7.0 SUMMARY AND CONCLUSIONS

7.1 SUMMARY

The RI focused on groundwater in the Muscoy Plume OU. Ten existing municipal supply wells in the Muscoy Plume OU were sampled during April through May 1993 as part of a larger Muscoy interim sampling event. Results from this RI were used to characterize the groundwater contamination and support the FS.

7.1.1 Nature and Extent of Contamination

Groundwater was analyzed for a broad scope of contaminants, including drinking water VOCs, semi-VOCs (base, neutral, acid extractable), PCBs, pesticides, total petroleum hydrocarbons, metals, and general water quality.

The COCs for the Muscoy Plume OU were selected as those contaminants which reach or exceed their individual MCLs for drinking water. These contaminants are summarized in Table 7-1. Table 7-1 lists detected concentrations of COCs in groundwater for 10 municipal supply wells in or near the Muscoy Plume OU. Concentrations of other volatile organic compounds and metals were detected in the groundwater associated with this project and are presented in Section 5.0 of this report.

Table 7-1

CONTAMINANTS OF CONCERN

Matrix	Contaminant of Concern	Maximum Concentration	Federal/State of CA Primary MCLs
Groundwater	TCE	6 µg/ℓ	5/5
	PCE	27 µg/ℓ	5/5
	cis-1,2-DCE	6 µg/ℓ	70/6

PCE was detected above the MCLs in 5 of the 10 municipal supply wells sampled during the Muscoy interim sampling event (URS 1993b). Based upon the integration of all available data, a contamination map was developed (Figure 5-1). VOC concentrations in groundwater from the 10 municipal supply wells are presented in Table 7-2.

Table 7-2
Concentrations of Contaminants of Concern in Groundwater
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Sample Number	Concentration (µg/ℓ)		
	Trichloroethene (0.2)	Tetrachloroethene (0.2)	cis-1,2-Dichloroethene (0.2)
Federal/State of CA Primary MCLs	5/5	5/5	70/6
MUNI-101-01	ND	ND	ND
MUNI-102-01	ND	ND	ND
MUNI-103-01	ND	ND	ND
MUNI-104-01	0.4	6	0.6
MUNI-105-01	0.8	6	2
MUNI-106-01	6	27	6
MUNI-107-01	3	9	2
MUNI-108-01	ND	0.2 J	ND
MUNI-109-01	1	7	0.9
MUNI-25-01	ND	ND	ND

Notes: Sample specific quantitation limits are shown in parentheses.
ND = Not Detected.
Values followed by the qualifier J are estimated quantities and useful for qualitative purposes only.

The greatest concentrations of TCE and PCE were identified in well MUNI-106 (TCE: 6 $\mu g/\ell$ and PCE: 27 $\mu g/\ell$) in the eastern portion of the Muscoy Plume OU. The horizontal distribution of contaminants along the eastern portion of the OU and the vertical distribution of contamination throughout this OU are not well defined but are considered sufficient to make a determination on a remedial alternative.

7.1.2 Fate and Transport

The contaminants of concern, TCE and PCE, are highly volatile chlorinated hydrocarbons that are relatively insoluble in water. Although exhibiting only low to moderate mobility in soil, these common groundwater contaminants can percolate fairly rapidly through sandy soils to reach underlying groundwater.

The movement of TCE and PCE in groundwater is principally affected by their moderately low solubility in water and their sorption potential or tendency to adsorb onto solid organic matter in the aquifer [commonly defined by the organic carbon partition coefficient (K_{oc}); and the soil/water distribution coefficient (K_d)]. Based on the data generated during this RI and the Newmark OU RI, however, there is no conclusive evidence suggesting that biotransformation may be significantly reducing or contributing to the attenuation of either contaminant in the Newmark plume.

Relatively insoluble organic liquids that are denser than groundwater, such as TCE and PCE, can form a dense non-aqueous phase liquid (DNAPL) that sinks through the aquifer and forms a contaminant pool on top of an underlying aquitard. The possible presence of a DNAPL in the Muscoy Plume OU was considered, but was not supported by the data gathered during this RI or the Newmark RI. For example, monitoring wells installed at the bedrock contact during the Newmark RI had the highest likelihood of encountering elevated levels of TCE or PCE indicative of DNAPLs. If DNAPLs were present it would be expected that levels of TCE or PCE approaching 1% of their solubility limits would have seen, or that dissolved levels would increase in the upgradient direction as DNAPLs were approached and then rapidly drop off. This evaluation is considered valid for the Muscoy Plume OU. However, this does not preclude the possibility of a DNAPL contaminant pool in the areas of the aquifer outside the Muscoy Plume OU. Further investigation for DNAPLs will be performed during the SOURCE OU RI.

The project flow model, developed to screen the remedial alternatives, was used to estimate groundwater flow and contaminant movement in the Muscoy Plume OU. The model employed MODFLOW, a computer program developed by the U.S. Geological Survey to simulate groundwater flow, and several post-processors to create contours, simulate contaminant pathlines, delineate capture-zones and produce graphics. The model was only capable of simulating the advection processes and thus the simulations do not reflect the effects of other processes, such as dispersion, retardation, and transformation.

The existing contamination in the Muscoy Plume OU is approximately two miles long and one and one-half miles wide at its widest point. An average groundwater velocity (500 ft/yr) for the Muscoy plume was estimated from model runs. Within 35 years the plume is projected to migrate approximately 8,000 feet resulting in a plume approximately three and one-half miles long and one and one-half miles wide at its widest point.

7.2 DATA LIMITATIONS

The data and subsequent interpretation presented in this RI report are based upon a single groundwater sampling event taken from existing municipal supply wells. Consequently, some uncertainties exist regarding the concentrations of contaminants found in the groundwater samples and the exact distribution of the contaminants in the groundwater within the Muscoy Plume OU. These uncertainties in lateral and vertical distribution of contaminants and in specific hydrogeological properties of the Muscoy Plume OU Investigation Area are typically addressed during the Remedial Design phase of the Superfund process. During the RD phase, the resources can be focused on collection of information critical to an optimum design. Sufficient information has been developed during the phase to support selection of a remedy.

8.0 REMEDIAL ACTION OBJECTIVES

8.1 IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA OR GUIDELINES TO BE CONSIDERED

ARARs are federal environmental and state environmental and facility siting requirements with which a RA at a Superfund site must comply. Section 121(d) of the CERCLA, 42 U.S.C. Section 9621(d), and the NCP, 40 CFR Part 300, require compliance with ARARs. Only state requirements that are more stringent than federal ARARs, and are legally enforceable and consistently enforced statewide may be ARARs.

