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Revision 0

Draft

Perched Water System Remedial Investigation/ Feasibility Study for the Test Reactor Area of the Idaho National Engineering Laboratory (Operable Unit 2-12) Volume 2 of 4

S. M. Lewis
P. O. Sinton
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J. W. Gordon

EG&G Idaho

Work performed under DOE Contract No. DE-AC07-76ID01570

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EXECUTIVE SUMMARY

This document presents the Feasibility Study (FS) for the Perched Water System (PWS) Operable Unit (PWS OU) at the Test Reactor Area (TRA) of the Idaho National Engineering Laboratory (INEL). The FS is the second volume of the Remedial Investigation/Feasibility Study (RI/FS) report for the PWS OU. The RI/FS was prepared in accordance with the *Federal Facilities Agreement/Consent Order* for the Idaho National Engineering Laboratory (Administrative Docket No. 1088-06-29-120) between the U. S. Environmental Protection Agency (EPA), the U. S. Department of Energy (DOE), and the State of Idaho using the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (55 Federal Register 8666) (CFR) Part 300 *et seq.*

EPA issued a final rule placing INEL on the National Priorities List (NPL) in the Federal Register on November 21, 1989 (54 Federal Register 44184). DOE, EPA, and the State of Idaho decided the TRA warm waste pond would be remediated through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1990, DOE, EPA, and the Idaho Department of Health and Welfare (IDHW) began negotiating an Interagency Agreement Action Plan to apply the CERCLA process, under requirements of the NCP, for the remedial effort at INEL. The action plan identifies 13 OUs within the TRA Waste Area Group 2 (WAG 2) that would be remediated through the CERCLA process. The PWS was identified as OU 2-12.

CERCLA requirements have been integrated with the National Environmental Policy Act (NEPA) for environmental restoration activities at DOE sites. The DOE Order complies with the Secretary of Energy's Notice ([SEN]-15-90) and the General Counsel of the Council on Environmental Quality's statement (CEQ 1990). Integrating requirements of NEPA into the CERCLA process is straightforward since the evaluation criteria used under CERCLA are similar in nature to the NEPA requirements. Specifically, evaluation of potential environmental impacts is performed in the analysis of the long-term effectiveness and permanence and the short-term effectiveness of each proposed alternative. The analyses address both long- and short-term consequences of operational and/or construction impacts associated with candidate remedial alternatives.

The FS process for this OU has entailed an initial screening of technologies and process options for remediation of the shallow and deep perched water zones beneath TRA. The initial screening resulted in the selection of representative process options to be considered in the development of remedial action alternatives.

DOE, through EG&G, Idaho, Inc., developed remedial action alternatives using the representative process options that remained after the screening phase of the feasibility study. The four alternatives developed for study were (1) No Action; (2) Physical/Chemical Ground-Water Treatment; (3) Evaporative Ground-Water Treatment; and, (4) Source Control. The FS evaluates these four alternatives in meeting the remedial action objectives established for this OU as well as the other evaluation criteria required to be analyzed under CERCLA.

During the detailed analysis, the alternatives were evaluated for overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence; reduction of toxicity, mobility, or volume, short-term effectiveness; implementability; and cost. The results of the evaluation are as follows:

- All the proposed alternatives will meet the objectives of protection of public health and the environment by the year 2116.
- The Health Risk Assessment (HRA) shows that the risks to public health from the ground water beneath the TRA by the year 2116 are predicted to be at or below an excess cancer risk of 10^{-6} for all alternatives.

- All the alternatives would comply with the ARARs, and in particular the chemical-specific primary drinking water standards, by the year 2116.

- The comparison of alternatives demonstrates that the No Action alternative would provide adequate protection to public health by the year 2116 at a reduced cost and with less impact to the environment as compared to the other alternatives.

The Physical/Chemical Ground Water Treatment alternative and the Evaporative Ground-Water Treatment alternative may achieve the chemical-specific ARARs sooner and may achieve a long-term reduction in public health risks sooner than the No Action or the Source Control alternatives. However, there are short-term public health risks and environmental impacts that may be created by implementating either of these two treatment alternatives.

The relative net present worth cost of the Physical/Chemical Ground Water Treatment alternative is $6.2 million. The relative cost of the evaporative Ground-Water Treatment alternative is $43.4 million. The relative cost of the Source Control alternative is $22.0 million. Each of these net present worth costs were calculated at a 5% discount rate.

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ACRONYMS

AEC	U. S. Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
ATR	Advanced Test Reactor
BLS	below land surface
CEC	cation exchange capacity
CEDE	committed effective dose equivalient
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COCA	Consent Order and Compliance Agreement
COC	contaminant of concern
DOE	U. S. Department of Energy
EPA	Environmental Protection Agency
EPHA	Environmental Protection and Health Act
ESRP	Eastern Snake River Plain
FFA/CO	Federal Facility Agreement and Consent Order
FML	flexible membrane liner
FY	fiscal year
GRA	general response action
HRA	Health Risk Assessment
IAG	Interagency Agreement
IDAPA	Idaho Air Pollution Act
IDHW	Idaho Department of Health and Welfare
INEL	Idaho National Engineering Laboratory
LDR	land disposal regulations
LD50	lethal dose 50
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MF	Microfiltration

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEP	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NPDES	National Pollutant Discharge and Elimination System
O&M	operating and maintenance
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
POTWs	publicly owned treatment works
PPE	personal protective equipment
PWS	Perched Water System
PVC	polyvinyl chloride
RA	risk assessment
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act
redox	oxidation/reduction
RfD	reference dose
RI/FS	Remedial Investigation/Feasibility Study
RO	reverse osmosis
RWMC	Radioactive Waste Management Complex
SEN	Secretary of Energy Notice
SRPA	Snake River Plain Aquifer
TBC	to be considered
TRA	Test Reactor Area
UF	Ultrafiltration
USGS	U. S. Geological Survey
WAG	Waste Area Group

1. Introduction

1. INTRODUCTION

Volume II of the Draft Remedial Investigation/Feasibility Study (RI/FS) presents the Feasibility Study for the Perched Water System (PWS) Operable Unit (OU) at the Test Reactor Area (TRA) of the Idaho National Engineering Laboratory (INEL). Work was performed in accordance with the *Federal Facility Agreement and Consent Order* (FFA/CO) between the U. S. Environmental Protection Agency (EPA), the U. S. Department of Energy (DOE), and the State of Idaho using the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under (Comprehensive environmental Response Compensation and Liability Act) CERCLA* (EPA 1988), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), (40 Code of Federal Regulations (CFR) 300 *et seq.* and Federal Register [March 8, 1990]). The FFA/CO was developed for INEL.

EPA proposed listing INEL on the National Priorities List (NPL) of the NCP on July 14, 1989 (54 Federal Register 29820) based on the NCP hazard ranking system. EPA issued a final rule listing INEL as an NPL site in the Federal Register on November 21, 1989 (54 Federal Register 44184).

DOE, EPA, and the State of Idaho decided the TRA warm waste pond would be remediated through CERCLA, which supersedes existing Resource Conservation and Recovery Act (RCRA)-driven Consent Order and Compliance Agreement (COCA) requirements. In March 1990, the *Phase I Draft Remedial Investigation/Feasibility Study Work Plan and Addendums for the Warm Waste Pond Operable Unit at the Test Reactor Area of the Idaho National Engineering Laboratory* (Van Deusen and Trout 1990) was developed as part of the RI/FS process. During preparation of the Phase I RI/FS Work Plan (Van Deusen and Trout 1990), DOE, EPA, and the Idaho Department of Health and Welfare (IDHW) began negotiating an Interagency Agreement Action Plan to apply the CERCLA process, under requirements of the NCP, to the remedial effort at INEL. The action plan identifies 13 OUs within the TRA Waste Area Group (WAG-2) that would be remediated through the CERCLA process. The PWS was identified as OU 2-12.

1.1 Report Purpose and Format

The FS report provides a comprehensive evaluation of potential remedial action alternatives for the PWS OU. The FS process presented in this report consists of three phases: (a) a summary of the identification and screening of technologies and associated process options identified during the first phase of the FS, (b) a description of candidate remedial alternatives developed from the screened list of treatment technologies, and (c) a detailed analysis of candidate remedial alternatives. Figure 1-1 shows a schematic flow diagram for the FS process. The detailed analysis represents a qualitative evaluation of the remedial alternatives, and where applicable, a quantitative evaluation using readily available information on the various process options. Treatability testing was not conducted as part of the RI/FS; therefore, specific treatability data were not available for the various treatment technologies. Assumptions used for the FS analysis are documented in the text.

The first phase of the FS as described in Section 2

- Identifies remedial action objectives (RAOs)
- Identifies general response actions (GRAs) that satisfy the RAOs
- Identifies and preliminarily screens potential remedial technologies
- Evaluates institutional controls
- Identifies and screens potentially applicable process options for each treatment technology type.

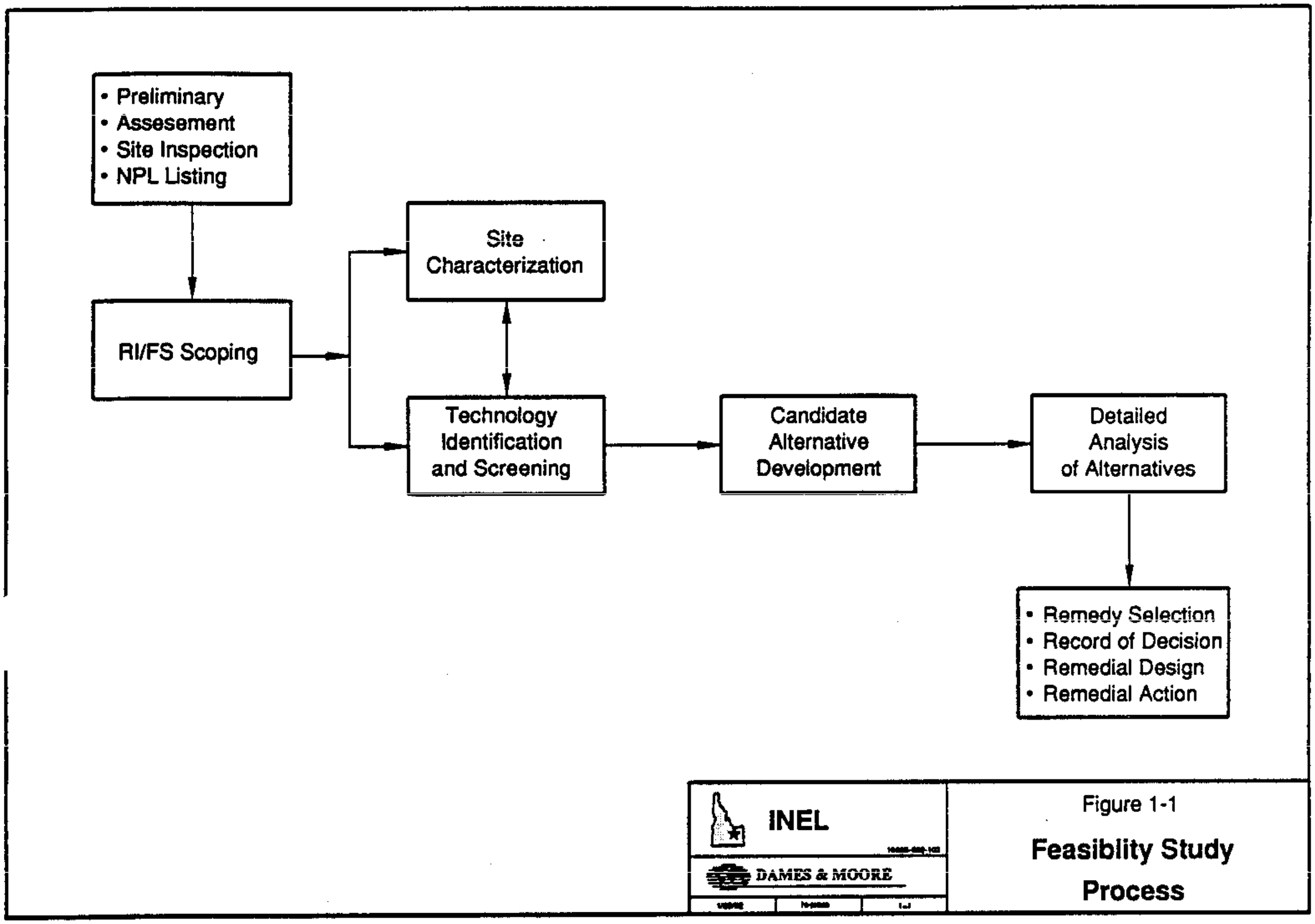


Figure 1-1. FS Process Schematic.

The second phase of the FS as described in Section 3 assembles the technologies into candidate remedial alternatives based on technologies that passed the initial FS screening phase. The final phase of the FS as described in Section 4 contains the detailed analysis of each screened remedial alternative. This analysis is based on the nine CERCLA evaluation criteria established in the NCP. The nine CERCLA evaluation criteria are

- Overall protection of human health and the environment
- Compliance with applicable and relevant or appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Analysis of each of the criteria except State and community acceptance are presented in this Draft RI/FS report. State and community acceptance will be performed after the public comment period on the Final Draft RI/FS. A preferred remedial alternative will be identified and presented in the Proposed Plan. The Draft Proposed Plan and RI/FS documents will be available to the public upon their submittal to EPA for review.

1.2 Remedial Investigation Summary

1.2.1 Site History and Description

INEL was established in 1949 by the U.S. Atomic Energy Commission (AEC) to build, operate, and test various nuclear reactors, fuel processing plants, and support facilities. To date, 52 reactors have been constructed, of which 13 are still operable. INEL also supports other government-sponsored projects, including energy, defense, and environmental and ecological research.

The eastern boundary of INEL is located 32 miles west of Idaho Falls, Idaho. The Site occupies 890 square miles of the northwestern portion of the Eastern Snake River Plain (ESRP) (Figures 1-2 and 1-3). INEL is bounded on the northwest by three major mountain ranges: Lost River, Lemhi, and Beaverhead. The remainder of INEL is bounded by parts of the ESRP (Bowman et al. 1984).

TRA was established in the early 1950s in the southwestern portion of INEL, north of the Big Lost River and approximately 47 miles west of Idaho Falls (Figure 1-3). The facility houses high neutron flux nuclear test reactors. Three major reactors have been built at TRA: the Materials Test Reactor, the Engineering Test Reactor, and the Advanced Test Reactor (ATR). Only ATR is operational today. More than 73 buildings and 56 structures have been constructed at TRA, providing four major types of functional support: reactor, laboratory, office, and crafts.

Chemical and radioactive wastes are generated from scientific and engineering research at TRA. Although these wastes are subject to treatment, the resulting wastes still contain low-level radioactive and chemical substances. As originally designed and installed, two separate waste streams were used at TRA, one for sanitary sewage and the other for all other

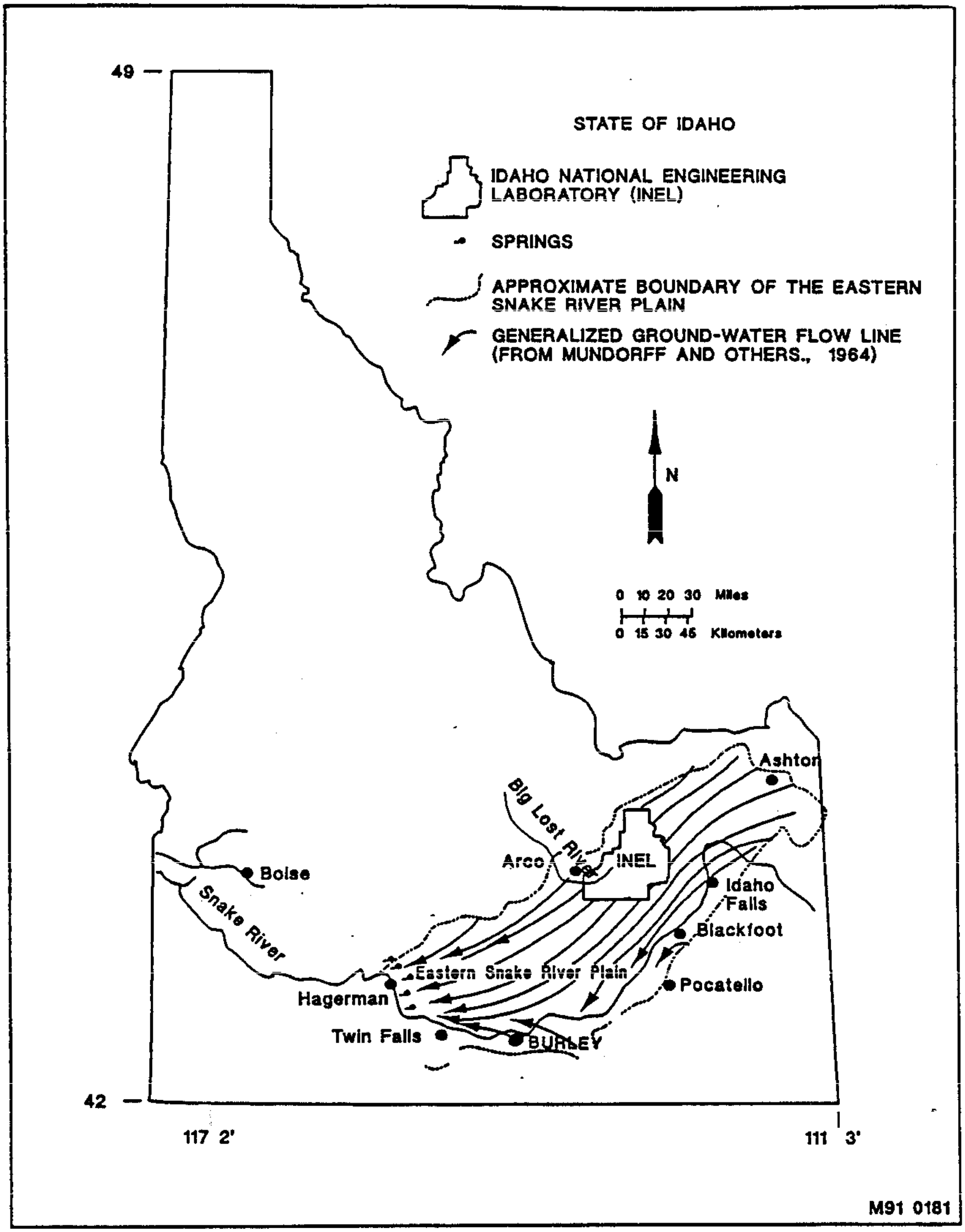
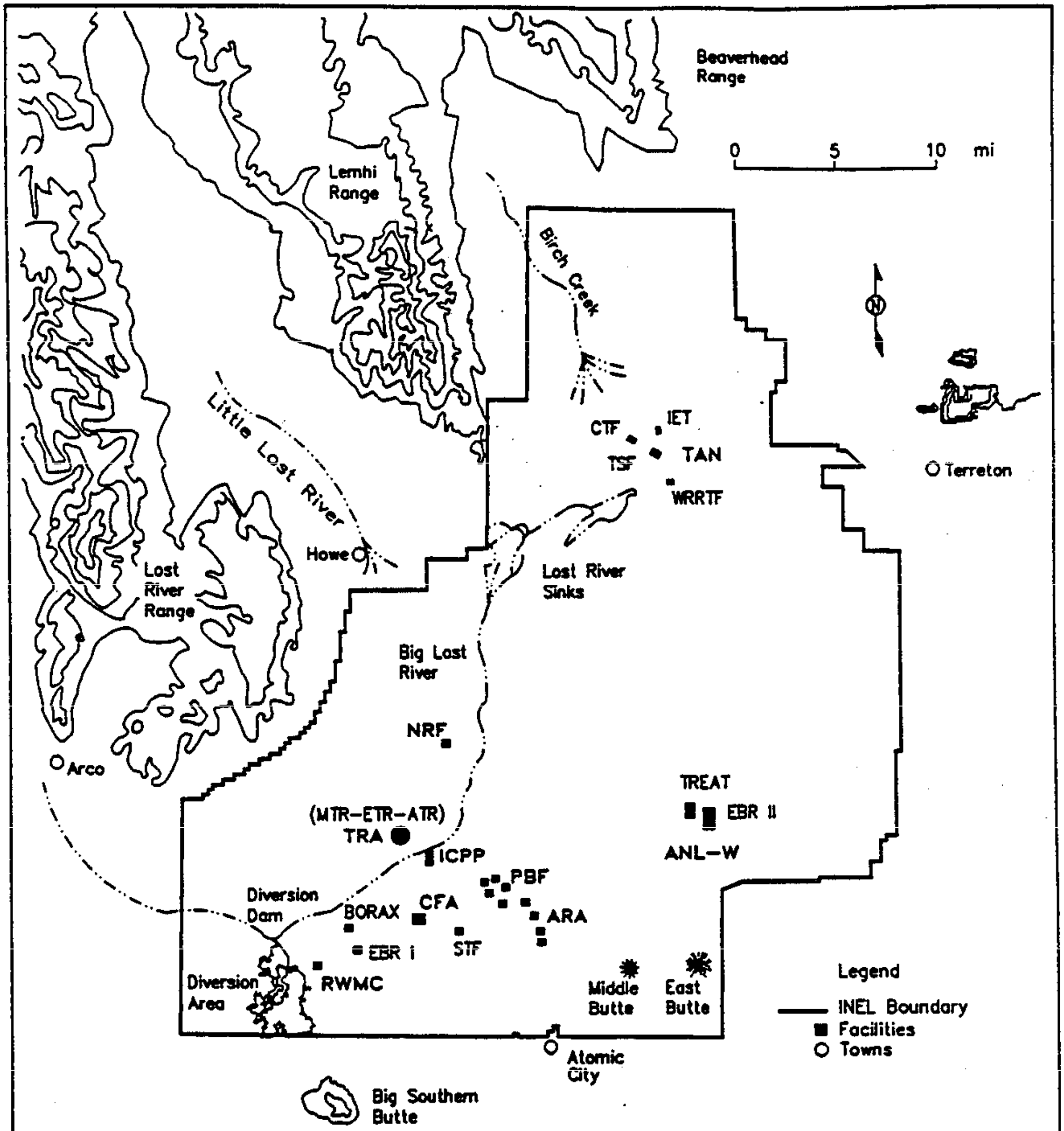


Figure 1-2. Map of Idaho showing the location of INEL, Snake River Plain, and generalized ground-water flow lines of the Snake River Plain Aquifer (Hull 1989).



ATR	Advanced Test Reactor	MTR	Materials Testing Reactor
ARA	Auxiliary Reactor Area	NRF	Naval Reactor Facility
ANL–W	Argonne National Laboratory–West	PBF	Power Burst Facility
CFA	Central Facilities Area	RWMC	Radioactive Waste Management Complex
CTF	Contained Test Facility	STF	Security Training Facility
ETR	Engineering Test Reactor	TAN	Test Area North
EBR–I	Experimental Breeder Reactor I	TRA	Test Reactor Area
EBR–II	Experimental Breeder Reactor II	TREAT	Transient Reactor Test (Facility)
ICPP	Idaho Chemical Processing Plant	TSF	Technical Support Facility
IET	Initial Engine Test	WRRTF	Water Reactor Research Test Facility

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Figure 1-3. Map of INEL, its principal sites, and surrounding area.

waste streams. Over the years, additional segregation of waste streams has occurred as methods of disposing of the waste streams evolved. Figure 1-4 shows the major historical disposal locations for the waste: the retention basin, ingestion well, chemical waste pond, sanitary waste pond, warm waste pond, Well U. S. Geological Survey (USGS)-53, and the cold waste pond.

Water discharged to unlined surface ponds at TRA percolates downward through the surficial alluvium and underlying basalts. A resulting shallow perched water zone has formed on the interface between the surficial sediments and the underlying basalts. Downward movement of ground water is again impeded by a low permeability layer of silt, clay, and sand encountered at a depth of about 150 feet. The deep perched water zone occurs on top of this low permeability interbed.

Ground-water investigations in the vicinity of TRA have been conducted since 1949 to characterize the chemical water quality. These investigations, and a brief description of each, are summarized in Table 1-1 of the RI.

1.2.1.1 Geology. INEL is located along the northern edge of the ESRP, a 50- to 70-mile-wide northeastern trending basin extending from the vicinity of Twin Falls on the southwest to the Yellowstone Plateau on the Northeast. The ESRP is underlain by a substantial volume of silicic and basaltic volcanic rocks with relatively minor sediment, except along its margins where drainages emerge from the neighboring highlands (Leeman and Whelan 1983). The Little and Big Lost Rivers as well as Birch Creek drain onto INEL from broad alluvium-filled valleys from the west and the north (Figure 1-3).

TRA is underlain by surficial alluvium deposited by the Big Lost River. The alluvium was deposited on uneven basalt flow surfaces and varies from about 32 to 55 feet in thickness. The alluvial sediments are primarily composed of sandy gravels with minor amounts of silt and clay. Fine grained sediments (silt and clay) are more prevalent in depressions in the basalt surface at the base of the alluvium.

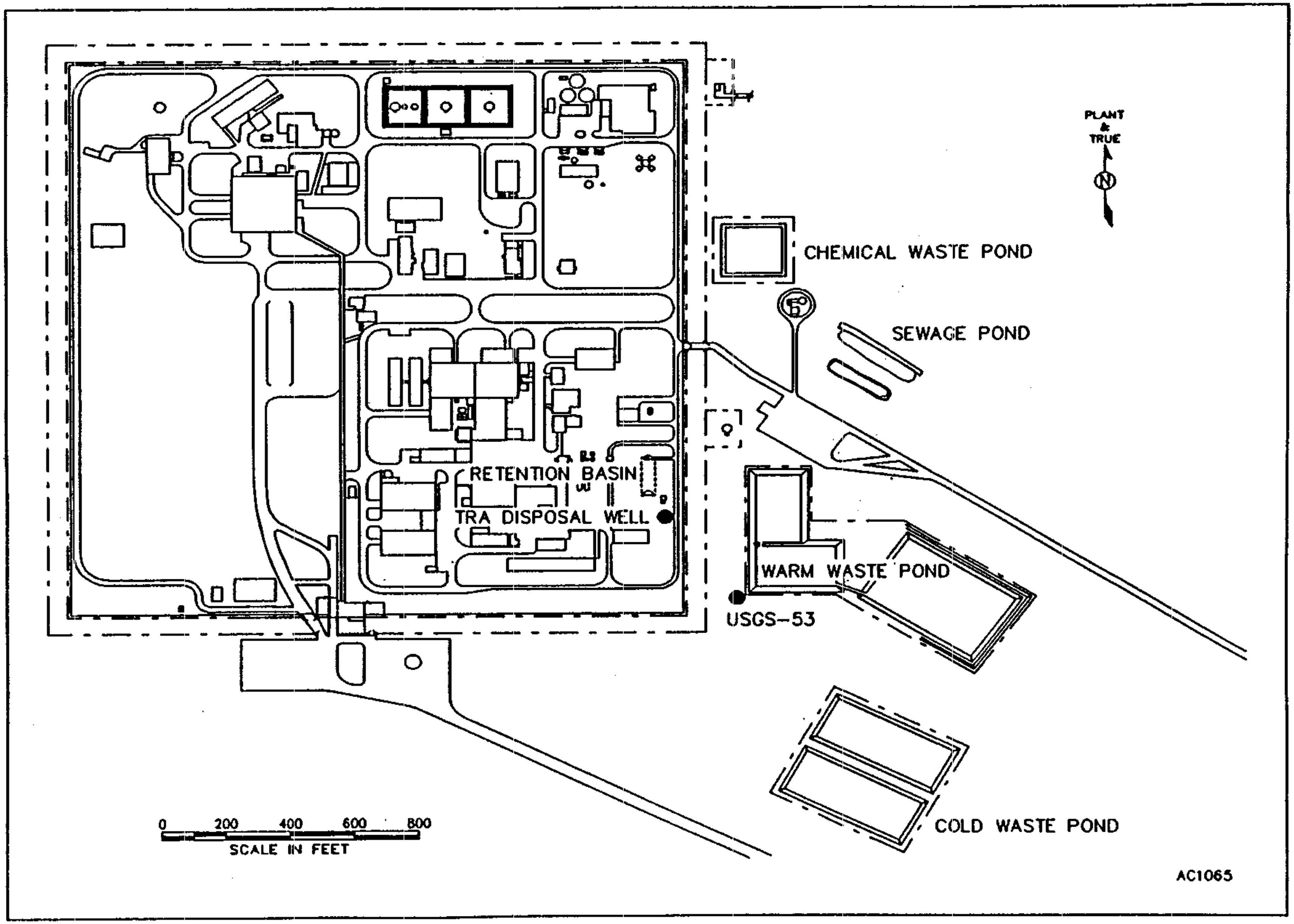

Figure 1-4. Figure showing TRA wastewater disposal pond locations.

The surficial alluvium is underlain by a thick sequence of Tertiary and Quaternary volcanic rocks and lesser sedimentary interbeds to a depth of more than 10,000 feet. Volcanic rocks in this sequence consist mainly of basaltic lava flows, ash, and cinders in the upper part, and rhyolitic ash flows and tuffs in the lower part (Anderson 1991). Basalt flows below the ESRP have erupted from local vents and fissures and individual flows cover relatively small areas.

The most prominent interbed sequence encountered in the vadose zone beneath TRA occurs between depths of about 140 to 200 feet below land surface (BLS) (Kuntz 1978). This sequence is composed of interbedded basalts and sediments including sand, silt, and clay with minor amounts of gravel. In most wells drilled in the vicinity of TRA, the interbed sequence consists of upper and lower sedimentary layers separated by basalt (Figures 3-11 and 3-12 in the RI).

Core samples from interbed sediments exhibited total porosities ranging from 20.4 to 54.8% and saturated vertical hydraulic conductivities ranging from 0.0000482 to 3.97 feet/day (Doornbos et al. 1991). Field-scale hydraulic conductivities, which are considered to be representative of horizontal conductivity of the basalt-sediment interbed sequence, were slightly higher, ranging from 0.00518 to 17.3 feet/day. The high percentage of fine-grained sediments in the basalt-interbed sequence provided sufficient hydraulic conductivity contrasts to cause the deep perched water zone in the overlying basalt.

1.2.1.2 Hydrogeology. Most of INEL is located in a topographically closed drainage basin, referred to as the Pioneer Basin, into which the Big Lost River, Little Lost River, and Birch Creek periodically drain (Bennett 1990). Today, most of the water flowing in these streams is diverted upstream of INEL for irrigation purposes.

The Big Lost River is the principal surface-water feature on INEL and is the closest major drainage to TRA. A discussion of annual discharge rates for the Big Lost River near TRA is given in Section 3 (see Figure 3-46) of the RI. Several storage and diversion systems exist on the Big Lost River. The Mackay Reservoir is located about 30 miles upstream of Arco, Idaho, and has a storage capacity of 44,500 acre-feet (Van Haaften et al. 1984). INEL flood diversion system was constructed in 1958 to protect INEL from potential flooding of the Big Lost River. This system uses a low dam to divert river flow into a series of spreading areas located in the southwestern portion of INEL. The capacity of the diversion system was increased to 9,300 cubic feet per second (cfs) in 1984 (Bennett 1986).

Perched ground water is unconfined and occurs when downward flow to the aquifer is impeded by fine sediments and/or dense basalt flows having relatively low permeability (Nace et al. 1959). The presence of perched water at TRA is directly related to infiltration from disposal ponds. Two distinct perched water zones, shallow and deep, have been recognized at TRA (Morris et al. 1964; Morris et al. 1965; Barraclough et al. 1967a; Barraclough and Jensen 1976; Barraclough et al. 1982; Lewis and Jensen 1984; Pittman et al. 1988). The shallow perched ground water occurs in the immediate vicinity of the ponds and retention basin, and forms on the interface between the surficial alluvium and the underlying basalts at about 50 feet BLS.

The deep perched ground water is caused by low-permeability sediments within the interbedded basalt-sediment sequence at depths of about 140 to 200 feet BLS. The interbed sequence includes silt, clay, sand, cinders, and gravel. The sequence appears to be laterally continuous in the vicinity of TRA and is about 300 feet above the Snake River Plain Aquifer (SRPA).

The water levels in the deep perched monitoring wells and the areal extent of the deep perched ground water have fluctuated in response to the volume of water discharged to the surface ponds. During March 1991, the areal extent of the deep perched ground water was about 6,000 feet $\times$ 3,000 feet, and the maximum saturated thickness was about 150 feet. The volume of deep perched ground water was calculated to be 1.4×10^9 gallons.

The SRPA exists beneath INEL and is about 200 miles long and 50 to 70 miles wide. The SRPA covers about 10,000 square miles and extends from Ashton, Idaho on the northeast to Hagerman, Idaho on the southwest (Figure 1-1) (Hull 1989). The aquifer consists of a series of basalt flows with interbedded sedimentary deposits and pyroclastic materials. Ground water in the SRPA is generally under unconfined conditions. Recharge to the aquifer is primarily by valley underflow from the mountains to the north and northeast of the plain, and from infiltration of irrigation water. Recharge to the aquifer within INEL boundaries is primarily by underflow from the northeastern portion of the plain and from the Big Lost River.

Site-wide water-level data compiled in July 1985 showed that the general direction of ground-water flow across INEL was toward the south-southwest at an average gradient of about 4 feet/mile (Pittman et al. 1988). The depth to the water table varied from about 200 feet BLS in the northern portion of INEL to about 900 feet BLS in the southern portion. At TRA, the depth to ground water is about 460 feet BLS and the gradient is about 2 feet/mile. Previous studies have estimated horizontal ground-water flow rates in the SRPA varying from 5 to 25 feet/day (Robertson et al. 1974).

1.2.2 Nature and Extent of Contamination

The liquid waste effluents currently generated at TRA consist of radiologically warm, cold, and hot waste streams, in addition to chemical and sanitary sewage waste streams. These waste products, except for the hot waste, are discharged to a series of wastewater ponds located outside the TRA perimeter fence. During the period of record from 1962 to 1990, a total of 6,770 million gallons of water were discharged from the waste streams to the vadose zone at TRA (Doornbos et al. 1991). Discharge volumes to the vadose zone at TRA remained near 200 to 300 million gallons/year except for a three-year period from 1979 to 1981 when discharge volumes were only 70 to 100 million gallons/year.

