamshells, universal processors with cutting shears or other similar types of equipment. Contaminants are not treated through this process, but the volume is decreased and converted to a more workable form for subsequent treatment or disposal. Dust-control measures are commonly taken during the operation, generally consisting of spraying or misting water over the work area. Dismantling is applicable to all types and sizes of structures as well as pipes and tanks.
Salvage	Salvage consists of recycling scrap metal, process equipment, and piping. It represents an opportunity to reduce disposal costs and minimize waste streams. Materials that are salvaged include metal structure materials (rebar, support beams, etc.) and process equipment and piping. In addition, salvage includes the recycling of any metal materials that are stockpiled in "boneyards" on post. All metal materials from Army-owned structures are salvaged through the Defense Reutilization and Marketing Office. Metal materials may either be resold to salvage companies, recycled on or off post, or redistributed to Army facilities.
On-Post Landfill	A landfill securely contains contaminated structure debris by providing a physical barrier both above and below the contaminated material. The low-permeability cover protects human and biota receptors from direct contact with the contaminants, and the low-permeability liner restricts contaminant mobility, protecting the underlying soil and groundwater. The landfill technology is applicable primarily for the disposal of untreated soil and debris, but may also be used for the disposal of treated debris and soil/debris mixtures. In addition, oversize materials removed during materials-handling activities for both soil and structures treatment alternatives will also require placement in a landfill.
Caustic Washing of Agent-Contaminated Structure Debris	Caustic washing is a physical/chemical treatment process in which agent-contaminated structural debris is excavated, mixed with caustic wash fluids in an aboveground unit to degrade agent, and then separated from the fluids. The process is carried out at ambient temperature and atmospheric pressure. The makeup of the treatment solution is based upon suspected contaminants and suspected contaminant concentrations. At RMA this process is based upon the suspected presence of GB, VX, lewisite, and mustard. Although there are chemical treatment alternatives that more effectively treat each individual contaminant, this process has been designed to treat all aforementioned compounds and generate by-products of greatly reduced toxicity.

Table 7.1-2 Description of Structures Technologies[1]

Technology	Description
Multilayer Cap	A multilayer cap reduces both the migration of hazardous substances into the surrounding environment by minimizing deep percolation through the contaminated media and the potential for direct exposures by humans or biota to contaminated media through containment (i.e., the isolation of the contaminated media). From top to bottom, a multilayer cap generally consists of three layers: a 4-ft-thick soil/vegetation layer designed to minimize erosion and promote drainage; a 1-ft-thick layer of crushed concrete or cobbles as a biota barrier serving to protect the underlying low-permeability soil layer; and a 2-ft-thick layer of compacted, low-permeability soil. The cap is constructed with sufficient slope to prevent ponding of rainwater. The vegetation used for the top layer consists of locally adapted perennial grasses and low-growing plants selected to minimize erosion and discourage burrowing animals from using the cover as habitat.

1 Detailed discussion of all structures remediation technologies considered is presented in the Detailed Analysis of Alternatives report.

Table 7.1-3 Description of Soil Technologies[1]

Technology	Description
Excavation	Excavation is the removal of soil, debris, drums, pipes, tanks, or any other solid material from the ground. Examples of conventional excavation equipment are bulldozers, backhoes, clamshells, drag lines, front-end loaders, and scrapers. Excavated soil is loaded and transported to a disposal area or treatment facility. Backfilling (using on-post borrow material) and reclamation is required following excavation. Additional process requirements for excavation may include dust suppression, control of air emissions, dewatering, or removal of debris or UXO.
Soil Cover	A soil cover isolates the contaminated media from potential receptors, such as humans or biota, thereby preventing direct exposures through direct contact. A soil cover consists of a variable-thickness layer of soil and may include crushed or formed concrete layers as biota/excavation barriers. Soil covers may be sloped for erosion control and are vegetated with locally adapted perennial grasses and low-growing plants. A soil cover is not intended to provide a low-permeability barrier to infiltration.
Multilayer Cap	A multilayer cap reduces both the migration of hazardous substances into the surrounding environment by minimizing deep percolation through the contaminated media and the potential for direct exposures by humans or biota to contaminated media through containment (i.e., the isolation of the contaminated media). From top to bottom, a multilayer cap generally consists of three layers: a 4-ft-thick soil/vegetation layer designed to minimize erosion and promote drainage; a 1-ft-thick layer of crushed concrete or cobbles as a biota barrier to protect the underlying low-permeability soil layer; and a 2-ft-thick layer of compacted, low-permeability soil. The cap is constructed with sufficient slope to prevent ponding of rainwater. The vegetation used for the top layer consists of locally adapted perennial grasses and low-growing plants selected to minimize erosion and discourage burrowing animals from using the cover as habitat.
Slurry Wall	Slurry walls are vertical barriers that serve to impede the lateral flow of contaminated groundwater. The installation of a slurry wall entails the excavation of a trench, placement of the slurry mixture in the trench, and addition of fill material in the slurry-filled trench. The slurry wall mixture (commonly backfill soil, bentonite, and water) is selected based on compatibility and optimization concerns. The completed slurry wall acts as a low-permeability barrier to lateral groundwater flow. Slurry walls may be installed around sites in conjunction with a multilayer cap to form an isolation cell around the contaminated soil.

Table 7.1-3 Description of Soil Technologies[1]

Technology	Description
Composite Cap	A composite cap reduces both the migration of hazardous substances into the surrounding environment by minimizing infiltration through the contaminated soil and the potential for direct exposures by both humans and biota to contaminated media through containment (i.e., the isolation of the contaminated media). A composite cap consists of multiple layers including a soil/vegetative layer and a flexible-membrane liner overlying a layer of compacted clay. The composite cap design used in the soil alternatives includes a biota-intrusion barrier, drainage layers (sand and geotextile), and a geogrid for stability. The cap is constructed with sufficient slope to prevent ponding of rainwater, and the vegetation used for the top layer consists of locally adapted perennial grasses and low-growing plants selected to minimize erosion and discourage burrowing animals from using the cover as habitat.
On-Post Landfill	A landfill securely contains contaminated soil by providing a physical barrier both above and below the contaminated material. The low-permeability cover protects human and ecological receptors from direct contact with the contaminants, and the low-permeability liner restricts contaminant mobility, protecting the underlying soil and groundwater. The landfill technology is applicable primarily for the disposal of untreated soil and debris, but may also be used for the disposal of treated debris and soil/debris mixtures. In addition, oversize materials removed during materials handling activities for both soil and structures treatment alternatives will also require placement in a landfill.
Thermal Desorption	Thermal desorption uses heat to physically separate volatile (and some semivolatile) organic compounds from soil or sludge. In general, the operating temperature of the desorber (95°C to 540°C) is not high enough to oxidize or destroy the organic compounds to any significant extent, i.e., the desorber separates the organic contaminants so that the secondary combustion chamber may destroy them. Offgas from the secondary combustion chamber is treated for particulates and acid-gas emissions. Thermal desorption also volatilizes some metals; the extent of volatilization is a function of the selected operating temperature. For example, at the higher range of thermal desorption temperatures, mercury is almost entirely volatilized and arsenic is partially removed. Thermal desorption, however, cannot be used as a treatment technology for inorganic contaminant remediation.
Off-Post Demilitarization of UXO	Off-post demilitarization of UXO involves excavation, packaging, and transportation of the UXO to an appropriate Army facility for demilitarization. This process, applicable to any UXO identified involves shipping HE or agent-filled UXO that is safe or rendered safe to an Army facility specially designed for UXO demilitarization.

Table 7.1-3 Description of Soil Technologies[1]

Technology	Description
Caustic Washing of Agent-Contaminated Soil	Caustic washing is a physical/chemical treatment process in which agent-contaminated soil is excavated, mixed with caustic wash fluids in an aboveground unit to degrade agent, and then separated from the fluids. The process is carried out at ambient temperature and atmospheric pressure. The makeup of the treatment solution is based upon suspected contaminants and suspected contaminant concentrations. At RMA, this process is based upon the suspected presence of GB, VX, lewisite, and mustard. Although there are chemical treatment alternatives that more effectively treat each individual contaminant, this process has been designed to treat all aforementioned compounds and generate byproducts of greatly reduced toxicity.
Incineration	Incineration is a high-temperature process that uses either direct or indirect heat exchange to alter or destroy organic contaminants in soil, sludge, sediment, or debris. In general, the operating temperature of the incinerator (640°C to 1,000°C) is high enough to destroy the contaminants by oxidation or pyrolysis. Natural organic material is also burned out of the soil matrix. Incineration will remove, but not destroy, volatile metals such as mercury and arsenic. Off gas from the incinerator passes through a cyclone separator to remove particulates. Residual organic contaminants are destroyed in a secondary combustion chamber. Off gas from the secondary combustion chamber is treated for particulates and acid-gas emissions.
Stabilization/ Solidification	Solidification/stabilization processes use additives, or binding agents, to limit the mobility of contaminants and improve the physical characteristics of the waste by eliminating free liquids and producing a solid with high structural integrity. Although solidification/stabilization has historically addressed inorganic contamination through the use of cement-based agents, the advent of specialized additives has broadened the applicability to media containing both inorganic and organic contamination. Solidification/stabilization can be accomplished using ex situ or in situ processes. Ex situ processes rely on mechanical mixing equipment, such as a pug mill, to properly mix the contaminated soil with the binding agents. Mixing for in situ processes is accomplished using auger or rotor mixers. The binding agents are either placed on the soil surface and are drawn in by the mixing equipment or are injected through nozzles in the augers. An overlapping drilling pattern is used to obtain complete contact with the contaminated soil volume.
Agricultural Practices (Landfarming)	This technology consists of using landfarming techniques either with farm machinery (V-ripper, plow, and disk) or a soil stabilizer along with seeding to facilitate stabilization and attenuation of contaminants in surface soils (0-ft to 1-ft depth interval). Mixing surface contamination with the soil below is expected to promote contaminant loss and to reduce both contaminant exposure to surface receptors and migration of contaminants by surface dust dispersion.

Table 7.1-3 Description of Soil Technologies[1]

Technology	Description
Pipe Plugging	This process option consists of filling the interior of pipes with grout. The purpose is to eliminate this contaminant migration pathway and immobilize contamination within the pipe, reducing its mobility. The technique involves using a mobile grout plant to mix and inject the plugging material into the pipe. The pipes to be plugged are first drained of any residual liquids, and any fittings that block the grout are cut from the pipe run. Aboveground pipe sections are cut into manageable lengths of 100 ft for diameters up to 12 inches and 50 ft for diameters up to 36 inches. The grout is pumped into the pipe run from the low end until it exits the high end, which is closed once grout starts coming out. The lower end is then closed off, and the grout is allowed to harden. Pumping grout from the low end to the high end helps to prevent the formation of voids.

[1] Detailed discussion of all soil remediation technologies considered is presented in the Detailed Analysis of Alternatives report.

Table 7.1-4 Site Evaluation Criteria and Principal Threat Criteria for Soil

Contaminants of Concern	Principal Threat Criteria[2]	Chronic Risk-Based Criteria 0- to 10-ft Interval		Acute and Subchronic Risk-Based Criteria 0- to 1-ft Interval (where lower than chronic)
		Site Evaluation Criteria[2]	Preliminary Remediation Goals[2]	Site Evaluation Criteria[2]
Aldrin	720	71	0.72	3.8
Benzene	10,400	1,040	10	
Carbon Tetrachloride[1]	2,300	30	2.3	
Chlordane[1]	3,700	55	3.7	12
Chloroacetic Acid[1]	77,000	77	77	
Chlorobenzene[1]	850,000	850	850	
Chloroform[1]	48,000	370	48	
DDE	13,000	1,300	13	
DDT[1]	14,000	410	14	14
DBCD	200	8	0.2	
1,2-Dichloroethane	3,200	320	3.2	
1,1-Dichloroethene	520	52	0.52	
DCPD[1]	NA	3,700	3,700	
Dieldrin	410	41	0.41	3.7
Endrin[1]	230,000	230	230	56
HCCPD[1]	NA	1,100	1,100	
Isodrin[1]	52,000	52	52	
Methylene Chloride[1]	35,000	2,300	35	
1,1,2,2-Tetrachloroethane	1,500	150	1.5	
Tetrachloroethylene[1]	5,400	410	5.4	
Toluene[1]	NA	7,200	7,200	
TCE	28,000	2,800	28	
Arsenic	4,200	420	4.2	270
Cadmium[1]	24,000	530	50	140
Chromium[1]	7,500	39	7.5	
Lead[1]	NA	2,200	2,200	
Mercury[1]	570,000	570	570	82

1 SEC based on noncarcinogenic PPLV.
2 Units presented in parts per million.

Table 7.1-5 Soil Exceedance Volumes by Medium Group[1,2]

Medium Group/Subgroup	Human Health Exceedance Volume[3] (BCY)	Principal Threat Exceedance Volume (BCY)	Excess Biota Volume; 0-1 ft (BCY)	Expected Agent Volume (BCY)	Expected UXO Volume (BCY)	UXO Debris Volume[4] (BCY)
Munitions Testing	0	0	0		450	89,000
North Plants	220	0	17,000	61		
Toxic Storage Yards	2,700	0	0	220		
Lake Sediments	16,000	0	19,000			
Ditches/Drainage	0	0	23,000			
Surficial Soil	87,000	1,500	460,000			
Basin A	160,000	32,000	88,000	710	94	47,000
Basin F Wastepile	600,000	600,000	0			
Secondary Basins	32,000	0	140,000			
Former Basin F	740,000	190,000	0			
Sanitary/Process Water Sewers	0	0	0			
Chemical Sewers	86,000	46,000	0	69		
Complex Trenches	400,000	400,000	0	1,300	1,300	130,000
Shell Trenches	100,000	100,000	0			
Hex Pit	3,300	3,300	0			
Sanitary Landfills[5]	14,000	0	23,000			
Section 36 Lime Basins	54,000	9,000	0	91		
Buried M-1 Pits	26,000	22,000	0	29		
S.P. Central Processing[6]	110,000	38,000	27,000	160		
S.P. Ditches	33,000	3,400	22,000			
S.P. Balance of Areas	130,000	11,000	510,000	160	50	5,000
Buried Sediments	16,000	0	0			
Sand Creek Lateral	15,000	0	90,000			
Section 36 Balance of Areas	64,000	0	140,000	300	160	78,000
Burial Trenches	28,000	0	0	12	550	57,000
Total	2,700,000	1,500,000	1,600,000	3,100	2,600	410,000

1 All volumes presented to two significant figures. Detailed volume calculations are available in the administrative record (Foster Wheeler 1996).

2 Individual volumes presented here may differ from those presented in the Detailed Analysis of Alternatives report (Volume IV, Appendix A) due to adjustments for overlap between exceedance categories. The total volume listed for each medium group remains consistent with those presented in the Detailed Analysis of Alternatives report.

3 The human health exceedance volume includes the principal threat exceedance volume.

4 The UXO debris volume includes human health exceedance volume as follows: Basin A, 16,500 BCY; Complex Trenches, 43,000 BCY; Section 36 Balance of Areas, 15,000 BCY; and Burial Trenches, 4,000 BCY.

5 This medium group also contains 380,000 BCY of nonhazardous soil and debris.

6 Exceedance volumes are based on a 5-ft depth cutoff due to difficulties in deeper excavation at this site. Additional exceedance volumes for the 5-ft to 10-ft depth interval are 32,000 BCY human health volume, including 17,000 BCY principal threat volume.

Table 7.1-6 Soil Exceedance Areas by Medium Group[1]

Medium Group/Subgroup	Human Health Exceedance Area (sy)	Principal Threat Exceedance Area (sy)	Excess Biota Area (sy)[2]	Potential Agent Area (sy)	Potential UXO Area (sy)
Munitions Testing	0	0	0		270,000
North Plants	330	0	50,000	28,000	
Toxic Storage Yards	1,700	0	0	130,000	
Lake Sediments	45,000	0	57,000		
Ditches/Drainage	0	0	70,000		
Surficial Soil	260,000	4,500	1,400,000		
Basin A	320,000	35,000	260,000	430,000	140,000
Basin F Wastepile	75,000	75,000	0		
Secondary Basins	92,000	0	410,000		
Former Basin F	350,000	110,000	0		
Sanitary/Process Water Sewers	0	0	0		
Chemical Sewers	100,000	49,000	0	76,000	
Complex Trenches	130,000	120,000	0	390,000	390,000
Shell Trenches	32,000	32,000	0		
Hex Pit	860	860	0		
Sanitary Landfills	12,000	0	69,000		
Section 36 Lime Basins	34,000	6,700	0	34,000	
Buried M-1 Pits	8,700	8,700	0	8,700	
S.P. Central Processing	140,000	42,000	80,000	98,000	
S.P. Ditches	50,000	5,500	65,000		
S.P. Balance of Areas	170,000	8,100	1,500,000	48,000	15,000
Buried Sediments	7,900	0	0		
Sand Creek Lateral	34,000	0	270,000		
Section 36 Balance of Areas	150,000	0	430,000	90,000	230,000
Burial Trenches	12,000	0	0	7,100	170,000
Total	2,000,000	500,000	4,700,000	1,300,000	1,200,000

[1] All areas presented to two significant figures. Detailed area calculations are available in the administrative record.

[2] Biota areas have been calculated to account for overlap with human health exceedance area and potential UXO area.

Table 7.2-1 Description of Water Alternatives

Alternative 1 Boundary Systems	Alternative 2 Boundary Systems / IRAs	Alternative 3 Boundary Systems / IRAs / Dewatering	Alternative 4 Boundary Systems / IRAs / Intercept Systems
Boundary systems continue to operate, but all on-post groundwater IRAs are dismantled. The ICS captures water from the Western Plume Group, the NWBCS captures water from the Northwest Boundary Plume Group, and the NBCS captures water from the North Boundary Plume Group.	Boundary systems continue to operate as in Alternative 1 and the on-post groundwater IRAs remain in operation. The IRAs include the two capture systems at the Motor Pool and Rail Yard area in the Western Plume Group that extract water and pump it for treatment at the ICS, the capture system north of Basin F in the North Boundary Plume Group that extracts water for treatment at the Basin A Neck System, and the Basin A Neck IRA that captures and treats water migrating from Basin A.	Boundary systems and IRAs continue to operate as in Alternative 2. Dewatering and treatment systems are installed to remove the contaminated central portions of the South Plants Plume Group and Basin A Plume Group groundwater. Dewatering accelerates lowering of the water table in South Plants and Basin A; the extracted water is treated in a new system. The South Tank Farm Plume in South Plants is treated separately by in situ biological treatment.	Boundary systems and IRAs continue to operate as in Alternative 2. Additionally, an extraction system is installed in the Section 36 Bedrock Ridge area to minimize contaminant migration from this part of the Basin A Plume Group. The extracted water is piped to the Basin A Neck system. Groundwater plumes in the South Plants area are monitored and lake-level maintenance or other means of hydaulic containment will be used to prevent South Plant plumes from migrating into the lakes at concentrations exceeding CBSGs.

Table 7.2-2 Capital and O&M Costs for Water Alternatives[1, 2]

	Capital		Operating		Total	
Plume Group	Total Cost	PW Cost[3]	Total Cost	PW Cost[3]	Total Cost	PW Cost[3]
Alternative 1						
Northwest Boundary	0	0	32,500,000	21,500,000	32,500,000	21,500,000
Western	0	0	5,940,000	4,890,000	5,940,000	4,890,000
North Boundary	0	0	51,200,000	33,900,000	51,200,000	33,900,000
Basin A	28,500	28,500	3,280,000	2,340,000	3,308,500	2,368,500
South Plants	0	0	3,270,000	2,340,000	3,270,000	2,340,000
On-Post Water Supply[4]	15,000,000	14,600,000	0	0	15,000,000	14,600,000
Total	15,000,000	14,600,000	96,200,000	65,000,000	111,000,000	80,000,000
Alternative 2						
Northwest Boundary	0	0	32,500,000	21,500,000	32,500,000	21,500,000
Western	0	0	5,940,000	4,910,000	5,940,000	4,910,000
North Boundary	80,000	80,000	51,400,000	34,100,000	51,480,000	34,180,000
Basin A	0	0	30,700,000	20,500,000	30,700,000	20,500,000
South Plants	0	0	3,270,000	2,340,000	3,270,000	2,340,000
On-Post Water Supply[4]	15,000,000	14,600,000	0	0	15,000,000	14,600,000
Total	15,100,000	14,700,000	124,000	83,400,000	139,000,000	98,000,000
Alternative 3						
Northwest Boundary	0	0	32,500,000	21,500,000	32,500,000	21,500,000
Western	0	0	5,940,000	4,910,000	5,940,000	4,910,000
North Boundary	80,000	80,000	51,400,000	34,100,000	51,480,000	34,180,000
Basin A	7,050,000	6,940,000	41,300,000	27,600,000	48,350,000	34,540,000
South Plants	5,740,000	5,740,000	20,000,000	14,100,000	25,740,000	19,840,000
On-Post Water Supply[4]	15,000,000	14,600,000	0	0	15,000,000	14,600,000
Total	27,900,000	27,400,000	151,000,000	102,000,000	179,000,000	130,000,000
Alternative 4						
Northwest Boundary	0	0	32,500,000	21,500,000	32,500,000	21,500,000
Western	0	0	5,940,000	4,910,000	5,940,000	4,910,000
North Boundary	80,000	80,000	51,400,000	34,100,000	51,480,000	34,180,000
Basin A	3,540,000	3,540,000	29,800,000	19,800,000	33,340,000	23,340,000
South Plants	80,000	80,000	7,400,000	5,100,000	7,480,000	5,180,000
On-Post Water Supply[4]	15,000,000	14,600,000	0	0	15,000,000	14,600,000
Total	18,700,000	18,300,000	127,000,000	85,400,000	146,000,000	104,000,000

1 Detailed discussion of cost estimates is presented in the Detailed Analysis of Alternatives report.
2 All costs presented in 1995 dollars.
3 Present-worth calculations are based on a 3 percent discount rate.
4 Based on acquisition of a water supply of 1,500 acre-feet. Final on-post water requirements will be determined in the water management plan during remedial design.

Table 7.3-1 Description of Structures Alternatives

Alternative 1 Landfill/Cap in Place	Alternative 2 Landfill/Consolidate	Alternative 3 Landfill
• *No Future Use, Significant Contamination History:* The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill. • *No Future Use, Other Contamination History:* The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris consolidated and capped (multilayer caps) in one of three places: the Rail Yard, North Plants, or the South Plants Central Processing Area. • *No Future Use, Agent History:* The structures are dismantled using dust controls and air monitoring, the debris monitored for the presence of Army chemical agent and caustic washed as necessary, and the resulting debris disposed in the on-post hazardous waste landfill.	• *No Future Use, Significant Contamination History:* The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill. • *No Future Use, Other Contamination History:* The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the Basin A consolidation area. • *No Future Use, Agent History:* The structures are dismantled using dust controls and air monitoring, the debris monitored for the presence of Army chemical agent and caustic washed as necessary, and the resulting debris disposed in the on-post hazardous waste landfill.	• *No Future Use, Significant Contamination History:* The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill. • *No Future Use, Other Contamination History:* The structures are dismantled using dust controls, metals salvaged (if appropriate), and the remaining debris disposed in the on-post hazardous waste landfill. • *No Future Use, Agent History:* The structures are dismantled using dust controls and air monitoring, the debris monitored for the presence of Army chemical agent and caustic washed as necessary, and the resulting debris disposed in the on-post hazardous waste landfill.

Table 7.3-2 Capital and O&M Costs for Structures Alternatives[1, 2]

Medium Group	Capital Total Cost	PW Cost[3]	Operating Total Cost	PW Cost[3]	Total Total Cost	PW Cost[3]
Alternative 1						
No Future Use, Significant Contamination History	1,088,000	1,014,000	13,206,000	12,252,000	14,294,000	13,266,000
No Future Use, Other Contamination History	72,000	68,000	38,728,000	35,685,000	38,800,000	35,753,000
No Future Use, Agent History	5,888,000	5,517,000	55,323,000	51,345,000	61,211,000	56,862,000
Total	7,048,000	6,599,000	107,257,000	99,282,000	114,000,000	106,000,000
Alternative 2						
No Future Use, Significant Contamination History	1,088,000	1,014,000	13,206,000	12,252,000	14,294,000	13,266,000
No Future Use, Other Contamination History	0	0	36,636,000	34,030,000	36,636,000	34,030,000
No Future Use, Agent History	5,888,000	5,517,000	55,323,000	51,345,000	61,211,000	56,862,000
Total	6,976,000	6,531,000	105,165,000	97,627,000	112,000,000	104,000,000
Alternative 3						
No Future Use, Significant Contamination History	1,088,000	1,014,000	13,206,000	12,252,000	14,294,000	13,266,000
No Future Use, Other Contamination History	4,112,000	3,834,000	37,847,000	35,098,000	41,959,000	38,932,000
No Future Use, Agent History	5,888,000	5,517,000	55,323,000	51,345,000	61,211,000	56,862,000
Total	11,088,000	10,365,000	106,376,000	98,695,000	118,000,000	109,000,000

1 Detailed discussion of cost estimates is presented in the Detailed Analysis of Alternatives report.
2 All costs presented in 1995 dollars.
3 Present-worth calculations are based on a 3 percent discount rate.

Medium Groups/ Subgroups	Alternative 1 Caps/Covers[1]	Alternative 2 Landfill/Caps[1]	Alternative 3 Landfill[1]	Alternative 4 Consolidation/Caps/ Treatment/Landfill	Alternative 5 Caps/Treatment/ Landfill[1]
Munitions Testing	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP.	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP.	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP.	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP.	Munitions screening; off-post detonation of UXO; landfill debris and soil above TCLP.
North Plants	Landfill human health exceedance; agent monitoring during excavation; caustic washing; install soil cover over soil posing risk to biota and processing area.	Landfill human health exceedance; agent monitoring during excavation; caustic washing; install soil cover over soil posing risk to biota and processing area.	Landfill human health exceedance; agent monitoring during excavation; caustic washing; install soil cover over soil posing risk to biota and processing area.	Landfill human health exceedance; agent monitoring during excavation; caustic washing; install soil cover over soil posing risk to biota and processing area.	Landfill human health exceedance; agent monitoring during excavation; caustic washing; install soil cover over soil posing risk to biota and processing area.
Toxic Storage Yards	Landfill human health exceedance; utilize New Toxic Storage Yard for borrow area; agent monitoring during excavation and site preparation; caustic washing.	Landfill human health exceedance; utilize New Toxic Storage Yard for borrow area; agent monitoring during excavation and site preparation; caustic washing.	Landfill human health exceedance; utilize New Toxic Storage Yard for borrow area; agent monitoring during excavation and site preparation; caustic washing.	Landfill human health exceedance; utilize New Toxic Storage Yard for borrow area; agent monitoring during excavation and site preparation; caustic washing.	Landfill human health exceedance; utilize New Toxic Storage Yard for borrow area; agent monitoring during excavation and site preparation; caustic washing.
Lake Sediments	Landfill human health exceedances; additional action determined by Parties based on continuing monitoring of biota in these areas.	Landfill human health exceedances; additional action determined by Parties based on continuing monitoring of biota in these areas.	Landfill human health exceedances and soil posing risk to biota (Upper Derby Lake); deferral to USFWS for aquatic sediments.	Landfill human health exceedances and consolidate soil posing risk to biota (Upper Derby Lake); deferral to USFWS for aquatic sediments.	Landfill human health exceedances and soil posing risk to biota (Upper Derby Lake); deferral to USFWS for aquatic sediments.

Table 7.4-1 Description of Soil Alternatives

Medium Groups/ Subgroups	Alternative 1 Caps/Covers[1]	Alternative 2 Landfill/Caps[1]	Alternative 3 Landfill[1]	Alternative 4 Consolidation/Caps/ Treatment/Landfill	Alternative 5 Caps/Treatment/ Landfill[1]
Surficial Soil	Landfill human health exceedances; additional action determined by Parties based on continuing monitoring of biota in these areas.	Landfill human health exceedances; additional action determined by Parties based on continuing monitoring of biota in these areas.	Landfill human health exceedances; additional action determined by Parties based on continuing monitoring of biota in these areas.	Landfill human health exceedances; consolidate soil posing risk to biota in Basin A, Former Basin F, and South Plants; additional action determined by Parties based on continuing monitoring of biota in these areas.	Agricultural practices for soil posing risks to biota and landfill human health exceedances.
Ditches/Drainage Areas	Additional action determined by Parties based on continuing monitoring of biota in these areas.	Additional action determined by Parties based on continuing monitoring of biota in these areas.	Landfill soil posing risk to biota.	Consolidate soil posing risk to biota in Basin A.	Landfill soil posing risk to biota.
Basin A	Cap principal threat and human health exceedances and soil posing risk to biota.	Cap principal threat and human health exceedances and soil posing risk to biota.	Landfill principal threat and human health exceedances; cap entire site including soil posing risk to biota.[2]	Construct soil cover with concrete barrier over principal threat and human health exceedances and soil posing risk to biota; consolidate soil posing risk to biota/structural debris from other sites.	Thermal desorption of principal threat soil; landfill human health including treated soil; cap entire site including soil posing risk to biota.[2]
Basin F Wastepile	Modify existing cap according to RCRA requirements (composite cap).	Modify existing cap according to RCRA requirements (composite cap).	Modify existing cap according to RCRA requirements (composite cap).	Landfill entire wastepile (principal threat exceedance) in triple-lined cell (excavate with vapor control) after drying saturated materials.	Thermal desorption of entire wastepile (principal threat exceedance) (excavate with vapor control); landfill treated soil.