Pursuant to Section 121(e)(1) of CERCLA, no federal, state or local permits (administrative requirements) are required for RAs conducted entirely on site. However, these on-site RAs must comply with the substantive requirements of all ARARs. Any portion of a RA which takes place off site must comply with all requirements legally applicable at the time the action is carried out, whether substantive or administrative.

8.1.1 Definition of ARARs and Other Criteria or Guidelines to be Considered (TBCs)

An ARAR may be either "applicable," or "relevant and appropriate," but not both. According to the NCP (40 CFR Part 300), "applicable" and "relevant and appropriate" are defined as follows:

- Applicable requirements are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, RA, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.

In addition, the NCP authorizes the EPA and the state to identify advisories, criteria, guidance or proposed standards to-be-considered (TBC). These TBCs consist of advisories, criteria, or guidance that were developed by the EPA, other federal agencies, or states that may be useful in developing CERCLA remedies. The TBC standards and guidelines may be selected by the EPA as requirements for the RA selected in the ROD.

8.1.2 Identification of ARARs

Neither CERCLA nor the NCP provides across-the-board standards for determining whether a particular remedy will effect an adequate cleanup at a particular site. Rather, the CERCLA process recognizes that each site will have unique characteristics that must be evaluated and compared to those requirements that apply under the given circumstances. Therefore, identification of ARARs is done on a site-specific basis.

The ARARs are identified and considered at the following steps in the remedial process:

- As part of the RI/FS scoping;
- During the site characterization phase of the RI;
- During development of remedial alternatives;
- During detailed analysis of the remedial alternatives; and
- When an alternative is selected.

The ARARs identified during the RI/FS are preliminary. The final determination of ARARs will not be made until the remedy for the Muscoy Plume OU is selected and documented in the Muscoy Plume OU ROD.

There are several different categories of ARARs that CERCLA actions may have to comply with: chemical-specific, location-specific, and action-specific. These categories are informational only and provide assistance in identifying those ARARs that apply to a particular remedy. Each category is explained in the following subsections.

8.1.2.1 Chemical-Specific ARARs

Chemical-specific ARARs are health- or risk-based concentration limits, numerical values or methodologies for various environmental media (i.e., groundwater, surface water, air, and soil) that are established for a specific chemical that may be present in a specific media at the site, or that may be discharged to the site during remedial activities. Since the RA established by the Muscoy Plume OU ROD will be an interim action designed primarily to inhibit the spread of contamination, chemical-specific requirements or cleanup levels that must be achieved in the aquifer by the final RA will not be ARARs for the Muscoy Plume OU (See 55 Fed. Reg. 8755).

The compounds listed in Table 8-1 represent those VOCs detected in groundwater in the Muscoy Plume OU. This analysis does not consider groundwater from wells at the edge of the Cajon Landfill, more than 4 miles northwest of the leading edge of the Muscoy plume, since this area has not been formally identified as part of the Newmark Superfund site. The San Bernardino County Solid Waste Management Department currently is performing a verification monitoring program at the Cajon Landfill for development of a corrective action plan pursuant to a January 28, 1991, directive from the Santa Ana Regional Water Quality Control Board. Those organic compounds that were included in the laboratory analysis but not detected are not listed in the table. The promulgated state and federal chemical-specific standards are listed for those contaminants that have actual standards. It should be noted that only PCE and TCE were detected in the Muscoy Plume OU groundwater at levels exceeding the standards specified in Table 8-1. However, one groundwater sample at one well showed cis-1,2-DCE at the state MCL of 6 ppb, but below the federal MCL of 70 ppb. DCA and freon 11 were detected at levels below state MCLs. There is no federal or state MCL for freon 12.

Table 8-1

POTENTIAL STATE AND FEDERAL CHEMICAL-SPECIFIC ARARs FOR THE MUSCOY PLUME OU FOR TREATED WATER SERVED AS DRINKING WATER (September 1994)

Chemical VOCs ($\mu g/\ell$)	U.S. EPA		Cal EPA (DTSC)	
	MCL	MCLG	MCL	SDWS
1,1-Dichloroethane (DCA)	--	--	5	--
cis-1,2-Dichloroethene (cis-1,2-DCE)	70	70	6	--
Dichlorodifluoromethane (Freon 12)	--	--	--	--
Tetrachloroethene (PCE)	5	0	5	--
Trichloroethene (TCE)	5	0	5	--
Trichlorofluoromethane (Freon 11)	--	--	150	--

NOTES:

Source: USEPA, Region IX, Drinking Water Standards and Health Advisories Tables, Updated July 1994.

MCL = Maximum Contaminant Level
MCLG = Maximum Contaminant Level Goal (40 CFR 141)
SDWS = State of California Secondary Drinking Water Standard
"--" indicates that no MCL or MCLG has been promulgated.

The potential chemical-specific ARARs for treatment plant effluent water at the Muscoy Plume OU are as follows:

Primary Drinking Water Standards

Federal MCLs and MCLGs: 40 CFR Part 141.
EPA has promulgated MCLs (40 CFR Part 141) under the Safe Drinking Water Act (SDWA), 42 U.S.C. Section 300f et. seq., to protect public health from contaminants that may be found in drinking water sources. Although MCLs are only applicable "at the tap" for water provided directly to 25 or more people or supplied to 15 or more service connections, they are relevant and appropriate to groundwater that is a current or potential source of drinking water. Since the groundwater at the Muscoy Plume OU is a potential source of drinking water, MCLs appear to be relevant and appropriate to treatment plant effluent from the Muscoy Plume OU.

Under the SDWA, EPA has also established nonenforceable Maximum Contaminant Level Goals (MCLGs) (40 CFR Part 141), which are more stringent requirements for drinking water than MCLs. NCP section 300.430(e)(2)(i)(B) provides that MCLGs set at levels above zero must be attained when they are relevant and appropriate to the circumstances of the release. 40 CFR Section 300.430(e)(2)(i)(B).

MCLGs are, therefore, potential ARARs for the treated effluent at the Muscoy Plume OU. A final ARARs determination will be made during preparation of the ROD.

California MCLs: 22 CCR 64444.5
California has also established drinking water standards for sources of public drinking water under the California Safe Drinking Water Act, Health and Safety Code Section 4010 et. seq. The standards for VOCs are set forth in California Code of Regulations, Title 22 ("22 CCR"), Section 64444.5. In some instances, state MCLs are more stringent than federal MCLs. In these cases, the more stringent state MCLs would be ARARs. There are also some chemicals where state MCLs exist but there are no federal MCLs. These state MCLs would also be ARARs.

Secondary Drinking Water Standards

California SDWS: 22 CCR 64471.
The State of California's Secondary Drinking Water Standards (SDWS), promulgated pursuant to the California SDWA and set forth in 22 CCR 64471, may be ARARs for the Muscoy Plume OU if the remedy selected includes serving treated groundwater as drinking water. The California SDWS are promulgated state standards applicable to public water system suppliers which address the aesthetic characteristics of drinking water. Although these standards are not applicable to non-public water system suppliers, they may be relevant and appropriate if the treated water for the Muscoy Plume OU is put into the public drinking water system.

