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**ALL DRAWINGS
ARE LOCATED
AT THE END OF
THE DOCUMENT**

TREATABILITY STUDY PLAN

903 Pad, Mound, and
East Trenches Areas

Operable Unit No. 2

Volume I

TEXT Treatability Study Plan
APPENDIX A Treatability Study Work Plans

 **EG&G ROCKY FLATS**

Environmental Restoration Program

October 16, 1990

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ADMIN RECORD

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By J. P. [Signature] (MNR)

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EXECUTIVE SUMMARY

The Rocky Flats Plant (RFP) is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver. The Plant buildings are located within an area of approximately 400 acres, known as the RFP security area. The security area is surrounded by a buffer zone of approximately 6,150 acres.

The RFP is currently an interim status Resource Conservation and Recovery Act (RCRA) hazardous waste treatment/storage facility. In the past, both storage and disposal of hazardous and radioactive wastes occurred at on-site locations. Preliminary assessments conducted under Phase 1 of the Environmental Restoration (ER) Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

The Department of Energy (DOE) wishes to pursue an interim remedial action for surface water at the 903 Pad, Mound, and East Trenches Areas, now termed Operable Unit 2 (OU2), at the Rocky Flats Plant (RFP). EG&G has prepared a proposed IM/IRA Plan to identify, screen, and evaluate appropriate interim remedial action alternatives, and select the preferred interim remedial action for the contaminated surface water. The purpose of this project is to provide technical support to the IM/IRA in the form of bench-scale treatability tests.

Numerous technologies that appeared to be potentially applicable for treating OU2 surface waters were screened for treatability testing. The technologies selected for bench-scale testing include the following:

- Granular Activated Carbon (GAC) for removal of Volatile Organics

- GAC for removal of Radionuclides
- Ion Exchange for removal of Radionuclides
- Selected Adsorbents for removal of Radionuclides
- Chemical Coagulation/Microfiltration for removal of Radionuclides
- Coagulation/Precipitation/Filtration for removal of suspended solids

This report discusses the technologies considered as well as the process used to screen them for treatability testing. A discussion on how water samples will be collected from the surface water stations and seeps at OU2 is also provided. A schedule for performing the treatability studies is also presented.

Volume I of this document includes the Treatability Study Plan, which provides site background information and a discussion of the technology screening and evaluation process. The second part of Volume I, Appendix A, includes the Treatability Study Work Plans (TSWPs) which describe in detail the proposed testing programs.

Volume II includes the Sampling and Analysis Plan (SAP). Within the SAP is the Field Sampling Plan (FSP) and the Laboratory Analysis Plan (LAP) for untreated samples. Also included in Volume II is the Quality Assurance Addendum (QAA). This QAA, along with the Draft Site-wide Quality Assurance Project Plan (QAPjP) for CERCLA Remedial Investigations/Feasibility studies at Rocky Flats (EG&G Rocky Flats, Inc., EG&G, 1990c), constitutes the project-specific QAPjP for the bench-scale treatability study.

Volume III presents the Health and Safety Plan (HSP) for this project.

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HEAT STRESS

COLD STRESS

RESPIRATOR INSPECTION, CARE, MAINTENANCE, AND
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SITE CONTROL

EMERGENCY PREPAREDNESS

PERSONNEL ASSIGNMENTS

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**ATTACHMENT G - MATERIAL SAFETY DATA SHEETS FOR LABORATORY
WORK**

The purpose of this project is to provide technical support in the form of bench scale treatability tests to the Rocky Flats Plant (RFP) Environmental Restoration Program. These tests are intended to support the surface water Interim Measure/Interim Remedial Action (IM/IRA) Proposed Decision Document, September 26, 1990 for Operable Unit 2 (OU2).

Numerous technologies that appeared to be potentially applicable for treating OU2 surface waters were screened for treatability testing. Contaminants consist of volatile compounds (VOC), radionuclides, and total suspended solids (TSS). The technologies selected for screening were limited to those already commercially established or which have demonstrated potential for processing similar contaminants. Additionally, the technologies considered were required to be readily implementable (i.e., standard pre-engineered units available) within a short time frame.

The following technologies were selected for testing on a laboratory/bench scale basis:

- Granular Activated Carbon (GAC) for removal of Volatile Organics
- GAC for removal of Radionuclides
- Ion Exchange for removal of Radionuclides
- Selected Adsorbents for removal of Radionuclides
- Chemical Coagulation/Microfiltration for removal of Radionuclides

- Coagulation/Precipitation/Filtration for removal of suspended solids
- Solidification/Stabilization of selected treatment system residuals

This report discusses the technologies considered and the process used to screen them for treatability testing. A discussion on how water samples will be collected from the surface water stations and seeps at OU2 is also provided. A schedule for performing the treatability studies is also presented.

Appendix A presents the Treatability Study Work Plans (TSWPs) for the selected technologies. Appendix B includes the Sampling and Analysis Plan (SAP). Within the SAP is the Field Sampling Plan (FSP) and the Analysis Plan for untreated samples. Appendix C includes the Quality Assurance Addendum (QAA), which is an addendum to the Quality Assurance Project Plan (QAPP). Appendix D presents the Health and Safety Plan (HSP).

TABLE 1-1

ACRONYMS AND ABBREVIATIONS

AAR	ACTIVATED ALUMINA ADSORPTION COLUMN
ARAR	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
BCR	BONE CHAR ADSORPTION COLUMN
CCl ₄	CARBON TETRACHLORIDE
CCM	REMOVAL OF RADIONUCLIDES BY CHEMICAL COAGULATION/MICROFILTRATION
CDH	COLORADO DEPARTMENT OF HEALTH
CERCLA	COMPREHENSIVE ENVIRONMENTAL REPORT, COMPENSATION, AND LIABILITY ACT OF 1980
CMS/FS	CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY
COC	CHAIN OF CUSTODY
CPF	REMOVAL OF SUSPENDED SOLIDS BY COAGULATION/PRECIPITATION/FILTRATION
CWC	COMPOSITED WATER CHARACTERIZATION
DOE	DEPARTMENT OF ENERGY
DOT	DEPARTMENT OF TRANSPORTATION
DQO	DATA QUALITY OBJECTIVE
EP	EXTRACTION PROCEDURE
ER	ENVIRONMENTAL REPORT
ESP	FIELD SAMPLING PLAN
FXR	FILOX ADSORPTION COLUMN
GAC	GRANULAR ACTIVATED CARBON
GAO	REMOVAL OF VOLATILES BY GRANULAR ACTIVATED CARBON

TABLE 1-1 (continued)

GAR	REMOVAL OF RADIONUCLIDES BY GRANULAR ACTIVATED CARBON
GRRAP	GENERAL RADIOCHEMISTRY AND ROUTINE ANALYTICAL SERVICES PROTOCOL
HSWA	HAZARDOUS AND SOLID WASTE AMENDMENTS OF 1984
HSP	HEALTH AND SAFETY PLAN
LAG	INTER-AGENCY AGREEMENT
IEX	REMOVAL OF RADIONUCLIDES BY ION EXCHANGE
IHSS	INDIVIDUAL HAZARDOUS SUBSTANCE SITES
IM/IRA	INTERIM MEASURE/INTERIM REMEDIAL ACTION
LAP	LABORATORY ANALYSIS PLAN
MS	MATRIX SPIKE
MSD	MATRIX SPIKE DUPLICATE
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
OU	OPERABLE UNIT
PCE	TETRACHLOROETHENE
QA	QUALITY ASSURANCE
QAA	QUALITY ASSURANCE ADDENDUM
QA/QC	QUALITY ASSURANCE/QUALITY CONTROL
QAPjP	QUALITY ASSURANCE PROJECT PLAN
RCRA	RESOURCE CONSTRUCTION AND RECOVERY ACT OF 1976
RFP	ROCKY FLATS PLANT
RFI/RI	RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION

TABLE 1-1 (continued)

RI/FS	CERCLA REMEDIAL INVESTIGATIONS/ FEASIBILITY STUDIES
SAP	SAMPLING AND ANALYSIS PLANT
SARA	SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986
SOP	STANDARD OPERATING PROCEDURE
SSR	SOLIDIFICATION/STABILIZATION OF RESIDUALS
TCE	TRICHLOROETHENE
TCLP	TOXICITY CHARACTERISTICS LEACHING PROCEDURE
TDS	TOTAL DISSOLVED SOLIDS
TOC	TOTAL ORGANIC COMPOUNDS
TPS	TEST PROGRAM SCHEDULE
TSP	TREATABILITY STUDY PLAN
TSS	TOTAL SUSPENDED SOLIDS
TSWP	TREATABILITY STUDY WORK PLAN
USEPA	U S ENVIRONMENTAL PROTECTION AGENCY
$\mu\text{g}/\ell$	MICROGRAMS PER LITER
VOC	VOLATILE ORGANIC COMPOUND

The Rocky Flats Plant (RFP) is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 2-1). The Plant buildings are located within an area of approximately 400 acres, known as the RFP security area. The security area is surrounded by a buffer zone of approximately 6,150 acres.

The RFP is currently an interim status Resource Conservation and Recovery Act (RCRA) hazardous waste treatment/storage facility. In the past, both storage and disposal of hazardous and radioactive wastes occurred at onsite locations. Preliminary assessments conducted under Phase 1 of the ER Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination. There are 20 sites designated as (IHSS) which comprise the 903 Pad, Mound, and East Trench Areas. These sites are known collectively as Operable Unit 2.

The Department of Energy (DOE) is pursuing an interim remedial action for surface water at the 903 Pad, Mound, and East Trenches Areas, now termed OU2, at the Rocky Flats Plant (RFP). In accordance with The Interagency Agreement (IAG) the Resource Conservation and Recovery Act of 1976 (RCRA) as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA), and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), an Interim Measures/Interim Remedial Action (IM/IRA) is being conducted to minimize the migration of hazardous substances via surface water from areas that pose a potential

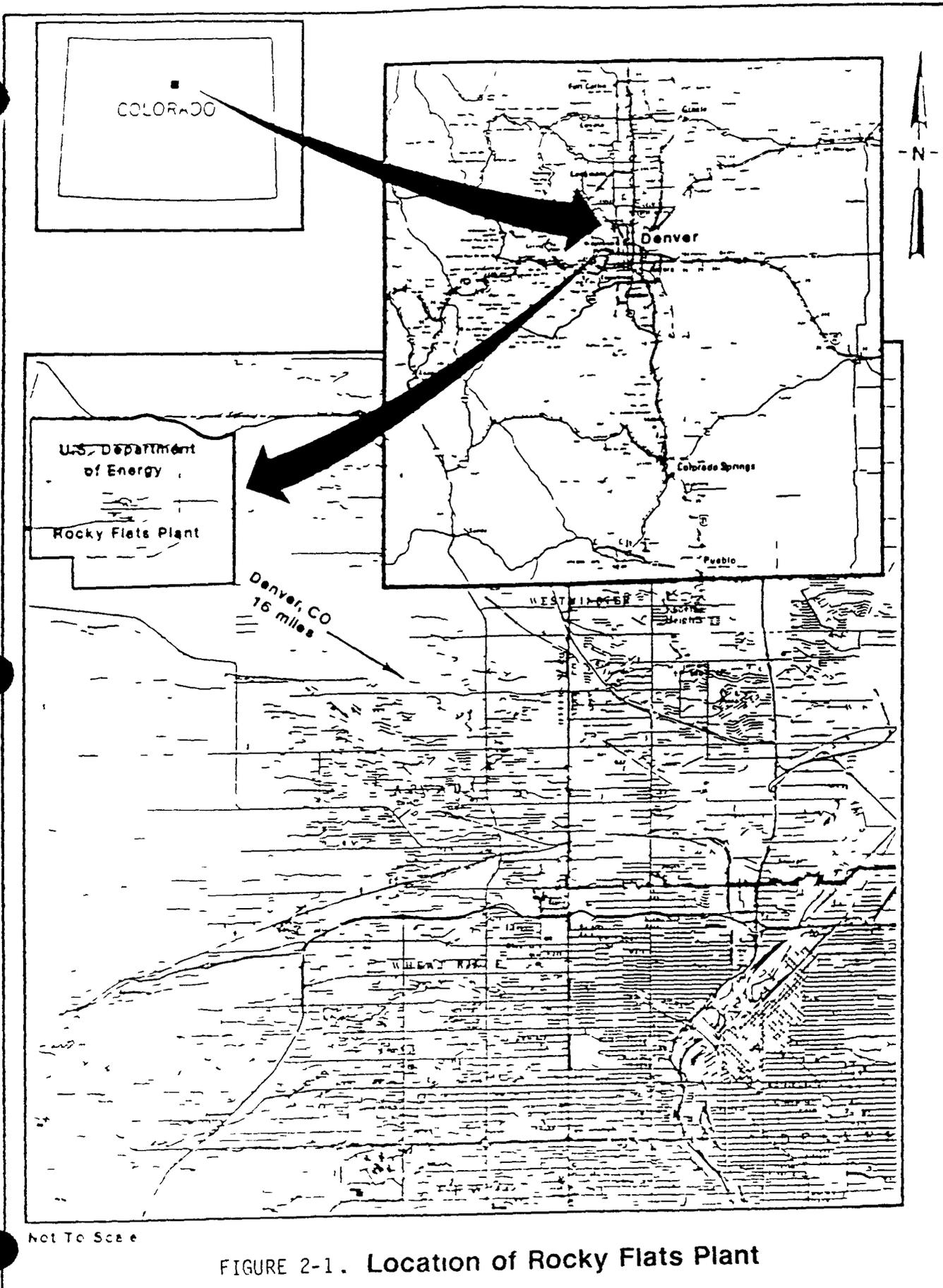


FIGURE 2-1. Location of Rocky Flats Plant

Source Surface Water IM/IRAP and Decision Document 25 May 1990 Draft

long-term threat to the public health and environment DOE is implementing an IM/IRA Plan at the request of Environmental Protection Agency (EPA) and Colorado Department of Health (CDH) Also a factor is the length of time it typically takes to finalize a RCRA Facility Investigation/Remedial Investigation (RFI/RI), and Corrective Measures Study/Feasibility Study (CMS/FS)

Organic and inorganic contamination of surface water has resulted from past operational practices no longer permitted under current regulations Subsection 2.3, Suspected Contaminant Sources, details the sites within Operable Unit No. 2

In March 1987, a Phase I Remedial Investigation (RI) under the Environmental Restoration (ER) Program [formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP)] began at OU2 The investigation consisted of the preparation of detailed topographic maps, radiometric and organic vapor screening surveys, surface geophysical surveys, a soil gas survey, a boring and well completion program, soil sampling, and ground and surface water sampling Phase I field activities were completed at OU2 during 1987, and a draft RI report was submitted to EPA and CDH on December 31, 1987 (Rockwell International, 1987a) Phase I data did not allow adequate definition of the nature and extent of contamination for the purpose of conducting a feasibility study of remedial alternatives pertaining to contaminated media A draft Phase II RI Sampling Plan that presents the details and rationale for further field work to achieve this objective was submitted to the regulatory agencies in June 1988 (Rockwell International, 1988a) This draft sampling plan was subsequently revised and submitted as a final Phase II RCRA Facility Investigation/Remedial Investigation Feasibility Study (RFI/RIFS) sampling plan in April 1990 (EG&G, 1990a) The plan was approved by EPA in May 1990

A draft Interim Remedial Action Plan (IRAP) plan for contaminated groundwater at OU2 was submitted in December 1989 (Rockwell International, 1989a) The plan was

prepared based on limited knowledge of the nature and extent of groundwater contamination. Regulatory agency review of the document determined that, although an IM/IRA for groundwater is required by the 1989 Agreement in Principle between DOE and CDH, insufficient information on the nature and extent of groundwater contamination exists at this time to pursue effective groundwater remediation. In order to facilitate early evaluation of the need for an IM/IRA for groundwater at OU2, the final Phase II RFI/RIFS sampling plan incorporates a phased investigation approach. The plan was approved by the regulatory agencies. The phased approach is to investigate alluvial and hydraulically connected bedrock migration pathways first, and then to subsequently investigate groundwater contaminant sources. This will allow planning, design, and implementation of a groundwater IM/IRA, if necessary, before completion of the RFI/RI and Corrective Measures Study/Feasibility Study (CMS/FS) for OU2. In February 1991, a Phase II alluvial Drilling Program will begin, with a Phase II Bedrock Drilling Program commencing in the summer, 1991.

EG&G has prepared an IM/IRA Plan to identify, screen, and evaluate appropriate interim remedial action alternatives, and select the preferred interim remedial action for the contaminated surface water.

2.1 DESCRIPTION OF SITE

Samples of surface water will be collected for use in the treatability study. Surface water sampling activities will be conducted and documented in a manner to ensure that sufficient data of known quality are collected to support sound decisions concerning treatment selection. The hydrogeology, hydrology, and climate associated with the site will affect sampling activities. These factors are described in the following sections.

2 1 1 Hydrogeologic setting

The hydrogeologic framework of the area under investigation directly affects the movement, quality, and volumes of groundwater and surface water available for sampling. Therefore, an overview of the hydrogeology is presented to describe hydrogeologic factors that impact sampling. A brief description of the stratigraphy and structural geology is included.

2 1 2 Stratigraphy

The rocks in the Rocky Flats Plant (RFP) area range in age from Precambrian to Holocene. The oldest rocks are the Precambrian gneisses, schists, and quartzites that form the core of the Front Range west of the area. Beneath the area, the Precambrian rocks are at a depth of about 12,000 feet. Stratigraphically above these rocks are sedimentary bedrock formations which range in age from Pennsylvanian to Late Cretaceous, and surficial deposits which range in age from Pleistocene to Holocene. The surficial deposits rest unconformably on the eroded surface of the folded and faulted bedrock formations (U S Geological Survey, 1976, 3p)

2 1 2 1 Surficial Deposits

The surficial units found in the area of this investigation are the Rocky Flats Alluvium (Pleistocene), the Slocum Alluvium (Pleistocene), and a minor area of Holocene or Pleistocene landslide deposit. The surficial materials are underlain by the Arapahoe Formation (Upper Cretaceous).

Surficial deposits within the RFP area are generally less than 50 feet thick and consist of terrace alluvium, colluvium, and valley-fill alluvium. All of the surficial deposits consist of clay, silt, sand, gravel, cobbles, and frequently boulders. The source of these

deposits is primarily the Precambrian quartzite from the mountains to the west, but also includes the sedimentary bedrock and older surficial deposits

The oldest surficial deposit on the RFP property is the Rocky Flats alluvium, which dominates the topography and hydrology of the entire property. The Rocky Flats Alluvium is a broad planar deposit which, in this area, is an alluvial fan deposited downslope from the mouth of Coal Creek Canyon. Contact springs commonly issue from the base of the Rocky Flats Alluvium. The next youngest formations are the Verdos and Slocum Alluviums. These formations are of little hydrologic importance.