Medium Groups/ Subgroups	Alternative 1 Caps/Covers[1]	Alternative 2 Landfill/Caps[1]	Alternative 3 Landfill[1]	Alternative 4 Consolidation/Caps/ Treatment/Landfill	Alternative 5 Caps/Treatment/ Landfill[1]
Former Basin F	Modify existing cap to RCRA-equivalent cap.	Modify existing cap to RCRA-equivalent cap.	Landfill principal threat and human health exceedances (excavate under vapor enclosure); cap entire site.	In situ solidification/ stabilization of principal threat exceedance volume; cap entire site with RCRA-equivalent cap.	Thermal desorption of principal threat soil (excavate under vapor enclosure); landfill human health exceedances including treated soil; cap entire site.
Secondary Basins	Cap human health exceedances and soil posing risk to biota.	Landfill human health exceedances and soil posing risk to biota.	Landfill human health exceedances and soil posing risk to biota.	Landfill human health exceedances; install soil cover over soil posing risk to biota.	Landfill human health exceedances and soil posing risk to biota.
Sanitary/Process Water Sewers	Plug remaining manholes.	Plug remaining manholes.	Landfill sewer lines.	Plug remaining manholes.	Plug remaining manholes.
Chemical Sewers	Plug sewer lines.	Plug sewer lines in South Plants Central Processing Area and Complex Trenches; landfill remaining principal threat and human health exceedances.[2]	Landfill principal threat and human health exceedances.[2]	Plug sewer lines in South Plants Central Processing Area and Complex Trenches; landfill remaining principal threat and human health exceedances.[2]	Thermal desorption of principal threat soil; landfill human health exceedances including treated principal threat soil.[2]
Complex Trenches	Cap principal threat and human health exceedances and soil posing risk to biota and install a slurry wall around disposal trenches.	Cap principal threat and human health exceedances and soil posing risk to biota and install a slurry wall around disposal trenches.	Cap principal threat and human health exceedances and soil posing risk to biota and install a slurry wall around disposal trenches.	Cap (RCRA-equivalent cap with concrete barrier) principal threat and human health exceedances and soil posing risk to biota and install a slurry wall around disposal trenches.	Cap principal threat and human health exceedances and soil posing risk to biota and install a slurry wall around disposal trenches.

Medium Groups/ Subgroups	Alternative 1 Caps/Covers[1]	Alternative 2 Landfill/Caps[1]	Alternative 3 Landfill[1]	Alternative 4 Consolidation/Caps/ Treatment/Landfill	Alternative 5 Caps/Treatment/ Landfill[1]
Shell Trenches	Modify existing cover and install slurry wall around trenches.	Modify existing cover and install slurry wall around trenches.	Landfill trenches after materials handling (excavate with vapor control).	Modify existing cover to be RCRA-equivalent cap and modify existing slurry wall around trenches.	Incinerate trenches; landfill treated soil (excavate with vapor control).
Hex Pit	Install cap and slurry wall around trenches.	Install cap and slurry wall around trenches.	Landfill disposal pit after materials handling (excavate with vapor control).	Treatment of approximately 1,000 bcy of principal threat material using an innovative thermal technology and landfill remaining soil (excavate with vapor control). Treatment will be revised to a solidification/ stabilization technology if all evaluation criteria for the innovative thermal technology are not met.	Incinerate disposal pit; landfill treated soil (excavate with vapor control).
Sanitary Landfills	Cap entire site.	Landfill human health exceedances, debris, and soil posing risk to biota.	Landfill human health exceedances, debris, and soil posing risk to biota.	Landfill human health exceedances; consolidate debris and soil posing risk to biota in Basin A.	Landfill human health exceedances, debris, and soil posing risk to biota.
Section 36 Lime Basins	Modify existing cover.	Modify existing cover.	Landfill principal threat and human health exceedances; cap entire site.[2]	Landfill principal threat and human health exceedances in triple-lined cell; repair existing soil cover.[2]	Landfill principal threat and human health exceedances; cap entire site.[2]

Medium Groups/ Subgroups	Alternative 1 Caps/Covers[1]	Alternative 2 Landfill/Caps[1]	Alternative 3 Landfill[1]	Alternative 4 Consolidation/Caps/ Treatment/Landfill	Alternative 5 Caps/Treatment/ Landfill[1]
Buried M-1 Pits	Install cap and slurry wall around entire site.	Install cap and slurry wall around entire site.	Landfill principal threat and human health exceedances (excavate with vapor control).[2]	Solidification/ stabilization and landfill of principal threat and human health exceedances (excavate with vapor control).[2]	Solidification/ stabilization and landfill of principal threat and human health exceedances (excavate with vapor control).[2]
South Plants Central Processing Area	Cap principal threat and human health exceedances and soil posing risk to biota.	Cap principal threat and human health exceedances and soil posing risk to biota.	Landfill principal threat and human health exceedances; cap entire site including soil posing risk to biota.[2]	Landfill principal threat and human health exceedances (excavate to depth of 5 feet); construct soil cover with biota barrier over entire site including soil posing risk to biota; consolidate soil posing risk to biota from other South Plants sites.[2]	Thermal desorption and solidification of principal threat exceedances; landfill human health exceedances including treated soil; cap entire site including soil posing risk to biota.[2]
South Plants Ditches	Cap principal threat and human health exceedances and soil posing risk to biota.	Landfill principal threat and human health exceedances and soil posing risk to biota.	Landfill principal threat and human health exceedances and soil posing risk to biota.	Landfill principal threat and human health exceedances; consolidate soil posing risk to biota into excavated areas; install soil cover (variable thickness) over entire site.	Thermal desorption of principal threat soil; landfill human health exceedances, including treated soil and soil posing risk to biota.
South Plants Balance of Areas	Cap principal threat and human health exceedances and soil posing risk to biota.	Landfill principal threat and human health exceedances and soil posing risk to biota.[2,3]	Landfill principal threat and human health exceedances and soil posing risk to biota.[2,3]	Landfill principal threat and human health exceedances; consolidate soil posing risk to biota into excavated areas; install soil cover (variable thickness) over entire site.[2,3]	Thermal desorption of principal threat soil; landfill human health exceedances, including treated soil and soil posing risk to biota.[2,3]

Medium Groups/ Subgroups	Alternative 1 Caps/Covers[1]	Alternative 2 Landfill/Caps[1]	Alternative 3 Landfill[1]	Alternative 4 Consolidation/Caps/ Treatment/Landfill	Alternative 5 Caps/Treatment/ Landfill[1]
Buried Sediments	Cap human health exceedances.	Landfill human health exceedances.	Landfill human health exceedances.	Landfill human health exceedances.	Landfill human health exceedances.
Sand Creek Lateral	Cap human health exceedances and soil posing risk to biota.	Landfill human health exceedances and soil posing risk to biota.	Landfill human health exceedances and soil posing risk to biota.	Landfill human health exceedances; consolidate soil posing risk to biota into Basin A.	Landfill human health exceedances and soil posing risk to biota.
Section 36 Balance of Areas	Cap human health exceedances and soil posing risk to biota.	Landfill human health exceedances and soil posing risk to biota.[2,3]	Landfill human health exceedances and soil posing risk to biota.[2,3]	Landfill human health exceedances; consolidate soil posing risk to biota into Basin A; install soil cover (variable thickness) over entire site.[2,3]	Landfill human health exceedances and soil posing risk to biota.[2,3]
Burial Trenches	Landfill human health exceedances.[2,3]	Landfill human health exceedances.[2,3]	Landfill human health exceedances.[2,3]	Landfill human health exceedances.[2,3]	Landfill human health exceedances.[2,3]

[1] Cap consists of a clay/soil cap unless otherwise noted.
[2] Agent monitoring during excavation and treatment of any soil containing agent by caustic washing.
[3] Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfilling of munitions debris and associated soil above TCLP.

Table 7.4-2 Capital and O&M Costs for Soil Alternatives[1]

Medium Group/Subgroup	Capital Cost Total Cost	Capital Cost Present Worth[2]	O&M Cost Total Cost	O&M Cost Present Worth[2]	Total Cost Total Cost	Total Cost Present Worth[2]
Sitewide Alternative 1 - Caps/Covers						
Munitions Testing	$ 7,110,000	$ 6,150,000	$ 713,000	$ 296,000	$ 7,820,000	$ 6,450,000
North Plants	$ 2,370,000	$ 1,770,000	$ 1,610,000	$ 670,000	$ 3,980,000	$ 2,440,000
Toxic Storage Yards	$ 4,310,000	$ 3,720,000	$ 1,330,000	$ 554,000	$ 5,640,000	$ 4,270,000
Lake Sediments	$ 3,350,000	$ 2,160,000	$ 154,000	$ 63,800	$ 3,500,000	$ 2,220,000
Surficial Soil	$ 12,420,000	$ 8,470,000	$ 680,000	$ 282,000	$ 13,100,000	$ 8,750,000
Ditches/Drainage Areas	$ -	$ -	$ -	$ -	$ -	$ -
Basin A	$ 58,400,000	$ 52,000,000	$ 3,580,000	$ 1,490,000	$ 61,980,000	$ 53,500,000
Basin F Wastepile	$ 8,160,000	$ 5,920,000	$ 6,360,000	$ 2,640,000	$ 14,500,000	$ 8,560,000
Secondary Basins	$ 53,900,000	$ 34,100,000	$ 2,930,000	$ 1,220,000	$ 56,800,000	$ 35,300,000
Former Basin F	$ 36,300,000	$ 24,400,000	$ 2,730,000	$ 1,130,000	$ 39,000,000	$ 25,500,000
Sanitary/Process Water Sewers	$ 344,000	$ 280,000	$ -	$ -	$ 344,000	$ 280,000
Chemical Sewers	$ 853,000	$ 719,000	$ 2,720,000	$ 1,130,000	$ 3,570,000	$ 1,850,000
Complex Trenches	$ 38,400,000	$ 26,600,000	$ 6,970,000	$ 2,900,000	$ 45,400,000	$ 29,500,000
Shell Trenches	$ 2,930,000	$ 2,400,000	$ 2,650,000	$ 1,100,000	$ 5,580,000	$ 3,500,000
Hex Pit	$ 676,000	$ 588,000	$ 984,000	$ 409,000	$ 1,660,000	$ 1,000,000
Sanitary Landfills	$ 14,300,000	$ 10,300,000	$ 1,000,000	$ 416,000	$ 15,300,000	$ 10,700,000
Section 36 Lime Basins	$ 4,520,000	$ 3,280,000	$ 1,200,000	$ 498,000	$ 5,720,000	$ 3,780,000
Buried M-1 Pits	$ 1,660,000	$ 1,450,000	$ 1,020,000	$ 422,000	$ 2,680,000	$ 1,870,000
South Plants Central Processing Area	$ 26,400,000	$ 21,500,000	$ 1,820,000	$ 757,000	$ 28,200,000	$ 22,300,000
South Plants Ditches	$ 8,590,000	$ 6,600,000	$ 1,410,000	$ 586,000	$ 10,000,000	$ 7,190,000
South Plants Balance Of Areas	$ 126,000,000	$ 96,800,000	$ 7,730,000	$ 3,210,000	$ 134,000,000	$ 100,000,000
Buried Sediments	$ 3,380,000	$ 2,840,000	$ 994,000	$ 413,000	$ 4,370,000	$ 3,250,000
Sand Creek Lateral	$ 16,500,000	$ 10,900,000	$ 2,160,000	$ 897,000	$ 18,700,000	$ 11,800,000
Section 36 Balance Of Areas	$ 46,800,000	$ 33,300,000	$ 3,900,000	$ 1,620,000	$ 50,700,000	$ 34,900,000
Burial Trenches	$ 8,190,000	$ 6,680,000	$ 772,000	$ 321,000	$ 8,960,000	$ 7,000,000
Total	$ 486,000,000	$ 363,000,000	$ 55,400,000	$ 23,000,000	$ 542,000,000	$ 386,000,000

Table 7.4-2 Capital and O&M Costs for Soil Alternatives[1]

	Capital Cost		O&M Cost		Total Cost	
Medium Group/Subgroup	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]
Sitewide Alternative 2 - Landfill/Caps						
Munitions Testing	$5,930,000	$5,130,000	$258,000	$110,000	$6,190,000	$5,240,000
North Plants	$2,160,000	$1,610,000	$1,360,000	$581,000	$3,520,000	$2,190,000
Toxic Storage Yards	$3,230,000	$2,790,000	$391,000	$167,000	$3,620,000	$2,960,000
Lake Sediments	$3,100,000	$2,000,000	$55,600	$23,800	$3,160,000	$2,020,000
Surficial Soil	$11,400,000	$7,510,000	$246,000	$105,000	$11,600,000	$7,620,000
Ditches/Drainage Areas	$0	$0	$0	$0	$0	$0
Basin A	$55,900,000	$49,000,000	$3,580,000	$1,530,000	$59,500,000	$50,500,000
Basin F Wastepile	$8,280,000	$6,190,000	$6,360,000	$2,720,000	$14,600,000	$8,910,000
Secondary Basins	$12,900,000	$8,290,000	$487,000	$208,000	$13,400,000	$8,500,000
Former Basin F	$38,200,000	$25,600,000	$2,730,000	$1,170,000	$40,900,000	$26,800,000
Sanitary/Process Water Sewers	$344,000	$280,000	$0	$0	$344,000	$280,000
Chemical Sewers	$12,000,000	$10,000,000	$608,000	$260,000	$12,600,000	$10,260,000
Complex Trenches	$40,100,000	$27,700,000	$6,970,000	$2,980,000	$47,100,000	$30,700,000
Shell Trenches	$2,980,000	$2,440,000	$2,650,000	$1,140,000	$5,630,000	$3,580,000
Hex Pit	$677,000	$590,000	$984,000	$421,000	$1,660,000	$1,010,000
Sanitary Landfills	$29,700,000	$21,500,000	$1,210,000	$520,000	$30,900,000	$22,000,000
Section 36 Lime Basins	$4,680,000	$3,490,000	$1,200,000	$513,000	$5,880,000	$4,000,000
Buried M-1 Pits	$1,680,000	$1,420,000	$1,020,000	$435,000	$2,700,000	$1,860,000
South Plants Central Processing Area	$17,400,000	$13,800,000	$1,820,000	$780,000	$19,200,000	$14,600,000
South Plants Ditches	$4,780,000	$3,670,000	$162,000	$69,400	$4,940,000	$3,740,000
South Plants Balance Of Areas	$47,600,000	$36,000,000	$2,130,000	$912,000	$49,700,000	$36,900,000
Buried Sediments	$1,890,000	$1,590,000	$45,400	$19,400	$1,940,000	$1,610,000
Sand Creek Lateral	$9,370,000	$6,200,000	$303,000	$130,000	$9,670,000	$6,330,000
Section 36 Balance Of Areas	$26,100,000	$18,600,000	$1,350,000	$576,000	$27,500,000	$19,200,000
Burial Trenches	$6,900,000	$5,460,000	$266,000	$114,000	$7,170,000	$5,570,000
Total	$347,000,000	$261,000,000	$36,200,000	$15,500,000	$383,000,000	$276,000,000

Table 7.4-2 Capital and O&M Costs for Soil Alternatives[1]

Medium Group/Subgroup	Capital Cost		O&M Cost		Total Cost	
	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]
Sitewide Alternative 3 - Landfill						
Munitions Testing	$5,790,000	$4,860,000	$197,000	$70,700	$5,990,000	$4,930,000
North Plants	$2,120,000	$1,590,000	$1,310,000	$470,000	$3,430,000	$2,060,000
Toxic Storage Yards	$3,030,000	$2,620,000	$215,000	$77,000	$3,250,000	$2,700,000
Lake Sediments	$4,320,000	$2,550,000	$84,500	$30,300	$4,400,000	$2,580,000
Surficial Soil	$11,200,000	$7,440,000	$188,000	$67,500	$11,400,000	$7,510,000
Ditches/Drainage Areas	$4,270,000	$2,830,535	$114,000	$40,854	$4,380,000	$2,870,000
Basin A	$74,300,000	$61,600,000	$4,810,000	$1,720,000	$79,100,000	$63,300,000
Basin F Wastepile	$8,310,000	$5,850,000	$6,360,000	$2,280,000	$14,700,000	$8,130,000
Secondary Basins	$12,700,000	$7,450,000	$373,000	$134,000	$13,100,000	$7,600,000
Former Basin F	$138,000,000	$85,900,000	$4,450,000	$1,600,000	$142,000,000	$87,500,000
Sanitary/Process Water Sewers	$10,300,000	$8,390,000	$26,600	$9,516	$10,300,000	$8,400,000
Chemical Sewers	$17,800,000	$14,900,000	$415,000	$149,000	$18,200,000	$15,000,000
Complex Trenches	$40,600,000	$22,800,000	$6,970,000	$2,500,000	$47,600,000	$25,300,000
Shell Trenches	$35,300,000	$24,100,000	$221,000	$79,300	$35,500,000	$24,200,000
Hex Pit	$4,770,000	$4,020,000	$7,300	$2,620	$4,780,000	$4,020,000
Sanitary Landfills	$30,000,000	$16,100,000	$929,000	$333,000	$30,900,000	$16,400,000
Section 36 Lime Basins	$10,100,000	$7,130,000	$1,430,000	$511,000	$11,500,000	$7,640,000
Buried M-1 Pits	$6,890,000	$5,800,000	$83,900	$30,100	$6,970,000	$5,830,000
South Plants Central Processing Area	$28,600,000	$21,900,000	$2,270,000	$815,000	$30,900,000	$22,700,000
South Plants Ditches	$4,710,000	$3,510,000	$124,000	$44,500	$4,830,000	$3,550,000
South Plants Balance Of Areas	$46,600,000	$34,000,000	$1,570,000	$562,000	$48,200,000	$34,600,000
Buried Sediments	$1,870,000	$1,530,000	$34,800	$12,500	$1,900,000	$1,540,000
Sand Creek Lateral	$9,230,000	$6,110,000	$232,000	$83,200	$9,460,000	$6,190,000
Section 36 Balance Of Areas	$25,500,000	$14,800,000	$914,000	$328,000	$26,400,000	$15,100,000
Burial Trenches	$6,770,000	$4,490,000	$199,000	$71,200	$6,970,000	$4,560,000
Total	$543,000,000	$372,000,000	$33,500,000	$12,000,000	$576,000,000	$384,000,000

Table 7.4-2 Capital and O&M Costs for Soil Alternatives[1]

	Capital Cost		O&M Cost		Total Cost	
Medium Group/Subgroup	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]
Sitewide Alternative 4 - Consolidation/Caps/Treatment/Landfill						
Munitions Testing	$6,150,000	$5,320,000	$379,000	$157,000	$6,530,000	$5,480,000
North Plants	$2,120,000	$1,580,000	$1,340,000	$557,000	$3,460,000	$2,140,000
Toxic Storage Yards	$3,160,000	$2,730,000	$334,000	$139,000	$3,490,000	$2,870,000
Lake Sediments	$3,790,000	$2,440,000	$81,700	$33,900	$3,870,000	$2,470,000
Surficial Soil	$20,000,000	$13,500,000	$361,000	$150,000	$20,400,000	$13,700,000
Ditches/Drainage Areas	$2,410,000	$1,600,000	$0	$0	$2,410,000	$1,600,000
Basin A	$52,900,000	$42,500,000	$4,330,000	$1,800,000	$57,200,000	$44,300,000
Basin F Wastepile	$130,000,000	$92,300,000	$2,180,000	$904,000	$132,000,000	$93,200,000
Secondary Basins	$7,840,000	$5,350,000	$2,010,000	$835,000	$9,850,000	$6,190,000
Former Basin F	$83,200,000	$52,800,000	$4,210,000	$1,750,000	$87,400,000	$54,600,000
Sanitary/Process Water Sewers	$344,000	$289,000	$0	$0	$344,000	$289,000
Chemical Sewers	$12,000,000	$10,400,000	$619,000	$257,000	$12,600,000	$10,700,000
Complex Trenches	$47,000,000	$31,100,000	$8,370,000	$3,480,000	$55,400,000	$34,600,000
Shell Trenches	$2,850,000	$2,330,000	$3,400,000	$1,410,000	$6,250,000	$3,740,000
Hex Pit	$5,180,000	$4,480,000	$9,800	$4,100	$5,190,000	$4,480,000
Sanitary Landfills	$14,600,000	$11,200,000	$58,600	$24,300	$14,700,000	$11,200,000
Section 36 Lime Basins	$8,170,000	$6,090,000	$326,000	$135,000	$8,500,000	$6,230,000
Buried M-1 Pits	$24,000,000	$20,100,000	$192,000	$79,800	$24,200,000	$20,200,000
South Plants Central Processing Area	$18,900,000	$15,400,000	$2,950,000	$1,220,000	$21,900,000	$16,600,000
South Plants Ditches	$3,020,000	$2,390,000	$142,000	$58,900	$3,160,000	$2,450,000
South Plants Balance Of Areas	$34,900,000	$27,600,000	$4,960,000	$2,060,000	$39,900,000	$29,700,000
Buried Sediments	$1,830,000	$1,540,000	$66,800	$27,700	$1,900,000	$1,570,000
Sand Creek Lateral	$4,720,000	$3,130,000	$62,400	$25,900	$4,780,000	$3,160,000
Section 36 Balance Of Areas	$19,100,000	$13,600,000	$3,500,000	$1,450,000	$22,600,000	$15,100,000
Burial Trenches	$7,100,000	$6,140,000	$377,000	$157,000	$7,480,000	$6,300,000
Contingent Soil Volume	$9,860,000	$8,020,000	$637,000	$265,000	$10,500,000	$8,300,000
Total	$525,000,000	$384,000,000	$40,900,000	$17,000,000	$566,000,000	$401,000,000

Table 7.4-2 Capital and O&M Costs for Soil Alternatives[1]

Medium Group/Subgroup	Capital Cost		O&M Cost		Total Cost	
	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]	Total Cost	Present Worth[2]
Sitewide Alternative 5 - Caps/Treatment/Landfill						
Munitions Testing	$5,710,000	$4,800,000	$174,000	$52,300	$5,880,000	$4,850,000
North Plants	$2,130,000	$1,590,000	$1,310,000	$393,000	$3,440,000	$1,980,000
Toxic Storage Yards	$3,020,000	$2,610,000	$214,000	$64,100	$3,230,000	$2,670,000
Lake Sediments	$4,300,000	$2,000,000	$74,600	$22,400	$4,370,000	$2,020,000
Surficial Soil	$11,700,000	$6,680,000	$166,000	$49,900	$11,900,000	$6,730,000
Ditches/Drainage Areas	$4,230,000	$2,570,000	$101,000	$30,200	$4,330,000	$2,600,000
Basin A	$73,300,000	$50,200,000	$13,300,000	$4,000,000	$86,600,000	$54,200,000
Basin F Wastepile	$87,200,000	$63,000,000	$206,000,000	$61,900,000	$293,000,000	$125,000,000
Secondary Basins	$12,500,000	$6,550,000	$329,000	$98,800	$12,800,000	$6,650,000
Former Basin F	$151,000,000	$98,600,000	$53,400,000	$16,000,000	$204,000,000	$115,000,000
Sanitary/Process Water Sewers	$344,000	$297,000	$0	$0	$344,000	$297,000
Chemical Sewers	$19,200,000	$16,100,000	$12,800,000	$3,850,000	$32,000,000	$20,000,000
Complex Trenches	$40,800,000	$22,900,000	$6,970,000	$2,090,000	$47,800,000	$25,000,000
Shell Trenches	$52,000,000	$31,100,000	$37,100,000	$11,100,000	$89,100,000	$42,200,000
Hex Pit	$5,490,000	$4,490,000	$1,220,000	$367,000	$6,710,000	$4,860,000
Sanitary Landfills	$29,700,000	$14,000,000	$820,000	$246,000	$30,500,000	$14,200,000
Section 36 Lime Basins	$10,100,000	$5,450,000	$1,410,000	$424,000	$11,510,000	$5,870,000
Buried M-1 Pits	$13,600,000	$10,800,000	$9,090,000	$2,730,000	$22,700,000	$13,500,000
South Plants Central Processing Area	$29,800,000	$24,300,000	$13,000,000	$3,890,000	$42,800,000	$28,200,000
South Plants Ditches	$4,740,000	$3,640,000	$781,000	$234,000	$5,520,000	$3,870,000
South Plants Balance Of Areas	$46,300,000	$36,100,000	$3,480,000	$1,040,000	$49,800,000	$37,100,000
Buried Sediments	$1,860,000	$1,130,000	$30,700	$9,210	$1,890,000	$1,140,000
Sand Creek Lateral	$9,150,000	$5,380,000	$205,000	$61,500	$9,360,000	$5,440,000
Section 36 Balance Of Areas	$25,200,000	$13,400,000	$840,000	$252,000	$26,000,000	$13,700,000
Burial Trenches	$6,700,000	$5,150,000	$177,000	$53,000	$6,880,000	$5,200,000
Total	$650,000,000	$433,000,000	$363,000,000	$109,000,000	$1,012,000,000	$542,000,000

[1] All costs presented in 1995 dollars.

[2] Present-worth calculations based on a 3 percent discount rate.

8.0 Comparative Analysis of Alternatives

The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to the others and to identify the tradeoffs to be made in selecting the preferred alternatives. A preferred alternative was developed for each contaminated medium (groundwater, structures and soil) because the interactions among potential soil alternatives and water or structures alternatives were most effectively addressed in this manner.

The NCP identifies nine criteria to be used in the evaluation of remedial alternatives during the Detailed Analysis of Alternatives (Figure 8.0-1). Criteria 1 and 2 (Overall Protection of Human Health and the Environment, and Compliance with ARARs) are considered "threshold criteria" that must be met by the preferred alternative. Criteria 3 through 7 (Short-Term Effectiveness; Long-Term Effectiveness; Reduction of Toxicity, Mobility, or Volume through Treatment; Implementability; and Cost) are considered "balancing criteria" because they are used to achieve the best overall solution, taking into account technical, cost, institutional, and risk concerns. As required by EPA guidance, costs are compared on a present worth basis. The present worth cost is the amount of principal (in current dollars) needed to yield the total cost over the desired time frame; it accounts for interest gained on principal invested at the start of the project and the cost of inflation over the life of the project. Criteria 8 and 9 (State Acceptance and Community Acceptance) are used to evaluate the feasibility of implementing an alternative in terms of its acceptance by regulatory agencies and the community.

8.1 Comparative Analysis of Alternatives for Groundwater

The four groundwater alternatives compared in this section all include continued operation of the boundary containment and treatment systems that are currently operational at RMA. Three of the four alternatives (Alternatives 2, 3, and 4) involve continued operation of the existing IRAs, and two alternatives (Alternatives 3 and 4) include construction of additional on-post extraction and treatment systems. The No Action alternative (which involves discontinuing the existing boundary systems) was evaluated in the FS, but because it does not achieve the threshold criteria (overall protection of human health and the environment and compliance with ARARs), it was not retained as a potential remedy. A summary of the comparative analysis of the groundwater alternatives is provided in Table 8.1-1.

8.1.1 Overall Protection of Human Health and the Environment

All four groundwater alternatives are protective of human health and the environment because groundwater is treated at the RMA boundary and because restrictions for potable on-post water use imposed by the FFA are observed. Nonpotable uses of on-post groundwater were not anticipated and risk was therefore not considered

in the HHRC for such uses. A risk evaluation would be performed prior to any future nonpotable use to ensure that such use is protective of human health and the environment.

A greater degree of protection is provided by Alternative 3 (Boundary Systems/IRAs/Dewatering), which reduces on-post migration through additional on-post extraction and treatment systems. The operation of the dewatering and extraction systems will reduce flow through Basin A Neck, reduce the South Plants groundwater mound, limit migration into the lakes, and prevent flow through the Section 36 bedrock ridge. Migration is also reduced by the on-post systems included in Alternatives 2 (Boundary Systems/IRAs) and 4 (Boundary Systems/IRAs/Intercept Systems). Because Alternative 4 includes an additional on-post system (the Section 36 Bedrock Ridge Extraction System), it is slightly more protective than Alternative 2. Alternatives 2 and 4 also result in a natural lowering of the water table in South Plants when combined with the soil covers or caps in this area. Lowering of the water table will reduce further spreading of contamination, thereby protecting human health and the environment. Alternative 1 (Boundary Systems) is adequately protective of human health and the environment, but is slightly less protective than the other three alternatives because it only addresses groundwater contamination at the boundaries. Site reviews will be conducted every 5 years to evaluate the effectiveness of the remedies and ensure protection of human health and the environment.

8.1.2 Compliance with ARARs

All four alternatives, if selected, are expected to meet chemical-specific ARARs identified for each treatment system and comply with action- and location-specific ARARs. The remediation goals for chloride and sulfate at the NBCS will be achieved through natural attenuation. The goal for sulfate will be the natural background concentration. Assessment of the chloride and sulfate concentrations will occur at the 5-year site review. Monitoring and assessment of NDMA contamination will occur in support of potential design refinement/design characterization to achieve the remediation goals specified for boundary groundwater treatment systems.

8.1.3 Long-Term Effectiveness and Permanence

All four alternatives provide a high degree of long-term effectiveness and permanence because operation of the boundary systems eliminates the potential for off-post exposure and because restrictions for potable on-post water use imposed by the FFA are observed. Nonpotable uses of on-post groundwater were not anticipated and risk was therefore not considered in the HHRC for such uses. A risk evaluation would be performed prior to any future nonpotable use to ensure that such use is protective of human health and the environment.

Boundary system operations are proven, effective, and reliable, and treatment residuals are safely disposed off post. All alternatives also reduce contaminant migration through passive dewatering, a result of a reduction of

infiltration and removal of water from process and fire protection pipes in the areas of South Plants and Basin A that will be covered as a part of the selected soil remedy. Additionally, Alternative 2 reduces contaminant migration through operation of the IRAs. Alternative 3 achieves contaminant reduction through active dewatering as well as operation of the on-post IRAs. Alternative 4 reduces contaminant migration through continued operation of the IRAs and the Section 36 Bedrock Ridge Extraction System.

8.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Operation of the boundary systems, which is a component of all four alternatives, provides substantial reduction in toxicity, mobility, or volume through treatment of contaminated groundwater; approximately 1 billion gallons per year of water are currently being treated at the systems. Alternatives 2, 3, and 4 provide additional reduction in toxicity, mobility, or volume because they involve operation of the IRAs and additional on-post extraction/treatment systems. Compared to Alternative 1, Alternatives 2 and 4 treat approximately 170 million additional gallons per year, while Alternative 3 treats an additional 215 million gallons per year for the first 10 years and 190 million gallons per year for the next 20 years. On-post treatment under Alternatives 2, 3, or 4 will be continued until remediation is complete.

All alternatives achieve reductions in contaminant mobility and volume through passive dewatering, which is a result of installation of the soil covers or caps in the Basin A and South Plants areas. Mobility and volume are not reduced through treatment but through passive methods. Alternative 3 achieves the most rapid reduction in toxicity, mobility, or volume through active dewatering, which lowers the water table, thereby reducing migration and leaching of residual contamination from soil. Alternative 4 is slightly more effective in reducing toxicity than Alternative 2 because the additional volume of contaminated water that is extracted and treated is small. Alternative 4 also reduces or prevents the mobility of contaminants in groundwater, thus reducing/preventing their migration into the First Creek alluvial channel.

8.1.5 Short-Term Effectiveness

All four alternatives are protective of workers, the community, and the environment during the construction and implementation phases. Alternative 2 has the least impact as it is already in place and involves no additional actions. Alternatives 1 and 4 have minimal potential impacts. For Alternative 1, these impacts are associated with demolition of the existing IRAs; for Alternative 4, they are associated with drilling and construction of the Section 36 Bedrock Ridge Extraction System. Alternative 3 involves more intrusive activities than the other three alternatives, but it can still be implemented within a fairly short time period and with minimal negative impact to workers, the community, and the environment.