8.1.2.2 Location-Specific ARARs

Federal and state location-specific ARARs are restrictions placed on the concentration of a contaminant or on the activities to be conducted because they are in a specific location. Examples of special locations

which may trigger ARARs include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

Floodplains

Executive Order 11988 and the regulations promulgated pursuant thereto (40 CFR Part 6 Appendix A) require federal agencies to avoid or minimize adverse impacts of federal actions upon floodplains. The portion of the City of San Bernardino in the vicinity of the Muscoy Plume OU has been classified by the Federal Emergency Management Association (FEMA) as an area of "minimal flood hazard," where no part of the community would be inundated by a base flood. (Muscoy Plume OU Remedial Investigation Report, Chapter 2.0) Therefore, the Muscoy Plume OU is not considered to be in a floodplain and no further consideration of floodplains in remedial planning is necessary.

Wetlands

Executive Order 11990 and the regulations promulgated pursuant thereto (40 CFR Part 6 Appendix A) require federal agencies to avoid or minimize adverse impacts of federal actions upon wetlands. At this stage of the Superfund process, no wetlands have been identified in the vicinity of the Muscoy Plume OU which would cause these requirements to be ARARs.

Historic Sites

The requirements of the National Historic Preservation Act, 16 U.S.C. Section 470, will be ARARs for the Muscoy Plume OU if the remedy impacts any historic sites protected under the Act. However, at this stage of the Superfund process, no historic sites have been identified in the vicinity of the Muscoy Plume OU which would be affected by potential remedial activity at this location.

Endangered Species

The Federal Endangered Species Act, 16 U.S.C. Section 1531 et. seq., and the regulations promulgated pursuant thereto (50 CFR Part 402) require action to conserve endangered species and critical habitats. Although the area affected by the Muscoy Plume OU is a developed urban community, the requirements of this Act will be ARARs for the Muscoy Plume OU if the remedy impacts any threatened or endangered species protected under the Act.

Protecting Fish, Plants and Birds From Water Pollution

Division 6, Chapter 2, Section 5650 of the California Fish and Game Code prohibits water pollution with substances that may be deleterious to fish, plants or birds. If any remedial alternatives for the Muscoy Plume OU include direct discharges of untreated water to surface water, this chapter may become an ARAR.

8.1.2.3 Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based requirements for remedial activities. The action-specific ARARs presented in this RI/FS report are intended to cover the potential remedial alternatives that may be applied to the Muscoy Plume OU.

Examples of potential remedial alternatives for groundwater cleanup for the Muscoy Plume OU may include groundwater extraction, treatment of the groundwater to remove VOCs (e.g., air stripping with emission control or granular activated carbon [GAC] filtration), and reuse of treated water (e.g., distribution as potable water or reinjection within the basin).

Air Stripping

Treatment of VOCs by techniques such as air stripping, whereby the volatiles are emitted to the atmosphere, may trigger certain action-specific ARARs at the Muscoy Plume OU with respect to air quality.

SCAQMD Rules 401, 402, 403, 1301-1313, and 1401

California Health and Safety Code Section 39000 et. seq. and the federal Clean Air Act, 42 U.S.C. Section 7401 et. seq., regulate air emissions to protect human health and the environment, and are the enabling statutes for state and federal air quality programs and standards. The substantive requirements of these programs are implemented primarily through Air Pollution Control Districts. The South Coast Air Quality Management District (SCAQMD) is the district regulating air quality in the San Bernardino area.

The SCAQMD has adopted rules that limit air emissions of identified toxics and contaminants. SCAQMD Rule 1401, which governs new source review of carcinogenic contaminants, is a potential ARAR for the Muscoy Plume OU. SCAQMD Rule 1401 requires that best available control technology (T-BACT) be employed for new stationery operating equipment, so the cumulative carcinogenic impact from air toxics does not exceed the maximum individual cancer risk limit of ten in one million (1×10^{-5}). This T-BACT rule may be an ARAR for the Muscoy Plume OU because compounds such as PCE and TCE are present in groundwater, and release of these compounds to the atmosphere may pose health risks exceeding SCAQMD requirements. The SCAQMD Regulation XIII, comprising rules 1301 through 1313, sets forth additional requirements for new source review and the substantive requirements of this Regulation may also be ARARs for the Muscoy Plume OU.

The SCAQMD also has rules limiting the visible emissions from a point source (Rule 401), prohibiting discharge of material that is odorous or causes injury, nuisance or annoyance to the public (Rule 402), and limiting down-wind particulate concentrations (Rule 403). The substantive requirements of these rules are potential ARARs for the Muscoy Plume OU.

Reinjection of Treated Water to The Aquifer

Any reinjection of treated water to the aquifer will trigger the following ARARs at the Muscoy Plume OU:

Federal Underground Injection Control Regulations: 40 CFR 144.12 - 144.13

The Federal Underground Injection Control regulations (set forth at 40 CFR Part 144), promulgated pursuant to the SDWA, 42 U.S.C Sections 300f et. seq., prohibit injection wells, such as those that would be located at the Muscoy Plume OU from (1) causing a violation of the primary MCLs in the receiving water and (2) adversely affecting the health of persons. 40 CFR Section 144.12. Section 144.13 of these regulations provides that contaminated groundwater that has been treated may be reinjected into the formation from which it is withdrawn if such injection is conducted pursuant to a

CERCLA cleanup and is approved by EPA. 40 CFR Section 144.13. These provisions appear to be ARARs in the event that treated water is reinjected at the Muscoy Plume OU.

Resource Conservation and Recovery Act--Section 3020, 42 U.S.C. Section 6939b.
Section 3020 of the Resource Conservation and Recovery Act (RCRA) provides that the ban on the disposal of hazardous waste into a formation which contains an underground source of drinking water (set forth in Section 3020(a)) shall not apply to the injection of contaminated groundwater into the aquifer if: (1) such injection is part of a response action under CERCLA; (2) such contaminated groundwater is treated to substantially reduce hazardous constituents prior to such injection; and (3) such response action will, upon completion, be sufficient to protect human health and the environment. RCRA Section 3020(b).

State Water Resources Control Board Resolution 68-16.
State Water Resources Control Board Resolution No. 68-16, which is incorporated in the Santa Ana Regional Water Quality Control Board's (SARWQCB) Water Quality Control Plan for the Santa Ana River (and specific Bunker Hill sub-basins), appears to be an ARAR for the Muscoy Plume OU to the extent that treated water is reinjected into the aquifer. Resolution 68-16 requires maintenance of existing state water quality unless it is demonstrated that a change will benefit the people of California, will not unreasonably affect present or potential uses, and will not result in water quality less than that prescribed by other state policies.