Water level elevations and areal extent of the deep perched ground water fluctuate in response to the volume of water being discharged to the surface ponds. Water movement in the deep perched ground-water zone is lateral as well as vertical. Lateral spreading continues until a sufficient area is covered to vertically transmit the available water downward through the perching layer. The size of the deep perched ground-water zone has remained fairly uniform over the years except between 1979 to 1981 when the size of the deep perched ground-water zone greatly decreased because of decreased discharge to the surface ponds. The extent of the deep perched zone is shown in Figure 1-5. With an increased discharge to the surface ponds since 1982, the deep perched ground water zone has returned to its previous size. The areal extent of the deep perched ground water was about 6,000 feet by 3,000 feet in March 1991. The maximum saturated thickness is estimated to be about 150 feet. The amount of water contained in the deep perched zone is calculated at 1.04×10^9 million gallons (Doornbos et al. 1991).

The chemical composition of the water discharged to the ponds has varied over the years. Prior to 1962, all wastewater generated at TRA, except sanitary sewage, was discharged directly to the warm waste pond. From 1952 to 1962, radionuclides, water softener and ion exchange column regeneration fluids, reactor cooling water containing hexavalent chromium, and other miscellaneous wastes were all disposed to the warm waste pond. The regenerating fluids would have been high in dissolved salts (mainly sodium, chloride, and sulfate) and may have had wide fluctuations in pH if solutions were not mixed or neutralized prior to disposal. In 1962, the regeneration fluids were diverted to the chemical waste pond for disposal. Water used in the secondary reactor cooling system that contained hexavelent chromium was disposed to the warm waste pond from 1952 until November 1964, when the TRA disposal well was used to dispose of this waste. After 1972, hexavalent chromium was no longer used at TRA as a corrosion inhibitor and no longer discharged to the disposal well. The warm waste pond is currently used to dispose of water containing only radioactive wastes.

Most of the radionuclides and toxic metal contaminants disposed into the pond are

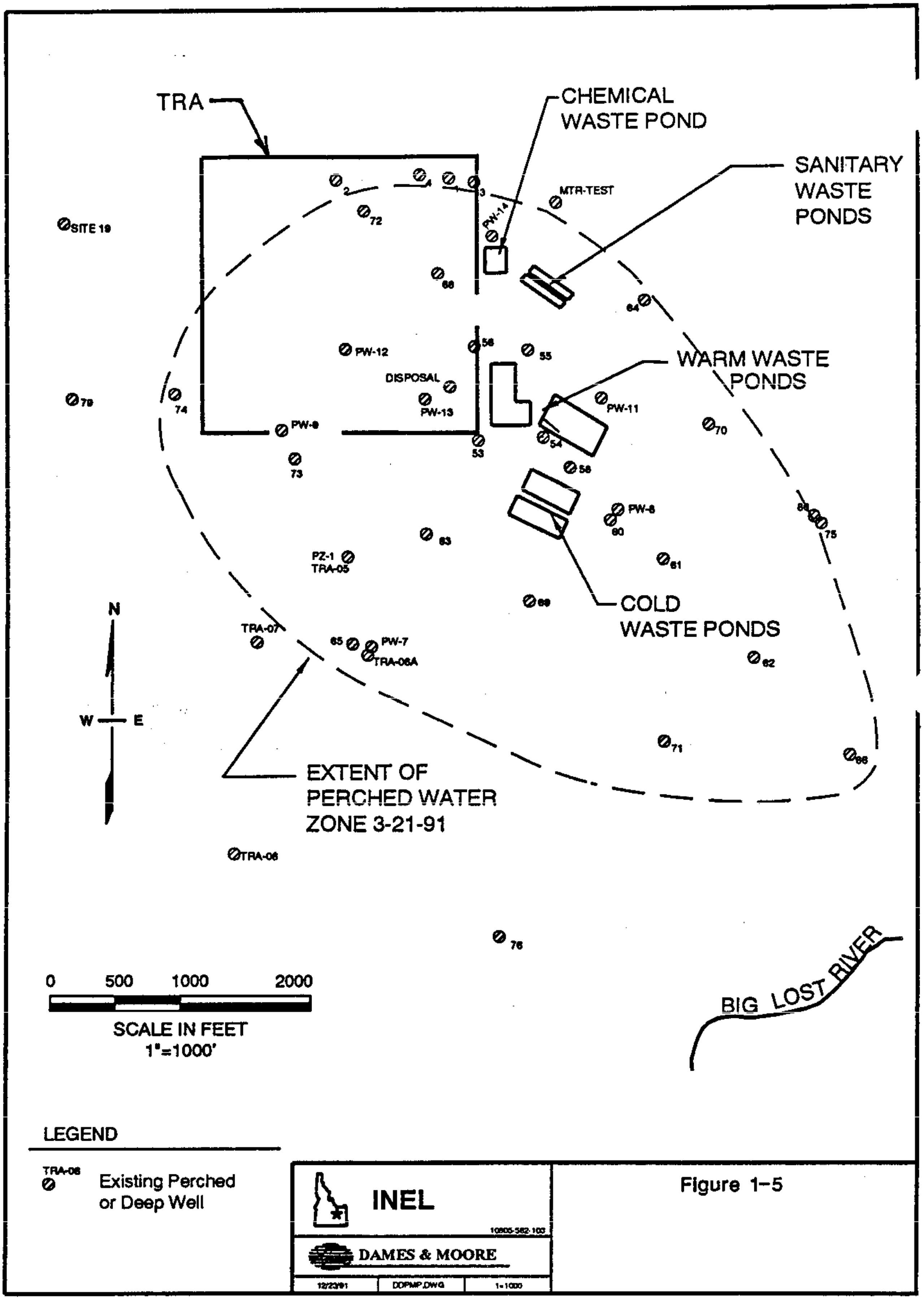

Figure 1-5. Deep Perched Ground Water Extent.

readily absorbed by clays in the upper 2 feet of the sediments beneath the pond. Strontium-90 was probably originally retained by the sediments but has now migrated into the PWS (Schmalz 1972). The metals and other radionuclides are retained in the warm waste pond sediments by interactions with organic materials. Based on the 1988 and 1990 sampling events at the warm waste pond, approximately two-thirds of the total mass of contaminants disposed to the warm waste pond are in the upper 2 feet of the pond sediments. However, tritium has not been retained.

The RI focused on identifying contaminants of concern (COCs) for assessing fate and transport and on conducting the Health Risk Assessment (HRA). The COCs for the PWS are tritium, fluoride, chromium, cadmium, manganese, cobalt, cobalt-60, americium-241, arsenic, beryllium, lead, strontium-90, and cesium-137. Section 4 of the RI describes the COCs detected in the shallow and deep perched water systems in relation to appropriate standards and background concentrations. A detailed summary of the substances detected in the PWS is also provided in the RI.

1.2.3 Fate and Transport

Contaminant fate and transport is discussed in greater detail in Section 5 of the RI, and is summarized here for review. The focus of the fate and transport assessment for the COCs is on the migration of contaminants from the TRA waste water ponds to the deep perched water system and from the deep perched water system to the SRPA. Most of the water that is discharged to the TRA waste ponds infiltrates into the subsurface. The overall sequence of the movement of water and contaminants in the subsurface is

$$\text{Ponds} \rightarrow \text{SPWZ} \rightarrow \text{DPWZ} \rightarrow \text{SRPA}$$

where SPWZ designates the shallow perched water zone and DPWZ designates the deep perched water zone. This sequence is the ground-water migration pathway.

Water discharged to the waste water ponds enters the surficial alluvium that typically consists of sandy gravels with minor amounts of silt and clay-size material. Laboratory hydraulic conductivities for the alluvial material ranged from 1.28 $\times 10^{-5}$ to 59.5 feet/day, and the cation exchange capacity (CEC) ranged from 3 to 26 meq/100 g. Water from the ponds moves downward through this material to the sediment-basalt interface at about 35 to 50 feet BLS. This interface is a low-permeability layer caused by finer-grained sediments clogging the openings in the basalt, which creates a shallow perched ground-water zone in the immediate vicinity of the ponds and the retention basin. The presence of a fine-grained layer on top of the basalt is probably not laterally continuous. As previously noted, vertical flow rates through the alluvium are on the order of 2 feet/day.

Water continues to move downward through the underlying basalts until encountering a second layer of low permeability at a depth of about 140 to 200 feet BLS. The SRPA is encountered at a minimum of approximately 450 feet BLS at the site. This low permeability layer, composed of basalts and interbedded sediments, appears to be laterally continuous throughout TRA and creates the deep perched ground-water zone. The composition of the sedimentary interbed is highly variable and includes silt, clay, sand, and cinders. Interbed sediment samples collected from this layer exhibited total porosities ranging from 20.4% to 54.8% and saturated hydraulic conductivities ranging from 0.0000482 to 3.97 feet/day. Field-scale hydraulic conductivities of this basalt-interbed sequence ranged from 0.00518 to 17.3 feet/day.

Once through the basalt-interbed perching layer, water moves downward through a 300-foot sequence of basalts and thin sedimentary interbeds to recharge the SRPA. The downward seepage rate is controlled by the release of water from the perching layer. Once in the SRPA, flow is to the south-southwest at a rate of approximately 4.3 feet/day.

The primary processes that affect the transport and fate of the COCs are infiltration of contaminated wastewater, advection, hydrodynamic dispersion, adsorption, radioactive decay, and other geochemical reactions.

Contaminants are introduced into the environment by infiltration of contaminated water from the ponds. Therefore, the concentration of a contaminant and the rate at which contaminated water infiltrates into the surficial materials has a direct effect on contaminant concentrations in the shallow perched water zone, deep perched water zone, and SRPA.

Advection is the process by which contaminants are carried with infiltrating waste water through the surficial sediments, basalt, and interbeds. With advective transport, contaminants are carried by the ground water at the same rate at which the ground water is moving and in the same direction. Advective transport is a function of hydraulic conductivity, porosity, and hydraulic gradient. Advection is the primary method by which contaminants migrate from the ponds to the SRPA.

Hydrodynamic dispersion is the process by which contaminants are dispersed away from the main body of a plume of contamination. One component, mechanical dispersion, is caused by variations in the velocity of ground water as it moves through pores and pore throats of varying size. The other component, chemical dispersion, is caused by chemical gradients. A chemical gradient is defined as a difference in concentrations of a given chemical at a specific boundary (e.g., at a solid/water interface). Chemicals tend to disperse from an area of higher to lower concentrations across such a boundary. Dispersion occurs both in the direction of flow and transverse to the direction of flow.

Dispersion in the unsaturated zone beneath TRA and in the perched zones does not cause dilution of contaminants as they move downward or as they spread laterally. The primary direction of dispersion in the unsaturated zone is vertical because of vertical hydraulic gradients and vertical fracturing in basalt. Dilution of contaminants is primarily caused beneath the Site by the mixing of water in the deep perched water zone with water from the cold waste pond, other water leakages and recharge from precipitation events. Dilution because of dispersion also occurs in the SRPA where water from the PWS mixes with SRPA water.

Sorption is the process by which contaminants adsorb onto or desorb off of sediments and rock. Adsorption provides for a contaminant sink; thus, sediments that are contaminated can provide a secondary source of contaminants in ground water. The adsorption distribution coefficient (K_d) is the parameter typically used to characterize adsorption and desorption. The K_d is related to a chemical concentration in water and on the soil. Adsorption retards the rate of movement of a contaminant and decreases the concentration of a contaminant in solution by removing the contaminant from solution. The larger the value of K_d the more a contaminant is retarded and attenuated. As shown in Table 5-1 of the RI, the relative mobility of the contaminants of concern, in order of most mobile to least mobile is as follows:

$$H,F > CrO_4^{2} > Cd > Sr > Mn,Co > Am > As > Be, Pb > Cs$$

A two-dimensional numerical ground-water flow and contaminant transport model was developed to characterize the flow and migration of contaminants between the ponds and the SRPA. The computer code TARGET (Dames & Moore 1985) was used to simulate the flow of ground water and the transport of contaminants. The rationale used to select TARGET is documented in Dames & Moore (1991). The specific computer code is called TARGET-2DU, (TARGET, Two-Dimensional, Unsaturated) Version 4.3. This code is documented in Dames & Moore (1985). The model was first calibrated for this modeling effort to historic water levels in wells and to historic concentrations of tritium and chromium in the deep perched water zone and the SRPA. The model was then used to predict the concentrations of the 14 COCs through time, to a point 125 years in the future that represents a future use scenario for the Site.

Figures 5-33 through 5-44 in the RI report show the predicted maximum concentrations of the COCs from 1952 to 2115 in the SRPA. These concentrations are for the upper 12.5 feet of the SRPA beneath the TRA. These are the ground-water concentrations used in the HRA. The COCs that are predicted through the modeling to attain peak concentration in the SRPA over the next 125 years are strontium-90, cadmium, chromium, and tritium. The remaining COCs are retarded to the extent that they are predicted not to attain peak concentration over the next 125 years.

1.2.4 Health Risk Assessment

1.2.4.1 Human Health Risk Assessment. The purpose of an HRA is to estimate present and future risks to human health and the environment. This estimation is necessary because direct measurement of the effects from very low levels of chemical exposure may not be possible. It represents an approximation of actual exposures, resulting in some uncertainty about the risk predicted to be associated with an activity. Data specifically addressing factors contributing to those risks frequently are not available. Consequently, these data gaps must be bridged using assumptions. The use of health-conservative assumptions is one approach to addressing uncertainty in the predicted risks. Use of health-conservative methods results in estimated levels of health risk that are greater than those that would actually be experienced as a result of exposure to potential contaminants at the Site.

The scope of the HRA presented in the RI report was limited to the evaluation of health risks directly attributable to COCs currently detected in the PWS and the migration of those COCs through the environment in the future.

The steps involved in the PWS HRA are as follows:

- Hazard identification, or selection of COCs, which are the chemicals of greatest health concern (i.e., the most toxic, mobile, persistent, or prevalent of those detected) from among the entire set of potential contaminants detected at the Site

- Exposure assessment, which involves the identification of potentially exposed populations, sources and pathways of potential exposure, and estimation of exposures through those pathways

- Toxicity assessment, which involves estimating non-adverse effects levels and health criteria

- Risk characterization, which combines the results of the exposure and toxicity assessments to provide numerical estimates of health risks.

Analytical results from the PWS were screened using an iterative process to determine those substances that represent the most prevalent or toxic contaminants in the PWS. The initial screen compared the maximum detected concentration for each chemical analyzed against the background concentration for that chemical. Mean (arithmetic) background concentrations were calculated for each chemical from analytical data collected from production wells TRA-03 and TRA-04, and the Site 19 well. Those substances with concentrations above the calculated background concentrations were then carried over for further consideration and screening.

Chemicals remaining as COCs for the HRA after the screen against background were then subject to a concentration-toxicity screen and subsequent hazard ranking. Only those contaminants that contribute to greater than 1% risk were retained for the HRA. Radionuclides with less than a 5-year half-life were also eliminated at this juncture since they will decay to background before migrating to a receptor location.

The HRA process of hazard identification, exposure assessment, and toxicity assessment are detailed in Section 6 of the RI. Risk characterization is the process of combining the results of the exposure and toxicity assessments for the COCs from the hazard identification process. This process provides numerical quantification relative to the existence and magnitude of potential public health concerns related to contamination detected at the Site.

These numerical estimates of health risks were calculated for a future on-site resident/farmer scenario in which the following pathways were considered:

- Ingestion of water
- Ingestion of beef
- Ingestion of crops from backyard gardens

Risk calculations are divided into carcinogenic and noncarcinogenic categories. Calculation of health risks from potential exposure to carcinogenic compounds involves the multiplication of cancer slope factors for each carcinogen and the estimated intake values for that chemical. There is uncertainty and conservatism built into this approach; however, EPA has stated that cancer risks estimated by this method produce estimates that provide a rough but plausible upper limit of risk. Thus, it is not likely that the true risk would be more than the estimated risk and it could be considerably lower.

Noncarcinogenic risk is assessed by comparison of the estimated daily intake of a contaminant to its applicable reference dose (RfD). If the estimated daily intake for any single chemical is greater than its RfD, the hazard index will exceed unity. Results of the risk characterization process are summarized for the carcinogenic and noncarcinogenic contaminants for the PWS, and are given in Section 6 of the RI report.

The potential exposure to noncarcinogenic contaminants falls below the individual RfDs for each of the COCs. Noncarcinogenic hazard indices are presented in Tables 6-14 and 6-15 of the RI for adult and child exposures, respectively. The constituent at the Site that poses the greatest potential for adverse health effects is cadmium (hazard index = 0.17). Since the hazard index is much less than 1, chronic exposure to modeled concentrations of contaminants in the SRPA is unlikely to represent significant noncarcinogenic health effects to humans.

Lifetime cancer risks from potential exposure to each carcinogenic contaminant were added across the exposure pathways. Cancer risks from the different routes of exposure were assumed to be additive, as recommended by EPA guidance. It should be noted that adding cancer risks from different exposure routes provides health-protective risk estimates. The total excess cancer risk to the future on-site resident/farmer is shown in Tables 6-12 and 6-13 of the RI. This risk is dominated by the ingestion of tritium through the drinking water pathway. The total excess carcinogenic risk in year 125 was calculated to be 1.5×10^{-7}.

1.2.4.2 Ecological Risk Assessment. The ecological risk assessment is a qualitative evaluation of the potential ecological effects associated with the PWS. Although the organization roughly parallels the evaluation of human health, the ecological assessment performed here is qualitative in nature. It focuses on the same contaminants and receptor locations as those evaluated in the human health assessment. The objectives of the study are to qualitatively evaluate the potential risk to ecological receptors from the COCs in the PWS. Like the human health assessment, the discussion of impacts is limited to the PWS as the sole source of contamination. The assessment identifies sensitive nonhuman species and characterizes potential exposure pathways including ingestion of contaminated ground water or vegetation, and uptake by plants.

As described in Section 6 of the RI, no credible current exposure scenario exists. The future exposure scenario includes using contaminated ground water for irrigation, and contaminants entering the food chain, resulting in potentially complete exposure pathways throughout the ecological system.

The risk characterization combines the results of the ecological exposure assessment and toxicity assessment presented in Section 6 of the RI. Because INEL Site is located in sagebrush habitat and data for the associated wildlife have not been developed, all of the conclusions are significant extrapolations. The potential for adverse environmental impact of release of the COCs was based on worst case modeling and assuming ingestion of the contaminated water. In many cases, the potential impact appeared to be minimal and lethal dose 50 (LD50) values were used to the potential impacts. These may over or underestimate the impacts under long-term exposure. Field surveys of receptor populations and measurement of community structure and ecosystem functions would be necessary to more accurately assess the potential ecological impacts.

Although ecological receptors are currently present on the Site, contact with COCs is not possible under current Site conditions. The depth to the PWS and the absence of any resurfacing phenomena prevent contact with the COCs. Because no complete exposure pathways are identified in the present scenario, the COCs do not appear to pose a potential ecological risk.

Under a future scenario, it is plausible that ecological receptors could come into contact with COCs currently in the PWS as water from the SRPA is pumped to the surface for agricultural use. However, as shown in Figure 5-54 of the RI the PWS itself will not exist in 125 years since its source will have been terminated. In addition, chemical concentrations in pumped water will be diluted with water from the SRPA not associated with the Site. This agricultural water can provide a source of contact to ecological receptors for ingestion, and dermal contact with water and soil is possible as chemicals are deposited onto soil as a result of irrigation. In addition, plants can cache some of the chemicals of concern, and transfers between trophic levels are possible for some of the chemicals with longer biological half lives. However, the concentrations of the COCs in the PWS are not judged to pose a credible risk to ecological receptors.

1.2.4.3 Conclusions. Based on the nature and extent of contamination, fate and transport assessment, and risk assessment, the concentration of COCs detected in the PWS are not expected to cause adverse health effects to ecological receptors or members of the public under current or future land use scenarios. While the health effects calculated in the HRA are within EPA limits, only tritium and cadmium approached EPA's point of departure. If perched water were pumped to the surface, the potential exists for additional tritium exposure to humans and the environment if the water were allowed to evaporate. This potential risk was not quantified as part of the HRA.

2. Technology Identification

2. TECHNOLOGY IDENTIFICATION AND SCREENING

2.1 Introduction

The purpose of the PWS OU Feasibility Study is to identify and evaluate potential remedial options that eliminate, reduce, or control risks to human health and the environment to the extent necessary to select a remedy. To achieve this goal, CERCLA and NEPA require the development and evaluation of remedial alternatives to ensure that an appropriate remedy is selected. CERCLA requires that remedial alternatives be developed and screened in a process that meets remedial action objectives for the operable unit, identifies and evaluates potentially suitable technologies, (including innovative technologies), and assembles suitable technologies into alternative remedial actions. A detailed analysis is then conducted of these candidate remedial alternatives that represent viable approaches to remedial action.

Development and evaluation of alternatives must reflect the scope and complexity of the remedial action under consideration and the Site problems being addressed. The scope of the PWS OU is limited to the shallow and deep perched water zones only, and does not include the SRPA. The remedial action is not intended to address problems associated with other geographical areas at TRA or INEL. Rather, these issues will be addressed as part of other OUs.

2.2 Remedial Action Objectives for Ground Water

The following RAOs were developed for the PWS OU to be consistent with the goals of the NCP, to mitigate COC movement in the PWS to the SRPA, and to restore ground-water resources to meet potential ARARs throughout the TRA Site.

For purposes of the FS, the assumption was made that the PWS will dissipate during the 100 year institutional control period following TRA closure. In addition, the HRA was performed using a future use scenario, with predicted COC concentrations in the SRPA from the ground-water modeling efforts. The RAOs given below are intended to protect human health and to account for possible effects of COCs on other potential receptors. The feasibility of achieving these RAOs will be evaluated in the FS process. The RAOs identified for the PWS at TRA are:

- To prevent risks to human health that would result from residential/agricultural usage of SRPA water containing COCs in excess of MCLs, or that would constitute carcinogenic risks in excess of 10^{-4} to 10^{-6} or a non-carcinogenic hazard index of greater than 1.0.
- To prevent human ingestion or direct contact with the shallow or deep perched ground water located beneath the TRA site.

Based on results of the HRA presented in the RI, the RAOs identified here will be evaluated for the future use scenario. The future use scenario assumes an agricultural use of land at TRA by an onsite resident/farmer. Onsite use of water from the SRPA is assumed to occur in 125 years, which accounts for 25 years of continued operation at TRA followed by 100 years of institutional controls.

2.2.1 Contaminants of Concern

As previously mentioned, the COCs for the PWS OU have been identified in the RI portion of this document (see Table 6-4). The COCs are arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, fluoride, cobalt-60, cesium-137, americium-241, strontium-90, and tritium. A discussion of the process used in developing this COC list is given in the RI (Section 6).

2.2.2 Potential Applicable or Relevant and Appropriate Requirements

An initial list of potential ARARs for the candidate remedial action alternatives is the next step in the FS process. Identification of potential ARARs for the candidate remedial action alternatives is determined in part by the COCs, site-specific circumstances, and media of concern. The focus of the remedial action alternatives at TRA is the presence of the COCs in the PWS. Therefore, as an initial step in identifying chemical-specific ARARs to the situation at the PWS OU, the National Drinking Water Standards or maximum contaminant levels (MCLs) were identified as a potential ARAR. A review of the contaminant concentrations in the PWS (see Table 4-1) and the MCLs (Table 4-2) revealed that the contaminant concentrations in the PWS exceed most of the MCLs established by EPA (and adopted by the State).

Section 121(d)(2) of CERCLA provides a statutory basis for determining applicable or relevant and appropriate requirements (ARARs) in a remedial action context. With respect to any hazardous substance, pollutant, or contaminant that will remain on Site, Section 121(d)(2) of CERCLA states

> If any standard, requirement, criteria or limitation under any federal environmental law . . . or any [stringent] promulgated standard, requirement, criteria or limitation under a state environmental or facility siting law . . . is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance, pollutant or contaminant, the remedial action shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance, pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria or limitation. 42 U.S.C. § 9621(d)(2).

"Applicable requirements" are those

> Cleanup standards, standards of control, or other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant or contaminant 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.

According to the final NCP, 40 CFR § 300.5 and the Compliance with Other Laws Manual, p. 1-10,

> "Relevant and appropriate requirements" are those Cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, 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 so that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

2.2.2.1 Development of Potential ARARs. An initial list of potential ARARs was prepared by EG&G Idaho and submitted to DOE on June 4, 1991 (see memorandum in Appendix K). The initial list provided in the memorandum was further refined during the FS screening of ARARs and is shown in Table 2-1.

2.2.2.2 To-Be-Considered Criteria, Advisories or Guidance. A to-be-considered (TBC) list was prepared that identifies criteria, advisories, guidance, or policies that do not meet the definition of ARARs but may assist in determining what is protective when there is no ARAR for a specific substance or activity. The TBCs identified for the PWS OU are

- EPA Guidance Documents
- DOE orders
- Executive Orders
- New Clean Air Act amendments
- Contaminated ground water at Superfund site;
- New Federal pollution minimization laws for contaminated ground water at Superfund sites (October 1986)

Table 2-1. Potential Federal and State ARARs for the TRA Perched Water System.

Statute	Regulation
Federal chemical-specific ARARs for the TRA Perched Water System	
Safe Drinking Water Act	40 CFR 141, "National Primary Drinking Water Standards"
	40 CFR 141, "Maximum Contaminant Level Goals"
	40 CFR 143, "National Secondary Drinking Water Standards"
Clean Water Act	40 CFR 131, "Water Quality Criteria"
Atomic Energy Act and Energy Reorganization Act	10 CFR 20, "U. S. Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation"
	10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste"
Resource Conservation and Recovery Act	40 CFR 264, "Maximum Concentration Limits"
	40 CFR 268, "Land Disposal Restrictions"
Emergency Planning and Community Right-to-Know Act of 1986	40 CFR 355, "Emergency Planning and Notification under CERCLA"
Federal action-specific ARARs for the TRA Perched Water System	
Resource Conservation and Recovery Act	40 CFR 257, "Criteria for Classification of Solid Waste Disposal Facilities and Practices"
	40 CFR 260, "Hazardous Waste Management Systems"
	40 CFR 262, "Standards Applicable to Generators of Hazardous Waste"
	40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities"
	40 CFR 267, "Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities"
	40 CFR 268, "Land Disposal Restrictions"

Table 2-1. (continued).

Statute	Regulation
Federal action-specific ARARs for the TRA Perched Water System	
Occupational Safety and Health Act	29 CFR 1910, "Occupational Safety and Health Standards"
National Environmental Policy Act	40 CFR 1500 - 1508, "Council on Environmental Quality Regulations for Implementing National Environmental Policy Act Procedures"
Hazardous Material Transportation Act	49 CFRs 171 - 179, "Standards for Transporters of Hazardous Waste"
Clean Air Act	40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards"
	40 CFR 61.90, "National Emission Standards for Radionuclide Emission from DOE facilities"
	40 CFR 200, "Standards of Performance for New Stationary Sources"
Atomic Energy act and Energy Reorganization Act	10 CFR 61, Subpart D, "Technical Requirements for Land Disposal Facilities"
Migratory Bird Treaty Act	50 CFR 20, "Migratory Bird Protection"
Bald and Golden Eagle Protection Act	50 CFR 22, "Bald and Golden Eagle Protection Act"
Endangered Species Act	50 CFR 17, "Endangered and Threatened Wildlife and Plants"
	50 CFR 225, "Federal/State Cooperation in the Conservation of Endangered and Threatened Species"
	50 CFR 226, "Designated Critical Habitat"
	50 CFR 402, "Interagency Cooperation"
Federal location-specific ARARs for the TRA Perched Water System	
National Historic Preservation Act	36 CFR 800
Archeological Resources Protection Act	36 CFR 7, "Protection of Archeological Resources"

Table 2-1. (continued).

Statute	Regulation
Federal location-specific ARARs for the TRA Perched Water System	
Archeological and Historic Preservation	36 CFR 296, "Protection of Archeological Resources; Uniform Regulations"
Preservation of American Antiquities Act	43 CFR 3
State ARARS	
Environmental Protection and Health Act (EPHA)	Idaho Code Section 39-101 through 119
Alteration of Channels	Idaho Code Section 42-3801 through 3812
Hazardous Waste Facility Siting Act	Idaho Code Section 39-5801 through 5820
Protection of Natural Resources	Idaho Code Section 67-5801 through 5804
Idaho Solid Waste Management Regulations	IDHW Title 1, Chapter 6, §01.6001 et seq.
General Water Quality Criteria	Idaho Air Pollution Act (IDAPA) Section 16.01.2200
Short-Term Activity Exemption	IDAPA Section 16.01.2301
Maintenance of Water Quality Standards	IDAPA Section 16.01.2302
Subsurface Waste Disposal Facility	IDAPA Section 16.01.2460
Hazardous Materials Spills	IDAPA Section 16.01.2850
Land Application of Wastewaters	IDAPA Section 16.01.2600
Toxic Substances	IDAPA Section 16.01.1011,01
Air Pollution Permits to Construct and Operating Permits	IDAPA Section 16.01.1012
Visible Emission	IDAPA Section 16.01.1201
Fugitive Dust	IDAPA Section 16.01.1251 to 1253
New Source Performance Standards	IDAPA Section 16.01.1951
Antidegradation Policy	IDAPA Section 16.01.2051
Water Use Classifications General Water Use Designations	IDAPA Section 16.01.2100

- Remedial action decisions at similar Superfund Sites

- Proposed standards under the Safe Drinking Water Act

- Federal/State rules pertaining to relevant subjects that are not promulgated criteria, limits, or standards (by definition of Section 121(d) of CERCLA, as amended).

The revised TBC list developed during the FS evaluation is shown in Table 2-2.

2.3 General Response Actions for Ground Water

General response actions are identified to address the RAOs using engineering judgment and following the guidelines presented in the Guidance Document (EPA 1988). Applicable GRAs are identified to address source control, COC migration, and institutional controls.

2.3.1 General Response Actions

General response actions identified for the PWS OU include the following:

1. No action, where current ongoing ground-water and waste stream monitoring activities would continue, and liquid wastes generated at TRA would continue to be discharged to the disposal ponds. Use of the existing warm waste pond is scheduled to be discontinued in 1992 if appropriate permits are obtained; however, a new, lined pond will be constructed for warm waste discharge. The no action response is used as a baseline alternative for comparison to other response actions.

2. Removal of contaminated perched ground water, followed by:

   (a). Physical/chemical treatment of perched ground water. This response action requires ground-water removal, and includes several treatment process options.

Table 2-2. Regulations to be considered.

Regulation	Title
<u>DOE Order Number</u>	
5480.1B	"Environment, Safety and Health Program for DOE Operations"
5480.3	"Hazardous and Radioactive Mixed Hazardous Waste Management"
5480.4	"Environmental Protection, Safety and Health Protection Standards"
5480.2A	"Radioactive Waste Management"
5400.5	"Radiation Protection of the Public and Environment"
5480.11	"Radiation Protection of Occupational Workers"
<u>Executive Orders</u>	
E.O. 11988	"Floodplain Management"
E.O. 11989	"Off-Road Vehicles on Public Lands"
E.O. 11990	"Protection of Wetlands"
E.O. 11991 and 11514	"Protection and Enhancement of Environmental Quality"
E.O. 11593	"Protection and Enhancement of Cultural Environment"
E.O. 12088	"Federal Compliance with Pollution Control Standards"
E.O. 12316	"Response to Environmental Damage"
E.O. 12342	"Environmental Safeguards on activities for Animal Damage and Control on Federal Lands"
E.O. 12580	Superfund Implementation
E.O. 11543	Protection and Enhancement of the Cultural Environment

Table 2-2. Regulations to be considered.

Regulation	Title
Rules	
Safe Drinking Water Act	Final Determination (EPA) of Sole Source Designation for the Eastern Snake River Plain Aquifer, Southern Idaho (194 FR 50634)
State Water Quality Plan	Draft Idaho Ground Water Quality Plan (Ground Water Quality Council et al. 1991).

(b). Evaporation of ground water. This response action requires ground-water removal followed by passive solar evaporation of the water in lined ponds.

3. Containment of contaminated perched ground water.

4. Treatment of liquid wastes currently being discharged to the various onsite disposal ponds. These liquid wastes can potentially be treated at the TRA operations facility and recycled for reuse, reducing total discharge flow rates to the disposal ponds.

5. Institutional controls, where Site access restriction or protective deeds and covenants can be used to prevent human contact with the ground water.

Technologies associated with these GRAs are presented, preliminarily described, and evaluated in Section 2.4. A GRA involving pond sediment removal was not listed above because these sediments are not included in the PWS OU. Warm waste pond sediments are being addressed as part of a separate Interim Action under OU 2-10. Sediment removal would be a contaminant source control measure that would affect PWS quality.

A new, lined warm waste disposal pond will be constructed prior to the scheduled sediment removal and closure activities planned for the existing three cells of the warm waste pond and the retention basin. At the present time, neither the cold nor chemical waste ponds are scheduled for closure. These ponds would be expected to continue accepting discharges from the TRA. Discharge to the sanitary waste pond will also continue as part of TRA operations. Available data do not show that the sanitary waste pond is a source of contamination. This will be confirmed as new characterization data become available on the ongoing Track 2 Investigation scheduled for completion in fiscal year (FY) 1993.

2.3.2 Volume/Area Estimates

The volume of wastewater discharged to the pond system has been estimated by EG&G Idaho for each pond over the operating period from 1952 to 1991. Current discharge information is being collected at TRA on a daily basis. Table 2-3 gives the total estimated discharge to each pond from 1952 to 1990 and current daily discharge to each pond. The greatest volume of process water was discharged to the onsite injection well and to the cold waste pond. Lesser discharge volumes were recorded for the remaining ponds. Current discharge rates show the greatest volume is to the cold waste pond at approximately 500 gpm. Lesser rates are observed for the remaining disposal ponds.

A volume estimate was made for the deep perched water zone as part of the RI. The total volume of the deep perched zone is estimated to be approximately 1.04×10^9 gallons. An area estimate was made using the plotted areal extent of the deep perched zone based on water level measurements obtained in April 1988, giving an approximate area of 293 acres.

An area estimate was not made for the shallow perched zone for several reasons, primarily because water level data for the shallow zone are intermittent. Historical data for the shallow perched water zone indicate that residence time is approximately 30 to 40 days[a]. For purposes of the FS, it was assumed that this shallow perched water would eventually reach the deep perched zone. Finally, using conservative estimates of a saturated thickness for the shallow zone, the volume of water potentially present with continued discharge to the pond system is roughly 3 to 4 orders of magnitude less than the deep perched zone. As such, the deep perched zone represents over 99% of the total volume of perched ground water beneath TRA.