2.1.2.2 Bedrock Formations

The Arapahoe Formation is the uppermost bedrock formation and is either exposed at land surface or covered unconformably by unconsolidated surficial deposits. The Arapahoe Formation is a continental deposit of lenticular sands interbedded with clay. Maximum thickness of the formation in the RFP area is about 270 feet. The contact between this unit and the overlying surficial materials produces intermittent seeps and springs in the investigation area. The Rocky Flats Alluvium contact with the underlying Arapahoe Formation is shown in Figure 2-2. Figure 2-2 also illustrates the locations of the surface water sampling sites to be considered for use in this investigation. Many of the sites are located near the point of contact between the alluvial and bedrock formations.

2.1.3 Hydrology

The hydrogeologic system exhibits dynamic interaction between groundwater and surface water. Annual fluctuations in the potentiometric surface produce periods during which no flow occurs from seeps in the investigation area.

A discussion of surface water chemistry for the 903 Pad, Mound, and East Trenches Areas is also one of groundwater chemistry as many of the surface water samples to be collected for this investigation will be collected from seeps that represent the surfacing of groundwater. In addition there is frequent interaction of surface water and groundwater in the drainages. For example, during drought periods of low stream flow, groundwater may contribute to streamflow under base flow conditions. Conversely, during wetter periods of the year with high volumes of streamflow, streamflow is recharged laterally into the aquifer adjacent to the stream. The seeps are intermittent and are located downslope and southeast of the 903 Pad Area.

2.1.3.1 Groundwater

Groundwater is present in the Rocky Flats Alluvium, colluvium, and valley fill alluvium under unconfined conditions. Recharge to the water table occurs as infiltration of incident precipitation and as seepage from ditches and creeks. In addition, retention ponds along South Walnut Creek and Woman Creek recharge the valley fill alluvium. Figure 2-3 presents the potentiometric surface of the water table measured on December 1, 1987, and the locations of alluvial and bedrock wells in the vicinity of OU2.

The shallow groundwater flow system exhibits large water level changes in response to precipitation events, stream flow, and ditch flow. For example, between mid-April and September, 1986, water levels declined as much as eight feet occur in wells which are completed in valley fill alluvium (U S DOE, May 25, 1990, 2-14 p). The water levels in alluvial wells are highest during the months of May and June. Water levels decline during late summer and fall, as evidenced by wells that go dry during this time of year.

Alluvial groundwater discharges to seeps, springs, surface water drainages, and subcropping Arapahoe formation sandstone at OU2. Groundwater in colluvial materials

south of the 903 Pad and East Trenches Areas discharges to the South Interceptor Ditch, and groundwater in valley fill materials discharges to Woman or South Walnut Creeks. Figure 2-2 illustrates the location of Woman Creek and South Walnut Creek, the shaded areas of Figure 2-2 are the areas overlain by alluvial materials. The dark line bordering the shaded areas delineates the approximate point of contact between alluvium and underlying Arapahoe Formation. The average groundwater flow velocities in the Rocky Flats Alluvium, Woman Creek Valley fill alluvium, and South Walnut Creek Valley fill alluvium are approximately 84 ft/yr, 145 ft/yr, and 20 ft/yr, respectively. The average groundwater flow velocities calculated for various surficial materials assume the materials are fully saturated year round. However, portions of the Rocky Flats Alluvium, colluvium, and valley fill alluviums are not saturated during the entire year. Thus, dissolved constituents in the shallow flow system do not actually move at the calculated velocities for the entire year.

2.1.3.2 Surface Water

Walnut, South Walnut, and Woman Creeks drain the OU2 site. The drainage basins of Walnut, South Walnut, and Woman Creeks are represented on Figure 2-4. Walnut Creek, Woman Creek and South Walnut Creek flow eastward.

South Walnut Creek

The headwaters of South Walnut Creek have been filled during construction of plant facilities. As a result of this, flow originates from a buried culvert located west of Building 991 (see Figure 2-5). The discharge from the corrugated metal pipe is augmented by flow from a concrete pipe (SW-59) at a point north of the Mound Area. The flow from the concrete pipe originates as seepage from the hillside south of Building 991 and flows into a ditch along the slope. The combined flow then enters the South Walnut Creek retention pond system.

Below the retention ponds, South Walnut Creek, Walnut Creek, and an unnamed tributary join within the buffer zone before flowing into Great Western Reservoir. Great Western Reservoir is located approximately one mile east of this confluence. The South Walnut Creek retention pond system (see Figure 2-2) consists of five ponds (B-1, B-2, B-3, B-4 and B-5) that retain surface water runoff and Plant discharges for the purpose of monitoring before downstream release of these waters. All flow in the pond system is eventually retained in Pond B-5 where it is monitored for quality before discharge in accordance with the Plant's National Pollutant Discharge Elimination System (NPDES) permit (discharge point 006). Ponds B-1 and B-2 are reserved for spill control, surface water runoff, or treated sanitary waste of questionable quality. Pond B-3 is used as a holding pond for sanitary sewage treatment plant effluent. The normal discharge of Pond B-3 is to a spray system located in the vicinity of the East Trenches. Pond B-4 and B-5 receive surface water runoff from the central portion of the Plant, and occasional discharges from Pond B-3.

The surface water runoff received by Pond B-4 is collected by the Central Avenue Ditch and upper reaches of South Walnut Creek.

Woman Creek

Woman Creek is located south of the Plant with headwaters in largely undisturbed Rocky Flats Alluvium. Storm runoff and water seeps from the southern part of the Plant is collected in the South Interceptor Ditch located north of the creek and delivered downstream to Pond C-2 (Figure 2-2). Pond C-1 (upstream of C-2) receives stream flow from Woman Creek. The discharge from Pond C-1 is diverted around Pond C-2 into the Woman Creek channel downstream. Water in Pond C-2 is discharged to Woman Creek in accordance with the Plant NPDES permit (discharge point 007).

Flow in Woman Creek and the South Interceptor Ditch is ephemeral. During 1986 and 1987, there was no visible surface flow in Woman Creek downstream of Pond C-2. The ephemeral nature of surface water flow observed for Woman Creek and the South Interceptor Ditch is due to changes in base flow conditions produced by the shallow ground-water table.

2.1.4 Meteorology and Climatology

Precipitation, principally from rainfall and to a lesser extent from snowmelt, produces surface runoff in the RFP area. The Rocky Flats Plant is situated in a semiarid region, averaging 15 inches of annual precipitation. Forty percent of the yearly total comes in the spring, much of it in the form of snow. Of the balance, 30 percent is accounted for by summer thunderstorms, with the rest occurring in the fall (11 percent) and winter months (19 percent). Average yearly snowfall averages 85 inches. Runoff control structures exist to channel surface water from the Plant to monitoring ponds. These structures are sized to accommodate the 100-year storm event which is equivalent to four inches of rain in a six hour period.

2.2 SURROUNDING AREAS

The Rocky Flats Plant (RFP) is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver. The Plant site consists of approximately 6,550 acres of federally-owned land in Sections 1 through 4, and 9 through 15, of T2S, R70W, 6th principal meridian. Plant buildings are located within an area of approximately 400 acres, known as RFP security area. The security area is surrounded by a buffer zone of approximately 6,150 acres.

2.3 SUSPECTED CONTAMINANT SOURCES

The IM/IRA Proposed Decision Document, September 26, 1990, describes the suspected contaminant sources in OU2. There are 20 sites designated as (IHSS) which comprise the 903 Pad, Mound, and East Trench Areas. These sites are known collectively as OU2, and are located east-southeast of the RFP (Figure 2-2). The following sections describe each of the sites.

903 Pad Area

Five sites are located within the 903 Pad Area (Figure 2-5). These sites are

- 903 Drum Storage Site (IHSS Ref No 112)
- 903 Lip Site (IHSS Ref No 155)
- Trench T-2 Site (IHSS Ref No 109)
- Reactive Metal Destruction Site (IHSS Ref No 140)
- Gas Detoxification Site (IHSS Ref No 183)

Presented below are brief descriptions of each of these sites and the wastes stored or disposed there.

903 Drum Storage Site (IHSS Ref No 112) - The site was used from 1958 to 1967 to store drums containing radioactively contaminated used-machine cutting oil. The drums, some of which corroded and leaked, contained oils and solvents contaminated with plutonium or uranium. Most of the drums contained lathe coolant consisting of mineral oil and carbon tetrachloride (CCl₄) in varying proportions. However, an unknown number of drums contained hydraulic oils, vacuum pump oils, trichloroethene (TCE), tetrachloroethene (PCE), silicone oils, and acetone. Ethanolamine was also added to

new drums after 1959 to reduce the drum corrosion rate. All drums were removed by 1968.

After the drums were removed, efforts were undertaken to scrape and move the plutonium-contaminated soil into a relatively small area, cover it with fill material, and top it with an asphalt containment cover. This remedial action was completed in November 1969. An estimated 5,000 gallons of liquid leaked into the soil during use of the drum storage site. The liquid was estimated to contain 86 grams of plutonium.

903 Lip Site (IHSS Ref No 155) - During drum removal and cleanup activities associated with the 903 Drum Storage Site, winds distributed plutonium beyond the pad to the south and east. Although some plutonium-contaminated soils were removed, radioactive contamination is still present at the 903 Lip Site in the surficial soils.

Trench T-2 Site (IHSS Ref No 109) - This trench was used prior to 1968 for the disposal of sanitary sewage sludge and flattened drums contaminated with uranium and plutonium.

Reactive Metal Destruction Site (IHSS Ref No 140) - This site was used during the 1950s and 1960s primarily for the destruction of lithium metal. Small quantities of other reactive metals (sodium, calcium, and magnesium) and some solvents were also destroyed at this location.

Gas Detoxification Site (IHSS 193) - Building 952, located south of the 903 Drum Storage Site, was used to detoxify various bottled gases between June 1982 and August 1983.

Mound Area

The Mound Area is composed of four sites (Figure 2-4) These are

- Mound Site (IHSS Ref No 113)
- Trench T-1 Site (IHSS Ref No 108)
- Oil Burn Pit No 2 Site (IHSS Ref No 153)
- Pallet Burn Site (IHSS Ref No 154)

These sites are described individually below

Mound Site (IHSS Ref No 113) - The Mound Site contained approximately 1,405 drums containing primarily depleted uranium and plutonium contaminated lathe coolant. Some drums also contained "Perclene". Perclene was a brand name of tetrachloroethene. Some of the drummed wastes placed in the Mound Site were in solid form. Cleanup of the Mound Site was accomplished in 1970, and the materials removed were packaged and shipped to an off-site DOE facility as radioactive waste. Subsequent surficial soils sampling in the vicinity of the excavated Mound Site indicated 0.8 to 112.5 disintegrations per minute per gram (d/m/g) alpha activity. This radioactive contamination is thought to have come from the 903 Drum Storage Site via wind dispersion rather than from the Mound Site.

Trench T-1 Site (IHSS Ref No 108) - The trench was used from 1954 until 1962 and contains approximately 125 drums filled with depleted uranium chips and plutonium chips coated with lathe coolant. The drums are still present in this trench.

Oil Burn Pit No 2 Site (IHSS Ref No 153) - Oil Burn Pit No 2 is actually two parallel trenches which were used in 1957 and from 1961 to 1965 to burn 1,083 drums of oil.

containing uranium. The residues from the burning operations and some flattened drums were covered with backfill. Cleanup operations were performed in the 1970s.

Pallet Burn Site (IHSS Ref No 154) - An area southwest of Oil Burn Pit No 2 was reportedly used to destroy wooden pallets in 1965. The types of hazardous substances or radionuclides that may have been spilled on these pallets is unknown. Cleanup actions were performed in the 1970s.

East Trenches Area

The East Trenches Area consists of nine burial trenches and two spray irrigation areas (Figure 2-4). The trench numbers and their respective IHSS designations are

- Trench T-3 - IHSS Ref No 110
- Trench T-4 - IHSS Ref No 111 1
- Trench T-5 - IHSS Ref No 111 2
- Trench T-6 - IHSS Ref No 111 3
- Trench T-7 - IHSS Ref No 111 4
- Trench T-8 - IHSS Ref No 111 5
- Trench T-9 - IHSS Ref No 111 6
- Trench T-10 - IHSS Ref No 111 7
- Trench T-11 - IHSS Ref No 111 8

Trenches T-3, T-4, T-10, and T-11 are located north of the east access road, and trenches T-5 through T-9 are located south of the east access road. The trenches were used from 1954 to 1968 for disposal of depleted uranium, flattened depleted uranium- and plutonium-contaminated drums, and sanitary sewage sludge. The wastes have not been disturbed since their burial.

IHSS numbers 216 2 and 216 3 were used for spray irrigation of sewage treatment plant effluent. These areas have been designated as IHSS because of the potential for chromium contamination that resulted from a Plant spill of chromic acid that entered the sanitary sewers on February 23, 1989. Based on results of sampling after the February spill, leachable chromium concentrations in soils were significantly below the RCRA Extraction Procedure (EP) Toxicity limits.

2.4 PROBABLE GROUNDWATER AND SURFACE WATER TRANSPORT PATHWAYS

Transport occurs in both groundwater and surface water. The sources were detailed above. Distribution in groundwater and surface water is discussed in Subsection 1.5.

2.5 CONTAMINANT DISTRIBUTION

Contaminants move from the groundwater system to the surface water system at seeps in the investigation area. The contaminants present in each area of OU2 are described in subsections 2.5.1 and 2.5.2.

2.5.1 Groundwater Contamination

The following discussion is based on the information presented in the draft Groundwater Interim Measures/Interim Remedial Action Plan and Decision Document, September 26, 1990. Many seeps or stream stations were dry during some samplings. The following discussion of volatile organics, metals and inorganics focuses on groundwater sampling results for the second quarter of 1989. This information is presented in the IM/IRA Draft Decision Document for OU2, May 1990. The discussion of 1989 radionuclide data in the IM/IRA report relies on first quarter results because complete second quarter data are unavailable.

2 5 1 1 Volatile Organic Contamination

Carbon tetrachloride (CCl_4), tetrachloroethene (PCE), and trichloroethene (TCE) are the primary volatile organic contaminants in the unconfined groundwater flow system

Carbon Tetrachloride

Carbon tetrachloride (CCl_4) occurs in groundwater east, southeast and northeast of the 903 Pad Area. Of the downgradient wells in this area, 1-71 and 15-87 contain the highest levels of CCl_4 , 690 and 1100 micrograms per liter ($\mu\text{g}/\text{l}$), respectively. The downgradient concentrations (in wells 36-87 and 42-86) are greater than the upgradient concentrations (in wells 17-87 and 25-87). This indicates that the northern East Trenches may be a second source of CCl_4 .

Tetrachloroethene

The Mound Area appears to be the primary source of tetrachloroethene (PCE) within the area of investigation. Well 1-74 contained 45000 $\mu\text{g}/\text{l}$. A plume of PCE with concentrations greater than 100 $\mu\text{g}/\text{l}$ extends east and southeast (downgradient) from the Mound Area to at least well 36-87. The extent of this plume is not well defined. PCE was also detected in wells southeast (downgradient) of the 903 Pad and Trench T-2 (2-71, 15-87, and 1-71), although the concentrations were lower than in the Mound Area wells.

Trichloroethene

The distribution of trichloroethene (TCE) indicates that all three RI areas are sources of this volatile organic. TCE in wells 1-71, 2-71, 14-87, and 15-87 suggests the upgradient 903 Drum Storage Site and possibly Trench T-2 and the Reactive Metal

Destruction Site as potential sources. Similarly, TCE in wells 1-74, 17-87, and 35-86 suggests the Mound Area as a source. TCE downgradient of Trenches T-3 and T-4 and also indicates the East Trenches as potential sources. Well 36-87 within the latter area exhibited the highest concentration, 12000 $\mu\text{g/l}$.

Other Volatile Organic Compounds

Second quarter 1989 data indicate contamination in groundwater by volatile organic compounds other than CCl_4 , PCE and TCE, but to a much lesser extent. Details concerning the distribution of other volatile organic compounds is included in the IM/IRA Draft Decision Document, May 1990.

2.5.1.2 Inorganic Contamination

The IM/IRA Draft Decision Document contains details concerning the distribution of inorganic contamination in OU2. The following summarizes the information contained in that document. Exact values and tables are contained in the Draft Decision Document.

Metals

Analytical data for waters from wells tested in the second quarter 1989, located at the 903 Pad, Mound and East Trenches Areas, showed above-background concentrations of all dissolved metals being measured except for beryllium, cadmium, cobalt, cesium, and thallium.

Dissolved Radionuclides

Three uranium isotope concentrations (U-234, U-235, and U-238) were measured above background at the 903 Pad, Mound and East Trenches Areas, in the first quarter of 1989. For example, several wells within or downgradient of the 903 Pad Area exhibit uranium 238 in excess of background, with a maximum of 28 ± 2 pCi/l at well 12-87 (in weathered sandstone). Mound Area wells 23-87 (in weathered sandstone) and 17-87 (in Rocky Flats Alluvium) both contained uranium above background, whereas wells 1-74 (in weathered claystone) and 35-86 (in valley fill alluvium) did not contain above-background uranium. The only well that did not have above-background concentrations of dissolved uranium in the vicinity of the East Trenches Areas was 3-74 (in weathered claystone). The areal distribution of uranium in this area is not well known. In general, other dissolved radionuclides were not present above background in the first quarter of 1989, but there were earlier samples that contained plutonium and/or americium above background. Results at wells 15-87 were the most elevated (plutonium - 0.522 ± 0.117 pCi/l and 0.199 ± 0.07 pCi/l, americium - 0.831 ± 0.148 pCi/l and 0.06 ± 0.05 pCi/l).

2.5.2 Surface Water Contamination

The following discussion is based on information presented in the proposed surface water IM/IKA Plan and Decision Document, September 26, 1990. Many seeps or stream stations were dry most of the year and could not be sampled.

Five tables from the IM/IRAP document are presented introductory to this section to list chemical-specific ARARs and flow-weighted maximum concentrations of contaminants of concern.