By decision dated July 9, 1993, the EPA Regional Administrator for Region IX decided that in determining the numeric standard required by Resolution 68-16, the following three factors must be balanced: (1) Site-specific considerations, including the hydrogeological conditions at the site, the contaminants discharged, the quality of the receiving water and the designated beneficial uses of the receiving water; (2) Treatment technologies; and (3) Cost.

Based on a site-specific analysis of the Muscoy Plume OU, EPA anticipates that the substantive reinjection standard for PCE, TCE, DCE, and DCA at the Muscoy Plume OU will be 0.5 ppb on a monthly median basis. This conclusion is preliminary and is based on data gathered over the last several years at existing state-funded groundwater treatment plants operating at the leading edge of the contaminant plumes of the Newmark Superfund site. This site-specific information shows that contaminant levels in the groundwater remain within a range that has been consistently treated to below 0.5 ppb PCE/TCE/DCE/DCA using conventional treatment technologies (granular activated carbon and air-stripping). The data from these existing treatment plants leads EPA to believe that the 0.5 ppb level can be attained on a monthly median basis assuming essentially identical conditions in the Muscoy Plume remedial action. Furthermore, treatment costs can be better defined based on cost data from the existing treatment plants. EPA's analysis relies on data from the existing treatment plants and assumes that EPA will be reinjecting the treated water into relatively clean groundwater at or near the edge of the contaminant plume. The 0.5 ppb monthly median reinjection standard will be reevaluated in the event that any of the above-referenced assumptions and data are revised, and the final numeric standard will be set forth in the Muscoy Plume OU ROD.

The same site-specific operational data that led EPA to the conclusion that PCE, TCE, DCE and DCA can be effectively and economically treated to the 0.5 ppb monthly median standard at the leading edge of the Muscoy Plume clearly show that neither freon 11 nor freon 12 are treated by liquid-phase granular activated carbon. This site-specific information is completely consistent with the information on freon

treatability throughout the industry. In addition, treatability studies for air stripping emission controls conducted by the state at this site confirm that freon is not efficiently removed with vapor-phase granular activated carbon. More importantly, in consideration of the designated (and actual) beneficial uses of the receiving water, EPA's Risk Assessment for this Operable Unit shows no increased risk to human health and the environment from freon at this site. Consequently, EPA has tentatively concluded that the reinjection standard for freon 11 is the MCL for freon 11 (150 $\mu g/\ell$). It should be noted that the maximum concentration of freon 11 and freon 12 detected in the Muscoy Plume investigation area was 4 $\mu g/\ell$ for freon 11 and 28 $\mu g/\ell$ for freon 12 (Table 5-1).

Temporary Discharges to Surface Water

National Pollutant Discharge Elimination System Program

EPA anticipates that there may be incidental, short-term discharges of treated water to the San Bernardino County flood control channel or to the City of San Bernardino storm drains during certain remedial activities (for example, during construction of the groundwater extraction system, the VOC treatment plant, and the monitoring wells, during groundwater sampling, and during system maintenance). The ARAR for any treated water that is discharged, on a short-term basis, to surface waters is the National Pollutant Discharge Elimination System (NPDES) Program which is implemented by the SARWQCB. Because the SARWQCB considered Resolution 68-16 in establishing the above-referenced effluent standards, compliance with the substantive effluent standards in Order No. 91-63-043 constitutes compliance with Resolution 68-16. Based on the waste discharge limitations adopted by the SARWQCB in Order No. 91-63-043, the EPA has tentatively concluded that groundwater that will be discharged, on a short-term basis, to surface waters on site must be treated to state or federal MCLs for PCE, TCE, cis-1,2-DCE, and DCA, the standards set forth in Order No. 91-63-043.

Temporary Discharges to POTW

EPA anticipates that there may be incidental, short-term discharges of treated water into the municipal sewer system (Publicly Owned Treatment Works or POTW) during certain remedial activities (see preceding paragraph for a description of these activities). In general, a discharge to a POTW is considered an off-site activity even if water is discharged to a sewer located on site. Consequently, requirements related to POTW discharge are not ARARs and are discussed here for informational purposes only. Any discharge to a POTW must comply with the requirements of the national pretreatment program and all applicable local pretreatment regulations, whether substantive or administrative.

Hazardous Waste Management

The State of California has been authorized to enforce its own hazardous waste program under the California Hazardous Waste Control Act, Health and Safety Code, Division 20, Chapter 6.5, in lieu of the RCRA program administered by the EPA. State regulations (in 22 CCR, Division 4.5) are now cited as ARARs instead of the federal RCRA regulations.

Certain "spent" halogenated solvents, including TCE and PCE, are listed hazardous wastes (F002) under 22 CCR Section 66261.31. Spent solvent mixtures/blends containing, before use, a total of 10% or more (by volume) of TCE, PCE and certain other halogenated solvents are also listed hazardous wastes under this provision. EPA continues to investigate the source of the contaminants in the groundwater in order

to determine whether the TCE and PCE may be classified as listed hazardous wastes. Regardless of the outcome of this investigation, the contaminants in the groundwater appear to be sufficiently similar to listed hazardous wastes (F002) to render portions of the state's hazardous waste regulations relevant and appropriate. If the groundwater in the Muscoy Plume OU is treated so it no longer contains a hazardous waste, the state hazardous waste regulations will no longer apply to the treated groundwater.

Storage Requirements: 22 CCR Sections 66264.170 - 66264.178

The container storage requirements set forth in 22 CCR Sections 66264.170 - 66264.178 may be relevant and appropriate for the storage of contaminated groundwater and spent carbon over 90 days.

Land Disposal Restrictions: 22 CCR Section 66268

The land disposal restrictions (LDRs) set forth in 22 CCR Section 66268 may be relevant and appropriate to discharges of contaminated groundwater to land. The remedial alternatives presented do not include land disposal of contaminated groundwater, except as may occur through activities incidental to the remedial action, such as purging monitoring wells. Any water discharged to land must be treated to MCLs for VOCs prior to discharge.

The LDRs set forth in 22 CCR 66268 may also be relevant and appropriate to the on-site disposal of spent carbon. These restrictions would be applicable requirements if the spent carbon contains sufficient quantities of hazardous constituents to render it a characteristic hazardous waste. However, the remedial alternatives presented do not contemplate on-site disposal of spent carbon and are therefore unlikely to trigger LDRs.

VOC Treatment Plant Requirements: 22 CCR Sections 66264.14, 66264.18, 66264.25, 66264.600-.603, and 66264.111-.115

The substantive requirements of the following state hazardous waste regulations appear to be relevant and appropriate to the VOC treatment plant: 22 CCR Section 66264.14 (security requirements); 22 CCR Section 66264.18 (location standards) and Section 66264.25 (seismic and precipitation standards).