2.4 Technology Identification and Screening

Remedial technologies that correspond to the GRAs listed previously are identified and preliminarily screened in this section. Remedial technologies not involving treatment include a no action scenario, institutional controls, and containment technologies. Technologies involving treatment include representative process options for physical/chemical, biological,

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a. Personal communication with Marty Doornbos, EG&G Idaho, Inc., Idaho Falls, Idaho, July, 1991.

Table 2-3. Total and daily process water discharged to the TRA pond system.

Pond	Period of Use	Total Discharge (gal)[a]	Daily Discharge (gpm)[b]
Warm Waste Pond/ Retention Basin	1952–1990	5.35×10^9	30–40
Cold Waste Pond	1982–1990	2.13×10^9	500
Chemical Waste Pond	1962–1990	726×10^6	15–20
Sanitary Waste Pond	1950–1990 1965–1990	310×10^6	15–20
Injection Well	1964–1982	3.89×10^9	400
USGS-53	1960–1964	2.2×10^8	100

a. Total discharge volume from 1952 through 1990.

b. Daily discharge based on 24 hours per day, seven days per week. Source: personal communication with Bob Beatty, EG&G Idaho, Inc., Idaho Falls, Idaho, 1991. The rates shown for the injection well and for USGS-53 are historical. Further, the rates for USGS-53 are only average values when in use, as this well was only used intermittently between 1960 and 1964.

and in situ treatment that reduce the toxicity, mobility, or volume of the perched ground water.

2.4.1 Technology Types and Process Options

Technology types and process options are identified in this section to represent relatively broad categories of potential contaminant removal or treatment methods. Process options are components of the technology types, and at least one process option is identified for each general technology type.

Remedial technologies applicable to each GRA category are preliminarily screened in this section. This initial screening emphasizes overall technical implementability of a process option. Information available regarding the physical Site characteristics and potential ground-water specific concerns is used for the initial screening.

Figure 2-1 shows the initially identified remedial technologies associated with each GRA. One or more process options are given for each remedial technology. A brief description and a screening comment are given for each process option. Technologies that are screened out at this stage are identified in Figure 2-1 by a double lined border, along with a brief description of its reason for failure. Descriptions of the initially identified remedial technologies are given in the following sections.

2.4.1.1 No Action. The no action response is a stand-alone remedial response that is used as a baseline to compare with the other candidate remedial alternatives. The no action response would involve the continuance of activities currently being conducted at TRA, with three exceptions. Items that will change from the current operating status as part of TRA operations, with or without active remedial actions, include:

- Discharge of warm waste to a new, lined warm waste pond, scheduled for completion in 1992, if appropriate permits are obtained

Ground-water General Response Action	Remedial Technology	Process Options	Description	Screening Comment
No Action Section 2.4.1.1	None	Not Applicable	No action.	Required for consideration by NCP as baseline comparison.
Removal/ Discharge Section 2.4.1.2	Extraction	Extraction/ Injection wells	Use of injection of uncontaminated water to injection wells to induce flow to extraction wells.	Potentially effective due to the nature of the perched water hydraulics.
		Extraction Wells	Strategically placed wells to remove contaminated ground water.	Potentially applicable.
	Subsurface Drains	Interceptor Trenches	Perforated piping installed to intercept and collect contaminated ground water.	Not feasible due to depth of the two perched water zones below ground surface.
	On Site Discharge	On Site Ponds	Discharge to either existing or newly constructed ponds.	Potentially applicable.
		Local, Dry Streambed	Discharge to Big Lost River channel.	Potentially applicable.
		Injection Well	Discharge to injection well on site.	Potentially applicable.
	Off Site Discharge	Injection Well	Discharge to injection well off site.	Not feasible to reinject radioactive wastewater in an off site well.
		POTW	Discharge to local POTW for treatment.	Not feasible to discharge radioactive to a POTW.

Indicates technology type or process option passes screening.

Indicates technology type or process option fails scree

Figure 2-1. Initial screening of technologies and process options for perched ground water.

Ground-water General Response Action	Remedial Technology	Process Options	Description	Screening Comment
Containment Section 2.4.1.3	Vertical Barriers	Slurry Walls	Cement/bentonite slurry placed in excavated trenches around contaminated zones.	Not feasible due to depth of the two perched water zones below ground surface.
		Sheet Piling	Steel corrugated sheets driven below grade around contaminated zones.	Not feasible due to depth of the two perched water zones below ground surface.
		Grout Curtains	High solids content grout injected under pressure around horizontal contaminated zones.	Not feasible due to depth of the two perched water zones below ground surface.
	Horizontal Barriers	Grout Injection	Horizontal grout injection into native soils or horizontal drill holes.	Not feasible due to depth of the two perched water zones below ground surface.
		Cryogenic Barriers	Solification/freezing native soils below contamination zones.	Not feasible due to depth of the two perched water zones below ground surface; not demonstrated for long-term use.

[single-line box] Indicates technology type or process option passes screening

[double-line box] Indicates technology type or process option fails screening

Figure 2-1. (continued).

Ground-water General Response Action	Remedial Technology	Process Options	Description	Screening Comment
Treatment of Perched water (Section 2.4.1.4)	Physical/ Chemical Treatment	Ion exchange	Water passed through resin-packed reactor to ionicaaly exchange contaminants	Potentially applicable.
		Membrane Technologies	Water passed through selective membrane where contaminants are concentrated	Potentially applicable
		Chemical Precipitation/ Co-precipitation	Chemical coagulants and floculants are added to water to precipitate and settle contaminants in a sludge.	Potentially applicable.
		Oxidation/Reduction	An oxidant or reductant is added to the water to change contaminants valence for further treatment or removal.	Potentially applicable.
		Carbon Adsorption	Contaminants absorbed to active absorption sites of carbon source and removed by concentration.	Limited capability for metals and radionucleide removal.
		Activated Alumina Adsorption	Same as for activated carbon, using an activated alumina media.	Limited capability for metals and radionucleide removal.
		Chelation/Ultra-filtration	Water passed through selective membrane under pressure, where contaminants are concentrated.	Potential for generating excessive solids compared to other options.

[single-line box] Indicates technology type or process option passes screening

[double-line box] Indicates technology type or process option fails screening

Figure 2-1. (continued).

Ground-water General Response Action	Remedial Technology	Process Options	Description	Screening Comment
Treatment of Perched Water (cont.) Section 2.4.1.4	Evaporative Treatment	Evaporation Pond(s)	Contaminated water discharged to lined pond(s); solar evaporation concentrates contaminants .	Potentially applicable.
	In Situ Treatment	Permeable Treatment Beds	Trenches excavated around contamination zones, filled with treatment media to concentrate contaminants.	Not feasible due to depth of the two perched water zones below ground surface.
		Chemical Reaction	Injection wells used to inject reductant into perched water for treatment.	Potentially applicable
	Biological Treatment	Biosorption	Algal cells in silica gel polymer removes metals by sorption.	Not feasible for radioactive treatment, low metals removal efficiency.
	Off site Treatment	POTW	Water pumped to POTW for treatment.	Not feasible to discharge radioactive wastewater to POTW for treatment.
		Commercial Facility	Water transported to off site commercial treatment facility.	Not feasible due to large volume of water; problems with removing radiological contaminants from site.
Source Control Section 2.4.1.5	Physical/ Chemical Treatment	Same as Above	Process water from TRA operations treated prior to pond discharge.	Potentially applicable.
		Brine Concentrator	Process water from TRA operations treated prior to pond discharge.	Potentially applicable.

Indicates technology type or option passes screening

Indicates technology type or process option fails screening

Figure 2-1. (continued).

Ground-water General Response Action	Remedial Technology	Process Options	Description	Screening Comment
Insitutional Controls Section 2.4.1.6	Access Restrictions	Controlled Access	Physical control of access to TRA site and contaminated ground water.	Potentially applicable.
	Property Restrictions	Deed Restrictions	Deeds on the TRA property to prevent future use of perched water.	Potentially applicable.
	Monitoring	Ground-water Monitoring	Water quality monitoring using existing wells.	Potentially applicable.

Indicates technology type or process option passes screening

Indicates technology type or process option fails screening

Figure 2-1. (continued).

- Treatment and possible disposal or storage of treated existing warm waste pond sediments, followed by pond closure

- Daily inspections and documentation of ongoing disposal activities at TRA.

The no action scenario assumes that contaminants will be naturally attenuated in the alluvial materials and the basalt. This response will be carried through the FS as a candidate remedial technology.

2.4.1.2 Removal/Discharge. Removal and discharge of the perched ground water involves pumping or passive collection (through gravity drains) of the water to a surface impoundment structure open to the atmosphere. This GRA alone is not capable of meeting the RAOs, but must be considered as part of any treatment activity that occurs above the ground surface. Representative technologies for this GRA include extraction, subsurface drains, onsite discharge, and offsite discharge.

Extraction–Removal by extraction requires a pumping system. The system may also include the injection of uncontaminated water to strategically placed wells to enhance recovery of COCs potentially present in the perched water. Based on available information regarding the perched water hydraulics, it appears that the use of injection wells may not be effective in enhancing recovery. However, the use of injection wells may be feasible, but are usually more effective for free phase liquid recovery than for recovering dissolved substances. Extraction/injection technologies pass the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

Subsurface Drains–Subsurface drains may consist of either open channels excavated around downgradient boundaries of contaminated zones, or trenches installed with perforated piping and backfilled. Both designs offer passive collection of ground water to a central location where water is pumped to a treatment and/or discharge point. Due to the depth of the two perched water zones, subsurface drains would not be capable of effective ground-water collection. Subsurface drains were considered to fail the initial screening and are not considered further in the FS.

Onsite Discharge–Onsite discharge would be made to either existing or newly constructed ponds, to the Big Lost River channel, or to an injection well. Treatment would be required if discharge were made to either unlined impoundments or to the river channel to prevent recontamination of the perched ground water or offsite contaminant transport. Ground-water treatment may not be required if discharge is made to newly constructed, lined ponds. Onsite discharge passes the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

Offsite Discharge–Offsite discharge would be made to either an offsite injection well or to a local publicly owned treatment work (POTW). However, due to the nature of the COCs, neither of these two options would be suitable. Requirements for offsite disposal of radioactive-bearing substances would prevent the use of either an injection well or a POTW. Offsite discharge options fail the initial screening and are not considered further in the FS.

2.4.1.3 Containment. Containment technologies are used as source control measures. Potentially implementable containment technologies for the PWS OU include installing vertical barriers or horizontal barriers around the perched water zone. These technologies are discussed below.

Vertical Barriers–Vertical barriers may consist of slurry walls, driven sheet piling, or grout curtains to mitigate lateral ground-water flow. Slurry walls are typically constructed by excavating a trench along the hydraulically downgradient boundary of the contaminated zone, and filling the trench with a cement/bentonite slurry. Sheet piling, usually corrugated steel sheets, is pneumatically driven from the ground surface to the desired depth. Applications of sheet piling are typically limited to soils that do not contain large cobbles or boulders. Grout curtains are installed by injecting a high solids content cement grout under pressure into the soil along a hydraulically downgradient boundary to fill soil voids and decrease the hydraulic conductivity of the aquifer material.

Since the depths of the shallow and deep perched water zones are approximately 50 feet and 150 feet BLS, respectively, installation of vertical barriers would be difficult. In addition to problems with depth requirements, the nature of the materials (i.e., alluvial gravel and basalt) would add difficulty to installing vertical barriers. The basalt layers between the two zones would render any of the available process options impractical for the deep zone. In addition, lateral migration of both of the perched water zones is currently limited, and vertical barriers would have limited usefulness in containing the contaminated ground water. Vertical barriers fail the initial screening and will not be considered further in the FS.

Horizontal Barriers–Horizontal barriers for the perched water consist of grout injection or cryogenic barriers to mitigate vertical ground-water movement to the regional SRPA. Grout injection involves placements of a cement grout under pressure into horizontal drill holes beneath the contaminated zone. Soil voids are filled in, reducing the hydraulic conductivity of the aquifer. Cryogenic barriers are constructed through the use of freezing pipes installed beneath the contaminated zone. A liquid cooling agent is used to freeze the surrounding soils to a specified design thickness. The liquid cooling agent is recirculated in a closed system to maintain the require temperature.

Such barriers may be feasible for the shallow perched zone, although this zone accounts for less than 1% of the total perched water at TRA. Similar to vertical barriers, the depth of the perched water zones would make the installation of horizontal barriers difficult. In addition, horizontal barriers would have to be combined with vertical barriers to prevent lateral ground-water migration. Finally, cryogenic barriers have not been demonstrated for permanent applications, but rather are considered temporary installations. Horizontal barriers fail the initial screening and will not be considered further in the FS.

2.4.1.4 Treatment of Perched Water. As stated previously, removal technologies are used as source control measures regarding the continued infiltration from the perched water zones to the regional SRPA. They involve the physical removal of ground water with subsequent transport to an aboveground location. Removal technologies have been discussed in earlier sections, although they would be included in any above ground treatment system, if necessary. Several treatment technologies have been identified during this phase of the FS, including physical/chemical, evaporative, in situ, biological, and offsite treatment. Discharge technologies are also part of above ground treatment scenarios, and have been discussed previously. A description of treatment technologies and associated process options are described in the following sections. Process options identified in this section are applicable to heavy metal and/or radionuclide removal, except tritium. At present, no process option exists to effectively remove tritium.

Physical/Chemical Treatment–Several physical/chemical process options have been identified for this treatment technology type. Physical/chemical process options identified include ion exchange, membrane technologies (e.g., reverse osmosis), chemical precipitation/co-precipitation, oxidation/reduction, adsorption, and chelation/ultrafiltration. A brief description of these process options is given below.

Ion Exchange: Ion exchange is accomplished by an ion exchange resin having ionic functional groups that allow for exchange ions in solution to become attached. The resins are synthetic materials usually having a high tolerance to wide ranges in pH and temperature. In most cases, the resins are chosen for their ability to selectively remove specific ions from solution. Since the exchange reaction is reversible, the resins can be regenerated, typically with a strong acid or base. Ion exchange passes the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

Membrane Osmosis: Membrane technologies such as reverse osmosis (RO) involve applying varying amounts of pressure to a solution to overcome the pressure potentials that force the water through semi-permeable membranes into a dilute phase. In the case of RO, small molecules and ions do not pass through the membrane and are concentrated in the reject stream. Typically, membrane technologies are used as a final polishing step in wastewater treatment for either low flows of highly concentrated solutions or higher flows having lower solute concentrations. Membrane technologies pass the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

Chemical Precipitation/Co-Precipitation: Chemical precipitation/co-precipitation allows for the transformation of solutes in solution to be converted to a solid phase. The solid phase is settled out by gravity into a sludge, thus concentrating the contaminants. Typically a chemical or group of chemicals (usually lime or sulfides) is mixed with the contaminated solution, whereby the solubility of the contaminants is reduced, forming a solid phase. The mixing is conducted in one reactor basin, while the passive sedimentation of the solids occurs in a quiescent sedimentation basin. Settled solids are removed. Treatability testing is typically required to verify chemical addition rates and final solubilities of the contaminants. Chemical precipitation/co-precipitation passes the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

Oxidation/Reduction: Oxidation/reduction (redox) refers to one or more reactions where the oxidation state of a contaminant (or reactant) is changed. This process option will be considered specifically for treatment of hexavalent chromium, where the +6 valence state is reduced to the less toxic and more easily precipitated +3 valence state. This process option may also be applicable to treatment of certain radionuclides. Redox passes the initial FS screening process and will be subject to the effectiveness, implementability, and cost evaluation.

Carbon Adsorption: Carbon adsorption is similar in concept to ion exchange in that the active receptor sites in the activated carbon adsorb contaminants. This process option is most often used for organics removal, and has limited applications to heavy metal and radionuclide removal. The perched water system COCs do not include organics. As a result, carbon adsorption fails the initial FS screening and will not be considered further.

Activated Alumina Adsorption: This process option is similar to activated carbon adsorption, although the activated alumina media is useful for removing certain anions not readily removed by ion exchange. Contaminant anions in solution are exchanged for hydroxide ions on the active adsorption sites; therefore, the process is most effective at a pH less than 8.2. Since the use of activated alumina for heavy metals and/or radionuclides has not been documented, the process is not applicable to treatment of TRA perched water. Activated alumina adsorption fails the initial FS screening and will not be considered further.

Chelation/Ultrafiltration: Chelation/ultrafiltration is similar to the membrane technologies, such as RO, where the contaminated waste stream is subject to a specific pressure, lower than that for RO. Solutes are concentrated in the reject stream while water passes through a semi-permeable membrane to a dilute phase. The solutes are concentrated in the reject stream by the mechanical action of sieving through the pores of the membrane. A chelating organic polymer is used to first selectively combine with metal cations, and the resulting high molecular weight complexes are retained by the molecular sieve. The use of this process option for metals removal has been demonstrated only recently, and is not as well understood as the other process options for metals removal. In addition, the generation of sludges along with the reject stream make this process less desirable. The use of chelation/filtration fails the initial FS screening and will not be considered further.

Evaporative Treatment–Evaporative treatment involves ground-water pumping from the PWS and discharge to a lined evaporation pond. Passive solar radiation acts to evaporate the ponded water and leaves the concentrated contaminants in the pond bed. The contaminants can then be removed and transported for disposal or may be left in place. If contaminants remain, the evaporation pond would be subsequently closed as a disposal site.

Limitations to this technology are that net evaporation rates in the pond or ponds must meet or exceed ground-water pumping rates, and seepage from the pond to the alluvium would not occur. Evaporative treatment passes the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

In Situ Treatment–In situ treatment for the perched water system includes permeable treatment beds and in situ chemical reaction treatment. Permeable treatment beds are constructed by excavating trenches around the contamination zones and backfilling with a treatment medium such as an ion exchange resin. Due to the limited areal extent and lateral movement of the perched water, permeable treatment beds fail the initial FS screening and are not considered further.

In situ chemical reactions are initiated by injecting appropriate chemicals to the perched water zones through strategically placed injection wells. Typically, the contaminants are precipitated to more nonsoluble forms, or are chelated into immobile, less toxic complexes. In some cases, the reaction process may be variable and unpredictable due to the nature of the deep aquifer hydraulics. In situ chemical reactions pass the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

Biological Treatment–Biological treatment is most often used for the removal of organics. The use of algal cells in a silica gel matrix has been used for metals removal, where metal cations are sorbed by the gel. Removal of radionuclides using this technique has not been demonstrated. Sorption of metals using a fixed bacterial film has been demonstrated at the benchscale, although it also has not been shown to be capable of radionuclide removal. Biological treatment for metals removal is also more sensitive to process upsets than process options such as ion exchange or RO. Biological treatment fails the initial FS screening and will not be considered further.

Offsite Treatment-Offsite treatment would include using either a local POTW or a commercial treatment facility. Typical treatment processes used at POTWs would prevent the use of such a treatment plant for the perched ground water. A commercial treatment plant is not feasible because of the difficulties associated with transport of radioactive water, and also from the large volume of ground water requiring treatment. Offsite treatment fails the initial FS screening and will not be considered further.

2.4.1.5 Source Control. Treating the daily discharge of process wastewater from TRA operations is considered a source control measure. Treating discharge flows would result in fewer contaminants that can potentially reach either the perched water zones or the regional SRPA. Treating process wastewater with physical/chemical methods may also reduce contaminant loading to existing or newly constructed discharge ponds. In addition, treated water may be recycled for use as process makeup water. The physical/chemical process options discussed in previous sections, and a proprietary brine concentration process, also can be applied potentially to the treatment of the TRA discharge, particularly the cold and chemical waste streams. This source control measure passes the initial FS screening, and will be subject to the effectiveness, implementability, and cost evaluation.

2.4.1.6 Institutional Controls. Institutional controls for the PWS include access restrictions, property restrictions, and ground-water monitoring. An evaluation of using institutional controls as a sole remedy for the PWS OU will be made, although in many cases they would become integrated with other remedial technologies in the development of a complete remedial alternatives.

Access restrictions involve the physical control of access to the TRA Site and the perched ground water beneath the Site for any use. Property restrictions include appropriate deed restrictions and restrictive covenants that control land use at TRA. These restrictions obligate the land owner to restrict the use of the property in some manner. In the case of the PWS, this includes preventing the use of the water for any purpose. Ground-water monitoring has been conducted in the past for the PWS. Continued water level and water quality monitoring would continue to provide an ongoing characterization of the extent of the PWS and potential contaminant concentrations. Due to the nature of the TRA location within INEL, the physical location of the PWS, and the overall use of INEL, these institutional controls would prevent access to, or use of water in the PWS. Institutional controls pass the initial FS screening and will be subject to the effectiveness, implementability, and cost evaluation.

2.4.2 Technology Evaluation

In accordance with the NCP and the Guidance Document (EPA 1988), each of the process options listed for the technology types identified in Section 2.4.1 that have passed the initial screening process must be preliminarily evaluated for its effectiveness, implementability, and cost. Effectiveness of a technology focuses on (a) the process option's effectiveness to treat the estimated volume of ground water and its ability to meet the RAOs, (b) potential human health and environmental impacts during construction and implementation, and (c) how proven and reliable the process option is with treating the contaminants present in the ground water. Implementability refers to the technical and administrative constraints, and the availability of resources to implement the given process option. The cost analysis at this stage of the FS is only a relative measure of capital and operating and maintenance (O&M) costs based on engineering judgment. Effectiveness of the process option is usually given more emphasis than implementability or cost in this initial evaluation. In addition to this evaluation, one or more representative process options are identified to be carried forward in the FS.

Representative process options were selected based on the potential effectiveness and level of development of the process option, with consideration of Site and material characteristics. Selection of representative process options was made using engineering judgment.

The purpose of selecting representative process options where more than one exists for a technology type is to simplify the subsequent phases of the FS evaluations by limiting the number of remedial technologies and alternatives to be considered without reducing the range of options. Final selection of process options is typically performed during final remedial design.

Figure 2-2 lists each of the technology types and process options that passed the initial screening process. A double line is shown for technology types or process options that are screened from further consideration in the FS. A brief discussion of the process options is given in the following sections.

2.4.2.1 Effectiveness Evaluation. The effectiveness evaluation of each process option is given below. Refer to Figure 2-2 for a summary of the effectiveness of these process options.

No Action–Although a new lined pond is planned for the warm waste discharge, the existing perched water system would remain in place, with continued infiltration to the regional SRPA. The no action option relies on COC dilution and dissipation to meet the RAOs for PWS OU.

Removal/Discharge–Removal/discharge of perched water includes extraction wells and onsite discharge options. Extraction wells for removing contaminated ground water would be expected to meet the RAOs if associated with treatment. No problems would be expected with pumping the ground water with the estimated areal extent and volume of the perched water system. The pumping and distribution system would require appropriate monitoring to ensure potential exposure to the contaminated water through accidental spills or leaks is minimized. This technology is both proven and reliable for removing ground water.

Discharge of ground water to onsite ponds, the Big Lost River, or an injection well may not achieve the RAOs without prior treatment. Use of discharge ponds would provide a

Ground-water General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
No Action	None	Not Applicable	Relies on dilution and dissipation to achieve RAOs.	Easy to implement.	None beyond costs for new warm waste pond.
Removal/ Discharge	Extraction	Extraction Wells	Proven technology. May not achieve RAOs without treatment.	Easy to implement.	Moderate capital, low O&M.
	On Site Discharge	On Site Ponds	Proven technology. May require treatment to achieve RAOs.	Easy to implement.	Moderate capital, low O&M.
		Local, Dry Streambed	May not provide necessary control of discharge. Requires treatment to achieve RAOs.	Moderately easy to implement.	Moderate capital, low O&M.
		Injection Well	May not provide necessary control of discharge. Requires treatment to achieve RAOs.	Difficult to implement.	Moderate capital, moderate O&M.

[thin box] Indicates technology type or process option passes screening.

[thick box] Indicates technology type or process option fails screening.

Figure 2-2. Evaluation of process options for perched ground water.

Ground-water General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Treatment of Perched Water	Physical/ Chemical Treatment	Ion Exchange	Effectiveness uncertain without treatability testing for radiological parameters.	Moderately easy to implement.	Moderate capital, moderate O&M.
		Membrane Technologies	Effectiveness uncertain without treatability testing for radiological parameters.	Moderately easy to implement.	Moderate capital, moderate O&M.
		Chemical Precipitation/ Co-precipitation	Effectiveness uncertain without treatability testing for radiological parameters and Cr.	Moderately easy to implement.	Moderate capital, moderate O&M.
		Oxidation/Reduction	Effectiveness uncertain without treatability testing for radiological parameters.	Moderately easy to implement.	Low capital, moderate O&M.
	Evaporative Treatment	Evaporation Pond(s)	Proven technology, but effectiveness dependent on evaporation rates.	Moderately easy to implement.	High capital, moderate O&M.
	In Situ Treatment	Chemical Reaction	Unreliable due to complex aquifer hydraulics. Contaminants may resolubilize.	Difficult to implement.	Moderate capital, moderate O&M.
Source Water Treatment	Physical/ Chemical Treatment	Brine Concentrator	Most effective with cold and chemical waste streams.	Moderately easy to implement.	Moderate capital, moderate O&M.

Indicates technology type or process option passes screening.

Indicates technology or process option fails screening.

Figure 2-2. (continued).

Ground-water General Response Action	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Insitutional Controls	Access Restrictions	Controlled Access	Effective in preventing access to contaminated ground water. May not achieve RAOs.	Easy to implement.	Low capital, low O&M.
	Property Restrictions	Deed Restrictions	Effective to prevent future uses of contaminated ground-water. May not achieve RAOs.	Easy to implement.	Low capital, low O&M.
	Monitoring	Ground-water Monitoring	Effective in monitoring contaminant levels, and may not achieve RAOs.	Easy to implement.	Low capital, low O&M.

(Thin box) Indicates technology type or process option passes screening.

(Double box) Indicates technology or process option fails screening.

Figure 2-2. (continued).

greater degree of control for managing treated ground water than the Big Lost River channel or an injection well. Anticipated volumes to be discharged would not likely exceed the capacity of a disposal pond(s) or a series of injection wells. Potential impacts to human health and the environment would be reduced by ground-water treatment. Use of onsite ponds is a proven and reliable technology for accepting the expected discharges. However, use of an injection well may be considered as appropriate in the Remedial Design/Remedial Action period.

Perched Water Treatment–Treatment of perched water includes physical/chemical treatment, evaporative treatment, and in situ treatment. The four screened physical/chemical process options are ion exchange, membrane technologies such as RO, chemical precipitation/co-precipitation, and redox. A treatment facility may require the use of one or several of these process options. Each of these process options is a conventional wastewater treatment technology, and would be capable of treating the volume of perched ground water at the TRA Site. Removal efficiencies of the process options would be expected to achieve the RAOs. At this stage of the FS, none of these process options can be selected as the single representative process option for the physical/chemical technology type.

There may be impacts to human health and the environment at a treatment facility if an inadvertent spill or leak occurs. Operating safety measures would be required to minimize potential releases from the treatment plant. Each of these process options are considered to be proven and reliable. Hexavalent chromium can be removed through any of the four process options, while treatment for the radiological parameters may require an ion exchange or RO process. Redox may be potentially applicable for treating the radionuclides. Treatability testing may be required to more accurately quantify the effectiveness of the process options for the ground water. None of the process options would be capable of removing tritium.

Evaporative treatment using a lined evaporation pond would be effective to reduce the concentration of the inorganic and radiological contaminants in the ground water. In order to achieve the RAOs, the evaporation pond must maintain its integrity to prevent re-infiltration of the water. The volume of contaminated ground water requiring treatment is relatively large. Therefore, the evaporation pond(s) would need to be sized so evaporation rates meet or exceed pumping rates. Quantitative data for evaporation rates on a seasonal basis would be required to determine acceptable pumping rates during each season. Evaporation is a proven technology for concentrating contaminants from solution, although reliability would be dependent on consistent evaporation rates.

In situ treatment is represented by the chemical reaction process option. In situ chemical reactions for the deep perched zone would be difficult to accurately monitor for effectiveness. In addition, assessing whether complete reactions occur would be difficult based on the current level of knowledge of aquifer hydraulics. Finally, if reactions were reversed the possibility exists for re-solubilization of the COCs.

Source Control-Source control would involve the use of the physical/chemical process options described previously for ground-water treatment, or a proprietary brine concentration process. Their effectiveness would be considered to be similar to that described earlier. The applicability of the treatment processes would be influenced by the TRA waste stream flow rates and chemical concentrations encountered with the waste streams, as compared to the perched ground water. A source control system would need to operate continuously for the life of the TRA, as opposed to the limited time frame of a ground-water treatment system.

Institutional Controls-Institutional controls and restricting access to the perched water and use of the water would be effective in meeting the second RAO, but would not prevent further releases to the perched zones. Ground-water monitoring allows for observations to be made regarding the extent of the perched water and the types and concentration of contaminants. Each of these institutional controls may be reliable for preventing direct human exposure, although as a sole remedy they would not prevent infiltration of contaminated perched water to the SRPA.

2.4.2.2 Implementability Evaluation. The implementability evaluation of each process option is given below. Figure 2-2 summarizes the implementability of these process options.

No Action–The no action scenario would be easy to implement. Construction of a new warm waste pond as specified for this option would not be difficult on a technical or administrative basis. The new pond would use standard proven construction technologies, and required permits can be obtained. Availability of construction materials and workers would not be expected to pose implementability problems.

Removal/Discharge–Installation of extraction wells would be easily implemented. Well placement and construction details pose the greatest technical concerns. Due to the level of understanding of the perched water system, no major problems associated with well placement and construction would be expected. Strategic well placement to optimize perched water recovery, based on aquifer hydraulics, may require modeling to determine the location of wells. Advanced approval of well locations would be required for any well construction activity, and would require coordination with daily TRA operations. Availability of well construction equipment, materials, and workers would not be expected to pose implementability problems.

Onsite discharge would be easiest to implement for specially constructed disposal ponds. Pumped ground water is either treated and discharged to a pond, or is pumped directly to an evaporation pond. There would be no technical constraints expected with construction and operation of a discharge pond. Administrative constraints may include siting the pond, although no permitting problems would be anticipated. Availability of construction materials and workers would not impact implementability of this technology. Use of the Big Lost River would pose administrative problems related to wastewater disposal to a stream channel. Use of an injection well may require more stringent monitoring requirements, adding difficulty to this option.

Perched Water Treatment–Each of the four physical/chemical process options identified would be implementable. A treatment facility would need to be constructed. The process option(s) used in a treatment facility would be expected to treat the ground water to lower contaminant concentrations that would meet the RAOs. All of the process options use conventional materials for construction and use conventional chemicals or treatment media. Availability of the needed materials for operation of a treatment facility, or workers to build and operate the facility would not impact the implementability of these physical/chemical process options.

Evaporative treatment through passive solar radiation would be easy to implement. Use of a lined pond would ensure that the contaminants concentrated in the pond for removal and would be expected to meet the RAOs. Technical constraints would include sizing the pond(s) so that evaporation rates meet or exceed the ground-water pumping rates. Seasonal variations in evaporation rates must be coordinated with ground-water pumping (i.e., evaporation rates are significantly greater in the summer months than the winter months). Administrative constraints would include siting of the evaporation pond(s) so that TRA operations would not be adversely impacted. Availability of construction materials and workers would not impact the implementability of evaporative treatment.

Implementing in situ chemical reactions would be difficult. To induce fluid circulation and the necessary chemical reactions, a potentially large number of chemical injection well and ground-water extraction/injection wells may be required. Administrative constraints would include siting a large number of wells. These wells may interfere with daily operations at the TRA. Availability of well construction equipment, materials, and workers would not pose implementability problems.

Source Control–As with the effectiveness evaluation, the implementability of using physical/chemical process options or the proprietary brine concentration process for treating the TRA waste water would be similar to that described earlier. System sizing, location, and operating life would coincide with the TRA operations. Requirements for installing a permanent treatment system would not impact its implementability.

Institutional Controls–Since access to the TRA Site is strictly controlled, property use restrictions are in place, and an ongoing ground-water monitoring program is being administered. These institutional controls will be continued and maintained. Most of INEL property was removed fro mthe public domain and is owned and operated by the DOE, providing greater ease for implementing institutional controls. No technical or administrative constraints would be expected with these institutional controls.

2.4.2.3 Cost Evaluation. The cost evaluation for each of the process options at this stage of the FS is based on engineering judgment relative to the other process options within the same technology type. Figure 2-2 summarizes this relative cost evaluation.

The no action scenario would have no associated costs beyond those anticipated for closure of the existing warm waste pond and construction and operation of a new warm waste pond. Process options identified for the removal/discharge GRAs appear to have moderate capital and low O&M costs, except ground-water evaporation which may have high capital costs. Each of the physical/chemical process options would likely have low to moderate capital and O&M costs. Each of the institutional controls identified would have low capital and O&M costs. Refined cost estimates are included in the detailed analysis of alternatives (Section 4).

2.4.3 Evaluation Summary

Figure 2-2 summarizes the technology types and process options that pass the initial FS effectiveness, implementability, and cost evaluation. The no action scenario is retained for comparison. Pumping wells will represent ground-water removal technologies. Discharge to onsite disposal ponds was selected as the representative process option as opposed to using the Big Lost River channel or an injection well. Disposal ponds were selected because greater operational control of the discharged water would be achieved.

Each of the four physical/chemical process options will remain as representative of the technology type, since additional process- and material-specific data are needed to determine the actual performance of each process option. Evaporation ponds are used as representative of the evaporative treatment technology type. In situ chemical reactions were screened out because of several effectiveness and implementability concerns. The proprietary brine concentration process was selected as representative of source control. Each of the three institutional controls will be retained since each would compliment the other during Site remediation. These institutional controls will become part of the complete candidate remedial alternatives.

3. Remedial Alternative Development

3. REMEDIAL ALTERNATIVE DEVELOPMENT

A list of potentially applicable technologies for meeting RAOs was developed in Section 2. From this list, technologies considered to be ineffective were dropped from further consideration in the FS. Representative process options from technology types that were not eliminated during the second screening stage are combined in this section to form the candidate remedial alternatives that will be evaluated in the detailed analysis phase of the FS (Section 4). Additional candidate remedial alternatives may be considered if public scoping meetings and governmental agencies indicate additional alternatives are needed.

Four candidate remedial alternatives have been compiled from the treatment technologies that passed the screening process. A description of the components for each remedial alternative is given in the following subsections. The four candidate remedial alternatives are (1) No Action, (2) Physical/Chemical Ground-Water Treatment, (3) Evaporative Ground-Water Treatment, and (4) Source Control.