Tables 2-1 through 2-4 present chemical specific ARARs for volatile organics, metals detected above background, inorganic constituents detected above background, and radionuclides detected above background in surface water at OU2

Table 2-5 presents flow weighted maximum concentrations at various groups of stations. The data presented in the table include the average and maximum concentrations at the group of stations, the estimated flow at the group of stations based on wet season flow measurement, the flow weighted average concentration, and the flow weighted maximum concentrations. Flow weighted averaging is intended to define the probable influent average and maximum concentrations for these constituents for the IM/IRA treatment system.

The IM/IRA discussion of surface water chemistry for the 903 Pad, Mound, and East Trenches Areas is tied to groundwater quality because the majority of the surface water samples collected for the investigation were taken from seeps that represent the surfacing of groundwater.

The IM/IRA document contains water quality data for samples obtained from several seeps downslope to the southeast of the 903 Pad. The surface water stations described in the IM/IRA document which should be sampled under this treatability test program are SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77. In addition to these stations, samples for treatability testing purposes should also be taken from the following stations: SW-53, SW-63, and SW-64. Available records indicate that only station SW-64, located on Woman Creek, typically contains flowing water during the month of October.

Station SW-50 is closest to the 903 Pad, and SW-57 and SW-52 are south of SW-50. SW-51 and SW-58 are located in a ditch along the road east of SW-50, however, overland flow of seepage from SW-50, SW-52, and SW-57 may also enter the ditch.

TABLE 2-1

CHEMICAL SPECIFIC ARARS
FOR VOLATILE ORGANIC COMPOUNDS
IN SURFACE WATER AT OPERABLE UNIT NO. 2

Chemical	Maximum Con- centration in Surface Water ^a (ug/L)	ARAR (ug/L)	ARAR Reference	Comment	Hazard Quotient/ Cancer Risk ^b
<u>Organic Compounds</u>					
Vinyl Chloride	15	10U	SDWA MCL	Standard is below detection limit, therefore, detection limit is ARAR	No oral Rfd/6 5 E-04
Methylene Chloride	44	5U	RCRA Subpart F		2 4E-03/1 1E-06
Acetone	130	50	Land Ban Constituent, Table CCWE, 40 CFR 268 Subpart D		1 4E-02/not considered an oral carcinogen
Carbon Tetrachloride	1005	5U	RCRA Subpart F		2 0E-01/1 9E-05
1,1 Dichloroethane	6J	5U	RCRA Subpart F		1 4E-03/1 3E-05
1,2 Dichloroethane	56	5U	RCRA Subpart F		7 1E-03 (based on trans isomer)/not considered an oral carcinogen
1,1 Dichloroethene	143	5U	RCRA Subpart F		1 6E-02/8 6E-05
Tetrachloroethene	280	5U	CDH Surface Water, Fish and Water Ingestion Standard	Standard is below detection limit, therefore, detection limit is ARAR	1 4E-02/7 5E-06
Trichloroethene	2500	5U	RCRA Subpart F		No oral Rfd/1 6E-06

TABLE 2-2
 CHEMICAL SPECIFIC ARARs
 FOR METALS DETECTED ABOVE BACKGROUND
 IN SURFACE WATER AT OPERABLE UNIT NO. 2

Chemical	Maximum Con- centration in Surface Water ^b (mg/l)	ARAR (mg/l)	ARAR Reference	Comment	Hazard Quotient/ Cancer Risk ^a
<u>Metals</u>					
Aluminum	28.3	5.0	CDH Agriculture Standard		No oral RfD/not considered an oral carcinogen
Arsenic	0.040	0.05 (0.025)	CDH Surface Water, Drinking Water Standard	The detection limit (0.025) is selected as ARAR because of the relatively high hazard quotient and cancer risk associated with the standard	0.7/1.25E-03
Barium	0.831	1.0	CDH Surface Water, Drinking Water Standard		5.7E-01/not considered an oral carcinogen
Beryllium	0.057	0.005U	RCRA Subpart F		2.8E-02/6.0E-04
Cadmium	0.024	0.01	CDH Surface Water, Drinking Water Standard		5.7E-01/not considered an oral carcinogen
Calcium	991	NS	No Standard		No oral RfD/not considered an oral carcinogen
Cesium	1.11	1.00U	No Standard, Background (1 mg/l) is TBC		No oral RfD/not considered an oral carcinogen
Chromium III	0.041	0.05	CDH Surface Water, Drinking Water Standard	Analytical result is total chromium.	1.4E-03/not considered an oral carcinogen
Chromium VI	0.041	0.011	CWA Water Quality Criterion	Analytical result is total chromium	6.4E-02/not considered an oral carcinogen

TABLE 2-2
 CHEMICAL SPECIFIC ARARS
 FOR METALS DETECTED ABOVE BACKGROUND
 IN SURFACE WATER AT OPERABLE UNIT NO. 2

Chemical	Maximum Con- centration in Surface Water ^b (mg/l)	ARAR (mg/l)	ARAR Reference	Comment	Hazard Quotient/ Cancer Risk*
<u>Metals (cont.)</u>					
Copper	0.066	0.025U	Clean Water Act Water Quality Criterion	Standard is below detection limit, therefore, detection limit is ARAR	1.9E-02/not considered an oral carcinogen
Iron	40.07 (3.69)	1.0 (0.3)	CDM Surface Water, Drinking Water Standard	Analytical results are total iron; dissolved iron in parentheses	No oral RfD/not considered an oral carcinogen
Lead	0.166	0.005U	CWA Water Quality Criterion	Standard is below detection limit, therefore, detection limit is ARAR	No oral RfD/not considered an oral carcinogen
Lithium	0.180	2.5	CDM Ground Water Standard		No oral RfD/not considered an oral carcinogen
Magnesium	136	NS	No Standard		No oral RfD/not considered an oral carcinogen
Manganese	3.18 (1.64)	1.0 (0.05)	CDM Surface Water; Drinking Water Standard	Analytical results are total manganese, dis- solved manganese in parentheses	1.4E-01 (7.1E-03)/not considered an oral carcinogen
Mercury	0.0007	0.0002U	CWA Water Quality Criterion	Standard is below detection limit, therefore, detection limit is ARAR	1.9E-02/not considered an oral carcinogen

TABLE 2-2
 CHEMICAL SPECIFIC ARARs
 FOR METALS DETECTED ABOVE BACKGROUND
 IN SURFACE WATER AT OPERABLE UNIT NO. 2

Chemical	Maximum Con- centration in Surface Water ^b (mg/L)	ARAR (mg/L)	ARAR Reference	Comment	Hazard Quotient/ Cancer Risk*
<u>Metals (cont.)</u>					
Molybdenum	0.114	0.1	CDM Ground Water, Agriculture Standard		No oral RfD/not considered an oral carcinogen
Nickel	0.065	0.02	RCRA Subpart F		2.9E-02/not considered an oral carcinogen
Potassium	31	NS	No Standard		No oral RfD/not considered an oral carcinogen
Selenium	0.013	0.01	CDM Surface Water, Drinking Water Standard		9.5E-02/not considered an oral carcinogen
Sodium	405	NS	No Standard		No oral RfD/not considered an oral carcinogen
Strontium	2.27	NS	No Standard	Background is TBC	No oral RfD/not considered an oral carcinogen
Vanadium	0.113	0.024	RCRA Subpart F		9.8E-02/not considered an oral carcinogen
Zinc	2.84	0.05	CWA Water Quality Criterion		7.0E-03/not considered an oral carcinogen

TABLE 2-3
CHEMICAL SPECIFIC ARARS
FOR OTHER INORGANIC CONSTITUENTS DETECTED ABOVE BACKGROUND
IN SURFACE WATER AT OPERABLE UNIT NO. 2

Chemical	Maximum Con- centration in Surface Water ^b (mg/l)	ARAR (mg/l)	ARAR Reference	Comment	Hazard Quotient/ Cancer Risk
<u>Conventional Pollutants</u>					
Nitrite	24	1.0	CDH Surface Water Standard	Analytical results are total nitrate plus nitrate nitrogen. Reanalysis required to determine if nitrite ARAR is exceeded.	2.9E-01/not considered an oral carcinogen
Nitrate	24	10.0	CDH Surface Water Standard	Analytical results are total nitrate nitrogen.	No oral RfD/not considered an oral carcinogen
Chloride	170	250	CDH Surface Water Standard		No oral RfD/not considered an oral carcinogen
Sulfate	228	250	CDH Surface Water Standard		No oral RfD/not considered an oral carcinogen
Bicarbonate as CaCO ₃	642	NS	No Standard		No oral RfD/not considered an oral carcinogen
TDS	790	400	CDH Ground Water Standard		No oral RfD/not considered an oral carcinogen

TABLE 2-4
 CHEMICAL SPECIFIC ARARS
 FOR RADIONUCLIDES DETECTED ABOVE BACKGROUND
 IN SURFACE WATER AT OPERABLE UNIT NO. 2

Chemical	Maximum Con- centration in Surface Water ^b (pCi/l)	ARAR (pCi/l)	ARAR Reference	Comment	Hazard Quotient/ Cancer Risk ^{***}
<u>Radionuclides</u>					
Gross Alpha	310	7 (11)**	CDH Ground Water Standard		No oral RfD/NA
Gross Beta	340	5 (19)	CDH Surface Water Standard		No oral RfD/NA
P ²³⁸ , P ²³⁹ , P ²⁴⁰	60	05 (05)	CDH Surface Water Standard		No oral RfD/7 0 x 10 ⁻⁷ , 8 0 x 10 ⁻⁸ , 8 0 x 10 ⁻⁸ ,
Am ²⁴¹	28	05 (05)	CDH Surface Water Standard		No oral RfD/8 0 x 10 ⁻⁷
H ³	1100	500 (500)	CDH Surface Water Standard		No oral RfD/1 4 x 10 ⁻⁶
Sr ^{89,90}	3 6	8	CDH Surface Water Standard		No oral RfD/1 2 x 10 ⁻⁶ , 1.4 x 10 ⁻⁵
Uranium ^{total}	23 6	5 (10)	CDH Surface Water Standard		No oral RfD/3 3 x 10 ⁻⁵

(a) Maximum compound concentrations determined from all available data (see Appendix A)

(b) Total concentration unless specified, does not include outliers (see Section 3.3)

U Detection limit

J Estimated below detection limit

B Compound also present in blank

TBC To be considered

(c) Below minimum detectable activity (MDA)

^a Hazard quotient is ratio of daily intake at level of ARAR based on the consumption of 2 liters/day and a body weight of 70 kg to the chronic oral RfD (EPA, 1990 - Health Effects Assessment Summary Tables, First/Second Quarters) RfD = Agency-wide reference dose, developed by an inter-office work group chaired by the Office of Research and Development, U S EPA, Washington, D C Cancer Risk = ARAR (ug/l) x Carcinogenic Potency Factor (ug/l)⁻¹

** Value is for Woman Creek, value in parentheses is for Walnut Creek

*** For radionuclides cancer risk = ARAR (pCi/l) x Pathway-specific unit risk (pCi/l)⁻¹ The cancer risk is not applicable to gross alpha and beta. Cancer risk depends not only on the form of radiation, but also on the radionuclide emitting the radiation because radionuclides selectively affect various organs

TABLE 2-5

FLOW WEIGHTED MAXIMUM CONCENTRATIONS

ANALYTE	903 PAD AND LIP (Flow = 3.5 GPM)		SU053 (Flow = 0.5 GPM)		UPPER SOUTH WALNUT CREEK (Flow = 38 GPM)		SU059 (Flow = 4.5 GPM)		SU063 (Flow = 5 GPM)		SU064 (Flow = 5 GPM)		FLOW WEIGHTED AVERAGE CONCENTRATION		FLOW WEIGHTED MAXIMUM CONCENTRATION
	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	
Volatiles Organics (Concentration Units = ug/l)															
Vinyl Chloride	10 U	5	5	10	6	15	5	10	5	10	5	10	6	15	15
Methylene Chloride (5)	5 U	3	3	5	7	44	3	5	3	5	3	5	6	34	34
Acetone (5)	50	6	6	11	13	130	6	13	5	10	4	5	11	99	99
Carbon Disulfide	5 U	2	2	2	3	5	3	5	3	5	3	5	3	5	5
1,1-Dichloroethene	5 U	27	140	3	7	143	21	133	3	5	3	5	9	17	17
1,1-Dichloroethane	5 U	2	3	5	3	6	3	6	3	5	3	5	3	6	6
1,2-Dichloroethene (total)	5 U	3	11	42	3	5	10	36	3	5	3	5	4	10	10
Carbon Tetrachloride	3 U	62	1005	3	24	173	284	605	10	17	3	5	47	249	249
Trichloroethene	5 U	132	2500	4	13	29	98	260	8	16	13	20	40	238	238
Tetrachloroethene	5 U	15	45	5	5	280	94	270	2	1	1	3	38	235	235

Dissolved Metals (Concentration Units = ug/l)															
ANALYTE	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. max
Antimony (Sb)	0.040	0.0300	0.0467	0.1330	0.0300	0.0600	0.0300	0.0600	0.0300	0.0600	0.0300	0.0600	0.0300	0.0600	0.0607
Beryllium (Be)	0.005 U	0.0050	0.0025	0.0050	0.0016	0.0053	0.0025	0.0050	0.0025	0.0050	0.0025	0.0050	0.0025	0.0050	0.0052
Iron (Fe)	0.308	1.581	1.4800	3.100	0.0374	0.2000	0.0225	0.1230	0.0327	0.0620	0.0173	0.0590	0.0056	0.0376	0.3676
Manganese (Mn)	0.058	0.2427	1.8400	0.0430	0.1914	0.0430	0.0144	0.0461	0.0120	0.0355	0.0140	0.0355	0.0079	0.0373	0.0373
Selenium (Se)	0.010	0.0031	0.0134	0.0050	0.0026	0.0050	0.0025	0.0050	0.0025	0.0050	0.0025	0.0050	0.0029	0.0063	0.0063
Strontium (Sr)	0.394	0.4180	0.9180	0.8170	0.1934	0.8000	0.5450	1.1700	1.6000	1.2500	1.1075	1.1700	0.3379	0.8177	0.8177
Vanadium (V)	0.100	0.0500	0.1000	0.1000	0.0797	1.0000	0.0500	0.1000	0.0300 (6)	0.1000 (6)	0.0300	0.1000	0.0300	0.1000	0.1000

Total Metals (Concentration Units = ug/l)															
ANALYTE	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. avg	C. max	C. max
Aluminum (Al)	5.000	4.3912	28.3000	6.4200	3.9927	25.4000	0.8900	22.8000	0.7500	0.7500	5.6167	15.4000	6.3435	24.0745	24.0745
Antimony (Sb)	0.040 U	0.0300	0.0460	0.0400	0.0309	0.0611	0.0403	0.1020	0.0300	0.0600	0.0300	0.0600	0.0316	0.0645	0.0645
Barium (Ba)	1.000	0.2274	0.5730	0.4480	0.2283	2.0200	0.2094	0.4610	0.1070	0.107	0.1560	0.2680	0.2195	1.5985	1.5985
Beryllium (Be)	0.005 U	0.0026	0.0049	0.0055	0.0051	0.0572	0.0037	0.0076	0.0025	0.0050	0.0025	0.0050	0.0045	0.0439	0.0439
Cadmium (Cd)	0.010	0.0025	0.0050	0.0050	0.0030	0.0142	0.0025	0.0050	0.0025	0.005	0.0040	0.0070	0.0030	0.0120	0.0120
Chromium (Cr)	0.050	0.0083	0.0288	0.0180	0.0151	0.2120	0.0090	0.0232	0.0050	0.01	0.0170	0.0410	0.0141	0.1642	0.1642
Cobalt (Co)	0.050 U	0.0250	0.0500	0.0500	0.0295	0.1320	0.0250	0.0500	0.0250	0.05	0.0250	0.0500	0.0283	0.1105	0.1105
Copper (Cu)	0.200	0.0172	0.0570	0.0299	0.0271	0.2930	0.0215	0.0446	0.0125	0.025	0.0220	0.0410	0.0252	0.2281	0.2281
Iron (Fe)	1.000	5.1538	24.7000	22.3000	12.0000	204.0000	5.7837	17.0000	1.3200	1.3200	6.3633	17.1000	10.3643	153.5478	153.5478
Lead (Pb)	0.050	0.0147	0.0576	0.0623	0.0140	0.2150	0.0124	0.0517	0.0060	0.0060	0.0025	0.0050	0.0178	0.1664	0.1664
Lithium (Li)	2.500	0.1553	3.2000	0.0448	0.0240	0.1520	0.4800	2.5600	1.2500 (6)	2.5000 (6)	0.0715	0.0925	0.1089	0.5859	0.5859
Manganese (Mn)	1.000	0.2272	0.9540	0.7190	0.3493	3.6600	0.0723	0.1970	0.4650	0.4650	0.1579	0.3680	0.3113	2.8410	2.8410
Mercury (Hg)	0.002	0.0001	0.0006	0.0007	0.0002	0.0024	0.0002	0.0006	0.0001	0.0002	0.0001	0.0002	0.0002	0.0019	0.0019
Molybdenum (Mo)	0.100	0.0494	0.0275	0.1000	0.0581	0.1740	0.0449	0.1191	0.0500 (6)	0.1000 (6)	0.0500	0.1000	0.0500	0.1922	0.1922
Nickel (Ni)	0.200	0.0225	0.0634	0.0400	0.0256	0.2400	0.0400	0.0400	0.0200	0.0400	0.0200	0.0200	0.0272	0.1426	0.1426
Selenium (Se)	0.010	0.0032	0.0126	0.0050	0.0026	0.0059	0.0044	0.0160	0.0110	0.0110	0.0055	0.0115	0.0031	0.0018	0.0018
Strontium (Sr)	0.382	0.3136	0.9190	0.8470	0.2317	0.8000	0.6094	1.3600	1.2500 (6)	1.2500 (6)	1.2333	1.3600	0.3699	0.9081	0.9081
Vanadium (V)	0.100	0.0282	0.0952	0.0500	0.0499	0.3550	0.0847	0.1950	0.0250 (6)	0.0250 (6)	0.0277	0.0330	0.0447	0.2444	0.2444
Zinc (Zn)	2.000	0.2829	2.8600	0.1210	0.2363	1.1900	0.8141	2.6600	0.0100	0.0200	0.0713	0.1260	0.2714	1.5159	1.5159

