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Phase II RFI/RI Work Plan (Bedrock)

Manual No. 21100-WP-OU02.2

EG&G ROCKY FLATS

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FINAL

PHASE II RFI/RI WORK PLAN
(Bedrock)

ROCKY FLATS PLANT
GOLDEN, COLORADO

903 PAD, MOUND AND EAST TRENCHES AREAS
(Operable Unit No 2)

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

ENVIRONMENTAL RESTORATION PROGRAM

REVIEWED FOR CLASSIFICATION/UCNI
By
Date

June 1991

Approved by

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LIST OF ACRONYMS

The following is a list of acronyms used throughout this work plan

ACL	Alternative Concentration Limit
AEC	U S Atomic Energy Commission
ARAR	applicable or relative and appropriate requirement
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
CAD	Corrective Action Decision
CCl_4	Carbon Tetrachloride
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	corrective measures study
CRP	Community Relations Plan
CWA	Clean Water Act
DOE	U S Department of Energy
DQO	data quality objective
EPA	U S Environmental Protection Agency
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
FIDLER	Field Instrument for Detection of Low Energy Radiation
FR	Federal Register
FS	feasibility study
FSP	field sampling plan
GAC	granular activated carbon
GC	gas chromatograph
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HSU	hydrostratigraphic unit
IAG	InterAgency Agreement
ICP	inductively compled plasma emission spectroscopy
IHSS	Individual Hazardous Substance Site
IRIS	Integrated Risk Information System
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MSL	mean sea level
NCP	National Contingency Plan
NCRP	National Council on Radiation Perfection and Measurements
NPDES	National Pollutant Discharge Elimination System
OVA	organic vapor analyzer
OVD	organic vapor detector
PCE	tetrachloroethylene
PPCD	Plan for the Prevention of Contaminant Dispersion

PSZ	Perimeter Security Zone
QA	Quality Assurance
QAA	Quality Assurance Addendum
QAPjP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA facility investigation
RI	remedial investigation (CERCLA)
ROD	Record of Decision
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SAS	Special Analytical Services
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SOPA	Standard Operating Procedure Addendum
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TBC	to be considered
TCE	trichloroethylene
TCL	Target Compound List
TDS	Total Dissolved Solids
UV	ultraviolet
VOC	volatile organic compounds
WQCC	Water Quality Control Commission

This document presents the work plan for the bedrock component of the Phase II RCRA Facility Investigation (RFI)/Remedial Investigation (RI) of the 903 Pad, Mound, and East Trenches areas (Operable Unit 2) at the Rocky Flats Plant Jefferson County Colorado Operable Unit 2 contains 20 Individual Hazardous Substance Sites (IHSSs) located on the east side of the Rocky Flats main plant complex area The IHSSs are potentially contaminated areas that have been identified during previous investigations and historical accounts of site usage The Operable Unit 2 area is being investigated because of the relationship of the IHSSs to soil and groundwater contamination that have been identified on site

This work plan includes a field sampling plan (FSP) that establishes the scope of field investigations and criteria that will be used to redirect and expand on the sampling efforts as necessary to accomplish the stated goals The FSP proposes 20 clusters of boreholes and wells that contain a total of 20 boreholes and 38 wells This program may be expanded during the course of the investigation to include additional wells screened in sandstone units that have not yet been identified

A previously prepared Phase II RFI/RI Alluvial Work Plan addresses characterization and the nature and extent of contamination of surface water and of soil and groundwater above the bottom of the upper hydrostratigraphic unit (HSU) This work plan addresses characterization and the nature and extent of contamination in the bedrock and HSUs beneath the upper HSU The data obtained during the two components of the RFI/RI field work will be combined and presented in a single RFI/RI report That report will be the basis for a corrective measures study/feasibility study (CMS/FS) and the baseline risk assessment

This Phase II RFI/RI work plan for bedrock characterization is based on the results of the Phase I RI as presented in the Phase II RFI/RI Alluvial Work Plan This bedrock work plan emphasizes the development of a conceptual model to describe the bedrock hydrogeology nature and extent of contamination in the bedrock release mechanisms exposure pathways, and receptors and presents an FSP that will support the baseline risk assessment Sections of the work plan address applicable or relevant and appropriate requirements (ARARs) data needs and data quality objectives (DQOs) remedial investigation and feasibility study tasks and the Phase II RFI/RI schedule

The Phase II RFI/RI Alluvial Work Plan addresses the upper HSU which consists of the alluvium and hydrologically connected bedrock Geologic characterization indicates that areas of subcropping sandstone bedrock are within the upper HSU For planning purposes, the delineation between the upper HSU and lower HSU(s) occurs 5 feet below the surface of the Arapahoe Formation bedrock, or 5 feet below the bottom of subcropping sandstone channels where they are present There is integration between the alluvial and bedrock work plans in the weathered bedrock, where lower sandstones subcrop and where contamination sources are present within these contiguous and overlapping areas

The predominant component of the groundwater hydraulic gradient in the lower HSU(s) appears to be downward However the low hydraulic conductivity of the unweathered claystone impedes the downward flow of groundwater There is geologic evidence (i e the presence of channel shaped fluvial depositional sequences containing sandstones) that the majority of groundwater flow that occurs may be laterally to the east There may be a potential for contaminated groundwater in the upper HSU to enter lower bedrock sandstones where they subcrop in localized areas beneath relatively shallow colluvium south and southeast of the 903 Pad area In general, the lower HSU(s) is(are) incompletely modeled

Based on the Phase I RI results and earlier studies carbon tetrachloride (CCl_4) tetrachloroethylene (PCE) and trichloroethylene (TCE) are the primary volatile organic contaminants found in the upper HSU in Operable Unit 2 Trace elements occasionally exceeding background levels include barium copper nickel, manganese and zinc Major anions are somewhat elevated above background throughout and downgradient of the 903 Pad, Mound and East Trenches areas Radionuclide levels in the upper HSU are generally within the statistical tolerance limits for the background groundwater data, but a few samples indicate minimum detectable amounts of plutonium and americium in the vicinity of the 903 Pad and possibly north of the Mound These conclusions are based almost entirely on unvalidated data

There are 20 existing wells in Operable Unit 2 that are screened entirely within the depth intervals believed to represent the lower (bedrock) HSU(s) These 20 monitoring wells were all constructed since 1986 most for the Phase I RI and have a relatively complete quarterly sampling program At least six additional pre 1986 wells are also present in Operable Unit 2 Construction details on these wells are not available The pre 1986 wells have not been used recently for obtaining groundwater quality samples Volatile organic compounds (VOCs) have been detected in 4 of the 20 recent wells (1887 BR 2087 BR 3487 BR and 4086) that are believed to represent the groundwater chemistry of the lower HSU(s) Only 12 of the 20 wells have available laboratory test data The measured concentrations of VOCs were as high as 140 $\mu g/l$ in one of these wells and under 20 $\mu g/l$ in the other 3 wells The primary contaminants that were tentatively identified in these wells are TCE and PCE Other volatile and semivolatile organic and inorganic compounds that have been identified in the upper HSU have generally not been identified in the bedrock Most of the available analytical data for the bedrock have not been validated

The objectives of the bedrock component of the Phase II RFI/RI are to characterize the bedrock hydrogeology and to sufficiently characterize the nature and extent of bedrock contamination to support the feasibility study baseline risk assessment, and remedial design At this time it is not definitely known whether or not contamination of the relatively deep unweathered bedrock exists

1 0 INTRODUCTION

This document presents the Work Plan for the bedrock component of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Remedial Investigation (RI) of the 903 Pad, Mound, and East Trenches areas (Operable Unit 2) at the Rocky Flats Plant, Jefferson County Colorado A previously prepared Phase II RFI/RI Work Plan (Alluvial) addresses characterization and the nature and extent of contamination of soils and groundwater above the bottom of the upper hydrostratigraphic unit (HSU) This work plan addresses characterization and the nature and extent of contamination in the bedrock and confined water bearing zones beneath the upper (alluvial) HSU Potential sources of bedrock contamination are present in the upper HSU It is not yet known whether or not the lower HSU(s) has been contaminated by the upper HSU The data obtained during the Alluvial and Bedrock components of the RFI/RI field work will be combined and presented in a single RFI/RI report That report will be the basis for the Corrective Measures Study/Feasibility Study (CMS/FS) and the baseline risk assessment

The purpose of this Phase II Bedrock RFI/RI Work Plan is to define the scope of work required to characterize the geologic and hydrologic conditions within the lower HSU of the Operable Unit 2 area This investigation is part of a comprehensive phased program of site characterization, remedial investigations feasibility studies and remedial/corrective actions currently in progress at the Rocky Flats Plant These investigations are pursuant to the U S Department of Energy (DOE) Environmental Restoration (ER) Program [formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP)] a Compliance Agreement among DOE the U S Environmental Protection Agency (EPA) and the State of Colorado Department of Health (CDH) dated July 31 1986 and a Federal Facility Agreement and Consent Order or Interagency Agreement (IAG) among DOE, EPA, and CDH dated January 22, 1991 (U S EPA 1991a) The program developed by DOE EPA, and CDH in response to the agreements addresses RCRA and CERCLA issues and has been integrated with the ER Program In accordance with the IAG the CERCLA terms Remedial Investigation and Feasibility Study" in this document are considered equivalent to the RCRA terms RCRA Facility Investigation and Corrective Measures Study"

1 1 ENVIRONMENTAL RESTORATION PROGRAM

The ER Program is designed to investigate and clean up contaminated sites at DOE facilities The ER Program being implemented is organized into in five major activities The first activity Installation Assessment includes preliminary assessments and site inspections to assess potential environmental concerns The second activity Remedial Investigations includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant migration pathways Feasibility Studies the third major activity evaluates remedial alternatives and develops remedial action plans to mitigate environmental problems identified as needing correction during the remedial investigations The fourth activity Remedial Design/Remedial Action, includes design and implementation of site specific remedial actions selected on the basis of the feasibility studies Finally Compliance and Verification implements monitoring and performance assessments of remedial actions and verifies and documents the adequacy of remedial actions carried out Installation assessment has already been completed at the Rocky Flats Plant (DOE 1986) and remedial investigations, feasibility studies and remedial design/remedial action are currently in progress for Operable Unit 2 (903 Pad, Mound, and East Trenches areas)

With respect to RI activities at Operable Unit 2, an initial (Phase I) field program was completed during 1987 and a draft Phase I RI report was submitted to EPA and CDH on December 31 1987 (Rockwell International 1987a) A Phase II RFI/RI Work Plan (Alluvial) dated April 12, 1990 (EG&G 1990c) that presents site specific plans for further field work to characterize sources and the extent of groundwater contamination in the upper HSU (surficial materials and subcropping sandstones) That work plan was granted conditional approval by the EPA and CDH and revisions were being made in response to the conditions of the approval at the time of the preparation of this work plan It is based on results presented in the draft Phase I RI report as well as subsequent groundwater sampling and analysis This Phase II RFI/RI Work Plan (Bedrock) is based primarily on data presented in the Phase II RFI/RI Work Plan (Alluvial) the results of recent and ongoing geologic characterization studies, and recent sampling and analysis data An interim remedial action is being planned to treat contaminated surface water in South Walnut Creek north of Operable Unit 2 Remedial action measures will be proposed in the final RFI/RI report

Results of the Phase I RI indicate that a complex bedrock geologic system exists beneath the 903 Pad, Mound and East Trenches areas A draft Geologic Characterization Report (EG&G 1990a) for the Rocky Flats Plant has been prepared based on consistent re evaluation of borehole log data and other geologic information That report contains a revised working model of the bedrock geology In order to further characterize the location, extent, and orientation of sandstones, and bedrock facies and stratigraphic relationships high resolution seismic reflection profiling was conducted at Operable Unit 2 (EG&G 1990b) This bedrock work plan combines the information obtained during the ongoing geologic characterization with the results of the seismic reflection work to further refine the working model of the bedrock geology The results are summarized herein

1.2 WORK PLAN SCOPE

The previous Phase II RFI/RI Work Plan (Alluvial) for the 903 Pad, Mound, and East Trenches areas presented results of the Phase I RI defined data quality objectives (DQOs) and data needs based on that investigation specified RI tasks and presented a Field Sampling Plan (FSP) for characterization of the upper hydrostratigraphic unit (HSU) which consists of the alluvium and hydrologically connected bedrock This

Phase II Bedrock RFI/RI Work Plan (Bedrock) includes the same basic components described above so that the two work plans may be integrated Much of the regional and Plant site background information and site locations and descriptions are excerpted from the alluvial work plan The descriptions of the physical characteristics of and nature and extent of contamination in the upper HSU are also from the alluvial work plan

This bedrock work plan emphasizes the development of a conceptual model to describe the bedrock hydrogeology nature and extent of contamination in the bedrock release mechanisms, exposure pathways and receptors and presents a field sampling plan (FSP) that will support the baseline risk assessment Data were compiled from a number of sources The following previous and ongoing studies and other information were the primary sources used in preparing this work plan (a list of references is presented in Section 11 0)

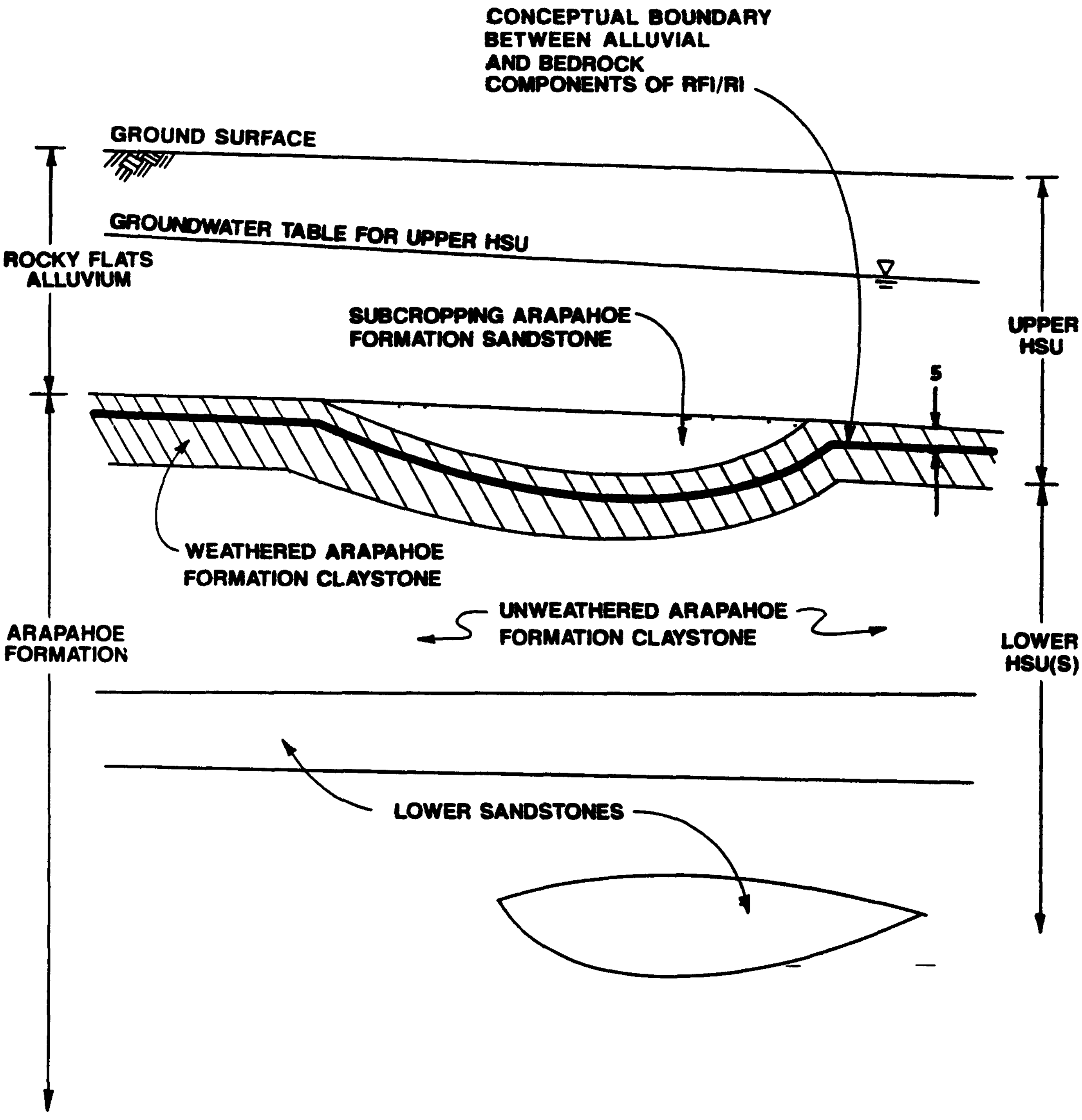
- Phase II RFI/RIFS Work Plan (Alluvial) for the 903 Pad, Mound, and East Trenches Areas (EG&G 1990c) (granted conditional approval by EPA and CDH)

- Ongoing geologic characterization (interim results presented in EG&G 1990a and EG&G 1990b)

- Recent Rocky Flats groundwater chemistry data from the Rocky Flats Environmental Database System (RFEDS) database

As part of the preparation of this work plan, the working physical model of the bedrock geology was refined by combining the geologic information presented in the three reports referenced above The bedrock hydrology and nature and extent of contamination were evaluated using data from the Phase II RFI/RI Work Plan (Alluvial) and subsequent analytical and groundwater data

Figure 1 1 depicts the conceptual boundary between the alluvial and bedrock components of the RFI/RI From a hydrologic standpoint subcropping sandstones have more in common with the overlying alluvial soils than with the underlying claystones and confined sandstones For the purpose of developing work plan scopes the boundary is considered to occur 5 feet below the surface of the weathered claystone This boundary is based on the vertical extent of investigation that has been selected for the alluvial component of the RFI/RI There will be some overlap between the two components of the RFI/RI However considering the above characterization of the alluvial soils and subcropping sandstones will be completed by the alluvial RFI/RI Overlap will occur in the weathered claystones where lower sandstones subcrop and where contamination sources are located within these contiguous and overlapping areas



NOTE HSU = HYDROSTRATIGRAPHIC UNIT

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

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

CONCEPTUAL BOUNDARY BETWEEN ALLUVIAL AND BEDROCK COMPONENTS OF RFI/RI

FIGURE 1 1

6/21/91

Section 1 0 of this work plan presents introductory information and a general characterization of the region and Plant site Descriptions of site locations and histories and prior site characterization activities are also presented in Section 1 0 Section 2 0 presents detailed descriptions of the site physical characteristics and nature and extent of contamination, culminating in a site conceptual model that is the basis for establishing data needs data quality objectives (DQOs) and developing a FSP Section 3 0 presents applicable or relevant and appropriate requirements (ARARs) developed for Operable Unit 2 bedrock Section 4 0 establishes data needs and DQOs considering the site characterization and the conceptual model Sections 5 0 and 6 0 summarize RFI/RI tasks and Feasibility Study (FS) tasks, respectively This RFI/RI Work Plan (Bedrock) only briefly addresses some of these tasks, such as Baseline Risk Assessment, treatability studies alternatives development and screening and analysis since the alluvial RFI/RI work plan presents more detailed discussions of them Section 7 0 presents a schedule for conducting the RFI/RIFS process A Field Sampling Plan (FSP) is presented in Section 8 0 to satisfy the data needs and DQOs identified in Section 4 0 A Quality Assurance Addendum (QAA) is described and Standard Operating Procedures Addenda (SOPA) are presented in Sections 9 0 and 10 0 respectively