3.1 Alternative 1-No Action

The No Action alternative is required under CERCLA as a baseline alternative with which to compare other candidate alternatives. No action assumes that additional activities would not occur with respect to infiltration of ponded TRA process water into the perched water zones and subsequent infiltration to the SRPA, except for the planned construction of a new, lined warm waste evaporation pond and closure of the three cells of the existing warm waste pond. This scheduled action also includes warm waste pond sediment treatment and either storage or disposal. The Proposed Plan for this activity has been prepared separately and is not part of the PWS OU. Closure of the existing warm waste pond and construction of a new pond would occur under each of the four candidate remedial alternatives. The newly planned warm waste pond has been designed to meet RCRA Subtitle C requirements, including a double-lined evaporation pond with a leak detection/collection system. Warm waste pond closure and construction of the new pond are scheduled to occur in 1992 if the appropriate permits are obtained.[a]

For purposes of the FS evaluation, the assumption has been made that no additional warm waste pretreatment at TRA would be performed to reduce contaminant concentrations or waste discharge below the current 10 gpm discharge rate. However, since the new warm waste pond is designed to prevent warm waste migration into the soils, this activity is considered to result in warm waste source removal.

Access restrictions, property use restrictions, and ground-water monitoring institutional controls would be expected to take place under the No Action alternative because of the land use nature of INEL facilities. These institutional controls would also take place under the other candidate remedial alternatives. The access and property use restrictions are assumed to remain in place for 125 years from the present.

Available information indicates that TRA will operate until 2014 in a similar manner to the present operations. Activities associated with the potential closure of the cold and chemical waste ponds are not known at this time. However, results of a recently completed HRA for the chemical waste pond indicate little or no threat to human health or the environment[a]. A similar HRA is scheduled to be completed for both the cold waste and sanitary disposal ponds in 1993. Based on chemical characteristics of the wastes discharged to these two ponds, and comparing this information to the COCs identified for the PWS OU, these ponds are not expected to contribute to unacceptable risks to human health or the environment. As a result, discharge rates to these ponds, as given in Section 2, have been assumed to remain unchanged for purposes of the FS.

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[a]Personal communication with Don Vernon EG&G Idaho Inc., Idaho Falls, Idaho, August, 1991

Based on the scenario presented for the No Action alternative, two-dimensional computer modeling of the PWS was performed to simulate the continued migration of perched water to the SRPA. A detailed discussion of the ground-water modeling performed is given in Section 5 of the RI report. Results of this modeling, in conjunction with the HRA, are discussed for the No Action alternative in the detailed analysis of alternatives (Section 4).

3.2 Alternative 2-Physical/Chemical Ground-Water Treatment

Physical/chemical ground-water treatment may involve the use of one or several treatment process options to achieve the RAOs. Ground water would be pumped to the surface from strategically placed extraction wells, and held for temporary storage in a suspended solids removal/flow equalization basin prior to treatment. Ground-water pumping would be identical for both Alternatives 2 and 3, physical/chemical treatment and evaporative treatment, respectively.

In order to estimate the number of extraction wells and their associated pumping rates needed for the remedial action, a horizontal, two-dimensional, finite difference model of the deep perched water zone was developed. The model for this effort only was configured as follows:

- Model cells for the deep perched zone are 100 feet by 100 feet.
- The spatial domain of the model corresponds to the areal distribution of the deep perched water zone in 1991 (see Figure 3-1).
- The lateral boundaries of the model were set as no flow boundaries.
- No areal recharge or discharge was allowed to occur. This was assumed in order to develop a conservative estimate of a sustainable pumping rate from the deep perched zone for the remediation period.

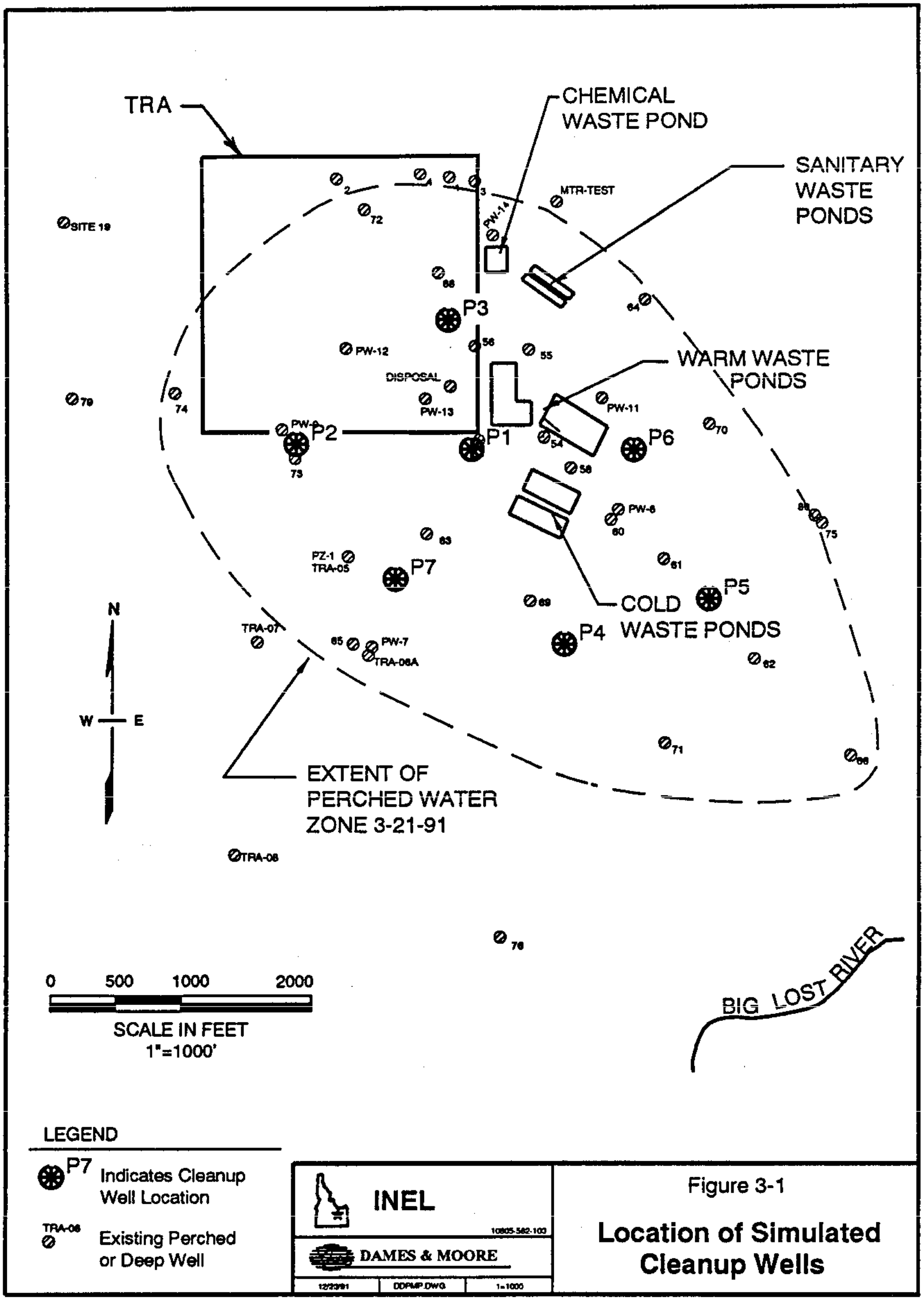

Figure 3-1. Location of simulated cleanup wells.

- A uniform initial head of 85 feet was specified in the model (this was computed as the ratio of the volume of water in the deep perched water zone over the area of the deep perched water zone in 1991).

- The hydraulic conductivity was set to 10 feet/day and the basalt rock was assumed to be isotropic in the horizontal direction. The specific storage was set to 5×10^{-5} ft^{-1} and the specific yield was set to 0.1 (as specified in the RI portion of this document).

- Seven extraction wells were included in the model, each pumping at a continuous rate of 25 gpm. The proposed locations of these wells are shown in Figure 3-1.

Transient simulations were performed to assess the rate of drawdown on the wells as a function of time using the 25 gpm discharge rate for all seven wells. Under the assumed conditions, the maximum and minimum drawdowns are shown in Figure 3-2. The actual rate of drawdown is likely to be less than the predicted drawdown shown in Figure 3-2 with the proposed 175 gpm pumping rate due to discharge to the cold waste pond.

Leakage from the PWS will also affect drawdown of the proposed extraction wells such that the actual drawdown would be a function of both leakage and pond discharge. The actual drawdown would likely be less than simulated even if both pond discharge and leakage from the PWS were considered. This is based on the observation that water levels in the PWS respond rapidly to discharge to the waste ponds (that is, the response of the PWS is more sensitive to pond discharge than to leakage from the PWS). Therefore, since no recharge was assumed to occur from TRA disposal ponds for this exercise nor was discharge to the SRPA assumed to occur, the total withdrawal of 175 gpm is assumed to be conservative. These modeling results are for estimating potential flowrates only, and are not for design purposes. Additional modeling efforts would be needed to confirm a maximum sustainable pumping rate for the PWS, taking areal discharge and recharge into account. At the present time a stable balance is assumed to exist between the on-going recharge from TRA disposal ponds and discharge to the SRPA. Installation of a pumping system would upset this current balance, but since the proposed pumping rates are below the discharge rates the deep perched zone would not be expected to completely dissipate. The selected

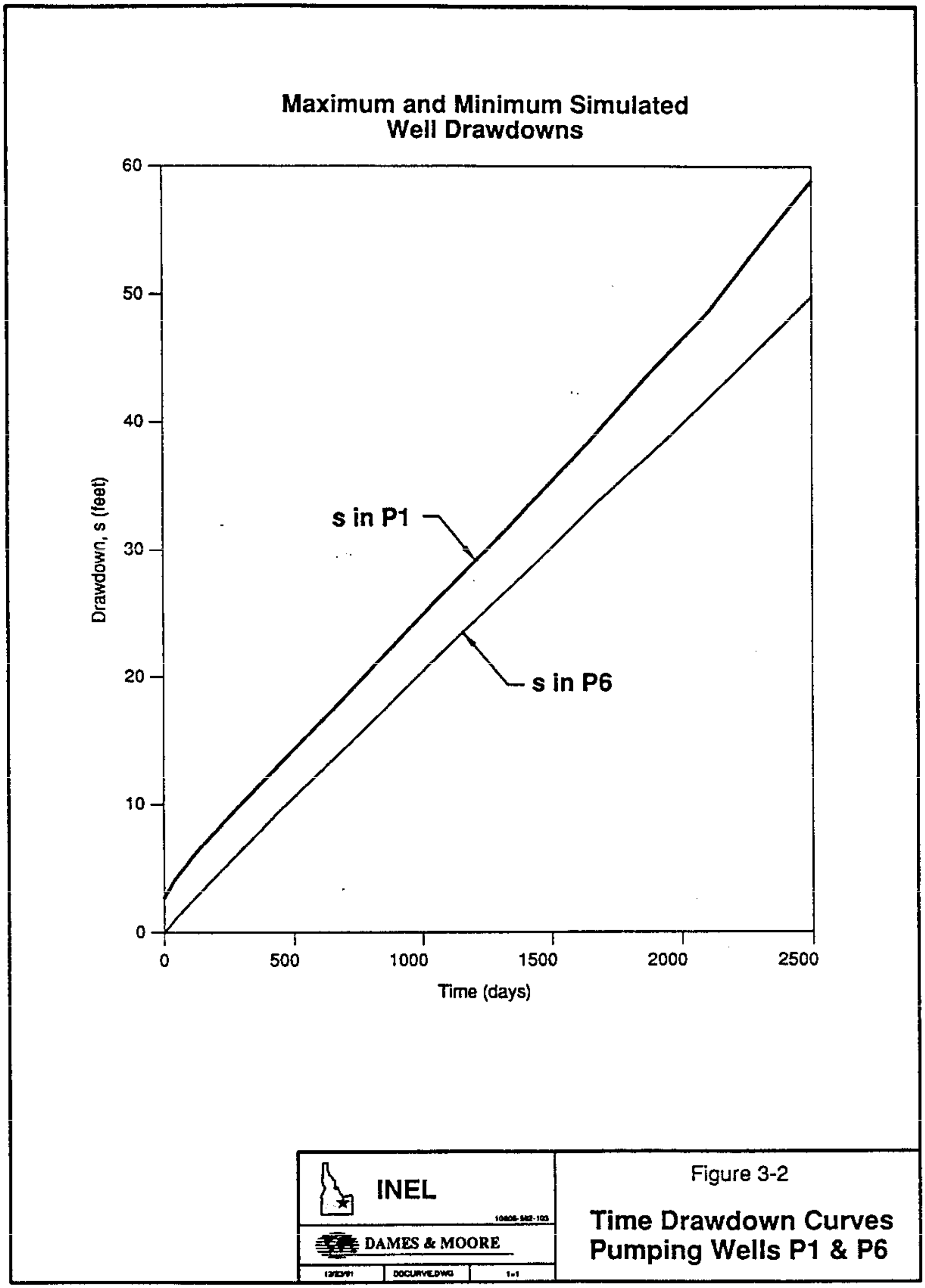

Figure 3-2. Time Drawdown Curves Pumping Wells P1 & P6

pumping rate is such that the radius of influence from the wells would capture the suspected extent of contaminated water in the deep perched zone.

For purposes of the FS the assumption has been made that approximately 75% of the water present in the PWS could be recovered through pumping. This percent recoverable was assumed using best engineering judgement; since well efficiency decreases as water levels decrease in each extraction well, a 75% recovery rate was assumed to be reasonable. This total recoverable volume would be approximately 785×10^6 gallons. Using a simplifying assumption, pumping this volume would require approximately nine years to complete at 250,000 gpd (i.e., 175 gpm), and assuming no new contaminated discharge occurs. Because water continuously enters and exits the PWS, the proposed nine year pumping period for remediation is considered to be conservative. Appropriate water quality monitoring would be performed during the course of the remedial action to evaluate the resulting changes in COC concentrations from pumping and treatment. Due to the continued dilution of the PWS with cold, chemical, and sanitary waste streams, the actual remediation period may be less than nine years, since COC concentrations would meet MCLs sooner. Well permitting, installation, and treatment plant construction and start-up would require an additional year to complete. Treatment plant decontamination and decommissioning and removal would be assumed to add an additional year to the remedial process.

Two fundamental issues must be addressed in evaluating the feasibility of the physical/chemical treatment alternative. First, since in situ ground-water treatment was eliminated from consideration during the technology screening process, the feasibility of ground-water extraction must be evaluated to determine whether COCs can successfully be transported to the surface for treatment. Second, physical/chemical treatment methods for removal of contaminants from the PWS must be evaluated for their overall protection of human health and the environment.

Results of mathematical modeling studies indicate that pumping rates of approximately 175 gpm, 0.25 million gpd are sustainable under current conditions, if the existing warm waste ponds are closed. Further discussions of the feasibility of physical/chemical treatment are based on this assumed pumping rate.

Process options considered for use include ion exchange, membrane technologies, chemical precipitation/co-precipitation, and/or redox reactions. In the case of ion exchange, a lined evaporation pond would be required to receive the regenerate solution, if produced, from exchange resin reactivation. A lined evaporation pond would also be required for the membrane technology brine streams. An evaluation of these potential physical/chemical treatment processes is made in the following sections in order to select a representative treatment train. Treatability studies would be required for any physical/chemical process prior to implementation as part of a remedial alternative.

3.2.1 Physical/Chemical Treatment Option Evaluation

As previously described, physical/chemical treatment refers to the use of conventional treatment processes to remove COC's from extracted ground water. In order to proceed with the detailed analysis of Alternative 2, a representative treatment train must be defined. This section evaluates the effectiveness and technical feasibility of the screened treatment process options. Through this evaluation process physical/chemical process options can be combined to create a potentially viable remedial alternative.

Several potentially applicable process options were eliminated from consideration during the technology screening process (see Section 2). These technologies include carbon adsorption, activated alumina adsorption, and chelation/ultrafiltration, biological treatment, in situ treatment, and off-site treatment. Conventional process options considered for possible inclusion in this remedial alternative consisted of:

- Coagulation/flocculation with iron (Fe^{+3} or Fe^{+6}) salts

- Chemical precipitation including hydroxide, carbonate, and/or sulfide precipitation

- Oxidation/reduction

- Physical settling and/or filtration

- Ion exchange with ion-specific resins

- Membrane technologies.

Evaluation of these process options was based on their potential effectiveness in removing the COCs as well as their technical feasibility. This evaluation was based on available site characterization data because no treatability testing has been performed as part of the RI/FS. The following assumptions were used as a basis for this technology assessment:

- The RA for the PWS OU (see Section 6 of the RI report) concluded that americium-241, cobalt-60, strontium-90, tritium, cesium-137, arsenic, beryllium, cadmium, chromium, fluoride, lead, and manganese were the contaminants of human health concern for site ground water.

- The metal pollutants present in the ground water would not need to be removed in order to meet ARARs for discharge of the treated effluent. Metal substances whose average concentrations in the deep perched zone currently exceed potential ground-water ARARs include manganese, although the manganese limit is only a secondary drinking water standard.

- Alpha emitting radionuclides were detected in subsurface materials up to 40 feet BLS; however, the previous studies indicate that uranium-234 and uranium-238 were the major alpha emitters in the deep perched zone. The occurrence and form of americium-241 is uncertain. The solubility of americium-241 is reported to be extremely low and is most likely present in ground water as colloidal americium oxyhydroxide solids.

- Previous studies indicate that cobalt-60 was present in concentrations up to 2 orders of magnitude above background concentrations in subsurface materials at depths from 30 to 60 feet BLS; however, order of magnitude reductions in cobalt-60 concentrations in ground water were reported between 1981 and 1991 from its relatively rapid rate of decay (i.e., cobalt-60 half-life is 5.3 years).

- The form that cobalt-60 exists in Site ground water is unknown, and specific cobalt-60 solids that might control its solubility have not been identified. For the purposes of this evaluation, the solubility control is assumed to be the blue cobalt precipitate, $Co(OH)_2$ ($K_{sp}=10^{-15}$). Data indicates that cobalt-60 is undersaturated with respect to this solid at a pH of 8.0.

- Strontium-90 exceeded Federal Primary Drinking Water Standards of 8 pCi/L in the deep perched aquifer; however, the form of strontium-90 in the PWS is unknown. Reported strontium activities indicate undersaturation with respect to a possible solubility control, strontianite, ($SrCO_3$, $K_{sp}=10^{-9.0}$), assuming equilibrium with carbonate at 10^{-5} M.

- None of the treatment processes would be effective in removing tritium. The detailed analysis of alternatives will examine whether the proposed treatment train alternative is effective for the potentially treatable radionuclides in order to meet risk-based limits, with the assumption that tritium would not be removed.

3.2.1.1 Coagulation/Flocculation. Coagulation/flocculation by the addition of iron salts is an effective, widely used method of water treatment. Contaminant removal occurs by two possible mechanisms. First, colloidal solids are destabilized during the formation of ferric hydroxide complexes. The destabilized particles are more readily agglomerated into large solid masses, or flocs, during the flocculation stage. Second, some dissolved species are adsorbed on the solid surfaces during floc formation. Ferric chloride ($FeCl_3$) is commonly used as a coagulant; however, potassium ferrate (K_2FeO_4) has recently proven effective in the removal of colloidal radionuclides in bench- and pilot-scale tests performed at several DOE facilities.[b] Contaminant removal is facilitated by the formation of ferric hydroxide/contaminant complexes that are readily separated from the aqueous phase.

Chemical species likely to be removed by iron coagulation and co-precipitation include chromium, americium-241, and possibly cobalt-60 in the particulate forms through destabilization, and manganese and cobalt-60 in the dissolved phase through co-precipitation

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[b]Personal communication with Gary Tye and Duane Churchwell, ADC, June, 1991.

(Yodnane et al. 1991). Dissolved strontium-90 is not expected to be removed due to its chemical similarity to calcium. Tritium would not be removed. Removal efficiency with iron precipitation would require quantification through bench- and/or pilot-scale treatability studies using representative samples of the perched ground water. Further, contaminant treatment efficiencies are difficult to predict due to their low concentrations in the PWS. For purposes of the FS evaluation, treatment efficiencies of 50% have been assumed for those substances likely to be removed by iron precipitation. This assumption is conservatively based on removal efficiencies reported in the literature and best engineering judgment. Available data for predicting potential treatment efficiencies show higher contaminant concentrations in solution by several orders of magnitude. As a result, a quantitative evaluation for physical/chemical treatment is difficult without appropriate treatability data.

Advantages of coagulation/flocculation include:

- No pretreatment such as neutralization, oxidation, and/or reduction would be required assuming near neutral pH conditions in the perched ground water. Iron coagulation is most effective in the pH range of 7.5 to 8.5.
- Both solids and dissolved species are removed within the limits discussed above, and some oxidized and reduced species may be adsorbed. Evidence suggests that hexavalent chromium may be removed by coprecipitation or adsorption on the surfaces of freshly precipitated iron hydroxides under oxidizing conditions (Boling, et al., 1991).
- Noncontaminants such as calcium, magnesium, and sulfate would not be removed, thereby, reducing reagent usage and the sludge volume. Sludge volumes are expected to be approximately 30% lower compared to chemical precipitation methods.
- The technology is readily available, relatively inexpensive, reliable, and would be easily evaluated through treatability testing.

Disadvantages of coagulation/flocculation include:

- Tritium and strontium-90 would not be removed.

- Removal efficiencies for other species such as dissolved chromium are unpredictable without treatability data.

3.2.1.2 Chemical Precipitation. Chemical precipitation refers to the use of various chemical reagents to change the pH of the water in order to lower contaminant solubilities and provide ligands for the formation of solid precipitates. Precipitation can be achieved through the use of hydroxides such as lime or caustic, carbonates such as soda ash, or sulfides such as sodium sulfite or sodium sulfide. The treatment objective is to form solid precipitates that are readily separable from the treated effluent. Treatment residuals would consist of the concentrated settled solid precipitates, which would have a maximum solids content of 20 to 30%. The treated effluent generally requires neutralization prior to discharge.

Potential removal efficiencies are dependent on the concentrations of contaminants present in the influent and their solubilities with respect to the solid precipitates formed under the optimum pH conditions. Cobalt-60 and strontium-90 are present in the PWS at low concentrations, and would not be expected to be removed by hydroxide or carbonate precipitation. Chromium and strontium-90 removal is theoretically possible through precipitation and subsequent settling. Cobalt-60 removal by sulfide precipitation is possible because its solubility may be lowered considerably with respect to cobalt sulfide ($K_{sp} = 10^{-21.3}$). Colloidal solids removal is possible by chemical precipitation by sweep flocculation, where particles are physically captured by the settling macroscopic flocs; however, removal by this mechanism may be unpredictable.

Quantifying removal efficiencies for chemical precipitation for the PWS water can be reliably predicted only through treatability testing. For purposes of the FS evaluation a removal efficiency of 50% for chromium and strontium-90 is assumed based on available data in the literature and best engineering judgment. No removal of americium-241 and cobalt-60 is assumed to occur with chemical precipitation due to their assumed presence in colloidal forms, as opposed to ionic forms. Tritium would not be removed with this technology.

Advantages of chemical precipitation for perched ground-water treatment include

- The technology is readily available, relatively inexpensive, reliable, and would be easy to evaluate through treatability testing.

Disadvantages of chemical precipitation include

- Chemical reagents must be provided in quantities greater than the stoichiometric requirement in order to raise the pH to the optimum treatment range and improve reaction kinetics.

- Pretreatment may also be required to oxidize and/or reduce species to forms that are more amenable to treatment; however, because these two pretreatment steps oppose each other, two-stage treatment may be necessary. For example, chromium is more amenable for removal in its reduced form while manganese is more amenable in its oxidized state.

- Elements that are not considered to be COCs such as calcium, magnesium, iron, sulfate, phosphate and others may also be precipitated, depending on the reagents used, thereby, increasing reagent demands and sludge volumes. Sludge volumes may be approximately 30% greater than those produced by coagulation/ flocculation.

- Use of polymers or coagulants may be required to improve solids settleability, thereby, adding to treatment costs and sludge volume.

- Colloidal solids and contaminants present at concentrations below their solubilities under optimum treatment conditions may not be effectively removed.

- The COCs would need to be ionized or dissolved in order to be removed.

3.2.1.3 Oxidation/Reduction. Oxidation/reduction technologies are variations of the chemical precipitation techniques. However, under this method the solubilities of target substances are lowered through chemical manipulation of the oxidation/reduction potential instead of adjusting pH, as with the chemical precipitation process option.

Chemical oxidation at near neutral pH may be effective in removing iron and manganese from the ground water through precipitation while removing some dissolved and particulate species through co-precipitation. Boling, et al., (1991) demonstrated effective removal of iron, dissolved manganese, dissolved and total chromium, and other priority pollutant metals from acid mine drainage by chemical oxidation with chlorine and permanganate. The mechanism of chromium removal was not described but physical capture of particulate chromium and adsorption and co-precipitation of the dissolved phases are possible.

Reduction may be effective in reducing chromium concentrations; however, removal of americium-241 and cobalt-60 by oxidation/reduction is uncertain. Further, removal of strontium-90 would not be expected due to its chemical similarity to calcium, which was not affected by oxidation/reduction in treatability studies performed by Boling, et al., (1991). Oxidation/reduction would not remove tritium.

Chemical reduction and precipitation through the use of sulfide salts is commonly used in the treatment of metal-bearing industrial wastewater. Most metal sulfides are highly insoluble, and certain dissolved species are readily precipitated in solutions of excess sulfide. However, chromium does not complex with sulfide, and a chemical precipitant such as lime or caustic is required to achieve precipitation of reduced chromium. Also, removal of colloidal radionuclides by physical capture or co-precipitation is uncertain. The oxidation/reduction process option would not remove tritium from the perched ground water.

Oxidation and reduction alone would not be effective for contaminant removal. However, these technologies may be required as pretreatment methods for use in conjunction with chemical precipitation.

Similarly to chemical precipitation/co-precipitation, advantages of oxidation/reduction for perched ground water treatment include

- The technology is readily available, relatively inexpensive, reliable, and would be easy to evaluate through treatability testing.

Disadvantages of oxidation/reduction include

- The mechanism for radionuclide removal is not certain, and has not been described in previous studies as an effective stand-alone process option.

- Strontium-90 and tritium would not be removed by this method.

3.2.1.4 Settling and/or Filtration. A solids separation process would be required for any of the three process options described above. Gravity separation of the precipitates formed during coagulation, chemical precipitation, and/or oxidation/reduction is typically used to separate solids. Settling basins or clarifiers of various designs are the principal means available for physically separating the solid and aqueous phases. Clarifiers serve the dual purpose of facilitating gravity separation and promoting solids thickening. Solids concentrations in the treated effluent are typically reduced below 100 parts per million (ppm) while solids concentrations in the waste sludge may be increased from less than 1% to over 4%.

Gravity separation, however, would not remove all solid particles formed during chemical treatment. The colloidal particle fractions would not settle due to their small size. Other small particles may require excessively long hydraulic retention times for effective removal. Therefore, filtration may be required to achieve an acceptable level of solids separation. Rapid sand or dual media filtration are conventional technologies proven to be effective in removal of non-settleable particles when used in conjunction with chemical coagulation/flocculation.

Advantages of settling and/or filtration include:

- The technology is readily available, relatively inexpensive, reliable, and would be easy to optimize for a variety of applications.
- Represents an effective method to further polish clarifier effluent prior to discharge.

Disadvantages of settling and/or filtration include:

- May require manual removal of sludge blanket as headloss through the filter becomes excessive.
- The filter media may require appropriate disposal with the contaminated sludges at the end of the remedial action.

3.2.1.5 Ion Exchange. Ion exchange is accomplished with an ion exchange resin having ionic functional groups that allow ionic species in solution to become attached and subsequently removed from the solution. Resins are synthetic materials (i.e., insoluble acids or bases) usually having a high tolerance to wide ranges in pH and temperature. In most cases resins are chosen for their ability to selectively remove specific ions from solution. Some resins are less selective and can be used to remove a wide range of ionic species. Because the exchange reaction is reversible, the resins can be regenerated. Regeneration is typically accomplished with a strong acid or base.

Most resins are polystyrene-based, with divinylbenzene used as a linking agent for the styrene molecules. Resins are divided into cation and anion exchange types. Cation exchangers are further separated into strong-acid, weak-acid, and chelating resins. Anion exchangers include strong-base and weak-base resins.

Strong-acid exchangers operate under any pH condition, and are typically most useful for highly charged cations and those having larger hydrated radii. Since these resins do not hold hydrogen ions effectively, they tend to be more difficult to regenerate than weak-acid resins. Weak-acid resins are easier to regenerate due to their association with the hydrogen ion, but operate poorly under a pH of 4. Chelating resins are similar to weak-acid resins and do not operate well below a pH of 4; however, they are typically well suited to selective cation removal. Relatively slow reaction kinetics is a major disadvantage of chelating resins, which results in the need for lower hydraulic loading rates.

Similar to strong-acid resins, strong-base resins do not associate well with the hydroxide ion and are more difficult to regenerate; however, they will operate under any pH condition. Strong-base resins are useful in removing the anions in the splitting of salts. Weak-base resins are generally not used for splitting salts and operate effectively only under lower pH conditions. Weak-base resins are usually regenerated easily.

There are two types of design for ion exchange systems, cocurrent and countercurrent (fixed head and continuous ion exchange, respectively). The cocurrent design involves passing a solution through the ion exchange column or reactor. The process may continue until breakthrough of the sought-after contaminant occurs. A backwash step fluidizes the resin bed and removes the suspended solids retained by the resin. A dilute acid or base solution is then passed through the column for regeneration and expelled using a water wash. The resin is usually washed again with clean water prior to being placed back into service. However, resin regeneration may not be desirable due to the removal of radionuclides from solution. The process may warrant disposal of the resin after all available exchange sites are occupied, thereby, reducing the potential handling steps required for the removed radionuclides.

Countercurrent, or continuous design allows the solution and the resin to pass countercurrent to one another. This hydraulic configuration results in a portion of the resin bed being continuously removed and regenerated. In the concurrent design, the entire resin bed becomes spent over time. The amount of resin available for exchange decreases until the entire resin bed is regenerated. In the continuous mode, an equilibrium can be established as needed for the resin exhaustion, regeneration, and rinsing steps. This allows lower required resin inventories than the concurrent design. Countercurrent design can be either a pulse or fluidized bed type. The pulse type moves the resin through the reactor chamber by applying either pressure or a vacuum to the system. Fluidized beds have uncompacted resin beds in the reactor that are suspended through the use of baffles or mechanical agitation. Each design configuration has advantages and disadvantages, although effluent quality is generally not significantly different with one type or the other.

A common ion exchange application includes waste treatment for removal and recovery of radioactive materials from nuclear reactor and laboratory wastes. The chemical specification of the radioactive COCs present in the PWS are not known, only specific activity levels. However, most forms of the oxides and hydroxides of cobalt-60, and oxides of americium-241 are insoluble in water. Therefore, the applicability of ion exchange treatment in effective removal of these contaminants would be difficult to assess without performing specific treatability testing with representative samples from the PWS. Bench-scale laboratory studies conducted by Allied Chemical Corporation indicated that strontium-90 may be removed from a wastewater stream using ion exchange. Based on available information, it is expected that a significant portion of the ionized forms of target radionuclides such as cobalt-60, americium-241, and strontium-90 could be effectively removed through ion exchange. However, the presence of other cations, such as calcium and magnesium, could introduce competition for exchange sites on the resin, and may significantly limit the overall treatment effectiveness.

In order to attain maximum treatment efficiency of an ion exchange system, some form of pretreatment may be required. Insoluble radionuclides, suspended solids and competing ions such as calcium should be removed from the influent stream. This may be accomplished through precipitation, coagulation, gravity settling, and/or filtration. Waste streams generated from the above treatment scheme would consist primarily of spent resins and the associated regenerate stream. Either a cocurent or countercurrent system design could potentially be used.

Advantages of ion exchange treatment include

- The technology is readily available, reliable, and can be easily evaluated with treatability testing.
- Strontium-90 may be removed.

Disadvantages of ion exchange treatment include

- Would be ineffective in removing insoluble, colloidal forms of the target COCs.
- May be ineffective if strong competition with other cations are present in the PWS.

3.2.1.6 Membrane Technologies. Membrane technologies generally refer to microfiltration (MF), ultrafiltration (UF), and reverse osmosis (RO). Each of these specific technologies are defined by the effective removal of the smallest particle or molecule that is retained on the membrane itself. In general, MF will remove particles ranging from 0.02 to 10 μm in diameter, UF will remove particles ranging from 0.001 to 0.02 μm in diameter, and RO will remove ions and particles ranging from 0.0001 to 0.001 μm in diameter. Removal of the ionic forms of the target substances of concern could potentially be accomplished through RO, while insoluble forms of these target substances would be most appropriately removed through UF.

Reverse osmosis membranes typically reject from 90 to 99% of the salts and 90% of the organic materials. There was no data available specifically related to rejection of radionuclides such as cobalt-60, americium-241, cesium-137, and strontium-90. Polyamide membranes are being used for treating industrial wastewater, particularly for removal of metals. These have high chemical and physical stability conducive to longer lifetimes. The reject stream, which constitutes a significant volume of the wastes generated through membrane filtration would also contain the radionuclides present in the influent stream. As with the other physical/chemical technologies discussed, tritium would not be removed through any of the membrane technologies. In addition, RO membranes are susceptible to fouling problems caused by iron, manganese, sulfur, and various other metal oxides. Therefore, pretreatment would be required prior to using RO. Coagulation/flocculation followed by gravity settling may be employed as a pretreatment step. Process- and material-specific treatability studies either at bench- or pilot-scale level would be required in order to examine the suitability of membrane technologies to treat PWS water.

Advantages of membrane technologies include:

- The technology is readily available and easily evaluated through treatability testing.
- May be effective in removing both colloidal and ionic contaminant forms.

Disadvantages of membrane technologies include:

- Would remove many ionic substances not considered to be COCs for the PWS, and could create competition for effective contaminant removal.
- Higher pressure requirements for either MF, UF, or RO create additional operating concerns, and can add overall complexity to the treatment process.

3.2.1.7 Selected Treatment Technologies. Based on the technical merits of the potential unit operations discussed above, Alternative 2, Physical/Chemical Ground-water Treatment, would be comprised of the following treatment train:

- Primary treatment consisting of iron coagulation/flocculation
- Gravity settling and rapid sand or mixed media filtration for primary solids separation, sludge thickening, filter pressing, and disposal.