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TABLE 2-5

FLOW WEIGHTED MAXIMUM CONCENTRATIONS

ANALYTE	ARAR	(1) 903 PAD AND LIP (Flow 3.5 GPM)		SU055 (Flow 0.5 GPM)		UPPER SOUTH WALNUT CREEK (Flow 38 GPM)		SU059 (Flow 4.5 GPM)		SU063 (Flow 5 GPM)		SU064 (Flow 6.5 GPM)		FLOW WEIGHTED AVERAGE CONCENTRATION		FLOW WEIGHTED MAXIMUM CONCENTRATION	
		C avg	C max	C avg	C max	C avg	C max	C avg	C max	C avg	C max	C avg	C max	C avg	C max	C avg	C max
D. of d Radionuclides (Concentration Units pCi/l)																	
Gross Alpha	11 00	2 800	5 670	4 700	8 480	3 800	20 600	11 000	16 000	8 300	8 250	6 300	6 340	4 6320	17 6998		
Gross Beta	19 00	2 000	4 500	7 000	10 000	43 700	5 100	19 000	18 240	19 000	18 900	7 200	7 200	8 8175	33 8643		
Plutonium 239 240	0 05	0 400	1 000	1 800	0 008	0 008	0 108	0 008	0 012	0 005	0 075	0 000	0 005	0 0516	0 1723		
Total Uranium	10 00	4 000	5 020	4 600	7 260	4 900	10 760	6 600	7 500	18 000	17 700	16 000	15 530	6 0816	10 1672		
Total Radionuclides (Concentration Units pCi/l)																	
Gross Alpha	11 00	85 000	350 000	125 000	230 000	73 000	780 000	96 000	310 000	5 500 (6)	11 000 (6)	26 000	34 000	71 568	631 718		
Gross Beta	19 00	29 000	45 000	7 800	14 000	54 000	570 000	96 000	340 000	9 500 (6)	19 000 (6)	55 000	93 000	56 653	463 155		
Plutonium 239 240	0 05	15 000	60 000	20 000	56 000	0 320	3 100	0 750	3 100	0 240	0 242	0 005	0 123	1 518	7 340		
Americium 241	0 05	2 000	33 000	9 500	28 000	0 083	0 440	0 300	1 300	0 050 (6)	0 100 (6)	0 005	0 010	0 317	2 955		
Tritium	500 00	230 000	829 000	222 000	310 000	225 000	500 000	200 000	200 000	1100 000	1100 000	200 000	110 000	229 437	466 049		
Total Uranium	10 00	4 500	18 100	5 700	8 470	5 500	11 100	7 900	16 600	21 000	20 500	13 000	23 500	6 445	13 213		
Total Inorganics (Concentration Units mg/l)																	
Nitrate Nitrite as N	10	2 9	24 0	2 0	0 2	3 2	5 6	4 0	5 0	2 5	5 0	1 3	0 2	3 1	6 3		
Total Dissolved Solids (TDS)	400	479 0	790 0	514 0	646 0	411 0	3300 0	477 0	580 0	643 0	675 0	694 0	720 0	469 8	2615 3		

(1) The 903 Pad and Lip area contains surface water stations SU050 SU051 SU052 SU055 SU057 SU058 AND SU077

(2) Upper South Walnut Creek contains surface water stations SU056 SU060 SU063 AND SU101

(3) C avg Average Analyte Concentration For a group of stations (e.g. 903 Pad and Lip and Upper South Walnut Creek) C avg is computed by first determining the arithmetic mean concentration at individual stations and then using this data to compute the arithmetic mean for the stations in the group. If a datum indicates non detected (i.e. U designation), the value used in computation of the arithmetic mean is one-half the Contract Required Detection Limit (CRDL). In cases where a station or group of stations has many non detect results in addition to one or more results below the detection limit for a contaminant, the calculated C avg may be greater than C max.

(4) C max Maximum Analyte Concentration C max is the maximum detected concentration in the entire data set for the station or group of stations. If the analyte is not detected (i.e. U designation) in any of the station samples, C max is set equal to the CRDL.

(5) Methylene chloride and acetone were detected in several laboratory blanks. Surface water data in which these common laboratory contaminants were detected in blanks are evaluated for computation of C avg and C max as follows: If the datum is less than 10 times the concentration found in the corresponding blank, the datum is evaluated as a non detect. 50 and 100 for methylene chloride and acetone respectively. If the datum is greater than 10 times the concentration found in the corresponding blank, the datum is evaluated at the concentration reported by the sample analysis.

(6) No concentration data has been reported for the indicated analyte and surface water station. C avg and C max are therefore set equal to one-half of the analyte CRDL, also a type I error, except city.

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Water in the ditch passes under the road south of these locations through a culvert. The discharge of the culvert is SW-55. SW-77 is another seep located on the east side of the road, immediately north of SW-55. The IM/IRAP document notes that SW-51, SW-58, and SW-55 are physically connected and they likely receive flow from SW-50, SW-52, and SW-57. Farther downgradient stations include seeps at SW-53, SW-63, and SW-64.

Surface water stations associated with Upper South Walnut Creek which should be sampled during this program include SW-59 and SW-61. The flow in South Walnut Creek upstream of Pond B-4 is primarily the combined flow from the discharge of culverts and a spring (SW-59) located at the base of the hill to the south and downstream of the culverts. SW-61 is located at the confluence, providing a point for sampling combined flow.

2.5.2.1 Volatile Organic Contamination

Carbon Tetrachloride

The upper reaches of South Walnut Creek as characterized, in part, by data for stations SW-59 and SW-61 contain CCl_4 in concentrations in excess of $2000 \mu\text{g/L}$. Low concentrations of CCl_4 occur at SW-63. Data for stations SW-59 and SW-61 indicate the presence of CCl_4 in concentrations in excess of $200 \mu\text{g/L}$.

Tetrachloroethane

Data stations SW-59 and SW-61 indicate the presence of PCE in concentrations in excess of $200 \mu\text{g/L}$. The IM/IRAP document does not cite specific incidences of PCE contamination for seeps in the vicinity of the 903 Pad Lip Site, but notes that PCE has been detected in many of the seeps in this area.

Trichloroethene

TCE is occasionally present at SW-53, and low concentrations of TCE occur at SW-63 (<0.20 µg/L) and at SW-64. Data for stations SW-59 and SW-61 indicate the presence of TCE in concentrations in excess of 200 µg/L.

Other Volatile Organic Compounds

Data for seeps in the vicinity of the 903 Pad Lip Site and farther downgradient at SW-53, SW-63, and SW-64 indicate organic contamination. Contaminants in seeps in the vicinity of the 903 Lip Site include 1,1-DCE, 1,2-dichloroethene (1,2-DCE), CCl₄, TCE, and PCE with concentrations of CCl₄ and TCE exceeding 1000 µg/L. 1,2-DCE is occasionally present at SW-53. Methylene chloride also occasionally occurs in these seeps but at concentrations near the detection limit.

Data for stations SW-59 and SW-61 indicate the presence of 1,1-DCE, 1,1-DCA, 1,2-DCE, vinyl chloride, acetone, bromo-dichloromethane and methylene chloride in concentrations of less than 200 µg/L.

2.5.2.2 Inorganic Contamination

The IM/IRAP document reports somewhat elevated concentrations of TCE, major ions, strontium, zinc, and uranium at most of these stations.

Total Radionuclides

Seeps in the vicinity of the 903 Lip Site, particularly SW-50 and SW-53, contained detectable plutonium and/or americium during one event in 1989, with two such events for SW-53. The samples contained substantial suspended solids and were not filtered.

at the time of collection. Surface soils in the vicinity of the seeps are contaminated with radionuclides. Further, total radiochemistry indicated notable higher plutonium and americium concentrations in unfiltered samples than in filtered samples, which the IM/IRAP document infers to mean that most of the radionuclides are present in a particulate form.

Recent preliminary analytical results for a sampling program which involved collection and incremental filtration of samples obtained at the 903 Pad Lip Area appear to support the hypothesis that plutonium and americium are primarily associated with particles in excess of 0.45 μm in size. These data indicated that the highest concentrations of total radionuclides were found in water samples obtained from SW-58, SW-55, SW-77, and SW-53. None of these sites is expected to contain water for sampling purposes during the months of October or November. In fact, available data indicate that these sites are dry during most of the year, flowing usually in late spring or early summer.

2.6 TREATMENT GOALS

The overall objective of the IM/IRA at OU2 is the mitigation of downgradient contaminant migration within surface water and the treatment of collected surface water to achieve acceptable levels. Remedial actions at Superfund sites must meet two fundamental clean-up requirements. First, they must attain a level of cleanup which, at a minimum, ensures protection of human health and the environment (CERCLA Section 121 (d)(2), 42 U.S.C. Section 9621 (d)(2)). Second, it is EPA policy that CERCLA cleanups attain or exceed the requirements of all applicable or relevant and appropriate Federal and state health and environmental requirements (ARARs). Tables 2-1 through 2-4 list the potential ARARs relevant to the IM/IRA at OU2.

The IAG, in paragraph 150, states "Interim Remedial Actions/Interim Measures shall, to the greatest extent practicable, attain ARARs " Also for interim actions, the NCP [40 CFR 300 430(f)] specifically notes that an ARAR can be waived if the action is to become part of the final remedy that will attain ARARs

The approach used to identify technologies entailed segregating the numerous contaminants at Rocky Flats into the three categories of contaminant types. These three types of contaminants include radionuclides, suspended solids, and organics. Engineering judgement and prior experience with practical technologies that have been used to treat the specific category of contaminants in full-scale facilities were the basis for the technology identification. Also included in this review are those technologies which have been demonstrated at the laboratory and pilot scale on similar contaminants and show potential for full-scale application but where data are presently inadequate for evaluation purposes. The effects of mixtures of contaminants are site specific and need to be evaluated. These practical technologies are listed in Table 3-1. Additionally, this section contains the findings from the literature review and vendor survey.

3.1 IDENTIFIED TECHNOLOGIES FOR OU2 SURFACE WATER

Oxidation/Reduction of Radionuclides - Chemical reduction-oxidation (redox) reactions are standard processes for breaking certain inorganics such as cyanide into their constituents or for altering the oxidation state of metals to facilitate additional treatment. The oxidation state of heavy metals such as chromium or plutonium are typically adjusted to enhance a subsequent precipitation process. Nontarget organics and inorganics may also react, creating undesirable side products and increasing the oxidant (or reductant) requirements.

Chemical Oxidation of Organics - Chemical oxidation is used to degrade hazardous organic materials to generally less toxic compounds. Oxidation systems, particularly those using ultraviolet (UV) light, ozone, and hydrogen peroxide, are powerful tools for

TABLE 3-1

LIST OF CANDIDATE PRACTICAL TECHNOLOGIES
PRACTICAL TECHNOLOGIES FOR OU2 SURFACE WATER

Radionuclides

Sorption
Reverse Osmosis
Chemical Coagulation/microfiltration
GAC Adsorption

Volatile Organics

Chemical Oxidation (UV/ozone/peroxide)
Granular Activated Carbon (GAC) Adsorption
Air Stripping
Steam Stripping
Distillation

Semivolatile Organics

Chemical Oxidation (UV/ozone/peroxide)
Reverse Osmosis
Steam Stripping
GAC Adsorption

Suspended Solids

Coagulation/Precipitation/Filtration

PRACTICAL TECHNOLOGIES FOR TREATMENT RESIDUAL STABILIZATION

Radionuclides

Vitrification
Washing (water, acid, chelating agents)
Solidification/Stabilization (pozzolanic-based)

treating a wide variety of common organic environmental contaminants. Disadvantages are similar to those for inorganic redox, nontarget organics and inorganics can produce undesirable side products and increase oxidant requirements.

Sorption of Radionuclides - Sorption of inorganics, metals, and radionuclides is a standard technique for removal and concentration of these contaminants from wastewater. The sorption media are generally chemically regenerated, which results in a concentrated side stream requiring further treatment or disposal. Common and proven sorption processes include ion exchange and Granular Activated Carbon (GAC), while less proven techniques involve the use of activated alumina, bone char, and proprietary sorption media. Ion exchange and GAC will be addressed separately.

Activated alumina is a porous form of aluminum oxide with a large surface area. For removal of aqueous contaminants, activated alumina is typically used in a column similar to that for ion exchange. It has been proven to be successful in the removal of arsenic and fluoride from ground water (Rubel, 1980). More recently, activated alumina has shown promise in absorbing plutonium from a low-level wastewater effluent at the Hanford Site (Barney et al, 1989). In the same study, plutonium adsorption on Bone Char Adsorbent was the most rapid and gave the highest decontamination factors. Waste stream specific laboratory testing would provide valuable information on the suitability of these sorbents for low-level radionuclide removal.

Ion Exchange of Radionuclides - Ion exchange processes are used for a wide range of applications, including commonly recognized systems such as demineralizers and water softeners. The goal of an ion exchange system is to remove undesirable ions of a certain type(s) from a solution and replace them with more acceptable ions (Clark et al, 1971). Radionuclides are commonly removed from waste streams at nuclear facilities using ion exchange.

Ion exchange resins, particularly anion exchange resins, have been used to recover uranium from mine run-off water for many years. Extensive studies on the laboratory scale report removal of uranium from natural waters as high as 99 percent (Sorg, 1988). A small full-scale ion exchange system was capable of removing uranium from drinking water supplies to as low as $1\mu\text{/L}$ (Jelinek, 1988). Ion exchange resins are typically rechargeable, however, the resins used in radioactive applications are generally only used once and are then disposed of as a solid waste. Although published information in the removal of plutonium from natural waters by ion exchange has not been found, there is indication that ionized plutonium is removable using this technology (Marston, 1990).

Granular Activated Carbon (GAC) Adsorption of Organics and Radionuclides - GAC adsorption is the most widely used and developed technology for treating groundwater contaminated with organics. It is effective for the removal of a wide range of organics from aqueous waste streams. It has been proven successful for carbon tetrachloride, chloroform, DDT, benzene, acetone, methylene chloride, phenol, trichloroethene, and xylene among others (EPA, 1985). GAC is typically regenerated with a thermal process and the regeneration process can be performed with either off-site or onsite facilities. There is also an indication that GAC adsorption may be an effective removal technology for radionuclides. Although the use of activated carbon as a means of plutonium removal from solvents has been investigated (Mailen, 1985), no published literature could be found on GAC's applicability to radionuclide removal from natural waters. Simple laboratory testing would yield the necessary data to determine the suitability of this technology to wastewater radionuclides.

Reverse Osmosis - Reverse osmosis processes involve the use of semipermeable membranes. By applying a pressure greater than the osmotic pressure, water is passed through the membrane while particulates, salts, and high molecular weight organics are retained. The retained, highly concentrated solution (retentate) contains dissolved salts, as well as the target contaminants and requires further treatment or disposal.

Centrifugation for Suspended Solids - In this process, the components of a liquid/liquid or liquid/solid mixture are separated mechanically by application of centrifugal force. Centrifugal forces are applied by rapidly rotating the mixture in a confined vessel. The heavy phases or solids are pushed towards the rim of the vessel and are removed by various methods. High gravity "pusher" type centrifuges are typically used for removal of suspended solids from process slurries, usually heavy metals, which are greater than 150 μm .

Electrodialysis - Electrodialysis is a membrane process used for removal of ionic species from aqueous waste streams. An electrodialysis system consists of ion exchange membranes within an electrolytic cell. An electrical current is applied across cation and anion exchange membranes, resulting in a transport of ions through the membranes. The resultant side stream consists of high concentrations of the removed anions and cations which must be treated and disposed.

Chemical Coagulation/Microfiltration for Radionuclide Removal - Chemical coagulation is the process of making dissolved chemical constituents insoluble so that they can be separated from a liquid. This is usually accomplished by adding a chemical that forms an insoluble compound with the target contaminant accompanied by a separation (filtration) step. During recent years, the USEPA and others have sponsored and conducted research studies to test the removal of uranium from drinking water (Sorg 1988, Lee & Bondiette, 1983). These studies indicated that chemical coagulation combined with filtration could effectively remove up to 90% of the uranium present. Other studies conducted at several Department of Energy sites have indicated reductions of uranium in ground water from 3460 ppb to 1-7 ppb (Hodgson, 1989) utilizing the same technology. This technology has also been widely demonstrated for the removal of uranium in mine water drainage.

Chemical coagulation/microfiltration processes are relatively simple to operate and the reagents and equipment are readily available. This treatment method generates a sludge that may require further treatment prior to disposal.

Coagulation/Precipitation/Filtration for Suspended Solids Removal - A vital component of a process train for water treatment is the removal of suspended solids to prevent fouling and plugging of downstream processes (i.e., ion exchange resins). Chemical coagulants are added to enhance the settleability of solids by reducing the barriers to agglomeration. The settled solids are removed using conventional filtration techniques.

Air Stripping - Air stripping is a proven technology for removal of volatile and semivolatile contaminants from the water. This process involves the transfer of contaminants from the contaminated liquid phase to the vapor phase by passing the two streams countercurrent through a packed tower. Air emission treatment is generally required. Vapor phase activated carbon systems are the most commonly used process for this purpose, but other alternatives, such as catalytic oxidation and fume incineration, exist. The vapor phase treatment unit is generally costly.

Steam Stripping - Steam stripping involves injecting steam into a solution to volatilize organic compounds. It can be operated as a batch or continuous process. The use of steam makes it possible to strip compounds of lower volatility than those removed by air stripping. Steam stripping is a well demonstrated technology, however, it does generate a concentrate that requires treatment or disposal and the process requires low cost steam.

Distillation - Distillation is a process that involves separating compounds according to their boiling point characteristics. The primary use of distillation is for reclaiming spent solvents from industrial processes, and it is generally applicable only to rather concentrated solutions. The process can be used to separate various volatile compounds.

or to separate mixtures of organics into light and heavy fractions. The light fraction can usually be recycled or used as a boiler feed, while the heavy fraction requires further treatment.

3.2 TREATMENT TECHNOLOGIES FOR RESIDUALS

Washing - Washing is based on the principle of contaminant removal from residuals by contacting with a liquid solution. Washing agents include water, acids, solvents, surfactants, or chelators. The washing technology can potentially be used to remove organics, metals, and radionuclides. The wash solution containing contaminants will require treatment and/or disposal.

Solidification/Stabilization - Solidification is a process in which contaminants are mechanically bound to solidification agents, reducing their mobility. This produces a solid matrix of waste with high structural integrity. Stabilization usually involves the addition of a chemical reagent to react with the contaminant, producing a less mobile or less toxic compound. Solidification and stabilization are frequently used together and are a well established method for reducing the mobility and toxicity of hazardous wastes. This process generates large volumes of solidified material requiring disposal.