The geologic characterization and seismic study reports used are not included in appendices to this work plan because both the geologic characterization and the high resolution seismic reflection profiling studies are in progress and the reports are working drafts that have not been prepared for distribution Pertinent data and summaries of that data are presented in figures and tables and in an appendix to this work plan Soil bedrock, and groundwater analytical chemistry data are presented in appendices to the alluvial work plan More recent bedrock groundwater chemistry data and bedrock analytical chemistry data are presented in appendices to this work plan and summarized in Section 2 0

1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION

1.3 1 Background

The Rocky Flats Plant is a government owned, contractor operated facility that is part of the nationwide nuclear weapons production complex. The Plant was operated for the U S Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975 At that time responsibility for the Plant was assigned to the Energy Research and Development Administration (ERDA) which was succeeded by the DOE in 1977 Dow Chemical U S.A an operating unit of the Dow Chemical Company was the prime operating contractor of the facility from 1951 until June 1975 Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant from July 1 1975 until December 31 1989 EG&G Rocky Flats Inc became the prime contractor at the Rocky Flats Plant on January 1 1990

1.3 1 1 Plant Operations

The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium uranium and non radioactive metals (principally beryllium and stainless steel) Parts made at the Plant are shipped elsewhere for assembly In addition, the Plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium

Both radioactive and non radioactive wastes are generated in the production process Current waste handling practices involve onsite and offsite recycling of hazardous materials, onsite storage of hazardous and radioactive mixed wastes, and offsite disposal of solid radioactive materials at another DOE facility However both storage and disposal of hazardous, radioactive and radioactive mixed wastes occurred on site in the past Preliminary assessments under the ER Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination

1.3 1.2 Previous Investigations

Various studies have been conducted at the Rocky Flats facility to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment The investigations performed prior to and during 1986 are summarized in Rockwell International (1986a) and include

- Detailed descriptions of the regional geology (Malde 1955 Spencer 1961 Scott 1960 1963 1970 1972, and 1975 Van Horn 1972 and 1976 DOE 1980 Dames and Moore 1981 and Robson et al 1981a and 1981b)

- Several drilling programs beginning in 1960 that resulted in the construction of 56 monitor wells prior to 1986

- An investigation of surface and groundwater flow systems by the U S Geological Survey (Hurr 1976)

- Environmental ecological, and public health studies that culminated in an environmental impact statement (DOE 1980)

- A summary report on groundwater hydrology using data from 1960 to 1985 (Hydro Search Inc 1985)

- A preliminary electromagnetic survey of the Plant perimeter (Hydro-Search, Inc 1986)

- A soil gas survey of the Plant perimeter and buffer zone (Tracer Research, Inc 1986)

Other investigations since 1986 include

- Routine environmental monitoring programs addressing air surface water groundwater and soils (Rockwell International 1975 through 1985 1986b 1987b and 1989b)

- Background Geochemical Characterization Report for 1989 (EG&G 1990d)

In 1986 two major investigations were completed at the Plant The first was the ER Program Phase 1 installation assessment (DOE 1986) which included analyses and identification of current operational activities active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported A number of sites were identified that could potentially have adverse impacts on the environment These sites were designated as Solid Waste Management Units (SWMUs) more recently renamed Individual Hazardous Substance Sites (IHSSs) by Rockwell International (1987c) and were divided into three categories

1 Hazardous waste management units that will continue to operate and need a RCRA operating permit

2 Hazardous waste management units that will be closed under RCRA interim status

3 Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or under CERCLA No RCRA or CERCLA regulatory distinction in the use of the terms site unit SWMU or IHSS is intended in this document

The second major investigation completed at the Plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire Plant site Plans for this study were presented in Rockwell International publications 1986c and 1986d, and study results were reported in Rockwell International publication 1986e Investigation results indicated four areas were significant contributors to environmental contamination, with each area containing several sites The areas are the 881 Hillside Area, the 903 Pad Area, the Mound Area and the East Trenches Area

Due to their proximity the 903 Pad, Mound, and East Trenches areas were grouped together and designated Operable Unit 2 A Phase I RI of Operable Unit 2 was completed in December 1987 (Rockwell International 1987a) and a draft Phase II RI Sampling Plan was submitted to the EPA and CDH in June 1988 (Rockwell International 1988a) A draft final Phase II RI/FS Work Plan (Alluvial) was submitted to the EPA and CDH in December 1989 (Rockwell International 1989c) and a final (Revision 0) of that document incorporating agency comments on both draft plans was issued April 12, 1990 (EG&G 1990e) EPA and CDH have granted conditional approval to the alluvial work plan

1.3.2 Physical Setting

The Rocky Flats Plant is located in northern Jefferson County Colorado approximately 16 miles northwest of downtown Denver (Figure 1 2) Other surrounding cities include Boulder Westminster and Arvada, which are located less than ten miles to the northwest east and southeast, respectively The Plant 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 Major buildings are located within a Plant security area of approximately 400 acres The security area is surrounded by a buffer zone of approximately 6 150 acres (Figure 1 3)

1.3.2 1 Topography

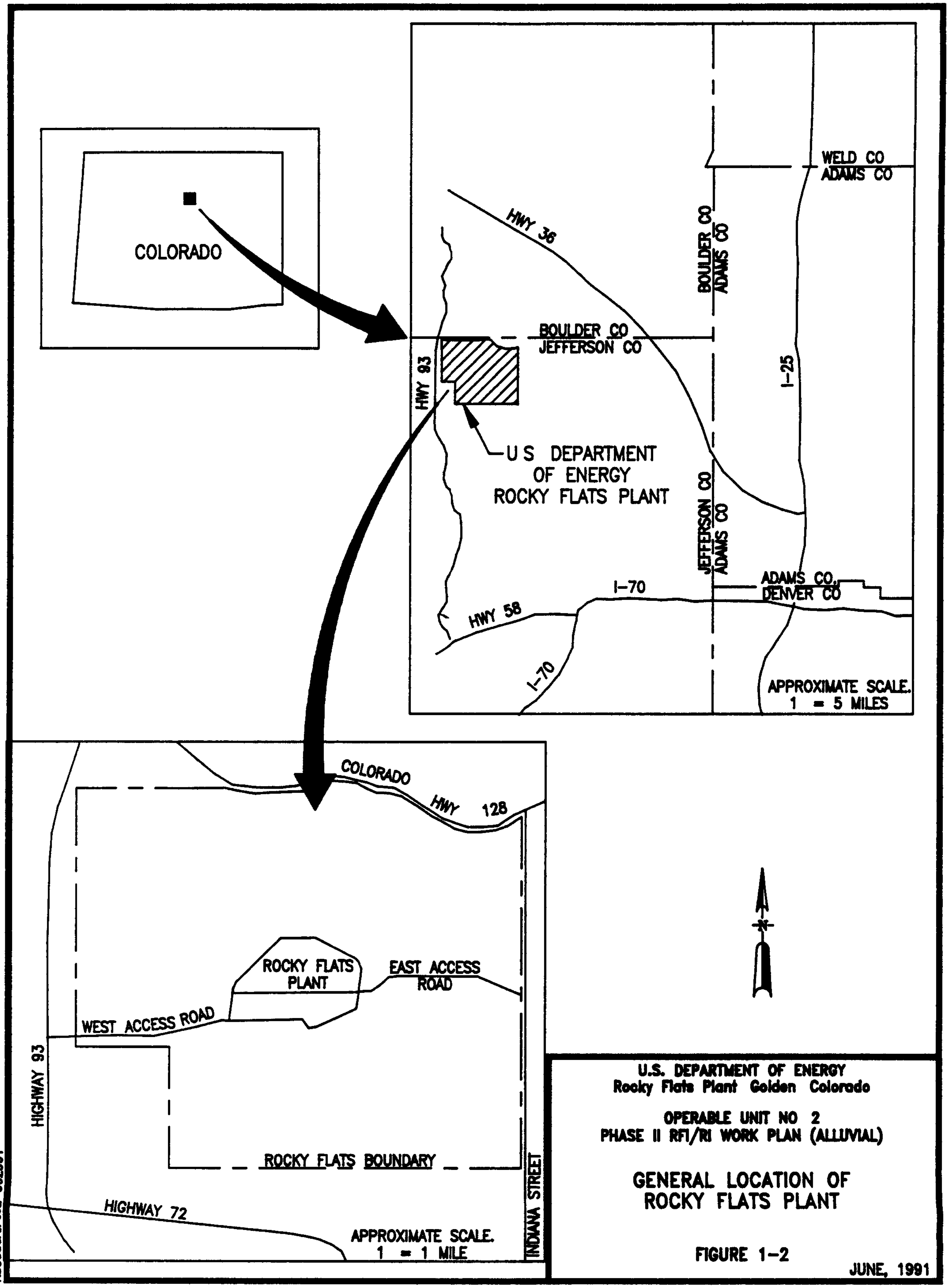
The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains The Plant is directly east of the north south trending Front Range located about 16 miles east of the Continental Divide Rocky Flats Plant is located on a broad, eastward sloping system of coalescing alluvial fans at an elevation of approximately 6 000 feet above mean sea level (MSL) The fans extend about five miles east of the Front Range The Main Plant Complex area is located near the eastern edge of the fans on a pediment between stream cut gullies or arroyos (North Walnut Creek and Woman Creek)

1.3.2.2 Surface Water Hydrology

Three intermittent streams drain the Rocky Flats Plant with flow generally from west to east These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1 3) Rock Creek drains the northwestern corner of the Plant and flows northeast through the buffer zone to its offsite confluence with Coal Creek An east west trending interfluve separates the Walnut Creek and Woman Creek drainages North Walnut Creek, South Walnut Creek, and an unnamed tributary drain the northern portion of the Plant security area These three forks of Walnut Creek join in the buffer zone and flow to Great Western Reservoir approximately one mile east of the confluence Woman Creek drains the southern Rocky Flats Plant buffer zone flowing eastward to Standley Reservoir The South Interceptor Ditch lies between the Plant and Woman Creek The South Interceptor Ditch collects runoff from the southern Plant security area and diverts it to Pond C 2, where it is monitored in accordance with the Plant s National Pollutant Discharge Elimination System (NPDES) permit prior to discharge to Woman Creek

1.3.2.3 Regional and Local Hydrogeology

The geologic interpretations presented in this work plan are based on information from Hurr (1976) and on the ongoing geologic characterization study These interpretations may be revised as more data are obtained during the Phase II Geologic Characterization and the bedrock component of the Phase II RFI/RI



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

OPERABLE UNIT NO 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

GENERAL LOCATION OF ROCKY FLATS PLANT

FIGURE 1-2

JUNE, 1991

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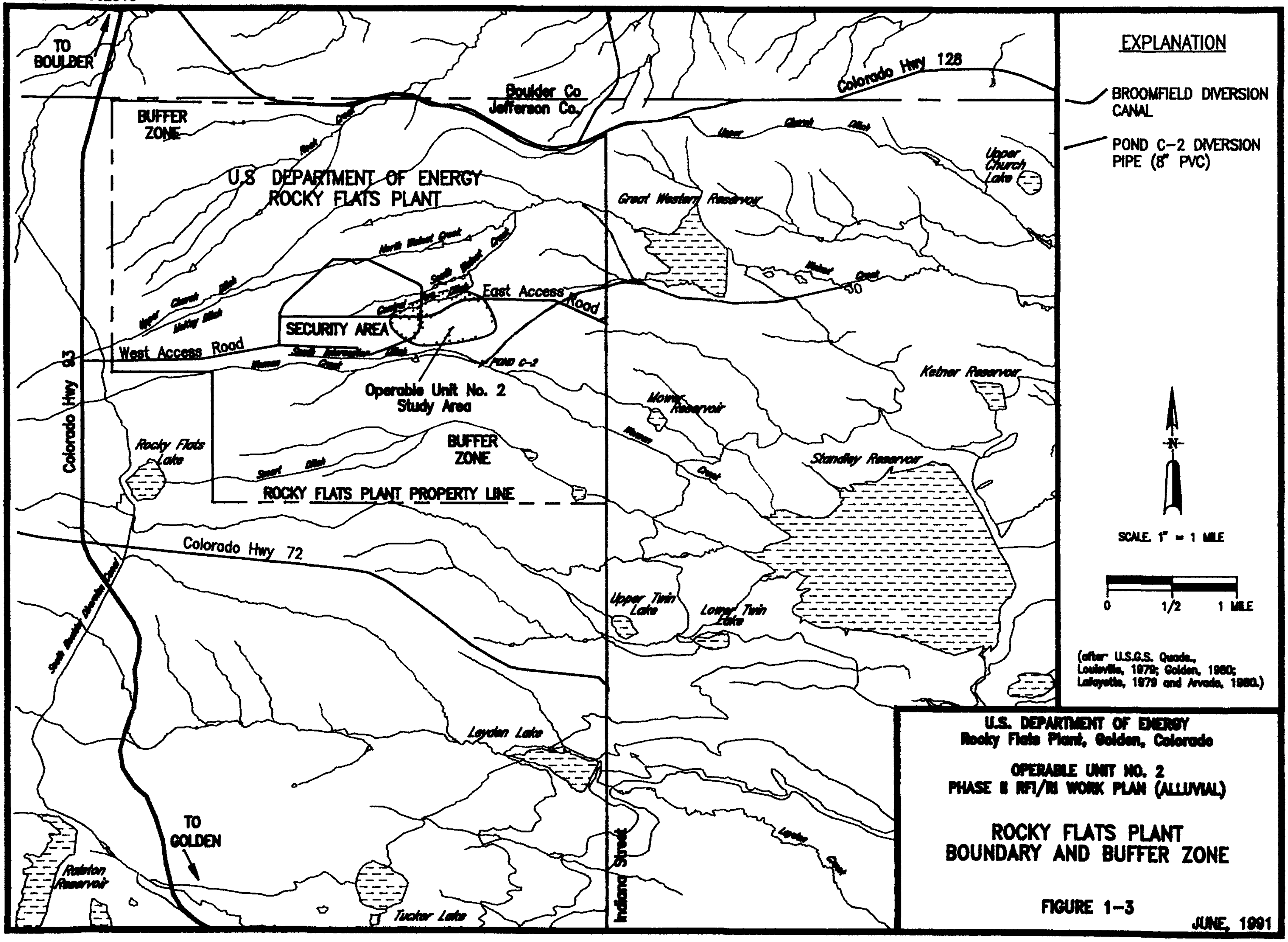

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Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

ROCKY FLATS PLANT
BOUNDARY AND BUFFER ZONE

FIGURE 1-3

JUNE, 1991

The stratigraphic section that pertains to Rocky Flats Plant includes, in descending order unconsolidated surficial units (Rocky Flats Alluvium various other alluvial deposits valley fill alluvium and colluvium) the Arapahoe Formation, the Laramie Formation, and Fox Hills Sandstone Figure 1-4 presents a generalized stratigraphic section of the Denver Basin bedrock and Figure 1 5 shows a generalized geologic section of the Denver/Front Range area Figure 1 6 shows a generalized stratigraphic section of the Rocky Flats Plant including unconsolidated deposits Figure 1 7 depicts the erosional surfaces of alluvial deposits east of the Front Range Colorado Groundwater occurs under unconfined conditions in both the surficial and shallow bedrock units In addition, confined groundwater flow occurs in deeper bedrock sandstones (e g Fox Hills Sandstone)

Rocky Flats Alluvium

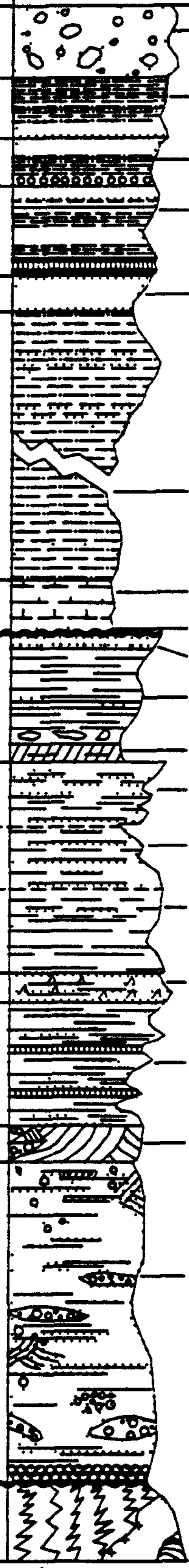
The Rocky Flats Alluvium underlies a large portion of the Plant The alluvium is a broad deposit consisting of a topsoil layer underlain by up to 100 feet of varying amounts of silt clay sand, and gravel Unconfined groundwater flow occurs in the Rocky Flats Alluvium which is relatively permeable Recharge to the alluvium is from precipitation, snowmelt and water losses from ditches, streams and ponds that are cut into the alluvium General movement of groundwater in the Rocky Flats Alluvium is from west to east and toward the drainages Groundwater flow is also controlled by pediment drainages in the top of bedrock Groundwater levels in the Rocky Flats Alluvium rise in response to recharge during the spring and decline during the remainder of the year Discharge from the alluvium occurs at seeps in the colluvium that covers the contact between the alluvium and bedrock along the edges of the valleys Most seeps flow intermittently The Rocky Flats Alluvium thins and discontinues east of the Plant boundary It does not directly supply water to wells located downgradient of the Rocky Flats Plant

Other Alluvial Deposits

Various other alluvial deposits occur topographically below and east of the Rocky Flats Alluvium in the Plant drainages Colluvium (slope wash) mantles the valley side slopes between the Rocky Flats Alluvium and the valley bottoms In addition, remnants of younger terrace deposits, including the Verdos Slocum and Louviers alluvial deposits, occur occasionally along the valley side slopes Recent valley fill alluvium occurs in the active stream channels

Unconfined groundwater flow occurs in these surficial deposits Recharge occurs through precipitation, infiltration from streams during periods of surface water runoff and by seeps discharging from the Rocky Flats Alluvium Discharge occurs through evapotranspiration and by seepage into other geologic formations, sandstone subcrops and streams The direction of groundwater flow is generally easterly and downslope through colluvial materials and then along the course of the stream in valley fill materials During the relatively short periods of high surface water flow that periodically occur some water is lost to bank storage in the valley fill alluvium and then returns to the stream after the runoff subsides

AGE	FORMATION	Thickness (feet)	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600	Boulder conglomerate with occasional thin siltstone lenses
TERTIARY	Denver	870	Yellowish-brown to grayish-olive fluvial tuffaceous claystone siltstone and sandstone interbedded with conglomerate and olive-gray mudflows
UPPER CRETACEOUS	Arapahoe	250	Yellowish-gray to yellowish-brown sandstone siltstone and claystone discontinuous conglomerate at base
UPPER CRETACEOUS	Laramie	700	Gray fine-to-medium-grained sandstone and silty clays thin coal beds in lower part
UPPER CRETACEOUS	Fox Hills	60	Tan fine-to-medium-grained sandstone and sandy shale
UPPER CRETACEOUS	Pierre	± 8000	Dark gray silty shale and few thin silty sandstones
UPPER CRETACEOUS	Niobrara	350	Dark gray very calcareous shale Foraminifers abundant (Smoky Hills Member) Light gray dense, fossiliferous limestone (F Hays Member)
UPPER CRETACEOUS	Benton	420	Brown sandy fossiliferous limestone Dark gray shale with bentonite streaks; thin limestones in middle part, few cone-n-cone concretions in lower part Dark gray brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group: So Platte	270	Light gray fine-to-medium-grained sandstone, several dark gray shales in middle part
LOWER CRETACEOUS	Dakota Group: Lytle	100	Light gray fine-to-coarse-grained locally conglomeratic sandstone frequent red and green siltstone interbeds
Jurassic	Morrison	365	Gray to greenish-gray to red shale and siltstone; thin limestones in middle part; lenticular sandstones in upper and lower part
Jurassic	Ralston Creek	110	Light tan siltstone and light red silty shale gypsiferous sandstone at base and locally conglomeratic
TRIASSIC?	Lykins	400	Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120	Grayish-white, fine-to-medium-grained cross-bedded sandstone; conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000	Red, fine-to-coarse-grained sandstone and conglomerate arkosic thin, lenticular red siltstones frequent throughout
PRECAMBRIAN			Gneiss, schist, and small granitic intrusions