Chemical precipitation was eliminated due to its limited or uncertain removal of contaminants compared to the potential removal efficiency for iron coagulation/flocculation. The potential effectiveness of ion exchange as a secondary or polishing treatment process appears to be limited based on the assumption that the COCs, remaining after primary treatment, are likely to exist as colloidal solids. High pressure membrane technologies such as RO were eliminated because removal of dissolved substances such as calcium, magnesium, and sulfate are not COCs for the PWS OU. Moderate pressure membrane technologies such as MF and UF were eliminated in favor of rapid sand or dual media filtration. The cost of UF is relatively high compared to rapid sand filtration and treatment efficiencies are comparable. If treatability testing indicated additional problems associated with iron coagulation/flocculation and sand filtration, the other physical/chemical technologies could be examined further for their applicability.

Figure 3-3 represents the conceptual schematic design for physical/chemical treatment under Alternative No. 2. The schematic will serve as a basis for the detailed analysis of this alternative. The evaluation of this treatment train is performed in Section 4 of this document using the following assumptions:

- Groundwater would be pumped from strategically placed extraction wells at a rate of 175 gpm (0.25 million gpd), and held for temporary storage in a flow equalization basin prior to treatment.

- The total volume of water to be treated over the course of remedial actions is estimated at approximately 7.8 x 10^8 gallons. This is equivalent to approximately 75% of the current estimated volume of water in the PWS.

- Because contaminant concentrations are relatively low, treatment efficiencies are difficult to predict without access to bench- or pilot-scale treatability data. Removal efficiencies of 50% for chromium, manganese, americium-241, and cobalt-60 are assumed for coagulation/flocculation using available information in the literature previously cited and best engineering judgement.

- No strontium-90 or tritium removal would occur during treatment.

- Removal of contaminants immobilized or adsorbed within the subsurface material matrix during pumping and treatment is uncertain. For purposes of the detailed analysis, the contaminant concentrations for the PWS are assumed to remain constant for a nine-year period.

- Ferric chloride is assumed to be the coagulant used in the primary treatment.

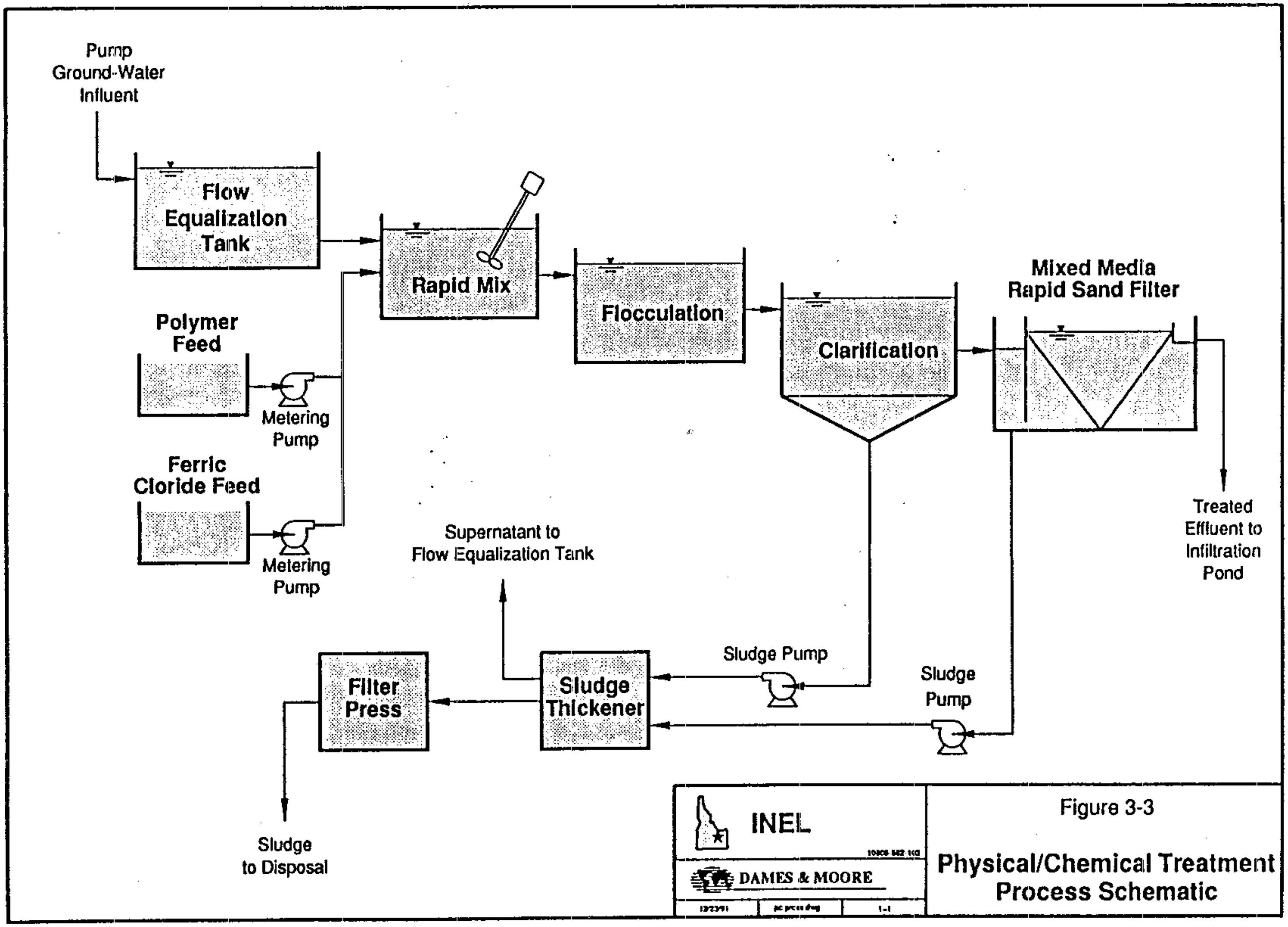

Figure 3-3. Physical/Chemical Treatment Process Schematic

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- Treated effluent would be discharged to an unlined pond and allowed to infiltrate. Treated groundwater would not be discharged to natural surface water bodies, storm sewers, or sanitary sewers. The use of strategically placed injection wells may be used in place of an unlined infiltration pond. A decision regarding the use of one or the other would be made in the Remedial Design/Remedial Action period. However, for FS purposes, an unlined disposal pond has been assumed to be representative of the disposal options. In addition, the potential exists for reusing the treated water for TRA operations. However, this would also be addressed in the Remedial/Design/Remedial Action period.

- Treatment residuals would be disposed on site in accordance with requirements of action-specific ARARs. For purposes of the detailed analysis, construction of a repository that meet RCRA Subtitle C standards is assumed for the disposal facility.

- Treatment facilities would be located adjacent to the TRA, but would be situated so they did not interfere with existing TRA operations.

- Existing site conditions are assumed to prevail throughout the duration of treatment with the exception of the closure of the existing warm waste ponds.

Location of a physical/chemical treatment facility would be in a newly constructed treatment facility in proximity to the TRA. Installation of a treatment plant would be made so that interferences of the TRA operation would not occur. Based on optimum well locations as determined by ground-water modeling efforts, a centrally located treatment facility would be constructed outside the TRA operations area. Additional activities associated with the existing warm waste pond closure, institutional controls, and planned examination of the cold and chemical waste ponds would be identical to those described for the No Action alternative.

3.3 Alternative 3-Evaporative Ground-Water Treatment

Evaporative ground-water treatment would involve pumping ground water for direct disposal to one or more lined evaporation ponds. Ground-water pumping for this alternative is identical to that described for Alternative No. 2. Well locations and optimum pumping rates have been determined by groundwater modeling efforts.

Pond sizing has been determined based on the optimum ground-water pumping rates and the estimated evaporation rate for the TRA. Ground-water pumping rates must be modified throughout the year due to seasonal variations in the evaporation rate at the TRA. Evaporative treatment of site ground water refers to the use of incident solar energy to reduce the volume of water and concentrate COCs in sediments, brine solutions, and/or precipitates for subsequent disposal. This alternative would not include the use of external, artificial sources of energy or devices to focus or intensify natural solar radiation. The use of external energy sources such as mechanical surface aerators may result in decreasing pond size requirements. However, for purposes of the FS, natural evaporation was assumed to be representative of the technology. Further detailed consideration can be given to external energy sources in the Remedial Design/Remedial Action phase.

For purposes of the FS the assumption was made that the ponds would be constructed in accordance with RCRA Subtitle C requirements. This includes a liner system with a leak detection/collection system, and a ground-water monitoring network consisting of four monitoring wells located in strategic locations around the facility boundary. Closure of the pond upon completion of ground-water pumping would involve closure in-place. Closure activities would be in accordance with all applicable RCRA requirements.

Location of the ponds would be in the vicinity of the TRA and would not be expected to interfere with TRA operations. Sizing of the ponds has been estimated using available regional hydrologic data. Preliminary estimates show that pond area required to effectively evaporate 250,000 gpd would be approximately 93 acres. Since the general land area surrounding the TRA is currently not developed, the pond could be located in general proximity to the TRA and the proposed ground-water extraction wells. Activities associated with the warm waste pond, institutional controls, and examination of the cold and chemical waste ponds would be identical to the No Action alternative.

Action-specific ARARs for the construction of evaporative treatment ponds may depend on the actual concentrations of contaminants extracted from the PWS. If contaminant concentrations exceed certain limits, facility standards delineated under RCRA may be relevant and appropriate.

For the purpose of all subsequent discussions and evaluations of this alternative, the following set of assumptions is applied:

- The combined surface areas of the evaporative pond system are based on the assumption of a pond storage capacity equal to two years of pumping volume and an average pan evaporation rate of approximately 36 inches per year. The system would consist of one or more lined surface-water impoundments with a total surface area of 93 acres, not including the areas of berms, access ways, or other supporting areas.

- Ground water would be pumped at rates of approximately 175 gpm (0.25 million gpd) followed by discharge to the surface water impoundments. The total volume of water to be pumped during the course of remedial action is estimated to be approximately 7.8×10^8 gallons.

- Given a total storage capacity equal to two year's pumping volume plus a free board allowance of 2 feet, the total depth of the ponds would be 5.5 feet.

- Ground water would be evaporated by natural incident solar radiation.

- The impoundments would be closed in accordance with action-specific ARARs for the site after completion of treatment, and bottom sediments would be disposed of in place in accordance with action-specific ARARs.

3.4 Alternative 4-Source Control

The Source Control alternative is characterized by reducing direct seepage to the PWS through additional treatment and recycling of current TRA process waters, except for the warm waste stream. Treatment currently used at the TRA to minimize radionuclide concentrations in the warm waste stream involves ion exchange. Modifications to reduce overall discharge volume include treatment of the cold and/or chemical waste streams through concentrating their chemical substances into a smaller volume and potentially recycling a distillate for reuse as a TRA process feed stream.

The cold waste stream represents over 90% of the total non-radioactive liquid discharge at the TRA. Of the three non-radioactive waste streams at the TRA, the cold and chemical streams have the greatest potential for overall flow reduction. For purposes of the FS, the sanitary waste stream discharge rates are assumed to remain unchanged for the operational life of the TRA.

As stated previously, results of a recently completed RA for the chemical waste pond indicate little or no threats to human health or the environment.[c] A similar RA is scheduled for both the cold and sanitary waste disposal ponds in 1993. However, based on chemical characteristics of the wastes discharged to these two ponds, and comparing this information to the COCs identified for the PWS OU, disposal activities at these two ponds are not expected to contribute to unacceptable risks to human health or the environment.

A commercially available, proprietary brine concentration technology was assumed to be a representative technology for source reduction of the cold, and possibly the chemical waste streams. Sizing and location of a treatment system for these waste streams would be different than ground-water treatment because of the differing chemical characteristics, concentrations, and estimated flow rates. While operational data from the existing treatment processes in place at the TRA could be used to assist in the design of a new or modified treatment system, material- and process-specific treatability testing data would be needed to further evaluate this proposed treatment technology. A schematic of the proposed concentration technology is shown in Figure 3-4.

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[c]Personal communication with, Don Vernon, EG&G Idaho Inc., August, 1991.

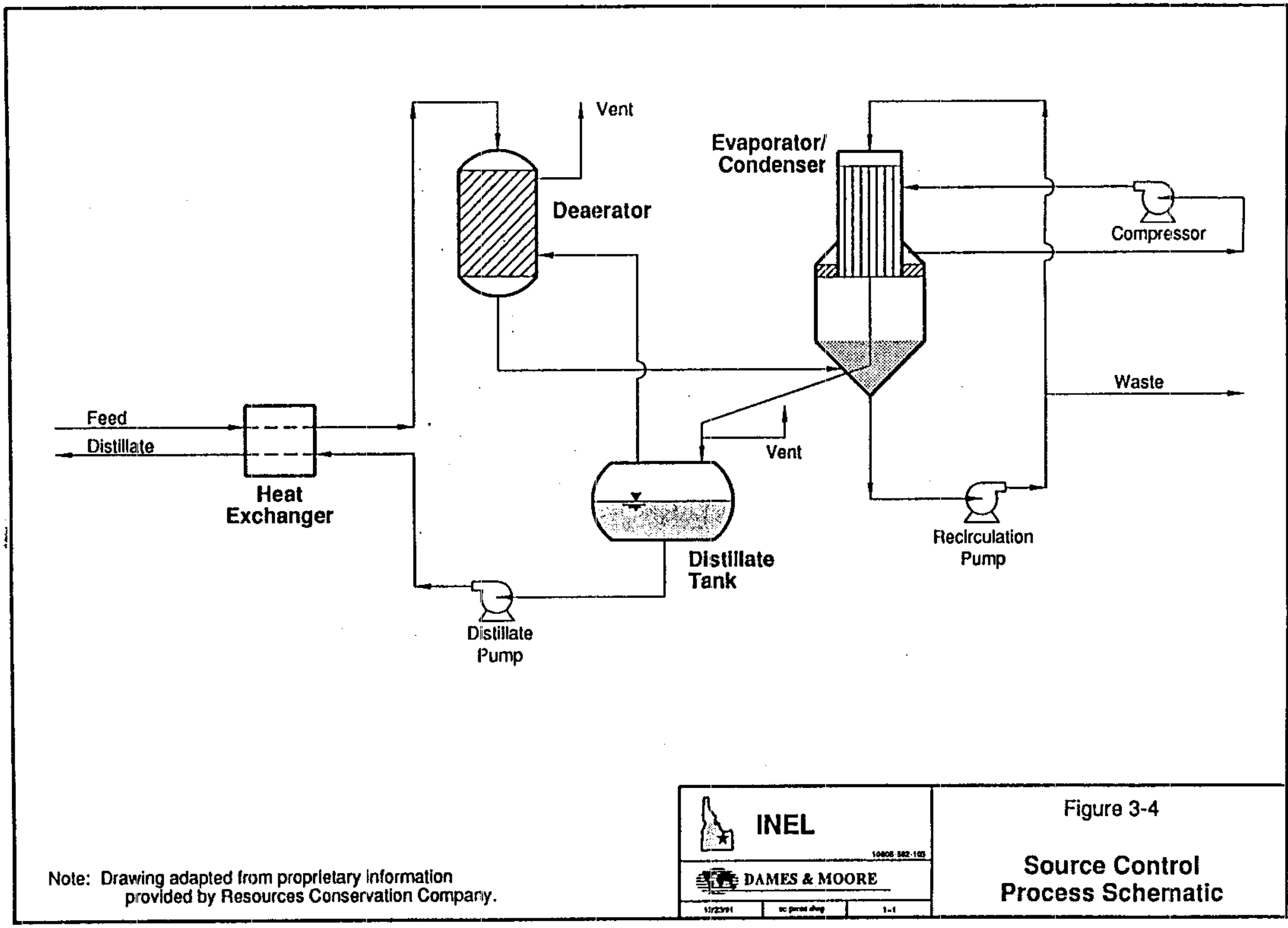

Figure 3-4. Source Control Process Schematic

The following assumptions have been used in developing the Source Control alternative:

- A location within the TRA operational area can be identified so minimum disruption of existing daily TRA operations are ensured.
- A chemical constituent concentration factor of 75 can be achieved with either the cold or chemical waste streams. The total waste stream flow rate to be treated averages approximately 500 gpm; thus, resulting in an effluent flow rate of approximately 7 gpm to be discharged to the existing disposal pond system.
- The proposed treatment unit would be capable of treating the cold waste stream alone, or a combined cold and chemical waste stream.

A discontinuance of the warm waste source, in addition to reduced chemical and cold waste discharge to the PWS via the discharge pond system would contribute to the gradual decrease in size of the shallow and deep perched zones beneath the TRA. Activities described for the warm waste pond, institutional controls, and examination of the cold and chemical waste ponds would be identical to the No Action alternative.

3.5 Summary

The four remedial alternatives described here represent a screened group of the most feasible remediation methods for the PWS OU. Further evaluation of these alternatives is presented in the detailed analysis of alternatives phase of the FS (Section 4). Treatability testing would be required for Alternative 2 through 4 in support of conclusions regarding the performance of specific treatment technology process options, should either of these be selected as the most favorable remedial alternative.

4. DETAILED ANALYSIS OF ALTERNATIVES

4.1 Introduction

This section presents results of the detailed analysis of remedial alternatives that were developed from the technologies and process options that passed screening in the initial phase of the FS. The detailed analysis of alternatives has been conducted in accordance with the NCP. This detailed analysis assesses individual remedial alternatives against the nine CERCLA evaluation criteria and compares the relative performance of each remedial alternative against the criteria.

The nine evaluation criteria are (1) overall protection of human health and the environment; (2) compliance with ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume; (5) short-term effectiveness; (6) implementability; (7) cost; (8) State acceptance; and (9) community acceptance. Analyses of the evaluation criteria numbers 1 through 7 are presented for each remedial alternative in this section. Evaluation of the State and community acceptance evaluation criteria will be performed after the public comment period on the RI/FS document is completed.

4.1.1 Methodology

The detailed analysis phase of the FS includes two components. The first component is an individual detailed analysis for each of the candidate remedial alternatives, which evaluates each remedial alternative using the first seven criteria listed above. The second component is a comparative analysis of alternatives that review the relative overall level of performance among the alternatives.

4.1.2 Detailed Analysis Process

For the detailed analysis of the four remedial alternatives from the initial phase of the FS, each remedial alternative is evaluated independently using the following evaluation criteria from § 300.430 of the NCP:

- *Overall protection of human health and the environment.* Alternatives shall be assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals consistent with § 300.430(e)(2)(i). Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

- *ARARs.* The alternatives shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws or provide a basis for invoking one of the waivers under paragraph (f)(1)(ii)(C) of this section

- *Long-term effectiveness and permanence.* Alternatives shall be assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative would prove successful. Factors that shall be considered, as appropriate, include:

  - Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

  - Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste. This factor addresses in particular the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.

- *Reduction of toxicity, mobility, or volume through treatment.* The degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include: (1) the treatment or recycling processes, the alternatives they employ and materials they will treat; (2) the amount of hazardous substances, pollutants, or contaminants that will be destroyed, or recycled; (3) the degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling and the specification of which reduction(s) are occurring; (4) the degree to which the treatment is irreversible; (5) the type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their substances; and (6) the degree to which treatment reduces the inherent hazards posed by principal threats at the site.

- *Short-term effectiveness.* The short-term impacts of alternatives shall be assessed considering: (1) short-term risks that might be posed to the community during implementation of an alternative; (2) potential impacts on workers during remedial action and the effectiveness and reliability of protective measures; (3) potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; (4) time until protection is achieved.

- *Implementability.* The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors as appropriate: (1) technical feasibility, including technical difficulties and unknowns associated with the construction and operation of the technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy; (2) administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for offsite actions); and, (3) availability of services and materials, including the availability of adequate offsite treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.

- *Cost.* The types of costs that shall be assessed include the following: (1) capital costs, including both direct and indirect costs; (2) annual operation and maintenance costs; and, (3) net present value of capital and O&M costs.

- *State acceptance.* Assessment of State concerns on the RI/FS will be addressed, in the Proposed Plan issued for the public comment. State concerns that shall be assessed include: (1) the State's position and key concerns related to the preferred alternatives and other alternatives; and, (2) State comments on ARARs or the proposed use of waivers.

- *Community acceptance*. This assessment 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 received.

Overall protection of human health and the environment and compliance with ARARS (unless a specific ARAR is waived) are threshold requirements that each alternative must meet in order to be eligible for selection as the recommended alternative. Long-term effectiveness and permanence, implementability, short-term effectiveness, reduction of toxicity, mobility and volume through treatment, and cost are considered primary balancing criteria. The remaining two criteria are considered to be modifying criteria.

4.1.3 Comparative Analysis of Alternatives

The comparative analysis assesses the relative performance among the alternatives against the evaluation criteria. Each alternative is evaluated individually against the threshold criteria (i.e., overall protection of human health and the environment, and compliance with ARARs), and the primary balancing criteria (i.e., long-term effectiveness and permanence, reduction of toxicity, mobility, or volume, short-term effectiveness, implementability, cost), and modifying criteria (i.e., State acceptance, and community acceptance). A comparative analysis is prepared, which gives a positive, neutral, or negative ranking for each alternative relative to the other alternatives. A comparative analysis summary indicates a net ranking for each alternative in order to aid in identifying a recommended alternative.

4.2 Detailed Analysis of Alternatives

Results of the detailed analysis for each candidate remedial alternative for the PWS OU based on the evaluation criteria identified in the NCP are identified in this section. As noted earlier, the evaluation of alternatives reflects the scope of the remedial action under consideration and the site problems being addressed. The scope of the PWS OU is limited only to the shallow and deep perched water zones beneath the TRA. The PWS OU is not intended to address issues related to the SRPA or other geographical areas at the TRA or INEL.

4.2.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is based on a comprehensive evaluation of each remedial alternative against the previously described evaluation criteria of long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Evaluation of overall protectiveness is considered by the NCP to be a threshold criterion, and failure to meet this criterion generally eliminates an alternative from further consideration. Assessment of an alternative's protectiveness integrates the analyses made under the other threshold criterion (i.e., compliance with ARARs) as well as under the primary balancing criteria, especially long-term and short-term effectiveness and permanence.

In order to meet this criterion, alternatives must adequately address the site-specific RAOs and must demonstrate protectiveness:

- Through their ability to eliminate, reduce, or control existing and potential risks associated with transport/exposure pathways
- By providing engineering controls and/or institutional controls in instances where risks to human health and the environment will remain after completion of remedial actions
- Through prevention of unacceptable risks and/or environmental contamination during alternative implementation.

Note that as a basic site condition for each alternative, the current warm waste source will be terminated. This will thus have a positive impact on overall protectin of human health and the environment.

4.2.1.1 Alternative 1–No Action. The No Action alternative would reduce concentrations of the COC in the PWS and the SRPA through time. Continued influence from the cold and chemical waste water disposal would result in continually decreasing contaminant concentrations. Also, radioactive decay will act to reduce radionuclide concentrations according to applicable halflives. Predicted contaminant concentration reductions for water from the PWS as it reaches the SRPA have been predicted as part of the ground-water modeling activities described in the RI portion of the document. The sensitivity of the computer model to material properties and source concentrations has been discussed in the RI. The ground-water flow and contaminant transport model is relatively robust because of the model's sensitivity to loading rate, adsorption, and hydraulic conductivity. The key uncertainty associated with the model includes the loading of some of COCs (cadmium, for example) for which little waste-stream data are available. Concentrations have been predicted for a time period 125 years from present, and are discussed further in Section 4.2.2.

Tritium is the only COC currently being discharged from the continuing operations at the TRA. Tritium discharge will be made to the new warm waste ponds scheduled for completion in 1992. This planned activity will remove the tritium source to the PWS, and ultimately the SRPA. Therefore, any potential threats to human health and the environment attributed to this current activity will diminish once the new warm waste pond is completed.

At present, the SRPA immediately hydraulically downgradient from the TRA and INEL is not being used for domestic or agricultural purposes. Future uses of the SRPA in this area would potentially be impacted by the present contaminant concentrations present in the SRPA beneath the TRA. Potential risks, however, have not been quantified as part of the PWS OU. Institutional controls currently in place at INEL would assist in preventing contact of the PWS and the SRPA water with human or animal populations at INEL.

No short-term risks have been identified in association with the No Action alternative. Evaluation of overall protection of human health and the environment for the No Action alternative can be made through the baseline RA. Detailed results of the BRA are given in Section 6 of the RI portion of this document. The scenario described under the risk assessment process included withdrawal of ground water from the SRPA hydraulically downgradient of the TRA and the PWS. Ground-water use was designated for both domestic and agricultural purposes 125 years from the present. This time frame accounts for the planned continued operation of the TRA until 2014 and a 100-year period of enforced institutional controls.

Predictive simulations of the response of the PWS through time were performed as part of the contaminant fate and transport analysis (RI section 5). The simulations indicate that the PWS would be reduced by 75% three years after the cold waste pond ceases to receive wastewater (Section 5.3.8 of the RI). In addition, continued discharge to the cold waste pond and, to a lesser extent, to the chemical waste pond and sanitary waste ponds would dilute COC concentrations in the PWS after closure of the warm waste pond. This dilution would cause a decrease in COC concentrations and associated risks.

Results of the BRA show that none of the COCs create an excess carcinogenic risk of 10^{-6} or greater. In addition, noncarcinogenic health impacts are not considered to be a concern for any of the four candidate remedial alternatives (i.e., a hazard index < 1). Risks due to tritium concentrations in the SRPA in the 125-year time period were the greatest of all the COCs. Tritium risks were calculated to represent a 10^{-7} excess carcinogenic risk under the No Action alternative. The ARARs analysis (Section 4.2.2) indicates that all chemical-, action-, and location-specific ARARs would be met for the future use scenario in 125 years.

4.2.1.2 Alternative 2–Physical/Chemical Ground-Water Treatment. Physical/chemical treatment would reduce the concentrations of the COCs in the PWS, thereby reducing potential transport of these contaminants to the SRPA. The extent that contaminant concentrations would be reduced at the point contact is made at the SRPA was assumed to be 50%, except for tritium and strontium-90. The point of contact is defined as the uppermost 12.5 feet of the SRPA beneath the PWS. Since process- and material-specific treatability data were not available, a 50% reduction in contaminant concentrations was used as a conservative treatment efficiency estimate for the radionuclides requiring treatment.

Discharge of treated water to infiltration ponds would not meet chemical-specific ARARS at the present time with the assumed treatment efficiency of 50%; if treatment efficiency were greater than the assumed 50%, the chemical-specific ARARs may be met. Treatability testing would be needed to quantify actual treatment efficiency. However, chemical-specific ARARs would be expected to be met prior to the time required under the No Action alternative.

Potential risks posed by migration of radionuclides to the SRPA would not be completely eliminated by the actions proposed under this alternative. Tritium reductions would be achieved only through dilution by mixing with waters infiltrating from the cold, chemical, and sanitary waste ponds, but the mass of tritium in the PWS would not be significantly reduced. Because tritium may act as a conservative tracer, its migration to the SRPA would only be delayed and/or diluted under this alternative. Treated ground water would meet DOE derived concentration guidelines for radiation protection of the public of 100 mrems per year if a 50% reduction in americium-241 and no tritium removal is assumed (DOE 5400.5).

As described in Section 4.2.3.2, Alternative 2 would not address the solid-phase residual contamination in the PWS. Only minor mass reductions of contaminants such as chromium and americium-241 would occur under this alternative compared to the total mass discharged to the PWS throughout the history of TRA operations. Control of this potentially significant source of residual contamination through engineering solutions would not be proposed under this alternative. Institutional controls that prohibit the domestic or industrial use of ground water would be implemented for the PWS, as previously described; however, institutional controls restricting the use of the SRPA beyond INEL boundaries would be difficult to implement. Potential risks associated with treatment residuals such as sludges would be effectively controlled through engineering an onsite repository.

Prevention of short-term risks would be adequately addressed through engineering controls proposed under this alternative as discussed in Section 4.2.5.2. No cross-media contamination would be expected to occur during remedial activities. Tritium would be discharged to infiltration ponds and subsequently to the PWS, although the magnitude of potential short-term risks associated with the operation of the pumping and treatment systems would be minor.

Physical/chemical treatment would reduce concentrations of some COCs within the PWS, thereby providing a degree of protection to future users of the SRPA beneath the TRA location (see Section 4.2.4.2). The total mass of contaminants removed from the PWS would be minor in comparison to the potential mass adsorbed or immobilized in the pond sediments or aquifer materials. This alternative would not address the potential for remobilization of solid-phase residual contamination within the aquifer materials.

4.2.1.3 Alternative 3–Evaporative Ground-Water Treatment. The evaporative treatment alternative would address the site-specific RAOs by reducing the contaminant of concern concentrations in the PWS, thereby reducing potential transport of contaminants to the SRPA. The extent that contaminant concentrations would be reduced was estimated to be 50% at the contact point with the SRPA. Actions proposed under this alternative would be expected to comply with the potential ARARs for the site by using appropriate engineering controls; however, a site-specific assessment of the potential evaporation pond locations would be needed to completely evaluate this alternative with respect to location-specific ARARs. In addition, evaporation of tritium to the atmosphere would need to be evaluated from a health-based risk basis. Selection of Alternative 3 would require completing an appropriate air quality dispersion model to predict tritium concentrations in the surrounding atmosphere as a result of its evaporation. A subsequent risk analysis would be performed to quantify risks associated with this remediation effort to human health and the environment. Air quality modeling and an associated risk assessment were beyond the scope of the current FS.

Potential risks posed by migration of radionuclides to the SRPA from the perched water zones would not be completely eliminated by the actions proposed under Alternative 2. Residual contamination would remain in the aquifer materials after completion of remedial actions in the form of adsorbed or immobilized solid-phase contaminants. These solid-phase contaminants would not be specifically addressed through pumping and physical/chemical treatment. Mobilization of adsorbed or solid-phase contaminants may occur as a result of continuing TRA wastewater disposal, and after TRA closure and decommissioning, through infiltration due to precipitation or flooding events. However, as discussed in the RI the potential impact of mobilizing solid-phase contaminants by infiltration is considered to be insignificant.

As described in Section 4.2.3.2, Alternative 3 would not address solid-phase residual contamination in the PWS. Only minor mass reductions of contaminants such as chromium, strontium-90, and americium-241 are predicted to occur under this alternative compared to the total mass of these contaminants discharged to the PWS throughout the history of TRA operations. Control of this potential source of residual contamination through engineering solutions are not proposed under this alternative. Institutional controls that prohibit the domestic or industrial use of ground water could be implemented for the PWS, although institutional controls restricting the use of the SRPA beyond INEL boundaries would not be difficult to implement. Potential risks associated with treatment residuals would be effectively controlled through engineering an onsite repository.

Prevention of short-term risks would be addressed through engineering controls as discussed in Section 4.2.5.3. Potential cross-media contamination would be expected to occur because of the release of tritium to the atmosphere during remedial activities. The total mass of tritium expected to be released during evaporative treatment would be on the order of 10^{-4} pounds over the duration of the project, but the magnitude of potential risks associated with air transport and possible down-wind deposition of tritium is unknown.

Evaporative treatment would reduce the concentration of COCs within the PWS and the SRPA for the future use scenario at 125 years from the present. This alternative may provide protection of human health and the environment prior to the No Action alternative, although the time frame to achieve this protection under Alternative No. 3 has not been quantified as part of the FS.

4.2.1.4 Alternative No. 4–Source Control. As stated previously, termination of the current warm waste source will occur under each alternative. This action will positively impact perched water quality for Alternative 4 as well. In addition, continued discharge of cold, chemical, and sanitary waste water to their respective disposal ponds would result in diluting concentrations of the COCs in the PWS. Source control of TRA operation effluents that infiltrate through the disposal ponds and form the PWS would result in a gradual volume decrease of the perched aquifers until operations cease at the TRA. Additional volume decreases within the PWS would continue after cessation of TRA operations until unsaturated hydraulic conditions prevail in the area of the current PWS. Solid-phase residual contamination in the aquifer materials would not be addressed under Alternative 4. Estimated discharge rates to the three remaining unlined ponds would total approximately 20 to 30 gpm under this alternative.

No short-term risks have been identified in association with implementing source control at the TRA. Evaluation of overall protection of human health and the environment for the source control alternative was not quantified as part of the FS. However, results of the HRA showed that the RAOs are met at the site for the future use scenario under the No

Action alternative (Section 6 of the RI). Source control would reduce the driving force for contaminants to the SRPA, and the protection of human health and the environment would be expected to be met prior to the time required for no action. The time frame to achieve this protection under the Source Control alternative has not been quantified as part of the FS.

4.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

The COCs at the PWS OU were identified during the RI of the TRA site. The COCs are arsenic, beryllium, cadmium, chromium, cobalt, fluoride, lead, manganese, cobalt-60, cesium-137, americium-241, tritium, and strontium-90. The COC concentrations found in the PWS during recent sampling (1991) are shown in Table 4-1.

The initial list of identified potential ARARs for the candidate remedial action alternatives at the TRA was presented in Section 2.2.2. The list of ARARs developed during the FS analysis is shown in Tables 4-1 through 4-5 by Federal and State chemical-specific requirements, Federal location-specific requirements, Federal action-specific requirements, and State action-specific requirements.

The chemical-specific ARARs identified for the PWS OU are the National Primary Drinking Water Standards referred to as maximum contaminant levels (MCLs) specific to each chemical. These Federal standards are displayed with COc concentrations in Table 4-1 along with the maximum contaminant level goals (MCLGs) and the other considered limitations. Table 4-2 shows the State of Idaho Drinking Water Standards that are the equivalent to the Federal standards.

The concentrations of contaminants in the PWS exceed the MCLs for most of the identified COC. The PWS discharges into the SRPA beneath the PWS, known as the Eastern SRPA. The Eastern SRPA was named a Sole Source Aquifer for drinking water in southern Idaho effective January 7, 1992 by EPA, Region X. This designation under the Safe Drinking Water Act affords protection of the Eastern SRPA from harm as specified by

Table 4-1. Contaminants of concern, 1991 sampling results and Federal chemical-specific ARARs.