In addition, an air stripper, advanced oxidation process (AOP) treatment system, or GAC contractor would qualify as a RCRA miscellaneous unit if the contaminated water constituted a hazardous waste. Therefore, the substantive requirements for miscellaneous units set forth in 22 CCR Sections 66264.600 - 66264.603 and related substantive closure requirements set forth in Sections 66264.111 - 66264.115 may be ARARs for the Muscoy Plume OU. The 22 CCR Section 66264.100 corrective action regulations may be TBC for the Muscoy Plume OU.

Certain other portions of state hazardous waste regulations appear to be relevant but not appropriate to the VOC treatment plant. EPA has identified the substantive requirements of 22 CCR Sections 66264.15 - 66264.16 (general inspection requirements and personnel training), and 66264.30 - 66264.56 (Preparedness and Prevention and Contingency Plan and Emergency Procedures) as relevant but not appropriate requirements for the Muscoy Plume OU treatment system. EPA has reached this conclusion because the treatment plant will be required to have health and safety plans under CERCLA that are substantively equivalent to the requirements of Sections 66264.15-66264.16 and 66264.30 - 66264.56.

8.1.3 Identification of Other Guidance and Criteria To-Be-Considered

Other standards, criteria or guidance TBCs are federal, state or local advisories or guidance that do not have the status of potential ARARs. If there are no specific federal or state ARARs for a particular chemical or remedial action, or if existing ARARs are not considered sufficiently protective, then guidance or advisory criteria should be identified and used to ensure public health and environmental protection. TBCs may provide health effects information with a high degree of credibility, technical information on performing or evaluating site investigations or RAs, and useful policies for dealing with hazardous substances. EPA will identify in the ROD those TBCs chosen as requirements for the selected remedy.

Proposed federal MCLs and MCLGs are considered potential TBCs. EPA has also developed Secondary MCLs (SMCLs) (40 CFR Section 143) which are non-enforceable limits designed to establish minimum aesthetic qualities in drinking water. SMCLs and proposed MCLs (Table 8-2) are TBCs for the Muscoy Plume OU if the remedy includes serving treated groundwater as drinking water.

The California DHS has established numerical criteria as State Action Levels (SALs) for selected chemicals in drinking water for which state MCLs have not yet been established. The DHS has established a policy by which any water system not meeting the SALs is required to take corrective action. SALs are TBCs for the Muscoy Plume OU.

The EPA has developed TBC guidance through their Health Effects Advisories for chemicals that may provide the best available standard for a particular chemical where no binding standard exists. Reference doses (RfDs) and cancer potency factors (CPFs) have also been developed for many chemicals. These are TBCs for the Muscoy Plume OU. As previously stated, TBC standards are not legally enforceable. However, once selected by the EPA in the ROD as part of the remedy, they must be complied with to the same extent as ARARs.

The California DHS has developed Applied Action Levels (AALs) intended to be used on the risk appraisal process, not as levels for cleanup. AALs are developed according to procedures outlined in The California Site Mitigation Decision Tree Manual (DHS 1986). AALs are not ARARs because they are not promulgated. The AALs may be TBCs for the Muscoy Plume OU to establish a protective level for those contaminants not having an ARAR or if the ARAR does not establish a protective level. These values are based on maximum acceptable exposure of biological receptors to substances associated with hazardous waste sites and facilities. AALs are derived by considering health effects without dealing with technical feasibility, economic concerns, or other factors. Because AALs are entirely health-based, they differ from standards developed by other agencies and divisions of DHS on both a criterion and use basis.

Substantive standards for the construction of public water supply wells have been published by the State of California. While these standards have not been specifically promulgated as an enforceable regulation and are therefore not ARARs, EPA has determined that the water supply wells at Muscoy Plume OU RA will comply with substantive water well construction standards, such as sealing the upper annular space to prevent surface contaminants from entering the water supply. However, standards for location of extraction wells are inappropriate for the Muscoy Plume OU RA because the effectiveness of the remedy is dependent upon well locations. Additionally, wells constructed solely for treatment and reinjection with no delivery to the public water supply system would not be subject to these water well standards. The California well standards are therefore TBCs for the Muscoy Plume OU.

Table 8-2

POTENTIAL STATE AND FEDERAL CHEMICAL-SPECIFIC TBCs FOR THE MUSCOY PLUME OPERABLE UNIT
September 1994

Chemical VOCs ($\mu g/\ell$)	U.S. EPA		Cal EPA (DTSC)
	SMCL	Proposed MCL	SAL
1,1-Dichloroethane (DCA)	--	--	--
cis-1,2-Dichloroethene (cis-1,2-DCE)	--	--	--
Dichlorodifluoromethane (Freon 12)	--	--	--
Tetrachloroethene (PCE)	--	--	--
Trichloroethene (TCE)	--	--	--
Trichlorofluoromethane (Freon 11)	--	--	150

Other U.S. EPA Secondary MCLs

Color	15 Color Units
Odor	3 (Odor Threshold Number)
pH	6.5 - 8.5 pH Units
Total Dissolved Solids	500 mg/ℓ

NOTES:

Source: USEPA, Region 9, Drinking Water Standards and Health Advisories Tables, Updated July, 1994.

"--" indicates that no level or standard has been established.
SMCL = Secondary Maximum Contaminant Level
SAL = State of California Action Level

8.1.4 Summary of ARARs and TBCs

A summary of the ARARs identified for the Muscoy Plume OU are listed on Table 8-3. Other standards, guidance, or TBCs have also been identified, and are also included on Table 8-3. A final list of requirements will be identified prior to completion of the ROD for the RA that is selected.

8.2 PRELIMINARY BASELINE RISK ASSESSMENT

The EPA, in accordance with the NCP (40 CFR Part 300), prepared a baseline risk assessment for the Muscoy Plume OU to support the selection of an interim RA. The baseline risk assessment is included as Appendix 7 of this RI/FS Report. The baseline risk assessment evaluated the potential health effects of the No Action Alternative under an unlikely scenario in which federal and state drinking water standards would not be enforced and residents within the area of the Muscoy Plume OU would be supplied with untreated groundwater from the underlying contaminated aquifer.

8.2.1 Background

Potential cancer risks for known or suspected carcinogens are estimated based on the possibility that one additional occurrence of cancer will result from exposure to an individual contaminant or multiple contaminants. A cancer risk estimated at 1E-06 (one-in-one-million or 10^{-6}) means that for every one million people exposed to the carcinogen(s) throughout their lifetime, the average incidence of cancer is increased by one extra case of cancer. The NCP considers a range of one-in-ten-thousand (1E-04) to one-in-one million acceptable at a particular Superfund site, depending upon the site, proposed usage, and chemicals of concern. Within this range, the level of risk which is considered acceptable is a risk management decision and is decided on a case-specific basis.