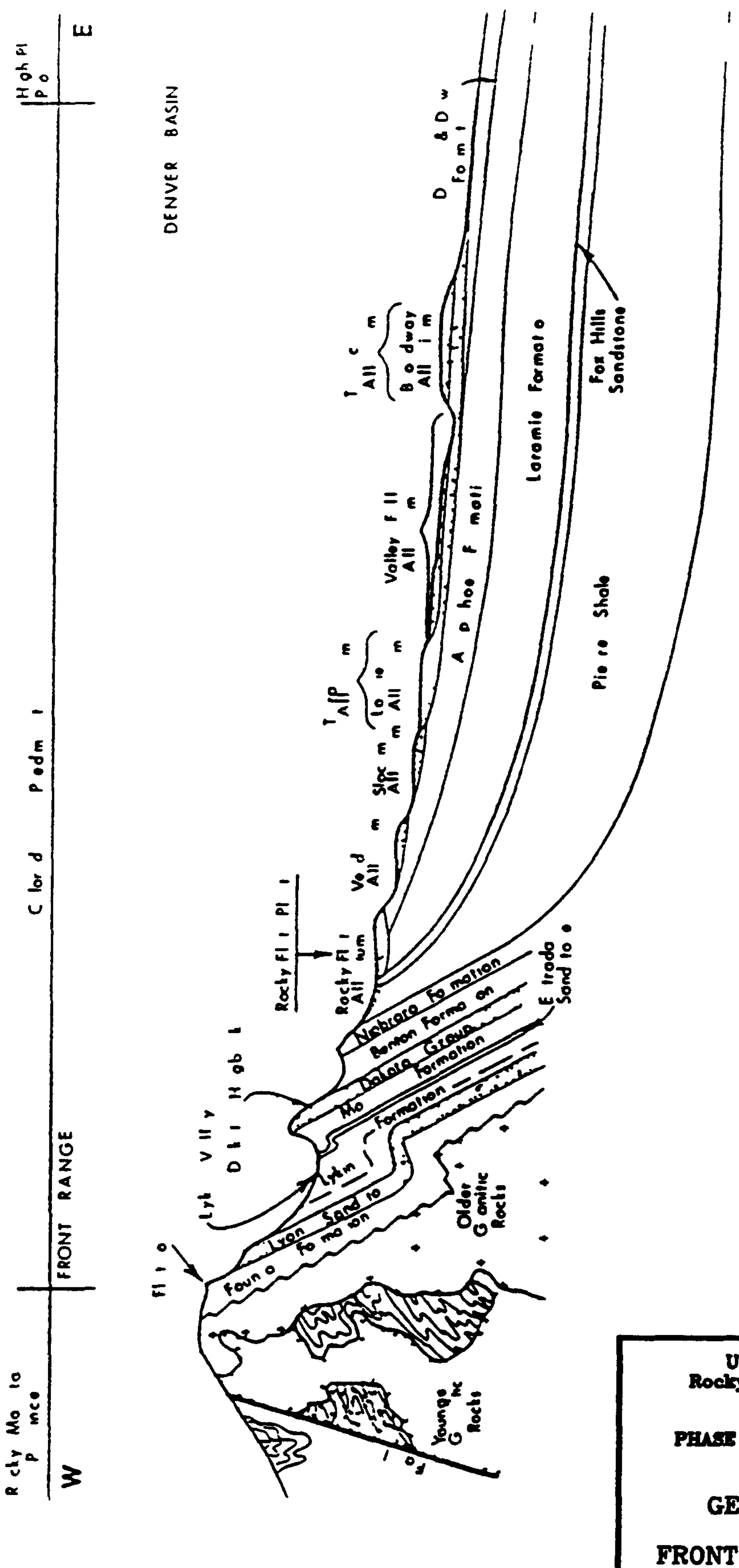
(modified from LeRoy and Weimer 1971)

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

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GENERALIZED STRATIGRAPHIC SECTION OF THE DENVER BASIN BEDROCK

FIGURE 1-4 6/21/91



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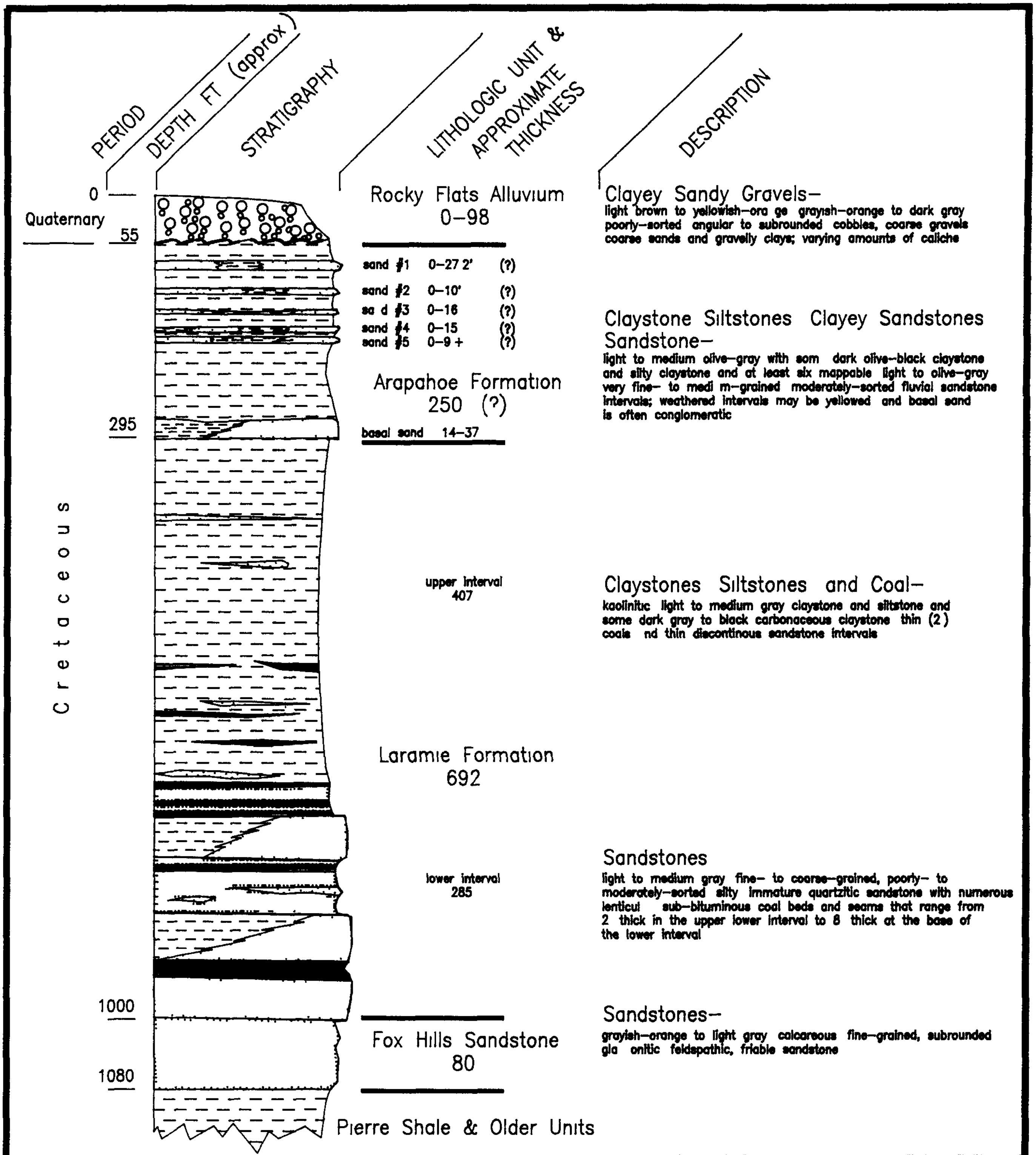
Rocky Flats Plant Golden, Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GENERALIZED EAST–WEST
GEOLOGIC SECTION
FRONT RANGE TO DENVER BASIN

FIGURE 1-5 6-21-91

225781-5



EXPLANATION

Alluvi m	Coal
F'ne–grained & coarse sandston	Fine–grained sa dston
S ltston nd layston	S'lty sandstone

(?) Query ind'cates prelim ry interpretation d mplete data

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

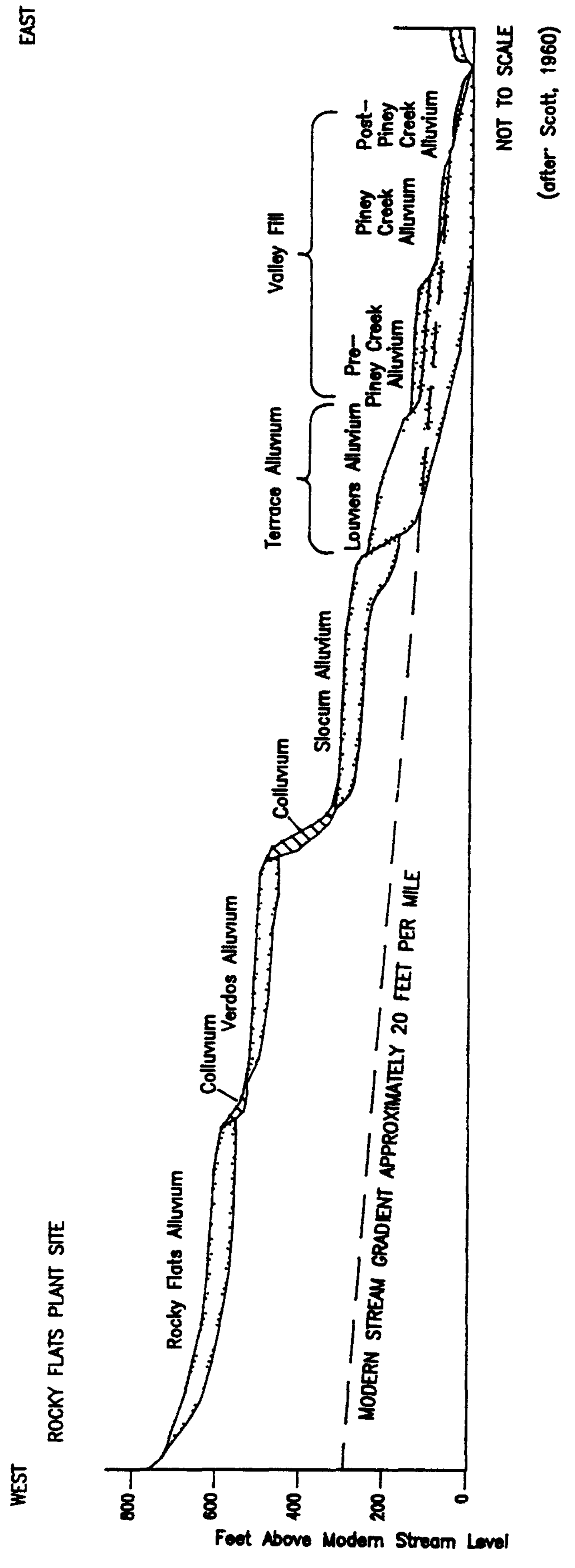
OPERABLE UNIT NO 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

LOCAL STRATIGRAPHIC SECTION OF THE ROCKY FLATS PLANT

FIGURE 1–6

July, 1991

R33151 PJ–080791



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

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE COLORADO

FIGURE 1 7 8/21/91

Arapahoe Formation

The Arapahoe Formation underlies surficial materials beneath the Plant This formation is a fluvial deposit composed of overbank and channel deposits It consists primarily of siltstones and claystones with some silty sandstones beneath the Plant Geologic characterization of the Arapahoe Formation beneath Rocky Flats indicates fluvial channel sequences containing sandstones occur in stream channel shaped structures Total formation thickness varies up to a maximum of 270 feet (Robson et al 1981a) and the unit is nearly horizontal beneath the Plant (less than two degree dip) The channel shaped fluvial sequences within the claystone are composed of predominantly fine grained sands and silts and their hydraulic conductivity is equivalent to or less than that of the overlying Rocky Flats Alluvium The Arapahoe Formation described by the earlier RFI/RI studies contains more clay and silt than typically described for other areas within the Denver Basin There is a remarkable similarity of the siltstones and claystones beneath Rocky Flats to those of the Laramie Formation

The Arapahoe Formation is recharged by groundwater from overlying surficial deposits and infiltration from streams The main recharge areas are under the Rocky Flats Alluvium although limited recharge from the colluvium and valley fill alluvium likely occurs along the stream valleys Recharge is greatest during the spring and early summer when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium are high Groundwater movement in the Arapahoe Formation is generally toward the east although the groundwater flow regime in the bedrock has generally not yet been characterized Regionally groundwater flow in the Arapahoe formation is toward the South Platte River in the center of the Denver Basin (Robson et al 1981a)

Laramie Formation and Fox Hills Sandstone

The Laramie Formation underlies the Arapahoe Formation and is composed of two units a thick upper claystone and a lower sandstone The Laramie Formation is approximately 700 feet thick The upper claystone interval is approximately 400 feet thick and is of very low hydraulic conductivity therefore the U S Geologic Survey (Hurr 1976) concluded that Plant operations will not impact any units below the upper claystone unit of the Laramie Formation

The lower unit of the Laramie Formation and the underlying Fox Hills Sandstone form a regionally important aquifer in the Denver Basin known as the Laramie Fox Hills Aquifer Near the center of the basin the aquifer thickness ranges from 200 to 300 feet These units subcrop west of the Plant and can be seen in clay pits excavated through the Rocky Flats Alluvium The steeply dipping beds of these units west of the Plant (approximately a 50 dip) quickly flatten to the east (less than 2 dip) Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and infiltration along the Front Range (Robson et al 1981b)

1.3.2 4 Meteorology

The area surrounding the Rocky Flats Plant has a semiarid climate characteristic of much of the central Rocky Mountain region Approximately 40 percent of the 15 inch annual precipitation falls during the spring season, much of it as wet snow Thunderstorms (June to August) account for an additional 30 percent of the annual precipitation Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively Snowfall averages 85 inches per year falling from October through May (DOE 1980)

Special attention has been focused on dispersion meteorology surrounding the Plant due to the potential for significant atmospheric releases of contaminants affecting the Denver metropolitan area Studies of air flow and dispersion characteristics (e g Hodgin 1983 and 1984) indicate that drainage flows (winds coming down off the mountains to the west) turn and move toward the north and northeast along the South Platte River valley and pass to the west and north of Brighton Colorado (DOE 1986)

1.3.3 Surrounding Land Use and Population Density

Approximately 50 percent of the area within 10 miles of the Rocky Flats Plant is in Jefferson County The remainder is located in Boulder County (40 percent) and Adams County (10 percent) The area within a two to three mile radius of the plant is primarily undeveloped rangeland Land within a 10 mile radius is used for a variety of purposes including grazing cattle raising horses growing crops such as wheat barley and hay residential development and commercial activities

A recent demographic study shows that approximately 2 2 million people live within 50 miles of the Rocky Flats Plant in 1989 (DOE 1990) Approximately 9 100 people lived within five miles of the Plant in 1989 (DOE 1990) The most populous sector was to the southeast toward the center of Denver Recent population estimates registered by the Denver Regional Council of Governments (DRCOG) for the eight county Denver metro region have shown distinct patterns of growth between the first and second halves of the 1980s Between 1980 and 1985 the population of the eight county region increased by 197,890 a 2 4 percent annual growth rate Between 1985 and 1989 a population gain of 71 575 was recorded representing a 1 0 percent annual increase (the national average) The 1989 population showed an increase of 2 225 (or 0 1 percent) from the same date in 1988 (DRCOG 1989)

There are 8 public schools within 6 miles of the Rocky Flats Plant The nearest educational facility is the Witt Elementary School, which is approximately 2 7 miles east of the Plant buffer zone The closest hospital is Centennial Peaks Hospital, located approximately 7 miles northeast The closest park and recreational area is the Standley Lake area which is approximately 5 miles southeast of the Plant Boating, picnicking, and limited overnight camping are permitted Several other small parks exist in communities within 10 miles The closest major park Golden Gate Canyon State Park, located approximately 15 miles to the southwest provides 8 400 acres of general camping and outdoor recreation Other national and state parks are located in the mountains west of the Rocky Flats Plant, but all are more than 15 miles away

Current commercial development within five miles of the Plant includes several research and development and light industrial businesses located directly south of the Plant and a gravel operation, Western Aggregates Inc on the northwest edge of the Plant s buffer zone In addition, the Jefferson County Airport is located nearly five miles to the northeast (Figure 5) The largest concentration of industrial use land within 10 miles of the Plant includes Coors Brewery which is located eight miles south of the Plant in Golden

Several ranches are located within 10 miles of the Plant primarily in Jefferson and Boulder Counties They are operated to produce crops, raise beef cattle supply milk, and breed and train horses According to the 1987 Colorado Agricultural Statistics 20 758 acres of crops were planted in Jefferson County (total land area of approximately 475 000 acres) and 68 760 acres of crops were planted in Boulder County (total land area of 405 760 acres) Crops consisted of winter wheat corn, barley dry beans, sugar beets, hay and oats Livestock consisted of 5,314 head of cattle 113 hogs, and 346 sheep in Jefferson County and 19 578 head of cattle 2 216 hogs and 12,133 sheep in Boulder County (Post 1989)

1.3 4 Ecology

A variety of plant life thrives within the Plant boundary Included are species of flora representative of tall grass prairie short grass plains lower montane and foothill ravine regions None of these species are on the endangered species list It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years Since the acquisition of the Rocky Flats Plant property vegetative recovery has occurred as evidenced by the presence of disturbance sensitive grass species such as big bluestem (Andropogon gerardii) and sideoats grama (Bouteloua curtipendula) No vegetative stresses attributable to hazardous waste contamination have been identified (DOE 1980)

The animal life inhabiting the Rocky Flats Plant and its buffer zone consists of species associated with western prairie regions The most common large mammal is the mule deer (Odocoileus lemionus) with an estimated 100 to 125 permanent residents There are a number of small carnivores, such as the coyote (Canis latrans) red fox (Vulpes fulva) striped skunk (Mephitis mephitis) and long tailed weasel (Mustela frenata) A profusion of small herbivores can be found throughout the Plant and buffer zone species such as the pocket gopher (Thomomys sp) white tailed jackrabbit (Lepus tounsedii) and the meadow vole (Microtus pennsylvanicus) (DOE 1980)