8.1.6 Implementability

Alternative 2 is most easily implemented because it involves continued operation of all existing systems without any additional construction or demolition. Alternatives 1 and 4 are slightly more difficult to implement than Alternative 2 because they involve installation of a small extraction and piping system (Alternative 4) or demolition of the existing IRAs (Alternative 1). Alternative 3 is the most difficult to implement since it requires installation of horizontal well networks and a new treatment system. All of the alternatives use available technologies that are both technically and administratively implementable, although horizontal wells are an innovative technology. The monitoring systems included in each alternative will allow evaluation of the effectiveness of the remedy, and additional actions could be implemented readily if monitoring indicated that ARARs were not being met.

8.1.7 Cost

The total present worth costs for the groundwater alternatives range from $80 million to $130 million (1995 dollars). Alternative 1 has the lowest cost at $80 million, Alternatives 2 and 4 have comparable present worth costs at $98 million and $104 million, respectively, and Alternative 3 is the most expensive alternative at $130 million. A breakdown of O&M costs for the components of each alternative is presented in Table 7.2-2.

8.1.8 State Acceptance

The state of Colorado has been actively involved throughout the RI/FS and remedy selection process for the On-Post Operable Unit. The state was provided the opportunity to comment on the RI/FS documents and on the Proposed Plan, and has taken part in numerous public meetings, including the public meeting on November 18, 1995, to inform the public of the content of the Proposed Plan. Written comments received from the state during the public comment period indicate their concern about the water-supply issue, the Medical Monitoring Program, the Trust Fund, and hydraulic control of the lakes in the South Lakes area.

Responses to the state's comments are provided in the Responsiveness Summary (Section 12).

8.1.9 Community Acceptance

Interested members of the public, including individual citizens, representatives of the local communities, and representatives of national groups, have been actively involved in reviewing the FS and evaluating potential remedial alternatives for the past 2 years as a result of the outreach program described in Section 3. The preferred groundwater alternative for the On-Post Operable Unit was presented to the public in the Proposed Plan, which provides a brief summary of all of the alternatives evaluated during the Detailed Analysis of Alternatives phase of the FS. The original comment period of 60 days was extended to 90 days at the request of some commenters.

The concerns expressed by the public included the water-supply issue, the adequacy of the selected remedy and the monitoring program, the implementation of the Medical Monitoring Program, the establishment of the Trust Fund, and presence of NDMA in groundwater.

Responses to the communities comments are provided in the Responsiveness Summary. (Section 12).

8.1.10 Conclusions

All four groundwater alternatives provide adequate protection of human health and the environment through continued operation of the boundary systems. Alternative 3 is more protective than the other alternatives because it removes the largest amount of contaminants and most rapidly reduces the potential for additional on-post migration. Alternative 4 is more protective than Alternative 2 because it involves additional treatment beyond the existing IRAs, and Alternative 2 is more protective than Alternative 1.

All alternatives will comply with ARARs and all provide equivalent long-term effectiveness and permanence. Alternative 3 provides the greatest reduction in toxicity, mobility, or volume through treatment, but it is less effective in the short term and less implementable than the other three alternatives because it involves construction of new extraction and treatment systems. Alternative 4 provides a greater reduction in toxicity, mobility, or volume through treatment than Alternatives 1 or 2, but it is slightly less effective in the short term and is slightly less implementable than Alternative 2. The short-term effectiveness and implementability of Alternative 1 is similar to that of Alternative 4, but Alternative 1 provides the least reduction in toxicity, mobility, or volume through treatment of contaminated groundwater.

Alternative 1 has the lowest present worth cost because all existing IRAs are discontinued, while Alternative 3 has the highest cost because it involves the most new construction and treatment. The costs of Alternatives 2 and 4 lie between Alternatives 1 and 3. Alternative 4 provides a small amount of additional treatment compared to Alternative 2 at a slightly higher cost.

Alternative 4 is superior to the other groundwater remedial alternatives for the On-Post Operable Unit for the following principal reasons:

- Alternative 4 is preferable to Alternatives 1 and 2 because it provides additional reduction of toxicity, mobility, or volume of contaminated groundwater at a reasonable cost and with minimal short-term effects. It is also readily implementable.
- Although Alternative 3 provides greater reduction of toxicity, mobility, and volume than Alternative 4, it is less readily implementable than Alternative 4. Furthermore, when considered in conjunction with the preferred soil alternative and the continued operation of the boundary groundwater containment and treatment systems, Alternative 3 provides limited added benefit compared to Alternative 4 at a higher cost.

8.2 Comparative Analysis of Alternatives For Structures

The three structures alternatives compared in this section involve removing all No Future Use structures and disposing the debris in the on-post hazardous waste landfill. All structures alternatives include the completion or continuation of structures IRAs as described in Section 7.3.3. The ultimate disposal method for the structures medium groups is chosen based on the following approach:

- The Agent History Group must be disposed in the hazardous waste landfill to comply with Army regulations.
- The Significant Contamination History Group contains structures with use histories that indicate a possibility of significant contamination. This group is disposed in the hazardous waste landfill.
- For the Other Contamination History Group, the disposal options include capping in place, consolidation in Basin A, or disposal in the on-post hazardous waste landfill.

The No Action Alternative (which involves leaving all structures in place) was evaluated in the FS, but it was not retained as a potential remedy because it did not achieve a threshold criterion (overall protection of human health and the environment). A summary of the comparative analysis of the structures alternatives is provided in Table 8.2-1.

8.2.1 Overall Protection of Human Health and the Environment

All three structures alternatives are protective of human health and the environment because all potentially contaminated structures are demolished and disposed to prevent exposure to humans or wildlife. Alternative 3 (Landfill) is slightly more protective than Alternative 2 (Landfill/Consolidate) because all structural debris is placed in the on-post hazardous waste landfill. Alternative 2 is in turn slightly more protective than Alternative 1 (Landfill/Cap in Place) because the debris that is not landfilled is consolidated at one location under a thick soil cover that includes a layer of concrete. Agent-contaminated debris is treated as necessary under all three alternatives, but other treatment is not undertaken because there is a potential for increased worker exposures at no added benefit.

8.2.2 Compliance with ARARs

All three structures alternatives comply with the chemical-, action- and location-specific ARARs listed in Appendix A.

8.2.3 Long-Term Effectiveness and Permanence

All three structures alternatives provide adequate long-term effectiveness and permanence. Removal and disposal of the structures involves significantly less long-term risk than leaving the structures in place and restricting access to them. Additionally, the majority of the structures must be removed to accommodate the soil remedial alternatives. Because structure debris is contained by capping or landfilling, there is low residual risk.

Because high levels of contamination are not expected to be associated with the majority of the structures, the long-term risks associated with waste management are expected to be low. Adequate controls are provided, and the permanence of the solution is verified by long-term monitoring. Alternatives 2 and 3 are slightly more effective in the long term than Alternative 1 because the structural debris is consolidated into central locations (the landfill and, for Alternative 2, Basin A) rather than remaining dispersed under several caps that require additional long-term maintenance.

8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

All three structures alternatives reduce contaminant toxicity, mobility, or volume through treatment. Demolition of structures reduces the standing volume. Capping or landfilling the structural debris reduces the mobility of contaminants through engineering controls, although this reduction may be compromised should the cap or landfill leak. Caustic washing irreversibly reduces the toxicity, mobility, and volume of Army chemical agent through treatment, but produces a hazardous liquid sidestream that will be treated on post. Alternative 3 is slightly more effective in reducing mobility than Alternative 2 because the structural debris is contained in a landfill, and Alternative 2 is slightly more effective in reducing mobility than Alternative 1 because the debris is consolidated into two central locations rather than dispersed under several caps that require additional long-term maintenance.

8.2.5 Short-Term Effectiveness

All three structures alternatives provide equal short-term effectiveness. Air monitoring and dust controls are required during demolition, transportation, and disposal. Worker protection will be required for physical hazards associated with dismantling and for chemical hazards associated with caustic washing and handling of agent-contaminated debris. Remediation is completed within 3 to 4 years under all three alternatives. Because high levels of contamination are not expected to be associated with the majority of the structures, the risks associated with short-term worker and community exposure are expected to be low for all alternatives.

There are unique concerns for structures with potential Army chemical agent presence. After demolishing the structures, caustic washing is administered to debris, as necessary, and the debris is disposed in the on-post hazardous waste landfill to comply with Army agent regulations. Because the highest probability of encountering agent residues is in process piping and tanks, which are currently being treated and removed as part of the chemical process-related IRA activities, the potential for encountering agent associated with building materials is low. Thus, short-term risks during such remediation activities are considered low for all alternatives.

8.2.6 Implementability

All three structures alternatives are generally technically and administratively feasible, although Alternatives 2 and 3 are more implementable because there are regulatory concerns with capping structural debris in place (Alternative 1). Implementation of structures remediation will require coordination with the remediation scheduled for other environmental media. However, because the time frame during which structures are to be demolished is relatively short, structures remediation should not hinder the remainder of the remediation efforts. The structures demolition must begin in the areas in which soil remediation is planned so that the soil remediation schedule is not delayed. Structures covered under any chemical weapons agreements may need to be removed to comply with the requirements of these agreements.

Significant Contamination History Group and Agent History Group structural debris will be placed into the on-post hazardous waste landfill as demolition proceeds. Accordingly, the landfill must be constructed and in operation prior to the commencement of demolition activities. Other Contamination History Group debris may be placed in the Basin A consolidation area, which requires minimal preparation; in the on-post hazardous waste landfill, which must be ready before demolition begins; or in the areas to be capped, which require minimal preparation. In general, structures must be removed before the soil remedy can be implemented.

8.2.7 Cost

The present worth costs (1995 dollars) are similar for all three alternatives ($106 million for Alternative 1, $104 million for Alternative 2, and $109 million for Alternative 3) because the alternatives only differ with regard to the disposal method for the Other Contamination History Group debris. There are several ongoing structures IRAs whose costs also contribute significantly to the total cost of structures remediation. The total estimated structures IRA costs are $76,000,000, of which $41,000,000 will be spent by the completion of the ROD (and is not included in the above costs), and an additional $35,000,000 will be spent in post-ROD removal actions (not included in the above costs). A breakdown of capital and O&M costs for the components of each alternative is presented in Table 7.3-2.

8.2.8 State Acceptance

The state has been actively involved throughout the RI/FS and remedy selection process for the On-Post Operable Unit. The state was provided the opportunity to comment on the RI/FS documents and on the Proposed Plan, and has taken part in numerous public meetings, including the public meeting on November 18, 1995, to inform the public of the content of the Proposed Plan. Written comments received from the state during the public comment period indicate that there were no major concerns regarding the structures remedy.

Responses to the state's comments are provided in the Responsiveness Summary (Section 12).

8.2.9 Community Acceptance

Interested members of the public, including individual citizens, representatives of the local communities, and representatives of national groups, have been actively involved in reviewing the FS and evaluating potential remedial alternatives for the past 2 years as a result of the outreach program described in Section 3. The preferred structures alternative for the On-Post Operable Unit was presented to the public in the Proposed Plan, which provides a brief summary of all of the alternatives evaluated during the Detailed Analysis of Alternatives phase of the FS. This original comment period of 60 days was extended to 90 days at the request of some commenters.

The concerns expressed by the public included questions with regards to the adequacy of the structures sampling and analytical program. Responses to the community's comments are provided in the Responsiveness Summary (Section 12).

8.2.10 Conclusions

All three structures alternatives provide adequate protection of human health and the environment. Treatment technologies are generally not included because of the exposure risks to workers and the limited benefits for all but the Agent History Group. On-post hazardous waste landfilling for the Significant Contamination History Group is a protective remedy that is included in all three alternatives. The long-term effectiveness of Alternatives 2 and 3 is higher than Alternative 1, which relies on caps in several disposal locations. All three alternatives are equivalent with respect to reduction of toxicity, mobility, or volume through treatment or engineering controls and short-term effectiveness. For Alternative 1, regulatory concerns remain about capping Other Contamination History Group debris in place, which makes its implementibility less certain. Consolidation or landfilling of Other Contamination History Group debris (under Alternatives 2 and 3, respectively) is implementable and cost effective.

Alternative 2 is superior to the other structures alternatives for the On-Post Operable Unit for the following principal reasons:

- Alternatives 2 and 3 are preferable to Alternative 1 because they are more implementable and structural debris is consolidated into one or two disposal locations.
- Alternative 2 is more desirable than Alternative 3 because the Other Contamination History Group structural debris is used as fill in Basin A, reducing the amount of clean borrow needed and reducing the total volume to be landfilled. This alternative is also slightly less costly than Alternative 3.

8.3 Comparative Analysis of Alternatives for Soil

The five soil alternatives that are compared in this section involve a combination of containment (as a principal element) and treatment technologies to reduce contamination. A summary of the comparative analysis of the soil alternatives is provided in Table 8.3-1.

As described in Section 7.1.3, the criteria for evaluating soil contamination helped focus the evaluation of potential remedial activities on areas of highest risk to human health and the environment. Alternatives were developed to include treatment of principal threat volumes, where practicable, with containment or institutional controls being enacted for the balance of the exceedance areas. The sheer volume of contaminated soil present on the site precludes a remedy in which all contaminants could be excavated and cost effectively treated.

8.3.1 Overall Protection of Human Health and the Environment

The five alternatives for soil provide overall protection of human health through a combination of containment and treatment. Alternatives 1 (Caps/Covers), 2 (Landfill/Caps), and 3 (Landfill) provide for protection of human health primarily through containment of human health exceedances, which interrupts exposure pathways and reduces the migration of contaminants to groundwater and the atmosphere. Alternatives 4 (Consolidation/Caps/Treatment/Landfill) and 5 (Caps/Treatment/Landfill) address portions of the most contaminated soil through treatment, but still rely on capping and landfilling to protect human health in the majority of the contaminated areas.

Under each of the five alternatives, the protection of wildlife is generally accomplished through containment of portions of the core areas of RMA that may pose a risk to biota by capping, covering, or landfilling. These actions interrupt the potential for biota exposure, and also prevent burrowing animals from coming into contact with contaminated soil. Outside the core area, these alternatives address surficial soil with low levels of contamination using two different approaches. Alternative 5 includes the treatment of approximately 1,600 acres through agricultural practices, which reduces the level of OCPs in near-surface soil but results in the disturbance of habitat over widespread areas of RMA. The other four alternatives address low-level surficial soil contamination by continued monitoring only, thereby avoiding the disruption of wildlife in these areas during remedial activities and habitat restoration.

Alternatives 3, 4, and 5 are more protective than Alternatives 1 or 2 because larger volumes of contaminated soil are contained in a secure landfill and/or treated. Alternatives 3 and 4 offer equivalent overall protectiveness because there is a tradeoff between landfilling a greater total volume under Alternative 3 versus landfilling the Basin F Wastepile and treating more material under Alternative 4. Alternative 5 is more protective than the other alternatives because more material is treated.

8.3.2 Compliance with ARARs

Each of the five alternatives complies with chemical-, action-, and location-specific ARARs. The number of ARARs, and the difficulties associated with demonstrating compliance with these ARARs, are substantially

higher for Alternative 5 based on the complexity of the alternative and the use of thermal treatment technologies.

8.3.3 Long-Term Effectiveness and Permanence

Each of the five alternatives results in minimal residual risk based on the adequacy and reliability of controls offered by each alternative. All five alternatives rely on containment of a significant portion of the contaminated soil to protect human health and the environment, requiring long-term maintenance and monitoring activities. Long-term management also includes access restrictions to capped and covered areas to ensure the integrity of the containment systems. Alternatives 4 and 5 leave smaller volumes of contaminated soil (approximately 8 percent and 40 percent of the human health exceedance volume, respectively, are treated) with lower levels of contamination requiring long-term controls; however, these alternatives still rely on containment of large volumes of contaminated soil (92 and 60 percent, respectively). Alternative 5 also includes the treatment of approximately 1,600 acres through agricultural practices, which reduces the level of OCPs in near-surface soil but results in the disturbance of habitat over widespread areas of RMA. The containment systems for the five alternatives are adequate and reliable for long-term protection of human health and the environment.

Alternative 1 addresses both highly contaminated soil and large volumes of contaminated soil through containment in place. The installation of caps/covers provides adequate protection for human health and wildlife by eliminating exposure to contaminated soil. The caps provide long-term reduction in the migration of contaminants to groundwater. Based on the operation of the existing groundwater systems and the groundwater removal systems to be installed as part of the selected water alternative, this alternative provides long-term effectiveness and a low residual risk. A residual risk may exist for biota because surficial soil that may pose a risk to biota is left in place and monitored. However, widespread areas of wildlife habitat are not disturbed to address this residual risk.

Alternatives 2 and 3 both rely on containment systems that effectively protect humans and biota from exposure to contaminated soil. The bottom liner of a landfill controls the migration of leachate. Landfill covers and caps both provide long-term protection by preventing infiltration into the contaminated materials and releases to the atmosphere. These two alternatives provide similar levels of long-term protection and minimal long-term risks, although landfilling does provide, by virtue of the liner, an increased level of containment than a cap does. Both of these alternatives involve potential risk for biota because surficial soil that may pose a risk to biota is left in place and monitored; however, widespread areas of habitat are not disturbed to address this residual risk.

Alternatives 4 and 5 treat portions of the most contaminated soil, thereby reducing the level of contamination in the soil requiring long-term controls. However, both alternatives use similar containment systems as the other three alternatives to address large volumes of lower-level contamination (92 percent and 60 percent of the human health exceedance volume, respectively). Alternative 5 does treat a larger volume of soil, primarily through treatment of the Basin F Wastepile, but still relies on containment of a large volume of soil to provide long-term protection. Alternatives 4 and 5 provide similar levels of long-term protection, but do not eliminate the need for long-term monitoring and maintenance of capped and landfilled areas.

8.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 4 and 5 provide the greatest reduction in toxicity, mobility, or volume through treatment. These alternatives permanently reduce the toxicity, mobility, or volume of contaminated soil through treatment of 207,000 and 1.1 million BCY of soil, respectively, and they reduce the mobility of contaminants in the remaining soil through containment with caps, soil covers, and landfills. The other three alternatives provide reduction in mobility through containment; however, Alternative 1 provides somewhat lower reduction in mobility because Alternatives 2 and 3 include landfilling of some of the contaminated soil, which provides some measure of additional containment of contaminants and reduction in mobility compared to capping. Ultimately, however, all containment alternatives rely on the effectiveness of the caps and soil covers to reduce infiltration.

8.3.5 Short-Term Effectiveness

The short-term effectiveness of the five alternatives is primarily governed by the risks posed during remedial actions and the time required until remediation goals are achieved. Short-term effectiveness decreases as a result of the increase in risks during remedial actions and the longer time frames for implementation of the more complex remedial alternatives.

Alternatives 1 and 2 have minimal to low short-term risks as the central portions of RMA (with high levels of contamination) are capped in place. Thus, the risks to workers and the surrounding community from the excavation, transportation, and treatment/disposal of soil with high-level contamination are avoided. The implementation time of these alternatives is approximately 17 and 16 years, respectively. Alternative 2 includes the landfilling of 2 million BCY of contaminated soil (instead of containment in place), but the risks associated with excavation, transportation, and disposal of this soil are not significantly increased compared to capping based on the low levels of contamination in the soil to be landfilled. These two alternatives address soil in the core area of RMA that may pose a risk to biota through containment, but do not entail additional remedial actions for surficial soil that may pose a risk to biota, which is left in place and monitored. In this manner, widespread areas of habitat are not disturbed to address soil with a low residual risk.

The other three alternatives involve excavation and treatment/disposal of portions of the most contaminated soil, which increases the short-term risks to workers and the community. Alternative 4 removes a smaller volume of highly contaminated soil, and therefore exhibits lower risks due to excavation, transportation, and disposal activities than Alternatives 3 or 5, which present the highest short-term risk to workers and the community. Under these alternatives, the largest volume of highly contaminated areas is excavated for treatment and/or disposal, requiring specialized vapor- and odor-suppression measures to minimize the release of contaminants. The implementation time frame for Alternative 5 is the longest at approximately 28 years. Although steps can be taken to control short-term risks during remedial actions under these three alternatives, the short-term effectiveness for these alternatives is lower than for Alternatives 1 or 2. Negative-pressure vapor enclosures are one approach to controlling vapors and odors that may be emitted from several areas to be excavated under Alternatives 3, 4, and 5. Work within enclosures would require extensive worker protection and could present significant hazards to workers. Although the air within the enclosure is collected and treated, or, where an enclosure was not used, other measures could be taken to mitigate short-term risks, the short-term risks of contaminant release associated with excavating these areas cannot be completely eliminated.

8.3.6 Implementability

The implementability of the five alternatives varies from easy for Alternatives 1 and 2, which are readily constructed using common construction equipment, to difficult for Alternative 5. This alternative presents difficulties in the construction and operation of the treatment technologies, which have not been implemented at any other site in the country at the scale required at RMA. The implementability of Alternatives 3 and 4 is moderate.

Alternatives 1 and 2 are both considered easy to implement because they consist of the proven and available technologies of capping and landfilling and because they do not require the use of vapor controls. Alternatives 3 and 4 involve a similar level of difficulty in the excavation, transportation, and disposal of large volumes of highly contaminated soil. Alternative 4, which makes use of readily available mobile equipment for treatment of soil by solidification/stabilization, is implementable. Implementability of the innovative thermal technology for the Hex Pit will be determined during remedial design treatability testing. Consolidation of some soil potentially posing risk to biota (as a source of gradefill) decreases the cost and disruption of habitat for borrow areas. Alternative 5 is the most difficult to implement and requires the longest time frame based on the difficulties with implementation of vapor controls, if necessary, and treatment technologies. There is a high level of uncertainty in the performance of thermal technologies on the complex contaminant mixtures and high salt levels in some principal threat soil, leading to a potential for failure to meet the treatment specifications and a potential for extensive shut-down time to modify and maintain the system.

8.3.7 Cost

The estimated present worth cost (in 1995 dollars) for Alternative 2 is the lowest at $276 million. The present worth cost for Alternative 1 is estimated to be $386 million, followed by Alternatives 3 and 4 at $384 and $401 million, respectively. The estimated present worth cost for Alternative 5 is the highest at $542 million for soil remediation. A breakdown of capital and O&M costs for the components of each alternative is presented in Table 7.4-2.

The greatest overall cost uncertainty is associated with the remediation of soil, and the uncertainty is higher for alternatives that include excavation and treatment than for alternatives that minimize the handling of highly contaminated soil through containment in place. The level of cost uncertainty is relatively low for Alternatives 1, 2, and 4 because demonstrated construction and excavation technologies are used. The cost uncertainty associated with Alternative 3 is moderate as demonstrated technologies are used for containment, although large volumes of highly contaminated soil are excavated. Alternative 5 entails the highest degree of cost uncertainty due to the use of complex treatment technologies and the excavation, transportation, treatment, and disposal of large volumes of highly contaminated soil.

8.3.8 State Acceptance

The state has been actively involved throughout the RI/FS and remedy selection process for the On-Post Operable Unit. The state was provided the opportunity to comment on the RI/FS documents and on the Proposed Plan, and has taken part in numerous public meetings, including the public meeting on November 18, 1995, to inform the public of the content of the Proposed Plan. Written comments received from the state during the public comment period indicate their concerns about the Medical Monitoring Program, the Trust Fund, and treatment of the Hex Pit.

Responses to the state's comments are provided in the Responsiveness Summary (Section 12).

8.3.9 Community Acceptance

Interested members of the public, including individual citizens, representatives of the local communities, and representatives of national groups, have been actively involved in reviewing the FS and evaluating potential remedial alternatives for the past 2 years as a result of the outreach program described in Section 3. The preferred soil alternative for the On-Post Operable Unit was presented to the public in the Proposed Plan, which provides a brief summary of all of the alternatives evaluated during the Detailed Analysis of Alternatives phase of the FS. The original comment period of 60 days was extended to 90 days at the request of some commenters.

The concerns expressed by the public included questions related to the Medical Monitoring Program, the Trust Fund, the adequacy of the selection remedy and the monitoring program, and concerns regarding the potential presence of dioxin. Responses to the community's comments are provided in the Responsiveness Summary (Section 12).

8.3.10 Conclusions

Alternative 1 provides the level of protection of human health and wildlife required under CERCLA by preventing exposures to contaminated soil. In addition, this alternative has minimal short-term risks since the central portions of RMA (with high levels of contamination) are capped in place, thereby avoiding the risks from excavation, transportation, and treatment/disposal of soil with high-level contamination. The mobility of the contaminants is reduced by minimizing the amount of infiltration that may mobilize the contaminants from the soil to the groundwater and eliminating the airborne migration pathway. However, no action is taken to reduce the toxicity or volume of the contaminated soil. The implementation time frame for Alternative 1 is less than the other alternatives, although its cost is higher than Alternative 2. The overall effectiveness of Alternative 1 is somewhat lower than the other alternatives based on the lower reduction in mobility resulting from capping as compared to landfilling or the destruction of contaminants through treatment. However, all alternatives rely on capping/landfilling of the majority of the contaminated soil to provide long-term risk reduction.

Alternative 2 protects humans and biota by providing a physical barrier, through capping and landfilling, to prevent exposures and reduce the amount of infiltration that may mobilize contaminants to groundwater. Caps/covers and landfills provide effective containment of the contaminated soil. The contaminated soil from the outlying sections of RMA that is landfilled poses a minor risk to workers and the community during excavation and transportation due to the low level of contamination in the soil. Soil in the core area of RMA with high levels of contamination (such as the Basin A, Disposal Trenches, and Basin F Medium Groups and South Plants Central Processing Area Subgroup) is left in place and capped. The mobility of the contaminants in these areas is further reduced by minimizing the infiltration through the contaminated soil and eliminating the airborne migration pathway. The overall effectiveness of Alternative 2 is high because it provides effective containment of the contaminants by balancing the short-term risks of excavation with long-term effectiveness.

Alternative 3 protects humans and biota by providing a physical barrier that prevents exposure through landfilling and capping. However, significant risks are posed to workers and the community during excavation and transportation of large volumes of highly contaminated soil. Although vapor- and odor-suppression measures are used during the excavation of several sites, the short-term risks associated with excavation of contaminated soil cannot be completely eliminated. The mobility of the contaminants is eliminated by placing

the contaminated soil in the landfill, but no action is taken to reduce the toxicity or volume of the contaminated soil. The overall effectiveness of Alternative 3 is moderate because it provides low long-term risk but entails high short-term risks during excavation and transportation of highly contaminated soil.

Alternative 4 protects humans and biota by treating some principal threat materials and providing a physical barrier (i.e., caps, soil covers, and landfill) to prevent exposure. Mobility of the contaminants is reduced by minimizing the amount of infiltration into the contaminated soil below the caps or in the landfill. The toxicity and mobility of contaminated soil is reduced through treatment of some principal threats by solidification/stabilization. Increased short-term risks are posed to workers and the community during excavation, transportation, and landfill of highly contaminated soil. The risks associated with excavation are reduced, but are not eliminated, through the use of vapor- and odor-suppression measures at several excavation areas. In addition, placement of soil excavated from the Basin F Wastepile and Section 36 Lime Basins in a triple-lined landfill cell provides added assurance of containment. The consolidation of 1.5 million BCY of contaminated soil in Basin A, Basin F, and the South Plants Central Processing Area prior to capping these sites lowers the cost of obtaining borrow materials and reduces the area disturbed for borrow. The implementability of this alternative is moderate because highly contaminated soil is excavated. However, the overall effectiveness of Alternative 4 is high because it provides low long-term risk, compensating for the increased short-term risk during excavation.

Alternative 5 treats areas of highly contaminated soil, thereby reducing the contaminant toxicity, mobility, or volume. However, workers and the community are exposed to the highest short-term risks under Alternative 5 (compared to other alternatives) during excavation, transportation, and treatment. Although vapor- and odor-suppression measures are used during the excavation of several sites, the short-term risks associated with excavation of highly contaminated soil cannot be completely eliminated. The mobility of the contaminants is minimized by placing the contaminated soil in a landfill. However, this alternative has a low overall effectiveness based on the high short-term risks during remedial actions and the longer time frame (a minimum of 14 years) until actions are completed. In addition, the implementability of this alternative is very difficult because of the large volume of highly contaminated soil (including the Basin F Wastepile) to be treated by thermal treatment.

Alternative 4 is superior to the other soil remedial alternatives for the On-Post Operable Unit for the following principal reasons:

- Alternative 4 is preferable to Alternatives 1, 2, and 3 because it provides additional reduction of toxicity, mobility, or volume of contaminated soil through some treatment with minimal short-term effects and more secure containment of the Basin F Wastepile materials in a new triple-lined landfill cells. Alternative 4 is also readily implementable.

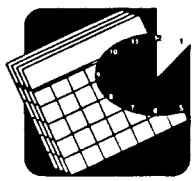
- Although Alternative 5 provides greater reduction of toxicity, mobility, or volume through more treatment than Alternative 4, it is much less readily implementable than Alternative 4 because the treatment technologies identified have never been used at the scale required at RMA. Furthermore, Alternative 5 is significantly more costly than Alternative 4, and the uncertainty of execution related to schedule and budget is much higher for Alternative 5 than for Alternative 4.

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.

2 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) addresses whether or not a remedy will meet all federal and state environmental laws and standards and/or provides grounds for a waiver.

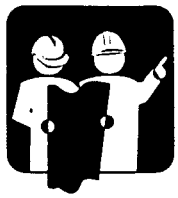
3 Short-Term Effectiveness addresses the period of time needed to complete the remedy and any adverse effects to human health and the environment that may be caused during the construction and implementation of the remedy.

4 Long-Term Effectiveness and Permanence refers to the ability of a remedy to provide reliable protection of human health and the environment over time.



5 Reduction of Toxicity, Mobility, or Volume through Treatment refers to the preference for a remedy that through treatment reduces health hazards, the movement of contaminants, or the quantity of contaminants at the site.

6 Implementability refers to the technical and administrative feasibility of a remedy. This includes the availability of materials and services needed to carry out a remedy. It also includes coordination of federal, state, and local governments to work together to clean up the site.



7 Cost evaluates the estimated capital, operating, and maintenance costs of each alternative in comparison to other equally protective alternatives.

8 State Acceptance indicates whether the state agrees with, opposes, or has no comment on the preferred alternative.

9 Community Acceptance includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment may not be completed until public comments on the Proposed Plan are reviewed.