8.2.2 Chemical Concentrations

Analytical data gathered during interim sampling activities for the Muscoy Plume OU RI were used to identify the chemicals of potential concern (COPCs) and quantify potential exposure levels. The COPCs consisted of nine volatile organic groundwater contaminants: PCE, TCE, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloropropane, vinyl chloride, dichlorodifluoromethane (freon 12), and trichlorofluoromethane (freon 11). Although vinyl chloride was detected in only one well at an estimated concentration of 0.1 $\mu g/\ell$, it was included as a COPC because it is a known human carcinogen and a possible PCE or TCE biodegradation product. Chemical concentrations used to evaluate exposures were based on a statistical evaluation of the analytical data using the 95% upper confidence limit (UCL) of the arithmetic mean (lognormal or normal distribution) when appropriate, or the maximum detected concentration whenever the 95 UCL was higher. Although this approach is conservative it is reasonable and necessary given the limited available groundwater data, and it is consistent with EPA guidance (EPA 1989a). Most COPC concentrations were the maximum detected levels. Vinyl chloride was tentatively identified in a single well (MUNI-106) at an estimated 0.1 $\mu g/\ell$. Since vinyl chloride is a known human carcinogen, the effect of 0.1 $\mu g/\ell$ vinyl chloride will also be calculated in this risk assessment, despite the lack of analytical or statistical certainty.

Table 8-3

Summary of Potential ARARs and TBCs for the Muscoy Plume Operable Unit

Potential ARARs

Federal Drinking Water Standards
(Source: Federal Safe Drinking Water Act (SDWA))
- 40 CFR Section 141, Maximum Contaminant Levels (MCLs)
- 40 CFR Section 141, Maximum Contaminant Level Goals (MCLGs)

California Drinking Water Standards
(Source: California Safe Drinking Water Act)
- California Code of Regulations, Title 22 ("22 CCR"), Sections 64444.5 and 64471, State MCLs and Secondary Drinking Water Standards

California Hazardous Waste Requirements
(Source: California Hazardous Waste Control Act)
- 22 CCR Sections 66264.14, 66264.18 and 66264.25 (VOC treatment plant security, location, seismic and precipitation requirements)
- 22 CCR Section 66264.170 -.178 (storage of hazardous waste)
- 22 CCR 264.600 -.603 and 66264.111 -.115 (substantive requirements for miscellaneous units - VOC treatment plant)
- 22 CCR Section 66268 (land disposal restrictions)

California Fish and Game Code, Division 6, Chapter 2, Section 5650 (protecting fish, plants and birds from water pollution)

South Coast Air Quality Management District (SCAQMD) Rules
(Source: California Health and Safety Code Section 39000 et. seq.; Federal Clean Air Act.)
- SCAQMD Rule 401 (limit the visible emissions from a point source)
- SCAQMD Rule 402 (discharge of material that is odorous or causes injury, nuisance or annoyance to the public)
- SCAQMD Rule 403 (limits down-wind particulate concentrations)
- SCAQMD Regulation XIII, comprising rules 1301 through 1313 (substantive requirements for new source review)
- SCAQMD Rule 1401 (best available control technology for toxics (T-BACT) for new stationery operating equipment)

State Water Resources Control Board Resolution 68-16 (maintaining high quality of waters in Bunker Hill Basin)

Federal Underground Reinjection Control Requirements
(Source: Federal Safe Drinking Water Act)
- 40 CFR Sections 144.12-144.13 (reinjection of treated groundwater as part of CERCLA response action)

Table 8-3 (Cont'd.)

Summary of Potential ARARs and TBCs for the Muscoy Plume Operable Unit

RCRA Section 3020 (reinjection of treated groundwater as part of CERCLA response action)

National Pollutant Discharge Elimination System Program
(temporary discharges to surface water)

Federal Endangered Species Act

National Historic Preservation Act

Executive Order 11988 (Floodplain Management)
- 40 CFR Part 6, Appendix A

Executive Order 11990 (Protection of Wetlands)
- 40 CFR Part 6, Appendix A

TBCs

Proposed federal MCLs and MCLGs

Secondary MCLs (40 CFR Section 143)

State Action Levels numerical criteria

California DHS Applied Action Levels (intended to be used on the risk appraisal process)

USEPA Health Effects Advisories (where no binding standard exists for a particular chemical)

USEPA Reference doses (RfDs) and cancer potency factors (CPFs)

California Hazardous Waste Control Act [California Code of Regulations, Title 22 ("22 CCR"), Division 4.5]
- 22 CCR Section 66264.100 corrective action regulations

California Water Well Standards

Chronic daily intakes (CDIs) were calculated for each COPC by applying the 95% UCL or maximum detected concentration, as appropriate for both the reasonable maximum exposure (RME) and average exposure scenarios. The other exposure parameters (ingestion rate, exposure frequency, exposure duration, averaging time, etc.) reflect either the average exposure scenario using the 50th percentile or median values; or the RME scenario using national upper-bound (90th - 95th percentile) exposure values.

8.2.3 Exposure Pathways

Two potential exposure pathways were evaluated: consumption of contaminated drinking water (i.e., oral intake or oral ingestion), and inhalation of airborne vapor-phase contaminants from showering and other exposure-related uses of untreated water (e.g., bathing, washing etc.). The dermal contact exposure pathway was not considered significant, and was not evaluated further or included as a CDI. The inhalation CDI was calculated by applying a volatilization constant based on standard upper-bound values (water usage, residence volume, air exchange rate, and transfer efficiency of the volatiles from water to air), and average or RME inhalation rates and exposure durations.

8.2.4 Quantification of Health Risks

The potential for adverse noncarcinogenic health effects and carcinogenic risks were evaluated for individual and multiple exposure pathways (ingestion, inhalation) and COPCs by applying accepted updated EPA (Integrated Risk Information System or IRIS database, Health Effects Assessment Summary Tables or HEAST) or state (Cal EPA cancer potency factors) chemical-specific toxicity values reflecting dose-response relationships.

Noncarcinogenic Risks. Potential contaminant-specific noncarcinogenic effects were determined by comparing the CDI with a dose-response toxicity value, or reference dose (RfD) for a given COPC and exposure pathway. Potential adverse health effects were indicated whenever the hazard quotient (HQ), calculated by dividing the estimated CDI by the RfD, was equal to or greater than unity (i.e., ≥ 1). For noncarcinogenic effects posed by the aggregate COPCs, a hazard index (HI) approach was used. When the HI, which is equal to the sum of the individual HQs, exceeded unity, is was assumed that there may be a concern for potential health effects.