Commonly observed birds include western meadowlarks (Sturnella neglecta) horned larks (Eremophila alpestris) mourning doves (Zenaidura macroura) and vesper sparrow (Pooecetes gramineus) A variety of ducks killdeer (Charadrius vociferus) and red winged black birds (Agelaius phoeniceus) are seen in areas adjacent to ponds Mallards (Anas platyrhynochos) and other ducks (Anas sp) frequently nest and rear young on several of the ponds Common birds of prey in the area include marsh hawks (Circus cyaneus) red tailed hawks (Buteo jamaicensis) ferruginous hawks (Buteo regalis) rough legged hawks (Buteo lagopus) and great horned owls (Bubo virginianus) (DOE 1980)

Bull snakes (Pituophis melanoleucus) and rattlesnakes (Crotalus sp) are the most frequently observed reptiles Eastern yellow bellied racers (Coluber constrictor) have also been reported on the site but these and other lizards are not commonly observed The western painted turtle (Chrysemys picta) and the western plains garter snake (Thamnophis radix) are found in and around may of the ponds (DOE 1980)

1 4 SITE LOCATIONS AND DESCRIPTIONS

This Bedrock RFI/RI Work Plan addresses Operable Unit 2, which contains the 903 Pad, Mound, and East Trenches areas located on the east side of Rocky Flats security area Several sites are included in each area Figure 1 8 shows the locations of these areas the sites within each area, and the operable unit boundary Each site was assigned a SWMU reference number by Rockwell International (1987c) Since then the SWMUs have been renamed IHSSs however the reference numbers are the same

Site descriptions presented in the following sections are taken from the Rocky Flats Plant CEARP Phase 1 report (DOE 1986) and the RCRA Part B Operating Permit Application (Rockwell International 1987c) as reported in EG&G (1990c) These descriptions are based on historical records aerial photography review and interviews with Plant personnel Further characterization of each site based on other historical reports is also included in the following discussions

1 4 1 903 Pad Area

Five sites are located with in the 903 Pad Area (Figure 1 8) 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)

Descriptions of each site within the 903 Pad Area are provided in the following sections

1 4 1 1 903 Drum Storage Site (IHSS Ref. No. 112)

The 903 Drum Storage Site is located in the eastern portion of the Plant security zone This area was used from October 1958 to January 1967 for storage of radioactively contaminated oil drums (Calkins 1970) Presented below is a description of drums stored at the drum storage site from Calkins (1970)

> Most of the drums transferred to the field were nominal 55 gallon drums, but a significant number were 30 gallon drums Not all were completely full Approximately three fourths of the drums were plutonium contaminated, while most of the balance contained uranium Of those containing plutonium most were lathe coolant consisting of a straight chain hydrocarbon mineral oil (Sell Vitrea) and carbon tetrachloride in varying proportions Other liquids were involved however including hydraulic oils, vacuum pump oil, trichloroethylene perchloroethylene silicone oils, acetone still bottoms etc Originally contents of the drums were indicated on the outside but these markings were made illegible through weathering and no other good records were kept of the contents Leakage of the oil was recognized early and in 1959 or possibly earlier ethanolamine was added to the oil to reduce the corrosion rate of the steel drums

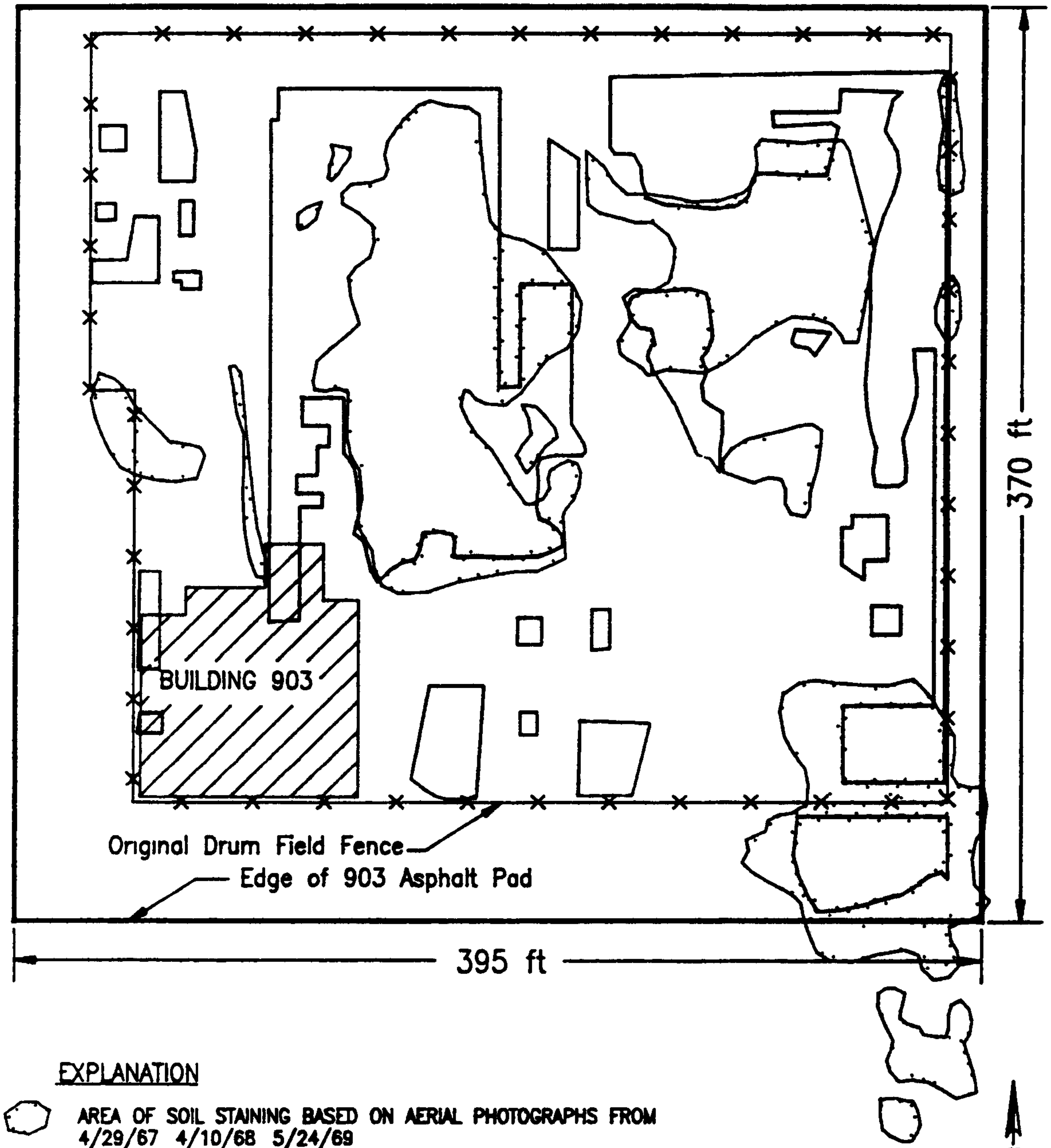
Drum leakage was noted at the 903 Drum Storage Site in 1964 during routine drum handling operations (Dow Chemical 1971) Corrective action consisted of transferring the contents of leaking drums to new drums and fencing the area to restrict access Approximately 420 drums leaked to some degree and, of these an estimated 50 leaked their entire contents An estimated 5 000 gallons of liquid (Freiberg 1970) containing 86 grams (g) [5 3 curies (Ci)] of plutonium leaked into the soil (Dow Chemical 1971) A heavy rainstorm in 1967 spread contaminants to a ditch south and southeast of the drum storage site (Dow Chemical 1971) however the location of the ditch is not provided by this reference

Figure 1 9 outlines drum locations and soil staining at the 903 Drum Storage Site based on a review of historical aerial photography As seen on this figure drum storage occurred primarily in the northern and eastern portions of the area Drums were not stored in the southwest portion, where Building 903 was constructed in 1967 and were only briefly stored at the southeast corner It appears that the drums stored south of the fenced area were placed at this location during cleanup operations as they appear only in the 1968 aerial photos

The shipment of drums to the 903 Drum Storage Site ended in January 1967 when drum removal efforts began Removal of all drums and wastes was completed in June 1968

Presented below is a chronology of the 903 Drum Storage Site cleanup as described by Freiberg (1970)

> From January 23 1967 through March 10 1967 uranium oil drums which were in good condition were transferred to Building 774 and processed



EXPLANATION

AREA OF SOIL STAINING BASED ON AERIAL PHOTOGRAPHS FROM 4/29/67 4/10/68 5/24/69

BARREL STORAGE LOCATIONS BASED ON AERIAL PHOTOGRAPHS FROM 5/5/63 4/29/65 4/29/67 9/10/68

NOTE BUILDING 903 LOCATION BASED ON AERIAL PHOTOGRAPHS FROM 4/10/68.

U S DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden Color d

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

APPROXIMATE LOCATIONS OF DRUM STORAGE 903 PAD DRUM STORAGE SITE

FIGURE 1 9 6/21/91

Buildmg 903 on March 10 1967 started processmg oil drums This buildmg was designated to prefilter the oil prior to transferrmg plutonium contaminated oil to Building 774 for final processmg

- From March 10 1967 through May 18 1967 there were a total of 191 drums of plutonium contaminated oil filtered and shipped to Building 774

On May 18 1967 operations at building 903 were discontinued due to the amount of time this process was taking

- Drum to-drum transfer in the field began May 18 1967 and the drums were [SIC] shipped to Building 774 without prior filtration in Building 903

From March 17 1967 through May 10 1967 in addition to the plutonium transfers there were 297 drums of uranium contaminated Alk Tri waste shipped to Building 774 and processed

May 10 1967 through May 28 1968 a total of 4 826 drums containing 50 gallons of oil each were sent to Building 774 and processed

- In addition to the oil storage area drums there were a total 650 drums from Building 776 current generation sent to Building 774 for processing a pipeline installed from Building 776 to Building 774 eliminated this additional oil drum generation

During the transfer operations it was noted that at the bottom of all drums a deposit of sludge remained after removal of the oil This sludge varied in depth from 1/2 inches to 3 inches and averaged approximately 1 inch By drum counter results the sludge within the empty drums contained a total of 5 152 grams (315 8 Ci) of plutonium These empty drums were later disposed of by adding Oil Dry and MicroCel to absorb the sludge The drums containing the plutonium sludge and absorbent were then incased in plastic, placed in boxes and shipped to the burial grounds [The location of the burial grounds is not provided by Freiberg (1970)]

There were originally a total of 5,237 drums at the drum storage site when cleanup operations began in 1967 After transfer of the contents to new drums, 4 826 drums, of which 3 572 drums contained plutonium contaminated oil, were transported to Building 774 This leaves the contents of 411 drums unaccounted for The most probable explanation for this discrepancy according to Freiberg (1970) is a combination of the following factors

- All of the drums originally sent to the storage site were not completely full
  Some of the volume was taken up by the sludge that was discarded with the empty barrels
- Leakage out of the barrels and onto the ground occurred

Information provided by Freiberg (1970) indicates that an estimated 5 000 gallons of oil leaked from drums onto the ground at the drum storage site This estimate was based on the memory and knowledge of those involved in site operations Based on oil samples taken from barrels, the average plutonium concentration was 4 54 x 10^{3} grams per liter (g/l) [280 pico Curies/liter (pCi/l)] Thus, approximately 86 g (5 3 Ci) of plutonium were released to soils at the drum storage site (Frieberg 1970)

In November 1968 site grading began at the 903 Drum Storage Site in preparation for applying an asphalt cap over the area This work included moving slightly" contaminated soil from around the fenced area to inside the fenced area A total of 33 drums of radioactively contaminated rocks were removed from the area to inside the fenced area (Freiberg 1970) A total of 33 drums of radioactively contaminated rocks were removed from the area in May 1969 and two courses of clean fill material were placed over the site during the late summer of 1969 The asphalt was applied in October 1969 and in February 1970 additional road base course material was applied to soils directly east and south of the asphalt pad due to soil contamination (Freiberg 1970)

The asphalt containment cover is rectangular and oriented north south (370 feet) and east west (395 feet) The pad dips slightly to the northeast at a drop of one foot per 100 feet The asphalt cover is approximately 8 centimeters (cm) (3 2 inches) thick and it is underlain by approximately 15 cm (6 inches) of loose gravel and 8 cm of fill dirt (Navratil et al 1979)

1 4 1.2 903 Lip Site (IHSS Ref. No. 155)

During drum removal and cleanup activities associated with the 903 Drum Storage Site winds redistributed plutonium beyond the pad to the south and east An estimated 1 Ci (16.3 g) of plutonium was redistributed beyond the asphalt pad and, of that 1 Ci, approximately 0.56 Ci (9 1 g) is believed to have been deposited in the 903 Lip Site (Barker 1982) The most contaminated area was immediately adjacent to the pad to the south and southeast Surveys at the time showed a maximum plutonium concentration of 2,258 picoCuries per gram (pCi/g) [5 680 disintegrations per minute per gram (dpm/g)] in the top 5 cm (2 inches) of soil at the 903 Lip Site (Barker 1982)

Soil cleanup efforts were undertaken in 1976 1978 and 1984 to remove plutonium contaminated soils from three different areas within the 903 Lip Site The 1976 soil removal operation began in June 1976 and ended in September 1976 This cleanup consisted of hand excavating contaminated soils from an area in the vicinity of the Reactive Metal Destruction Site until soil contamination levels were below the detection limit of the Field Instrument for Detection of Low Energy Radiation (FIDLER) The detection limit of the FIDLER is 250 counts per minute (cpm) The FIDLER counts are an instrument dependent measure of surface activity and cannot be converted to plutonium concentration in the soil The excavated area was covered with clean top soil and reseeded with native grasses Thirty five boxes, weighing a total of 125 000 pounds were removed and shipped offsite for disposal during the 1976 cleanup (Barker 1982) The offsite disposal location was not provided by Barker (1982) Recent radiological surveys have been conducted to further assess radioactive contamination These include an aerial gamma survey conducted in July 1989 (EG&G 1990e) and a ground based gamma survey conducted in 1990

The 1976 soil removal technique of hand excavation was inefficient considering the large amount of contaminated soils requiring removal at the 903 Lip Site In June 1978 a second soil removal project began north of the 1976 removal using a front end loader alone and in conjunction with a bulldozer All soil that exceeded 2 000 cpm as determined by a FIDLER survey was removed Cleaned areas were resurveyed and soil removal continued until background level readings (approximately 250 cpm by a FIDLER survey) were obtained Topsoil was then applied to the excavated area, and the site was revegetated with native grasses During the 1978 soil removal 1448 boxes weighing approximately 4 7 million pounds, were removed and shipped offsite (Barker 1982) The offsite disposal location was not provided by Barker (1982)

Approximately 0 5 Ci (8 2 g) of plutonium were removed from the 903 Lip Site during the two soil removal projects This quantity is based on an average soil plutonium concentration of 545 pCi/g (1,200 dpm/g) and a soil density of one gram per cubic centimeter (g/cm^3) (Barker 1982)

A third soil cleanup was performed along the eastern edge of the 903 Lip Site in 1984 A total of 214 tri wall pallets of contaminated soil were removed from the area The excavated area was backfilled with clean topsoil (Setlock 1984)

1 4 1.3 <u>Trench T 2 Site (IHSS Ref. No. 109)</u>

Trench T 2 is located south of the 903 Drum Storage Site and west of the Reactive Metal Destruction Site within the 900 Area (Figure 1-6) This trench was used prior to 1968 for the disposal of sanitary sewage sludge and flattened drums contaminated with uranium and plutonium This trench is believed to measure approximately 15 feet wide by 200 feet long by 5 feet deep (Rockwell International 1987c) Barrels were noted in the western end of Trench T 2 during 1987 investigations

1 4 1 4 <u>Reactive Metal Destruction Site (IHSS Ref. No. 140)</u>

The Reactive Metal Destruction Site is located on the hillside south of the 903 Drum Storage Site (Figure 1 6) This site was used during the 1950s and 1960s primarily for the destruction of lithium metal (DOE 1986) Approximately 400 to 500 pounds of metallic lithium were destroyed on the ground surface in this area and the residues primarily lithium carbonate buried (Illsley 1978) Smaller unknown quantities of sodium calcium magnesium solvents and unknown liquids were also destroyed at this location (Illsley 1978)

Based on review of historical aerial photography the Reactive Metal Destruction Site was used from 1968 to 1971 Barrels were noted in the southwestern corner of IHSS 140 during 1987 investigations

1 4 1.5 Gas Detoxification Site (IHSS Ref. No. 183)

Building 952 located south of the 903 Drum Storage Site was used to detoxify various gases from lecture bottles between June 1982 and August 1983 The lecture bottles held approximately one liter of compressed gas each The gases consisted of various types of nitrogen oxides, chlorine hydrogen sulfide sulfur tetrafluoride methane hydrogen fluoride and ammonia, which were used in Plant research and development work Gas detoxification was accomplished by using various commercial neutralization processes available at the time After neutralization, glassware used in the process was triple rinsed, crushed, and deposited in the present landfill The neutralized gases released into the environment during detoxification would no longer be detectable (Rockwell International 1987c)

1 4.2 Mound Area

The Mound Area is composed of four sites (Figure 1-6) 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

1 4.2 1 Mound Site (IHSS Ref. No. 113)

The Mound Site located north of Central Avenue in the eastern Plant security area, was used between April 1954 and September 1958 for drum disposal Approximately 1 405 drums containing primarily depleted uranium and beryllium contaminated lathe coolant (a mixture of about 70 percent hydraulic oil and 30 percent carbon tetrachloride) were placed at the Mound Site (Rockwell International 1987c) [Records do not indicate that the barrels were actually buried (Calkins 1970)] It is likely that some of the coolant also contained enriched uranium and plutonium (Rockwell International 1987c) Some drums also contained Perclene (Smith 1975) Perclene was a brand name of tetrachloroethene (Sax and Lewis 1987) Some of the drummed wastes placed in the Mound Site were in solid form (Rockwell International 1987c)

Cleanup of the Mound Site was accomplished in May 1970 and the materials removed were packaged and shipped to an offsite DOE facility for disposal Listed below is an inventory of the 1 405 drums removed from the Mound Site in 1970 (Dow Chemical 1971)

No. of Drums	Contents
903	30 gallon drums of depleted uranium solid waste
21	30-gallon drums of depleted uranium oil waste
12	30 gallon drums of plutonium contaminated oil waste "The plutonium content was so low that it was measurable only by the most sensitive laboratory techniques (Dow Chemical 1971)
102	55 gallon drums of depleted uranium solid waste
282	55 gallon drums of depleted uranium oil waste
85	55 gallon drums of enriched uranium oil waste
1 405	TOTAL DRUMS

Subsequent surficial soil sampling in the vicinity of the excavated Mound Site indicated 0 8 to 112 5 dpm/g (0 4 to 51 pCi/g) activity This radioactive contamination is thought to have come from the 903 Drum Storage Site via wind dispersion rather than from the Mound Site as it was limited to the surface (Rockwell International 1987c)

1 4.2.2 Trench T 1 Site (IHSS Ref. No. 108)

The trench was used from 1954 until 1962 and contains approximately 125 drums filled with approximately 25 000 kilograms (kg) (55 115 pounds) of depleted uranium chips (Dow Chemical 1971) and plutonium chips coated with small amount of lathe coolant (Rockwell International 1987c) The estimated dimensions of Trench T 1 are 15 feet wide by 200 feet long by 5 feet deep (Rockwell International 1987c) Trench T 1 was covered with about two feet of soil, and the corners were marked (Rockwell International 1987c)