Figure 8.0-1

Cleanup Evaluation Criteria

Rocky Mountain Arsenal
Prepared by Foster Wheeler Environmental Corporation

Table 8.1-1 Comparative Analysis of Water Alternatives

Criteria	Alternative 1 Boundary Systems	Alternative 2 Boundary Systems/ IRAs (No Additional Action)	Alternative 3 Boundary Systems/ IRAs/Dewatering	**Alternative 4 Boundary Systems/ IRAs/Intercept Systems**
Overall Protection of Human Health and the Environment	*Protective.* Provides protection through operation of boundary systems.	*Protective.* Provides protection through operation of boundary systems and minimizes on-post migration through operation of IRAs.	*Protective.* Provides protection through boundary systems and minimizes on-post migration through operation of IRAs and additional on-post systems.	***Protective.* Provides protection through boundary systems and minimizes on-post migration through operation of IRAs and additional on-post systems.**
Compliance with ARARs	*Complies* with action-, chemical-, and location-specific ARARs through active treatment and natural attenuation of inorganics.	*Complies* with action-, chemical-, and location-specific ARARs through active treatment and natural attenuation of inorganics.	*Complies* with action-, chemical-, and location-specific ARARs through active treatment and natural attenuation of inorganics.	***Complies* with action-, chemical-, and location-specific ARARs through active treatment and natural attenuation of inorganics.**
Long-Term Effectiveness and Permanence	*Low residual risk.* Potential for off-post exposure is lowered. No on-post exposure due to FFA restrictions. Long-term monitoring required; contaminant migration reduced through passive dewatering.	*Low residual risk.* Potential for off-post exposure is lowered. No on-post exposure due to FFA restrictions. Long-term monitoring required; contaminant migration reduced through IRAs, source capture, and passive dewatering.	*Low residual risk.* Potential for off-post exposure is lowered. No on-post exposure due to FFA restrictions. Long-term monitoring required; contaminant migration reduced through IRAs, source capture, and active dewatering.	***Low residual risk.* Potential for off-post exposure is lowered. No on-post exposure due to FFA restrictions. Long-term monitoring required; contaminant migration reduced through IRAs, source capture, and passive dewatering.**
Reduction of Toxicity, Mobility, or Volume (TMV)	*TMV reduced at boundary.* Contaminants removed by GAC adsorption, reducing toxicity and volume.	*TMV reduced at boundary and on post.* Contaminants removed by GAC adsorption and air stripping, reducing toxicity and volume; source capture at Basin A Neck and passive dewatering limit migration.	*TMV reduced at boundary and on post.* Contaminants removed by GAC adsorption and air stripping, reducing toxicity and volume; dewatering and source capture significantly limit migration and mobility.	***TMV reduced at boundary and on post.* Contaminants removed by GAC adsorption and air stripping, reducing toxicity and volume; source capture and passive dewatering limit mobility.**

Selected alternative

Table 8.1-1 Comparative Analysis of Water Alternatives

Criteria	Alternative 1 Boundary Systems	Alternative 2 Boundary Systems/ IRAs (No Additional Action)	Alternative 3 Boundary Systems/ IRAs/Dewatering	**Alternative 4 Boundary Systems/ IRAs/Intercept Systems**
Short-Term Effectiveness	*Effective*. Minimal negative impact; achieves RAOs.	*Effective*. No additional impact associated with continued operation; achieves RAOs.	*Effective*. Minimal negative impact associated with installation of dewatering system; achieves RAOs.	***Effective*. Minimal negative impact associated with installation of extraction system; achieves RAOs.**
Implementability	*Technically and administratively feasible*.	*Technically and administratively feasible*. No additional construction involved.	*Technically and administratively feasible*. Treatment by proven technologies except for in situ biological treatment in South Plants.	***Technically and administratively feasible*. Treatment by proven technologies.**
Present Worth Cost	$80 million	$98 million	$130 million	**$104 million**
Conclusion	*Not selected*. Meets evaluation criteria, but provides less protection than other alternatives.	*Not selected*. Meets evaluation criteria, but does not provide additional control and protection beyond what is currently in place.	*Not selected*. Meets evaluation criteria and provides additional on-post controls, but at higher cost than the other alternatives.	***Selected*. Meets evaluation criteria and is consistent with the proposed soil alternative. Provides adequate on-post controls at minimal added cost.**

Selected alternative

Table 8.2-1 Comparative Analysis of Structures Alternatives

Criteria	Alternative 1 Landfill/Cap in Place	**Alternative 2 Landfill/Consolidate**	Alternative 3 Landfill
Overall Protection of Human Health and the Environment	*Protective*. Debris is contained by capping or landfilling. Agent debris is treated as necessary.	***Protective*. Debris is contained by consolidation or landfilling. Agent debris is treated as necessary.**	*Protective*. Debris is contained by landfilling. Agent debris is treated as necessary.
Compliance with ARARs	*Complies* with action-, chemical-, and location-specific ARARs.	***Complies* with action-, chemical-, and location-specific ARARs.**	*Complies* with action-, chemical-, and location-specific ARARs.
Long-Term Effectiveness and Permanence	*Low residual risk*. Structural debris is contained by capping or landfilling. Adequate controls; long-term monitoring is required. Habitat is improved at site but limited at landfill.	***Low residual risk*. Structural debris is contained by consolidation or landfilling. Adequate controls; long-term monitoring is required. Habitat is improved at site but limited at landfill.**	*Low residual risk*. Structural debris is contained by landfilling. Adequate controls; long-term monitoring is required. Habitat is improved at site but limited at landfill.
Reduction of Toxicity, Mobility, or Volume (TMV)	*TMV Reduced*. Capping or landfilling reduces mobility. Reduction in mobility may be reversed if cap or landfill leaks. Caustic wash irreversibly reduces TMV of agent, but produces a hazardous liquid sidestream that must be treated.	***TMV Reduced*. Consolidation or landfilling reduces mobility. Reduction in mobility reversed if consolidation area or landfill leaks. Caustic wash irreversibly reduces TMV of agent, but produces a hazardous liquid sidestream that must be treated.**	*TMV Reduced*. Landfilling reduces mobility. Reduction in mobility may be reversed if landfill leaks. Caustic wash irreversibly reduces TMV of agent, but produces a hazardous liquid side-stream that must be treated.

Selected alternative

Criteria	Alternative 1 Landfill/Cap in Place	**Alternative 2 Landfill/Consolidate**	Alternative 3 Landfill
Short-Term Effectiveness	*Effective*. Dust controls needed for demolition. Worker protection necessary for physical hazards associated with dismantling and for chemical hazards associated with caustic washing and handling agent-contaminated debris. Habitat improved at site, limited at disposal areas. RAOs achieved in 3 to 4 years.	***Effective*. Dust controls needed for demolition. Worker protection necessary for physical hazards associated with dismantling and for chemical hazards associated with caustic washing and handling agent-contaminated debris. Habitat improved at site, limited at disposal areas. RAOs achieved in 3 to 4 years.**	*Effective*. Dust controls needed for demolition. Worker protection necessary for physical hazards associated with dismantling and for chemical hazards associated with caustic washing and handling agent-contaminated debris. Habitat improved at site, limited at disposal areas. RAOs achieved in 3 to 4 years.
Implementability	*Technically and administratively feasible*. Regulatory concerns with capping.	***Technically and administratively feasible*.**	*Technically and administratively feasible*.
Present Worth Cost[1]	$106 million	**$104 million**	$109 million
Conclusion	*Not selected*. Meets evaluation criteria and is consistent with soil remedial alternatives. Not identified as the preferred alternative due to regulatory concerns over capping debris from Other Contamination History structures.	***Selected*. Meets evaluation criteria and is consistent with soil remedial alternatives.**	*Not selected*. Meets evaluation criteria and is consistent with soil remedial alternatives. Not identified as the preferred alternative because it is less cost effective than Alternative 2.

Selected alternative

[1]These costs do not include $35 million in post ROD removal actions.

Table 8.3-1 Comparative Analysis of Soil Alternatives

Criteria	Alternative 1 Caps/Covers	Alternative 2 Landfill/Caps	Alternative 3 Landfill	**Alternative 4 Consolidation/Caps/ Treatment/Landfill**	Alternative 5 Caps/Treatment/ Landfill
Overall Protection of Human Health and the Environment	*Protective*. Exposures to humans and animals prevented by containing contaminated soil in place.	*Protective*. Exposures to humans and animals prevented by containing contaminated soil in place.	*Protective*. Exposures to humans and animals prevented by containing contaminated soil in place.	***Protective*. Exposures to humans and animals prevented by containing contaminated soil in place and by treating some of the principal threat volume.**	*Protective*. Exposures to humans and animals prevented by containing contaminated soil in place and by treating principal threat volume.
Compliance with ARARs	*Complies* with action-, chemical-, and location-specific ARARs.	*Complies* with action-, chemical-, and location-specific ARARs.	*Complies* with action-, chemical-, and location-specific ARARs.	***Complies* with action-, chemical-, and location-specific ARARs.**	*Complies* with action-, chemical-, and location-specific ARARs. More difficult due to action-specific ARARs regarding treatment.
Long-Term Effectiveness and Permanence	*Minimal residual risk*. Relies on caps and groundwater controls to prevent migration and exposure.	*Minimal residual risk*. Relies primarily on caps and groundwater controls, with some landfilling, to prevent migration and exposure.	*Minimal residual risk*. Relies on landfilling, with some caps and groundwater controls to prevent migration and exposure.	***Minimal residual risk*. Relies on treatment of some highly contaminated soil, groundwater controls, and capping/landfilling to prevent migration and exposure.**	*Minimal residual risk*. Relies on treatment of most of the highly contaminated soil and landfilling/capping to prevent migration and exposure.
Reduction of Toxicity, Mobility, or Volume (TMV)	*TMV Reduced*. Mobility reduced through containment; no toxicity or volume reduction.	*TMV Reduced*. Mobility reduced through containment; no toxicity or volume reduction.	*TMV Reduced*. Mobility reduced through containment; no toxicity or volume reduction	***TMV Reduced*. TMV of some highly contaminated soil reduced through treatment; relies on containment for most mobility reduction.**	*TMV Reduced*. TMV of the most highly contaminated soil reduced through treatment; relies on containment for additional mobility reduction.

Selected alternative

Table 8.3-1 Comparative Analysis of Soil Alternatives

Criteria	Alternative 1 Caps/Covers	Alternative 2 Landfill/Caps	Alternative 3 Landfill	**Alternative 4 Consolidation/Caps/ Treatment/Landfill**	Alternative 5 Caps/Treatment/ Landfill
Short-Term Effectiveness	*Effective.* Minimal short-term risk. No excavation or potential releases.	*Effective.* Low short-term risk. High-risk sites not excavated; minimal potential for releases.	*Effective.* Moderate short-term risk. All sites excavated and transported with high potential for releases.	***Effective.*** **Moderate short-term risk. Some high-risk sites excavated and transported; moderate potential for releases.**	*Effective.* Higher short-term risk. Most high-risk sites excavated, transported, and treated; large volumes of less contaminated soil moved; high potential for releases.
Implementability	*Implementable.* Easy to construct caps on schedule; short time to complete.	*Implementable.* Easy to construct caps and landfill for soil with low levels of contamination; short time to complete.	*Moderate implementability.* Construction and permitting of large landfill for highly contaminated material may delay schedule.	***Moderate implementability.*** **Construction and permitting of large landfill for highly contaminated material may delay schedule.**	*Difficult implementability.* Construction and permitting of large landfill and thermal treatment facility may delay schedule. Problems in excavation, treatment, and emissions control; longest time to complete.
Present Worth Cost	Total: $386 million	Total: $276 million	Total: $384 million	**Total: $401 million**	Total: $542 million
Conclusion	*Not selected.* Higher long-term risks and no substantial cost savings compared to other alternatives.	*Not selected.* Higher long-term risk, although low cost.	*Not selected.* High short-term risks without improving long-term protection, which ultimately relies on containment.	***Selected.*** **Cost effective; balances short-term risks with higher long-term protection.**	*Not selected.* High cost, short-term risks, and difficult to implement.

Selected alternative

9.0 Identification of the Selected Remedy

The selection of the preferred remedy for remediation of groundwater, structures, and soil for the On-Post Operable Unit was based on the NCP evaluation criteria, which are described in Figure 8.0-1 and discussed with respect to each of the alternatives evaluated in Sections 8.1 through 8.3. As a result of these evaluations, the selected remedy for the On-Post Operable Unit consists of implementing Groundwater Alternative 4, Structures Alternative 2, and Soil Alternative 4. These selected alternatives are described in detail in Section 7. Remediation goals for the selected remedy satisfies the evaluation of statutory requirements under CERCLA as described in Section 10.

9.1 Groundwater Alternative 4 – Boundary Systems/IRAs/Intercept Systems

The selected groundwater alternative is Alternative 4. This alternative includes operation of all existing boundary systems and on-post groundwater IRA systems, installation of a new extraction and piping system, and development of an extended monitoring program. The specific components of the alternative are as follows:

- Operation of the three boundary systems, the NBCS, NWBCS, and ICS, continues. These systems include extraction and recharge systems, slurry walls (NBCS and NWBCS) for hydraulic controls, and carbon adsorption for removal of organics. The systems will be operated until shut-off criteria, as described below, are met.
- Operation of existing on-post groundwater IRA systems continues. The Motor Pool and Rail Yard IRA systems, which pipe water to ICS for treatment, will be shut down when shut-off criteria, as described below, are met. The Basin F extraction system continues to extract water that is treated at the Basin A Neck system and the Basin A Neck system continues to extract and treat water from Basin A until shut-off criteria are met.
- A new extraction system will be installed in the Section 36 Bedrock Ridge area. Extracted water will be piped to the Basin A Neck system for treatment (e.g., by air stripping or carbon adsorption).
- Water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems. The biological health of the ecosystems will continue to be monitored.

  Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance.
- Confined aquifer wells are monitored in the South Plants, Basin A, and Basin F areas. Specific monitoring wells will be selected during remedial design.
- Those monitoring wells installed in the confined aquifer that may represent pathways for migration from the unconfined aquifer (approximately 30–40 wells) are closed and sealed; replacement wells will be installed if the Parties jointly determine that specific wells to be closed are necessary for future monitoring.
- Chloride and sulfate are expected to attenuate naturally to the CSRGs.
- Monitoring and assessment of NDMA contamination will be performed in support of design refinement/design characterization to achieve remediation goals specified for the boundary groundwater treatment systems.

CSRGs were established for each containment/treatment system on the basis of ARARs and health-based criteria. The ARAR-based values were either Colorado Basic Standards for Groundwater (CBSGs), federal maximum contaminant levels (MCLs), or non-zero maximum contaminant level goals (MCLGs). The health-based values are to-be-considered criteria (TBCs) and were based on EPA health advisories and/or EPA Integrated Risk Information System database criteria. All of the boundary CSRGs are consistent with those derived for the ROD for the Off-Post Operable Unit (Harding Lawson Associates 1995). CSRGs were developed for each of the existing boundary and IRA systems, depending on the specific contaminants found upgradient of each system and whether the systems were on post or at the boundary. Tables 9.1-1, 9.1-2, 9.1-3, and 9.1-4 present the CSRGs for the three boundary systems, and the Basin A Neck system. Where the CSRG is below the detection limit, the detection limit is listed next to the CSRG. Except where technically impractical, the detection limit is less than the CSRG.

Criteria for shutting down boundary systems and internal systems have also been developed and are provided as follows:

- Existing wells within the boundary and off-post containment systems can be removed from production when concentrations of constituents detected in the well are less than the ARARs listed in Appendix A and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the remediation goals described above and the CSRGs listed in Tables 9.1-1, 9.1-2, and 9.1-3. Wells removed from production and monitoring wells upgradient and downgradient of the boundary and off-post containment systems will be monitored quarterly for a period of 5 years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Boundary and off-post containment system extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.
- Existing wells within the internal containment systems can be removed from production when concentrations of constituents detected in the wells are less than ARARs listed in Appendix A and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the CSRGs listed in Table 9.1-4. Wells removed from production and monitoring wells upgradient and downgradient of the internal containment systems will be monitored quarterly for a period of 5 years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Internal containment system extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.
- Shell and the Army will operate the ICS for 2 years or until the Rail Yard/Motor Pool plumes no longer require containment at the ICS.

Figure 9.1-1 illustrates the selected alternative. Additional detail on this alternative is provided in the Detailed Analysis of Alternatives report.

9.2 Structures Alternative 2 – Landfill/Consolidate

Structures Alternative 2 is the selected alternative for the structures medium. This alternative applies to all No Future Use structures, i.e., structures in the Other Contamination History, Significant Contamination History, and Agent History Groups. Under this alternative, the following activities will occur:

- All No Future Use structures will be demolished.
- Agent History structures will be monitored for the presence of Army chemical agent, and treated by caustic washing as necessary prior to disposal.
- Both Agent History and Significant Contamination History Group structural debris will be disposed in the on-site hazardous waste landfill.
- Other Contamination History Group structural debris will be used as grade fill in Basin A, which will subsequently be covered as part of the soil remediation.
- Structural assessments and review of ACM and PCB contamination status and disposition of ACM or PCB-contaminated materials will be performed as described in Section 7.3.3.
- Process-related equipment not remediated as part of the Chemical Process-Related Activities IRA will be disposed in the on-post hazardous waste landfill.

An inventory of structures in each medium group is presented in Tables 5.4-6, 5.4-7, 5.4-8, and 5.4-9. Refinement of the Future Use structures inventory will be completed during remedial design. Most of the demolition at RMA will consist of dismantling with standard dust-suppression measures Remediation goals and standards have been identified for each medium group (see Table 9.5-1). The Other Contamination History Group structural debris is disposed by consolidation in Basin A. This procedure includes transporting the debris to the consolidation area and using it as a portion of the gradefill required by the soil remediation. When the consolidation area has been regraded, it will be covered as part of the soil remediation. Significant Contamination History Group and Agent Contamination History Group structural debris is disposed in the on-post hazardous waste landfill. The slabs and foundations of structures located in the South Plants Central Processing Area within principal threat or human health soil exceedance excavation areas are removed to a depth of 5 ft. In most cases, floor slabs and foundations for the Other Contamination History and Significant Contamination History Groups are left behind after demolition (unless contaminated soil is to be excavated from beneath the slabs or foundations). Floor slabs are broken to prevent water ponding. Additional detail on this alternative is provided in the Detailed Analysis of Alternatives Report.

9.3 Soil Alternative 4 – Consolidation/Caps/Treatment/Landfill

The selected soil alternative is Alternative 4. This alternative includes consolidation of 1.5 million BCY of soil with low levels of contamination into Basins A and F and the South Plants Central Processing Area; capping or soil cover of contaminated soil in the Basins, South Plants, North Plants, and Section 36 sites (including Shell and Complex Trenches); treatment (primarily by in situ solidification/stabilization) of 217,000 BCY of

principal threat soil; and on-post landfilling of 1.7 million cubic yards of soil and debris, including the Basin F Wastepile. The specific components of this alternative are listed below and are summarized in Table 9.3-1:

- On-Post Hazardous Waste Landfill – Construction of a RCRA- and TSCA-compliant hazardous waste landfill on post.
- Former Basin F – Treatment of approximately 190,000 BCY of principal threat soil in the Former Basin F to a depth of 10 ft (measured from below the base of the overburden) using in situ solidification/stabilization to reduce the mobility of the contaminants and minimize further contamination of groundwater. The mixture of solidification agents will be determined during remedial design by treatability testing. This treatability testing will be used to verify the effectiveness of the treatment process and establish operating parameters for the design of the full-scale operation. The entire site is capped (including the Basin F Wastepile footprint) with a RCRA-equivalent cap that includes a biota barrier.
- Basin F Wastepile – Excavation of approximately 600,000 BCY of principal threat soil and liner materials from the wastepile and containment in dedicated triple-lined landfill cells at the on-post hazardous waste landfill facility. Excavation is conducted using vapor- and odor-suppression measures as necessary. If the wastepile soil fails EPA's paint filter test, the moisture content of the soil will be reduced to acceptable levels by using a dryer in an enclosed structure. Any volatile organics (and possibly some semivolatile organics) released from the soil during the drying process are captured and treated; however, the main objective of this process is drying. Prior to excavation of the wastepile, overburden from the existing cover is removed and set aside. The excavation area is backfilled with on-post borrow material and stockpiled overburden.
- Basin A – Construction of a soil cover consisting of a 6-inch-thick layer of concrete and a 4-ft-thick soil/vegetation layer over the principal threat and human health exceedance soil and soil posing a potential risk to biota, and consolidation of debris and soil posing a potential risk to biota and structural debris from other sites. No RCRA-listed or RCRA-characteristic waste from outside the AOC will be placed in Basin A. Any UXO encountered will be removed and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.
- South Plants Central Processing Area – Excavation and landfill of principal threat and human health exceedance soil to a depth of 5 ft and caustic washing and landfill of any agent-contaminated soil found during monitoring. Backfill excavation and placement of a soil cover consisting of a 1-ft-thick biota barrier and a 4-ft-thick soil/vegetation layer over the entire site to contain the remaining human health exceedance soil and soil posing a potential risk to biota. Soil posing a potential risk to biota from other portions of South Plants may be used as backfill and/or gradefill prior to placement of the soil cover.
- South Plants Ditches – Excavation and landfill of principal threat and human health exceedance soil. Excavation of soil posing a potential risk to biota and consolidation under the South Plants Central Processing Area soil cover. Backfill excavated area with on-post borrow material. These sites are contained under the South Plants Balance of Areas soil cover.
- South Plants Balance of Areas – Excavation (maximum depth of 10 ft) and landfill of principal threat and human health exceedance soil and caustic washing and landfill of any agent-contaminated soil found during monitoring. Any UXO encountered will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Excavation of soil posing a potential risk to biota and consolidation as backfill and/or gradefill under the South Plants Central Processing Area soil cover and/or for use as backfill for excavated areas within this medium group. The former human health exceedance area is covered with a 3-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to verify that the soil under the 1-ft-thick soil cover does not exceed human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft-thick cover will be extended over these areas or the

exceedance soil will be excavated and landfilled. The top 1 ft of the entire soil cover area will be constructed using soil from the on-post borrow areas.

- Section 36 Balance of Areas – Excavation and landfill of human health exceedance soil and UXO debris and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover and the human health excavation area is backfilled with on-post borrow material. Prior to excavation, a geophysical survey is conducted to locate potential UXO. Any UXO encountered will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The former human health exceedance area is covered with a 2-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover.
- Secondary Basins – Excavation and landfill of human health exceedance soil. The excavated area is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over the entire area of Basins B, C, and D, including the potential biota risk area.
- Complex Trenches – Construction of a RCRA-equivalent cap, including a 6-inch-thick layer of concrete, over the entire site. Installation of a slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be reevaluated during remedial design. Soil excavated for the slurry wall trench is graded over the surface of the site and is contained under the cap. Prior to installing the slurry wall and cap, a geophysical survey is conducted to locate potential UXO within construction areas. Any UXO encountered will be removed and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.
- Shell Trenches – Modification of the existing soil cover to be a RCRA-equivalent cap with a biota barrier. Expansion of the existing slurry wall around the trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design. Soil excavated for the slurry wall trench is graded over the surface of the site and is contained under the cap.
- Hex Pit – Treatment of approximately 1,000 BCY of principal threat material using an innovative thermal technology. The remaining 2,300 BCY are excavated and disposed in the on-post hazardous waste landfill. Remediation activities are conducted using vapor- and odor-suppression measures as required. Treatability testing will be performed during remedial design to verify the effectiveness of the innovative thermal process and establish operating parameters for the design of the full-scale operation. The innovative thermal technology must meet the treatability study technology evaluation criteria described in the dispute resolution agreement (PMRMA 1996). Solidification/stabilization will become the selected remedy if all evaluation criteria for the innovative thermal technology are not met. Treatability testing for solidification will be performed to verify the effectiveness of the solidification process and determine appropriate solidification/stabilization agents. Treatability testing and technology evaluation will be conducted in accordance with EPA guidance (OSWER-EPA 1989a) and EPA's "Guide for Conducting Treatability Studies under CERCLA" (1992).
- Section 36 Lime Basins – Excavation and containment of principal threat and human health exceedance soil in a triple-lined landfill cell at the on-post hazardous waste landfill facility. Prior to excavation of exceedance soil, overburden from the existing cover is removed and set aside. The excavated area is backfilled with clean borrow and the soil cover is repaired. Caustic washing and landfill of any agent-contaminated soil found during monitoring.
- Buried M-1 Pits – Approximately 26,000 BCY of principal threat and human health exceedance soil is treated by solidification/stabilization and then landfilled. The mixture of solidification/stabilization agents will be determined during remedial design by treatability testing. This treatability testing will be used to verify the effectiveness of the treatment process and establish operating parameters for the design of the full-scale operation. Excavation is conducted using vapor- and odor-suppression

measures. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The excavated area is backfilled with clean borrow.

- Burial Trenches – UXO in these sites is located using a geophysical survey, excavated, and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Excavation and landfill of human health exceedance soil and backfill with on-post borrow material. Caustic washing and landfill of any agent-contaminated soil found during monitoring. Removal and landfill of munitions debris and nearby soil in excess of TCLP.
- Chemical Sewers – For sewers located within the South Plants Central Processing Area and Complex Trenches area, the sewer void space is plugged with a concrete mixture to prohibit access to these lines and eliminate them as a potential migration pathway for contaminated groundwater. The plugged sewers are contained beneath the soil cover or cap in their respective sites. For sewers located outside the South Plants Central Processing Area and Complex Trenches areas, sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced.
- Sanitary/Process Water Sewers – Void space inside sewer manholes is plugged with a concrete mixture to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Aboveground warning signs are posted every 1,000 ft along the sewer lines to indicate their location underground.
- North Plants – Excavation and landfill of human health exceedance soil. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. The excavated area is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over the soil posing a potential risk to biota and the footprint of the North Plants processing area.
- Toxic Storage Yards – Excavation and landfill of human health exceedance soil. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. The excavated area is backfilled with on-post borrow material. The New Toxic Storage Yards are used as a borrow area for both low-permeability soil and structural fill.
- Munitions Testing – UXO in these sites is located using a geophysical survey, excavated, and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Removal and landfill of munitions debris and nearby soil in excess of TCLP.
- Lake Sediments – Excavation and landfill of human health exceedance soil and excavation and consolidation of soil posing risk to biota from Upper Derby Lake to Basin A. The excavated human health exceedance area is backfilled with on-post borrow material and the consolidated material is contained under the Basin A cover. Aquatic sediments are left in place and the area is monitored to ensure that the sediments continue to pose no unacceptable risk to aquatic biota.
- Ditches/Drainage Areas – Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.
- Sanitary Landfills – Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.
- Buried Sediments – Excavation and landfill of human health exceedance soil. The excavated area is backfilled with on-post borrow material.

- Sand Creek Lateral – Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.
- Surficial Soil – Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of soil posing a potential risk to biota from this medium group and excavation and landfill of soil from the pistol and rifle ranges. The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled.
- Excavation and disposal in the on-post TSCA-compliant landfill of PCB-contaminated soil (three areas identified by the PCB IRA with concentrations of 250 ppm or greater). Soil identified with concentrations ranging from 50 to 250 ppm will be covered with at least 3 ft of soil (five areas identified by the PCB IRA).
- Contingent Volume – Excavation and landfill of up to 150,000 BCY of additional volume to be identified based on visual field observations. An additional 14 samples from North Plants, Toxic Storage Yards, Lake Sediments, Sand Creek Lateral, and Burial Trenches and up to 1,000 additional confirmatory samples may be used to identify the contingent soil volume requiring excavation.
- Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.

Exceedance volumes for all medium groups are listed in Table 7.1-5. For sites with excavation as part of the selected remedy, the exceedance volume is considered the volume to be excavated and no confirmatory sampling will occur during implementation, other than to identify contingent volume.

Additional detail on this alternative is provided in the Detailed Analysis of Alternatives report. Figure 9.3-1 shows the selected sitewide soil remedy; Figures 9.3-2, 9.3-3, and 9.3-4 show the major excavation areas and cap or cover components of the selected soil remedy; and Figure 9.3-5 shows the areas where exceedance volumes are left in place and the type of containment systems used in those areas following implementation of the selected remedy. Tables 9.3-2 and 9.3-3 show the disposition of exceedance volumes and Table 9.3-4 details the capped/covered areas for the selected soil remedy. A process will be presented in future implementation documents that will allow for independent confirmation that volumes (defined spatially) are removed. The process will allow for verification by the state or EPA during remedial action.

9.4 Additional Components of the Selected Remedy

The Army, Shell, EPA, USFWS, and state of Colorado have agreed to several additional components that will be included in the overall on-post remedy. These components have been considered in the selection of the preferred alternatives and are as follows:

- Provision of $48.8 million held in trust to provide for the acquisition and delivery of 4,000 acre-feet of potable water to SACWSD and the extension of the water-distribution lines from an appropriate water supply distribution system to all existing well owners within the DIMP plume footprint north of RMA as defined by the detection limit for DIMP of 0.392 parts per billion (ppb). In the future, owners of any domestic wells, new or existing, found to have DIMP concentrations of 8 ppb (or other relevant CBSG at the time) or greater will be connected to a water-distribution system or provided a deep well

or other permanent solution. The Army and Shell have reached an Agreement in Principle with SACWSD, enclosed as Appendix B of this ROD, regarding this matter.

- In compliance with NEPA, PMRMA will separately evaluate the potential impacts to the environment of both the acquisition of a water supply for SACWSD and for extension of water-distribution lines.

- The Army and Shell will fund ATSDR to conduct an RMA Medical Monitoring Program in coordination with CDPHE. The program's nature and scope will include baseline health assessments and be determined by the on-post monitoring of remedial activities to identify exposure pathways, if any, to any off-post community.

  A Medical Monitoring Advisory Group (MMAG) has been formed to evaluate information concerning exposure pathways and identify and recommend appropriate public health actions to CDPHE and ATSDR and to communicate this information to the community. CDPHE and ATSDR will use the recommendations of the MMAG to jointly develop an appropriate medical monitoring plan and jointly define the trigger for when such a plan will take effect. Any human health assessment completed by CDPHE and ATSDR will be formally reviewed by the Parties and the MMAG prior to issuance to the public. The MMAG includes representatives from the affected communities, regulatory agencies, local governments, Army, Shell, USFWS, and independent technical advisors. Any necessary technical advisors will be identified in coordination with CDPHE and funded through ATSDR.

  The primary goals of the Medical Monitoring Program are to monitor any off-post impact on human health due to the remediation and provide mechanisms for evaluation of human health on an individual and community basis, until such time as the soil remedy is completed. On behalf of the communities surrounding RMA, the MMAG will develop and submit to CDPHE and ATSDR specific recommendations defining goals, objectives, and the methodology of a program designed to respond effectively to RMA-related health concerns of the community.