Contaminants of Concern	Shallow Perched Mean Concentration	Deep Perched Mean Concentration	Primary MCL	Proposed Primary MCL	MCLG	Proposed MCLG	Secondary MCL	To Be Considered
Americium - 241[a]	2110 pCi/L	25.0 pCi/L		15 pCi/L[c]		0		
Arsenic	20.9 µg/L	4.9 µg/L	50.0 µg/L					
Beryllium	40.0 µg/L	1.3 µg/L		1.0 µg/L[d]		0		
Cadmium	47.5 µg/L	3.0 µg/L	5.0 µg/L		5.0 µg/L			
Cesium - 137[b]	2.63×10^6 pCi/L	15.0 pCi/L	4 millirem/yr[c]					
Chromium	1360 µg/L	93.5 µg/L	100.0 µg/L		100.0 µg/L	0		
Cobalt - 60[a]	1.53×10^6 pCi/L	14.3 pCi/L	4 millirem/yr[c]					
Cobalt	131 µg/L	10.0 µg/L						0.35 mg/L[e]
Fluoride	561µg/L	180 µg/L				0	2 mg/L	
Lead	864 µg/L	9.4 µg/L	50.0 µg/L[f]		0			
Manganese	1.95×10^4 µg/L	255 µg/L					50.0 µg/L	
Strontium - 90[b]	4560 pCi/L	31.9 pCi/L	8 pCi/L[b]			0[c]		
Tritium[b]	1.85×10^6 pCi/L	1.15×10^5 pCi/L	2.0×10^5 pCi/L[c]			0[c]		

a. Alpha and photon emitter.
b. Beta and/or photon emitter.
c. MCL for beta and photon sources are based on the average annual concentration from man-made sources. If two or more radionuclides are present, the sum total of their annual dose equivalent to the total body or to any organ can not exceed 4 millirem per year.
d. Proposed MCL. F.R. Volume 55, Number 143.
e. EPA Region III Risk-Based Concentration Table. February 27, 1991.
f. Lead - New Standard is based on selection of the appropriate treatment technology technique; based on source intake, corrosion control and existing service line conditions. The past interim MCL established by EPA was 50 mg/l.

Table 4-2. State chemical-specific ARARs.

Contaminants of Concern	MCL Inorganic Chemicals (μg/L)	Secondary Quality Standards
Americium - 241[(a)]	15 pCi/L	
Arsenic	50.0 μg/L	
Beryllium		
Cadmium	10.0 μg/L	
Cesium - 137[(b)]	4 millirem/yr[(c)]	
Chromium	50.0 μg/L[(d)]	
Cobalt - 60[(b)]	4 millirem/yr[(c)]	
Cobalt		
Fluoride	1.4 - 2.4 mg/l[(e)]	
Lead	50.0 μg/L	
Manganese		50.0 μg/L
Strontium - 90[(b)]	8 pCi/L	
Tritium[(b)]	2.0×10^5 pCi/L	

a. Alpha and photon emitter

b. Beta and/or photon emitter

c. MCL for beta and photon sources are based on the average annual concentration from man-made sources. If two or more radionuclides are present, the sum total of their annual dose equivalent to the total body or to any organ shall not exceed 4 millirem per year.

d. State Standards for MCLs cannot exceed Federal Standard [Idaho Code, Title 37, Chapter 21, Section 2102].

e. Dependent on the annual average of the maximum daily air temperature of the area of the community water intake system.

Table 4-3. Potential Federal action-specific ARARs for TRA Perched Water System.

Statute	Regulation	Alternative 1		Alternative 2	Alternative 3	Alternative 4
		1991	2116			
Resource Conservation and Recovery Act	40 CFR Part 257, Criteria for Classification of Solid Waste Disposal Facilities and Practices	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes
	40 CFR Part 260, Hazardous Waste Management Systems	Not ARAR	Not ARAR	A/Yes	A/Yes	Not ARAR
	40 CFR Part 261, Identifying Hazardous Waste	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes
	40 CFR Part 262, Standards Applicable to Generators of Hazardous Waste	Not ARAR	Not ARAR	A/Yes	A/Yes	Not ARAR
	40 CFR Part 263 Standards Applicable to Transporters of Hazardous Waste	Not ARAR	Not ARAR	R/Yes	R/Yes	Not ARAR
	40 CFR Part 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	Not ARAR	Not ARAR	R[b]/Yes[c2]	A[b]/Yes	Not ARAR
	40 CFR Part 267, Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	Not ARAR	Not ARAR	R[b]/Yes[c]	A[b]/Yes	Not ARAR
	40 CFR Part 268, Land Disposal Restrictions	Not ARAR	Not ARAR	R[b]/Yes[c]	A[b]/Yes	Not ARAR
Occupational Safety and Health Act	29 CFR Part 1910, Occupational Safety and Health Standards	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes

Table 4-3. (continued)

Statute	Regulation	Alternative 1		Alternative 2	Alternative 3	Alternative 4
		1991	2116			
National Environmental Policy Act	40 CFR Parts 1500 through 1508, Council on Environmental Quality Regulations for Implementing National Environmental Policy Act Procedures	A/Yes	A/Yes	A/Yes	A/Yes	A/Yes
Hazardous Material Transportation Act	49 CFR Parts 171 through 179, Hazardous Materials	Not ARAR	Not ARAR	R/Yes	R/Yes	R/Yes
Clean Air Act	40 CFR Part 50, National Primary and Secondary Ambient Air Quality Standards	Not ARAR	Not ARAR	R/Yes	R/Yes	R/Yes
	40 CFR Part 61.90, National Emission Standards for Radionuclide Emission from DOE Facilities	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes
Clean Water Act	40 CFR Part 122, "Storm Water Discharge Permit"	Not ARAR	Not ARAR	A/Yes	A/Yes	Not ARAR
	40 CFR Part 401, "Point Source Discharge"	Not ARAR	Not ARAR	Not ARAR	Not ARAR	Not ARAR
Atomic Energy Act and Energy Reorganization Act	10 CFR Part 61, Subpart D, "Technical Requirements for Land Disposal Facilities"	Not ARAR	Not ARAR	A/Yes	A/Yes	Not ARAR
Migratory Bird Treaty Act	50 CFR Part 20, Migratory Bird Protection	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes

Table 4-3. (continued)

Statute	Regulation	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Bald and Golden Eagle Protection Act	50 CFR Part 22, "Bald and Golden Eagle Protection Act"	Not ARAR	A/Yes	A/Yes	A/Yes
Endangered Species Act	50 CFR Part 17, "Endangered and Threatened Wildlife and Plants"	Not ARAR	A/Yes	A/Yes	A/Yes
	50 CFR Part 225, "Federal/State Cooperation in the Conservation of Endangered and Threatened Species"	Not ARAR	A/Yes	A/Yes	A/Yes
	50 CFR Part 226, "Designated Critical Habitat"	Not ARAR	A/Yes	A/Yes	A/Yes
	50 CFR Part 402, "Interagency Cooperation"	Not ARAR	A/Yes	A/Yes	A/Yes

a. A = applicable
R = relevant and appropriate
No = will not meet ARAR.
Yes = will meet ARAR.

b. Contingent upon EPA establishing treatment standards for mixed waste and standards being met for waste substances.

c. Contingent upon RCRA delisting of listed substances.

Table 4-4. Potential Federal location-specific ARARs for the TRA Perched Water System.

Statute	Regulation	Alternative 1 1991	Alternative 1 2116	Alternative 2[a]	Alternative 3[a]	Alternative 4[a]
National Historic Preservation Act	36 CFR Part 800	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes
Archeological Resources Protection Act	36 CFR Part 7, "Protection of Archeological Resources"	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes
Archeological and Historic Preservation Act	36 CFR Part 296, "Protection of Archeological Resources; Uniform Regulations"	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes
Preservation of American Antiquities Act	43 CFR Part 3	Not ARAR	Not ARAR	A/Yes	A/Yes	A/Yes

a. A = Applicable

Table 4-5. Potential State ARARs for the TRA Perched Water System.

Potential State ARARs	Citation	Alternative 1 1991[a]	Alternative 1 2116[a]	Alternative 2[a]	Alternative 3[a]	Alternative 4[a]
Toxic Substances, Air Quality	IDAPA §16.01.1011,01	Not ARAR	Not ARAR	A/Yes	A/Yes	A/UNK
Air Pollution Permits to Construct and Operating Permits	IDAPA §16.01.1012	Not ARAR	Not ARAR	A/Yes[b]	A/Yes[b]	A/UNK
Visible Emission	IDAPA §16.01.1201	Not ARAR	Not ARAR	Not ARAR	Not ARAR	Not ARAR
Fugitive Dust	IDAPA §16.01.1251 to 1253	Not ARAR	Not ARAR	A/Yes	A/Yes	Not ARAR
New Source Performance Standards	IDAPA §16.01.1951	Not ARAR	Not ARAR	Not ARAR	Not ARAR	A/UNK
Water Use Classifications General Water Use Designations	IDAPA §16.01.2100	R/No	R/Yes[b]	R/Yes[b]	R/Yes[b]	R/Yes[*]
General Water Quality Criteria	IDAPA §16.01.2200	R/N	R/Yes	R/UNK	R/UNK	R/UNK
Short-Term Activity Exemption	IDAPA §16.01.2301	R/UNK	R/Yes[b]	R/Yes[b]	R/Yes[b]	R/Yes[*]
Maintenance of Water Quality Standards	IDAPA §16.01.2302	Y/R	R/Yes	R/Yes	R/Yes	R/Yes
Subsurface Waste Disposal Facility	IDAPA §16.01.2460	R/N	R/Yes	R/Yes[b]	R/Yes[b]	R/Yes
Hazardous and Deleterious Material Storage	IDAPA §16.01.2800	R/UNK	R/UNK	R/UNK	R/Yes	R/UNK
Land Application of Wastewaters	IDAPA §16.01.2600	Not ARAR	Not ARAR	A/Yes[b]	Not ARAR	Not ARAR
Environmental Protection and Health Act (EPHA)	Idaho Code §39-101 through 119	R/No	R/Yes[b]	R/Yes[b]	R/Yes[b]	R/Yes[b]
Alteration of Channels	Idaho Code §42-3801 through 3812	Not ARAR	Not ARAR	A/Yes	A/Yes	Not ARAR
Hazardous Waste Facility Siting Act	Idaho Code §39-5801 through 5820	Not ARAR	Not ARAR	Not ARAR	Not ARAR	Not ARAR
Protection of Natural Resources	Idaho Code §67-5801 through 5804	R/No	R/Yes	R/Yes[b]	R/Yes[b]	R/Yes[b]
Idaho Solid Waste Management Regulations	IDHW Title 1, Chapter 6, §01.6001 et seq.	Not ARAR	Not ARAR	A/Yes[b]	A/Yes	A/Yes

a. A = applicable
R = relevant and appropriate
UNK = unknown
No = will not meet ARAR
Yes = will meet ARAR.

b. Assumes substantive permit requirements of the State can be met.

§ 1424(e) of the Act. The EPA is required to review federally financially-assisted projects proposed for the area of the Eastern SRPA.

Review of the *Idaho Ground Water Quality Plan* issued in December 1991 and the State Department of Health and Welfare's "Water Quality Standards promulgated pursuant to Idaho Code, "§ 39-105, has also been considered in the ARARs analysis. The State's intent, according to the Ground Water Quality Plan, is to develop standards based on the drinking water standards. The drinking water standards have been determined as the ARARs based on the above facts being acknowledged and agreed to by the State. Location-specific and action-specific ARARs are shown on Tables 4-3 through 4-5.

Tables 4-3 through 4-5 also include columns for each alternative beside each of the Federal location-specific, Federal action-specific, and other State requirements. These tables delineate the requirements as applicable, relevant and appropriate, or not an ARAR. In addition, the status of compliance for each alternative in achieving the requirements is shown. Determinations of compliance are based on results of the FS analysis, including estimates of COC removal efficiencies. Further evaluation of compliance will be necessary during the remedial action plan development for the selected alternative. Discussion of the preliminary determinations of compliance for each alternative, including chemical-specific ARARs, follows after a general discussion of ARARs.

The objective of remediation at the PWS OU is remediation and/or removal of the contaminated ground water from the PWS. The candidate remedial alternatives are focused on this main objective, therefore, the regulatory requirements for each of the proposed alternatives are focused on the removal and/or remediation activity. Although there are related actions to the remediation of the PWS, such as construction of a new warm waste pond, the related actions are not specific to the scope of the PWS OU feasibility study. The ARARs associated with these related actions are not the subject of this FS and are not presented in the following ARARs analysis.

An HRA was completed for this OU (Section 6 of the RI). Risk levels associated with chemical constituent toxicity were used to assist in determining the COCs in the ground water. The HRA included an evaluation of contaminants in the PWS under present conditions (1991) and in the future (125 years hence, in the year 2116). The evaluation was based on a two-dimensional ground-water flow model (Section 5 of the RI). The infiltration of each COC at maximum concentration was predicted to assist inunderstanding contaminant migration. The HRA used the predicted migration of COCs into the upper 12.5 feet of the SRPA beneath the TRA. The HRA evaluated the fate of the COCs in particular scenarios to assist with prediction of human health concerns.

The evaluation of the ability of each alternative to comply with ARARs also used results from the ground-water flow model. The concentration of COCs expected in the SRPA in the years 1991 and 2116, assuming closure of the existing warm waste pond in 1992, was used to determine compliance with the MCLs. The No Action alternative is evaluated for the years 1991 and 2116 as is shown on Tables 4-3 through 4-6. The point that perched water from the PWS enters the SRPA is the point used to determine whether a MCL would be achieved with implementation of the No Action alternative. The same point of contact is used for each alternative.

The SRPA is used as a primary drinking water source; therefore, the waters in the SRPA are required to meet the national primary and secondary drinking water standards at the intake source point. The national drinking water standards are established as MCLs as shown for specific chemical substances on Table 4-1. The focus of the alternatives for the PWS OU is to achieve these MCLs for ground waters beneath the TRA area.

4.2.2.1 Alternative 1-No Action. Alternative 1 assumes that no remediation and/or removal of the contaminated ground water would take place. The source of the infiltrated COCs will cease to exist when the existing warm waste pond is closed (i.e., no additional

Table 4-6. Predicted maximum contaminant of concern concentrations in the SRPA

COCs	Predicted Maximum Concentrations in SRPA 1991	Predicted Maximum Concentrations in SRPA 2116
Americium-241[b]	1.69×10^{-7} pCi/L	9.54×10^{-5} pCi/L
Arsenic	8.35×10^{-15} μg/L	3.20×10^{-4} μg/L
Beryllium	1.05×10^{-15} μg/L	5.4×10^{-12} μg/L
Cadmium	9.18 μg/L	1.30 μg/L
Cesium-137[a]	4.84×10^{-21} pCi/L	1.22×10^{-16} pCi/L
Chromium	506 μg/L	6.91 μg/L
Cobalt	1.53×10^{-7} μg/L	4.1×10^{-5} μg/L
Cobalt-60[a]	9.16×10^{-5} pCi/L	0.017 pCi/L
Fluoride	7.06×10^{-12} μg/L	1.73×10^{-8} μg/L
Lead	8.76×10^{-15} μg/L	5.02×10^{-11} μg/l
Manganese	9.32×10^{-5} μg/l	0.016 μg/l
Strontium-90[a]	0.02661 pCi/L	0.29 pCi/L
Tritium[a]	282,656 pCi/L	6.6×10^{-5} pCi/L

a. Beta and/or photon emitter
b. Alpha and photon emitter

COCs would be added to the PWS via the waste disposal ponds. The infiltration of COCs to the SRPA would be limited to migration of ionized or colloidal forms of the COCs present in aquifer materials beneath the TRA.

The maximum COC concentrations at the point of contact in the SRPA as predicted through ground-water modeling for the years 1991 and 2116 are shown in Table 4-6. Results of the HRA show there is no excess carcinogenic risk to humans in the year 2116. The following discussions summarize the compliance with ARARs in 1991 and in 2116 under the No Action alternative. Specific action and location-specific determinations of compliance are found on Tables 4-3 through 4-5.

Chemical-Specific ARARs-The COC concentrations in the SRPA would meet the majority of Federal primary drinking water standards (i.e., the MCLs), according to the 1991 predicted concentrations. The MCLs that would not be met are cadmium, chromium, and tritium.

Under the No Action alternative, in the year 2116 chemical characteristics of the PWS would change significantly with migration of substances into the SRPA. All COCs present in the SRPA ground water are anticipated to meet the MCLs by 2116, although the annual dose equivalent MCL is predicted not to exceed the 4 mrem per year level (Tables 412 and Table 4-6).

Location-Specific ARARs-Selection of Alternative 1 would not involve any surface disturbance or surface activities related to the PWS. Therefore, location-specific requirements are not ARARs for this alternative.

Action-Specific ARARs-Many of the action-specific requirements identified on Tables 4-3 and 4-5 are not ARARs for the No Action alternative. Construction and operational activities that invoke many or all of the action-specific requirements would not take place with this alternative.

Requirements potentially relevant and appropriate to the No Action alternative concern the State of Idaho water quality standards (Regulations codified under the Idaho Administrative Procedure Act Sections 16.01.2100, "Water Quality Classifications"; 2200, "General Water Quality Criteria"; 2301, "Short-Term Activity Exemption"; 2460, "Subsurface Sewage or Waste Disposal"; 2850, "Hazardous Material and Petroleum Product Spill". Specifically, the classification of ground waters in the State as drinking watersupplies unless specific cases preclude the "economic feasibility of" domestic use of the water [IDAPA 16.01.2101.05] requires a determination by the State that the ground waters entering the SRPA can be classified other than for domestic use in the near term. Until such a State determination is or can be made, Alternative 1 would not meet most of the State requirements concerning water use and classification for a period of time not to exceed 125 years. The State water quality standards, as stated above, (relevant and appropriate requirements) are unknown at this time and will require a clarification and a determination is made by the State. One hundred and twenty-five years hence, the State water quality requirements identified as not in compliance in 1991 would be achieved, based on the dissipation of the PWS and the predicted future COC concentrations in the SRPA.

Overall Compliance with ARARs—The No Action alternative would not immediately achieve chemical-specific ARARs and the action-specific ARARs. However, based on predicted COC concentrations in the SRPA in the year 2116, the No Action alternative would meet the chemical-specific and action-specific ARARs. There would not be any location-specific ARARs associated with this alternative. In addition, the determination of compliance with ARARs assumes that all water-quality-related action-specific ARAR issues can be resolved with the State during the specified period of time in the FFA/CO, and beyond to the year 2116.

4.2.2.2 Alternative 2-Physical/Chemical Ground-Water Treatment. Alternative 2 involves ground-water pumping and subsequent treatment in an onsite facility. Treated ground water would be discharged to unlined on site infiltration ponds. Treatability data do not exist for the specific contaminated ground-water waste streams. Compliance with the

Federal primary drinking water standards would be the design and operating criteria for the physical/chemical treatment systems designed under this alternative. Treatability studies would be required to confirm whether the effluent would meet the MCLs.

Chemical-Specific ARARs-The average quality of water pumped from the PWS exceeds MCLs and/or MCLGs, or proposed standards identified in Table 4-1 for all COCs except fluoride. The treated effluent would meet the MCLs for the non-radionuclide inorganic substances and americium-241, cesium-137, and cobalt-60. The designed treatment is not expected to remove tritium and may not be effective for strontium-90 removal; however, the predicted radionuclide concentrations at the point of contact with the SRPA are estimated to meet the 4 mrem[1] annual dose equivalent drinking water standard.

The COC concentrations in the SRPA at the end of the remediation period have been quantified as part of the FS for Alternative 2. However, the MCLs would be expected to be achieved in the SRPA after an estimated period of approximately 10 years under Alternative 2. The period of time prior to compliance with the MCLs may be reduced depending on the actual removal efficiencies for the radionuclides.

Location-Specific ARARs-All of the location-specific ARARs identified for the site would be met. There have not been any potential location-specific conflicts identified with the development and operation of the treatment system under this alternative. Given the controlled access and general site characteristics (high desert plain), it is anticipated that all ARARs would be met or could be met with appropriate mitigation.

Action-Specific ARARs-Compliance with the potential action-specific ARARs for the site would be achieved mainly through application of appropriate engineering controls during the design and construction of the treatment and disposal facilities. The infiltration pond would

[1] MCL for beta and photon sources are based on the average annual concentration from manmade sources. If two or more radionuclides are present, the sum total of their annual dose equivalent to the total body or organ cannot exceed 4 mrem/yr.

not meet relevant and appropriate RCRA Subtitle C design requirements. The solid waste disposal requirements are applicable to the situation and would be met with implementation of this alternative.

Section 4 of the RI identified past disposal practices involving potential use of listed hazardous waste substances. The RI revealed low concentrations of listed waste substances (1,1,1-trichloroethane, 1,2,4-trichlorobenzene, and other volatile substances) during sampling of the PWS. For purposes of the FS, the assumption was made that delisting of the RCRA hazardous waste substances would be pursued with this alternative per 40 CFR 260.20 and 260.22 (See Superfund Publication: 9347.3-09FS, September 1990). Substantive requirements of the delisting process would be met with a delisting demonstration that the listed waste substances are below health-based risk levels of 10^{-6}.

As described for Alternative 1, the water quality standards for classification and use of groundwaters do not appear to be met (without an evaluation by the State as to beneficial uses of the ground waters beneath the TRA). Radionuclide concentrations allowed to reinfiltrate to the PWS would meet the MCLs by the year 2116 at the point of contact with the SRPA.

Implementation of this alternative would result in the potential release of radionuclides to the atmosphere during handling and disposal of the treated effluent. Assuming, after evaluation of these releases, that the State air quality requirements for constructing a treatment and disposal facility can be met. The assumption was made that the action-specific ARARs would be met with implementation of this alternative.

Applicable worker safety standards of Occupational Safety and Health Administration (OSHA) and Nuclear Regulatory Commission (NRC) would be incorporated into the operation, maintenance, and decommissioning of the facilities. All proposed construction and/or operational activities would comply, as necessary, with the applicable Endangered

Species Act and critical habitat regulations. Discussions with the U.S. Fish and Wildlife Service would be pursued upon selection of this remedial action alternative.

Overall Compliance with ARARs–The physical/chemical treatment alternative would not meet the MCL for combined beta and photon-emitting radionuclides in 1991. However, the COC concentrations entering the SRPA would achieve the MCLs by the year 2116. The action- and location-specific ARARs would be met assuming all State substantive requirements can be achieved through appropriate engineering controls and agreement from the State regarding all substantive permit requirements being met for air and water quality. Further evaluation of the State water quality standards and radiation control standards would be required should Alternative 2 be selected.

4.2.2.3 Alternative 3–Evaporative Ground-Water Treatment. Ground-water treatment under Alternative 3 occurs through water evaporation and subsequent COC concentration within lined evaporation ponds. The ponds would be equivalent to RCRA Subtitle C impoundments with leak detection/collection systems. After completion of ground-water pumping from the PWS, the ponds would be closed in accordance with Subtitle C requirements.

The only COC not expected to concentrate within the pond system would be tritium. The radioactivity associated with tritium would enter the atmosphere and dissipate.

Chemical-Specific ARARs–Pumped water from the PWS exceeds the MCLs or proposed MCLs for the substances previously identified under Alternative 2. The pumped water from the PWS would be treated by the evaporation process to achieve the MCLs. Through time the residual COCs present in the PWS and entering the SRPA would meet MCLs.

Location-Specific ARARs–The potential location-specific ARARs identified for the Site are expected to be met since Site characteristics have not identified potential siting problems. However, a large land area would be required for siting the evaporation ponds and final determinations of compliance would be made in the future depending on the actual site chosen.

Action-Specific ARARs–The National Emission Standards for Hazardous Air Pollutants (NESHAPS–40 CFR § 61.90, National Emission Standards for Hazardous Air Pollutants from DOE Facilities) are identified as potentially restricting the evaporation of contaminated ground water involving the release of tritium to the atmosphere. Without detailed air quality modeling, a final determination regarding the compliance of this alternative with National Emission Standards for Hazardous Air Pollutants (NESHAPs) is not possible. However, based on preliminary calculations of the concentration of tritium that would be discharged to the impoundment, air releases would not exceed the standards.

Alternative 3 would meet all applicable requirements of RCRA Subtitle C for the design, construction, and operation of waste impoundments and repositories. The ponds would consist of a double FML system with a leak detection and collection system and a ground-water monitoring network at the ponds. The hazardous waste substances of the PWS could be delisted under RCRA as discussed under Alternative 2.

Assuming delisting can be pursued, there may not be applicable land disposal restrictions (LDRs). However, the EPA is expected to rule on LDRs for mixed waste and final closure of the repository may include additional requirements not identified in the ARARs analysis.

Overall Compliance with ARARs–Chemical-specific ARARs would be achieved for ground- water quality at the SRPA through restricted releases of chemical substances to site surface and ground waters. Releases of tritium to the atmosphere would require meeting State air pollution standards. Providing state requirements can be met, action-specific requirements would be expected to be achieved with this alternative. Compliance with potential location-specific ARARs is expected to be achieved, although a Site-specific assessment of potential pond locations would be required to more accurately evaluate Site-specific compliance.

4.2.2.4 Alternative 4–Source Control. The source control alternative would consist of additional treatment of currently generated TRA process water from the cold and chemical waste streams. At present, neither of these two waste streams are contributing COCs to the PWS. Alternative 4 also includes no proposed action for the PWS. Therefore, the impacts of implementing Alternative 4 are similar to implementing Alternative 1. The discussion of compliance with ARARs under Alternative 1 also pertains to Alternative 4.

Chemical Specific ARARs–Ground water at the point of contact with SRPA would meet the Federal primary drinking water standards in the year 2116.

Location Specific ARARs–This alternative may involve additional construction of building(s). For purposes of the FS the assumption was made that the location-specific ARARs would be met based on the known general site characteristics and successful implementation of any applicable mitigation measures. Further investigation of Site-specific restrictions would be necessary once Site-specific plans are known.

Action Specific ARARs–Many of the action-specific requirements identified on Tables 4-3 and 4-5 are not ARARs for this alternative as is the case for Alternative 1. Treatment facilities planned under this alternative are to treat non-hazardous and non-radioactive substances only. Once site-specific plans are available, further evaluation of the action-specific ARARs would be required. Assuming the substantive requirements of the State water quality standards can be satisfied, the action-specific requirements would be met with this alternative.

Overall Compliance with ARARs–Alternative 4 would achieve the chemical-specific ARARs by the year 2116, as described for Alternative 1.

4.2.3 Long-Term Effectiveness and Permanence

Factors considered under long-term effectiveness and permanence include:

- Magnitude of residual risk from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. Characteristics of the contaminants that remain after remediation are considered, including volume, toxicity, mobility, and their tendency to bioaccumulate.

- Adequacy and reliability of controls, such as containment systems and institutional controls, necessary to manage treatment residuals and untreated ground water. This factor addresses in particular the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.

4.2.3.1 Alternative 1–No Action. Based on results of ground-water modeling and the BRA (Sections 5 and 6 of the RI), the planned warm waste source removal and continued infiltration of both cold and chemical waste streams would not result in long-term adverse impacts to human health and the environment from exposure to the SRPA beneath the TRA. The baseline RA estimated the carcinogenic risk associated with the future use scenario at the TRA to be 1.5×10^{-7} in 125 years. Long-term effectiveness and permanence would thus be achieved by the No Action alternative. As previously stated, the noncarcinogenic health impacts are not considered to be a concern for the future use scenario.

Closure of the existing warm waste ponds will significantly reduce introduction of radionuclides to the PWS. The volume, toxicity, and mobility of the COCs would decrease under this alternative due to the continued dilution of the PWS with cold, chemical, and sanitary wastewater infiltration. Solid-phase residual contamination in the PWS would not be addressed as part of this alternative. The COCs would not tend to bioaccumulate due to their physical location in the PWS.

Exposure controls or other long-term management activities included under this alternative include existing institutional controls of restricted site access and land use restrictions, continued monitoring and documentation of waste stream characterization for TRA process effluents, and continued monitoring of the chemical characteristics of the PWS. These existing controls would be expected to be adequate and reliable in terms of long-term effectiveness and permanence of the Source Control alternative.

The scope of the PWS OU RI/FS does not include evaluation of potential impacts related to other portions of the TRA. Risks associated with surrounding geographical areas at the TRA will be addressed through the other operable units of the TRA site.

4.2.3.2 Alternative 2–Physical Chemical Ground-Water Treatment. In addition to the planned warm waste source removal, removal of the contaminated perched water followed by treatment, contaminant concentration, and treated ground-water discharge to an unlined infiltration pond would provide for additional effective and permanent long-term protection. The magnitude of remaining risk from the presence and continued infiltration of the perched water bodies to the SRPA has been estimated using the same techniques used for the baseline RA. Conservative assumptions were used in the calculations of remaining risk under Alternative 2. The primary assumption involved a 50% reduction in contaminant concentrations at the point of contact with the SRPA, except for tritium and strontium-90. Tritium and strontium-90 were not assumed to be reduced as a result of physical/chemical treatment. As with the baseline RA, the future use scenario included using the SRPA for domestic and agricultural purposes hydraulically downgradient of the TRA. Estimated results of the risk analysis for Alternative 2 indicate that carcinogenic risks for the future use scenario are 1.5×10^{-7}, which do not differ significantly from carcinogenic risks associated with the No Action alternative. This is due to the fact that tritium and strontium-90 contribute to a significant portion of the carcinogenic risk. Similar to the No Action alternative, the noncarcinogenic health impacts are not considered to be a concern for the future use scenario.

The Physical/Chemical Treatment alternative is described in detail in Section 3.2 of this report. Chemical coagulation/flocculation followed by sedimentation and rapid sand filtration to remove colloidal and dissolved contaminants are key elements of the conceptual treatment train proposed for this alternative.

Wastewater treatment sludges would be generated under this alternative. These sludges would contain the COCs removed from the ground water in addition to any other metal species and suspended solids amenable to treatment. The volume of sludge generated would be a function of (a) the types and quantities of coagulant employed, (b) the total chemical make up of the water including contaminants, other metals amenable to co-precipitation, and suspended solids concentration, (c) other chemicals required to facilitate flocculation and settling such as polymers, and (d) the settling and dewatering characteristics of the sludge.

The potential production rate of treatment residuals was estimated within approximately ± 50% based on average contaminant concentrations in the deep perched groundwater and an assumed 50% treatment efficiency, as discussed in Section 4.1.2. The estimated mass and volume of treatment sludges was approximately 6 cubic feet per day. These estimated sludge quantity estimates would be refined through treatability studies prior to initiating a final treatment design for Alternative 2. Potential long-term risks associated with generation of treatment residuals would be adequately managed through disposal in an appropriate on site repository.

As previously stated, physical/chemical treatment methods are not expected to remove tritium, and the risks associated with tritium would remain essentially unaltered by actions proposed under this alternative. In addition, the potential efficacy of conventional treatment in the removal of radionuclides in very low concentrations is uncertain and a 50% removal efficiency was assumed as a conservative estimate. Dissolved and colloidal metals including chromium, manganese, americium-241, and possibly cobalt-60 are expected to be amenable to treatment by chemical coagulation and/or co-precipitation. Strontium-90 is not expected to be removed due to its chemical similarity to calcium. This assumption could be evaluated through treatability testing.

During ground-water extraction, the water quality in the PWS would be expected to reach equilibrium with the quality of water infiltrating from the waste disposal ponds, and with contaminants immobilized or adsorbed within the aquifer materials, assuming the warm waste contribution is eliminated. Adsorbed and immobilized contaminants present in the solid phase in the aquifer material represent a potential source of residual contamination for the PWS. The potential influence of solid phase residual contamination on equilibrium ground-water quality is uncertain; however, only relatively minor removal of this residual would be expected to occur during pumping from retardation effects associated with sorption phenomena in the aquifer materials. The potential success of ground-water pumping and treatment could be limited due to the tendency of ground water to equilibrate with the adsorbed residual contaminants in these materials.

For example, a maximum of 600 pounds of chromium could be removed from the aquifer during pumping based on average chromium concentrations in the deep perched zone. This removal rate would be insignificant compared to the estimated 31,000 pounds of chromium discharged to the aquifer from disposal wells from 1964 to 1972 or to the total estimated 55,000 pounds discharged from 1952 through 1972 (EG&G 1991). Therefore, the potential risks associated with chromium and other contaminants present in the adsorbed phase may not be significantly reduced through implementation of a pump and treat alternative. Contaminants would not tend to bioaccumulate due to their physical location in the PWS, or their nature in the sludge in the engineered repository.

Estimated treatment efficiencies (and, thus the 50% contaminant reduction at the point of contact with the SRPA) for coagulation/flocculation were conservatively set at 50% for two reasons. First, the average concentrations for metal and radionuclide contaminants in the deep perched ground water are extremely low, and may be approaching the limitations of coagulation technologies. Also, treatment efficiencies would be expected to decrease as the concentrations of target compounds decreases through treatment. Second, unfavorable reaction kinetics and other unknown factors may limit the practical extent of treatment of some target compounds. As previously stated, treatability testing would be required to identify potential reaction limiting factors for chemical coagulation-flocculation.

Following remedial action completion and treatment facility decontamination and decommissioning, monitoring, maintenance, and management of the on site repository could be required for 30 years. Ground-water monitoring, leak detection systems, and repository cover integrity requirements would be implemented. Maintenance operations may consist of repairs to the cover system, collection and treatment of any leachate generated, and/or maintenance and replacement of mechanical systems as needed. Administrative responsibilities would consist of compliance with all appropriate permit requirements for the repository. Risks associated with repair and/or replacement of any component of the repository system would be minimized by taking the appropriate precautions during repair and/or replacement operations.

Exposure controls or other long-term management activities included under this alternative include existing institutional controls of restricted site access and land use restrictions, continued maintenance and monitoring of the onsite repository where the wastes would be disposed in accordance with action-specific ARARs of the site. Potential risks could be adequately addressed through repository design and construction specifications. These existing controls would be expected to be adequate and reliable in terms of long-term effectiveness and permanence of the Physical/Chemical Treatment alternative.

The overall risk remaining at the site after completion of remedial actions is rated moderate. Risks associated with generation and disposal of treatment residuals would be low. The treatment systems employed in this alternative are expected to meet or exceed assumed treatment efficiencies, but potential risks would remain due to the untreated residual contamination in the aquifer material and no tritium removal.

4.2.3.3 Alternative 3–Evaporative Ground-Water Treatment. Two evaporative treatment alternatives and the assumptions on which they are based are described in Section 4.1.3 of this document. Alternative 3 consists of evaporative treatment in ponds constructed to RCRA Subtitle C specifications, including double FML systems, drainage layers, leak detection and collection systems, and ground-water monitoring networks.

Treatment residuals for this alternative would consist of sediments, salts, and precipitates that would form in the evaporation ponds. Residual materials would contain most of the COCs except tritium and volatile organic compounds. The weight of treatment residuals was estimated to range from 3.7 million pounds to 7.4 million pounds, depending on the assumed quality of the extracted groundwater over the duration of nine years of pumping. Using this mass of residuals and assuming a specific gravity of 1.80 for the dried solids, the volume of treatment residuals would be approximately 1,200 to 2,400 cubic yards, again depending on average concentrations of the COCs over the pumping period. The residual solid materials would remain in place in the evaporation ponds. The ponds would be subsequently closed in accordance with RCRA Subtitle C requirements, thereby minimizing the potential risks associated with the remaining residuals.