Weed cutting activities in October and November 1968 unearthed two drums inadequately covered with fill material Both drums were sampled and analyzed for total plutonium and uranium contents before they were disposed offsite (Illsley 1983) The offsite disposal location was not provided by Illsley (1983) One of the drums sampled contained an oil water mixture with 55 pCi/l of plutonium and 2.3×10^5 pCi/l of uranium The other drum contained an oily sludge with 4 6 pCi/g of plutonium and 1.2×10^6 pCi/g of uranium (Illsley 1983)

1 4.2.3 Oil Burn Pit No. 2 Site (IHSS Ref. No. 153)

Oil Burn Pit No 2 is actually two parallel trenches that were used in 1957 and from 1961 to 1965 to burn approximately 1 082 drums of oil containing uranium (Rockwell International 1987c) In March and April of 1957 the contents of an estimated 169 uranium contaminated waste oil drums were burned No further burning took place until 1961 Frequent burning of waste oil took place from June 1961 to May 1965 The contents of approximately 914 drums were burned during this time The drums used for the oil burning operation were generally reused however 300 empty drums were discarded by flattening and burying them in the burning pits (Dow Chemical 1971) The uranium concentrations of the burned waste oil is unknown The residues from the burning operations and the flattened drums were covered with backfill In 1978, the area was excavated to a depth of approximately 5 feet and 289 boxes (56 cubic feet per box) of contaminated soil were removed and shipped offsite to an authorized DOE disposal site (Illsley 1983) The offsite disposal location was not provided by Illsley (1983)

1 4.2 4 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 This site was cleaned up and reclaimed in the 1970s (DOE 1986) Two locations for the Pallet Burn Site are shown on Figure 1 8 The westernmost location was reported by Owen and Steward (1973) However based on review of historical aerial photographs there was no disturbance at this western location The eastern location was identified from 1963 and 1965 aerial photography of the area

1 4.3 East Trenches Area

The East Trenches Area consists of nine burial trenches and two spray irrigation sites These sites 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)
	East Spray Irrigation Sites	(IHSS Ref Nos 216.2 and 216.3)

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 south of the east access road The wastes in these trenches have not been disturbed since their burial The spray irrigation areas are located east of Trenches T 5 through T 9 (Figure 1 6)

1 4.3 1 Trenches T 3 through T 11 (IHSS Ref. Nos. 110 and 111.1 111.8)

These trenches as well as Trench T 2, were used from 1954 to 1968 for disposal of approximately 125 000 kg of sanitary sewage sludge contaminated with uranium and plutonium and approximately 300 flattened empty drums contaminated with uranium (Illsley 1983) Radiation content of the sewage sludge ranged form 8 4 x 10^5 dpm/kg (382 pCi/g) to 7 9 x 10^6 dpm/kg (3,590 pCi/g) (Owen and Steward 1973) Total alpha radioactivity in Trenches T 2 through T 8 is estimated to be 100 to 150 milliCuries (0 1 to 0 14 Ci) (Dow Chemical 1971) Trenches T-4 and T 11 also contain some plutonium and uranium contaminated asphalt planking from the solar evaporation ponds (Illsley 1983)

According to Illsley (1983) samples were collected from Trenches T 9 T 10 and T 11, and the results were as follows

> Samples from T 11 contained plutonium in the ranges from 4.5 to 50 pCi/g and uranium 238 in the range between 0 9 and 158 pCi/g Trench T 10 was found to contain uranium in the range between 40 and 126 pCi/g and Pu 239 in the range from 0 18 to 14 pCi/g Plutonium concentrations in collected samples varied from 0 40 to 68 pCi/g and uranium was found in the range between 2 4 and 450 pCi/g in Trench T 9

The sampling dates and collection methods of these samples are unknown

1 4.3.2 East Spray Irrigation Sites (IHSS Ref. Nos. 216.2 and 216.3)

IHSS numbers 216 2 and 216.3 were used for spray irrigation of sewage treatment plant effluent These areas have been designated as IHSSs because effluent containing low concentrations of chromium was inadvertently sprayed in the area in February and March 1989 The chromium entered the sanitary sewage treatment plant on February 3 1989 subsequent to a spill of chromic acid in Building 444 (Rockwell International 1989d)

1.5 PRIOR SITE CHARACTERIZATION

Site characterization activities have been conducted at Rocky Flats over approximately the past 30 years Drilling programs initiated in 1960 resulted in the construction of 56 groundwater monitoring wells Plant wide prior to 1986 At least six of these pre 1986 wells are located within Operable Unit 2 Screen intervals and other construction details of these wells are unknown The six pre 1986 wells and their depths are

Well 171 24 feet deep Well 271 30 feet deep Well 174 24 feet deep Well 374 24 feet deep Well 774 50 feet deep and Well 2274 162 feet deep Other previous activities are listed in Subsection 1.3 1.2 of this work plan

A Phase I RI was conducted in 1986 and 1987 to initiate the second major activity of the ER Program at Rocky Flats Figure 1 10 shows the locations of boreholes drilled and monitoring wells installed in 1986 and 1987 as well as the locations of several monitoring wells installed in 1971 and 1974 Little is known about the construction details of the earlier wells Several figures in Section 2.0 show the area where the majority of the boreholes are located at a larger scale

1.5 1 Phase I Remedial Investigation

A Phase I RI (Rockwell International 1987a) was conducted to initiate the second major activity of the Rocky Flats ER Program at Operable Unit 2

The Phase I RI consisted of the following field activities

- Electromagnetic, resistivity and magnetometer geophysical surveys
- A soil gas survey
- Soil sample collection from 33 boreholes
- Completion of 10 Alluvial and 14 bedrock monitoring wells
- Groundwater sampling of new and previously existing wells
- Slug testing of 13 wells
- Packer testing of cored bedrock wells
- Collection of 22 surface water seep samples
- Air monitoring for total long lived alpha, plutonium and volatile organics during field activities

In addition to the Phase I investigation at the 903 Pad, Mound, and East Trenches areas, several monitoring wells were installed in these areas as part of a Plant wide hydrologic investigation in 1986 (Rockwell International 1986e) Surface water soil, and air samples have also been collected at these areas as part of various investigations The Phase II RFI/RI Work Plan (Alluvial) presents a more complete summary of the Phase I RI than this bedrock work plan does This work plan presents data from the Phase I RI and other previous work that are pertinent to bedrock characterization Radiological surveys of the ground surface have also been conducted, the results of which are presented in the alluvial work plan These included a survey of the 903 Pad in 1968 and an aerial radiological survey of the entire plant (EG&G 1990e) In addition further ground based radiological measurements were obtained in summer/fall 1990 the results of which are not yet published

1.5.2 Recent Geologic Characterization

Subsequent to the draft Phase I RI report EG&G identified inconsistencies in the methods that had been used for logging geologic materials and interpreting geologic data As a result a project was initiated to develop a geologic characterization of the Rocky Flats Plant by conducting a literature review reclassifying previously obtained samples using standardized procedures conducting further laboratory testing on previously obtained samples processing seismic data, and then reinterpreting the geology based on all available data

Interim results of this ongoing study are presented in a draft report (EG&G 1990a) However that report is a working draft which has not been prepared for distribution That report presents summaries of stratigraphy and structural geology of the area and regions, the current working model of Plant geology conclusions based on the working model and recommendations for further work required to continue the ongoing characterization Data and summaries of the data pertinent to bedrock in Operable Unit 2 are presented in figures and tables and in Appendix A to this work plan

Shallow high resolution seismic reflection profiling (EG&G 1990b) has been conducted to supplement the ongoing geologic characterization efforts A primary focus of the seismic work has been to delineate both subcropping and confined channel shaped fluvial sequences containing sandstone in the predominantly claystone Arapahoe Formation bedrock The study involved obtaining, reducing, and interpreting data from 14 seismic reflection lines in the Operable Unit 2 area That report is also a working draft which is not prepared for distribution

1.5.3 Phase II RFI/RI Work Plan (Alluvial)

The Phase II RFI/RI Alluvial Work Plan (EG&G 1990c) presents detailed summaries of data obtained during the Phase I RI However both the data and the discussion of site hydrogeology and nature and extent of contamination concentrate on the geologic materials and groundwater contained in the upper HSU The FSP contained in the alluvial work plan addresses the investigation of the upper HSU (subsurface sediments above the conceptual boundary shown in Figure 1 1)

This section describes the current understanding of the bedrock physical characteristics the nature and extent of contamination, and potential bedrock pathways to human receptors or the environment in Operable Unit 2 Existing data were obtained from previous site investigations as summarized in Subsection 1.5 The description of site characterization presented in this work plan includes excerpts from the Alluvial Work Plan (EG&G 1990c) but it concentrates on the assimilation of data pertinent to characterizing the bedrock Much of the bedrock data were included but not evaluated in the alluvial work plan The description of site physical characteristics and nature and extent of contamination presented in Subsections 2 1 and 2 2, respectively were combined to develop a site conceptual model, Subsection 2.3

2 1 SITE PHYSICAL CHARACTERISTICS

The physical characteristics of the region and plant site are presented in Subsection 1.3 Site locations and descriptions including historical accounts of site activities are presented in Subsection 1 4 This section of the work plan summarizes existing subsurface data and presents the current working model of the site geohydrology emphasizing bedrock geology and the hydrostratigraphic unit(s) (HSU[s]) underlying the upper HSU

2 1 1 Geology

2 1 1 1 Surficial Geology

Surficial materials at the 903 Pad, Mound, and East Trenches areas consist of the Rocky Flats Alluvium colluvium and valley fill alluvium unconformably overlying bedrock (Figure 2 1) The area is situated on a pediment of Rocky Flats Alluvium that extends eastward from the Plant The Rocky Flats Alluvium consists of a poorly to moderately sorted, poorly stratified deposit of clays silts sands, gravels and cobbles A portion of the 903 Pad Area extends south off the pediment toward the South Interceptor Ditch Colluvium is present on the hillside south of the 903 Pad and East Trenches areas and on the hillside north of the Mound and East Trenches areas Valley fill alluvium is present in the drainage of Woman Creek south of the 903 Pad and East Trenches areas and in the South Walnut Creek drainage north of the Mound Area

Buried pediment drainages and ridges eroded into the Arapahoe Formation bedrock surface are present at the base of the Rocky Flats Alluvium (Figure 2 2) A relatively small pediment drainage is present starting near the southeast corner of the Mound Area and extending southeast where it is truncated by the hillside A larger pediment drainage starts south of the west end of the East Trenches and trends northeast, traversing the central portion of the East Trenches A bedrock ridge is present on the north side of this pediment drainage starting in the Mound Area and trending east northeast across the northwest portion of the East Trenches Area A topographic high in the bedrock surface occurs on the south side of the larger pediment drainage just south of the central portion of the East Trenches

2 1 1.2 Bedrock Geology

Significant work has been conducted recently to refine the characterization of the bedrock at Rocky Flats An ongoing geologic characterization program addressing Rocky Flats (EG&G 1990a) is in progress based on a comprehensive literature search, reprocessing and describing previously obtained core samples reprocessing previously obtained seismic data, and collecting and analyzing selected samples for grain size analyses The geologic characterization is an on going program that will incorporate all geologic information Plant wide for continued refinement of the working geologic model The referenced report is a draft internal working document Data and results of this characterization that are pertinent to the Operable Unit 2 bedrock are presented in this work plan In addition to these efforts, high resolution seismic reflection profiling was conducted in the Operable Unit 2 area (EG&G 1990b) This report is also an internal working draft document therefore pertinent data are summarized in this work plan The geologic interpretations presented in this work plan are based on information from Hurr (1976) and on the ongoing geologic characterization study These interpretations may be revised as more data are obtained during the Phase II Geologic Characterization and the bedrock componet of the Phase II RFI/RI

The Cretaceous age Arapahoe Formation underlies surficial materials at the 903 Pad, Mound and East Trenches areas The high resolution seismic reflection program indicated that the Arapahoe Formation dips at less than 2 degrees to the east The Arapahoe Formation, which is approximately 250 feet thick in the vicinity of the Plant consists of fluvial claystones with interbedded sandstones, siltstones, and occasional lignite deposits Contacts between these lithologies are both gradational and sharp

Fining upward graded sandstone sequences within the Arapahoe Formation are representative of both laterally accreted point bar deposits and floodplain splay deposits Laterally accreted point bar deposits occur by the slow migration of fluvial channels and splay deposits are formed by breaching of channel banks during floods (Blatt et al 1980) Overbank flood deposits consist of very fine sand and mud deposited near the stream channel or on the stream flood plain Channel fill deposits are formed in abandoned channels by a reduction in stream discharge or by cutoff of a meander (formation of oxbow lakes) (Blatt et al 1980)

Based on previous investigations and on the on going geologic characterization by EG&G bedrock in the 903 Pad Mound and East Trenches areas is predominantly claystone (EG&G 1990c) However six channel sandstone intervals have been preliminarily identified beneath the Rocky Flats Plant These are general stratigraphic intervals each of which contains sandstone only at some locations They have been sequentially numbered according to increasing depth Thus Arapahoe Sandstone No 1 is the uppermost sandstone which subcrops in many areas Arapahoe Sandstone No 6 is present at or near the base of the Arapahoe Formation

Generally the Arapahoe Sandstones that occur within 30 to 40 feet of the base of the alluvium are oxidized and are pale orange yellowish gray and dark yellowish orange The sandstones that are not in the weathered zone are light gray and olive gray Most of the sandstones are very fine to medium grained poorly to moderately sorted subangular to subrounded silty clayey and quartzitic, with trough and planar cross stratification The claystones and silty claystones are light to medium olive gray occasionally olive black with some dark yellowish orange claystones in the weathered intervals near the base of the alluvium The yellowish orange and yellowish brown color is the result of the iron oxide staining

The geologic characterization study to date has included mapping the estimated areal extent of Arapahoe Sandstone Nos 1 3 and 4 In the context of this geologic model these sandstone deposits are fluvial sequences composed of predominantly fine grained sands and silts with some clays They are channel deposits that are aggregated or stacked together in a zone in the subsurface rather than a single channel Therefore the sandstones shown do not all necessarily classify as sand by soil classification methods The lateral extent of these channel shaped fluvial sequences in each of the lithologic intervals 1 3 and 4 was estimated based on previous borehole information Figure 2 3 shows the estimated lateral extent and thickness isopachs of the Arapahoe Sandstone No 1 and Figures 2 4 and 2 5 show the estimated lateral extents of the Arapahoe Sandstone Nos 3 and 4 Sandstone was also found in the Numbers 2 and 5 intervals in several boreholes in the Operable Unit 2 area However there was not sufficient information to estimate the lateral extent of sandstones within these intervals Figures 2-6A and 2-6B 2 7A and 2 7B and 2 8A and 2 8B show cross sections depicting the Arapahoe Sandstone intervals along three alignments through the Operable Unit 2 area The alignments A A B B and G G are shown in Figures 2 3 2 4 and 2 5 These sections are from the draft Geologic Characterization Report (EG&G 1990a)

Significant areas of the Arapahoe Sandstone No 1 are known to subcrop beneath the Rocky Flats Alluvium in the 903 Pad Mound and East Trenches areas It is believed that nearly the entire area shown as the Arapahoe Sandstone No 1 subcrops beneath the Rocky Flats Alluvium Based on the cross sections shown in Figures 2-6A 2-6B 2 7A, 2 7B 2 8A and 2 8B the Arapahoe Sandstone Nos 2, 3 and 4 may subcrop in localized areas of the hillside to the south and southeast of the 903 Pad Area As a result of the significant areal extent of subcropping Arapahoe Sandstone No 1 and since significant contamination has been found in this uppermost sandstone interval all of the Arapahoe Sandstone No 1 is presumed to be within the upper HSU

Therefore the conceptual boundary between the alluvial and bedrock components of the RFI/RI passes beneath the Arapahoe Sandstone No 1 Figure 1 1 shows the conceptual boundary between the alluvial and bedrock components of the RFI/RI Although there are areas where the lower sandstone units may subcrop beneath colluvium on the valley slopes the areal extent of these subcrops is estimated to be relatively small and the sandstone units are not considered to be in the upper HSU Therefore they will be treated as part of the bedrock component of the RFI/RI

High resolution seismic reflection profiling (EG&G 1990b Rockwell International 1989g) was conducted to help refine the working model of the bedrock geology particularly in the Operable Unit 2 area There are some differences between the geologic model presented in this work plan and the high resolution seismic reflection profiling report in the estimated thickness and areal extent of the Arapahoe Sandstone No 1 Since the Arapahoe Sandstone No 1 is considered to be within the upper HSU further characterization of it and resolution of differences between the geologic characterization and high resolution seismic profiling results will be part of the alluvial RFI/RI activities

In general the high resolution seismic reflection profiling was not conducted in the areas where the Arapahoe Sandstone Nos 3 and 4 are indicated by the interim geologic characterization results Therefore it was not determined by the seismic work conducted to date whether there may be relatively large and continuous channel shaped fluvial sequences containing sandstone within these lithologic intervals as depicted in Figures 2 4 and 2 5 or whether the occurrence of fluvial channel sequences in these intervals is more localized and discontinuous The high resolution seismic reflection profiling report indicated the presence of two relatively small areas of relatively thick sandstone containing deposits The areal extents of these sandstones are shown in Figures 2 4 and 2 5 and the depths and thicknesses indicated by seismic results are shown in section in Figure 2 8A They are indicated to be 50 to 60 feet thick, compared to the 10 to 20 foot thickness generally indicated for the intervals described by the draft geologic characterization However the interpretation of the seismic data is based to a large extent on estimates of seismic velocities The investigation described in this work plan includes boreholes and geophysical logging at these locations to help correlate seismic velocities with lithology The ongoing geologic characterization by EG&G may include further work to assist in refining these interpretations There appears to be a potential for the sandstones inferred from the seismic work to correspond to the Arapahoe Sandstone Nos 3 through 5 intervals

Table 2 1 presents a tabular summary of lithology well screen intervals and the depth of the contact between the alluvial and bedrock components of the RFI/RI based on wells and boreholes drilled into the bedrock Data on which this table is based are presented in Appendix A, an excerpt from the geologic characterization report This information, along with the bedrock surface elevations in Figure 2 2 and Arapahoe Sandstone No 1 isopachs shown in Figure 2 3 was used to develop a contour map of the base of the upper HSU (Figure 2 9) Note that based on Figure 1 1 the depth to the contact between work plan components is 5 feet lower than the upper HSU bottom surface shown in Figure 2 9