  Elements of the program could include medical monitoring, environmental monitoring, health/community education or other tools. The program design will be determined through an analysis of community needs, feasibility, and effectiveness.

- Trust Fund – During the formulation and selection of the remedy, members of the public and some local governmental organizations expressed keen interest in the creation of a Trust Fund to help ensure the long-term operation and maintenance of the remedy once the remedial structures and systems are installed. In response to this interest, the Parties have committed to good-faith best efforts to establish a Trust Fund for the operation and maintenance of the remedy, including habitat and surficial soil. Such operation and maintenance activities will include those related to the new hazardous waste landfill; the slurry walls, caps, and soil and concrete covers; all existing groundwater pump-and-treat systems; the groundwater pump-and-treat system to intercept the Section 36 Bedrock Ridge Plume; the maintenance of lake levels or other means of hydraulic containment; all monitoring activities required for the remedy; design refinement for on-post surficial soil as described in Section 9.4; and any revegetation and habitat restoration required as a result of remediation.

  These activities are estimated to cost approximately $5 million per year (in 1995 dollars). The principal and interest from the Trust Fund would be used to cover these costs throughout the lifetime of remedial program.

  The Parties recognize that establishment of such a Trust Fund may require special legislation and that there are restrictions on the actions federal agencies can take with respect to proposing legislation and supporting proposed legislation. In addition to the legislative approach, the Parties are also examining possible options that may be adapted from trust funds involving federal funds that exist at other remediation sites. Because of the uncertainty of possible legislative requirements and other options, the precise terms of the Trust Fund cannot now be stated.

  A trust fund group will be formed to develop a strategy to establish the Trust Fund. The strategy group may include representatives of the Parties (subject to restrictions on federal agency

participation), local governments, affected communities, and other interested stakeholders, and will be convened within 90 days of the signing of the ROD.

Notwithstanding these uncertainties, it is the intent of the Parties that if the Trust Fund is created it will include the following:

- A clear statement that will contain the reasons for the creation of the Trust Fund and the purposes to be served by it.
- A definite time for establishing and funding the Trust Fund, which the Parties believe could occur as early as 2008, when the remedial structures and systems may have been installed.
- An appropriate means for competent and reliable management of the Trust Fund, including appropriate criteria for disbursements from the Trust Fund to ensure that the money will be properly used for the required purposes.

- Continued operation of the CERCLA Wastewater Treatment Plant to support the remediation activities.
- Stored, drummed waste identified in the waste management element of the CERCLA Hazardous Waste IRA may be disposed in the on-post hazardous waste landfill in accordance with the CDD (Harding Lawson Associates 1996).
- Continued monitoring, as part of design refinement, for areas that may pose a potential risk to biota as outlined in the following process:
  - The BAS of technical experts (such as ecotoxicologists, biologists, and range/reclamation specialists) from the Parties will focus on the planning and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The BAS will provide interpretation of results and recommendations for design refinements to the Parties' decision makers.
  - The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to refine design boundaries for surficial soil and aquatic contamination to be remediated.
    - Phase I and the potential Phase II of the SFS will be used to refine the general areas of surficial soil contamination concern. The field BMFs will be used to quantify ecological risks in the Area of Dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of excess risks (Figure 6.2-6).
    - Pursuant to the FFA process, USFWS will conduct detailed site-specific exposure studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC report as appropriate). These studies will address both the aquatic resources and at least the surficial soil in and around the Area of Dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.
    - Results from both the SFS/risk assessment process and the site-specific studies will be considered in risk-management decisions, which may further refine the areas of surficial soil and aquatic contamination to be remediated. (In the event of a conflict between management of RMA as a wildlife refuge and performance of remedial response actions, the Rocky Mountain Arsenal National Wildlife Refuge Act indicates that response actions will take priority.)
  - The BAS will serve as a technical resource to the Parties' decision makers by using technical expertise in analyzing, and potentially collecting, data sufficient to support design refinement for surficial soil areas and aquatic resources that will break unacceptable exposure pathways in consideration of minimizing habitat disturbance. Further, it will assess through monitoring the efficacy of remedies in breaking unacceptable pathways to biota. If any additional sites are identified, the remedy will be implemented as follows:

  - It will be staged to allow habitat recovery.
  - It will be performed first on locations selected through a balance of factors such as:
    - The Parties agree an area has a negative impact on or excessive risk to fish or wildlife.
    - The effort will not be negated by recontamination from other remediation activities.
    - The existing fish and wildlife resource value.
  - It will include revegetation of a type specified by USFWS; if the initial revegetation is not successful, the appropriate adjustments will be made and revegetation again implemented.
  - It will provide that the locations and timing of remediation are to be determined with consideration of and in coordination with USFWS refuge management plans and activities.
- The SFS, biomonitoring programs, and recommendations of the BAS will be used to refine the areas of remediation during remedial design.

- Any UXO encountered during remediation will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.
- Within 180 days after issuance of the Notice of Availability for the ROD, the Army will append to the ROD a complete, detailed schedule for completion of activities associated with the selected remedy. The schedule will identify the enforceable project milestone dates for design activities. Future design documents will detail milestone dates for implementation activities. Revisions to this schedule will be initiated prior to the start of each fiscal year to allow adequate time for review and concurrence by the Parties.

9.5 Remediation Goals and Standards

The treatment components of the selected groundwater remedy will meet the CSRGs presented in Tables 9.1-1 through 9.1-4, and the components of the selected soil and structures remedy will meet the remediation goals and standards presented in Table 9.5-1. The selected remedies will comply with the performance standards as provided in Appendix A (ARARs).

9.6 Cost of the Selected Remedy

The total estimated cost (in 1995 dollars) for the selected remedy is $2.2 billion (present worth $1.8 billion). Table 9.6-1 presents the capital and O&M costs for the selected alternatives. The time required for implementation is approximately 17 years, with groundwater system operations continuing for at least 30 years. The implementation of the remedy could be accelerated if funding is available that exceeds $100 million/year.

9.7 Long-Term Operations

Long-term operations are those ongoing activities that will be performed after the initial remediation work is completed and that will continue after EPA releases the site to USFWS as a wildlife refuge. These include monitoring and maintaining containment systems, such as the caps and the landfill, and continuing the operation of groundwater treatment systems.

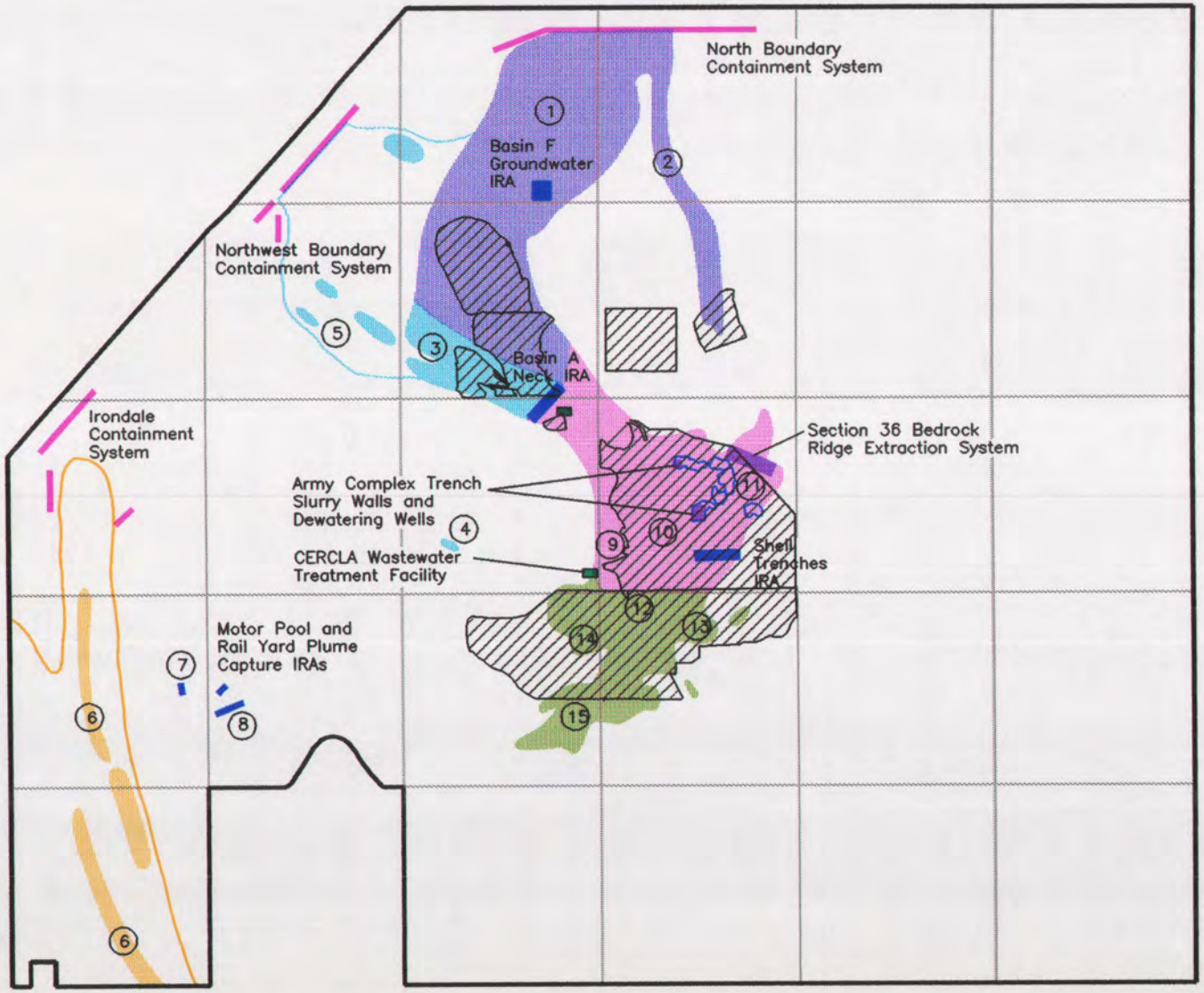
Soil sites where covers or caps are constructed will be inspected on a regular basis, and damage to the vegetative cover or any eroded soil will be repaired. Long-term management also includes access restrictions to capped and covered areas to ensure the integrity of the containment systems. Where human health exceedances are left in place at soil sites, groundwater will be monitored, as necessary, to evaluate the effectiveness of the remedy. The on-site hazardous waste landfill will be closed and monitored according to RCRA and TSCA requirements. Long-term activities at this facility will include leachate collection and disposal, regular cover inspections with repair of vegetative cover damage or erosion, and sampling of upgradient and downgradient wells to monitor for migration of landfill contaminants into the groundwater. Monitoring activities for biota will continue by USFWS in support of evaluating the effectiveness of the selected remedy.

Long-term activities for the water medium include continued operation of the NWBCS, NBCS, ICS, the Basin A Neck and North of Basin F Groundwater IRA systems, and the new Section 36 Bedrock Ridge groundwater Extraction System. Operation of wells within these systems may be discontinued according to the shutdown criteria listed in Section 9.1. Maintenance of lake levels and groundwater monitoring will be continued as described in Section 9.1.

A network of monitoring wells will be sampled to evaluate the effectiveness of the remedy. A select number of deep wells will also be sampled to monitor any contamination in the confined aquifer. Surface water will be monitored and managed in a manner consistent with the selected remedy.

There are no long-term activities directly associated with the structures medium groups as all potentially contaminated structures will be demolished and the structural debris placed into the on-post hazardous waste landfill or used as fill under the Basin A cover. These sites will be monitored and maintained as described above.

Technical working groups or subcommittees will combine their efforts to evaluate the effectiveness of the remedy and make recommendations to the Parties' decision makers. In addition, site reviews will be conducted at least every 5 years (following the signing of the ROD) for all sites where contaminants that exceed remediation goals are left in place. The effectiveness of containment remedies will be evaluated to determine what additional remedial actions may be required if containment is found to be inadequate. In the event other contaminants not included as COCs are identified as a concern (e.g., dioxin) during or after design or implementation, an evaluation will be conducted as required by EPA guidance (OSWER-EPA 1989a) to ensure that the remedial action is protective of human health and the environment. At a minimum, evaluations will be part of the 5-year site review.



LEGEND

- Boundary System
- Treatment System
- Existing IRA
- Slurry Wall
- Groundwater extraction well
- Capped/Covered Area

- North Boundary Plume Group
  - (1) Basins C and F Plume
  - (2) North Plants Plume
- Northwest Boundary Plume Group (Outlined in blue:)
  - (3) Basin A Neck Plume
  - (4) & (5) Sand Creek Lateral Plumes
- Western Plume Group
  - (6) Western Plume (Outlined in yellow:)
  - (7) Motor Pool Plume
  - (8) Rail Yard Plume
- Basin A Plume Group
  - (9) South Plants North Plume
  - (10) Basin A Plume
  - (11) Section 36 Bedrock Ridge Plume
- South Plants Plume Group
  - (12) South Plants North Source Plume
  - (13) South Plants Southeast Plume
  - (14) South Plants Southwest Plume
  - (15) South Tank Farm Plume

[1] Colored portions of plumes indicate summed total organic concentrations above 100 ug/l.

-N-

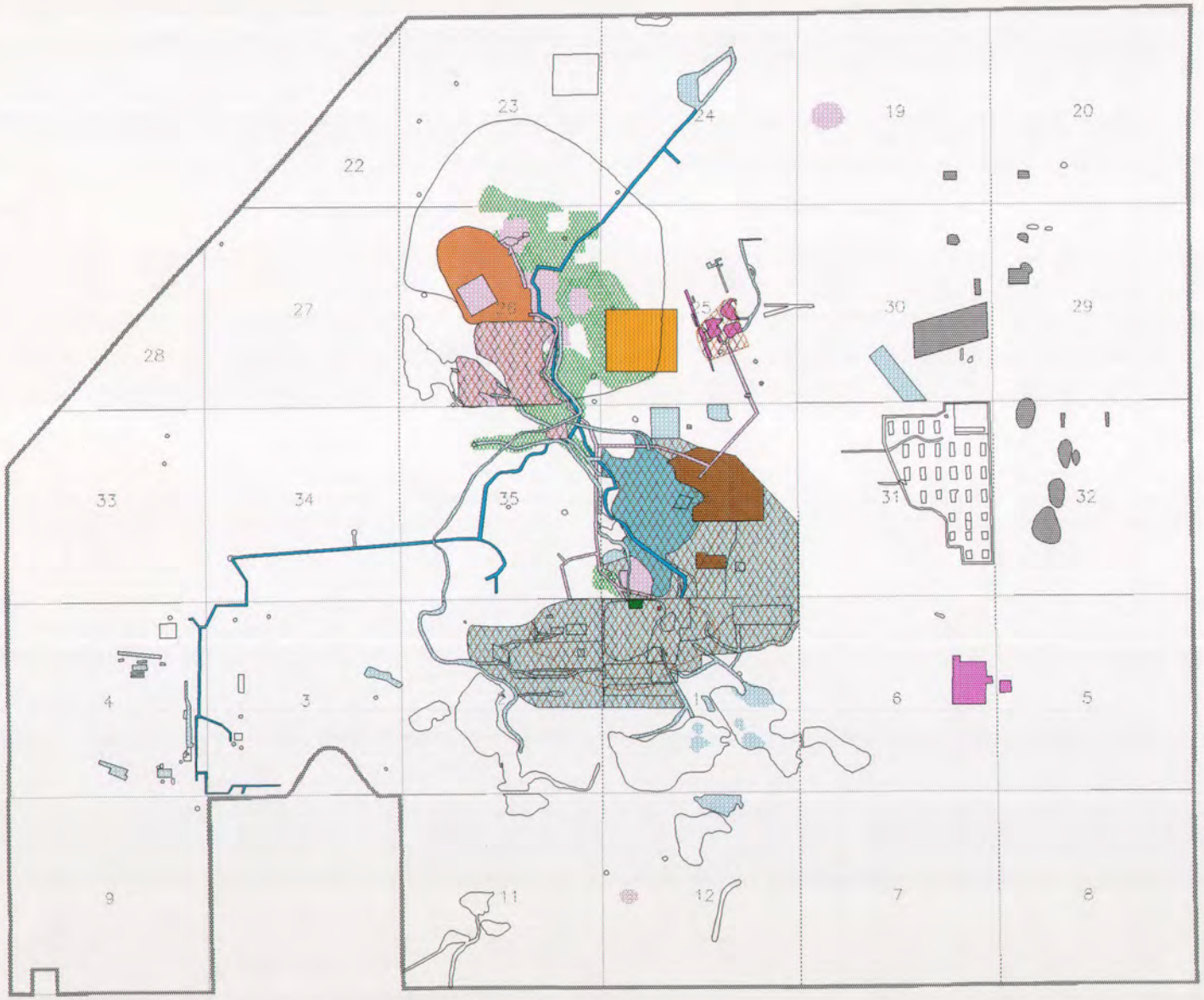
0 3000
Scale in Feet

Prepared for:
Office of the Program Manager
for Rocky Mountain Arsenal
June 1996

FIGURE 9.1-1
Alternative 4: Continued Operation of Existing Boundary Systems and IRAs and Extraction from Section 36 Bedrock Ridge

Prepared by:
Foster Wheeler Environmental Corporation

File Name: F:\PROJECTS\RMA\F9_1-1.DWG
Date 6/06/96
Drawn by TH/JLS
Checked by SA



Legend

- RMA Boundary
- SAR Site Boundary[1]
- In-situ Solidification of Principal Threat Volume; RCRA-Equivalent Cap
- RCRA-Equivalent Caps
- Direct Solidification/Stabilization
- Innovative Thermal Treatment (Hex Pit)
- Basin A Consolidation Area
- Landfill Human Health Soil,[2] Consolidation of Biota Soil
- Landfill Human Health Soil[3]
- Landfill Site
- Soil Covers
- Agent Screening Area (Caustic wash/landfill)
- UXO Screening Area (Detonation/landfill)
- Surficial Soil Consolidation
- Access Restrictions
- 5 Section Number

[1] Study Area Report (see Remedial Investigation Summary Report, Ebasco 1992a)

[2] Debris from the Sanitary Landfills Medium Group will be consolidated.

[3] Wastepile material will be dried prior to landfilling, if necessary, to pass EPA paint filter test.

-N-

1500 0 1500 3000 Feet

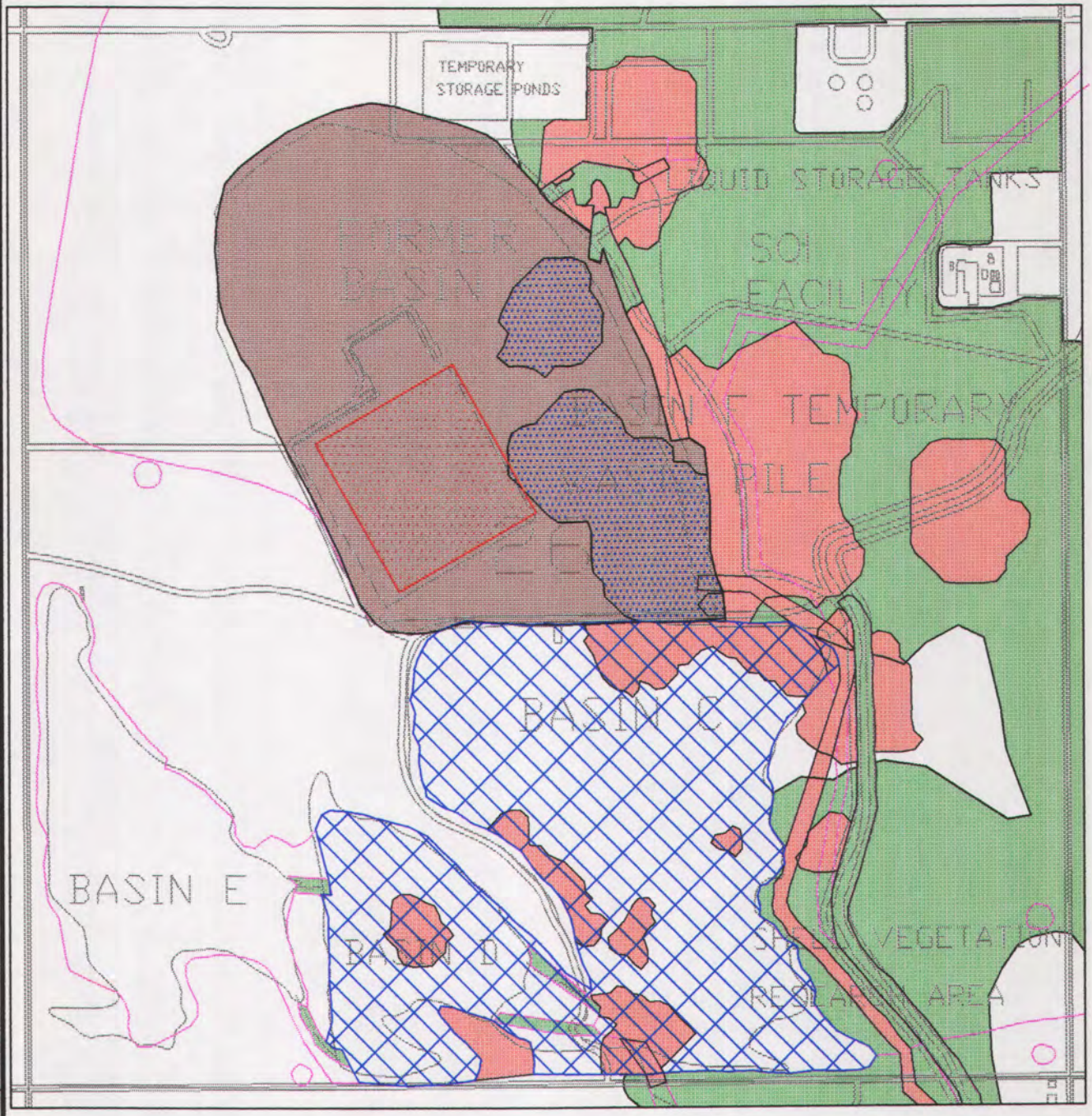
Prepared for: U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 9.3-1

Selected Soil Remedy Consolidation/Caps/Treatment/Landfill

Foster Wheeler Environmental Corporation
June 1996

File Name: C:\SOIL\SROD\FIG931
Date 6/06/96
Drawn by XG
Checked by SA



Legend

- Former Basin F Solidification Area
- RCRA–Equivalent Cap
- Human Health and Principal Threat Excavation Area
- Biota Excavation Area
- Basin F Wastepile Excavation
- 2–Foot Soil Cover Area
- SAR Site Boundary (Study Area Report; see Remedial Investigation Summary Report, Ebasco 1992a.)
- 31 Section Number
- Section Line
- Drainage
- Road
- Railroad

-N-

0 400 800
Scale in Feet

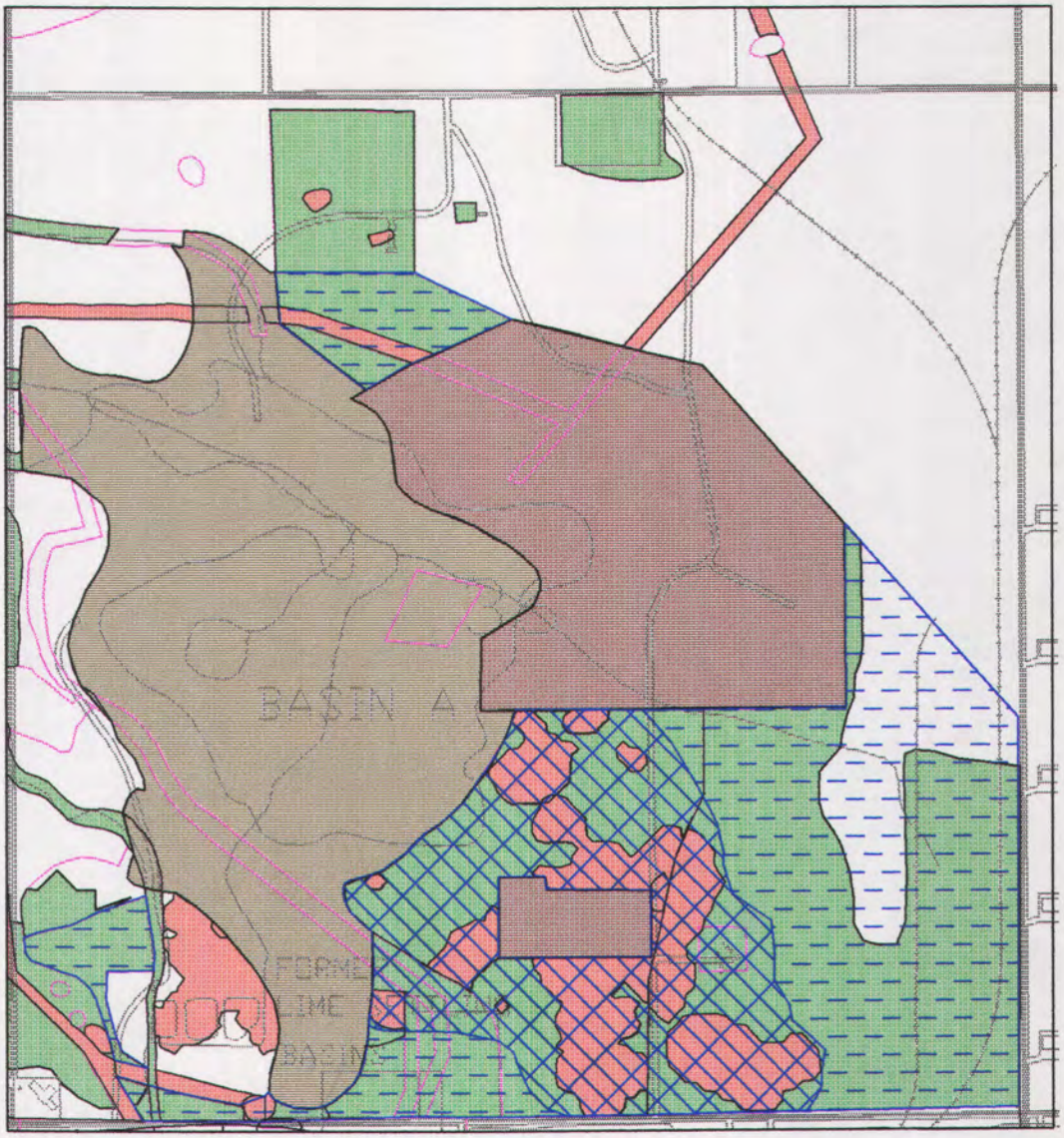
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared July 1996

Figure 9.3–2
Section 26 Excavation Areas and Cap/Cover Components

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.

File Name: F:\PROJECTS\ARSENAL\ROD\SEC26_EX.DWG
Date 7/22/96
Drawn by JLS
Checked by SA



Legend

- Basin A Consolidation Area with 4-Foot Soil Cover/6-Inch Concrete Layer
- RCRA-Equivalent Caps
- Human Health and Principal Threat Excavation Area
- Biota Excavation Area
- 2-Foot Soil Cover Area
- 1-Foot Soil Cover Area
- SAR Site Boundary (Study Area Report; see Remedial Investigation Summary Report, Ebasco 1992a.)
- 31 Section Number
- Section Line
- Drainage
- Road
- Railroad

N

0 500 1000
Scale in Feet

Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

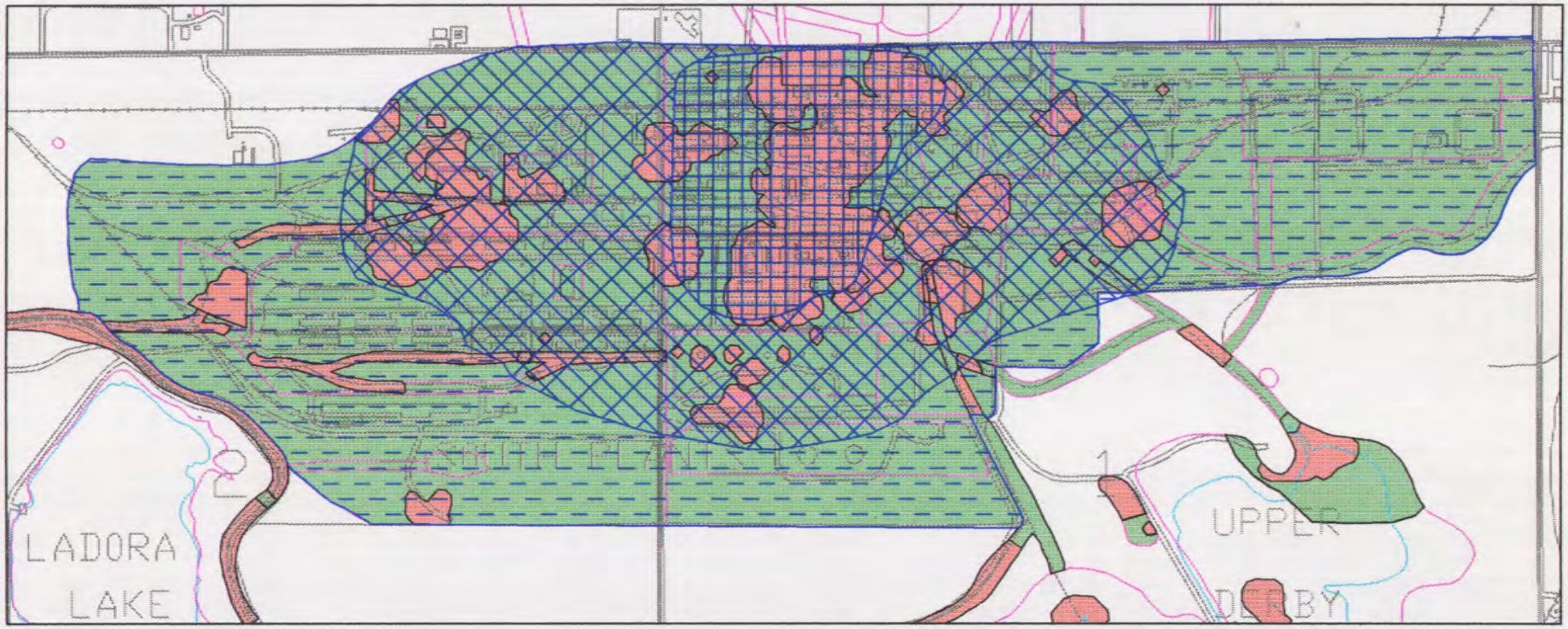
Prepared June 1996

Figure 9.3-3

Section 36 Excavation Areas and Cap/Cover Components

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.