Tritium would be released to the atmosphere during evaporative treatment. After complete evaporation of all extracted ground water, tritium would be widely dispersed due to atmospheric transport, and some would be redeposited along its transport pathways. The magnitude of the risk associated with this transport of tritium is uncertain; however, preliminary estimates of the committed effective dose equivalent (CEDE) due to tritium release show a maximum dose of 2.8×10^{-3} mrem per year at a location 5 kilometers northeast of the proposed pond locations. This is less than the Federal threshold CEDE standard of 10 mrem per year. Detailed air quality modelling studies may be required to adequately estimate this potential risk prior to implementing Alternative 3.

The magnitude of remaining risk for COCs in the PWS has been estimated assuming that a 10% reduction in exposure point concentrations (i.e., at the SPRA point of contact) would occur for each of the nine years in the proposed remedial action period. Using this assumption a reduction of approximately 62% of the COC concentrations in the PWS would occur over a nine-year ground-water pumping period. The estimated carcinogenic risks for the future use scenario under the Evaporative Treatment alternative is 5.7×10^{-8}, which is one order of magnitude below the carcinogenic risks for Alternatives 1 and 2. Similarly to Alternatives 1 and 2, the noncarcinogenic health impacts are not considered to be a concern for the future use scenario.

During ground-water extraction for evaporative treatment, the water quality in the PWS would be expected to reach equilibrium with the quality of water infiltrating from the cold and chemical waste ponds and with contaminants immobilized or adsorbed within the aquifer materials, as discussed previously. Ground water tends to equilibrate to chemical concentrations associated with concentrations present in the solid phase. Potential risks associated with this equilibrium water quality are uncertain; however, a significant untreated solid-phase residual is expected to remain adsorbed to the aquifer materials. Therefore, the potential success of ground-water pumping and treatment could be limited. Contaminants would not tend to bioaccumulate due to their physical location in the PWS, or their nature within the evaporation ponds.

Evaporative treatment efficiency for Alternative 3 is expected to be nearly 100% for all contaminants removed from the aquifer except tritium. Tritium will not be separated from the evaporated water. This estimated efficiency applies only to the evaporative process itself. Contaminant removal efficiency from the aquifer is expected to be low. Long-term management, maintenance, and monitoring requirements for the closed evaporation ponds are expected to be similar or equal to those for the treatment residual repository described under Alternative 2.

Following remedial action completion and evaporation pond closure, monitoring, maintenance, and management of the evaporation repositories would be required for 30 years. Ground-water monitoring, leak detection systems, and repository cover integrity would be required. Maintenance operations may consist of repairs to the cover system, collection and treatment of any leachate generated, and/or maintenance and replacement of mechanical systems as needed. Administrative responsibilities would consist of compliance with all appropriate permit requirements for the repository. Risks associated with repair and/or replacement of any component of the repository system would be minimized by taking the appropriate precautions during repair and/or replacement operations.

Exposure controls or other long-term management activities included under this alternative include existing institutional controls of restricted site access and land use restrictions, continued maintenance and monitoring of the evaporation pond repositories where the wastes would be closed in-place in accordance with action-specific ARARs of the site. Potential risks could be adequately addressed through repository design and construction specifications. These existing controls would be expected to be adequate and reliable in terms of long-term effectiveness and permanence of the Evaporative Treatment alternative.

The overall risk remaining at the site after completing the remedial actions proposed under Alternative 3 is rated to be moderate. Risks associated with generation and disposal of treatment residuals would be low, and the treatment efficiencies are expected to approach 100% for all COCs except tritium. The potential risks associated with the release and transport of tritium are considered to be low, although detailed air quality monitoring may be required to further evaluate effects due to tritium.

4.2.3.4 Alternative 4–Source Control. Results of ground-water modeling and the baseline RA indicated that with the planned warm waste source removal and continued infiltration of both cold and chemical waste streams there would be no long-term adverse impacts to the SRPA hydraulically downgradient from the TRA under the Source Control alternative. The Source Control alternative is similar to the No Action alternative with the exception of the reduced effluent flow rates to the cold and chemical waste ponds. The baseline RA was used to evaluate the long-term effectiveness and permanence of Alternative

No. 4 for the future use scenario. Continuing infiltration from the cold and chemical waste ponds produces a driving force for downward migration of COCs. Because the driving force for COC migration to the SRPA would be reduced under Alternative 4 the exposure point concentrations would be reduced further than those under the no action alternative. However, these concentrations have not been estimated for the FS. As a result, the carcinogenic risk associated with the Source Control Alternative would be less than the 1.5×10^{-7} risk estimated for no action. As a worst case, the carcinogenic risks would be similar to that for the No Action alternative. Thus, long-term effectiveness and permanence would be achieved by the Source Control alternative. As with the other three alternatives, the non-carcinogenic health impacts are not considered to be a concern for the future use scenario.

Closure of the existing warm waste ponds will significantly reduce introduction of radionuclides to the PWS. The volume, toxicity, and mobility of the COCs would decrease under this alternative due to the continued dilution of the PWS with cold, chemical, and sanitary waste water infiltration. Solid-phase residual contamination in the PWS would not be addressed as part of this alternative. Contaminants would not tend to bioaccumulate due to their physical location in the PWS.

Exposure controls or other long-term management activities included under this alternative include existing institutional controls of restricted site access and land use restrictions, continued monitoring and documentation of waste stream characterization for TRA process effluents, and continued monitoring of the chemical characteristics of the PWS. These existing controls would be expected to be adequate and reliable in terms of long-term effectiveness and permanence of the Source Control alternative.

4.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The reduction of toxicity, mobility, and volume of perched ground water through treatment has only been evaluated on a conceptual basis. Information available in the literature was used as appropriate to develop the conceptual understanding of perched ground-water treatment. Treatability testing would be required to evaluate any treatment process described in order to fully quantify treatment technology effectiveness. This evaluation method measures the degree to which alternatives employ recycling or treatment to reduce toxicity, mobility, or volume, including how treatment is used to address the potential threats to human health and the environment posed by the Site.

The NCP states that reduction of toxicity, mobility, or volume through irreversible treatment is the preferred method of mitigating threats to human health and the environment at CERCLA sites. Evaluation of the selected alternatives with respect to this criterion must address (a) processes used and materials the processes would treat (b) the amounts of hazardous materials that would be destroyed or permanently immobilized (c) the degree of irreversible toxicity or volume reduction (d) the degree to which treatment is irreversible (e) quantities and magnitudes of risk associated with treatment residuals and (f) the overall degree to which treatment is employed to mitigate the potential hazards present at the site. Exposure to COCs through ingestion of ground water is the only potential human exposure route for the TRA PWS OU.

4.2.4.1 Alternative 1-No Action. Transport of COCs in the PWS through continued infiltration to the SRPA would continue, although additional warm waste infiltration will terminate in 1992. No treatment activities for the perched ground water would occur, nor would the COCs be destroyed or recycled under this alternative. While ground-water treatment is not specified for the No Action alternative, the toxicity and volume of the PWS would be decreased. Due to continued dilution of the perched ground water by cold, chemical, and sanitary wastewater infiltration COC concentrations would decrease, thereby reducing these concentrations at the point of contact with the SRPA.

Planned evaporation of the warm waste after 1992 will result in a slightly reduced volume (approximately 15,000 gpd) of water infiltrating into the PWS and subsequently the SRPA. Mobility of the COCs would likely change as a result of the discontinued warm waste infiltration. Depending on the forms of the various COCs and their respective solubilities, solid-phase residual contaminants in the aquifer materials may solubilize over time and move through the PWS; however, the predominant oxide forms of the radionuclides assumed to be present in the PWS are essentially insoluble and would not be considered to contribute to an increase in contaminant concentrations for perched water reaching the SRPA.

Again, since treatment does not occur for the No Action alternative, there are no physical or chemical treatment reactions to evaluate. However, with warm waste pond closure activities, the PWS chemistry may change as described above. Any physical or chemical changes that result from the warm waste pond closure would be considered irreversible since warm waste is not planned to be discharged again to the PWS at any time in the future. Solid phase residuals would remain in the aquifer materials (their persistence, toxicity, and mobility have been discussed above). No action would reduce the potential threats to human health at the PWS OU by eliminating new warm waste discharge and continued infiltration of the remaining waste streams.

4.2.4.2 Alternative 2-Physical/Chemical Ground-Water Treatment. Chemical coagulation/flocculation would be used for metal and radionuclide removal under this alternative. However, treatment efficiencies of this proposed process are uncertain because of treatability data are unavailable. As a result, other unit operations may be required to polish the effluent to improve the overall treatment efficiency. Testing and evaluation of any proposed treatment process would be required before implementing a physical/chemical treatment alternative.

Concentrations of chromium and manganese in the treated effluent would be below the chemical-specific ARARs for the Site. Based on the assumed 50% removal efficiency the total mass of chromium and manganese removed during the nine years of pumping and treatment would be approximately 300 pounds and 830 pounds, respectively. Due to the extremely low average concentrations of americium-241 and cobalt-60 in the perched ground water, the mass of these radionuclides removed would be on the order 10^{-5} to 10^{-8} pounds after nine years of pumping and treatment. An estimated 10^{-4} pounds of tritium would be removed from the aquifer during pumping; however, no tritium removal would occur through this conventional treatment train, and the tritium would be discharged back to the PWS with the treated effluent, except for minor losses expected to reach the atmosphere through evaporation.

The mass of COCs removed during treatment would be less than one percent compared to the non-contaminant metals removed. For example, more than 45,000 pounds of iron would be removed over the duration of remedial action under Alternative 2. Contaminants removed from the treated ground water would not be destroyed, but would be effectively immobilized by chemical precipitation and adsorption. These estimates are based on the assumed 50% treatment efficiency. Treatability studies would be required to more accurately quantify the mass of contaminants potentially removed under this alternative.

The potential toxicity of treated ground water with respect to chromium and manganese would be reduced through the proposed physical/chemical treatment methods. The treated effluent would be expected to meet chemical-specific ARARs for the OU. Removal of half the americium-241 and cobalt-60 would not be expected to have a major impact on the overall toxicity of the treated water since these radionuclides are present in extremely low average concentrations. No reduction of toxicity with respect to tritium would be expected to occur, although the chemical-specific ARARs for these radionuclides would be met at the point of contact with the SRPA in a maximum of 125 years. Strontium-90 would meet the chemical-specific ARARs at the present time.

Toxicity of the contaminants precipitated in a solid phase would be decreased through immobilization. Contaminants in the solid phase would be expected to be resistant to leaching under normal ambient conditions; however, treatability testing would be required to obtain adequate quantities of solid material for toxicity testing.

The potential overall toxicity reduction for the perched ground water achievable under this alternative is uncertain due to the unknown equilibrium concentrations of contaminants in the PWS after remedial action completion. As described in Section 4.2.3.2, the final COC concentrations in the PWS after pumping and physical/chemical treatment would be a function of the quality of water infiltrating into the PWS and the concentration of contaminants adsorbed to the aquifer materials. The mass of contaminants potentially removed from the PWS would consist of only a small fraction of the total mass of contaminants discharged to the disposal pond system.

The volume of perched ground water containing COCs would not be reduced to a large extent through pumping and physical/chemical treatment since the chemical-specific ARAR for tritium would not be met at the present time. The chemical-specific ARAR for tritium would be met in a maximum of 125 years. Some reduction in contaminant levels would be expected to occur in the treated ground water and in the water remaining in the PWS at the present time as a result of treatment. In addition, termination of warm waste infiltration will also result in a slightly decreased flow to the PWS.

As stated in Section 4.2.3.2, the volume of treatment residuals would be approximately 730 cubic yards over the treatment period (i.e., 6 cubic feet per day for nine years). Potential risks associated with these treatment residuals would be managed through disposal in an engineered onsite repository.

Treatment by chemical coagulation/precipitation would be irreversible; however, metal contaminants could potentially be released from the treatment sludges under either extremely high or low pH conditions. Since such extreme pH conditions would not be expected to develop within a RCRA Subtitle C repository, the immobilization of contaminants in the treatment sludges would be considered irreversible.

Contaminants adsorbed on aquifer materials could potentially be mobilized following completion of pumping and treatment. Concentrations of these contaminants would be expected to achieve equilibrium with solid-phase residual contaminants after pumping is completed. Treatment may be reversed to the extent that the final equilibrium concentration exceeds concentrations temporarily achieved during pumping.

Alternative 2 would partially meet the statutory preference for treatment in reducing toxicity, mobility, and volume of perched ground water at the Site. Two COCs, tritium and strontium-90, would not be removed during treatment. Only minor reductions of residual contaminants adsorbed on the aquifer materials would be expected to occur, and ground water in the PWS may equilibrate with this solid phase residual contamination. However, increases in ground-water concentrations of COCs that may become solubilized and tend to migrate to the SRPA would not likely be a major contaminant source, as was discussed with the No Action alternative.

4.2.4.3 Alternative 3-Evaporative Ground-Water Treatment. Evaporative treatment would use incident solar radiation to concentrate the non-volatile COCs in sediments or precipitates within a series of evaporation ponds. Upon evaporation, tritium would be transferred to the atmosphere and dispersed. Details of this treatment approach are discussed in Section 3.3.

Contaminants would not be destroyed during evaporative treatment, but would be concentrated, immobilized, and disposed onsite in evaporation ponds meeting RCRA Subtitle C requirements. Treatment efficiencies would approach 100% for all COCs except tritium. Tritium would be displaced from the perched water to the atmosphere. The total mass of chromium and manganese removed during nine years of pumping and evaporation was estimated to be approximately 600 pounds and 1,700 pounds, respectively. Due to the extremely low average concentrations of americium-241 and cobalt-60 in the perched ground water, the mass of these radionuclides removed would be on the order 10^{-5} to 10^{-8} pounds after nine years of pumping. An estimated 10^{-4} pounds of tritium would be removed from the aquifer and dispersed to the atmosphere. Approximately 3.7 to 7.4 million pounds, or 1,200 to 2,400 cubic yards of sediment and salts would remain in the ponds following complete evaporation.

The mass of COCs removed during treatment would be approximately 0.03% compared to the noncontaminant metals removed. The solids remaining in the evaporation ponds would consist primarily of carbonate, sulfate, phosphate, nitrate, chloride, and other salts of calcium, iron, potassium, sodium, and other metals. For example, more than 45,000 pounds of iron, 300,000 pounds of sulfate, and 900,000 pounds of calcium were estimated to be removed over the duration of this remedial action.

The toxicity of the contaminants precipitated in a solid phase within the evaporation ponds would be decreased through immobilization. However, the contaminated solids formed by evaporation would not be resistant to leaching under normal ambient conditions, and may be readily solubilized if wetted. Ambient conditions would not prevail within the RCRA Subtitle C evaporation ponds upon their closure. Thus, immobilization of contaminants in the evaporation solids would be considered irreversible.

The potential overall reduction in toxicity of the perched ground water achievable under Alternative 3 is uncertain because of the unknown equilibrium concentrations of contaminants in the ground water after completion of the proposed pumping activities, as described for Alternative 2. Also, as described previously in Section 4.2.3.2, the final concentrations in the aquifer materials after pumping would be a function of the quality of the water infiltrating into the PWS and the concentrations of contaminants adsorbed in the aquifer materials. The mass of contaminants potentially removable from the aquifer would consist of only a small fraction of the contaminants discharged to the waste disposal ponds throughout the history of TRA.

The volume of PWS water containing COCs brought to the surface by pumping would be greatly reduced through evaporative treatment. Some reduction in contaminant levels would be expected to occur in the water remaining in the PWS as a result of pumping; however, an overall volume reduction of contaminated water would be expected to occur since the water remaining in the PWS would contain lower COC concentrations after the remedial action.

Contaminants remaining in the perched zones adsorbed on aquifer materials could be potentially mobilized following completion of treatment. Concentrations of these contaminants would be expected to achieve equilibrium with solid phase residual contaminants after pumping is completed.

This alternative would partially meet the statutory preference for treatment to the extent that equilibrium ground-water quality would represent a reduction in the toxicity, mobility, and volume of perched ground water. Treatment residuals would be immobilized primarily through onsite disposal, not by treatment. Also, tritium would be released directly to the environment during treatment.

4.2.4.4 Alternative 4-Source Control. Transport of COCs in the PWS through continued infiltration to the SRPA would continue, although additional warm waste infiltration will terminate in 1992. No treatment activities for the perched ground water would occur, nor would the COCs be destroyed or recycled under this alternative. While ground-water treatment is not specified for the source control alternative, the toxicity and volume of the PWS would be decreased to a certain extent. Due to continued dilution of the perched ground water by cold and chemical waste infiltration contaminant of COC concentrations would decrease, thereby reducing these concentrations at their point of contact with the SRPA.

Reduced cold and chemical waste streams, along with the planned evaporation of the warm waste after 1992, will result in a moderately reduced volume (approximately 375,000 gpd) of water infiltrating into the PWS and subsequently the SRPA. Mobility of the COCs would likely change as a result of the reduced infiltration rates. Depending on the chemical forms of the various COCs and their respective solubilities, solid-phase residual contaminants in the aquifer materials may solubilize over time and move throughout the PWS; however, the predominant oxide forms of the radionuclides assumed to be present in the PWS are essentially insoluble and would not be considered to contribute to a significant increase in contaminant concentrations for perched water reaching the SRPA.

Since perched ground-water treatment does not occur for this alternative, there are no physical or chemical treatment reactions to evaluate. The source control alternative would reduce toxicity, mobility, and volume of the COCs in the PWS by eliminating new warm waste discharge and reducing infiltration of the cold and possibly the chemical waste streams. This infiltration reduction removes the driving force for COCs to reach the SRPA.

Treatment and recycling of cold and chemical waste streams would not reduce the total mass of various elements and compounds discharged to the respective disposal ponds, although the process would concentrate these substances in the waste streams. Since the cold and chemical waste ponds do not currently contribute COCs to the PWS, as identified in the baseline RA the continued disposal of more concentrated waste streams would not be expected to result in additional toxicity, mobility, or volume to the PWS and its subsequent impact on the SRPA.

4.2.5 Short-Term Effectiveness

Short-term effectiveness is measured relative to protecting human health (both community and worker) and the environment during implementation of a given alternative. Under this criterion, the selected alternatives are evaluated with respect to (a) potential risks to surrounding communities during construction and/or implementation, (b) potential risks to workers performing construction, remedial actions, or treatment activities, (c) possible environmental impacts resulting from implementation of remedial actions, and (d) the length of time required to achieve protection for human health and the environment.

4.2.5.1 Alternative 1-No Action. No additional short-term risks would be created for the local community or environment as a result of no action on the PWS OU. The closest human population center is located approximately 12 miles from TRA at Atomic City. Currently existing risks, considered to be low, would decrease with time because of warm waste pond closure and continued cold and chemical waste infiltration. Any risks to human health and the environment associated with closure of the existing warm waste ponds, and construction of the new warm waste evaporation ponds are considered as part of a separate OU, and have not been considered as part of the PWS OU.

Potential impacts to workers at TRA would not change as a result of no action. Existing safety measures used at TRA and INEL for permanent workers and visitors would be effective and reliable protection from COCs present in the PWS. Institutional controls would provide necessary protection for surrounding communities from contact with the PWS.

Potential environmental impacts as a result of no action would not change from impacts caused by current TRA operations. Migration of perched ground water to the SRPA would continue, although COC concentrations would decrease through time. This continued decrease in concentrations would result in reducing potential adverse impacts to human health and the environment. Ground-water monitoring activities in place for continued perched water quality characterization would assist in an ongoing evaluation of contaminant migration through the PWS. Since there have been no risks to human health and the environment at TRA from the presence of the PWS under a current use scenario (as described in the Baseline RA), the time until protection is achieved has not been evaluated as part of the FS.

4.2.5.2 Alternative 2-Physical/Chemical Ground-Water Treatment. Potential risks from implementing chemical coagulation/precipitation would be expected to be low. The closest human population center Atomic City, is located approximately 12 miles from TRA. Potential accidental releases of contaminated ground water would occur at remote locations with little potential for human exposure. The proposed treatment chemicals would not represent a potential threat to the nearby communities in the event of spills or accidents.

Construction of treatment facilities and an onsite repository for treatment residuals would not be expected to present increased risks to the public.

During implementation of Alternative 2, contaminated ground water would be pumped to the surface for treatment, and small quantities of tritium would be released to the atmosphere through evaporation. Also, transfer of tritium from the ground water to the atmosphere would occur during discharge of the treated water to infiltration ponds. The magnitude of the potential risks associated with tritium releases to the atmosphere are unknown, but should be expected to be low because of its relatively low concentrations in the ground water and its limited opportunities for evaporation.

Tritium is expected to behave as a conservative tracer throughout the treatment process. Tritium would infiltrate from the discharge pond into the PWS where it would be additionally diluted and dispersed. Potential short-term risks associated with the redistribution of tritium in the PWS would be low since infiltrated water would also be diluted with water infiltrating from the cold, chemical, and sanitary waste ponds, and perched ground water is not used as a source of agricultural, industrial, or domestic water supplies.

Protecting construction personnel and treatment plant operators would be a major concern under this alternative. Worker exposure to radionuclides through direct contact, ingestion, and/or inhalation could represent potential risks, although the magnitude of these risks is uncertain. Contaminants may be concentrated in wastewater treatment sludges, and handling of the sludges may represent potential risks to workers; however, these potential risks could be mitigated through the required use of appropriate personal protective equipment (PPE) by plant operators, in accordance with applicable safety regulations in place as part of current TRA and INEL operations.

Construction workers could be exposed to increased risks during drilling of extraction wells and placement of the wastewater sludges in the repository. However, workers could be adequately protected by the use of appropriate levels of PPE. These levels could be specified in all contract documents for the construction and operation of treatment facilities.

Construction and operation of ground-water treatment facilities would not represent an irreparable threat to Site flora and fauna. In previous studies, no Federal rare or endangered plants were identified at INEL (Doornbos, et al. 1990). Nine plant species on the list of sensitive species prepared by the State of Idaho exist at INEL. However, only three are in the vicinity of TRA, but only within approximately two miles of the site. However, further studies would be required to evaluate the potential risks to endangered flora in order to ensure that construction activities would not destroy the habitats of any candidate or sensitive species.

The site characterization study (EG&G Idaho 1991) concluded that the area around TRA was not a suitable habitat for endangered animal species or species of special concern to the Idaho Department of Fish and Game. Several species of endangered wildlife such as bald eagles and peregrine falcons have been observed at the Site, but were not identified as resident populations. Waterfowl species of State concern have also been observed at the site, but no habitat for sensitive species was identified in the vicinity of TRA (Doornbos, et al. 1991). Therefore, implementation of this alternative would not be expected to result in negative impacts to terrestrial fauna. Impacts to aquatic biota and surface waters would not be a concern during implementation of this alternative since no natural surface water bodies exist in the vicinity of TRA.

Evaluating Alternative 2 is based on the assumption that any newly constructed facility would be located outside of, but adjacent to, TRA. Minor short-term environmental impacts such as wind and/or surface-water erosion during construction of these facilities should be anticipated and appropriate mitigating efforts should be implemented. Special precautions would have to be observed in the siting of newly constructed facilities to avoid disturbance of any solid, hazardous, and/or mixed waste repositories or contaminated soils that may exist in the vicinity of TRA, or in an area that would interfere with TRA operations.

The ground-water extraction system and treatment facilities proposed under this alternative would be expected to be constructed in approximately six months to one-year from the start of the remedial action. Given an average pumping rate of 0.25 MGD, pumping would be expected to remove approximately 75% of the current volume of the deep perched zone approximately nine years after pumping begins. Use of the evaporation ponds as the onsite engineered sludge repository could occur simultaneously with infiltration pond construction, treatment plant construction, and pumping well installation. An additional one-year period has been assumed for decontamination and decommissioning the treatment facilities and closure of the treatment sludge repository. Therefore, the entire remedial project is expected to require a minimum time of approximately 11 years to complete; however, the time required to remove the majority of the COCs present in the PWS may be reduced if vertical contaminant migration, dilution from the cold, chemical, and sanitary waste pond infiltration, and the relatively short half-lives of some radionuclides are taken into account.

4.2.5.3 Alternative 3-Evaporative Ground-Water Treatment. Potential risks from evaporation of contaminated ground water would be expected to be low for Alternative 3. The closest human population center is approximately 12 miles from TRA, and potential accidental releases of contaminated ground water would occur in the general area of TRA with little possibility for human exposure. Construction of an onsite repository for treatment residuals would not be expected to present increased risks to the public.

During implementation of this alternative, contaminated ground water would be pumped to the surface for direct discharge to evaporation ponds, where tritium would be released to the atmosphere. The magnitude of the potential risks associated with tritium releases to the atmosphere are unknown, but would be expected to be low because of the low mass of tritium present in the extractable ground water. An estimated total mass of tritium on the order of 10^{-4} pounds would be released during the nine years of pumping and evaporation. Air quality computer modeling would be required to estimate potential risks from the release of this amount of tritium to the atmosphere.

Risks to surrounding communities from potential evaporation pond leaks would be low since no industrial or domestic usage of the perched ground water occurs in the vicinity of TRA. When evaporative treatment is completed, the potential for air transport of treatment residuals would be greatly increased and could represent a potential exposure pathway for surrounding communities during high wind events. Dust control measures may be required during the pond closure period to protect these communities and construction workers from potential risks associated with this exposure route.

Worker protection issues would not represent a significant concern during evaporative treatment. Exposure to radionuclides through direct contact, ingestion, and/or inhalation could represent potential risks; however, few opportunities for worker exposure would exist during the treatment process, and these risks could be mitigated by the use of the appropriate level of PPE. At the end of the remedial action, contaminants would be concentrated within the ponds. Handling these residuals could represent a risk to workers during planned pond closure activities. However, these potential risks could be successfully mitigated through the required use of appropriate PPE and dust control measures.

As with Alternative 2, construction workers could also be exposed to increased risks during drilling and construction of extraction wells. Workers could be adequately protected by the use of appropriate levels of PPE and adherence to all appropriate safety measures for this activity.

Construction and operation of evaporative treatment facilities could result in potential environmental impacts because of the disturbance of large land surface areas. Because of large areal requirements for the evaporation ponds, potentially suitable locations may be limited. Potential encroachment on sensitive terrestrial biota habitats may be required to accommodate the ponds. An evaluation of these issues would be required before implementing Alternative 3.

Plant and animal species could be impacted depending on the location of the evaporation ponds. Previous studies identified no rare or endangered plants at INEL (EG&G Idaho 1991). Nine plant species on the list of sensitive species prepared by the State of Idaho exist at INEL. However, only three are in the vicinity of TRA, but only within approximately two miles of the site. Further studies of potential pond locations would be required to evaluate the potential risks to native flora to ensure that construction activities would not destroy the habitats of candidate or sensitive plant species.

The Site characterization study concluded that the area around TRA was not a suitable habitat for endangered animal species or species of special concern to the Idaho Department of Fish and Game (EG&G Idaho 1991). Several species of endangered wildlife such as bald eagles and peregrine falcons have been observed at the Site, but no resident populations were identified; however, resident populations of species of special concern to the Idaho Fish and Game were identified within INEL, and the habitats of these species could be impacted by the creation of large ponds. A Site-specific assessment would be required to accurately evaluate the potential for habitat loss during construction and operation of the ponds.

Waterfowl and shore birds of concern to the State have been observed at the site, but no habitat for sensitive species was identified in the vicinity of TRA (EG&G Idaho 1991). Construction of large ponds could be attractive to migrating waterfowl and shore birds as resting habitat, and their use of the ponds could represent a potential environmental exposure pathway. Measures to discourage the use of the ponds by wildlife such as fences and waterfowl hazing could be implemented to mitigate possible environmental impacts to these animals.

Impacts to aquatic biota and surface waters would not be a concern during implementation of Alternative 3 since no natural surface water bodies exist in the vicinity of

TRA. Potential releases of ground water to the environment could be addressed through design and construction quality control procedures.

Special precautions would have to be observed in the siting of newly constructed facilities to avoid disturbing ongoing TRA operations. Site restoration following completion of evaporative treatment would be have to be addressed in the facility closure plans for the ponds. Reclamation techniques are available for the restoration of disturbed arid lands, and these techniques should be incorporated into the Site closure plans to comply with action-specific ARARs.

The ground-water extraction system and treatment facilities proposed under this alternative could be constructed in approximately one year from the start of the remedial action. Given an average pumping rate of 0.25 MGD, pumping would be expected to remove approximately 75% of the current volume of the deep perched zone approximately nine years after pumping begins. A period of up to one year may be required to evaporate the water in the ponds after the end of pumping. An additional year has been assumed for pond closure. Therefore, the entire remedial project would be expected to require approximately 12 years to complete. However, the time required to remove the majority of the COCs present in the PWS may be reduced from this estimate if vertical migration of contaminants, dilution from the cold, chemical, and sanitary waste ponds, and the relatively short half-lives of some radionuclides are taken into account.

4.2.5.4 Alternative 4-Source Control. No additional short-term risks would be created for the local community or environment as a result of the source control alternative. As stated previously, the closest human population center is Atomic City, located approximately 12 miles from TRA. Currently existing risks, considered to be low, would decrease with time because of warm waste pond closure and reduced infiltration of the cold and chemical waste streams. Any risks to human health and the environment associated with closure of the existing warm waste ponds, and construction of the new warm waste evaporation ponds are considered as part of a separate OU, and have not been considered as part of the PWS OU.

Implementing additional treatment processes at TRA itself would not be expected to contribute risks to the surrounding communities. Such treatment modifications for the cold and possibly the chemical waste streams would not be expected to alter overall operation of the TRA with respect to waste stream handling and disposal.

Potential impacts to workers at TRA would not change as a result of implementing source control. Existing safety measures used at TRA and INEL for permanent workers and visitors would be effective and reliable protection from COCs present in the PWS, and in the waste streams generated during routine TRA operations. Institutional controls for TRA and INEL would provide necessary protection for surrounding communities from contact with the PWS.

Potential environmental impacts as a result of source control would be similar to those described for the No Action alternative. Specifically, there would be no significant changes from impacts caused by current TRA operations. Migration of perched ground water to the SRPA would continue, although COC concentrations would decrease through time with the reduced infiltration rates. This continued decrease in concentrations would result in reducing potential adverse impacts to the environment.

Ground-water monitoring activities in place for continued perched water quality characterization would assist in an ongoing evaluation of contaminant migration through the PWS. Since there have been no risks to human health and the environment at TRA from the presence of the PWS under a current use scenario (as described in Section 6 of the RI), the time until protection is achieved has not been quantified for purposes of the FS.

4.2.6 Implementability

An assessment of implementability includes an evaluation of technical feasibility (e.g., the ease of constructing the alternative and the construction time requirements, administrative feasibility of the alternative, and the availability of services and materials to the Site). These issues are evaluated to confirm whether significant obstacles exist that would prevent the candidate remedial alternatives from adequately addressing the remedial objectives for the Site.

4.2.6.1 Alternative 1-No Action. There are no implementability concerns with this alternative since no action would occur at TRA for the PWS OU. Current ongoing activities at TRA would continue, including the continued discharge of cold, chemical, and sanitary waste streams to their respective disposal ponds, ground-water quality monitoring of both the PWS and the SRPA, and continued use of access and property restriction institutional controls for TRA and INEL. There would be no expected difficulties with either the technical or administrative feasibility for no action because current TRA operations would remain unchanged. While closure of the existing warm waste ponds and construction of new evaporation ponds will occur at TRA and will impact the PWS, these activities will be conducted in accordance with a separate OU. Implementing changes in the warm waste disposal at TRA has not been evaluated as part of the PWS OU.

4.2.6.2 Alternative 2-Physical/Chemical Ground-Water Treatment. The ground-water extraction, conventional physical/chemical treatment, and sludge disposal technologies proposed for this alternative have been proven reliable for similar applications. No potential technical problems in the construction of the extraction well field would be expected in view of the numerous monitoring wells constructed in the PWS. Design and construction of ground-water pumping systems is well understood and could be performed by any qualified contractor. The treatment plant would consist of a readily available package plant and other common components, and could be constructed by any general contractor with treatment plant construction experience.

The reliability of the proposed treatment train to effectively reduce the concentrations of Site-specific contaminants can be adequately evaluated only through treatability testing performed on actual ground-water samples from the Site. This testing would require the use of laboratory facilities certified to conduct radiological analyses and properly dispose of the samples and residuals generated during the testing. The proposed treatment train could be modified based on the results of treatability testing. Coagulants and their dosages could be changed to maximize treatment efficiencies, and additional processes could be added to polish the effluent before discharge, if needed.

No potential difficulties would be expected with respect to monitoring the treatment processes. Analytical methods are available for the detection of the COCs at concentrations sufficient to detect treatment plant failures or upsets. As with most industrial wastewater treatment plants, a monitoring program consisting of onsite monitoring of key operational parameters combined with laboratory analysis of effluent contaminant concentrations could be readily implemented. Such a monitoring system should be able to detect any significant deterioration in effluent quality.

This alternative would be easily implemented with respect to meeting administrative requirements with the assumption that pumping and treatment systems are operated in accordance with the action-specific ARARs for the Site. Discharge permits under the National Pollutant Discharge and Elimination System (NPDES) would not be required since the proposed remedial action would be conducted under CERCLA regulations; however, Federal authorization may be needed to discharge the treated water, and monitoring of the treated effluent would likely be required to demonstrate compliance with this potential action-specific ARAR.

The technologies proposed under the Physical/Chemical Treatment alternative are readily available, relatively simple, and easily operated and maintained. The skilled personnel required to design and construct the pumping and treatment systems would be readily available, and personnel could be hired and trained to successfully operate and maintain the facilities.

The space required to locate the treatment facilities, infiltration pond, and sludge repository is currently available in the vicinity of TRA. The total land area required for the treatment plant would be on the order of 15,000 square feet, whereas the area of the infiltration pond would be on the order of one acre; however, this requirement may be changed depending on the hydraulic conductivity of the subsurface soils at the pond location. The sludge repository may require approximately 3,000 square feet.

4.2.6.3 Alternative 3-Evaporative Ground-Water Treatment. The ground-water extraction, evaporative treatment, and sediment disposal technologies proposed for Alternative 3 have been proven effective in meeting the requirements of this alternative. No potential technical problems in the construction of the extraction well field would be expected, as described previously. Design and construction of ground-water pumping systems is well understood and could be performed by any qualified contractor.