Vitrification - The vitrification process involves heating the waste matrix to a very high temperature and either combining the matrix with molten glass or heating the matrix until it melts. Once cooled, the molten mass solidifies into a stable, noncrystalline solid resistant to leaching of the inorganic, metal, and radionuclide contaminants. Organic components are destroyed by pyrolysis. The process can be conducted either *in situ* or off-site, however, the process is generally expensive.

The objective of this technology screening and evaluation section is to assess the potential treatment technologies for OU2 surface water that were previously identified in Section 3.0 of this document.

Subsection 4.1 presents the screening criteria used to evaluate the potential treatment technologies, and in Subsection 4.2 the technologies are screened against these criteria to refine the list of technologies for inclusion in this treatability study program.

4.1 SCREENING CRITERIA

The technologies were screened and evaluated against criteria which contribute to effectiveness and implementability. The screening criteria are outlined for each technology in Tables 4-1 through 4-4 and are explained below.

Effectiveness refers to a technology's ability to treat a given volume of waste based on cleanup goals. The implementation criterion is used in this treatability study to eliminate technologies that are clearly unworkable or impossible to implement because of institutional or technical problems. Cost is not a significant factor in the initial phase of the technology screening and is not relevant for this first phase of treatability studies. This cost criterion will, however, be important for the screening of alternatives and the detailed analysis of alternatives, and treatability studies may be required for cost estimation purposes at that time. In summary, effectiveness, and implementability are the key factors for the treatability study selection for alternatives evaluation where data are inadequate.

TABLE 4-1

ORGANIC TREATMENT TECHNOLOGIES
SCREENING MATRIX

Technology	Chemical Oxidation	Granular Activated Carbon	Air Stripping	Steam Stripping	Distillation
Screening Criteria					
Effectiveness					
● Significant reduction in parameter of concern	Yes, demonstrated technology in treating parameters of concern	Yes, non-selective will treat all contaminants with various efficiencies for each	Yes	Yes	Yes
● Formation of new toxic reaction compounds	Some low potential if not complete reaction	No	No	No	No
● Potential to achieve effluent limitations	Yes	Yes	Yes, in conjunction with vapor phase GAC or other adsorbent	Yes, produces condensation	Yes
● Proven or expected performance at concentration range	Yes, widely proven at these concentration ranges	Yes, widely proven at these concentration ranges	Yes, widely proven at these concentration ranges	Yes	Yes
● Flexibility to variations in feed water contaminant concentrations	Yes, will tolerate small fluctuations in contaminant concentration levels	Yes	Yes	Yes	Yes
Implementability					
● Readily available equipment at scale	Yes	Yes	Yes	Yes	No, highly specialized equipment
● Utility/Personnel requirements	Significant utility and personnel training requirements	Minimal	Minimal	Significant utility requirements, minimal personnel	Significant utility requirements, minimal personnel
● Treatment residual management	Minimal residual management	Significant spent carbon disposal or recovery	Significant adsorbent disposal or recovery	Significant adsorbent	Significant concentrated contaminant disposal
● Amenable to laboratory scale testing	Yes, but specialized equipment not readily available at lab scale	Yes, lab scale equipment readily available	No, proven technology, no advantage in lab testing	Yes	Yes
● Include in this phase of treatability study program	No, recommended for potential future pilot scale testing	Yes, wide variety of contaminants warrant lab testing	No, recommended for potential future pilot scale testing	No	No

TABLE 4-2

RADIONUCLIDE TREATMENT TECHNOLOGIES
SCREENING MATRIX

Technology	Sorption	Granular Activated Carbon	Reverse Osmosis	Electro - Dialysis	Coagulation/ Micro - Filtration	Ion Exchange
Screening Criteria						
Effectiveness						
● Significant reduction in parameters of concern	Yes, on certain rad compounds	Yes, on certain rad compounds	Yes	Yes	Yes, on certain rad compounds	Yes, on certain rad compounds
● Formation of new toxic reaction compounds	No	No	No	No	No	No
● Potential to achieve effluent limitations	Yes, on certain rad compounds	Yes, on certain rad compounds	Yes	Yes	Yes, on certain rad compounds	Yes, on certain rad compounds
● Proven or expected performance at concentration range	Studies indicate favorable results	Studies indicate favorable results	Studies indicate favorable results	Studies indicate favorable results	Studies indicate favorable results	Studies indicate favorable results
● Flexibility to variations in feed water contaminant concentration	Yes	Yes	Yes	Yes	Yes	Yes
Implementability						
● Readily available equipment at scale	Yes	Yes	No, specialized equipment	No, specialized equipment	Yes	Yes
● Utility / Personnel requirements	Minimal	Minimal	Significant utility and personnel requirements	Significant utility and personnel requirements	Significant utility and personnel requirements	Minimal
● Treatment residual management	Significant spent sorbent disposal or recovery	Significant spent sorbent disposal or recovery	Significant concentrate & spent media disposal	Significant concentrate & spent media disposal	Significant filtrate disposal	Significant spent resin disposal or recovery
● Amenable to laboratory-scale testing	Yes	Yes	Yes, but specialized equipment not readily available at lab	No, specialized equipment not readily available at lab	Yes	Yes
● Include in this phase of treatability study program	Yes	Yes	No	No	Yes	Yes

TABLE 4-3

TOTAL SUSPENDED SOLIDS TREATMENT TECHNOLOGIES
SCREENING MATRIX

Technology	Centrifugation	Coagulation/ Precipitation/ Filtration
Screening Criteria Effectiveness		
• Significant reduction in parameter of concern	Yes, limited applications in suspended solid removal	Yes, widely used technology for suspended solid removal
• Formation of new toxic reaction compounds	No	No
• Potential to achieve effluent limitations	Yes, very particle size specific	Yes
• Proven or expected performance at concentration range	Yes, but limited data available	Yes
• Flexibility to variations in feed water contaminant concentrations	Yes	Yes
Implementability		
• Readily available equipment at scale	No, specialized equipment	Yes
• Utility/Personnel requirements	Significant	Minimal
• Treatment residual management	Moderate	Significant filtrate disposal
• Amenable to laboratory scale testing	No, laboratory-scale equipment not readily available	Yes
• Include in this phase of treatability study program	No	Yes

TABLE 4-4

RESIDUAL TREATMENT TECHNOLOGIES
SCREENING MATRIX

Technology	Vitrification	Solidification/ Stabilization	Washing
Screening criteria			
Effectiveness			
● Significant reduction in parameter of concern	Yes	Yes	Yes
● Formation of new toxic reaction compounds	Possible	No	No
● Potential to achieve treatment objectives	Yes	Yes	Yes, data limited on rad compounds
● Proven or expected performance at concentration range	Yes	Yes	Yes, may require process modifications
● Flexibility to variations in contaminant concentrations			
Implementability			
● Readily available equipment at scale	Yes	Yes	No
● Utility / personnel requirements	Significant utility and moderate personnel	Moderate	Moderate
● Treatment residual management	Vitrified residual will require disposal	Increase in residual volume requiring disposal	Additional liquid waste stream requiring disposal
● Amenable to laboratory-scale testing	No, lab scale equipment not readily available	Yes	
● Include in treatability testing program	No	Yes	No

Technologies selected for this treatability study to support the initial phase of the OU2 are developed or potentially applicable technologies that have not been sufficiently tested on the site-specific compounds or mixtures to provide the information needed for the evaluation. Site-specific conditions for which there are insufficient information are typically related to radioactive and mixed contamination in the surface water. Certain processes also require testing because of dependency on other environmental conditions. The treatability tests will provide information on the effectiveness of a technology as it relates to the OU2 surface water contamination problem. They will also indicate the relative efficiency of each treatment technology, if additional technologies must be added to the treatment train, or if the technology should be eliminated altogether. Implementation problems, such as sidestream generation, will also be studied and evaluated. This treatability study will support the decision to carry forward a technology or eliminate it from consideration in the latter stages of this study.

4.2 EVALUATION OF PRACTICAL TECHNOLOGIES

The criteria in Section 4.1 were applied to the list of practical technologies presented in Table 3-1. The following sections present the rationale for the selection or elimination of the practical technologies for OU2.

4.2.1 Water Technologies for OU2 Surface Water

Oxidation/reduction is a standard and proven technology for most target organics at Rocky Flats, with the exception of the chlorinated volatile organic compounds (VOCs). However, since the oxidation states of the radionuclides are generally unknown, the probability of success using an oxidation/reduction process is uncertain. This technology could be tested at later phases of this study to determine its suitability in adjusting the oxidation state of radionuclides to enhance a subsequent precipitation process.

Although sorption processes are established technologies for the treatment of organics and inorganics, their use for radionuclide removal has not been utilized in a full scale system. Sorbents such as activated alumina and bone char have, however, been demonstrated at laboratory- and pilot-scale and warrant further investigation for OU2 surface water.

GAC adsorption is a technology for which substantial information exists for numerous individual organic compounds. Data for some types of mixtures, such as mixtures of chlorinated VOC, however, do not exist. The suitability of GAC for organic and for radionuclide removal from a mixed waste will require laboratory testing as part of this treatability program.

Membrane processes such as reverse osmosis and electro dialysis are proven technologies for certain contaminants found at the site, and the alternative evaluation can proceed based on existing site specific information. None of these processes were selected for inclusion in this treatability study program since they can be evaluated without further testing.

A "pusher" high-gravity centrifuge was investigated for the removal of suspended solids from the contaminated seepwater. This type of centrifuge is typically used for removal of solids greater than 150 μm from process slurries. According to a vendor contact, a centrifuge is not suitable for this application where the suspended solids are in low concentrations and are considerably less than 150 μm in size. For these reasons, centrifugation was eliminated from further consideration as a candidate for laboratory testing.

Chemical precipitation/filtration is a well documented technology that works for radionuclides and suspended solids. Sufficient information exists to evaluate this technology as a remedial alternative, but treatability studies will be needed in the

technology screening phase to enable selection of the appropriate type of precipitation and filtration for the specific compounds of concern.

Air stripping is known to remove volatile organics, and steam stripping removes somewhat less volatile compounds. Their efficiencies can be estimated based on existing data, and no treatability study is needed prior to the design phase. Distillation is also a technology for which existing information is sufficient for evaluating it as a remedial alternative.

4.2.2 Residual Treatment Technologies

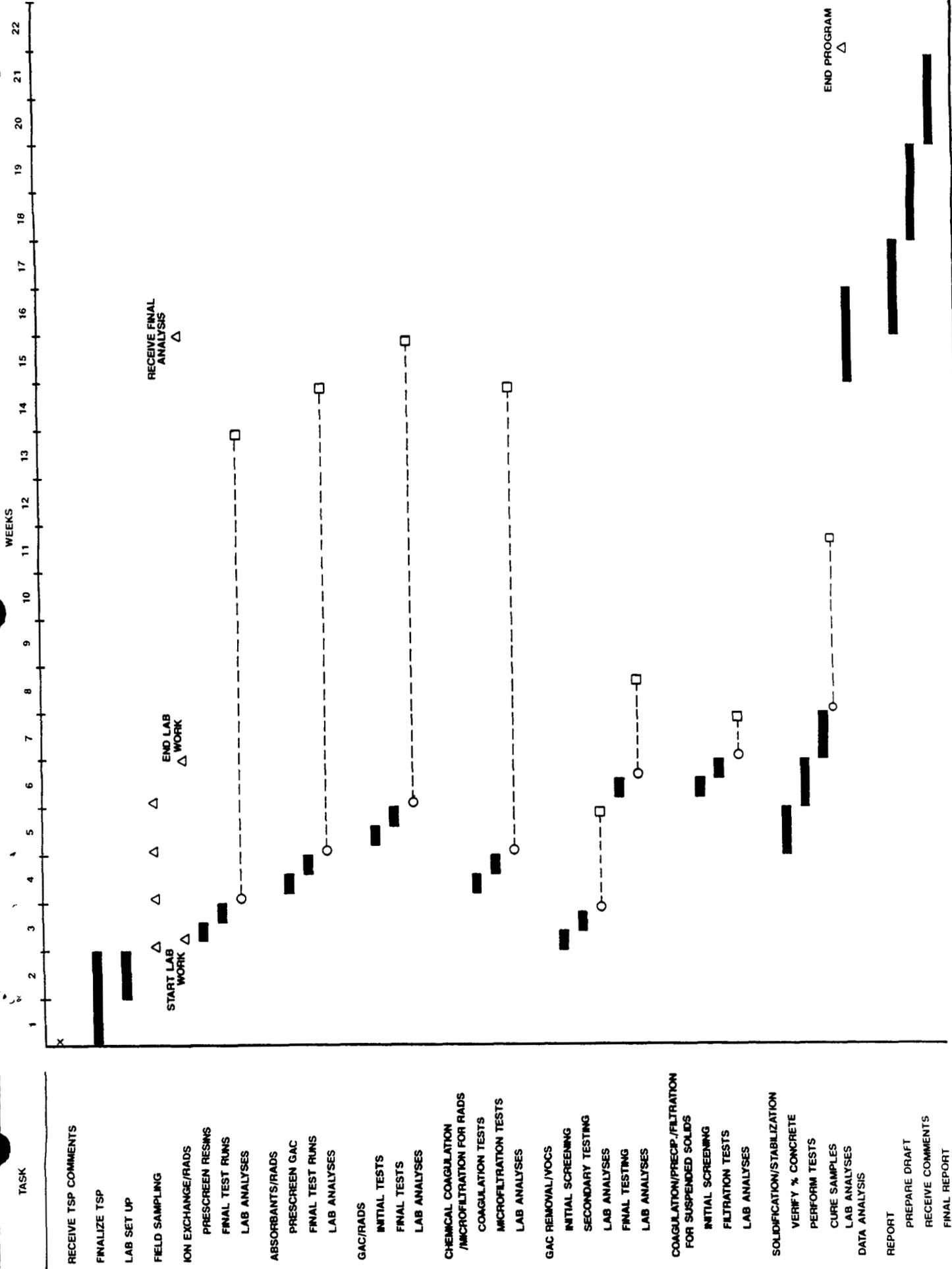
Residual washing (i.e., spent ion exchange resin) is a function of the physical, chemical, and mineralogical characteristics of the residual and the chemical properties of the contaminant. Washing of contaminants of sorption media has been proven to work (i.e., acid washing of ion exchange resin) and sufficient information exists to evaluate this residual treatment technology as part of a remedial alternative.

Since solidification/stabilization effectiveness is a function of the residual and contaminant characteristics and concentrations, and its applicability is strongly dependent on the waste-specific composition, a treatability study will be necessary.

Vitrification has been applied to and proved for different radioactive and mixed wastes, primarily for treatment of contaminated soil. Its applicability for treatment of waste residuals, specifically ion exchange resins and GAC, is limited. Vitrification will no longer be considered as a technology option for residual treatment.

Figure 5-1 provides a schedule of the bench-scale treatability studies. This schedule begins with the receipt of comments from EG&G on the draft Test Program Schedule (TPS) and ends with the delivery of the final report. The duration of the program is greatly impacted by the turnaround time for the radionuclides analyses, which is 66 days. Data analysis and report preparation cannot begin until most of this laboratory data is available.

BENCH SCALE TREATABILITY STUDIES
ROCKY FLATS OUP TASK ORDER 20



APPENDIX A TREATABILITY STUDY WORK PLANS

Included in this Appendix are the treatability study work plans for the various technologies to be evaluated. These treatability testing programs involving laboratory screening yield technology validation data in which a "yes" or a "no" answer is obtained on whether or not the technology should be considered further. This program is not intended to provide scale-up information or cost estimates for full scale implementation. The focus of these investigations is the determination of the removal efficiencies and/or the effectiveness of the technology in treating the contaminant type of concern.

It is anticipated that during the field sampling activities, variability in contaminant concentrations may be encountered due to variations in seep flow and time between sampling events. However, this will not significantly impact the results of this testing program since its primary goal is to determine if the selected technologies are generally effective. Direct comparisons of one technology with another would require optimization of design, establishment of design criteria, establishment of treatment goals, and capital and operating cost estimates. A treatability study program designed to facilitate this level of comparison would require that the technologies process identical wastewaters.

The treatability study work plans (TSWP) for OU2 seep water treatment are as follows:

- A.1 TSWP Granular Activated Carbon - Organics and Radionuclides
- A.2 TSWP Ion Exchange - Radionuclides
- A.3 TSWP Adsorbents - Radionuclides
- A.4 TSWP Chemical Coagulation/Microfiltration - Radionuclides
- A.5 TSWP Coagulation/Precipitation/Filtration - Suspended Solids

A.1
TREATABILITY STUDY WORK PLAN
GRANULAR ACTIVATED CARBON (GAC) -
ORGANICS AND RADIONUCLIDES

A. OBJECTIVES

Treatability screening tests will be performed to evaluate the removal efficiencies of various types of GAC for the treatment of organic contaminants and radionuclides in the surface water at the Rocky Flats Plant (RFP). The organics of interest include vinyl chloride, methylene chloride, 1,1-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethene (total), carbon tetrachloride, trichloroethene, and tetrachloroethane. The radionuclides of interest include uranium, plutonium, americium, and gross alpha and beta activity.

B. APPROACH

These treatability screening tests will be performed on the laboratory "bench-top" utilizing small glass columns containing the various types of GAC to be tested. An initial test run will be performed on each type of GAC. Chemical analysis of the column effluent by use of gas chromatograph will serve as a general indicator of the overall performance of the GAC for organic removal. Gross alpha and beta activity of the column effluent will serve as a general indicator of radionuclide removal. Based on the results of this initial screening, a second series of tests will be performed utilizing the two types of GAC with highest removal efficiencies of organics and radionuclides. During this secondary testing phase, the removal efficiency of each type of GAC will be evaluated based on the analyses of the specific chlorinated organics and radionuclides of interest. Final testing of these two carbons will also be conducted to determine chlorinated organic compound specific capacities for each type of GAC.

C TEST EQUIPMENT AND SET UP

Figure A 1-1 shows the basic equipment setup for a typical laboratory scale GAC test apparatus. Table A.1-1 shows required GAC test equipment. Wastewater will be fed from the waste feed tank to the GAC column by the action of a peristaltic pump. All flows through the columns will be downflow. The separate systems, operating in parallel, will be fed simultaneously from the common waste feed tank to ensure influent consistency. Prefiltering of the feed may be necessary to remove any sediments which could plug in the GAC column. The effluent will be collected in a waste tank. Three-way valves located before and after the glass column will allow for sampling to determine system performance.