File Name: F:\PROJECTS\ARSENAL\ROD\SEC36_EX.DWG
Date 6/06/96
Drawn by JLS
Checked by SA



Legend

- Human Health and Principal Threat Excavation Area
- Biota Excavation Area
- South Plants Central Processing Area Cover (4-foot soil cover with biota barrier)
- 3-Foot Soil Cover Area
- 1-Foot Soil Cover Area
- SAR Site Boundary (Study Area Report; see Remedial Investigation Summary Report, Ebasco 1992a.)
- 31 Section Number
- Section Line
- Drainage
- Road
- Railroad

-N-

0 500 1000
Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared June 1996

Figure 9.3-4

South Plants Excavation Areas and Cover Components

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.

Checked by SA | Drawn by JLS | Date 6/06/96 | File Name: F:\PROJECTS\ARSENAL\ROD\SP_EX.DWG

Legend

- Principal Threat Exceedance Area
- Human Health Exceedance Area[1]
- Biota Exceedance Area
- RCRA–Equivalent Cap[2]
- Soil Cover[2, 3]
- 31 Section Number
- Section Line

[1] Exceedance soil in South Plants Central Processing Area remains below the 5–ft depth of excavation.

[2] RCRA–equivalent caps and Basin A and South Plants Central Processing Area soil covers include a biota–intrusion layer.

[3] Soil covers vary in thickness from 1 to 4 ft.

-N-

0 2150 4300

Scale in Feet

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Prepared June 1996

Figure 9.3–5

Containment Systems for Exceedances Remaining in Place following Remediation

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corp.

File Name: F:\PROJECTS\ARSENAL\ROD\RMA_EX.DWG
Date 5/17/96
Drawn by JLS
Checked by SA

Table 9.1-1 CSRGs for the Northwest Boundary Containment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)	
VHOs (Volatile Halogenated Organics)		
Trichloroethylene	3[1]	
Chloroform	6[2]	
OPHBGs (Organophosphorous Compounds; Isopropylmethyl Phosphonofluoridate (GB) Agent Related)		
DIMP (Diisopropylmethyl phosphonate)	8[2]	
Other Organics		
NDMA (n-Nitrosodimethylamine)	0.007[4]	(0.033)[3]
OCPs (Organochlorine Pesticides)		
Dieldrin	0.002[2]	(0.05)[3]
Endrin	0.2[2]	
Isodrin	0.06[1]	
Arsenic	2.35[1]	

1 Health-based value from the ROD for the Off-Post Operable Unit (Harding Lawson Associates 1995).
2 Colorado Basic Standards for Groundwater. The Basic Standards for Groundwater, 5 CCR 1002.8, Section 3.11.
3 Current certified reporting limit or practical quantitation limit readily available from a certified commercial laboratory.
4 Risk-based value from Integrated Risk Information System (OHEA-EPA 1995).

Table 9.1-2 CSRGs for the Irondale Containment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)
VHOs (Volatile Halogenated Organics)	
Trichloroethylene	5[1,2]
Other Organics	
DBCP (Dibromochloropropane)	0.2[1,2]

1 Colorado Basic Standards for Groundwater. The Basic Standards for Groundwater, 5 CCR 1002.8, Section 3.11.
2 Federal maximum contaminant levels, 40 CFR 141.

Table 9.1-3 CSRGs for the North Boundary Containment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)	
VHOs (Volatile Halogenated Organics)		
1,2-Dichloroethane	0.4[1]	(1.0)[5]
1,2-Dichloroethylene	70 [1,2]	
Carbon tetrachloride	0.3 [1]	(0.99)[5]
Chloroform	6 [1]	
Methylene chloride	5 [1,2,6,7]	
Tetrachloroethylene	5 [1,2]	
Trichloroethylene	3 [3]	
VHCs (Volatile Hydrocarbon Compounds)		
DCPD (Dicyclopentadiene)	46 [3]	
VAOs (Volatile Aromatic Organics)		
Benzene	3 [3]	
Xylenes	1,000 [3]	
Toluene	1,000 [1,2]	
OSCMs (Organosulfur Compounds; Mustard Agent Related)		
1,4-Oxathiane	160 [3]	
Dithiane	18 [3]	
OSCHs (Organosulfur Compounds; Herbicide Related)		
Chlorophenylmethyl sulfide	30 [4]	
Chlorophenylmethyl sulfone	36 [4]	
Chlorophenylmethyl sulfoxide	36 [4]	
OPHGBs (Organophosphorous Compounds; Isopropylmethyl Phosphonofluoridate (GB) Agent Related)		
DIMP (Diisopropylmethyl phosphonate)	8 [1]	
OPHPs (Organophosphorous Compounds; Pesticide Related)		
Atrazine	3 [1,2]	
Malathion	100 [3]	

Table 9.1-3 CSRGs for the North Boundary Containment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)	
OCPs (Organochlorine Pesticides)		
Aldrin	0.002[1]	(0.05)[5]
Dieldrin	0.002 [1]	(0.05)[5]
Endrin	0.2[1]	
Isodrin	0.06[3]	
Other Organics		
DBCP (Dibromochloropropane)	0.2[1,2]	
NDMA (N-Nitrosodimethylamine)	0.007[6]	(0.033)[5]
Arsenic	2.35[3]	
Anions		
Fluoride	2,000 [1, 10]	
Chloride	250,000 [1, 8]	
Sulfate	540,000 [1, 8, 9]	

1 Colorado Basic Standards for Groundwater. The Basic Standards for Groundwater, 5 CCR 1002.8, Section 3.11.
2 Federal maximum contaminant levels, 40 CFR 141.
3 Health-based value from the ROD for the Off-Post Operable Unit (Harding Lawson Associates 1995).
4 EPA Region VIII Health Advisory value.
5 Current certified reporting limit or practical quantitation limit readily available from a certified commercial laboratory.
6 Risk-based level from the Integrated Risk Information System (OHEA-EPA 1995).
7 Methylene chloride is a common laboratory contaminant and analytical anomalies may be observed during compliance monitoring.
8 As described in Section 7.2.2, chloride and sulfate are expected to attenuate naturally, achieving remediation goals with time.
9 Inorganic CSRG for sulfate may be the natural background concentration.
10 The federal MCL for fluoride is 4,000 µg/l.

Table 9.1-4 CSRGs for the Basin A Neck IRA Treatment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)	
VHOs (Volatile Halogenated Organics)		
1,2-Dichloroethane	0.4[1]	(1.1)[4]
1,1,1-Trichloroethane	200[1,2]	
1,1-Dichloroethylene	7[1,2]	
Carbon tetrachloride	0.3[1]	(1.0)[4]
Chlorobenzene	100[1,2]	
Chloroform	6[1]	
Tetrachloroethylene	5[1,2]	
Trichloroethylene	5[1,2]	
VHCs (Volatile Hydrocarbon Compounds)		
Dicyclopentadiene	46[3]	
VAOs (Volatile Aromatic Organics)		
Benzene	5[1,2]	
OPHPs (Organophosphorus Compounds; Pesticide Related)		
Atrazine	3[1,2]	
SHOs (Semivolatile Halogenated Organics)		
Hexachlorocyclopentadiene	50[1]	
OCPs (Organochlorine Pesticides)		
DDT (Dichlorodiphenyltrichloroethane	0.1[1]	
Dieldrin	0.002[1]	(0.1)[4]
Endrin	0.2[1]	
OSCHs (Organosulfur Compounds; Herbicide Related)		
Chlorophenylmethylsulfide	30[3]	
Chlorophenylmethylsulfone	36[3]	
Chlorophenylmethylsulfoxide	36[3]	
Dicyclopentadiene	46[3]	
OSCMs (Organosulfur Compounds; Mustard Agent Related)		
1,4-Oxathiane	160[3]	
Dithiane	18[3]	

Table 9.1-4 CSRGs for the Basin A Neck IRA Treatment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)
Arsenic	50[1,2]
Mercury	2[1,2]

1 Colorado Basic Standards for Groundwater. The Basic Standards for Groundwater, 5 CCR 1002.8, Section 3.11.
2 Federal maximum contaminant levels, 40 CFR 141.
3 Health-based value from the ROD for the Off-Post Operable Unit (Harding Lawson Associates 1995).
4 Current practical quantitation limit or certified reporting limit.

Table 9.3-1 Summary of the Selected Soil Remedy

Medium Groups/Subgroups	Remedial Action
Munitions Testing	Munitions screening; off-post detonation of UXO (450 BCY); landfill debris and soil above TCLP (89,000 BCY).
North Plants	Landfill human health exceedance (220 BCY); agent monitoring during excavation; caustic washing; construct soil cover over biota risk area and processing area footprint (160,000 SY).
Toxic Storage Yards	Landfill human health exceedance (2,700 BCY); utilize New Toxic Storage Yard for borrow area; agent monitoring during site excavation and preparation; caustic washing.
Lake Sediments	Landfill human health exceedances (16,000 BCY); consolidate soil posing risk to biota from Upper Derby Lake (19,000 BCY) into Basin A or South Plants; deferral to USFWS for aquatic sediment.
Surficial Soil	Landfill human health exceedances (87,000 BCY); consolidate soil posing risk to biota in Basin A/Former Basin F/South Plants (460,000 BCY).
Ditches/Drainage Areas	Consolidate soil posing risk to biota in Basin A (23,000 BCY).
Basin A	Construct soil cover with formed concrete layer over principal threat and human health exceedances and soil posing risk to biota (670,000 SY); consolidate debris and soil posing risk to biota (790,000 BCY) and structural debris (160,000 BCY) from other sites.
Basin F Wastepile	Landfill entire wastepile (principal threat exceedance) (600,000 BCY) in triple-lined cell (with vapor controls) after drying saturated materials.
Former Basin F	In situ solidification/stabilization of principal threat volume (190,000 BCY); construct RCRA-equivalent cap over entire site (including Basin F Wastepile footprint) (525,000 SY).
Secondary Basins	Landfill human health exceedances (32,000 BCY); construct soil cover over soil posing risk to biota (520,000 SY).
Sanitary/Process Water Sewers	Plug remaining manholes.
Chemical Sewers	Plug sewer lines in South Plants Central Processing Area and Complex Trenches; landfill remaining principal threat and human health exceedances (64,000 BCY).
Complex Trenches	Construct RCRA-equivalent cap with formed concrete layer over principal threat and human health exceedances and soil posing risk to biota (390,000 SY) and install a slurry wall around disposal trenches.
Shell Trenches	Modify existing cover to be a RCRA-equivalent cap (32,000 SY) and modify existing slurry wall around trenches.

Table 9.3-1 Summary of the Selected Soil Remedy

Medium Groups/Subgroups	Remedial Action
Hex Pit	Treatment of buried material (1,000 BCY) using an innovative thermal technology (with vapor controls); landfill remaining volume (2,300 BCY). Solidification/stabilization will become the selected remedy if all evaluation criteria for the innovative thermal technology are not met.
Sanitary Landfills	Landfill human health exceedances (14,000 BCY); consolidate debris and soil posing risk to biota in Basin A (410,000 BCY).
Section 36 Lime Basins	Landfill principal threat and human health exceedances in triple-lined cell (54,000 BCY); repair existing soil cover.[1]
Buried M-1 Pits	Solidification of principal threat and human health exceedances (26,000 BCY) and landfill (with vapor controls).[1]
South Plants Central Processing Area	Landfill principal threat and human health exceedances (110,000 BCY); construct soil cover over entire site including soil posing risk to biota (220,000 SY); consolidate soil posing risk to biota from other sites (370,000 BCY).[1]
South Plants Ditches	Landfill principal threat and human health exceedances (33,000 BCY); consolidate soil posing risk to biota into excavated areas or South Plants Central Processing Area (22,000 BCY); construct soil cover over entire site (120,000 SY).
South Plants Balance of Areas	Landfill principal threat and human health exceedances (130,000 BCY); consolidate soil posing risk to biota into excavated areas or South Plants Central Processing Area (510,000 BCY); construct soil cover over entire site (1,700,000 SY).[1,2]
Buried Sediments	Landfill human health exceedances (16,000 BCY).
Sand Creek Lateral	Landfill human health exceedances (15,000 BCY); consolidate soil posing risk to biota into Basin A (90,000 BCY).
Section 36 Balance of Areas	Landfill human health exceedances and debris (140,000 BCY); consolidate soil posing risk to biota into Basin A (140,000 BCY); construct soil cover over entire site (850,000 SY).[1,2]
Burial Trenches	Landfill human health exceedances and debris (85,000 BCY).[1,2]
Contingent Volume	Landfill identified volume (up to 150,000 BCY).

1 Agent monitoring during excavation and treatment of any soil containing agent by caustic solution washing.
2 Munitions screening prior to excavation, off-post detonation of any munitions encountered, and landfill munitions debris/soil above TCLP.

Table 9.3-2 Final Disposition of Soil Exceedance Volumes[1]

Medium Group/Subgroup	RCRA Landfill[2]	Enhanced RCRA Landfill[2]	Consolidation in Basin A	Consolidation in Basin F	Consolidation within South Plants	Treatment[3]	Caustic Washing and Landfill	UXO Demilitarization Off Post
Munitions Testing	89,000							450
North Plants	220						61	
Toxic Storage Yards	2,700						220	
Lake Sediments	16,000		19,000					
Ditches/Drainage Areas			23,000					
Surficial Soil	87,000		109,000	351,000				
Basin A								5
Basin F Wastepile		600,000						
Secondary Basins	32,000							
Former Basin F[3]						190,000		
Sanitary/Process Water Sewers								
Chemical Sewers	61,000						20	
Complex Trenches								130
Shell Trenches								
Hex Pit[3]	2,300					1,000		
Sanitary Landfills	14,000		406,000					
Section 36 Lime Basins		54,000					91	
Buried M-1 Pits[3]						26,000	29	
South Plants Central Processing Area	110,000						160	
South Plants Ditches	33,000				22,000			
South Plants Balance of Areas	135,000				510,000		160	50
Buried Sediments	16,000							
Sand Creek Lateral	15,000		90,000					
Section 36 Balance of Areas	142,000		140,000				300	160
Burial Trenches	85,000							550
Totals	840,000	654,000	787,000	351,000	532,000	217,000	1,040	1,340

[1] All volumes given in bank cubic yards. The soil volumes referenced in this table are summarized in Table 7.1-5, and are based on the TECHBASE software and other calculations. All soil volumes referenced in this table are subject to the addition of "contingent volumes" based on findings during implementation of remedial activities.

[2] Landfill volume does not include contingent soil volume (up to 150,000 BCY), structures demolition debris, treated material volume, or landfill daily cover.

[3] Treatment detailed as follows: Former Basin F, in situ solidifcation; Hex Pit, innovative thermal; Buried M-1 Pits, solidification and landfill.

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Table 9.3-3 Untreated Soil Exceedance Volumes Remaining In Place[1,2]

Medium Group/Subgroup	Human Health	Principal Threat	Biota	Agent	UXO	UXO Debris	Consolidated Soil from Other Sites	Total Volume Remaining in Place
Munitions Testing								
North Plants			17,000					17,000
Toxic Storage Yards								
Lake Sediments								
Ditches/Drainage Areas								
Surficial Soil								
Basin A	160,000	32,000	88,000	710	89	47000[3]	787,000	1,080,000
Basin F Wastepile								
Secondary Basins			140,000					140,000
Former Basin F	550,000						351,000	901,000
Sanitary/Process Water Sewers								
Chemical Sewers	24,000	11,500		49				24,000
Complex Trenches	400,000	400,000		1,300	1,170	130,000[4]		532,000
Shell Trenches	100,000	100,000						100,000
Hex Pit								
Sanitary Landfills								
Section 36 Lime Basins								
Buried M-1 Pits								
South Plants Central Processing Area	32,000[5]	17,000[5]	27,000				370,000	429,000
South Plants Ditches								
South Plants Balance of Areas							162,000	162,000
Buried Sediments								
Sand Creek Lateral								
Section 36 Balance of Areas								
Burial Trenches				12				
Totals	1,270,000	561,000	272,000	2,070	1,260	177,000	1,670,000	3,390,000

1 All volumes given in bank cubic yards.

2 All volumes remaining in place are contained beneath soil covers or caps.

3 Debris volume remaining includes 17,000 BCY human health exceedance volume and 30,000 BCY of biota risk volume.

4 Debris volume remaining includes 43,000 BCY human health exceedance volume and 87,000 BCY of biota risk volume.

5 Remaining volume at a depth greater than 5 ft.

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Table 9.3-4 Cap and Soil Cover Components[1]

Medium Group/Subgroup	RCRA-Equivalent Caps	Soil Covers: 4 ft minimum thickness	3 ft minimum thickness	2 ft minimum thickness	1 ft minimum thickness
Munitions Testing					
North Plants				157,000	
Toxic Storage Yards					
Lake Sediments					
Ditches/Drainage Areas					
Surficial Soil					
Basin A[2]		667,000			
Basin F Wastepile					
Secondary Basins				523,000	
Former Basin F	525,000				
Sanitary/Process Water Sewers					
Chemical Sewers					
Complex Trenches[2]	390,000				
Shell Trenches	32,000				
Hex Pit					
Sanitary Landfills					
Section 36 Lime Basins					
Buried M-1 Pits					
South Plants Central Processing Area		230,000			
South Plants Ditches[3]					
South Plants Balance of Areas			826,000		1,010,000
Buried Sediments					
Sand Creek Lateral					
Section 36 Balance of Areas				345,000	506,000
Burial Trenches					
Totals	947,000	897,000	826,000	1,030,000	1,520,000

1 All areas given in square yards.

2 Cap or cover includes a 6-inch formed concrete layer.

3 South Plants Ditches sites are included under the South Plants Balance of Areas cover area.

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
RCRA/TSCA Hazardous Waste Landfill	Munitions Testing; Secondary Basins; Chemical Sewers; Sanitary Landfills; South Plants Central Processing Area; South Plants Ditches; South Plants Balance of Areas; Buried Sediments; Sand Creek Lateral; Section 36 Balance of Areas; Burial Trenches; Buried M-1 Pits; Hex Pit; North Plants; Toxic Storage Yards; Lake Sediments; Surficial Soil; No Future Use Structures, Significant Contamination History; No Future Use Structures, Agent History	Landfill • Standard: Landfill principal threat and human health soil exceedance volumes, UXO debris, agent-contaminated material, and structural debris. • Standard: Design landfill to meet state 1,000-year siting criteria. • Standard: Ensure all material disposed in landfill passes EPA paint filter test. Cap • Standard: Minimize infiltration by limiting the hydraulic conductivity of the clay/synthetic composite barrier layer (1×10^{-7} cm/sec or less for clay layer). • Standard: Meet or exceed all RCRA, TSCA, and state requirements. Liner • Standard: Minimize percolation by limiting the hydraulic conductivity of the compacted clay layer to 1×10^{-7} cm/sec or less. • Standard: Install two composite liners, each consisting of 3 ft of compacted clay and a synthetic liner. • Standard: Meet or exceed all RCRA, TSCA, and state requirements.	RCRA/TSCA regulations; State RCRA regulations; CAMU Designation Document

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
Enhanced RCRA Hazardous Waste Landfill	Basin F Wastepile; Section 36 Lime Basins	Landfill • Standard: Landfill principal threat and human health soil exceedance volumes and agent-contaminated material. • Standard: Design landfill to meet state 1,000-year siting criteria. • Standard: Ensure all material disposed in landfill passes EPA paint filter test. Cap • Standard: Minimize infiltration by limiting the hydraulic conductivity of the clay/synthetic composite barrier layer (1×10^{-7} cm/sec or less for clay layer). • Standard: Meet or exceed all RCRA, TSCA, and state requirements. Enhanced liner • Standard: Minimize percolation by limiting the hydraulic conductivity of the compacted clay layer to 1×10^{-7} cm/sec or less. • Standard: Install two composite liners, each consisting of 3 ft of compacted clay and a synthetic liner, and one additional composite liner. • Standard: Meet or exceed all RCRA and state requirements.	RCRA regulations; State RCRA regulations; CAMU Designation Document

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
RCRA-Equivalent Cap	Former Basin F; Complex (Army) Trenches w/concrete layer; Shell Trenches	• Ensure cap performance is equivalent to RCRA landfill cap with these objectives: – Standard: Allow no greater range of infiltration through the cap than the range of infiltration that would pass through an EPA-approved RCRA cap. – Standard: Prevent contact between hazardous materials and humans/biota by using biota barriers and maintaining institutional controls. – Goal: Serve as effective long-term barriers. – Standard: Demonstrate cap performance equivalent to a RCRA landfill cap according to an EPA- and state-approved demonstration that will include comparative analysis and field demonstration. • Goal: Maximize runoff and minimize ponding. • Standard: Maintain cover percolation less than or equal to the percolation of the underlying native soil. • Goal: Minimize erosion by wind and water. • Goal: Prevent damage to integrity of cap by biota and humans. • Goal: Maintain cover of locally adapted perennial vegetation.	State and federal RCRA regulations
UXO Clearance	Munitions Testing; Basin A; Section 36 Balance of Areas; Complex (Army) Trenches; Burial Trenches; South Plants Balance of Areas	• Standard: Identify, transport off post, neutralize, and destroy explosives/explosive residue. • Standard: Ensure excavation of all identified munitions-contaminated soil exceeding TCLP (Munitions Testing and Burial Trenches) and munitions debris and disposal in the on-post RCRA landfill.	Army surety safety and UXO regulations

Table 9.5-1 Remediation Goals and Standards for the On-Post Operable Unit

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
Agent Decontamination	North Plants; Toxic Storage Yard; Section 36 Balance of Areas; Buried M-1 Pits; Burial Trenches; South Plants Central Processing Area; South Plants Balance of Areas; Section 36 Lime Basins; Chemical Sewers; No Future Use Structures, Agent History	• Standard: Certify 3X decontamination or caustic wash of soil and structural debris to achieve 3X decontamination. • Standard: Ensure disposal of 3X-decontaminated soil and structural debris in the on-post RCRA landfill.	Army surety safety regulations
Soil Cover (South Plants Consolidation Area)	South Plants Central Processing Area; South Plants Ditches; South Plants Balance of Areas	• Standard: Consolidate biota soil exceedance volume in South Plants Central Processing Area. • Standard: Maintain minimum cover thickness of 4 ft. • Goal: Minimize infiltration through cover. • Goal: Maximize runoff and minimize ponding. • Standard: Maintain cover percolation less than or equal to the percolation of the underlying native soil. • Goal: Minimize erosion by wind and water. • Goal: Prevent damage to integrity of cover by biota and humans. • Standard: Prevent biota and humans from accessing underlying contaminated soil by using biota barriers and maintaining institutional controls. • Goal: Maintain cover of locally adapted perennial vegetation.	Detailed Analysis of Alternatives; EPA guidance

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
Soil Cover with Concrete Layer (Basin A Consolidation Area)	Basin A; Lake Sediments; Surficial Soil; Section 36 Balance of Areas; Sand Creek Lateral; Sanitary Landfills; Ditches/Drainage Areas; No Future Use Structures, Other Contamination History	• Standard: Consolidate biota soil exceedence volume and structural debris in Basin A. • Standard: Maintain minimum cover thickness of 4 ft. • Goal: Maximize runoff and minimize ponding. • Standard: Maintain cover percolation less than or equal to the percolation of the underlying native soil. • Goal: Minimize erosion by wind and water. • Goal: Prevent damage to integrity of cover by biota and humans. • Standard: Prevent biota and humans from accessing underlying contaminated soil by using biota barriers and maintaining institutional controls. • Goal: Maintain cover of locally adapted perennial vegetation.	Detailed Analysis of Alternatives; EPA guidance
Soil Cover	Secondary Basins; North Plants; South Plants Ditches; South Plants Balance of Areas; Section 36 Balance of Areas	• Standard: Maintain minimum cover thicknesses specified in Section 9.3 of ROD. • Goal: Maximize runoff and minimize ponding. • Standard: Maintain cover percolation less than or equal to the percolation of the underlying native soil. • Goal: Minimize erosion by wind and water. • Goal: Prevent damage to integrity of cover by biota. • Standard: Prevent humans from accessing underlying contaminated soil by maintaining institutional controls. • Goal: Maintain cover of locally adapted perennial vegetation.	Detailed Analysis of Alternatives; EPA guidance
Solidification/ Stabilization	Former Basin F	• Standard: Comply with requirements of Basin F closure plan and design documents.	State RCRA regulations; EPA guidance

Table 9.5-1 Remediation Goals and Standards for the On-Post Operable Unit

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
Innovative Thermal Technology	Hex Pit	• Standard: Design to achieve 90% or greater destruction of contaminants. • Standard: Landfill all treatment residuals and untreated material in the on-post hazardous waste landfill.	EPA guidance
Solidification/ Stabilization	Buried M-1 Pits	• Standard: Design to reduce contaminant concentrations in leachate; a 90 to 99% reduction in contaminant concentrations in leachate is a general guidance and may be varied within a reasonable range considering the effectiveness of the technology and the cleanup goals for the site. • Goal: Design treatability testing to achieve a 90% reduction in contaminant concentrations in leachate. • Standard: Landfill all solidified material in the on-post RCRA landfill. • Standard: Provide adequate unconfined compressive strength after solidification/stabilization to meet disposal requirements.	EPA guidance
Plugging	Sanitary/Process Water Sewers; Chemical Sewers	• Standard: Interrupt exposure pathway by permanently plugging all Sanitary Sewer manholes. • Standard: Interrupt exposure pathway by permanently plugging all chemical sewer lines and manholes not excavated.	Detailed Analysis of Alternatives

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
Slurry Wall	Complex (Army) Trenches; Shell Trenches	• Goal: Minimize groundwater flow across the slurry wall with a design goal 1x 10^{-7} cm/sec hydraulic conductivity. • Goal: Construct slurry wall with sufficient thickness to withstand maximum hydraulic gradient. • Goal: Construct slurry wall with materials that are compatible with the surrounding groundwater chemistry. • Goal: Minimize migration by keying the slurry wall in an underlying low permeability strata. • Goal: Dewater as necessary to ensure containment.	Detailed Analysis of Alternatives
Drying	Basin F Wastepile	• Standard: Ensure dried material passes EPA paint filter test. • Standard: Comply with requirements of Basin F closure plan and design documents.	State regulations
Excavation	Munitions Testing; Secondary Basins; Chemical Sewers; Sanitary Landfills; South Plants Central Processing Area; South Plants Ditches; South Plants Balance of Areas; Buried Sediments; Sand Creek Lateral; Section 36 Balance of Areas; Burial Trenches; Hex Pit Buried M-1 Pits; North Plants; Toxic Storage Yards; Lake Sediments; Section 36 Lime Basins; Surficial Soil; Ditches/Drainage Areas; Basin F Wastepile	• Standard: Excavate all contaminated soil identified in the ROD for treatment, landfilling, or consolidation that corresponds to the areal and vertical extent detailed by the soil volume calculations in the administrative record.	State regulations; EPA guidance

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
PCB Removal		Equipment • Standard: Remediate in accordance with PCB IRA requirements. Structures • Standard: Remove structural materials with PCB concentrations of 50 ppm or greater that exist above ground level, as well as contaminated parts of floor slabs and foundations identified for removal, and dispose in the on-post TSCA-compliant landfill. • Standard: PCB-contaminated sections of floor slabs or foundations that are not identified for removal, and that have PCB concentrations of less than 50 ppm, will be left in place. Soil • Standard: Interrupt exposure pathway with a minimum of 3 ft of soil in the five areas identified as having PCB contamination <250 ppm. • Standard: Removal of contamination >250 ppm in the three areas identified by the PCB IRA and disposal in on-post TSCA-compliant landfill. • Standard: If necessary, any suspected PCB soil contamination areas will be characterized further during remedial design. If additional PCB-contaminated soil is found with concentrations of 50 ppm or greater, the Army will determine any necessary remedial action in consultation with EPA.	TSCA PCB regulations
Asbestos Removal		• Standard: Removal of asbestos and ACM to attain TSCA requirements.	TSCA asbestos regulations; State regulations

Technology	Medium Group/Subgroup	Remediation Goals[1] and Standards[2]	Primary Components of Rationale[3]
Groundwater Treatment System	Groundwater	• Standard: Capture and treat contaminated groundwater to meet or exceed CSRGs as specified in the ROD.	CBSG, MCL, MCLG, Risk-based criteria
Structure Demolition	No Future Use Structures, Agent History	• Standard: Certify 3X decontamination or caustic wash to achieve 3X decontamination.	State regulations; Army surety safety regulations
Structure Demolition	No Future Use Structures, Significant Contamination History; No Future Use Structures, Other Contamination History	• Standard: Demolish all structural material identified in the ROD for landfilling or consolidation.	State regulations
Air Emissions Control	All medium groups	• Goal: Control emissions, as necessary, during remediation. • Standard: Control emissions and odors for Basin F Wastepile excavation and Former Basin F remediation, in accordance with Basin F closure plan and design documents. • Standard: Meet air quality and odor standards that are ARARs. • Goal: Control air emissions as necessary to attain criteria that will be developed via an air pathway analysis program that will ensure that the remedial action will be protective of human health and the environment and minimize nuisance odors.	

[1] A broadly defined remediation objective supported by regulatory requirement, regulatory guidance, on agreement by the Parties. Typically, goals are less quantitative or measurable than standards.

[2] A quantitative or physical objective for remediation design that is based on a regulatory requirement, regulatory guidance, standard practice, or agreement by the Parties.

[3] This column indicates only a reference to ARARs in Appendix A as a portion of the rationale used to support the remediation goal. It does not include ARARs, nor is it intended to replace any ARARs. A complete listing of ARARs is presented in Appendix A.

Table 9.6-1 Total Estimated Cost for the Selected Remedy[1,2]

	Capital		Operating and Maintenance		Total Cost	
Cost Element	Total Cost[3]	Present Worth Cost	Total Cost[3]	Present Worth Cost	Total Cost[3]	Present Worth Cost
Soil	$530 million	$380 million	$41 million	$17 million	$570 million	$400 million
Water	$19 million	$18 million	$130 million	$85 million	$150 million	$100 million
Structures[4]	$7 million	$6.5 million	$140 million	$130 million	$150 million	$140 million
Pre-ROD Costs[5]	$750 million	$750 million	—	—	$750 million	$750 million
PMRMA Mission Support	$550 million	$430 million	—	—	$550 million	$430 million
Total Cost	$1.9 billion	$1.6 billion	$310 million	$230 million	$2.2 billion	$1.8 billion

1 Detailed cost information is provided in the Detailed Analysis of Alternative report.
2 All costs presented in 1995 dollars.
3 Total cost does not account for inflation over the time frame for remediation.
4 Structures cost includes $35 million to complete ongoing IRAs.
5 Pre-ROD costs include RI/FS and IRA costs and are listed to illustrate the total costs for complete remediation of RMA.

10.0 Statutory Determinations

This section describes how the selected remedy meets statutory requirements and complies with CERCLA and NCP requirements.