A reliable supply of commercially available pond and repository liner materials and experienced qualified contractors would be available for construction of the proposed evaporation ponds. The pond liner systems have an appropriate design life required for this alternative using commercially available liner materials. The reliability of evaporative treatment is well established by extensive meteorological data for the area. These data indicate that an average net pan evaporation rate of approximately 36 inches per year could be expected over the duration of treatment.

The evaporation ponds would be equipped with a double FML system between which a leak detection and collection system would be installed. Also, a ground-water monitoring system would be installed to detect any failures of the double liner system. The reliability of this design in the prevention of undetected releases from the ponds would be high over the design life of the facility.

Alternative 3 would be easily implemented with respect to meeting administrative requirements assuming that pumping and evaporation systems are operated in accordance with the action-specific ARARs for the Site. Discharge permits under NPDES would not be required since the proposed remedial action would be conducted under CERCLA regulations and no water would be discharged to surface-water bodies or ground water.

The technologies proposed under the Evaporative Treatment alternative are readily available, relatively simple, and easily operated. Skilled personnel required to design and construct the pumping and evaporation systems would be readily available, and personnel could be easily hired and trained to successfully operate and maintain the facilities.

The availability of a land area large enough to meet the space requirements for the construction of the evaporation ponds may be problematic. A relatively flat area of approximately one quarter of a square mile with suitable soil properties for construction of the ponds and associated berms and vehicle travel ways may not be available in the vicinity of TRA; however, remote sites or sites with more suitable construction properties may be available within INEL property. A preliminary pond siting evaluation would be required to more accurately assess the implementability of evaporative treatment with respect to land area availability.

4.2.6.4 Alternative 4-Source Control. The use of the proprietary brine concentrator treatment technology for treatment and recycling TRA operational waste streams under the Source Control alternative has been proven and reliable for similar industrial treatment applications. No potential technical problems would be expected for sizing and implementing this technology in the existing cold and chemical process streams. However, treatability studies would be required to confirm treatment effectiveness for each waste stream considered. Treatability testing would require the use of appropriate laboratory facilities to conduct the proper chemical analyses. The proposed treatment train could be modified as needed based on the results of treatability testing.

No potential difficulties would be expected with respect to monitoring the treatment processes. Analytical methods are available to detect the performance of the brine concentration system on a continuous basis. As with most industrial wastewater treatment plants, a monitoring program consisting of onsite monitoring of key operational parameters combined with laboratory analysis of effluent chemical concentrations could be readily implemented. Such a monitoring system should be able to detect any deterioration in effluent quality.

There would be no expected difficulties for the Source Control alternative with either the technical or administrative feasibility for the waste discharge activities. While closure of the existing warm waste ponds and construction of new evaporation ponds will occur at TRA and will impact the PWS, these activities will be conducted in accordance with a separate OU. Implementing changes in the warm waste disposal at TRA has not been evaluated as part of the PWS OU.

Alternative 4 would be easily implemented with respect to meeting administrative requirements, similar to the No Action alternative. The technology proposed under this alternative is readily available, relatively simple, and easily operated and maintained. The skilled personnel required to design and construct the pumping and treatment systems would be readily available, and personnel could be hired and trained to successfully operate and maintain the facilities.

The space required within TRA to locate these additional treatment processes would most likely be available. The total space requirements for the proposed processes are approximately 7,000 square feet. Additional building space may be required outside of existing structures, which would require coordination with TRA operations to develop the most appropriate site. A facility siting study would be needed to determine the optimum location with respect to points of effluent generation and disposal pond location.

4.2.7 Cost

The cost analysis includes delineation of capital, O&M, and future capital costs. Future capital costs are capital costs that would be required for construction activities in a year other than year zero. A net present worth analysis and present worth discount rate sensitivity analysis are also performed for each alternative. Backup information supporting the cost estimates is given in Appendix J.

The unit capital and O&M costs for each alternative are presented as a constant dollar analysis in 1991 dollars. All costs are before taxes, do not include salvage, and do not assume depreciation. As specified in the NCP, the cost estimate prepared for the detailed analysis represents a +50/-30% degree of accuracy. Specific assumptions used to develop the cost estimates are outlined for each alternative.

4.2.7.1 Alternative 1-No Action. The only costs associated with the No Action alternative relate to ongoing ground-water quality monitoring and TRA effluent quality monitoring activities. Costs associated with existing warm waste pond closure and construction of the new warm waste evaporation ponds are included under a separate OU. Since costs for the ongoing monitoring activities at TRA would occur under each of the alternatives, a cost analysis was not performed for this alternative.

4.2.7.2 Alternative 2-Physical/Chemical Ground-Water Treatment. Capital costs associated with Alternative No. 2 include ground-water pumping well installation, treatment plant installation, infiltration pond and sludge repository excavation, piping installation from the wells to the treatment plant, electrical connections, sludge pond closure, and decontamination and decommissioning of the treatment plant. The O&M costs for this alternative include a treatment plant operator, electrical supply requirements, and long-term maintenance and monitoring of the sludge repository. Assumptions used in preparing the +50/-30 cost estimate include:

- No grading of roads would be required except around the infiltration pond and sludge repository, and no asphalt or concrete drives would be needed.

- No Site utilities for water or sewer are included.

- Excess material excavated for the infiltration pond would be stockpiled onsite; a portion of this material could be screened and used for sludge repository construction. Construction water needed for the excavations would be supplied by others. Clay and topsoil materials required for sludge repository capping would be supplied from a local contractor within 30 miles of the Site. Revegetation of the closed and capped sludge repository is included.

- A six-inch concrete slab on grade was assumed for the treatment plant foundation.

- The construction season for pond and repository excavation, well installation, and treatment plant installation is April 1 to November 15. All construction activities could be completed within one operating season.

- The treatment plant is a package unit, which can be placed directly on the provided concrete slab. A prefabricated metal building would be used to contain the plant. A full-time operator would be needed for the treatment plant.

- The electrical power source is within 300 feet of use. Electrical costs would be approximately $0.028 per kwh.

- Routine maintenance of the plant and the extraction wells would be approximately 1% of initial capital costs, for each item.

- A total of 7 pumping wells would be drilled to a depth of 200 feet BLS, with 100 feet of well screen. The wells would be 6 inches in diameter and constructed of polyvinyl chloride (PVC). A gravel pack material and surface seal would be provided for each well. A 1.5 HP stainless steel ground-water pump capable of sustaining a 25 gpm flow rate would be placed in each well.

- Costs for decontamination and decommissioning of the treatment plant have been estimated as 25% of the total capital acquisition costs, including the applied contingency. This also assumes that disposal of the treatment plant as low-level waste would be made at the Radioactive Waste Management Complex (RWMC) at INEL at no additional cost to the project.

- Markup values on the base contractor, subcontractor, and material costs are as follows: 6% mobilization/demobilization for contractors, 20% overhead and profit for the contractor, 5% general and administrative markup on materials, 15% for engineering and design, 49.6% applied for management (17.1% for construction management, 22.5% for project management, and 10% for management reserve), 1.5% for a contractor bond, 0.5% for insurance; and, 30% as a contingency.

- Costs for treatability studies have not been included.
- Costs for any applicable permits and/or taxes have not been included.
- No administrative or other related costs for DOE have been included.

Total capital and O&M costs for Alternative 2 are summarized in Table 4-7. Backup data for each cost item given in Table 4-7 are provided in Appendix J. Capital costs total $2,860,000. Annual O&M costs have been divided into those needed for the nine years of the proposed remedial action, and those needed for the long-term (30 years) repository maintenance and monitoring. The O&M costs for the 9 years of remedial action total $366,000 for each of the 9 years; the O&M costs for the long-term repository maintenance and monitoring are estimated to be $34,000 for each of the 30 years. These costs were used to calculate the net present worth of Alternative 2 (Section 4.2.7.5). Decontamination and decommissioning costs were estimated to be $527,000.

4.2.7.3 Alternative 3 – Evaporative Ground-Water Treatment. Capital costs associated with Alternative 3 include ground-water pumping well installation, excavation pond excavation, piping installation from the wells to the evaporation ponds, electrical connections to the pumps, and evaporation pond closure. The O&M costs for Alternative 3 include electrical supply requirements for the ground-water pumps, and long-term maintenance and monitoring of the closed evaporation ponds. Assumptions used in preparing the +50/-30 cost estimate include:

- No grading of roads will be required except around the evaporation ponds, and no asphalt or concrete drives would be needed.

Table 4-7. Alternative 2 - Physical/chemical treatment capital and operating and maintenance cost summary

Description	Labor	Material	Subcontract	Contractor OH&P (20%)	G&A on Materials (5%)	Bond & Insurance (2%)	Subtotal Construction	Management (49.6%)[#]	ED&I (15%)	Subtotal	Contingency (30%)	Total Estimated Cost[*]
Mobilization	0	0	40,000	8,000	0	800	48,800	24,205	7,320	80,235	24,097	104,000
Treatment Plant	0	8,000	175,000	36,600	400	3,500	223,500	110,856	33,525	367,881	110,364	478,000
Plant Building	0	0	51,000	10,200	0	1,020	62,220	30,861	9,333	102,414	30,724	133,000
Earthwork	0	0	41,000	8,200	0	820	50,020	24,810	7,503	82,333	24,700	107,000
Ground-Water Wells	0	320,000	174,000	98,800	16,000	3,480	612,280	303,691	91,842	1,007,813	302,344	1,310,000
Piping	0	60,000	11.000	14,200	3,000	220	88,420	43,856	13,263	145,539	43,662	189,000
Fencing	0	0	21,000	4,200	0	420	25,620	12,708	3,843	42,171	12,651	55,000
Electrical	0	0	85,000	17,000	0	1,700	103,700	51,435	15,555	170,690	51,207	222,000
Sludge Pond Cap	0	0	100,000	20,000	0	2,000	122,000	60,512	18,300	200,812	60,244	261,000
Subtotal Construction	0	388,000	698,000	217,200	19,400	13,960	1,336,560	662,934	200,484	2,199,888	659,993	2,860,000
Plant Labor	114,000	0	0	22,800	0	0	136,800	67,853	20,520	225,173	67,552	293,000
Utilities/Maintenance	0	0	28,000	5,600	0	560	34,160	16,934	5,124	56,227	16,868	73,000
Repository Maintenance	0	0	13,000	2,600	0	260	15,860	7,867	2,379	26,106	7,832	34,000
Subtotal Operations	114,000	0	41,000	31,000	0	820	186,820	92,663	28,023	307,506	92,252	400,000
Decontamination/Decommissioning	0	0	527,000	0	0	0	527,000	0	0	527,000	0	527,000

* Total values have been taken to the nearest thousand dollar amount.

\# Based on INEL guidance: 17.1% construction management, 22.5% project management, 10% management reserve.

- Excess material excavated for the evaporation ponds would be stockpiled on-site; a portion of this material could be screened and used for construction of the required liner and drainage system. Construction water needed for the excavations would be supplied by others. Clay and topsoil materials required for pond capping would be supplied from a local contractor within 30 miles of the Site. Revegetation of the closed and capped ponds is included.

- The construction season for pond excavation and well installation is April 1 to November 15. All construction activities could be completed within one operating season.

- The electrical power source is within 300 feet of use. Electrical costs would be approximately $0.028 per kwh.

- Routine maintenance costs would be approximately 1% of well installation costs.

- A total of 7 pumping wells would be drilled to a depth of 200 feet BLS, with 100 feet of well screen. The wells would be 6 inches in diameter and constructed of PVC. A gravel pack material and surface seal would be provided for each well. A 1.5 HP stainless steel ground-water pump capable of sustaining a 25 gpm flow rate would be placed in each well.

- There would be no prime contractor markup on subcontractors charges.

- Markup values on the base contractor and material costs are as follows: 6% mobilization/demobilization for contractors, 20% overhead and profit for the contractor, 5% general and administrative markup on materials, 15% for engineering and design, 49.6% for construction and project management, 1.5% for a contractor bond, 0.5% for insurance, and 30% as a contingency.

- Costs for treatability studies have not been included.

- Costs for any applicable permits and/or taxes have not been included.

- No administrative or other related costs for DOE have been included.

Total capital and O&M costs for Alternative 3 are summarized in Table 4-8. Backup data for each cost item given in Table 4-8 is provided in Appendix J. Capital costs total $48,469,000. Annual O&M costs have been divided into those needed for the nine years ofthe proposed remedial action, and those needed for the long-term repository maintenance and monitoring (i.e., 30 years). The O&M costs for the 9 years of remedial action total

Table 4-8. Alternative 3 - Evaporative treatment capital and operating cost summary

Description	Direct Cost Labor	Direct Cost Material	Direct Cost Subcontract	Contractor OH&P (20%)	G&A on Materials (5%)	Bond & Insurance (2%)	Subtotal Construction	Management (49.6%)[#]	ED&I (15%)	Subtotal	Contingency (30%)	Total Estimated Cost[*]
Mobilization	$0	$0	$688,000	$137,600	$0	$13,760	$839,360	$416,323	$125,904	$1,381,587	$414,476	$1,796,000
Earthwork	0	0	2,203,000	440,600	0	44,060	2,687,660	1,333,079	403,149	4,423,888	1,327,167	5,751,000
Ground-Water Wells	0	320,000	174,000	98,800	16,000	3,480	612,280	303,691	91,842	1,007,813	302,344	1,310,000
Piping	0	354,000	53,000	81,400	117,700	1,060	507,160	251,551	76,074	834,785	250,436	1,085,000
Fencing	0	0	102,000	20,400	0	2,040	124,440	61,722	18,666	204,828	61,448	266,000
Electrical	0	0	70,000	14,000	0	1,400	85,400	42,358	12,810	140,568	42,171	183,000
Pond Cap	0	0	7,365,000	1,473,000	0	147,300	8,905,300	4,456,709	1,347,795	14,789,804	4,436,941	19,227,000
Pond Leak Detection	0	0	7,221,000	1,444,200	0	144,420	8,809,620	4,369,572	1,321,443	14,500,635	4,350,190	18,851,000
Subtotal Construction	$0	$674,000	$17,876,000	$3,710,000	$33,700	$357,520	$22,651,220	$11,235,005	$3,397,683	$37,283,908	$11,185,172	$48,469,000
Operations												
Plant Labor	$28,000	$0	$0	$5,600	$0	$0	$33,600	$16,666	$5,040	$55,306	$16,592	$721,000
Utilities	0	0	2,000	400	0	40	2,440	1,210	366	4,066	1,205	5,000
Maintenance	0	8,000	23,000	6,200	400	620	38,220	18,957	5,733	62,910	18.873	82,000
Subtotal Operations	$28,000	$8,000	$25,000	$12,200	$400	$660	$74,260	$36,833	$11,139	$122,232	$36,670	$159,000

* Total values have been taken to the nearest thousand dollar amount.

\# Based on INEL guidance: 17.1% construction management, 22.5% project management, 10% management reserve.

$77,000 for each of the 9 years; the O&M costs for the long-term repository maintenance and monitoring are estimated to be $82,000 for each of the 30 years. These costs were used to calculate the net present worth of Alternative 3 (Section 4.2.7.5).

4.2.7.4 Alternative 4 – Source Control. Capital costs for Alternative 4 include procurement and installation of the brine concentrator at the TRA Site. Associated O&M costs include a treatment unit operator, routine maintenance, and electrical supply requirements. Assumptions used in preparing the +50/-30 cost estimate include the following:

- The treatment unit is provided as a package unit designed for the specified flow rate of 500 gpm and known chemical composition of the waste stream(s). A suitable location within the TRA operating area would be assumed to be available for the treatment unit. A footprint of approximately 70 by 100 feet would be needed.
- Routine maintenance would be approximately 1% of initial capital costs, excluding installation costs.
- An operator would be needed for two hours out of each eight-hour shift.
- Electrical requirements would be approximately 80 kwh per 1,000 gallons treated. Electrical costs would be approximately $0.028 per kwh.
- Markup values on the base contractor, and material costs are as follows: 6% mobilization/demobilization for contractors, 20% overhead and profit for the contractor, 5% general and administrative markup on materials, 15% for engineering and design, 49.6% for construction and project management; 1.5% for a contractor bond, 0.5% for insurance; and 30% as a contingency.
- Costs for treatability studies have not been included.
- Decontamination and decommissioning costs for the brine concentration unit have not been included. These costs are assumed to be included in the decontamination and decommissioning activities for TRA.
- No administrative or other related costs for DOE been included.

Total capital and O&M costs for Alternative 4 are summarized in Table 4-9. Backup data for each cost item given in Table 4-9 are provided in Appendix J. Capital costs total $12,729,000. Annual O&M costs include those for the years of the proposed remedial action (i.e., for the remaining 23 years of TRA operation). The O&M costs for the 23 years of remedial action total $688,000 for each of the 23 years. The majority of this O&M cost is for the electrical requirements of the brine concentrator. These costs were used to calculate the net present worth of Alternative 4 (Section 4.2.7.5).

4.2.7.5 Net Present Worth Cost Summary. A net present worth analysis was performed for each of the remedial alternatives. Table 4-10 presents results of the net present worth analysis. All remedial alternatives had a negative net present worth except for the No Action alternative. Values for capital, O&M, and future capital were estimated using information gathered for purposes of the FS. A 5% discount rate is recommended in the NCP for all present worth calculations. The summary in Table 4-10 includes a sensitivity analysis that shows the net present worth costs for each alternative using 3% and 10% discount rates. The variables evaluated included the remedial alternative initial and future capital costs, as well as the O&M costs.

The following assumptions were made for purposes of the net present worth analysis:

- Capital costs for Alternative 2 were considered to be initial capital required during the first year of remediation, except for the sludge pond cap and the treatment plant decontamination and decommissioning costs. These items were assumed to be incurred in year nine as future capital following the remediation program. The O&M costs were divided into annual costs for the 9-year remediation period, and for the 30-year long-term maintenance and monitoring of the sludge repository.

- Capital costs for Alternative 3 were considered to be initial capital required during the first year of remediation, except for the evaporation pond cap. This item was assumed to be incurred in year nine as future capital following the remediation program. The O&M costs were divided into annual costs for the 9-year remediation period, and for the 30-year long-term maintenance and monitoring of the closed evaporation ponds.

Table 4-9. Alternative 4 - Source control capital and operating cost summary

Description	Direct Cost: Labor	Direct Cost: Material	Direct Cost: Subcontract	Contractor OH&P (20%)	G&A on Materials (5%)	Bond & Insurance (2%)	Subtotal Construction	Construction Management (49.6%)#	ED&I (15%)	Subtotal	Contingency (30%)	Total Estimated Cost*
Construction												
Mobilization	$0	$0	$276,000	$55,200	$0	$5,520	$336,720	$167,013	$50,508	$554,241	$166,272	$721,000
Treatment Plant	0	0	3,000,000	600,000	0	60,000	3,660,000	1,815,360	549,000	6,024,360	1,807,308	7,832,000
Installation/Startup	0	0	1,600,000	320,000	0	32,000	1,952,000	968,192	292,800	3,212,992	963,898	4,177,000
Subtotal Construction	$0	$0	$4,876,000	$975,200	$0	$97,520	$5,948,720	$2,950,565	$892,308	$9,791,593	$2,937,478	$12,729,000
Operations												
Plant Labor	$28,000	$0	$0	$5,600	$0	$0	$33,600	$16,666	$5,040	$55,306	$16,592	$72,000
Utilities	0	0	206,000	41,200	0	4,120	251,320	124,655	37,698	413,673	124,102	538,000
Maintenance	0	0	30,000	6,000	0	600	36,600	18,154	5,490	60,244	18,073	78,000
Subtotal Operations	$28,000	$0	$236,000	$52,800	$0	$4,720	$321,520	$159,475	$48,228	$529,223	$158,767	$688,000

* Total values have been taken to the nearest thousand dollar amount.

\# Based on INEL guidance: 17.1% construction management, 22.5% project management, 10% management reserve.

Table 4-10. Estimated net present worth analysis.

Item	1 No Action	2 Physical/Chemical Treatment	3 Evaporative Treatment	4 Source Control
	Alternative No.			
Initial Capital	0	2,599,000	29,242,000	12,729,000
O&M	0	366,000[a] 34,000[b]	77,000[a] 82,000[b]	688,000[d]
Future Capital	0	788,000[c]	19,227,000[c]	0
Total Net Present Worth (3% Discount)	0	6,719,000	46,184,000	24,042,000
Total Net Present Worth (5% Discount)	0	6,231,000	43,444,000	22,009,000
Total Net Present Worth (10% Discount)	0	5,361,000	38,613,000	18,841,000

a. years 0–9
b. years 0–30
c. years 9
d. years 0–23

- Capital costs for Alternative 4 were considered to be initial capital required during the first year of remediation. The O&M costs were assumed to be annual costs for the duration of the TRA operations (i.e., 23 years).

Alternative 2 had a negative net present worth of $6.2 million at a 5% discount rate. Alternative 3 had a negative net present worth of $43.4 million at a 5% discount rate. Alternative 4 had a negative net present worth of $22.0 million at a 5% discount rate. No additional costs are assumed beyond those already in place for the No Action alternative.

4.2.8 Detailed Analysis Summary

Table 4-11 provides a summary of each alternative relative to the seven evaluation criteria. This information was used in part to develop the comparative analysis.

4.3 Comparative Analysis

The comparative analysis reviews the four candidate remedial alternatives described above in relation to threshold criteria, primary balancing criteria, and modifying criteria as specified in the NCP. The threshold criteria include overall protection of human health and the environment and compliance with ARARs. These two criteria must be met by an alternative in order to be eligible for selection. Primary balancing criteria include long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost. Modifying criteria include State and community acceptance.

The remedial alternatives are evaluated in this comparative analysis relative to one another, discussing the advantages and disadvantages of each alternative. As a quick reference, Table 4-11 summarizes the relative performance for each alternative under each evaluation criteria. A more detailed comparison among the alternatives for each evaluation criteria is provided in the following sections.

Table 4-11. Individual Evaluation of Remedial Alternatives

Criteria	Alternative 1 No Action	Alternative 2 Physical/Chemical Treatment	Alternative 3 Evaporative Treatment	Alternative 4 Source Control
Overall Protectiveness	Provides adequate protection of human health and the environment under future use scenario.	Protection of human health and the environment achieved through removal of metals and radionuclides from the PWS.	Protection of human health and the environment achieved through removal of metals and radionuclides from the PWS.	Protection of human health and the environment achieved reducing the contaminant driving force from the PWS to the SRPA.
Compliance With ARARs	Would attain ARARs.	Would attain ARARs.	Would attain ARARs.	Would attain ARARs.
Long-Term Effectiveness and Permanence	Existing risk would gradually decrease with continued dilution from cold, chemical, and sanitary waste ponds.	Existing risk reduced through ground-water pumping and treatment. Maintenance and monitoring of the RCRA Subtitle C repository required.	Existing risk reduced through ground-water pumping and evaporation. Maintenance and monitoring of the RCRA Subtitle C evaporation ponds required.	Risk of contaminant release reduced through volume reductions to the PWS.
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduction in toxicity and volume over time, especially after TRA operations terminate.	Reduction in toxicity, mobility, and volume through pumping and treatment. Treatment sludge generated for disposal.	Reduction in toxicity, mobility, and volume through pumping and evaporation. Solid evaporated material remains for disposal.	Reduction of mobility and volume through flow reductions from TRA.
Short-Term Effectiveness	Not applicable.	Safety requirements required for treatment plant personnel. No expected impacts to surrounding communities. Potential environmental impacts. Eleven years to implement.	Safety requirements for personnel in vicinity of evaporation ponds. No expected impacts to surrounding communities. Potential environmental impacts. Twelve years to implement.	No additional safety requirements beyond existing TRA measures. No expected impacts to surrounding communities. Would operate in conjunction with TRA operations until TRA closure.
Implementability	Ongoing monitoring program considered implementable.	Straightforward construction and operation. Services, equipment, and technology are readily available. Treatability testing required.	Straightforward construction and operation. Services, equipment, and technology are readily available.	Straightforward implementation with existing TRA operations. Simple to operate, proven technology. Services, equipment, and technology are readily available. Treatability testing required.
Present Worth Cost at 5% Discount	No additional costs beyond ongoing monitoring costs.	$6,231,000	$43,444,000	$22,009,000

4.3.1 Overall Protection of Human Health and the Environment

Each alternative would provide for overall protection of human health and the environment. However, only Alternatives 2 and 3 would achieve this through treatment and/or containment. Alternative 1 achieves the RAOs identified in Section 2 of this document. Specifically, excess carcinogenic risks would be less than 10^{-6}, and the noncarcinogenic risks would have a hazard index less than 1 with the future use scenario for an onsite agricultural use 125 years from the present. Alternatives 2 through 4 would further reduce risks below those estimated for the No Action alternative, and would involve treating the perched ground water or reducing the current wastewater infiltration rates to the PWS. Potential risks associated with activities proposed under Alternatives 2 through 4 would not be expected to adversely impact worker or community populations in the vicinity of TRA, although there may be potential environmental impacts from the required disturbances for implementing these alternatives.

Evaluating overall protection to human health and the environment requires examination of compliance with ARARs, short-term effectiveness, and long-term effectiveness and permanence. Each of the alternatives would attain ARARs identified for the PWS OU for the 125-year future-use scenario. While each alternative would meet the RAOs specified for this OU, Alternative 1 would not require additional time to implement. Alternatives 2 and 3 would require 11 to 12 years to complete, while Alternative 4 would require 1 year to implement and would continue operating with the TRA until 2014 when the facility is scheduled for closure. Each alternative would achieve long-term effectiveness and permanence. Alternative 2 emphasizes perched ground-water treatment as the means to mitigate continued releases to the SRPA. Alternative 3 relies on continuous ground-water evaporation to mitigate ground-water discharge to the SRPA, and Alternative 4 relies on additional treatment steps for the existing TRA process effluent to minimize a continued driving force for COCs present in the PWS to migrate to the SRPA.

4.3.2 Compliance with ARARs

As previously stated, each of the alternatives would attain ARARs identified for the PWS OU for the 125-year future-use scenario. None of the treatment alternatives (2 through 4) would meet the chemical-specific ARARs at the present time; however, the current use scenario for the PWS OU is not considered to be viable because of current access and property use restrictions in place for TRA and INEL. The treatment alternatives would be expected to meet ARARs before the No Action alternative, although the time at which ARARs would be met was not quantified as part of the FS.

4.3.3 Long-Term Effectiveness and Permanence

Each of the alternatives would provide a high degree of long-term effectiveness and permanence. No action would achieve long-term protection through continued monitoring of the ground-water quality, TRA effluent quality, and the use of institutional controls. These activities, in conjunction with other proposed remedial actions for Alternatives 2 through 4 would add to the long-term effectiveness and permanence. Both Alternatives 2 and 3 would begin to reduce COC concentrations in the PWS and concentrate these substances in either a treatment sludge or an evaporated solid material. These solids would be placed in an appropriately designed on site repository. Alternative 4 would reduce the driving force for the COCs from the PWS to the SRPA. Long-term monitoring and maintenance of the sludge repository under Alternative 2 and the evaporation ponds under Alternative 3 would be required to ensure long-term effectiveness and permanence. There would not be any long-term maintenance and monitoring requirements for either Alternative 1 or 4.

4.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Only Alternatives 2 and 3 provide for toxicity, mobility, or volume reductions through treatment; however, both the No Action and Source Control alternatives would result in reductions of these evaluation parameters through time with continued dilution from the cold and chemical waste streams, and the eventual dissipation of the PWS. The greatest immediate toxicity reductions would occur with Alternative 3: all ground water removed would be completely evaporated, with no re-infiltration to the PWS. However, an evaporated solid material containing the retained metals and radionuclides would be generated and would require in-place disposal in the evaporation ponds. Approximately 1,200 to 2,400 cubic yards of evaporated solid material would be generated under Alternative 3. The toxicity and mobility of contaminants present in this solid material would need to be determined through treatability testing. Mobility of contaminants within the PWS would be reduced because of the removal of the COCs and the adsorbed or physically trapped solid-phase residual remaining within the aquifer materials. Volume reductions would also occur under Alternative 3 to the extent of the maximum sustainable pumping capacity.

Alternative 2 would provide concentration reduction of COCs after treatment and re-infiltration to the PWS. Mobility of the contaminants present in the PWS would be reduced because of the removal of the COCs and the adsorbed or physically trapped solid-phase residual remaining within the aquifer materials, similar to the Evaporative Treatment alternative. The physical/chemical treatment processes would generate approximately 730 cubic yards of sludge requiring proper disposal. This sludge would contain the retained metals and radionuclides from the treatment process. The toxicity and mobility of contaminants present in this solid material would need to be determined through treatability testing. Similar to the Evaporative Treatment alternative, the mobility of contaminants within the PWS would be reduced because of the removal of the COCs and the adsorbed or physically trapped solid-phase residual remaining within the aquifer material. Volume reductions of the PWS would also occur under Alternative 2 to the extent of the maximum sustainable pumping capacity; however, the treated ground water would be returned to the PWS through infiltration ponds.

The Source Control alternative would reduce the driving force for COCs to continue to migrate to the SRPA. This action would result in reduced mobility of COCs in the PWS. Total volume of the PWS would also be reduced significantly from reduced TRA process effluent infiltration. No toxic solid residuals would be generated as a result of reducing the TRA effluent flow rates. Under the No Action alternative, the continued TRA process discharge would maintain the existing contaminant driving force in the PWS, although dilution would result in lowering COC concentrations reaching the SRPA. No solid residuals would be generated under Alternative 1. Volume reductions would begin to occur after TRA operations terminate in 2014.

4.3.5 Short-Term Effectiveness

As stated previously, each candidate alternative would meet the RAOs for the future use scenario 125 years from the present. While the current use scenario for the PWS OU is not viable, Alternatives 2 through 4 would be expected to achieve the RAOs before the No Action alternative. The time to achieve this protection of human health and the environment was not quantified as part of the FS; however, these alternatives have been assumed to require from 11 to 23 years to complete.

No short-term risks to either the workers or surrounding communities would result from implementation of either the No Action or Source Control alternatives. There would be no additional potential environmental impacts under no action beyond existing potential impacts from TRA operations. Ongoing monitoring of both the ground water and process effluent quality would be reliable to evaluate the potential for impacts to human health and the environment as a result of no action. Under the Source Control alternative no potential environmental impacts have been identified that would differ significantly from the No Action alternative. Source control would begin immediately and would continue to operate until TRA operations were terminated.

For both Alternatives 2 and 3, short-term risks would be possible during installation of the ground water pumping wells. Accepted safety practices used commonly on sites such as TRA would be needed to provide the necessary level of worker protection. Surrounding communities would not likely be impacted from the well installation activities. In addition, the routine operation requirements of each of these alternatives would require proper personnel training to mitigate potential exposure to metals and radionuclides. Spills or leaks from the treatment plant would require the use of safety measures similar to those employed at TRA. While the release of tritium under Alternative 3 would be made directly to the atmosphere, radiation doses estimated at various points around the evaporation ponds would not be expected to exceed NESHAPS; thus, adverse impacts to the surrounding communities under this alternative would not be significant. The repository design proposed under Alternative 2 for the treatment sludge, and the evaporation pond design for Alternative 3 would be effective and reliable to mitigate potential environmental impacts caused by the concentration of metals and radionuclides at the surface from the perched ground-water.

Each of Alternatives 2 through 4 would have associated land disturbances (e.g., repository construction, treatment plant construction), and thus potential environmental impacts from their implementation. At the end of remedial activities under Alternatives 2 and 3, the ground water production wells would need to be abandoned in accordance with applicable regulations. In addition, the solid waste repository for Alternative 2 treatment sludge would require proper closure, as well as the proper closure for the evaporation ponds under Alternative 3. The physical/chemical treatment plant for Alternative 2 would require proper decontamination and decommissioning. The brine concentrator proposed under Alternative 4 would be decontaminated and decommissioned with the TRA facilities at the time of their closure.

4.3.6 Implementability

There are no technical or administrative constraints related to the feasibility of implementing the alternatives. There would be no requirements for services or materials to implement the No Action Alternative beyond what is needed for the ongoing water quality monitoring program and maintaining the existing institutional controls. For Alternatives 2 through 4, the proposed technologies are all standard, proven, and reliable. Implementing any of these alternatives would not pose significant technical or administrative difficulties.

Services and materials required for implementing these alternatives would be readily available and would not be expected to present problems with construction and/or operation of the activities described for each.

4.3.7 Cost

Based on the present worth analysis, the No Action alternative has the lowest net negative present worth because the activities described would continue regardless of the remedial alternative selected. Alternative 3 has the greatest net negative present worth of \$43.4 million at a 5% discount rate. Alternatives 4 and 2 have the remaining highest net negative present worth values of \$22.0 million and \$6.2 million at a 5% discount rate, respectively. Costs for Alternative 2 may be increased should the selected representative technology require modifications, or if a new, as yet undetermined technology, be needed to achieve effective treatment results.

4.4 CONCLUSIONS

Results of the baseline and the comparative analysis indicate that for the future use scenario, each of the candidate remedial alternatives meets the RAOs for the PWS OU. Each alternative meets the criteria specified for overall protection of human health and the environment, each would meet the ARARs developed for the OU, and each would achieve long-term effectiveness and permanence. Alternatives 2 and 3 would provide for reduction of mobility and volume through treatment, although Alternatives 1 and 4 would provide for an eventual reduction in mobility and volume of COCs in the PWS. Alternatives 2 and 3 also have potential short-term exposure to workers during remedial action implementation. In addition, each would pose potential environmental impacts during remediation. Each of the four candidate alternatives would be technically and administratively implementable. Alternative 3 has the greatest total cost, followed by Alternatives 4, 2, and 1, respectively. While Alternatives 2 and 3 are assumed to provide for attainment of RAOs, they contribute additional complexity and cost to PWS remediation.

5. Consultation and Coordination

5. CONSULTATION AND COORDINATION

The FS was prepared by Dames & Moore, a professional limited partnership, under contract No. C90-132741-008, Mod 2 on behalf of EG&G, Idaho Inc. EG&G Idaho is managing WAG-2 at the INEL on behalf of the DOE-Idaho field Office. WAG-2 encompasses the PWS OU. The FS was required to be conducted by EPA, since the INEL and the PWS OU are contained on the NPL of contaminated sites. All work was performed in accordance with the FFA/CO between DOE and EPA.

This Preliminary Draft of the FS is submitted for internal review to EG&G Idaho before submittal to EPA. The State of Idaho comments to the FS will be resolved before submission of the Draft FS for agency review.

6. References

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