D TEST RUNS

Initial Screening Tests

Initial screening tests will be made on a total of five types of GAC. The five types of carbon are

- 1 Calgon Filtersorb 300
- 2 Calgon Filtersorb 400
- 3 Norit 4000
- 4 Yakima - CYP
- 5 Yakima - C-C

Due to the low levels of chlorinated organics and radionuclides present in the OU2 surface waters and the small volumes to be processed, it is not anticipated that the GACs will become exhausted. The GAC performance will be evaluated based on percent peak reduction by GC analysis for organics, and total alpha and beta activity.

FIGURE A.1-1

GRANULAR ACTIVATED CARBON TEST APPARATUS
FOR ORGANIC AND RADIONUCLIDE REMOVAL

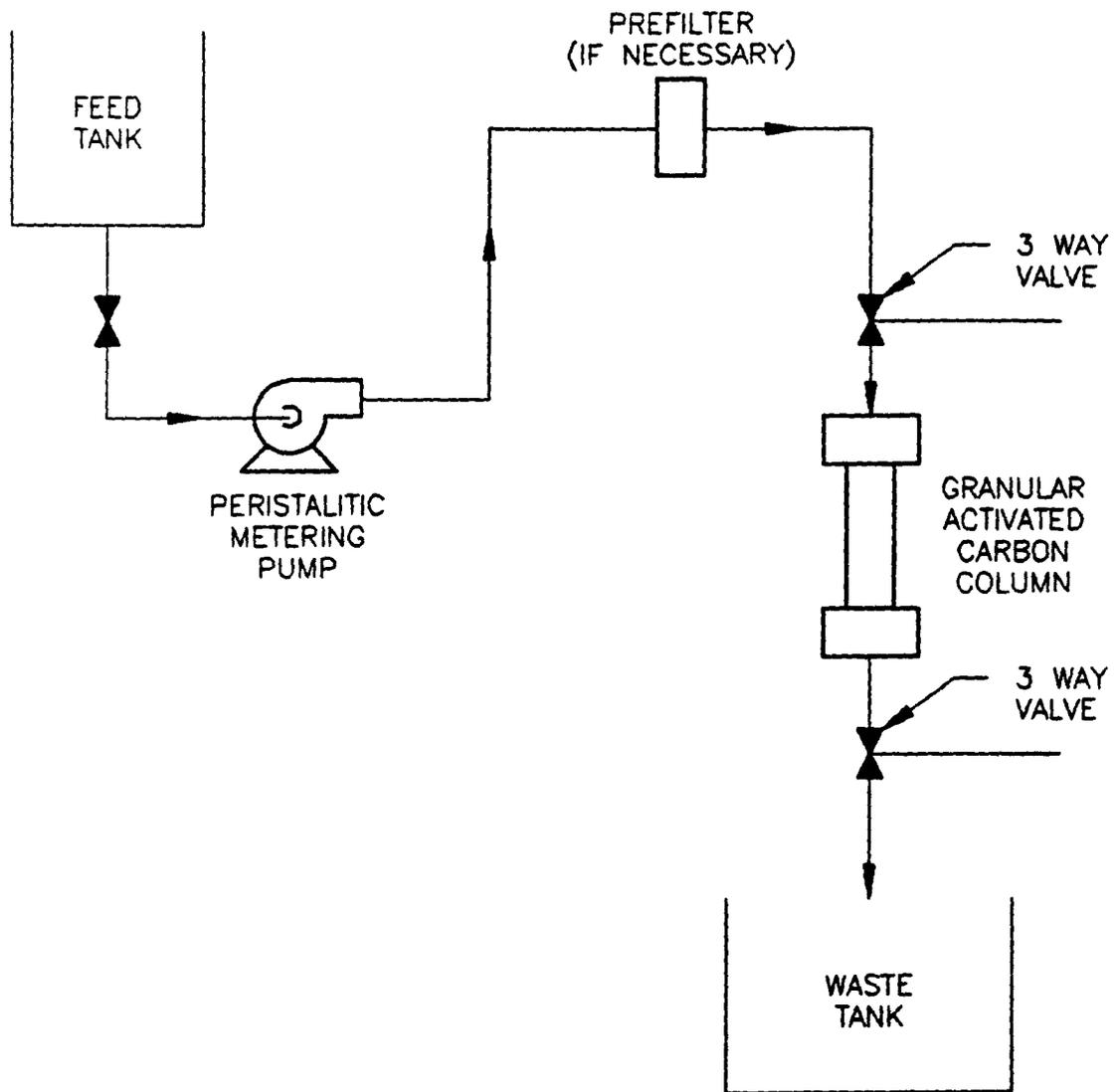


TABLE A.1-1
GAC TEST COMPONENTS

1 each -	Feed Tank Five (5) gallon capacity Pyrex or stainless steel
1 each -	Shutoff valve Whitey or equal ¼ inch - stainless steel
10 each -	3-way valve Whitey or equal ¼ inch stainless steel
5 each -	Peristaltic Pump Master Flex or equal
5 each -	GAC Columns, 1 inch diameter by 2 ft high glass construction complete with end stoppers, hose fittings, and support material for the GAC
5 each -	10 liter pyrex or equivalent waste jars
50 ft -	¼ in ID teflon tubing or equal

radionuclides During testing, it may be necessary to prefilter the waste in order to alleviate turbidity in the surface water prior to introduction in the GAC columns The prefiltering requirements will be determined prior to the start of the column tests

The first set of tests will utilize five GAC columns operating simultaneously The surface water will be run through the columns Influent and effluent samples will be taken to determine preliminary efficiencies on each carbon for chlorinated organic and radionuclide removal

If sufficient removal efficiency data are not generated during these initial test runs, certain parameters may be changed (i e , GAC volume, flow rate) and the tests may be repeated to accurately determine removal efficiencies

Secondary Testing

Based on the results of the initial screening tests, the two carbons with the best removal efficiencies will be retested during the secondary testing phase The testing in this phase will be similar to the initial screening tests except that compound specific analyses will be conducted to determine chlorinated organic and radionuclide compound specific removal efficiencies for each carbon In addition, the secondary testing will incorporate the water quality parameters, as well as a full metals analysis to fully characterize the effluent streams With a comparison of the full analysis for the weekly composited field samples as discussed in the Sampling and Analysis Plan (SAP) (Appendix B) and the above analysis, any inhibiting influences caused by other containments can be determined

Final Testing

Based on the results of the secondary testing, the two carbons analyzed will be retested in order to determine chlorinated organic compound specific capacity for each. This testing will be conducted in the same testing apparatus as all the other tests. The data generated during the initial and secondary tests will be evaluated to determine approximate breakthrough times for each carbon. The final testing will be run with compound specific analyses to determine compound specific capacities and breakthrough times for each carbon. The sampling frequencies will be based on the results of the ongoing gas chromatographic analyses during this phase of testing.

E TEST PROCEDURES

Execution of the initial screening, secondary testing and the capacity evaluation will be accomplished by the following procedures

- 1 Set up laboratory apparatus as shown in Figure A 1-1
- 2 Fill column one-third full with deionized water
- 3 Load the GAC into each column until column is approximately one-half full. Record weight and volume of carbon added to column. Add distilled water to saturate the carbon bed. Let the column stand static for 24 hours.
- 4 Attach a deionized water line to the bottom of the column by use of the three way valve. Backwash each column to a 10 to 25 percent bed expansion for 10 minutes with distilled water to deaerate the carbon bed.

Tap each column during the backwash and visually observe that all air pockets are evacuated from the column

- 5 Flow rate through each column for the initial screening shall be 10 ml/min and 30 ml/min for the secondary testing and capacity evaluations
- 6 Run wastewater through columns for approximately 4 hours or 15 bed volumes for the initial screening runs, and two hours or 23 bed volumes for the secondary testing For the capacity evaluation run wastewater through columns as long as necessary
- 7 Collect samples for analysis in accordance with the sampling and analysis plan (SAP) (Appendix B)

The sample volumes shall be as follows

Gas chromatography testing	10 mls
Complete testing of organics of interest	80 mls
Gross alpha and beta testing	100 mls
Complete testing of radionuclides of interest	4 liters

- 8 After completion of each test run, thoroughly clean all equipment with non-phosphate detergent, then rinse all equipment with 01 N hydrochloric acid, followed by a thorough rinse with ASTM grade deionized water

F SAMPLING AND ANALYTICAL REQUIREMENTS

The GAC testing program will require sampling and analysis for organics and radionuclides. This organic and radionuclide analysis will include the analytes listed on Table A 1-2 and Table A.1-3. In addition, a water quality parameter analysis and a full metals screen will be conducted during the secondary testing. All sampling and analytical activities will be conducted in accordance with the SAP contained in Appendix B of this document.

G DATA COLLECTION AND ANALYSIS

Initial screening tests. Compare the untreated wastewater with the treated samples. Calculate percentage reduction as follows:

$$\% \text{ REDUCTION} = \left(\frac{\text{Initial Peak Area} - \text{Final Peak Area}}{\text{Initial Peak Volume}} \right) \times 100$$

Calculate radionuclide percentage reduction as follows:

$$\% \text{ REDUCTION} = \left(\frac{\text{Initial Gross Alpha and Beta Activity} - \text{Final Gross Alpha and Beta Activity}}{\text{Initial Gross Alpha and Beta Activity}} \right)$$

The two GAC types with the greatest percentage reduction will be selected for the secondary testing.

Secondary testing. Percentage reduction for all analytes will be calculated as above. Initial and final concentrations of individual analytes will also be reported.

TABLE A.1-2
GAC TESTS
ANALYTE LIST (ORGANICS)

Vinyl Chloride
Methylene Chloride
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene (total)
Carbon Tetrachloride
Trichloroethene
Tetrachloroethane

TABLE A.1-3
GAC TESTS
ANALYTE LIST (RADIONUCLIDES)

Gross Alpha
Gross Beta
Uranium 233 and 234, 235 and 238
Plutonium 239 and 240
Americium

Final testing The compound specific capacity for each GAC will be calculated as follows

$$\text{Capacity, mg/g} = \frac{\text{mg adsorbed}}{\text{g carbon}}$$

H RESIDUAL MANAGEMENT

Rinsates	100 liters
Treated Wastewater	200 liters
Contaminated GAC	5 liters

All treatability testing residuals will be packaged accordingly and returned to the RFP

I REPORTING

A report will be prepared discussing the results of the testing Tables will be prepared for each sample matrix tested listing the organic and radionuclide removal efficiencies for the various GACs

A general assessment of the suitability of GAC for OU2 chlorinated organic and radionuclide removal will also be included

A OBJECTIVES

Treatability screening tests will be performed to evaluate the removal efficiencies of various ion exchange resins for the treatment of radionuclide contaminants in the OU2 surface water at the Rocky Flats Plant. The radionuclides of interest include uranium, plutonium, americium, and gross alpha and beta activity.

B APPROACH

These treatability screening tests will be performed on the laboratory "bench-top," utilizing small glass columns containing the various ion exchange resins to be tested. An initial test run will be performed on each ion exchange resin. Gross alpha and beta activity of the column effluent will serve as a general indicator of the overall performance of the resin. Based on the results of this initial screening, a second series of tests will be performed utilizing the three resins with highest removal efficiencies. During this secondary testing phase, the removal efficiency of each resin will be evaluated based on the analyses of the specific radionuclides of interest.

C TEST EQUIPMENT AND SET UP

Figure A 2-1 shows the basic equipment setup for a typical laboratory-scale ion exchange test apparatus. Table A.2-1 shows the required ion exchange test equipment. Wastewater will be fed from the waste feed tank to the ion exchange column by the action of a peristaltic pump. The separate systems, operating in parallel, will be fed

FIGURE A.2-1
ION EXCHANGE TEST APPARATUS
FOR RADIONUCLIDE REMOVAL

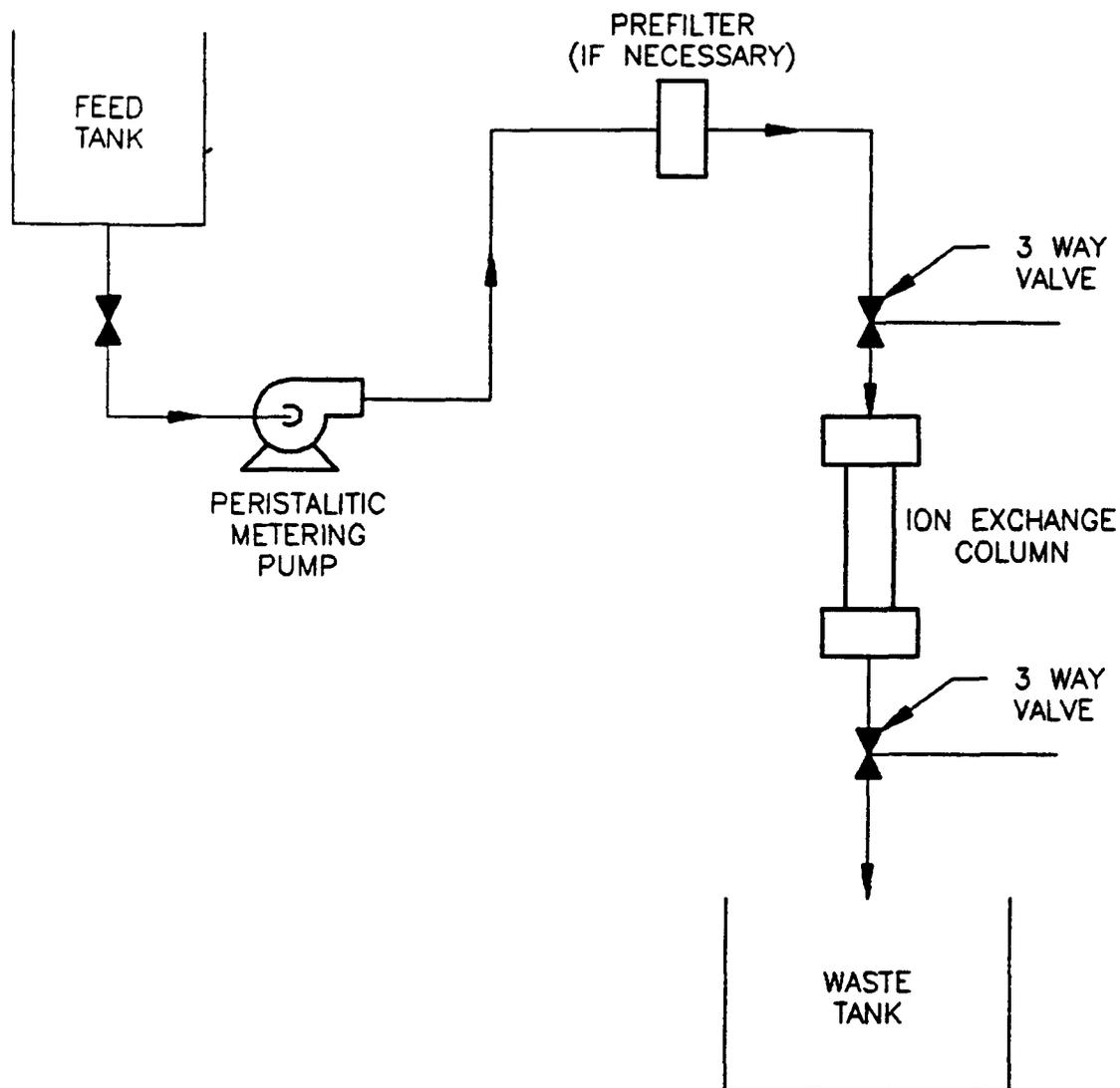


TABLE A.2-1

ION EXCHANGE TEST COMPONENTS

1 each -	Feed Tank Five (5) gallon capacity Pyrex or stainless steel
1 each -	Shutoff valve Whitey or equal ¼ inch - stainless steel
6 each -	3-way valve Whitey or equal ¼ inch stainless steel
3 each -	Peristaltic Pump Master Flex or equal
3 each -	Ion Exchange Columns 1-inch diameter by 2 feet high glass construction complete with end stoppers, hose fittings, and support material for the absorbent
3 each -	Graduated Beakers Ten (10) liters each Pyrex
30 ft -	¼ inch I D teflon tubing or equal

simultaneously from the common waste feed tank to ensure influent consistency. Prefiltering of the feed may be necessary to remove any sediments which could plug or cause channeling in the ion exchange column. The effluent will be collected in a waste tank. Three-way valves located before and after the glass column will allow for sampling to determine system performance.

D TEST RUNS

Initial screening tests will be made on a total of nine ion exchange resins. The nine resins are:

1	Dowex 21K -	Strong Base Anion
2	Dowex SBR-P	Strong Base Anion
3	Dowex 50	Cationic Resin
4	ROHM & HAAS (R&H) IRA - 400 -	Strong Base Anion
5	R&H IRC- 718	Strong Base Anion
6	R&H DP- 1	Weak Acid Cation
7	R&H IRA- 430	Weak Acid Cation
8	Ionac A-641	Strong Base Anion
9	Purohite NRW-7	Mixed Bed

All anionic resins will be in the chloride form. Cationic resins will be in the hydrogen form.

Due to the low levels of radionuclides present in the OU2 surface waters and the small volumes to be processed, it is not anticipated that the ion exchange will become exhausted. The resin performance will be evaluated based on percentage reduction in gross alpha and beta activity. During testing it may be necessary to prefilter the waste in order to alleviate turbidity in the surface water prior to introduction in the ion

exchange columns. The prefiltering requirements will be assessed prior to the start of the initial screening tests.

The first two sets of tests will utilize the nine ion exchange columns operating simultaneously. The surface water will be run through the columns at an unadjusted pH. Influent and effluent samples will be taken to determine preliminary efficiencies on each resin.

A second set of tests will then be conducted on the nine resins. These tests will be run at an adjusted pH (9-10) to determine the effect of pH on removal efficiencies.

If sufficient removal efficiency data are not generated during these initial test runs, certain parameters may be changed (e.g., resin volume, flow rate) and the tests may be repeated to accurately determine the removal efficiencies.

Secondary Testing

Based on the results of the initial screening tests, the three resins with the best removal efficiencies will be retested during the secondary testing phase. The testing in this phase will be similar to the initial screening tests except that total analyses will be conducted to determine radionuclide compound specific removal efficiencies for each resin. In addition, the secondary testing will incorporate the water quality parameters, as well as a full metals analysis to fully characterize the effluent streams. With a comparison of the full analysis for the weekly composited field samples as discussed in the SAP (Appendix A) and the above analysis, any inhibiting influences caused by other contaminants can be determined.