10.1 Consistency with the Statutory Requirements of CERCLA in Section 121

The selected remedy complies with Section 121 of CERCLA as described below.

10.1.1 Protection of Human Health and the Environment

The selected remedy will result in the remediation of the On-Post Operable Unit contaminated groundwater, structures, and soil consistent with the RAOs established for these media. It will eliminate, reduce, or control risks posed through each exposure pathway by engineering controls, treatment, or institutional controls so that cumulative site risks are reduced to acceptable levels. All human health, principal threat, and biota risk is being addressed by the selected remedy, thus resolving the risks at the On-Post Operable Unit. Additional biota studies are being performed in support of design refinement in areas (termed the Area of Dispute) where the potential risks to biota have not been agreed upon. There will be no unacceptable short-term risks or cross-media impacts caused by implementation of the remedy.

10.1.1.1 Groundwater

The groundwater remedial actions proposed under Alternative 4 will address the potential risks to human health and the environment by continuing treatment of groundwater at the boundary systems (NWBCS, NBCS, and ICS) as well as the on-post groundwater IRA systems (Basin A Neck, Motor Pool/Rail Yard, and North of Basin F IRAs), and through construction of a new groundwater extraction system northeast of the Army Complex Trenches (in the Section 36 Bedrock Ridge area). The toxicity, mobility, and volume of contaminated groundwater will be reduced through activated carbon (primarily) and air stripping treatment technologies. The extent of NDMA groundwater contamination and potential design refinements to achieve the remediation goals are currently being evaluated (see Section 7.2.2).

Contaminant concentrations at the RMA boundary will be reduced to meet or surpass the CSRGs, which represent applicable federal or state standards and are consistent with the ROD for the Off-Post Operable Unit. Consumption of groundwater or surface water on post will be restricted by institutional controls in accordance with the FFA. Nonpotable uses of on-post groundwater were not anticipated and risk was therefore not considered in the HHRC for such uses. A risk evaluation would be performed prior to any future nonpotable use to ensure that such use would be protective of human health and the environment. Continued monitoring of shallow (unconfined aquifer) and deeper (confined aquifer) groundwater and 5-year reviews of the site will be used to evaluate the effectiveness of the remedy. Water levels in Lake Ladora, Lake Mary, and Lower Derby

Lake will be maintained to support aquatic ecosystems. The biological health of the ecosystems will continue to be monitored. Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance.

10.1.1.2 Structures

The structures remedial actions proposed under Alternative 2 will address the potential risks to human health and the environment by demolishing and disposing of all No Future Use structures (approximately 94 percent of all remaining structures at RMA, which include all contaminated and potentially contaminated structures). As the structural debris is removed, materials are segregated for purposes of recycling and waste classification. Economically recyclable materials such as scrap metals are collected for salvage. Demolition debris from structures in the Significant Contamination History Group will be placed in the on-post hazardous waste landfill. Structures in the Agent History Group will be monitored following demolition, and any debris showing agent contamination will be treated; all debris from this group will then be placed in the on-post hazardous waste landfill. Debris from structures in the Other Contamination History Group will be used as fill under the cover in Basin A. Chemical process-related equipment, ACM, and PCB contamination not addressed during IRAs will be segregated during demolition and disposed in the on-post hazardous waste landfill (see Section 7.3.3).

These remedial actions achieve the structures remedial action objectives and reduce the mobility of contaminants through containment in the on-post hazardous waste landfill or under the Basin A cover. The potential for exposure to humans or biota is thereby controlled. Toxicity is reduced through treatment of agent-contaminated structural debris by caustic washing.

10.1.1.3 Soil

The soil remedial actions proposed under Alternative 4 will address the potential risks to human health and the environment using a combination of containment (as a principal element) and treatment technologies. A discussion of the human health and ecological risks is presented in Section 6.1 and Section 6.2, respectively. Approximately 180,000 BCY of principal threat soil at the Former Basin F site will be treated to a depth of 10 ft below the base of the overburden by in situ solidification/stabilization and the site will be contained with a RCRA-equivalent cap. All soil/sludge from the Buried M-1 Pits will be treated by ex situ solidification/ stabilization, followed by placement in the on-post hazardous waste landfill. Approximately 1,000 BCY of principal threat soil from the Hex Pit will be treated using an innovative thermal technology. Solidification/stabilization will become the selected remedy for the Hex Pit if all evaluation criteria for the innovative thermal technology are not met. These treatment actions, in addition to the more than 11 million

10.1.2 Compliance with ARARs

A comprehensive listing of chemical-, location-, and action-specific ARARs and TBCs that are pertinent to the selected remedy were developed and are presented in Appendix A. The identified ARARs and TBCs address the water, soil, and structures at RMA. A summary of location- and chemical-specific ARARs for the selected remedy is presented in Tables 10.1-1 and 10.1-2, respectively. A summary of action-specific ARARs related to the selected remedy is presented in Table 10.1-3. Not every action specified in the summary of action-specific ARARs (Table 10.1-3) will apply to every activity in the selected remedy. For example, ARARs regarding air emissions during demolition do not apply to GAC adsorption of contaminants from groundwater.

The identified ARARs and TBCs comply with Section 121(d) of CERCLA. ARARs were identified according to the procedures outlined in the most recent EPA guidance (OERR-EPA 1988a, b; OSWER-EPA 1989b, c) and the NCP.

10.1.2.1 Chemical-Specific ARARs

RMA chemical-specific ARARs set concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Such ARARs either set protective cleanup levels for the COCs in the designated media or indicate an appropriate level of discharge based on health- and risk-based analyses and technological considerations. Chemical-specific ARARs were established for individual groundwater treatment systems, surface water, soil, and structures and are presented in Appendix A and are summarized in Table 10.1-2. The selected remedy will comply with all chemical-specific ARARs, which are described below by medium.

Water

RMA groundwater and surface water ARARs include federal standards based on the following regulatory programs:

- Safe Drinking Water Act (SDWA) MCLs: 40 CFR 141 Subparts B and G, 40 CFR 143.3
- SDWA Maximum Contaminant Level Goals: 40 CFR 141 Subpart F
- Clean Water Act (CWA) Water Quality Criteria: 33 USC Section 1313
- RCRA MCLs: 40 CFR Section 264.94

With respect to state standards, ARARs cited include any state provisions that are equivalent to or more stringent than federal requirements:

- Colorado Rules and Regulations Pertaining to Hazardous Waste
- Colorado Basic Standards for Groundwater
- Colorado Primary Drinking Water Regulations
- Colorado Basic Standards and Methodologies for Surface Water

ARARs and TBCs for groundwater and surface water were identified by evaluating the current lists of target contaminants addressed by the groundwater and surface water monitoring programs and identifying corresponding standards, regulations, or requirements.

Structures

TSCA establishes cleanup levels for PCB spills occurring after May 4, 1987 and EPA (OERR-EPA 1990) presents cleanup standards that may serve as TBCs for PCB-contaminated structural surfaces and debris. The LDR Best Demonstrated Available Technology (BDAT) levels are ARARs for structural debris if placement occurs. Placement considerations are detailed in Section 7.1.1.

Soil

The proposed RCRA Corrective Action Rule example action levels (55 FR 30798, July 27, 1990), LDR Universal Treatment Standard (UTS) and TSCA PCB Spill Cleanup Policy (40 CFR Part 761 Subpart G), are TBC values for soil and sediments at RMA. LDR BDAT levels (40 CFR Part 268) are cited ARARs if placement occurs. Several other Colorado and federal laws and regulations set specific values for certain contaminants in specific media, but no laws other than TSCA, Clean Air Act, and RCRA set specific values that are likely ARARs or TBCs for RMA soil and sediments. EPA proposed soil treatment standards in the UTS rule on September 14, 1993, but deferred action on soil LDRs when that rule was finalized; consequently, UTSs are TBCs with respect to soil at RMA. In addition, there are no chemical-specific standards set by SDWA or CWA or the state equivalents for soil and sediments. TSCA establishes guidance on action levels for PCBs in soil.

Air

RMA chemical-specific ARARs for air include the following: National Ambient Air Quality Standards (40 CFR 50) and National Emission Standards for Hazardous Air Pollutants (40 CFR 61). State standards that are equivalent or more stringent than federal requirements are also considered ARARs, specifically the Colorado Ambient Air Standards (5 CCR 1001-5 Regulation 3 and 5 CCR 1001-14) and Control of Hazardous Air Pollutants (5 CCR 1001-8).

10.1.2.2 Location-Specific ARARs

RMA location-specific ARARs are those requirements that restrict, depending upon the location or characteristics of the site and the requirements that apply to it, remedial activities or limit allowable contaminant levels. Examples of such regulations include siting laws for hazardous waste facilities, laws regarding activities in wetlands or floodplains, and laws regarding preservation of historic or cultural sites. The selected remedy will comply with all location-specific ARARs, which are listed in Appendix A and summarized in Table 10.1-1.

gallons of contaminated liquids from the Former Basin F already treated by incineration as part of the Basin F IRA, will achieve permanent reductions in the toxicity, mobility, or volume of some highly contaminated soil. Although the selected remedy in large part is a containment remedy, these treatment components satisfy CERCLA statutory preference for treatment. The large volume of contaminated soil present on the site precludes a remedy in which all contaminants could be excavated and cost-effectively treated.

Approximately 1.7 million BCY of contaminated soil from a number of soil medium groups at RMA (Basin F Wastepile, Section 36 Lime Basins, South Plants Central Processing Area, South Plants Ditches, South Plants Balance of Areas, Secondary Basins, Munitions Testing, Chemical Sewers, Sanitary Landfills, Lake Sediments, Surficial Soil, Buried Sediments, Sand Creek Lateral, Section 36 Balance of Areas, and Burial Trenches) will be contained in the on-post hazardous waste landfill. Another 1.5 million BCY of soil that may pose a risk to biota will be excavated and used as fill under the Basin A and South Plants soil covers and Basin F RCRA-equivalent cap. The Army and Shell Trenches will be contained in place with slurry walls and RCRA-equivalent caps. Soil covers will be constructed over all of the South Plants area; the processing areas of the North Plants; all of Basins A, B, C and D; and the Section 36 Balance of Areas. PCB-contaminated soil will be remediated as described in Section 9.3. These containment actions, in conjunction with institutional controls, will prevent exposure of humans to contaminants, reduce exposure of biota to contaminants, and reduce contaminant mobility.

10.1.1.4 Additional Components of the Remedy

Additional actions described in Section 9.4 that contribute to protection of human health and the environment and are an integral part of the on-post remedy are the following:

- Provision of $48.8 million held in trust to provide for the acquisition and delivery of 4,000 acre-feet of potable water to SACWSD and the extension of water-distribution lines from an appropriate municipal water supply distribution system to all existing well owners within the DIMP plume footprint north of RMA as defined by the detection limit for DIMP of 0.392 parts per billion. The Army and Shell have reached an Agreement in Principle with SACWSD, enclosed as Appendix B of this ROD, regarding this matter.
- In compliance with NEPA, PMRMA will separately evaluate the potential impacts to the environment of both the acquisition of a replacement water supply for SACWSD and for the extension of water-distribution lines.
- The Army and Shell will fund ATSDR to conduct an RMA Medical Monitoring Program in coordination with CDPHE. The primary goals of the Medical Monitoring Program are to monitor any off-post impact on human health due to the remediation and provide mechanisms for evaluation of human health on an individual and community basis until such time as the soil remedy is completed. Elements of the program could include medical monitoring, environmental monitoring, health/community education, or other tools. The program design will be determined through an analysis of community needs, feasibility, and effectiveness.
- Trust Fund – During the formulation and selection of the remedy, members of the public and some local governmental organizations expressed keen interest in the creation of a Trust Fund to help ensure

the long-term operation and maintenance of the remedy once the remedial structures and systems have been installed. In response to this interest, the Parties have committed to good-faith best efforts to establish a Trust Fund for the operation and maintenance of the remedy, including habitat and surficial soil. Such operation and maintenance activities will include those related to the new hazardous waste landfill; the slurry walls, caps, and soil and concrete covers; all existing groundwater pump-and-treat systems; the groundwater pump-and-treat system to intercept the Section 36 Bedrock Ridge Plume; the maintenance of lake levels or other means of hydraulic containment; all monitoring activities required for the remedy; design refinement for areas that may pose a potential risk to biota as described in Section 9.4; and any revegetation and habitat restoration required as a result of remediation.

These activities are estimated to cost approximately $5 million per year (in 1995 dollars). The principal and interest from the Trust Fund would be used to cover these costs throughout the lifetime of the remedial program.

The Parties recognize that establishment of such a Trust Fund may require special legislation and that there are restrictions on the actions federal agencies can take with respect to proposing legislation and supporting proposed legislation. In addition to the legislative approach, the Parties are also examining possible options that may be adapted from trust funds involving federal funds that exist at other remediation sites. Because of the uncertainty of possible legislative requirements and other options, the precise terms of the Trust Fund cannot now be stated.

A trust fund group will be formed to develop a strategy to establish the Trust Fund. The strategy group may include representatives of the Parties (subject to restrictions on federal agency participation), local governments, affected communities, and other interested stakeholders, and will be convened within 90 days of the signing of the ROD.

Notwithstanding these uncertainties, it is the intent of the Parties that if the Trust Fund is created it will include the following:

- A clear statement that will contain the reasons for the creation of the Trust Fund and the purposes to be served by it.
- A definite time for establishing and funding the Trust Fund, which the Parties believe could occur as early as 2008, when the remedial structures and systems may have been installed.
- An appropriate means for competent and reliable management of the Trust Fund, including appropriate criteria for disbursements from the Trust Fund to ensure that the money will be properly used for the required purposes.

- Restrictions on land use or access are incorporated as part of this ROD. The Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 and the FFA restrict future land use, and prohibit certain activities such as agriculture, use of on-post groundwater as a drinking source, and consumption of fish and game taken at RMA. Continued restrictions on land use or access are included as an integral component of all on-post alternatives. Long-term management includes access restrictions to capped and covered areas to ensure the integrity of the containment systems.
- Continued operation of the CERCLA Wastewater Treatment Plant to support the remediation activities.
- Stored, drummed waste identified in the waste management element of the CERCLA Hazardous Wastes IRA may be disposed in the on-post hazardous waste landfill in accordance with the CDD (Harding Lawson Associates 1996).
- Continued monitoring as part of remedial design to refine the remediation of surficial soil and lake sediments that may pose a potential risk to wildlife (see Section 6.2.4.3).

10.1.2.3 Action-Specific ARARs

RMA action-specific ARARs and TBCs are standards that restrict or control specific remedial activities related to the management of hazardous substances or pollutants. These requirements are triggered by a particular remedial activity, not by specific chemicals or the location of the activity. There may be several ARARs for any specific action. These action-specific ARARs do not in themselves determine the appropriate remedial alternative, but indicate performance levels to be achieved by an alternative. The selected remedy will comply with all action-specific ARARs, which are listed in Appendix A and summarized in Table 10.1-3.

10.1.2.4 Other Requirements

In addition to the chemical-, location-, and action-specific ARARs and TBCs cited above, there are a number of other requirements and potential requirements that constrain or direct remedial actions at RMA. These additional items are detailed in Appendix A and include the following:

- Federal Facility Agreement
- Endangered Species Act
- Migratory Bird Treaty Act
- Bald and Golden Eagle Protection Act
- Army UXO and agent management and disposal requirements
- Chemical Weapons Convention

10.1.3 Cost Effectiveness

Cost effectiveness is determined by evaluating three of the five balancing criteria to determine overall effectiveness: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to ensure that the remedy is cost effective.

Proportional to cost, the selected remedy for groundwater, structures, and soil provides the best overall effectiveness of all the alternatives considered. The selected remedy will achieve the remedial action objectives for the contaminated media and greatly reduce the toxicity, mobility, or volume of contamination. The remedy makes use of proven technologies that will be protective over the long term and minimize or mitigate short-term impacts during remediation. The selected remedy is therefore cost effective in mitigating risks posed at the site by contaminated groundwater, structures and soil.

10.1.4 Utilization of Permanent Solutions to the Maximum Extent Practicable

The selected remedy for the On-Post Operable Unit makes use of proven treatment and containment technologies for the most highly contaminated soil and structures at RMA, and makes use of reliable groundwater treatment technologies. Approximately 207,000 BCY of contaminated soil will be treated, and

more than 1.8 million BCY of soil and structural debris will be contained in a new RCRA- and TSCA-compliant hazardous waste landfill to be constructed on post. Groundwater treatment will continue at a rate of several hundred million gallons per year until shut-off criteria are met, at which time pumping rates may be reduced.

Although the selected remedy in large part is a containment remedy, this remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable. Components of the selected remedy satisfy the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. The large volume of contaminated soil present on the site precludes a remedy in which all contaminants could be excavated and cost effectively treated. The selected remedy has received state and community acceptance.

10.2 State and Community Acceptance

10.2.1 State Acceptance

The state of Colorado concurs with the selected remedy for RMA as providing the best balance of the nine criteria. The state also concurs with the selected ARARs.

10.2.2 Community Acceptance

Based on comments to the Proposed Plan, community members view the remedy as an acceptable approach to reduce risks at a reasonable cost, with the proviso that an additional water supply, Medical Monitoring Program, and Trust Fund be established as described in Section 9.4. Some community members feel that additional treatment of soil should be performed.

10.3 Consistency with NCP

The process used to select the remedy for RMA is consistent with the NCP. Specifically, alternatives were first identified and screened from a broad range of alternatives that achieved the RAOs and then evaluated against the nine evaluation criteria presented in the NCP (see Section 8). Also in accordance with the NCP, the selected remedy fulfills the following requirements:

- It will be protective of human health and the environment.
- It will attain ARARs or provide grounds for invoking a waiver.
- It will be cost effective (provided that it first satisfies the threshold criteria).
- It will use permanent solutions to the maximum extent practicable.

10.4 Consistency with NEPA

Implementation of the selected remedy is in compliance with NEPA. Numerous studies conducted in support of the FS process have indicated that there are no likely significant environmental impacts. Therefore, in accordance with the procedures contained in Army Regulation 200-2, PMRMA is advising the public that the remediation program is in compliance with NEPA and that no further documentation is necessary. However, PMRMA will separately evaluate the potential impacts to the environment of both the acquisition of a replacement water supply by SACWSD and for the extension of water-distribution lines.

10.5 Summary

The preferred remedy for the On-Post Operable Unit includes Groundwater Alternative 4, Structures Alternative 2, and Soil Alternative 4. The remedy was selected in accordance with the requirements of CERCLA and the NCP. The remedial actions that comprise the selected remedy will reduce the toxicity, mobility, or volume of contamination and address the risks to human health and the environment through treatment and institutional controls for contaminated groundwater; demolition, treatment (as necessary for Army agent), and containment for all No Future Use structures; and a combination of containment (as a principal element) and treatment technologies for contaminated soil.

Table 10.1-1 Summary of Location-Specific ARARs for the Selected Alternatives

ARAR/TBC	Requirement	Citation	Description
Location-Specific	Protection of Wetlands	Executive Order 11990 42 USC Section 1344 40 CFR Part 230, Subpart H 33 CFR Parts 320-330 40 CFR 6.302(a) 40 CFR 6, Appendix A, Sections 3(a) and 3(a)	Requires consideration of impacts to wetlands in order to minimize their destruction, loss, or degradation, and to preserve/enhance wetland values. Potentially applicable to activities which would impact wetlands
	Protection of Floodplains	Executive Order 11988 40 CFR 257.3-1(a) 40 CFR 264.18(b) 6 CCR 1007-3, 264.18(b) 40 CFR 6. Appendix A 40 CFR 6.302(b) Section 3(a), 3(b), and 3(b)(4) 44 FR 43239 (July 24, 1979)	Potentially applicable to activities occurring within the 100-year floodplain.
	Endangered Species Act	16 USC 1531	Establishes requirements for the protection of federally listed threatened and endangered species and their habitat. Potentially applicable to activities which could affect threatened or endangered species or their habitat. Note: the Endangered Species Act, along with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act, are not ARARs, but independently apply to remedial activities.
	RCRA Subtitle C - Location Standards	40 CFR 264.18(a) 6 CCR 1007-3, 264.18(a) 6 CCR 1007-2, Part 2	New treatment facilities, storage facilities, or hazardous waste disposal facilities should not be within 200 ft of a fault. Facilities should not be located in areas prone to earthquakes, floods, fire, or other disasters that could cause a breakdown of the public water system.
	Fish and Wildlife Coordination Act and Wild and Scenic Rivers Act	16 USC Part 661-663 40 CFR 6.302 (e) and (g) 16 USC 1274 et seq.	Fish or wildlife resources that may be affected by actions resulting in control or structural modification of any natural stream or body of water should be protected. Federal agencies taking such actions must consult with USFWS. The Wild and Scenic Rivers Act established requirements for water resource projects affecting wild, scenic or recreational rivers in the National Wild and Scenic Rivers system. Applicable to area(s) affecting stream or river.

Table 10.1-1 Summary of Location-Specific ARARs for the Selected Alternatives

ARAR/TBC	Requirement	Citation	Description
	National Historic Preservation Act	16 USC 470 aa et seq. 36 CFR 800 44 FR 6068	The National Historic Preservation Act identifies procedures for protection of Historically and Culturally Significant Properties, including Colorado's delegated responsibilities under the act. Applicable to historically or culturally significant properties.
	Prehistoric, historic, or archeological sites owned or controlled by a federal agency	36 CFR 60 36 CFR 63 Proposed 36 CFR 66	Department of Interior regulations for determining site eligibility for the National Register of Historic Places and standards for data recovery should be complied with.
	Historical, prehistoric, and archeological resources and State register of Historic Places Act	CRS § 24-80-401 et seq. CRS §24-80.1-101 et seq.	Consultation with the Colorado Historic Society, the State Archaeologist, and State Register of Historic Places is required before an action is taken.
	Cultural resource owned or controlled by a federal agency	35 FR 8921	Executive Order 11593: Any federal agency controlling culturally significant resources is the designated leader in the preservation of those resources. This order ensures that all culturally significant resources located on an agency's property are protected. The federal agencies are responsible for identifying, evaluating, and nominating (where appropriate) to the National Register of Historic Places all culturally significant resources found on their land.
	Archeological or historic site owned or controlled by a federal agency	16 USC 469 et seq.	The Archeological and Historic Preservation Act of 1974 requires that a federal agency notify the Secretary of Interior regarding any agency project that will destroy a significant archeological site. The Secretary of the notifying agency may support data recovery programs to preserve the resource.

ARAR/TBC	Requirement	Citation	Description
	Historically significant property owned and managed by the U.S. Army	Army Regulation 420 32 CFR 650.181 to 193 Technical Manual 5-801-1 Technical Note 78-17 32 CFR 229	U.S. Department of the Army has procedures and standards for preserving historically significant properties and procedures for implementing the Archeological Resources Protection Act. Department of the Army Regulations 420 prescribe Army policy procedures and responsibilities for compliance with the National Historic Preservation Act of 1966, as amended, for maintaining the preservation of historically significant sites, the hiring of qualified personnel to manage the sites, and the conduct of state-of-the-art preservation standards regarding personnel and projects for accomplishment of the historic preservation program. This regulation also requires that each installation prepare a historic preservation plan or have documentation on file indicating that no resources appropriate for such management planning exist.
	Archaeological resources on U.S. Department of the Army installations	16 USC 470 aa et seq.	The Archeological Resources Protection Act of 1979 establishes criminal and civil penalties for anyone damaging archeological resources. This act also allows the Secretary of the Army to issue excavation permits for archeological resources.
	Prehistoric, historic, or archeological sites owned or controlled by the U.S. Army	16 USC 470a 36 CFR 800	The National Historic Preservation Act of 1966 requires the Secretary of the Interior to inventory, evaluate, and nominate (where appropriate) significant properties to the National Register of Historic Places.
		43 CFR 3	Preservation of American antiquities: Provides for the protection of historic or prehistoric remains of any object of any antiquity on federal lands.
		43 CFR 7 36 CFR 296	Protection of archeological resources: Provides for the protection of archeological resources located on public lands.
		Executive Order No. 11593, May 13, 1971, 36 FR 8921, Section 2(b)	According to Executive Order No. 11593, each federal agency shall exercise caution to ensure that any such property that might qualify for inclusion is not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate significantly.

Table 10.1-1 Summary of Location-Specific ARARs for the Selected Alternatives

ARAR/TBC	Requirement	Citation	Description
		16 USC 470 aa et seq. 36 CFR 60.6	Based on the historical and field inventory information, the significance of all identified sites should be evaluated following criteria set forth in 36 CFR 60.6 and in accordance with guidelines from the Colorado State Historic Preservation Office before conducting any ground-altering activity. The act also requires the Army agency to consult with the Advisory Council on historic issues that may affect those significant properties. A federal agency should take into account the effect of the project on any National Register-listed or eligible property and is directed to complete an appropriate data recovery program before such a site is damaged or destroyed.
	National Historic Landmark Program	36 CFR 65	The National Historic Landmark Program was established to identify and designate National Historic Landmarks and encourage the long range preservation of nationally significant properties that illustrate or commemorate the history and prehistory of the United States.
	Colorado Requirements for Siting of Hazardous Waste Disposal Sites	6 CCR 1007-2, Part 2	State siting requirements control the location, design, and design performance of hazardous waste disposal sites. Such disposal sites must be located and designed in a manner that ensures long-term protection of human health and the environment. Disposal sites must be designed to prevent adverse effects on: • Groundwater • Surface water • Air quality • Public health and the environment
	National Wildlife Refuge System Administration Act	16 USC 668dd et seq.	The National Wildlife Refuge Administration Act prohibits the taking or possessing any fish, bird, mammal, or other wild vertebrate or invertebrate animals or part or nest or egg thereof within any such area; or enter, use, or otherwise occupy any such area for any purpose; unless such activities are performed by persons authorized to manage such area or unless such activities are permitted.

Table 10.1-2 Summary of Chemical-Specific ARARs for the Selected Alternatives

ARAR/TBC	Requirement	Citation	Description
Chemical Specific	Safe Drinking Water Act	40 CFR 141	Drinking water standards that apply to specific contaminants and have been determined to have an adverse effect on human health. These standards, expressed as MCLs and MCLGs, are potential ARARs for groundwater and/or surface water cleanup and replacement standards
	Colorado Primary Drinking Water Regulations	5 CCR 1003-1	
	Clean Water Act Ambient Water Quality Criteria	Guidance Criteria 33 USC Sections 1313-1314	Federal Water Quality Criteria established for the protection of human health and or aquatic organisms are not enforceable; however, Section 121(d)(2)(A) of CERCLA states that remedial actions must attain FWQC where they are relevant and appropriate under the circumstances of a release or threatened release.
	RCRA MCLs	40 CFR Section 264.94	Concentration limits for hazardous constituents in groundwater used for the protection of groundwater.
	Colorado Rules and Regulations Pertaining to Hazardous Waste	6 CCR 1007-3	Provides definitions and the general and specific standards necessary for the storage, treatment, and disposal of hazardous waste.
	Colorado Basic Standards for Groundwater	5 CCR 1002-8	Statewide standards and a system of classifying groundwater and adopting water quality standards for such classifications to protect existing and potential uses of groundwater.
	Colorado Basic Standards and Methodologies for Surface Water	5 CCR 1002-8	Basic standards and an antidegradation rule for maintaining and improving the quality of surface waters in Colorado.
	RCRA Corrective Action Rule	40 CFR Part 264 Subpart S 6 CCR 1007-3, Part 264, Subpart(s) 55 FR 30798, July 27, 1990 (TBC)	Corrective action standards proposed to establish a comprehensive regulatory framework for implementing the EPA's corrective action program under RCRA. The proposed standards include constituent-specific concentration levels for the protection of groundwater and soil.
	PCB Remedial Action Guidance	Guidance on Remedial Actions for Superfund Sites with PCB Contamination 40 CFR 761 Subpart G (TBC)	Provides recommended approach for evaluating and remediating Superfund sites with PCB contamination. Provide spill cleanup requirements for PCB spills that occurred after May 4, 1987.
	National Ambient Air Quality Standards	40 CFR 50	Sources cannot cause or contribute to an exceedance of a national ambient air quality standard.

Table 10.1-2 Summary of Chemical-Specific ARARs for the Selected Alternatives

ARAR/TBC	Requirement	Citation	Description
	National Emissions Standards for Hazardous Air Pollutants	40 CFR 61, Subpart M	No visible emissions allowed unless alternative waste management procedures followed.
	Colorado Ambient Air Quality Standard	5 CCR 1001-5, Regulation 3 5 CCR 1001-14	Sources cannot cause or contribute to an exceedance of a national or Colorado ambient air quality standard.
	Colorado Standards for Control of Hazardous Air Pollutants	5 CCR 1001-8	Standard for hazardous air pollutants not to be exceeded.

Table 10.1-3 Summary of Action-Specific ARARs for the Selected Alternatives

ARAR/TBC	Requirement	Citation	Description
Action-Specific	Worker Protection		
	Health and safety protection	29 CFR Part 1910	29 CFR 1910 provides guidelines for workers engaged in activities requiring protective health and safety measures regulated by OSHA. Requirements provided in 29 CFR 1910.120 apply specifically to the handling of hazardous waste/materials at uncontrolled hazardous waste sites. Note: OSHA regulations are independently applicable regulatory requirements, not ARARs.
		29 CFR 1910.120 (b) to (j)	29 CFR 1910.120 (b) through (j) provides guidelines for workers involved in hazardous waste operations and emergency response actions on sites regulated under RCRA and CERCLA.
		29 CFR 1926 Subpart P	29 CFR 1926 Subpart P provides guidelines for workers engaged in activities related to construction and utilization of trenches and ditches.
	Worker exposure	ACGIH 1991-1992 (TBC) NIOSH 1990 (TBC) 29 CFR 1910.1000	Chemical-specific worker exposure guidelines established by OSHA, ACGIH, and NIOSH.
	Air Emissions		
	Particulate emissions	5 CCR 1001–3, Regulation 1, Section III (D) 5 CCR 1001-5, Regulation 3 5 CCR 1001-2, Section II	Colorado air pollution regulations require owners or operators of sources that emit fugitive particulates to minimize emissions through use of all available practical methods to reduce, prevent, and control emissions. In addition, no off-site transport of particulate matter is allowed. Fugitive dust-control measures will be written into workplans in consultation with the state. Estimated emissions from the proposed remedial activity per Colorado APEN requirements.