Carcinogenic Risks. The potential cancer risk (i.e., excess upper-bound lifetime cancer risk over a 70-year lifetime) at a calculated CDI was estimated by applying chemical-specific cancer potency factors (CSFs). The CSF, generally with an upper 95th percentile confidence limit, converts the estimated CDI averaged over a lifetime of exposure to an upper-bound estimated incremental risk of an individual developing cancer. For carcinogenic effects posed by the aggregate COPCs, separate total cancer risks for each exposure pathway were calculated by summing the substance-specific cancer risks. The excess lifetime cancer risk for a specific or aggregate exposure is expressed as a proportion (e.g., one-in-one-million, or 10^{-6}, also expressed as 1E-06). The cancer risk represents the incremental increase in an individual's lifetime chance of developing cancer as a result of the exposure(s). Because an individual's background risk of cancer is approximately one in four (0.25) adding a one-in-one-million risk (0.000001) to the background risk is of little significance. The small risk levels would be of concern only if the exposed population includes many millions. An increased cancer risk range of E-04 to E-06 (1 in 10,000 to 1 in 1,000,000) is considered acceptable by the EPA for use with Superfund sites, as well as among scientific and regulatory communities.

8.2.5 Estimated Risks - Quantitative Assessment

Noncarcinogenic Health Risks. As shown in Table 8-4, the CDIs for both exposure pathways were determined not to exceed the RfDs for any individual COPC (i.e., HQ < 1) or for the sum of all eight COPCs (i.e., HI < 1). For ingestion and inhalation exposures to groundwater contamination from an average exposure scenario as shown in Table 8-4, the HI was equal to 0.09 for the ingestion pathway, 0.34 for the inhalation pathway, and 0.43 for both pathways. For the RME scenario, the HI was estimated to be 0.14 for the ingestion pathway and 0.49 for the inhalation pathway. The major contaminant contributing to the noncarcinogenic health risk is PCE.

Carcinogenic Health Risks. Table 8-5 summarizes the carcinogenic risk estimates. The incremental individual excess lifetime cancer risk from the average exposure scenario for all eight COPCs was estimated to be 1E-05 (1 in 100,000) for both exposure pathways, including 4E-06 (4 in 1,000,000) for the ingestion pathway and 6E-06 (6 in 1,000,000) for the inhalation pathway.

As shown in Table 8-5, the cancer risk associated with the RME scenario for both exposure pathways was estimated to be 5E-05 (5 in 100,000), including 2E-05 (2 in 100,000) for the ingestion pathway, and 3E-05 (3 in 100,000) for the inhalation pathway. The major contaminant contributing to the cancer risk is PCE. The additional risk associated with vinyl chloride tentatively identified in one groundwater sample was approximately 4E-06.

If the Muscoy Plume OU groundwater were treated to existing federal and state drinking water standards (MCLs) for PCE and TCE (5 $\mu g/\ell$) and all other COPC contaminant levels and exposure values remained at the RME scenario used in this baseline risk assessment, the total estimated incremental lifetime cancer risk would be 1.5E-05.

8.2.6 Ecological Risks

An ecological assessment was conducted to provide a qualitative evaluation of potential risks to the Muscoy Plume OU area biota (flora and fauna) or ecological communities as a result of exposure to the existing groundwater contaminants.

The assessment determined the presence of sensitive habitats and the possible occurrence of some federal and state endangered plant species on some of the remaining undisturbed alluvial fans and floodplains within Lytle Creek Wash and Lytle Creek. Apart from these areas, most of the Muscoy Plume OU is highly developed, and does not support a diversity of native plant species or significant habitat or wildlife populations.

There are no indications that the contaminated groundwater from the Muscoy Plume OU plume reaches the surface or is being discharged to surface waters (i.e., no potential pathways). Of the potential ecological receptors, particularly sensitive habitats and listed species, there appears to be no complete exposure pathway for any of the chemical stressors (COPCs) associated with the existing Muscoy plume.

Table 8-4

SYSTEMIC TOXICITY SUMMARY
CHRONIC HAZARD INDEX ESTIMATES
AVERAGE AND REASONABLE MAXIMUM EXPOSURE (RME) SCENARIOS

Chemical	Concentration (C_w) (mg/ℓ)	Average Exposure Scenario			Reasonable Maximum Exposure Scenario		
		Ingestion Hazard Quotient	Inhalation Hazard Quotient	Hazard Index	Ingestion Hazard Quotient	Inhalation Hazard Quotient	Hazard Index
Tetrachloroethene (PCE)	0.027	0.0518	0.185	0.237	0.077	0.27	0.35
Trichloroethene (TCE)	0.006	0.0192	0.0685	0.088	0.027	0.10	0.13
cis-1,2-Dichloroethene	0.006	0.0115	0.0411	0.053	0.017	0.06	0.08
trans-1,2-Dichloroethene	0.0004	0.0004	0.0014	0.002	0.0001	0.002	0.002
1,1-Dichloroethane	0.0008	0.0002	0.0004	0.001	0.0002	0.0006	0.001
1,2-Dichloropropane	0.0003	0.0052	0.0187	0.024	0.008	0.027	0.04
Dichlorodifluoromethane (Freon 12)	0.017	0.0016	0.0204	0.022	0.002	0.030	0.03
Trichlorofluoromethane (Freon 11)	0.004	0.0003	0.0014	0.002	0.0004	0.002	0.002
Vinyl Chloride	0.0001(1)	NA	NA	NA	NA	NA	NA
TOTAL		0.09	0.34	0.43	0.14	0.49	0.63

(1) Concentration estimated, data qualitatively acceptable (J-qualified).
NA = Not applicable or not classified as a human carcinogen (i.e., EPA Group D or E).

Table 8-5

CARCINOGENIC RISK ESTIMATES
AVERAGE AND REASONABLE MAXIMUM EXPOSURE (RME) SCENARIOS

Chemical	Concentration (C_w) (mg/ℓ)	Average Exposure Scenario			Reasonable Maximum Exposure Scenario		
		Ingestion	Inhalation	Total Chemical-Specific Cancer Risk	Ingestion	Inhalation	Total Chemical-Specific Cancer Risk
Tetrachloroethene (PCE)	0.027	3.47E-06	4.99E-06	8.46E-06	1.71E-05	2.43E-05	4.14E-05
Trichloroethene (TCE)	0.006	2.22E-07	7.50E-07	0.75E-06	1.10E-06	2.57E-06	3.67E-06
cis-1,2-Dichloroethene	0.006	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	0.0004	NA	NA	NA	NA	NA	NA
1,1-Dichloroethane	0.0008	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	0.0003	5.04E-08	1.80E-07	2.3E-07	2.49E-07	8.75E-07	1.12E-06
Dichlorodifluoromethane (Freon 12)	0.017	NA	NA	NA	NA	NA	NA
Trichlorofluoromethane (Freon 11)	0.004	NA	NA	NA	NA	NA	NA
Vinyl Chloride	0.0001(1)	4.69E-07	2.64E-07	7.33E-07	2.32E-06	1.29E-06	3.61E-06
TOTAL		4.21E-06	5.96E-06	1.02E-05	2.08E-05	2.90E-05	4.98E-05

(1) Concentration estimated, data qualitatively acceptable (J-qualified).
NA = Not applicable or not classified as a human carcinogen (i.e., EPA Group D or E).