E TEST PROCEDURES

Execution of both of the initial screening and secondary testing will be accomplished by the following procedures

- 1 Set up laboratory apparatus as shown in Figure A 2-1
- 2 Fill column one-third full with deionized water
- 3 In a separate vessel, add sufficient amount of deionized water and ion exchange resin to form a slurry
- 4 Transfer slurry to column until column is approximately one-half full At no time during the test should the liquid level fall below the Ion Exchange Resin level
- 5 Attach a Deionized Water line to the bottom of the column by use of the three-way valve Upflow deionized water into the base of the column, gradually increase flow until the bed of resin expands to near the top of the column Maintain this flow until the air pockets are removed and all the resin has achieved mobility Stop flow of water and permit resin to settle by gravity Adjust the liquid level to 1 to 2 cm above resin bed
- 6 Flow rate through each column for the initial screening shall be 10 ml/min and 30 ml/min for the secondary testing These flow rates may be adjusted during the test runs based on preliminary findings
- 7 Run wastewater through columns for approximately 4 hours or 15 bed volumes for the initial screening and 2 hours or 23 bed volumes for the secondary testing
- 8 Collect samples for analysis in accordance with the LAP (Appendix B)

The sample volumes shall be as follows

Gross alpha and beta testing	100 ml
Complete testing of radionuclides of interest	4 liters

- 9 After completion of each test run, thoroughly clean all equipment with non-phosphate detergent, then rinse consecutively with 01 N hydrochloric acid and ASTM grade deionized water

F SAMPLING AND ANALYTICAL REQUIREMENTS

The ion exchange testing program will require sampling and analysis for radionuclides. These radionuclides will include gross alpha and beta activity, uranium, plutonium and americium listed on Table A 2-2. In addition, a water quality parameter analysis and full metals screen will be conducted during the secondary testing. All sampling and analytical activities will be conducted in accordance with the SAP contained in Appendix B of this document.

G DATA COLLECTION AND ANALYSIS

Initial screening tests Compare gross alpha and beta activity of the untreated wastewater with the treated samples. Calculate percentage reduction as follows

$$\% \text{ Reduction} = \left(\frac{\text{Initial Activity} - \text{Final Activity}}{\text{Initial Activity}} \right) \times 100$$

The three ion exchange resins with the greatest percentage reduction will be selected for the secondary testing.

TABLE A.2-2
ION EXCHANGE TESTS
ANALYTE LIST

Gross Alpha

Gross Beta

Uranium 233 and 234, 235 and 238

Plutonium 239 and 240

Americium 241

Secondary testing Percentage reduction for all analytes will be calculated as above
Initial and final concentrations of individual analytes will also be reported

H RESIDUAL MANAGEMENT

Rinsates	100 liters
Treated Wastewater	100 liters
Contaminated Resin	3 liters

The contaminated resin will be utilized in the stabilization/solidification laboratory testing described in a separate treatability study work plan (TSWP)

I REPORTING

A report will be prepared discussing the results of the testing Along with the efficiency calculations for each column test, a general assessment on which ion exchange resin(s) proved effective will also be presented

A.3

TREATABILITY STUDY WORK PLAN
ADSORBENTS (ACTIVATED ALUMINA, BONE CHAR & FILOX)
- RADIONUCLIDES

A OBJECTIVES

Treatability screening tests will be performed to evaluate the removal efficiencies of various types of adsorbent (Activated Alumina, Bone Char & Filox) for the treatment of radionuclide contaminants in the OU2 surface water at the Rocky Flats Plant. The radionuclides of interest include uranium, plutonium, americium, and gross alpha and beta activity.

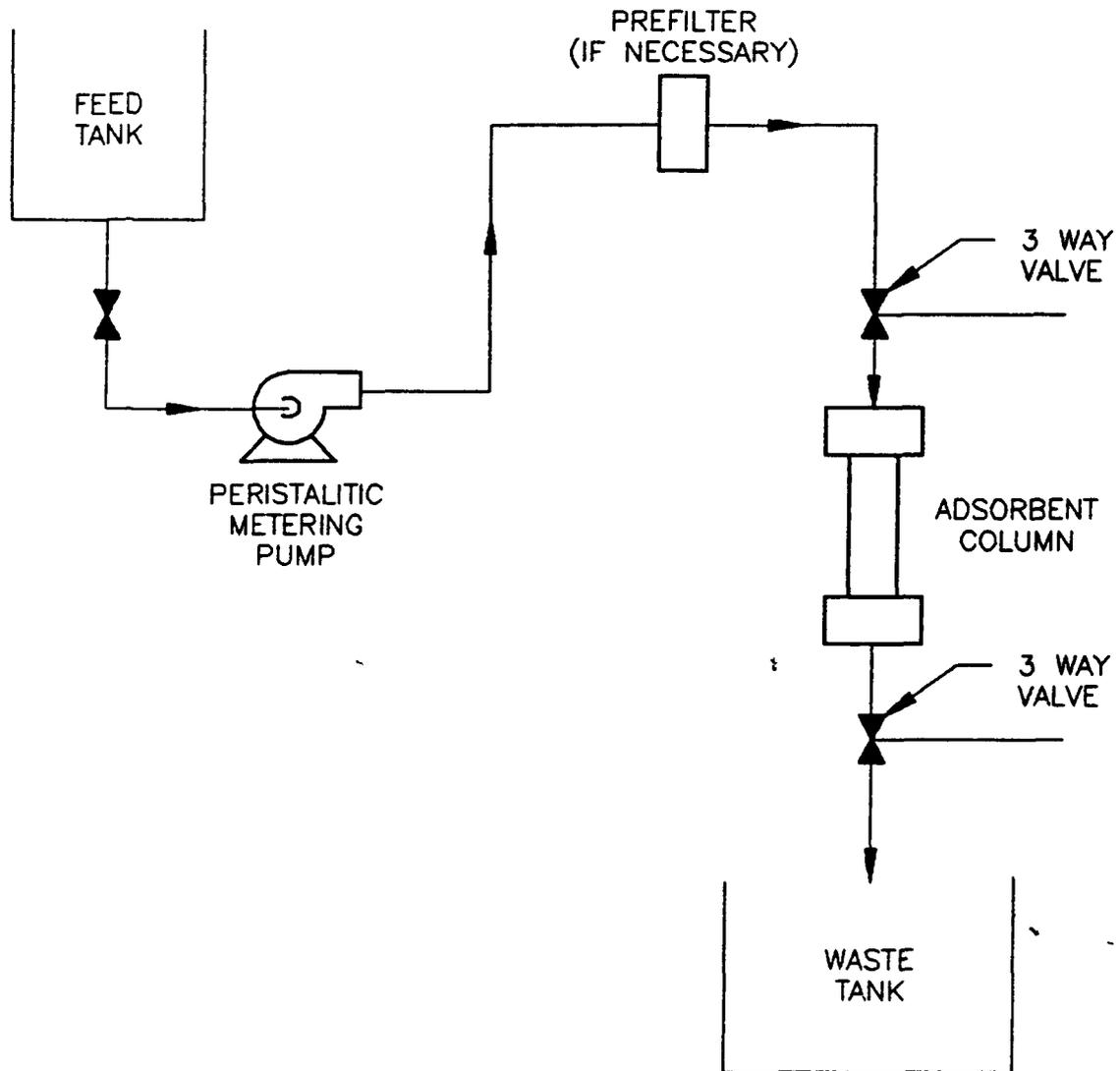
B APPROACH

These treatability screening tests will be performed on the laboratory "bench-top" utilizing small glass columns containing the various types of adsorbent to be tested. An initial test run will be performed on each type of adsorbent. Gross alpha and beta activity of the column effluent will serve as a general indicator of the overall performance of the adsorbents. Based on the results of this initial screening, a second series of tests will be performed utilizing the same adsorbents. During this secondary testing phase, the removal efficiency of each adsorbent will be evaluated based on the analyses of the specific radionuclides of interest.

C TEST EQUIPMENT AND SET UP

Figure A 3-1 shows the basic equipment setup for a typical laboratory-scale adsorbent test apparatus. Table A 3-1 shows the required adsorbent test equipment. Wastewater will be fed from the waste feed tank to the adsorbent column by the action of a

FIGURE A.3-1
ADSORBENT* TEST APPARATUS
FOR RADIONUCLIDE REMOVAL



* ADSORBENT INCLUDES ACTIVATED ALUMINA,
BONE CHAR & FILOX

TABLE A.3-1
 ADSORBENT TEST COMPONENTS

1 each -	Feed Tank Five (5) gallon capacity Pyrex or stainless steel
1 each -	Shutoff valve Whitey or equal $\frac{1}{4}$ inch - stainless steel
6 each -	3-way valve Whitey or equal $\frac{1}{4}$ inch stainless steel
3 each -	Peristaltic Pump Master Flex or equal
3 each -	Adsorbents Columns 1 in diameter by 2 ft high glass construction complete with end stoppers, hose fittings, and support material for the adsorbent
3 each -	Graduated Beakers Ten (10) liters each Pyrex
30 ft -	$\frac{1}{4}$ in I D teflon tubing or equal

peristaltic pump The separate systems, operating in parallel, will be fed simultaneously from the common waste feed tank to ensure influent consistency Prefiltering of the feed may be necessary to remove any sediments which could plug or cause channeling in the adsorbent column The effluent will be collected in a waste tank Three-way valves located before and after the glass column will allow for sampling to determine system performance

D TEST RUNS

Initial screening tests will be made on three different types of adsorbents The three adsorbents are

- 1 Activated Alumina
- 2 Bone Char
- 3 Filox

Due to the low levels of radionuclides present in the OU2 surface waters and the small volumes to be processed, it is not anticipated that the adsorbents will become exhausted The adsorbent's performance will be evaluated based on percentage reduction in gross alpha and beta activity During testing, it may be necessary to prefilter the waste in order to alleviate turbidity in the surface water prior to introduction in the adsorbent columns The prefiltering requirements will be assessed prior to the start of the initial screening tests

If sufficient removal efficiency data are not generated during these initial test runs, certain parameters may be changed (i e , adsorbent volume, flow rate), and the tests may be repeated as necessary to accurately determine removal efficiencies

Secondary Testing

Based on the results of the initial screening tests, two adsorbents will be retested during the secondary testing phase. The testing in this phase will be similar to the initial screening tests except that total analyses will be conducted to determine radionuclide compound specific removal efficiencies for each adsorbent. In addition, the secondary testing will incorporate the water quality parameters, as well as a full metals analysis to fully characterize the effluent streams. With a comparison of the full analysis for the weekly composited field samples as discussed in the SAP (Appendix B) and the above analysis, any inhibiting influences caused by other contaminants can be determined.

E TEST PROCEDURES

Execution of both of the initial screening and secondary testing will be accomplished by the following procedures:

- 1 Set up laboratory apparatus as shown in Figure A 3-1
- 2 Fill column one-third full with deionized water
- 3 In a separate vessel, add sufficient amount of deionized water and adsorbent to form a slurry
- 4 Transfer slurry to column until column is approximately one-half full. At no time during the test should the liquid level fall below the adsorbent level.
- 5 Attach a deionized water line to the bottom of the column by use of the three-way valve. Upflow deionized water into the base of the column, gradually increase flow until the bed of adsorbent expands to near the top bed of the column. Maintain this flow until the air pockets are removed and all the adsorbent has achieved mobility. Stop flow of water and

permut resin to settle by gravity Adjust the liquid level to 1 to 2 cm above adsorbent bed

- 6 Flow rate through each column for the initial screening shall be 10 ml/min, and 30 ml/min for the secondary testing
- 7 Run wastewater through columns for approximately 4 hours or 15 bed volumes for the initial screening, and 2 hours or 23 bed volumes for the secondary testing
- 8 Collect samples for analysis in accordance with the SAP (Appendix B)

The sample volumes shall be as follows

Gross alpha and beta testing	100 ml
Complete testing of radionuclides of interest	4 liters

- 9 After completion of each test run, thoroughly clean all equipment with non-phosphate detergent, then rinse consecutively with 01 N hydrochloric acid and ASTM grade deionized water

F SAMPLING AND ANALYTICAL REQUIREMENTS

The adsorbent testing program will require sampling and analysis for radionuclides These radionuclides will include gross alpha and beta activity, uranium, plutonium, and americium listed on Table A 3-2 In addition, a water quality parameter analysis and a full metals screen will be conducted during the secondary testing All sampling and analytical activities will be conducted in accordance with the SAP contained in Appendix B of this document

TABLE A.3-2
ADSORBENT TESTS
ANALYTE LIST

Gross Alpha

Gross Beta

Uranium 233 and 234, 235 and 238

Plutonium 239 and 240

Americium

G DATA COLLECTION AND ANALYSIS

Initial screening tests Compare gross alpha and beta activity of the untreated wastewater with the treated samples Calculate percent reduction as follows

$$\% \text{ Reduction} = \left(\frac{\text{Initial Activity} - \text{Final Activity}}{\text{Initial Activity}} \right) \times 100$$

The two adsorbent types with the greatest percentage reduction will be selected for the secondary testing

Secondary testing Percent reduction for all analytes will be calculated as above Initial and final concentrations of individual analytes will also be reported

H RESIDUAL MANAGEMENT

Rinsates	100 liters
Treated Wastewater	100 liters
Contaminated Resin	2 liters

The contaminated adsorbent will be utilized in the stabilization/solidification laboratory testing described later

All untreated wastewater, treated wastewater, and residuals not used for further testing will be properly packaged and sent back to the RFP

I REPORTING

A report will be prepared discussing the results of this test. Removal efficiencies for each adsorbent will be presented in tabular form. A general assessment of the applicability of adsorbents to low level radionuclide removal will also be included.

A.4
TREATABILITY STUDY WORK PLAN
CHEMICAL COAGULATION/MICROFILTRATION
- RADIONUCLIDES

A OBJECTIVES

Laboratory-scale tests will be performed to evaluate the effectiveness of coagulation, precipitation, and microfiltration for removing radionuclides from OU2 surface waters. The primary objective is to determine the most effective coagulant, and its corresponding optimum dosage and operating pH. The effectiveness of microfiltration for further reduction of radionuclides will also be evaluated.

B APPROACH

Coagulation/precipitation will be evaluated using jar tests. An initial set of test runs will be performed to screen the various coagulants studied. Each coagulant will be tested at several dosages and pHs. Multiple jar testing equipment will be utilized to facilitate side-by-side comparison of the various combinations evaluated.

Based on the results of the initial screening, the best combinations of coagulants, dosages, and operating pHs will be selected for the microfiltration study. The settled supernatant from the selected combination will be processed through submicron sized filter discs to simulate the operation of a cross-flow microfilter.

C EQUIPMENT AND SETUP

Jar testing will be performed using a multiple jar testing apparatus with either paddle or magnetic stirrers. Testing will be done using both 1-liter and 5-liter pyrex graduated beakers. A reagent rack for adding reagents simultaneously to each of the beakers will also be utilized. Figure A.4-1 shows a typical rack used for this purpose.

Filter testing will be performed using a Millipore (or equal) filter holder, glass funnel, and graduated Erlenmeyer flask. A vacuum pump is also required to draw the sample through the filter. Figure A 4-2 illustrates the test setup.

D TEST RUNS

The initial screening tests will evaluate the following coagulants:

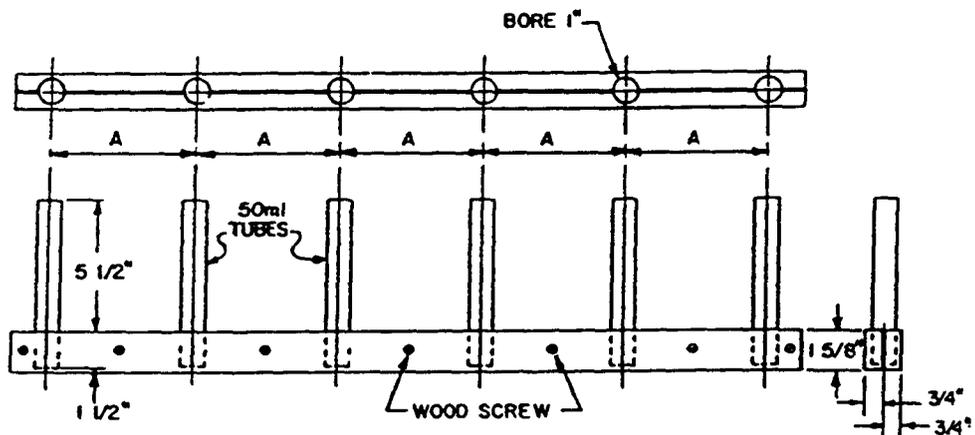
- Aluminum sulfate
- Ferrous sulfite
- Ferric sulfate
- Ferric chloride
- Polyelectrolyte (as coagulant aid)

These coagulants (with or without polyelectrolyte) will be jar tested at up to 4 dosages and 2 pH levels. The number of tests will be approximately 32 total. The settled water from each test will be analyzed for gross alpha and beta activity.

Based on the results of the initial screening, the six best combinations of coagulant, dosage, and pH will be selected for further evaluation. The selected combination will be rerun using larger jars. The settled water will be run through the submicron filter.