TABLE 2 1

SUMMARY OF BOREHOLES AND WELLS IN OPERABLE UNIT 2 USED FOR BEDROCK WORK PLAN

W ll/Borehole Designatio	Ground Elevation	W ll or Borehole	Depth t Bedrock	Thickness f SS #1	Depth Contact between Alluvial and Bedrock RI	Screened Depth Int rval/ Lithology/HSU	LITHOLOGY** SS #1	SS #2	SS #3	SS #4	SS #5	Total Depth
2686	5974.48	W	10.5		15.5	4.0-13.5/AL/U						17.0
3486	5910.44	W	15 9		20.9	44.2-56.2/SS#3/L			48.0-54.0			100 0
4086	5941.23	W	45.0		50.0	88.0-111.5/CS/L		90 1 102.1	118.0-122.0			124.8
4186	5940 03	W	44 6		49.6	3 9-44 7/AL/U						44.8
4286	5954.34	W	28.3		33.3	6.1 29 7/AL/U						35 0
5986	5914.32	W	7.5		12.5	19.0-28.0/SS#3/L			20.0-23.5			32.5
6286	5897.54	W	22.0		27.0	25.2-35.2/SS#3/U			25.3-33.0	40.3-47.3	50-59.2	59.3
6386	5896.55	W	14.8		19.8	3.8-15.2/AL/U						17.3
287	5930.56	W	7.25		12.25	3.2-9 1/AL/U						16.0
0387BR	5930.58	W	20.8		25.8	102.8-107.8/CS/L			28.0-31.0			117.0
0587BR	5927 76	W	11.0		16.0	42.0-51.2/SS#3/L			45 7 51.0			61 0
687A	5898.22	B	5.2		10.2	ABANDONED			12.2-26.8	30.0-32.6		32.6
787BRA	5928.21	B	6.0		11.0	ABANDONED			38.6-47.6			47.5
887BR	5919 70	W	8.7		13 7	84.0-89.0/CS/L			18.9-31.2			106.0
987BR	5980.22	W	12.7	19.2	36.9	14.5-32.2/SS#1/U	12.7 31 9					37.5
1087	5981.96	W	11.3	5 7	22.0	3.5-12.0/AL/U	11.3-17 0					17 0
1287BR	5934 74	W	3.5		8.5	4.9-10.0/CS/U						15 9
1487BR	5855.00	W	5.2		10.2	19.0-24.0/SS#5/L				9-12.5	19-25.5	25.5
1587	5970.89	W	21.9		26.9	5.8-22.1/AL/U						27.0
1687BR	5969.06	W	22.2		27.2	100.0-125.0/SS#3/L			100.5-117.0		140.5-144.5	174.0
1787	5967.56	W	25.0		30.0	3.5-25.5/AL/U						30.3
1887BR	5967.38	W	25.2		30.2	127.0-133.5/SS#4/L			109.2-117.2	127.0-133.2		147.0
2087BR	5968.10	W	11.8		16.8	107.3-116.1/SS#3/L			107.3-116.3			126.2
2187	5927.58	W	8.0		13.0	3.3-10.4/AL/U						17.0
2287BR	5930.70	W	12.8		17.8	81.0-89 1/SS#4/L				83.8-87.8	96.0-101.0	111.0
2387BR	5972.34	W	15.2	17.5	37 7	17.2-37 6/SS#1/U	15.2-32.7					45.3
2487	5957 79	W	15 1		20 1	3.5-13.6/AL/U						18.3
2587BR	5958.91	W	16.5	27.2	49 7	17.5-43.5/SS#1/U	17.5-44 7					47.0
2787	5947.52	W	44.2		49.2	3.5-43 0/AL/U						47 7
2887BR	5947 17	W	43.5		48.5	187.4 197.4/CS/L			109.0-118.0			207 0

TABLE 2 1
SUMMARY OF BOREHOLES AND WELLS IN OPERABLE UNIT 2 USED FOR BEDROCK WORK PLAN
(Continued)

W ll/Borehole Designa ion	Ground Elevatio	W ll or Borehole	Depth t Bedrock	Thickness f SS #1	Depth t C act between Alluvial and Bedrock RI	Screened Depth I erval/ Lithology/HSU**	LITHOLOGY** SS #1	SS #2	SS #3	SS #4	SS #5	Total Depth
3087BR	5811.87	W	16.0		21 0	85.8-94.4/CS/L						110.0
3187BR	5945 02	W	45.0		50 0	110 7 129 4/SS#3/L			112.5-129.0			140.0
3287	5946.12	W	46.2		51.2	36.0-46.6/AL/U						51.3
3387	5945.27	W	19.0		24.0	15 0-20.0/AL/U						24.5
3487BR	5945.21	W	20.0		25 0	97.3-104.3/CS/L			100 7 109.2			124 0
3587	5949.36	W	9 1		14 1	3.5-9.3/AL/U						14.4
3687BR	5949.04	W	7.4	43 0	68.0	19.8-63.4/SS#1/CS/U	20.0-63 0					74.5
4487	5949.53	W	3.2		8.2	1.5-3.5/AL/U						7 0
4587BR	5949.42	W	4 0		9.0	89.5-101 1/SS#5/L					95.8-99.8	112.0
4987	5912.68	W	9.0		14 0	1.8-4.8/AL/U						10.0
5087	5933.21	W	12.5		17.5	3.5-13.5/AL/U		14.5-27.0				27.0
5689BR(B217489)	5961.20	W	25.0	31 7	76.1	142.0-148.7/CS/L	39.4-71 1				142.5-146.2	220.0
5789BR(B217589)	5952.90	W	17.3	10 0	61 0	85.2-92.9/SS#4/L	46.0-56.0					221.3
5889BR(B217689)	5960.50	W	22.0	32.0	59.0	98.5-105 1/SS#4/L	22.0-54 0				212.0-?	220 1
6089BR(B217789)	5954.90	W	23.6		28.6	72.0-86.0/CS/L		101.7 105 1				220.0
BH587	5954.20	B	4.5		9.5							13.0
BH1787	5956.00	B	5.25		10.25							12.4
BH2287	5978.50	B	22.2		27.2							27.2
BH2387	5964.20	B	8.0		13 0							12.5
BH2487	5953.60	B	4.9		9 9							12.3
BH2587	5953.20	B	14.8		19.8							25.2
BH2787	5944 70	B	9.9		14 9							17.0
BH2887	5946.70	B	5.9		10.9							15 0
BH3187	5973.80	B	7.6	2.2	15.2		8.0-10.2					15 9
BH3287	5971 70	B	7 7	6.9	19.6		7 7 14.6					20.5
BH3387	5967.90	B	9.2	4.3	20.3		11.0-15.3					20.8
BH3487	5971.40	B	16.7	8.0	29 7		16.7 24 7					24 7
BH3587	5970.50	B	14.3	6.0	25.3		14.3-20.3					20.3
BH3687	5969.40	B	20.6		25 6							26.0

TABLE 2 1
SUMMARY OF BOREHOLES AND WELLS IN OPERABLE UNIT 2 USED FOR BEDROCK WORK PLAN
(Continued)

W ll/Borehole Designatio	Ground Elevation	Well or Borehole	Depth t Bedrock	Thickness f SS #1	Depth Contact betwee Alluvial and Bedrock RI	Screened Depth Interval/ Lithology/HSU	LITHOLOGY** SS #1	SS #2	SS #3	SS #4	SS #5	Total Depth
BH3787	5968.80	B	14.0	6.3	33.0		21 7 28.0					28.0
BH3887	5965.30	B	14.6		19 6							23.9
BH3987	5956.90	B	14.5	7.5	27.0		14.5-22.0					22.0
BH4087	5953 70	B	8.0		13.0							14.5
BH4187	5950.20	B	15 0		20.0							19.5
BH4287	5950.50	B	24.0	26.8	55.8		24 0-50.8					55.5
BH4387	5956.50	B	27.2		32.2							34 7
BH4487	5956.10	B	27.0	6.2	38.2		27.0-33.2					34.5
BH4587	5952.70	B	20.0	20.0	45.0		20 0-40.0					40 0
BH4687	5952.60	B	27.0		32.0							32.0
BH4787	5951.40	B	26.2		31.2							28.2
BH4887	5949.40	B	13.2		18.2							17.3
BH4987	5953.00	B	22.0		27.0							25.8
BH5087	5949.20	B	12.0		17 0							19.5
BH5587	5944.90	B	37.0		42.0							39.5

All depths and elevations reported in feet

HSU Hydrostratigraphic Unit
U Portion of well screen or entire well screen in upper HSU
L Entire well screen in lower HSU( ) based on boundary between alluvial" and "bedrock" components f RFI/RI bown in Figure 1 1

** SS#1 Arapahoe Formation Sandstone Number 1
SS#2 Arapahoe Formation Sandstone Number 2
SS#3 Arapahoe Formation Sandstone Number 3
SS#4 Arapahoe Formation Sandstone Number 4
SS#5 Arapahoe Formation Sandst ne Number 5
CS Arapahoe Formation Claystone/Siltst ne

2 1.2 Groundwater Hydrology

Unconfined groundwater flow occurs in the surficial materials and in subcropping sandstones In addition subcropping claystones may be saturated in some locations particularly where weathered and fractured Confined groundwater flow occurs in the lower sandstone units and possibly in saturated zones of claystone with sufficient hydraulic conductivity The majority of wells that have been installed in weathered claystone throughout the Plant are in unsaturated zones and are typically dry

2 1.2 1 Groundwater Flow System in Upper HSU

Recharge/Discharge Conditions

Groundwater is present under unconfined conditions in the Rocky Flats Alluvium colluvium valley fill alluvium and subcropping sandstones Recharge to the upper HSU occurs from infiltration of incident precipitation and as seepage from ditches, creeks, and ponds The shallow groundwater flow system is dynamic with large water level changes occurring in response to precipitation events and stream and ditch flow Alluvial water levels are highest during the spring and early summer months of May and June Water levels generally decline during the second half of the year at which time some wells go dry The shallow groundwater flow system supports ephemeral flow in the creeks

Alluvial groundwater discharges from seeps to colluvium in surface water drainages and to subcropping Arapahoe Sandstone in the 903 Pad Mound and East Trenches areas Seeps occur along the edge of the pediment (at the alluvium/bedrock contact) and on the hillside slopes Visible seeps on the hillsides may be due to thinning of colluvial materials There are several seeps downslope to the southeast of the 903 Pad Surface water stations established at these seeps in the 903 Pad Lip Area are designated SW 50 SW 51 SW 52 SW 55 SW 57 SW 58 and SW 77 Figure 2 10 shows the locations of these seeps 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 Overland flow of seepage from SW 50 SW 52, and SW 57 enter the ditch 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 just north of SW 55 It is noted therefore that SW 51 SW 58 and SW 55 are physically connected and likely receive flow from SW 50 SW 52 and SW 57 Farther downgradient stations include seeps at SW 53 SW-62, SW-63 and SW-64 SW 27 SW 30 SW 54 and SW 70 on the South Interceptor Ditch and SW 26 SW 28 and SW 29 on Woman Creek Ground water in valley fill materials discharges to Woman Creek or South Walnut Creek the average linear velocity of groundwater in Woman Creek valley fill is 145 ft/yr (Rockwell International 1987a) Estimates of average linear velocity of the groundwater range from about 10 to 620 ft/yr based on the range of hydraulic conductivity values (EG&G 1990c)

South Walnut Creek valley fill is less conductive than that along Woman Creek, based on lithologic descriptions and hydraulic conductivity tests of Well 3586 A drawdown recovery test and a slug test have been performed in Well 3586 The hydraulic conductivity of South Walnut Creek Alluvium calculated from the drawdown recovery test was 9×10^{-5} cm/s Results of the slug test indicated a hydraulic conductivity of 1×10^{-4} cm/s Assuming a mean conductivity of 9.5×10^{-5} cm/s an effective porosity of 0 1 and an average gradient of 0 02 ft/ft the average linear velocity of groundwater in South Walnut Creek valley fill is estimated to be about 20 ft/yr (Rockwell International 1987a)

The estimated average linear velocities of groundwater calculated for various surficial materials assume the materials are fully saturated year round However as discussed above portions of the Rocky Flats Alluvium colluvium and valley fill alluviums are not saturated during the entire year In some areas the shallow groundwater flow occurs only nine months of the year (generally November through July) Thus in such areas the resultant average linear velocity of groundwater calculated as a yearly estimate would be reduced in the shallow alluvial materials (approximately 65 ft/yr in Rocky Flats Alluvium 110 ft/yr in Woman Creek valley fill alluvium and 15 ft/yr in South Walnut Creek valley fill alluvium [EG&G 1990c])

2 1.2.2 <u>Confined Groundwater Flow System(s)</u>

Flow within the lower sandstones is believed to generally be from west to east, consistent with the gradual easterly dip of the bedrock however the geometry of the sandstone units and the groundwater flow paths in the bedrock are not well understood at this time Also there is not sufficient information to estimate groundwater flow rates in the lower sandstones To estimate flow rates would require knowledge of hydraulic gradients within the individual sandstone units and further characterization of hydraulic conductivity and effective porosity values in the bedrock units

The results of packer tests conducted in the bedrock during the Phase I RI generally indicate low values of hydraulic conductivity on the order of 1×10^{-8} to 1×10^{-6} cm/sec, in both the unweathered sandstones and claystone Although not supported by the available packer test data, geologic descriptions and particle size data on the sandstone and claystone appear to indicate that higher confined groundwater flow rates occur in the fluvial sequences containing sandstones and siltstones than in the claystones Slug tests conducted in wells screened in the unconfined Arapahoe Sandstone No 1 indicated higher hydraulic conductivities in the range of 5×10^{5} to 1×10^{3} cm/sec (Well 0987) (data presented in appendices to Rockwell International 1987a)

Figures 2 12 through 2 20 present well hydrographs for selected wells located near each other These hydrographs demonstrate that relatively high apparent downward gradients generally occur in the Arapahoe Formation across the site The lowest apparent vertical gradient shown in Figures 2 12 through 2 20 was calculated to be approximately 0 33 between Well 5986 which is screened in the Arapahoe Sandstone No 3 and Well 0887 which is screened in claystone at depths between 84 and 89 feet These two wells are located in the 881 Hillside area to the west of the southwest corner of Operable Unit 2

The relatively high apparent vertical hydraulic gradient in the bedrock indicates that flow which occurs in the unweathered claystone will tend to be predominantly in a downward direction Steep downward vertical gradients are often found in the topographically elevated portions of groundwater flow systems where the shallow surface materials are relatively high in hydraulic conductivity (which typically leads to high rates of infiltration of precipitation) and the deeper strata are relatively low in hydraulic conductivity Based on the geologic description of the unweathered claystones at this site it is currently believed that the downward flow of groundwater through the claystones will be impeded by the low hydraulic conductivity of these deposits The groundwater flow rates through the claystone are expected to depend primarily on the degree of weathering or fracturing (i e secondary hydraulic conductivity) rather than on the porosity and permeability in the pore spaces between individual soil particles (i e primary effective porosity and hydraulic conductivity)

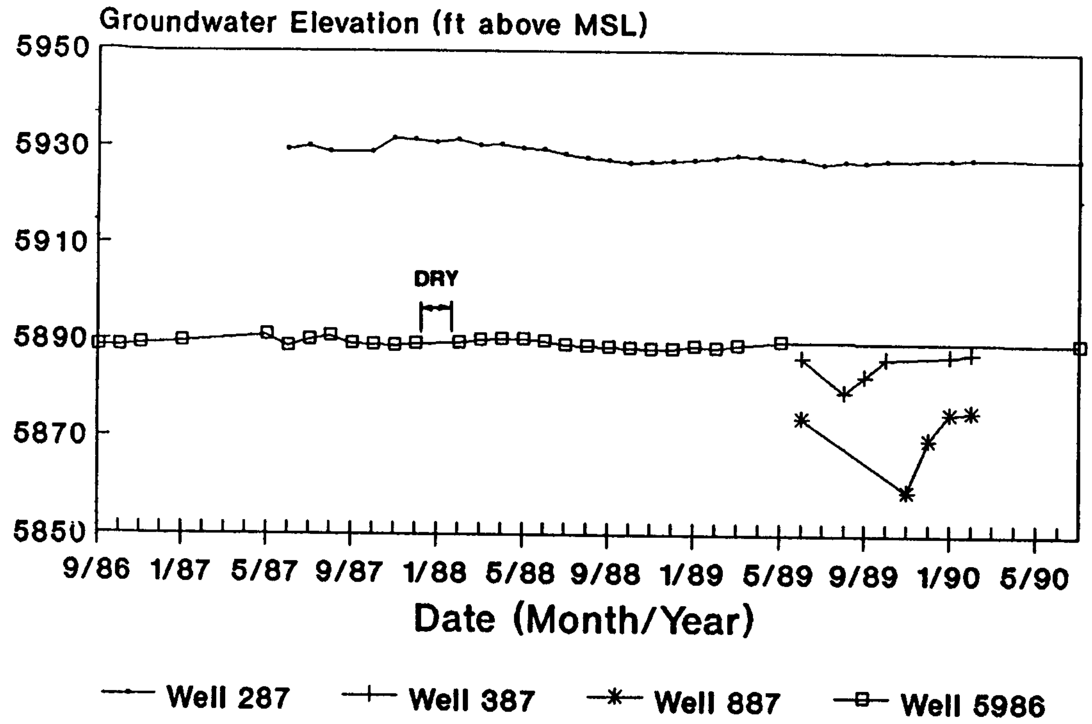
2 1.3 Surface Water Hydrology

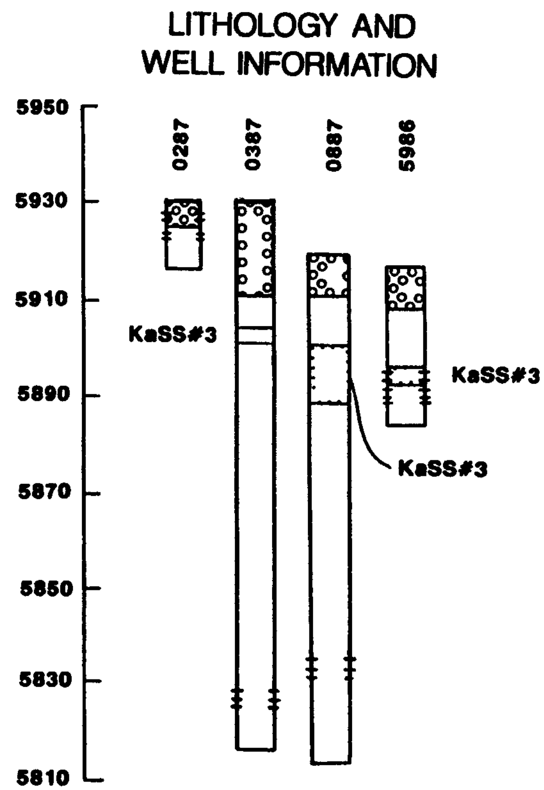
2 1.3 1 <u>South Walnut Creek</u>

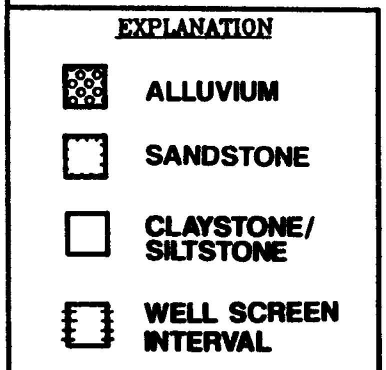
The headwaters of South Walnut Creek were filled during construction of Plant facilities The drainage from the Central Avenue area between the 903 Pad Area and the Mound Area is diverted into a large diameter corrugated metal pipe that discharges into South Walnut Creek beneath a perimeter access road embankment outside of the Perimeter Security Zone (PSZ)

A second culvert is a large diameter concrete culvert that diverts storm flows from the area east of Building 991 within the PSZ to South Walnut Creek This concrete culvert also discharges beneath the perimeter access road and into the South Walnut Creek drainage