8.2.7 Conclusions

The current contaminant levels in the Muscoy Plume OU plume would not meet state or federal drinking water standards (MCLs) for PCE and possibly TCE and cis-1,2-DCE, if this water were to be delivered directly to local residents without treatment. However, the levels are currently below the concentrations that would pose an unacceptable cancer risk to human health, as defined by the NCP and CERCLA.

Given the absence of potential exposure pathways, there is no expectation for significant impact to the Muscoy Plume OU area biota or sensitive ecological communities. The potential ecological risks to undeveloped areas outside of the Muscoy Plume OU were not evaluated in the ecological assessment. Nevertheless, plume containment would avoid potential impacts to biota or sensitive ecological communities outside of the Muscoy Plume OU if there were any discharge of untreated groundwater to surface water or a groundwater-to-surface water connection existed.

9.0 GENERAL RESPONSE ACTIONS

General response actions describe those actions that may fulfill the RA objectives of the Muscoy Plume OU RI/FS. In accordance with the EPA Interim Final (1988a, 1988b), the general response actions for groundwater are grouped into four categories:

- No Action
- Institutional Actions
- Containment
- Collection/Treatment/End Use

Table 9-1 summarizes the technologies and processes that were evaluated for each of the general response actions. The technologies and processes are discussed in the following sections.

9.1 NO ACTION

The No Action general response action is included in accordance with the NCP and is used in the alternative development step of the FS to provide a baseline for comparing with other groundwater remediation alternatives. Although it involves no active clean-up of contaminated groundwater, the No Action response action includes the development of a monitoring program for documenting contaminant movement. This response does not meet the RA objectives.

9.2 INSTITUTIONAL ACTIONS

Institutional actions are implemented to prevent direct human contact with impacted groundwater by restricting the use and development of the aquifer. This response action will accomplish the human health objective by preventing ingestion of impacted groundwater but it does not reduce contamination in the aquifer to the levels specified in the environmental protection objective.

9.3 CONTAINMENT

Containment methods utilize physical or hydraulic barriers to prevent contact between contaminated groundwater and potential receptors, and to reduce contaminant migration. Containment methods generally require long-term monitoring of groundwater quality.

Table 9-1

TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives	General Response Action	Technology	Process Option
For Human Health: Prevent ingestion of water having TCE in excess of 5 $\mu g/\ell$ and PCE in excess of 5 $\mu g/\ell$. For Environmental Protection: Reduce groundwater aquifer contaminant concentrations below 5 $\mu g/\ell$ for both TCE and PCE.	No Action	Monitoring	Monitoring
	Institutional Actions	Groundwater use restrictions	Alternate Water Supply
	Containment	Vertical Barrier	Slurry Wall
			Grout Curtain
			Steel Sheet Piling
			Passive Treatment Walls
		Horizontal Barrier	Grout Injection
	Collection/Treatment/End Use Collection	Extraction	Extraction Wells
			Municipal Supply Wells
		Subsurface Drains	French Drain
	Treatment	Biological	Aerobic Oxidation
			Anaerobic Digestion
		Physical/Chemical (On Site)	Aqueous Phase Granular Activated Carbon (GAC)
			Air Stripping with Vapor-Phase GAC Treatment of Off Gas

Table 9-1 (Cont'd.)

TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives	General Response Action	Technology	Process Option
	Treatment (Cont'd.)	Physical/Chemical (On Site) (Cont'd.)	Air Stripping with Advanced Oxidation Off Gas Treatment
			Air Stripping with Off Gas Treatment by Incineration
			Air Stripping with Off Gas Treatment by Resin Based Adsorption (Padre System)
			Advanced Oxidation (Ozone)
			Advanced Oxidation (Ozone/Peroxide)
			Advanced Oxidation (UV)
			Reverse Osmosis
			Ion Exchange
			Precipitation
			Air Sparging
			Vacuum Vapor Extraction
			Hot Water or Steam Flushing/Stripping
		Physical/Chemical Off Site	POTW
			RCRA Facility

Table 9-1 (Cont'd.)

TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIAL ACTION OBJECTIVES

Remedial Action Objectives	General Response Action	Technology	Process Option
	Treatment (Cont'd.)	Physical/Chemical In-situ	Oxygen Enhancement with Hydrogen Peroxide Oxygen Enhancement with Air Sparging Permeable Treatment Beds Chemical Oxidation
		Physical/Chemical Other	Natural Attenuation with Monitoring
	End Use	On-site Discharge of Treated Groundwater	Reinjection
			Surface Drainage
		Off-site Discharge of Treated Water	POTW
			Municipal Water Supply

9.4 COLLECTION/TREATMENT/END USE

The collection/treatment/end use general response action encompasses a range of actions described below which are grouped together in order to form a complete response action alternative. This response action has the potential to accomplish both human health and environmental objectives to a varying degree depending on how technologies and processes are combined. The degree to which RA objectives are accomplished by selected technical collection/treatment/end use alternatives is fully evaluated in Section 13.0.

9.4.1 Collection

Contaminated groundwater may be collected from the aquifer by way of extraction wells or subsurface drains. Extraction wells may either be municipal water production wells or wells specifically sited and designed to capture all or part of the contaminated groundwater plume. Both extraction wells and subsurface drains are evaluated in Section 10.0, which presents the results of initial screening of technologies and process options.

9.4.2 Treatment

Treating contaminated groundwater implements one or more methods of biological, physical, and chemical treatment technologies. Groundwater treatment may be completed on or off site. The degree and nature of contamination and the effluent specifications dictate the treatment requirements. Implementability of different treatment technologies and processes is affected by the following factors: type of contamination; contaminant concentration; volume of contaminated groundwater; and flow rate of contaminated groundwater.

9.4.3 End Use

Following collection and treatment of contaminated groundwater, an appropriate and preferably beneficial end use of the treated water must be incorporated into the remedy. Methods may include reinjection into the aquifer, transfer to a municipal water supply system, discharge to a POTW, application to the ground surface or discharge to a river or drainage channel. For treatment methods that do not destroy the contaminants removed from the water, consideration must be given for final end use of this material as well.