FIGURE A.4-1
 CHEMICAL COAGULATION/MICROFILTRATION
 FOR RADIONUCLIDES

Reagent Rack for Multiple Stirrer
 Jar Test Apparatus



A = ϵ Distance between jars in
 multiple stirrer apparatus
 (6" for a Phipps-Bird)

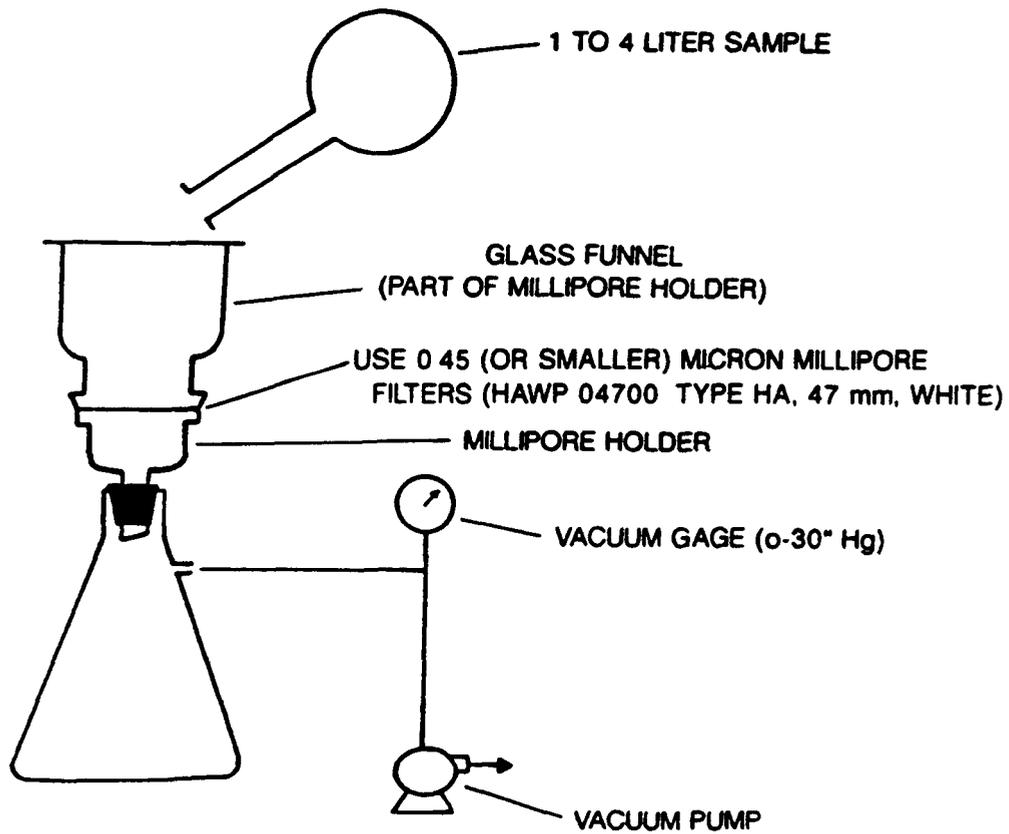
TUBES - 1" x 7" 50ml Color
 Comparator Type

RACK - Oak 3/4" x 1-5/8"

SOURCE ASTM D2035

FIGURE A.4-2
CHEMICAL COAGULATION/MICROFILTRATION
FOR RADIONUCLIDES

Microfiltration



apparatus to simulate a cross-flow microfilter. In addition, the secondary testing will incorporate the water quality parameters and a full metals analysis to fully characterize the effluent streams. With a comparison of the full analysis for the weekly composited field samples as discussed in the SAP (Appendix B) and the above analysis, any inhibiting influences caused by other contaminants can be determined. The initial sample, filter inlet and filter outlet will be analyzed for the constituents listed in Figure A 4-3.

E TEST PROCEDURES

Jar Testing

- 1 Measure equal volumes of sample into each of the jars. As many samples may be used as there are positions on the multiple jar tester. Record the sample temperature at the start of the test.
- 2 Load the test chemicals in the reagent racks. Use one rack for each series of chemical additions. Before using, make up each tube in the rack to a final volume of 10 ml with water. If the intended dosage requires a larger volume of reagent, all tubes should be diluted with water to the same volume.
- 3 Start the multiple stirrer operating at the "flash mix" speed of approximately 120 rpm. Add the test solution at predetermined dosage levels and sequence. Flash mix for approximately 1 minute after the additions of chemicals. Record the flash mix time and speed (rpm).

FIGURE A.4-3
 CHEMICAL COAGULATION/MICROFILTRATION
 FOR RADIONUCLIDES
 Jar Test Data Sheet

Sample _____ pH _____ Turbidity _____ Date _____
 Location _____ Temperature _____ Sample Size _____ ml

JAR NUMBER						
	1	2	3	4	5	6
Chemicals, mg/liter (a)						
Flash Mix Speed, rpm						
Flash Mix Time, min						
Slow Mix Speed, rpm						
Slow Mix Time, min						
Temperature, °F						
Time First Flocc, min						
Size Flocc						
Settling rate						
Turbidity						
pH						

(a) indicate order of addition of chemicals

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- 4 Reduce the speed as necessary to the minimum required to keep floc particles uniformly suspended throughout the "slow mix" period. Slow mix for 20 minutes. Record the time for the first visible floc formation. Every 5 minutes (during the slow mix period), record relative floc size and mixer speed (rpm). If coagulant aids are used, mixing speed is critical because excessive stirring tends to break up early floc formation and may redisperse the aid.
- 5 After the slow mix period, withdraw the paddles and observe settling of floc particles. Record the time required for the bulk of the particles to settle.
- 6 After 15 minutes of settling, record the appearance of floc on the beaker bottom. Record the sample temperature. By means of a pipet or siphon, withdraw an adequate sample volume of supernatant liquor from the jar at a point one half of the depth of the sample, to conduct the suspended solids analyses.

Filtration Tests

- 1 Place Millipore filter in holder
- 2 Start vacuum pump
- 3 Perform jar test, using 5 liter beakers, as described previously. Collect the settled water for use in this test.
- 4 Pour sample into funnel, filling it to the brim and maintaining it full until the completion of the test.

5 Continue filtration run until four liters have been collected

F SAMPLE SIZE REQUIREMENTS

Initial testing will be performed using 1 0 liter beakers Based on 32 initial runs, a total of 32 liters of sample will be required

The filtration tests will be performed using 5 0 liter beakers The 15 tests anticipated will require a total of 75 liters of sample

G SAMPLING AND ANALYTICAL REQUIREMENTS

This testing program will require sampling and analysis for radionuclides These radionuclides will include gross alpha and beta activity, uranium, plutonium, and americium In addition, a water quality parameter analysis and a full metals screen will be conducted during the secondary testing All sampling and analytical activities will be conducted in accordance with the SAP contained in Appendix B of this document

H DATA COLLECTION AND ANALYSIS

A data sheet for use during the jar tests is shown in Figure A.4-2

The only analysis that will be done will, for the initial jar tests, be gross alpha and beta activity of the untreated sample and the decanted wastewater after settling

For the filtration tests, the constituents listed in Table A 4-1 will be analyzed. This will include

- Initial sample before jar test
- Decanted sample after jar test (filter inlet sample)
- Filter outlet

Percent reduction in suspended solids and/or radionuclides will be calculated and recorded for each test as follows

$$\% \text{ Reduction} = \frac{\text{Initial Concentration} - \text{Final Concentration}}{\text{Initial Concentration}} (100)$$

I RESIDUALS

The residuals from the test program will include the following

Wastewater	107 liters
Contaminated Filter Disc	6 liters

J REPORTING

A report will be prepared discussing the results of the testing. For the jar tests, tables will be prepared listing the final suspended solids concentration and removal efficiency for each of the operating conditions evaluated. The results of the filtration tests, i.e., inlet and outlet radionuclides concentrations and percent removals, will also be reported. A general assessment of this technology for use at RFP OU2 will also be presented.

TABLE A.4-1
CHEMICAL COAGULATION/MICROFILTRATION TESTS
ANALYTE LIST

Gross Alpha

Gross Beta

Uranium 233 and 234, 235 and 238

Plutonium 239 and 240

Americium 241

A 5

TREATABILITY STUDY WORK PLAN
COAGULATION/PRECIPITATION/FILTRATION
FOR SUSPENDED SOLIDS

A OBJECTIVES

Laboratory-scale tests will be performed to evaluate the effectiveness of coagulation, precipitation and filtration for removing suspended solids from OU2 surface waters at the Rocky Flats Plant. The primary objective is to determine the most effective coagulant, and its corresponding optimum dosage and operating pH. The effectiveness of filtration for further reduction of suspended solids will also be evaluated.

B APPROACH

Coagulation/precipitation will be evaluated using jar tests. An initial set of test runs will be performed to screen the various coagulants studied. Each coagulant will be tested at several dosages and pHs. Multiple jar testing equipment will be utilized to facilitate side-by-side comparison of the various combinations evaluated.

Based on the results of the initial screening, the best combinations of coagulants, dosages, and operating pHs will be selected for the filtration study. The settled supernatant from the selected combinations will be processed through laboratory columns containing filter sand.

In all cases, effectiveness will be evaluated by suspended solids analyses of the influent and effluent from each test.

C EQUIPMENT AND SETUP

Jar testing will be performed using a multiple jar testing apparatus with either paddle or magnetic stirrers. Testing will be done using both 1 liter and 2 liter pyrex graduated beakers. A reagent rack for adding reagents simultaneously to each of the beakers will also be utilized. Figure A 5-1 shows a typical rack used for this purpose.

Filter testing will be performed using a 10 inch diameter glass column filled with two feet of filter sand. A feed tank and peristaltic pump will be used to pump the wastewater to the filter column.

D TEST RUNS

The initial screening tests will evaluate the following coagulants:

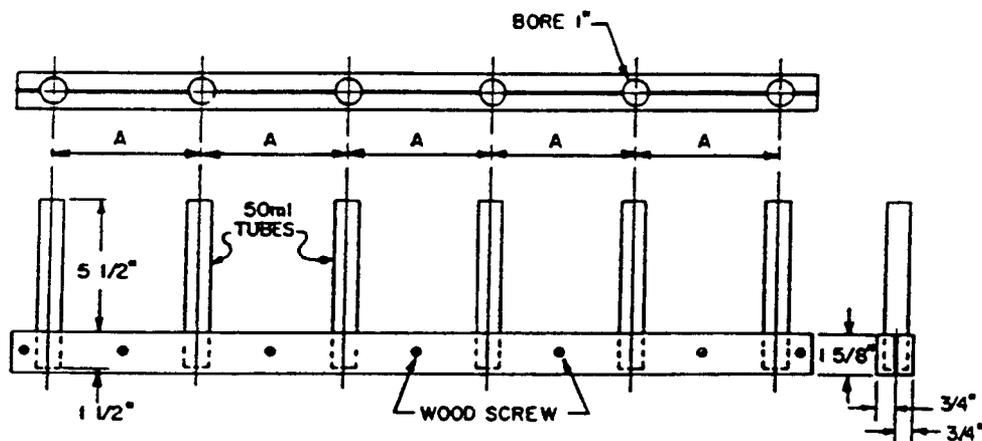
- Aluminum sulfate
- Ferrous sulfite
- Ferric sulfate
- Ferric chloride
- Polyelectrolyte (as coagulant aid)

These coagulants (with or without polyelectrolyte) will be jar tested at up to five dosages and 3 pH levels. The total number of tests will be approximately 75. The settled water from each test will be analyzed for suspended solids.

Based on the results of the initial screening, the 15 best combinations of coagulant, dosage and pH will be selected for further evaluation. The selected combinations will be rerun. The settled water will be run through glass columns filled with filter sand to

FIGURE A 5-1
 COAGULATION/PRECIPITATION/FILTRATION
 FOR SUSPENDED SOLIDS

Reagent Rack For Multiple Stirrer
 Jar Test Apparatus



A = ϵ Distance between jars in
 multiple stirrer apparatus
 (6" for a Phipps-Bird)

TUBES - 1" x 7" 50ml Color
 Comparator Type

RACK - Oak 3/4" x 1-5/8"

Source ASTM D2035

simulate conventional sand filters. Suspended solids in the filter inlet and filter outlet will be measured. In addition, the secondary testing will incorporate the water quality parameters and a full metals analysis to fully characterize the effluent streams. With a comparison of the full analysis for the weekly composited field samples as discussed in the SAP (Appendix B) and the above analysis, any inhibiting influences caused by other contaminants could be determined.

E TEST PROCEDURES

Jar Testing

- 1 Measure equal volumes of sample into each of the jars. As many samples may be used as there are positions on the multiple jar tester. Record the sample temperature at the start of the test.
- 2 Load the test chemicals in the reagent racks. Use one rack for each series of chemical additions. Before using, make up each tube in the rack to a final volume of 10 ml with water. If the intended dosage requires a larger volume of reagent, all tubes should be diluted with water to the same volume.
- 3 Start the multiple stirrer operating at the "flash mix" speed of approximately 120 rpm. Add the test solution at predetermined dosage levels and sequence. Flash mix for approximately 1 min after the additions of chemicals. Record the flash mix time and speed (rpm).
- 4 Reduce the speed as necessary to the minimum required to keep the floc particles uniformly suspended throughout the "slow mix" period. Slow mix for 20 min. Record the time for the first visible floc formation. Every 5

min (during the slow mix period), record relative floc size and mixer speed (rpm) If coagulant aids are used, mixing speed is critical because excessive stirring tends to break up early floc formation and may redisperse the aid

- 5 After the slow mix period, withdraw the paddles and observe settling of floc particles Record the time required for the bulk of the particles to settle
- 6 After 15 min of settling, record the appearance of floc on the beaker bottom Record the sample temperature By means of pipet or siphon, withdraw an adequate sample volume of supernatant from the jar at a point one half of the depth to conduct the suspended solids analyses

Filtration Tests

- 1 Perform jar tests as described above
- 2 After the solids have settled, carefully siphon off the supernatant liquid into a separate feed container This must be done slowly and carefully to prevent re-entraining the settled sludge
- 3 Pump the collected fluid through the sand filter column using a peristaltic pump
- 4 Collect a sample of the filter effluent after running approximately 5 bed volumes of water through the filter Also, collect a sample of the unfiltered water for analysis

F SAMPLE SIZE REQUIREMENTS

Initial testing will be performed using 1 0-liter beakers. Based on 75 initial runs, a total of 75 liters of sample will be required.

The filtration tests will be performed using 2 0-liter beakers. The 15 tests anticipated will require a total of 30 liters of sample.

G SAMPLING AND ANALYTICAL REQUIREMENTS

The only analyses performed during these tests are for suspended solids. In addition, a water quality parameter analysis and a full metals screen will be conducted during the secondary testing. All sampling and analytical activities will be conducted in accordance with the SAP contained in Appendix B of this document.

H DATA COLLECTION AND ANALYSIS

A data sheet for use during the jar tests is shown in Figure A 5-2.

The only analysis that will be done will be for suspended solids. For each test, the following data will be collected and recorded:

- Initial sample before jar test
- Decanted sample after jar test (filter inlet sample)
- Filter outlet

FIGURE A.5-2
 COAGULATION/PRECIPIATION/FILTRATION
 FOR SUSPENDED SOLIDS
 Jar Test Data Sheet

Sample _____ pH _____ Turbidity _____ Date _____
 Location _____ Temperature _____ Sample Size _____ ml

	JAR NUMBER					
	1	2	3	4	5	6
Chemicals, mg/litre (a)						
Flash Mix Speed, rpm						
Flash Mix Time, min						
Slow Mix Speed, rpm						
Slow Mix Time, min						
Temperature, °F						
Time First Floc, min						
Size Floc						
Settling rate						
Turbidity						
pH						

(a) indicates order of addition of chemicals

Basis ASTM D2035

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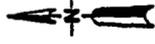
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LEGEND

ALLUVIAL MATERIALS



SCALE IN FEET

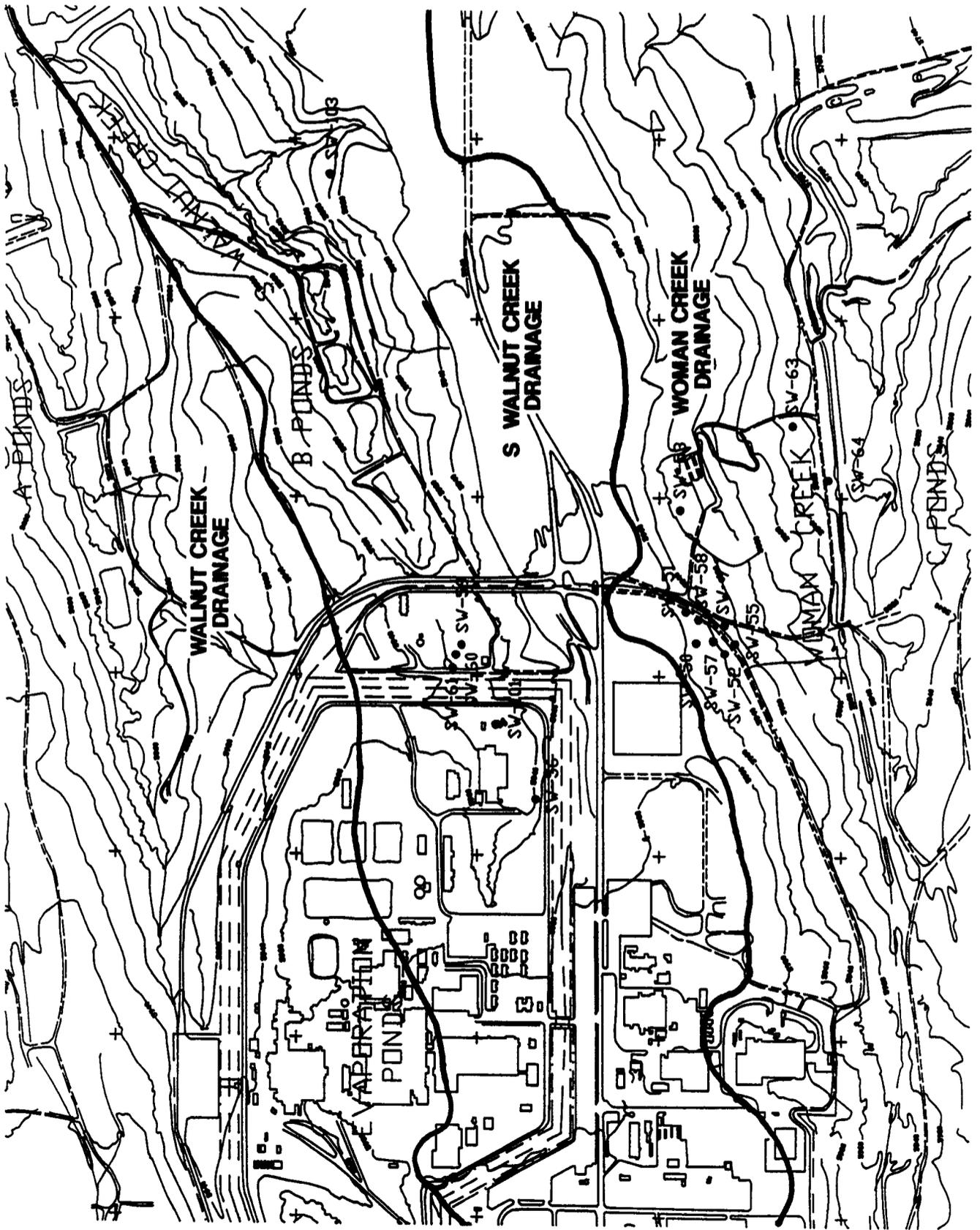
CONTOUR INTERVAL = 20

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2.2

SURFACE WATER SAMPLING SITES
AND ALLUVIUM LOCATIONS





CONTOUR INTERVAL = 20'

Source: Harj R. Theodore, Hydrology of Nuclear Precipitation Plant Site, Rocky Flats, Jefferson County, Colorado, U.S. Geological Survey, Open File Report, 78-268 Denver, Colorado, March, 1978

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 2 4

DRAINAGE BASINS