A third culvert diverts flows from the western part of the PSZ to a point downstream of the two culverts described above The third culvert terminates near the sewage plant discharge channel in South Walnut Creek The combined flows, typically less than 10 gallons per minute (gpm) based on flow data from the first three quarters of 1989 then enter the South Walnut Creek retention pond system Below the retention ponds South Walnut Creek joins North Walnut Creek and an unnamed tributary within the buffer zone before flowing into Great Western Reservoir located approximately one mile east of this confluence



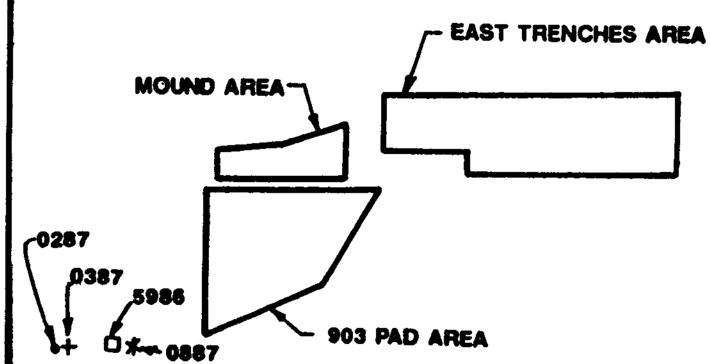




APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
0287 0387	0 48	28
0887 5986	0.33	28

* GRADIENTS ARE POSITIVE DOWNWARD



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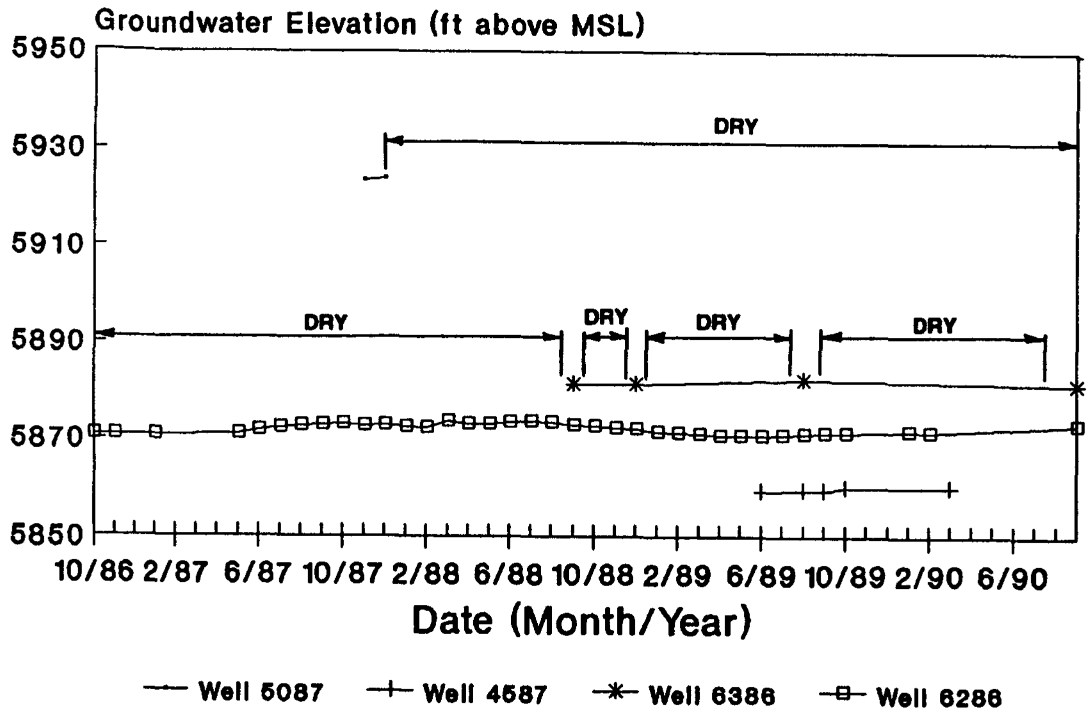
Rocky Flats Plant, Golden Colo do

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

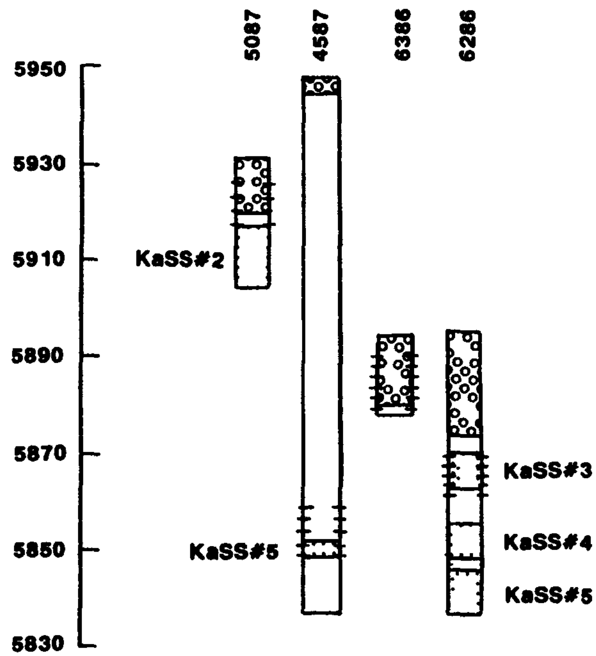
WELL HYDROGRAPHS
(LOWER 881 HILLSIDE)

Figure 2 12

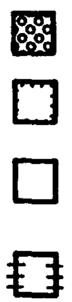
6/21/91



LITHOLOGY AND WELL INFORMATION



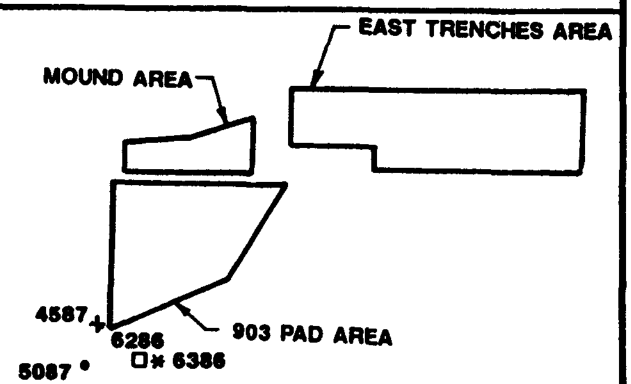
EXPLANATION



APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
6386-6286	0 94	29

GRADIENTS ARE POSITIVE DOWNWARD



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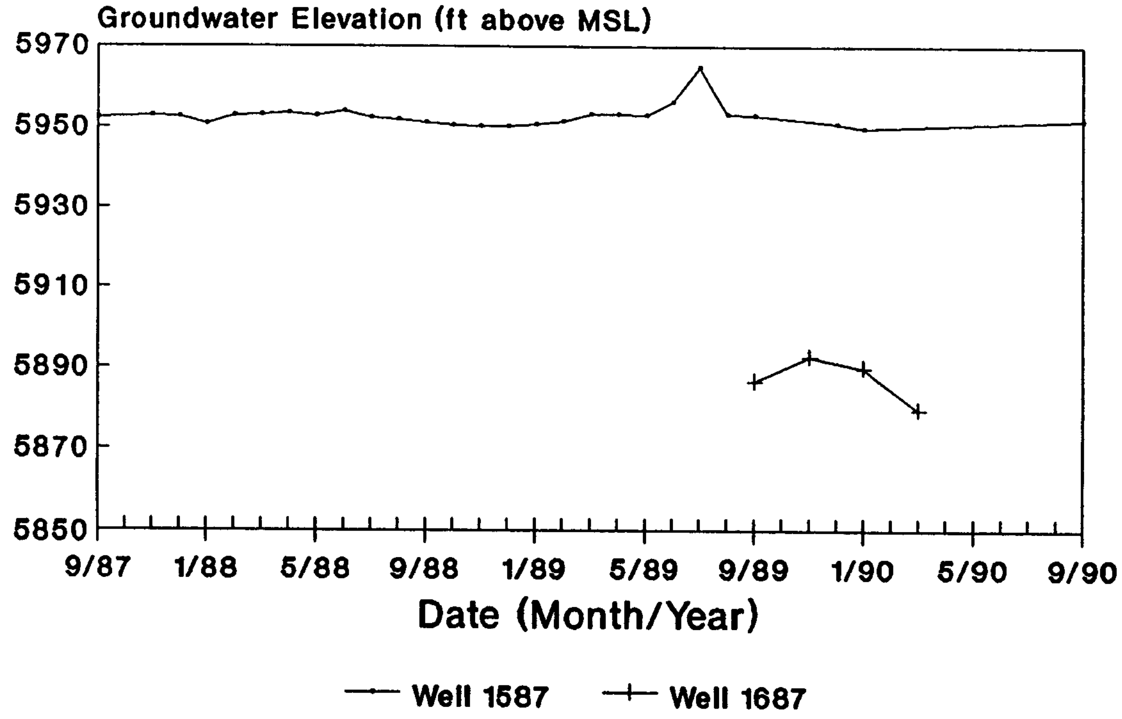
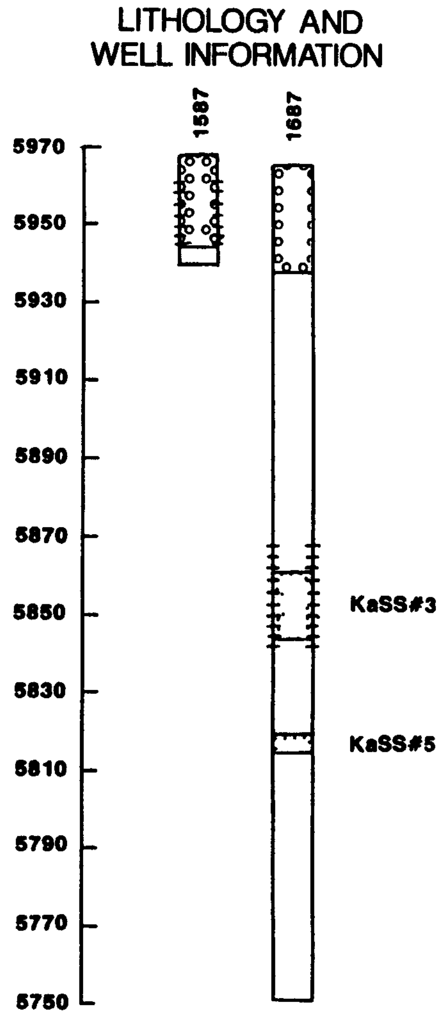
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

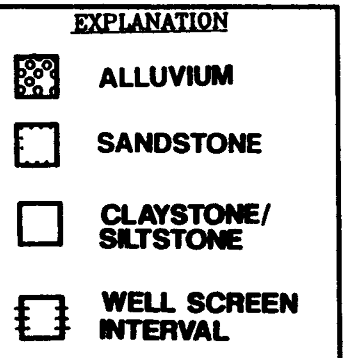
WELL HYDROGRAPHS (SOUTH 903 PAD AREA)

Figure 2 13

6/21/91



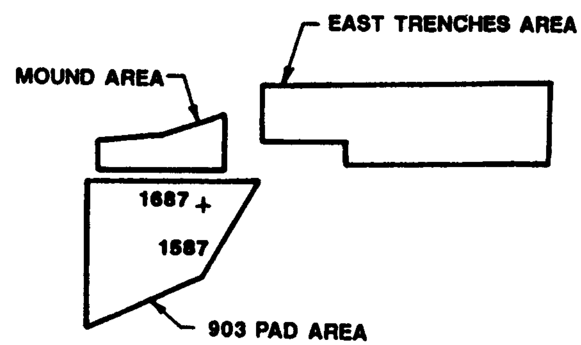




APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
1587 1687	0 65	120

GRADIENTS ARE POSITIVE DOWNWARD



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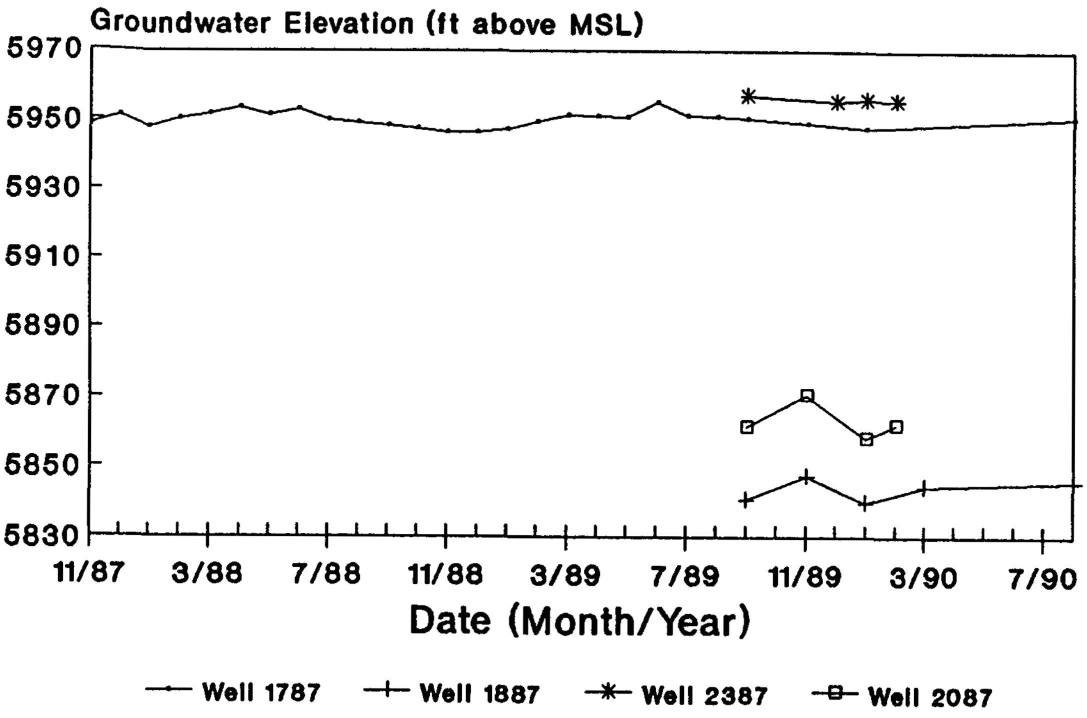
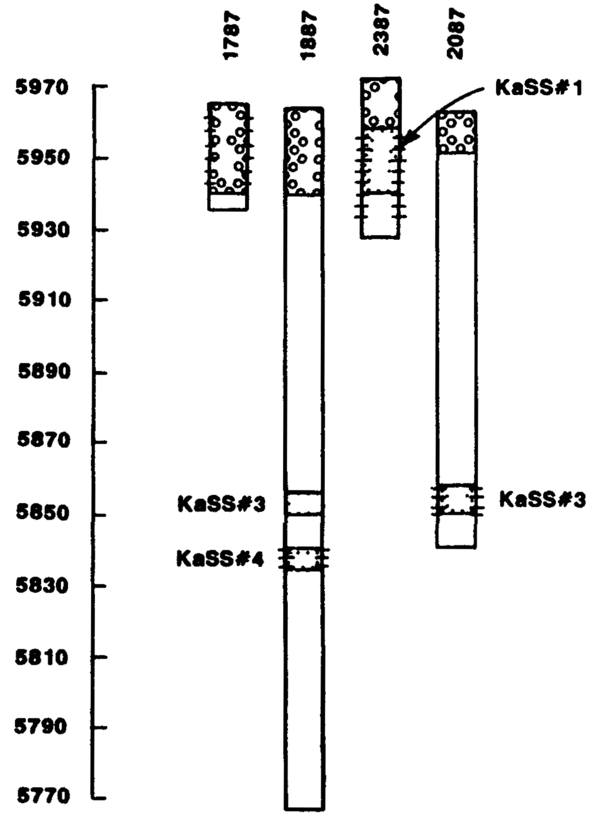
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS
(903 PAD AREA)

Figure 2 14 6/21/91



LITHOLOGY AND
WELL INFORMATION



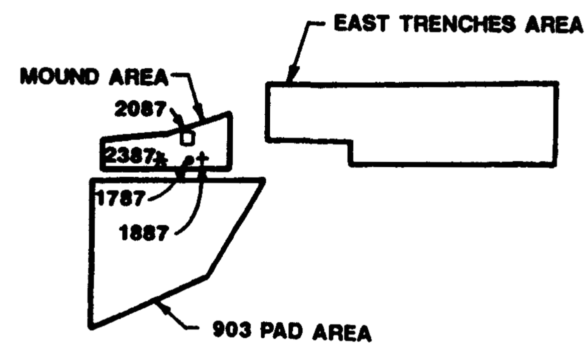
EXPLANATION

- ALLUVIUM
- SANDSTONE
- CLAYSTONE/ SILTSTONE
- WELL SCREEN INTERVAL

APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
1787 1887	0 92	32
1787 2087	0 90	267
1887 2387	1 08	428
1887 2087	1 02	295
2387 2087	1 05	335

GRADIENTS ARE POSITIVE DOWNWARD



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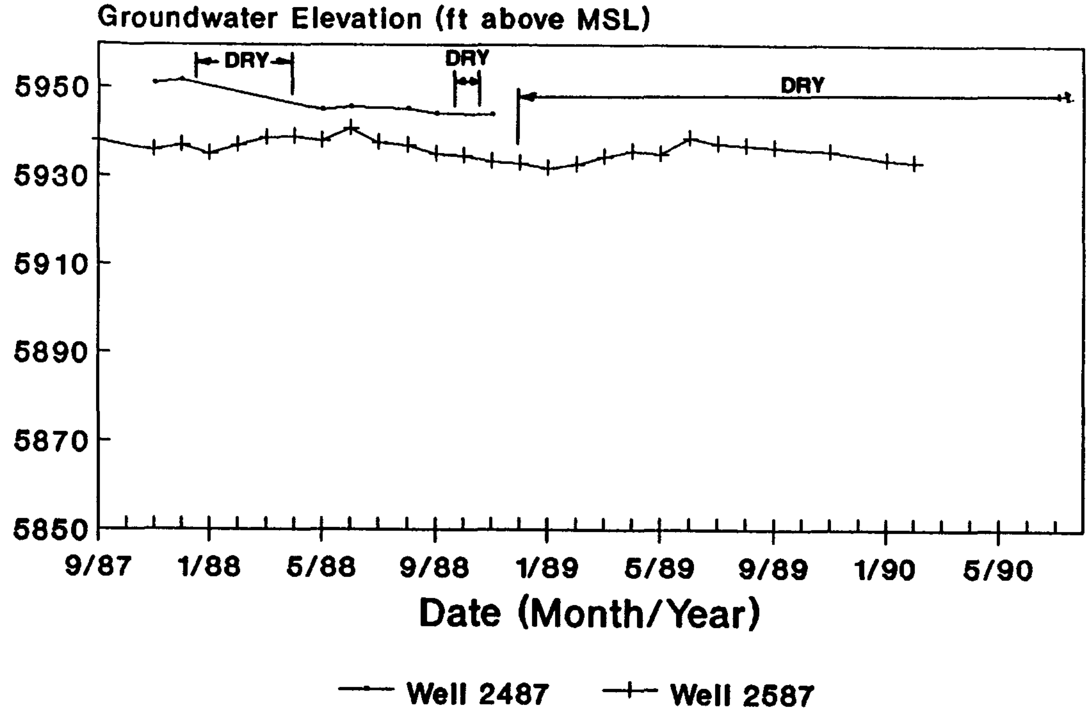
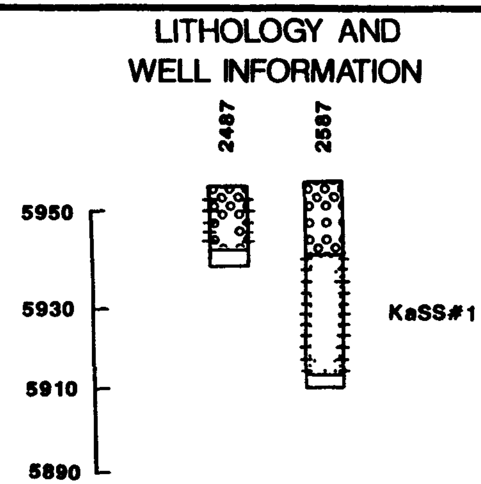
Rocky Flats Plant, Golden Colorad