ARAR/TBC	Requirement	Citation	Description
	Emission of hazardous air pollutants	5 CCR 1001-10, Regulation 8 40 CFR Part 61 42 USC Section 7412	Emission of certain hazardous air pollutants is controlled by NESHAPs. Remediation activities could potentially cause emission of hazardous air pollutants. National standards for site remediation sources that emit hazardous air pollutants are scheduled for promulgation by the year 2000. Standards will be developed for 189 listed hazardous air pollutants.
	Volatile organic chemical emissions	5 CCR 1001-9, Regulation 7	VOC regulations apply to ozone nonattainment areas. The air quality control area for RMA is currently nonattainment for ozone. Storage and transfer of VOCs and petroleum liquids are controlled by these requirements. Disposal of VOCs is regulated for all areas, including ozone nonattainment. The regulations control the disposal of VOCs by evaporation or spilling unless reasonable available control technologies are utilized.
	Odor emissions	5 CCR 1001-4, Regulation 2	Colorado odor emission regulations require that no person shall allow emission of odorous air contaminants that result in detectable odors that are measured in excess of the specified limits.
	Air emissions from diesel-powered vehicles associated with excavation and backfill operations	5 CCR 1001-15, Regulation 12	Colorado Diesel-Powered Vehicle Emission Standards for Visible Pollutants apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways, and state.
	Standards for asbestos waste disposal	40 CFR 61 Subpart M	Prevents discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing waste; requires disposal of asbestos-containing waste as soon as possible at disposal site; requires transport vehicles be marked appropriately during loading and unloading operations.
	PM/CO Emissions	42 USC Section 7502-7503	New or modified major stationary sources in a nonattainment area are required to comply with the lowest achievable emission rate.

ARAR/TBC	Requirement	Citation	Description
	Visibility protection	40 CFR 51.300-307 40 CFR 52.26-29	Remediation activities must be conducted in a manner that does not cause adverse impacts on visibility. Visibility impairment interferes with the management, protection, preservation, or enjoyment of federal Class I areas.
		5 CCR 1001-14 CRS Section 42-4-307(8)	The Colorado Ambient Air Quality Standard for the AIR Program area is a standard visual range of 32 miles. The averaging time is 4 hours. The standard applies during an 8-hour period from 8:00 a.m. to 4:00 p.m. each day (Mountain Standard Time or Mountain Daylight Time, as applicable). The visibility standard applies only during hours when the hourly average humidity is less than 70 percent.
	Design/installation of caps/covers	Final Covers on Hazardous Waste Landfills and Surface Impoundments (EPA/530/SW-89/047) (TBC)	Caps and covers must be designed and installed to prevent wind dispersal of hazardous wastes. They should be designed, constructed, and installed as specified in this EPA report.
	Smoke and opacity	5 CCR 1001-3, Regulation 1, Section II.A	Remedial activities must be conducted in a manner that will not allow or cause the emission into the atmosphere of any air pollutant that is in excess of 20% opacity.
	<u>Waste Characterization</u>		
	Solid waste determination	40 CFR 260 6 CCR 1007-3 Part 260 40 CFR 260.30-31 6 CCR 1007-3 Section 260.30-31 40 CFR 261.2 6 CCR 1007-3 Section 261.2 40 CFR 261.4 6 CCR 1007-3 Section 261.4	A solid waste is any discarded material that is not excluded by a variance granted under 40 CFR 260.30 and 260.31. Discarded material includes abandoned, recycled, and waste-like materials. These materials may have any of the following qualities: • Abandoned material may be – Disposed – Burned or incinerated

ARAR/TBC	Requirement	Citation	Description
			– Accumulated, stored, or treated before or in lieu of being abandoned by being disposed, burned, or incinerated • Recycled material that is – Used in a manner constituting disposal – Burned for energy recovery – Reclaimed – Speculatively accumulated • Waste-like material is material that is considered inherently waste-like.
	Solid waste classification	6 CCR 1007-2, Section 1	If a generator of wastes has determined that the wastes do not meet the criteria for hazardous wastes, they are classified as solid wastes. The Colorado solid waste rules contain five solid waste categories: industrial wastes, community wastes, commercial wastes, special wastes, and inert material.
	Determination of hazardous waste	40 CFR 262.11 6 CCR 1007-3 Section 262.11 40 CFR Part 261 6 CCR 1007-3 Part 261	Wastes generated during remedial activities must be characterized and evaluated according to the following method to determine whether the waste is hazardous: • Determine whether the waste is excluded from regulation under 40 CFR 261.4 • Determine whether the waste is listed under 40 CFR 261 • Determine whether the waste is identified in 40 CFR 261 by testing the waste according to specified test methods or by applying knowledge of the hazardous characteristics of the waste in light of the materials or the process used.
	<u>Waste Management</u>		
	Discharge of liquid wastes	40 CFR Part 122 40 CFR Part 125 40 CFR Part 129 40 CFR 262 40 CFR 264	Any wastewater generated during remedial activities will be routed to the on-post CERCLA Wastewater Treatment Plant if it is not hazardous waste and will not interrupt the existing treatment system. If wastewater is routed to the on-post treatment plant, it must be treated in accordance with NPDES requirements.

ARAR/TBC	Requirement	Citation	Description
	Asbestos waste handling management	40 CFR 61, Subpart M	Prevents discharge of visible emissions during collection, processing, packaging, or transporting any asbestos-containing wastes; requires disposal of asbestos-containing waste as possible at disposal site; requires transport vehicles be marked appropriately during loading and unloading operations.
		5 CCR 1001-10, Regulation Part B, Section 8.B.III.c.8	Asbestos waste will be managed according to applicable substantive requirements for asbestos handling, transportation, and storage.
	Asbestos waste storage management	6 CCR 1007-2, Part B, Section 5.4	Asbestos waste will be managed according to applicable substantive requirements for asbestos storage.
	PCB storage	40 CFR 761.65	Storage facilities must be constructed with adequate roofs and walls; have impervious floors with curbs (no floor drains expansion joints or other openings); and be located above 100-year floodplain (applies to PCBs at concentrations of 50 ppm or greater)
			Temporary storage (<30 days) of PCB containers containing nonliquid PCBs, such as contaminated soil, rags, debris, need not comply with above requirements. Containers must be dated when they are placed in storage.
			All storage areas must be properly marked and stored articles must be checked for leaks every 30 days.
	PCB decontamination standards	40 CFR 761.79	PCB containers to be decontaminated by triple rinsing of internal surfaces with solvent containing <50 ppm PCB.

ARAR/TBC	Requirement	Citation	Description
	PCB chemical waste landfilling standards	40 CFR 761.75	Landfill must be located in thick, relatively impermeable soil formation or on soil with high clay and silt content; synthetic membranes must be used when these conditions cannot be met. In addition, other structural requirements include avoidance of location in a floodplain; required runon/runoff structures if below the 100-year floodplain; and ground/surface water monitoring for specified parameters. PCB wastes must be segregated from wastes not chemically compatible with PCBs.
			The landfill must include a leachate monitoring system.
	PCB incineration standards	40 CFR 761.70	Incineration requirements for nonliquid PCB apply to PCB concentrations >50 ppm and include specified dwell times; combustion efficiency of 99.9999 percent; process record/monitoring requirements; automatic shut-off standards; a maximum mass air emission of 0.001 g PCB per kg of PCB entering the incinerator.
	TSCA-PCB design standards	40 CFR 761 Subpart D	On-post hazardous waste landfills shall be designed and operated in compliance with applicable substantive requirements of 40 CFR 761 Subpart D.
	Treatment, storage, or disposal of RCRA hazardous waste.	Part 264.100 (e)(2) 6 CCR 1007-3 Section 264.100(e)(2)	Corrective action program.
		Part 264 Subpart I 6 CCR 1007-3 Part 264 Subpart I	Applicability of the requirements of containers.
		Part 264 Subpart F 6 CCR 1007-3 Part 264 Subpart F	Corrective action for solid waste management units.
		Part 264 Subpart J 6 CCR 1007-3 Part 264 Subpart J	Applicability of the requirements for tanks or tank systems.

ARAR/TBC	Requirement	Citation	Description
		Part 264 Subpart L 6 CCR 1007-3 Part 264 Subpart L	Design and operating requirements for waste piles.
		Part 264 Subpart M 6 CCR 1007-3 Part 264 Subpart M	Design and operating requirements for land treatment.
		Part 264 Subpart N 6 CCR 1007-3 Part 264 Subpart N	Design and operating requirements for landfills.
		Part 264 Subpart O 6 CCR 1007-3 Part 264 Subpart O	Applicability of incinerator requirements.
		Part 264.16 (a)(1) 6 CCR 1007-3 Section 264.16(a)(1)	Personnel training.
		Part 264.31 (a) 6 CCR 1007-3 Section 264.31(a)	Facility design and operation requirements.
		Part 264.51 (a) 6 CCR 1007-3 Section 264.51(a)	Purpose and implementation of contingency plans.
		Part 264.52 (a) 6 CCR 1007-3 Section 264.52(a)	Content of contingency plans.
		Part 264 Subpart cc 6 CCR 1007-3 Part 264 Subpart cc	Air emission standards for tanks.

ARAR/TBC	Requirement	Citation	Description
	Management of Remediation Wastes		
	Corrective action management units	40 CFR 264, Subpart S 6 CCR 1007-3, Part 264 Subpart S 6 CCR 1007-2, Part 2	The CAMU regulations allow for exceptions from otherwise generally applicable LDRs-UTS and minimum technology requirements for remediation wastes managed at CAMUs. These regulations provide flexibility and allow for expedition of remedial decisions in the management of remediation wastes. One or more CAMUs may be designated at a facility. Placement of hazardous remediation wastes into or within the CAMU does not constitute land disposal of hazardous wastes so the LDRs-UTS are not triggered.
	Temporary Units	6 CCR 1007-3 Section 264.553 40 CFR 264.553	Design, operating, or closure standards for temporary tanks and container storage areas may be replaced by alternative requirements. The TU must be located within the facility boundary, used only for the treatment/storage of remediation waste, and will be limited to one year of operation with a one year extension upon approval by the regulatory authority.
	Detonation of UXO Containing High Explosives	AR 75-15 AR-385-10 AR 385-64 AMC-R 385-100	If UXO is encountered during excavation, workers must comply with the substantive requirements of AMC-R 385-100, AR 75-15, AR 385-10, and AR 385-64.
	UXO detonation	AR 75-15	HE UXO will be detonated in compliance with the substantive requirements of AR 75-15 regarding demilitarization of class V materials.
	On-post detonation of UXO	40 CFR 264 Subpart X 6 CCR 1007-3 Section 264 Subpart X	On-post detonation of UXO must comply with the substantive requirements of the environmental performance standards described in 40 CFR 264 Part 264, including 264.601 (6 CCR 1007-3 Section 264.601) and substantive portions of the monitoring, analysis, reporting, and corrective action requirements of 40 CFR 264.602 (6 CCR 1007-3, Section 264.602).

ARAR/TBC	Requirement	Citation	Description
	Chemical Agent Decontamination		
	Agent decontamination	AR 385-61 AR 50-6	Decontamination of chemical agent-contaminated material must comply with the requirements of AR 385-61 and AR 50-6.
	Decontamination and Disposal Standards for Chemical Agents	AR 385-61 AR 50-6	Army regulations provide standards for decontamination of items exposed to chemical agents. Material, equipment, and clothing that has been decontaminated to the 3X level may be landfilled in a RCRA-approved hazardous waste landfill.
	Treatment and disposal of hazardous debris	40 CFR 268.45 6 CCR 1007-3, Part 268.45	Hazardous debris generated during remedial activities must be treated using specific technologies to extract, destroy, or immobilize hazardous constituents on or in the debris if placement occurs. In certain cases, the debris may no longer be subject to RCRA Subtitle C regulation after treatment.
	On-post land disposal of hazardous wastes	40 CFR Part 264 6 CCR 1007-3 Part 264 40 CFR Part 268 6 CCR 1007-3 Part 268 EPA/540/G-89/006 (TBC)	Based upon a determination of whether the disposal technique constitutes placement, LDRs-UTS may be applicable. If placement occurs, the on-site disposal facility must comply with the substantive requirements of 40 CFR Part 264 (6 CCR 1007-3 Part 264) and 40 CFR Part 268 (6 CCR 1007-3 Part 268).
	Treatment, storage, or disposal of hazardous waste	40 CFR Part 264 6 CCR 1007-3 Part 264	If remedial activities at RMA generates hazardous wastes, the wastes must be treated and stored in accordance with RCRA regulations.
		40 CFR Part, Subpart L 6 CCR 1007-3 Section 264, Subpart L 40 CFR Part 268 6 CCR 1007-3 Part 268	Wastes stored in stockpiles that are determined to be RCRA hazardous wastes must be stored, treated, and disposed in compliance with RCRA regulations, including LDRs-UTS if placement occurs.
		40 CFR Part 264, Subpart I 6 CCR 1007-3, Section 264, Subpart I Section 264.171-173	Applicability of the requirements for containers.

ARAR/TBC	Requirement	Citation	Description
	Stormwater Management		
	Discharge of stormwater to on-post surface waters	40 CFR Parts 122-125	Stormwater runoff, snow melt runoff, and surface runoff and drainage associated with industrial activity (as defined in 40 CFR 122) from RMA remedial actions that disturb 5 acres or more and that discharge to surface waters must be conducted in compliance with the stormwater management regulations.
	Dredged Material Management		
	Discharge of Dredged Materials	40 CFR 230 Subpart B	Dredging operations in wetland areas must be managed in accordance with the applicable requirements based on the impacts resulting from specific dredged material discharges associated with sediment removal activities.
	Certification of Federal Licenses and Permits (401 Certification)	33 USC Section 1341 Section 401 of Clean Water Act	Provides for state review of facility operations for the purposes of ensuring that applicable effluent limitations or other limitations or other applicable water quality requirements will not be violated.
	Wastewater Treatment/Disposal		
	Discharge of wastewater to the treatment plant	40 CFR Part 122 40 CFR Part 125 40 CFR Part 129	Any wastewater generated during cleanup or remedial actions will be directed to the on-post RMA wastewater treatment plant and treated in accordance with NPDES requirements.
		40 CFR Part 262 6 CCR 1007-3 Part 262	Wastewater that is determined to be a hazardous waste must be treated in accordance with the provisions of RCRA.
		40 CFR Part 264 6 CCR 1007-3 Part 264	Some of the Colorado standards for owners and operators of hazardous waste management, storage, and disposal facilities are more stringent than the equivalent federal regulations. These standards are detailed on Appendix A, Table A-12.
		40 CFR Part 144.13(c) 40 CFR Part 146	Injection trenches and wells must be constructed per the requirements of EPA's Underground Injection Control Program.

ARAR/TBC	Requirement	Citation	Description
	Monitoring		
	Groundwater monitoring	40 CFR 264 Subpart F 6 CCR 1007-3 Part 264 Subpart F 2 CCR 402-2, Rule 10 RCRA Groundwater Monitoring TEGD (TBC)	Groundwater monitoring will be conducted for the presence of hazardous constituents in the groundwater downgradient from solid waste management units. Monitoring wells should be constructed and installed according to the requirements of 2 CCR 402-2, Rule 10 and the guidance in the RCRA Groundwater Monitoring TEGD.
		6 CCR 1007-3	Colorado groundwater regulations specify requirements for determining background groundwater quality.
	Noise abatement	Colorado Revised Statute, Section 25-12-103	The Colorado Noise Abatement Statute provides that "Applicable activities shall be conducted in a manner so any noise produced is not objectionable due to intermittence, beat frequency, or shrillness. Noise is defined to be a public nuisance if sound levels radiating from a property line at a distance of twenty-five feet or more exceed the sound levels established for the specified time periods and zones."

11.0 Documentation of Significant Changes

The Proposed Plan indicated that the preferred remedy for the Hex Pit would be identified prior to the ROD and that remedies being considered involved solidification and thermal treatment technologies. As this ROD details, the selected remedy for the Hex Pit is treatment using an innovative thermal technology. Treatment will be applied to approximately 1,000 BCY of principal threat material; the remaining 2,300 BCY of soil will be excavated and disposed in the on-post hazardous waste landfill. Process performance will be evaluated through treatability testing during remedial design. Solidification/stabilization will become the selected remedy if all evaluation criteria for the innovative thermal technology are not met.

There are no other significant changes to the ROD. However, overall remedy implementation time frames and present worth costs presented in the ROD differ slightly from those presented in the Proposed Plan due to modifications in scheduling and funding limitation assumptions.

Glossary

Glossary

Active Dewatering – Lowering the water table by pumping and extraction or other water-removal methods.

Acute Exposure – Based on the exposure model developed for RMA, an exposure duration of 1 to 14 days.

Agent – A solid, liquid, or gas that through its chemical properties produces lethal or damaging effects on man, animals, material, or plants or that produces a screening or signaling smoke. Examples of chemical agents at RMA include Sarin (GB), a nerve agent, and mustard (HD), a blistering agent.

Agent Monitoring – Analytical technique used during excavation to survey soil for the presence of Army chemical agent.

Agricultural Practices – A process that involves tilling the soil with farm machinery and seeding it with locally adapted vegetation in a manner consistent with RMA refuge management plan. Agricultural practices have been shown to reduce the level of surficial soil contamination.

Air Monitoring – Collection of air samples that are analyzed for key contaminants to ensure that allowable concentrations are not exceeded.

Air Stripping – As it applies to groundwater treatment, extracting contaminated groundwater and pumping to an air stripper, which is a tall, hollow vessel. The water is pumped to the top of the vessel and allowed to splash down to the bottom. As the water passes through the air, contaminants are transferred from the water to the air, which is in turn treated before it is discharged to the atmosphere.

Alternative – An option for cleaning up a site.

Applicable or Relevant and Appropriate Requirements (ARARs) – Federal and state legal requirements that a selected remedy for a site will meet, such as allowable levels of chemicals in water.

Bioaccumulation – The amplification of the concentration of a chemical between the initial source (e.g., water, soil, or sediment) and a specified target species or trophic box. A bioaccumulative chemical can increase in concentration in a living organism as the organism breathes contaminated air, drinks contaminated water, or consumes contaminated food.

Biomagnification – The process by which tissue concentrations of bioaccumulative chemicals increase as a chemical passes up the food chain (e.g., from plant to insect, mouse, and hawk). It is measured as the ratio of the concentration of a chemical in an organism to the concentration in the diet of the organism.

Boundary System – Groundwater extraction, containment, and treatment system at RMA boundaries. There are three such systems, the Irondale, Northwest, and North boundary systems.

Cap – An in-place containment technology. The standard cap design consists of a layer of soil/vegetation, a crushed layer of concrete or cobbles, and a layer of low-permeability soil. Caps are sloped for erosion control and are vegetated with locally adapted perennial grasses and low-growing plants.

Caustic Washing – A treatment process in which agent-contaminated soil or structural debris is treated with caustic (high pH) fluids to degrade the agent compounds.

CERCLA – Comprehensive Environmental Response, Compensation and Liability Act. Also known as Superfund, a law passed in 1980 that establishes a program to identify inactive hazardous waste sites, ensure they are cleaned up, evaluate damages to natural resources, and create claims procedures for parties remediating the sites.

Chronic Exposure – Based on the exposure model developed for RMA, an exposure duration of 7 to 30 years.

Composite Sample – A representative sample that has been combined from several samples of the same medium. In this sampling method, samples are systematically collected either vertically and/or horizontally from a medium and thoroughly mixed together to form a representative sample. Examples of composite samples are depth composites often used in subsurface soil sampling and area composites used in surficial soil sampling.

Conceptual Remedy – Agreement for a Conceptual Remedy for the Cleanup of the Rocky Mountain Arsenal. Signed by the Parties on June 13, 1995, it outlines the general approach for the remediation of RMA. The Conceptual Remedy was the result of dispute resolution (as provided in the FFA) and formed the basis for the Detailed Analysis of Alternatives report and Proposed Plan.

Consolidation – Movement of soil with low levels of contamination to areas proposed for capping or covering. The consolidated soil is placed underneath the cap or cover to develop slopes so that surface-water runoff can be controlled and collected.

Containment – A remedial action that interrupts exposure pathways through the use of physical barriers and reduces the spread of contamination.

Contaminant of Concern (COC) – A chemical selected for evaluating potential human or animal health effects. Selection is based on concentration, toxicity, and site-specific information.

Cover – A layer of clean soil that isolates contamination in place, thereby preventing exposure to humans and animals. A soil cover consists of a variable thickness layer of soil and may include crushed or formed concrete layers as biota/excavation barriers. Soil covers may be sloped for erosion control and are vegetated with locally adapted perennial grasses and low-growing plants.

Detection Limit – The lowest concentration of a chemical that can be distinguished from the background response of an analytical instrument.

Dismantling – Controlled demolition of a structure using heavy equipment. Contaminants are not treated in this process, but the volume of structural material is decreased and converted into a more workable form for disposal.

Dust Controls – An action, such as spraying water or foam, used to control the emission of dust (e.g., during excavation activities).

EPA Paint Filter Test – A test that demonstrates the presence or absence of free liquid in waste material to be landfilled (based on a test method in SW 846, Method 9095).

Ex Situ – Not in the original place (Latin). With reference to hazardous waste treatment, this refers to excavation or extraction from the ground prior to treatment.

Excavation – The removal of soil, debris, drums, pipes, tanks, or any other solid material from the ground.

Exposure Duration – The amount of time a receptor is exposed to a chemical.

Exposure Pathway – The pathway a chemical travels from the source to the individual. At RMA, two pathways were evaluated, direct (consuming, contacting, or breathing contamination) and indirect (breathing contaminated vapors).

Extraction System – A system of wells used to remove groundwater from an aquifer.

Feasibility Study (FS) – An investigation that recommends the selection of a protective, cost-effective alternative for remediation. It usually is begun during the Remedial Investigation (RI); together these investigations are commonly referred to as the RI/FS.

Federal Facility Agreement (FFA) – A legal document that sets the framework for cleanup at RMA.

Gas Chromatography/Mass Spectrometry (GC/MS) – A laboratory analytical method used to detect organics in soil or water.

Geophysical Survey – A technique used to locate buried metal, such as unexploded ordnance, using nonintrusive instruments that measure various properties of subsurface materials.

Granular Activated Carbon (GAC) – A treatment method used to remove organic chemicals from contaminated groundwater.

Habitat Modifications – The exclusion of biota from contaminated areas by installing physical barriers (e.g., a chain-link fence) or changing the quality of the habitat (e.g., sowing grasses that are less attractive to biota as an environment in which to live).

Hazard Index (HI) – A value that represents the summation of hazard quotients for a particular chemical for all exposure pathways evaluated.

Hazard Quotient (HQ) – The ratio of the estimated actual daily chemical intake (dose) to the estimated allowable daily intake that is not likely to cause adverse health effects.

Hazardous Waste Landfill – A secure disposal facility that is specially designed, operated, closed, and monitored to control the potential release of hazardous substances into the environment.

Horizontal Well – A well that is drilled with a major portion of its length parallel to the ground surface and that could be used to capture contamination in plumes.

Human Health Exceedance – At RMA, soil posing risk to human health as determined by concentrations of chemicals present above action levels developed in the Integrated Endangerment Assessment/Risk Characterization for carcinogens (an excess lifetime cancer risk of 10^{-4}) and noncarcinogens (a hazard index of 1.0).

Hydrology – The science dealing with the properties, distribution, and circulation of water.

ICP Metals – Metals detected by Inductively Coupled Plasma, a laboratory analytical method.

Implementability – The ability to execute and complete the remedial actions required under an alternative. Evaluation of implementability includes, for example, considering the availability of materials and skilled workers.

In Situ – In the original place (Latin). With reference to hazardous waste treatment, this refers to treatment in the ground (i.e., without excavation or extraction).

In Situ Biological Treatment – An in-place biodegradation process that takes advantage of the naturally occurring micro-organisms in the aquifer. Oxygen and nutrients containing nitrogen are added to the aquifer so that organisms grow more numerous. As the population increases, the organisms turn to the contamination present in the aquifer as a source of food, thereby breaking down and destroying the contamination.

In Situ Vitrification – A thermal treatment process using electrical current to melt soil or sludges in place, resulting in a chemically inert and stable glass product.

Incineration – A treatment technology involving destruction of waste or contamination by controlled burning at high temperatures.

Inorganic – Pertaining to or composed of chemical compounds that do not contain carbon as the principal element, i.e., matter other than plant or animal.

Interim Response Action (IRA) – A remedial measure that is implemented in an expedited time frame before the final remedy and that has been determined to be necessary and appropriate for the site.

Maximum Contaminant Level (MCL) – The maximum permissible level of a contaminant in water delivered to users of a public water system as specified in the Safe Drinking Water Act. MCLs are enforceable water-quality standards and are applicable or relevant and appropriate requirements for groundwater remediation.

Medium *(pl. media)* – A specific environment such as groundwater, surface water, soil, sediment, or air.

Medium Groups – Similarly contaminated soil sites, groundwater plumes, or structures.

Migration Pathway – The way in which a chemical moves through the environment. For example, a constituent in soil may be susceptible to transport by wind suspension as fugitive dust, by alluvial erosion during periods of seasonal and/or episodic surface-water runoff, or by dissolving in infiltrating rainwater.

Multilayer Cap – A cap that prevents exposure to humans and animals by isolating the contamination. From top to bottom, it generally consists of three layers: a 4-ft-thick soil/vegetation layer, a 1-ft-thick layer of crushed concrete or cobbles, and a 2-ft-thick layer of compacted low-permeability soil to provide long-term minimization of infiltration.

Munitions Screening – Technique used prior to excavation to survey soil for the presence of munitions (weapons and ammunition) and/or munitions debris.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) – The federal regulations that govern the implementation of CERCLA.

National Priorities List – A list published by the U.S. Environmental Protection Agency that ranks all of the CERCLA sites in order of priority for remediation.

Operable Unit – Term for a geographic area or a separate activity undertaken as part of a cleanup conducted under CERCLA.

Organic – Pertaining to or composed of compounds that contain carbon as a principal element.

Organizations – The U.S. Army, U.S. Environmental Protection Agency, U.S. Agency for Toxic Substances and Disease Registry, U.S. Fish and Wildlife Service, U.S. Department of Justice, and Shell Oil Company. They signed the Federal Facility Agreement.

Parties – U.S. Department of the Army, Shell Oil Company, State of Colorado, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service. They oversee the remedial process at RMA.

Passive Dewatering – Lowering the water table without actively removing the water by pumping and extraction or other methods. It is accomplished by limiting the infiltration of water across an area using controls such as a cap or cover or elimination of water utilities.

Plume – An area of contaminated groundwater containing one or more chemicals at concentrations that exceed remediation goals.

Preliminary Pollutant Limit Value (PPLV) – Risk-based concentrations of chemicals in soil that are considered protective of human health given a defined set of exposure and toxicity assumptions.

Principal Threat Exceedance – At RMA, soil that is considered to be highly toxic or highly mobile that would pose a significant risk to human health should an exposure occur (i.e., more than 10^{-3} excess lifetime cancer risk or a hazard index of 1,000).

Probabilistic PPLVs – Risk-based concentrations of chemicals in soil developed to represent the likelihood of a potential effect on an organism as a result of exposure to a chemical constituent. In a probabilistic evaluation, a range of input values can be assigned to reflect variability, the shape of the range defined, and a prescribed certainty assigned to a range of results, thereby providing an informed context within which risks can be managed. At RMA, for example, the use of a 5th percentile preliminary pollutant limit value (PPLV) would protect 95 percent of an exposed human population.

RCRA-Equivalent Cap – A cap with physical barriers that achieve the performance standards of a cap as described in the Resource Conservation and Recovery Act, a law that regulates the management of hazardous waste from point of generation to disposal. A multilayer cap was assumed to be RCRA equivalent in this ROD for purposes of costing alternatives.

Receptor – The animal or person for which potential exposure and risk to a chemical is evaluated.

Record of Decision (ROD) – A public document that records and explains the cleanup alternative(s) to be used at a CERCLA site. It is based on information from the Remedial Investigation/Feasibility Study, public comments, and community concerns.

Remedial Investigation (RI) – A study that reports the types, amounts, and locations of contamination at a site.

RF Heating – A thermal treatment process using radio frequency (RF) energy to heat soil in place, volatilizing contaminants, which are collected at the ground surface.

Slurry Wall – A buried vertical barrier commonly made of a soil and bentonite clay mixture.

Soil Cover – See **Cover.**

Soil Posing Risk to Biota – Area containing a potential risk to biota as defined by a hazard quotient greater than 1.0. The hazard quotient is calculated using a biota risk model based on an animal's foraging range (the average area over which they obtain their food). "Biota" refers to wildlife.

Soil Vapor Extraction – Removes volatile compounds from contaminated soil in the unsaturated zone by applying a vacuum using vapor extraction wells and blowers. Vacuum blowers induce air flow through the soil matrix, stripping volatile compounds from the soil. Contaminated vapor is withdrawn through extraction wells,

collected, and treated. Enhanced soil vapor extraction may use heating elements to include removal of some semivolatile compounds.

Soil Venting – A technique used to extract contaminated vapors from soil above the water table, usually by applying a vacuum to a system of wells.

Solidification/Stabilization – A process in which a hardening agent (such as cement) is combined with contaminated soil. The mixture is allowed to harden, fixing the contaminants in a less leachable form.

Subchronic Exposure – Based on the exposure model developed for RMA, an exposure duration of 2 weeks to 7 years.

Supplemental Field Study (SFS) – An assessment designed to determine whether potential risk to wildlife is present in the area peripheral to the center of RMA.

Surface Heating – General technology name for soil treatment technologies that involve heating soil to volatilize contaminants. During treatment, volatile and semivolatile organic compounds are vaporized from the solid phase and either recovered or destroyed by an off-gas treatment system.

TCLP – Toxicity Characteristic Leaching Procedure. A test used to evaluate whether a waste exhibits characteristics of toxicity as specified in the Resource Conservation and Recovery Act.

Thermal Desorption – A process that uses heat to vaporize (desorb) contamination from solid materials. The air stream generated during the process is treated to remove the contaminants.

Transportation – The movement of structural, soil, or liquid material from a site to disposal or treatment facilities.

Unexploded Ordnance (UXO) – Generic term for military munitions that are potentially active. Munitions are filled with high explosives (HE-filled) or chemical agent.

Unsaturated Zone – The subsurface zone above the water table. Also known as the vadose zone.

Use History – Narratives (e.g., plant operational records, official Army and Shell histories, depositions from operating personnel) that describe how a particular structure was used during its operational history. To focus investigations at RMA, structures were grouped into similarly contaminated (or uncontaminated) medium groups based on use histories.

Vapor- and Odor-Suppression Measures – Vapor-suppressing materials, such as foam or liners, or a transportable structure, used during excavation to control emissions of odors and gases.

Volatile – A chemical constituent that readily evaporates (volatilizes) from a solid or liquid state to a gaseous or vapor state. This process may be enhanced by applying heat or reducing pressure or by a combination of these processes.

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