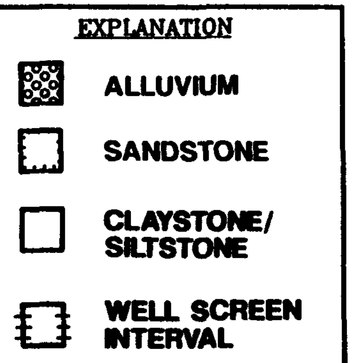
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (MOUND AREA)

Figure 2 15 6/21/91



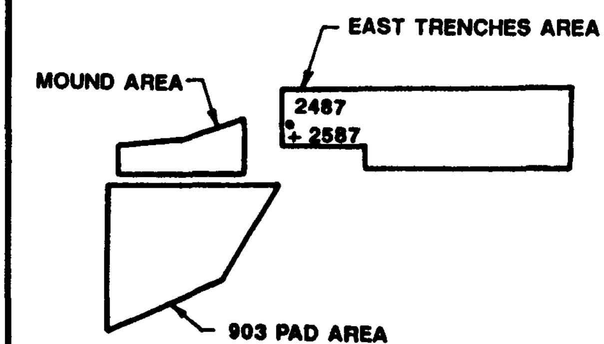




APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
2487 2587	0 51	32

* GRADIENTS ARE POSITIVE DOWNWARD



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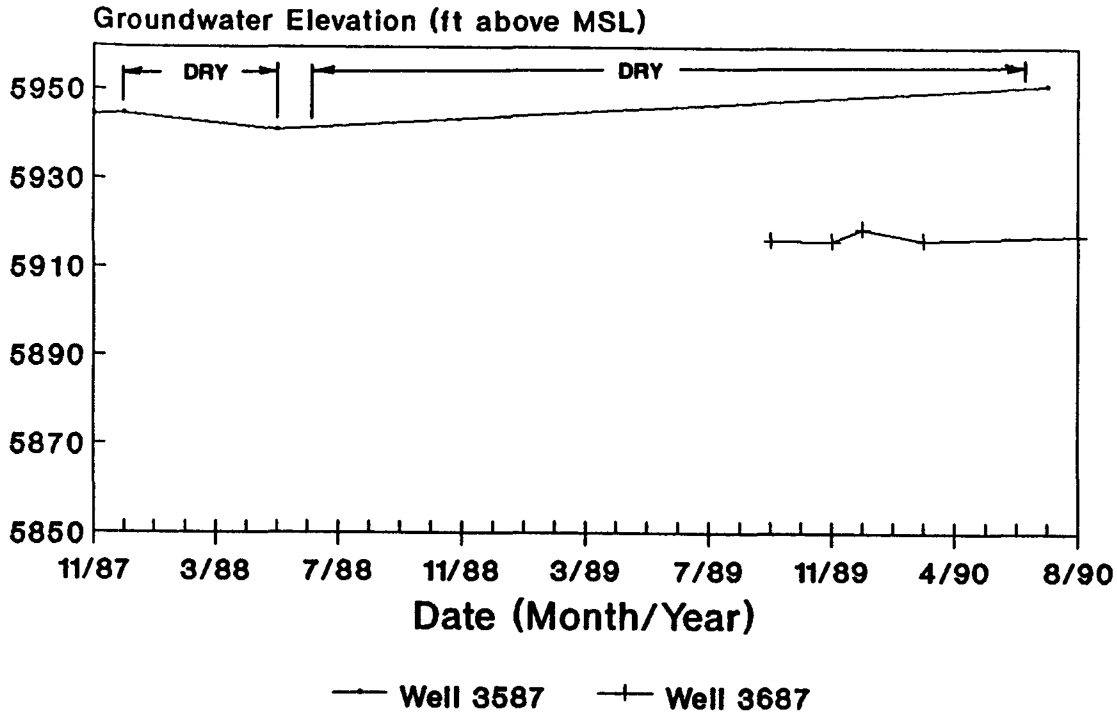
Rocky Flats Plant, Golden, Color d

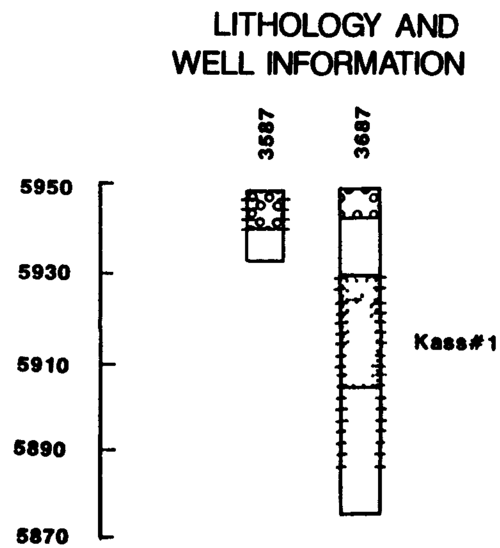
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

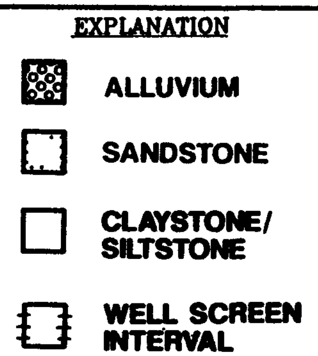
WELL HYDROGRAPHS (WEST EAST TRENCHES AREA)

Figure 2 16

6/21/91



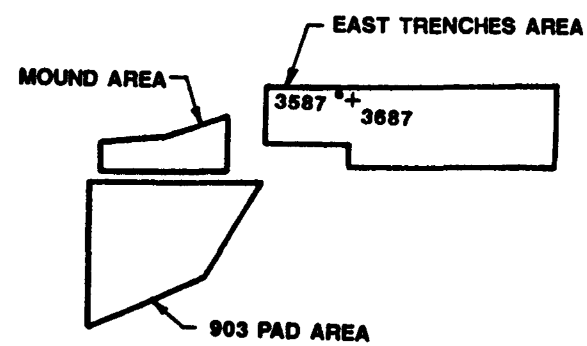




APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
3587-3687	0.80	27

GRADIENTS ARE POSITIVE DOWNWARD



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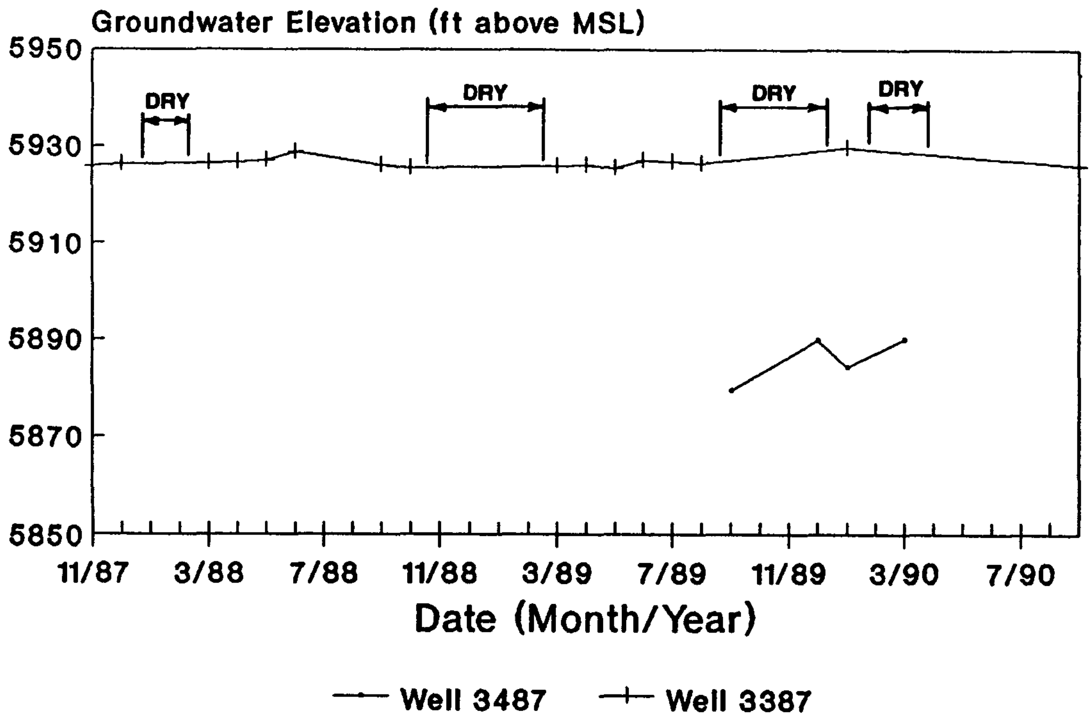
Rocky Fl ts Plant, Golden Colorad

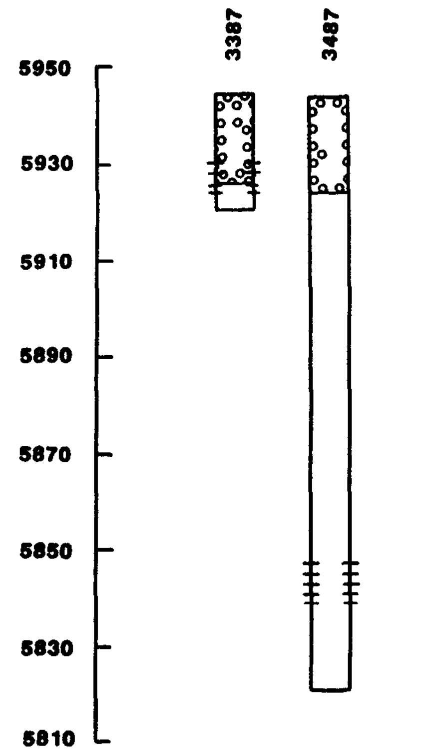
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

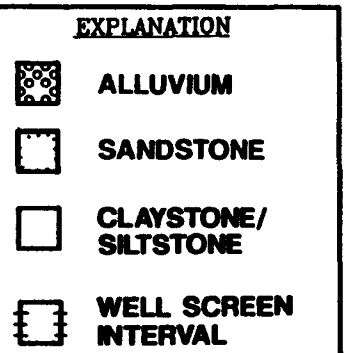
WELL HYDROGRAPHS (WEST CENTRAL EAST TRENCHES AREA)

Figure 2 17 6/21/91



LITHOLOGY AND WELL INFORMATION

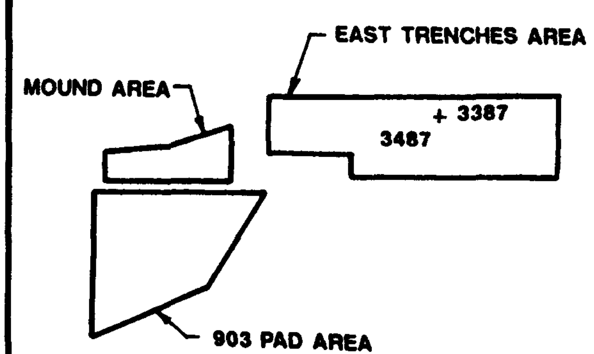




APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
3487-3387	0 49	22

GRADIENTS ARE POSITIVE DOWNWARD



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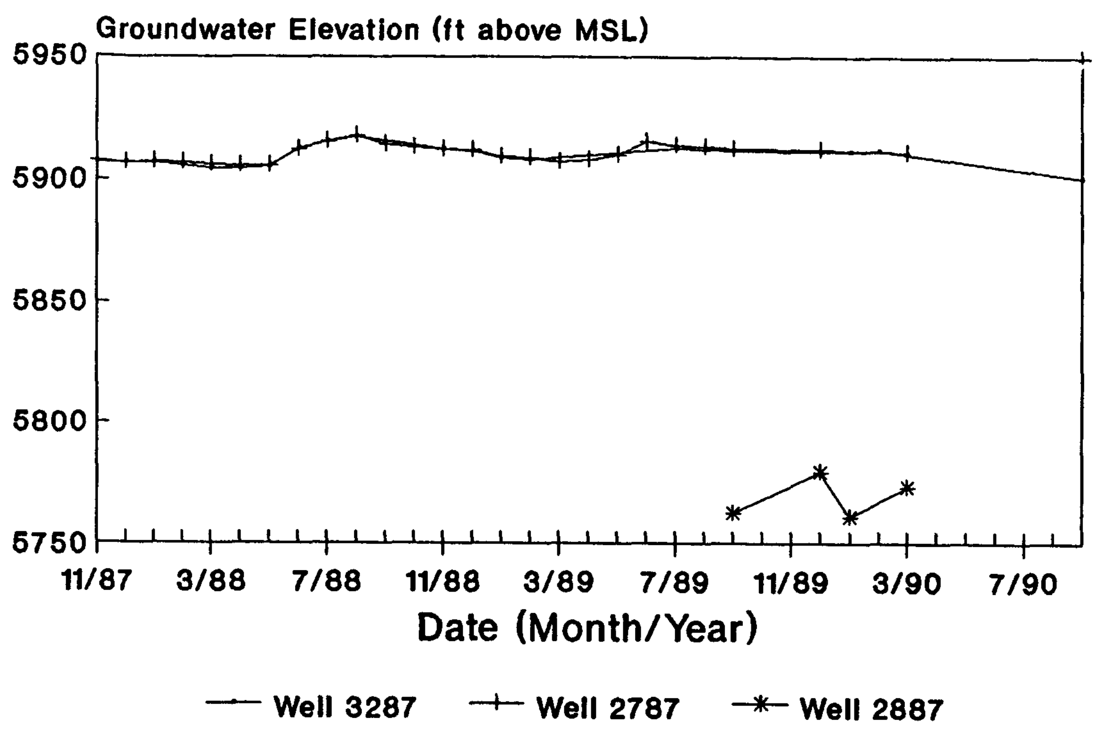
Rocky Fl ts Plant, Golden, Color do

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

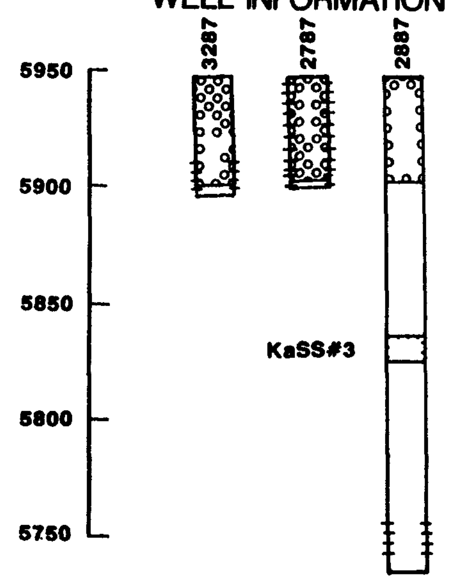
WELL HYDROGRAPHS (CENTRAL EAST TRENCHES AREA)

Figure 2 18

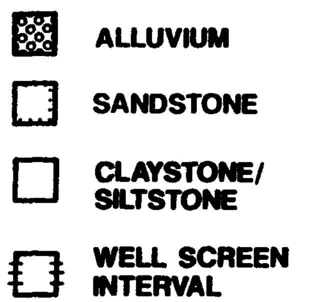
6/21/91



LITHOLOGY AND WELL INFORMATION



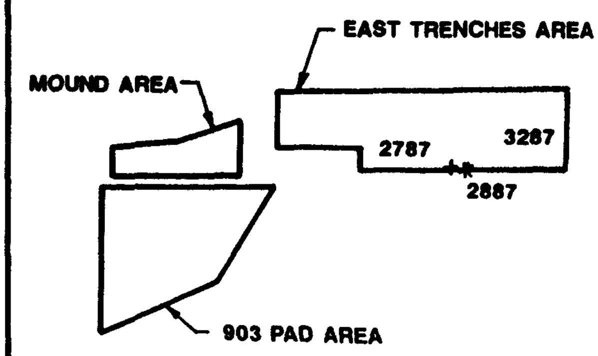
EXPLANATION



APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
3287 2787	NEAR 0	319
2787 2887	0 83	38

GRADIENTS ARE POSITIVE DOWNWARD



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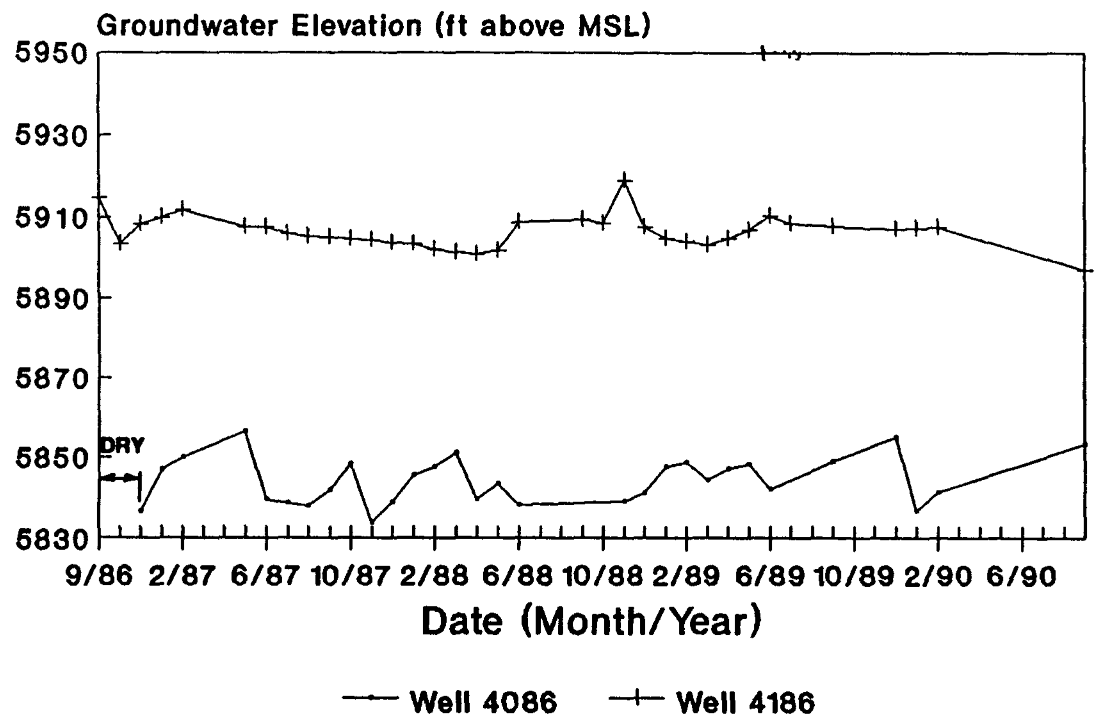
Rocky Flats Pl nt, Golden, Colo d

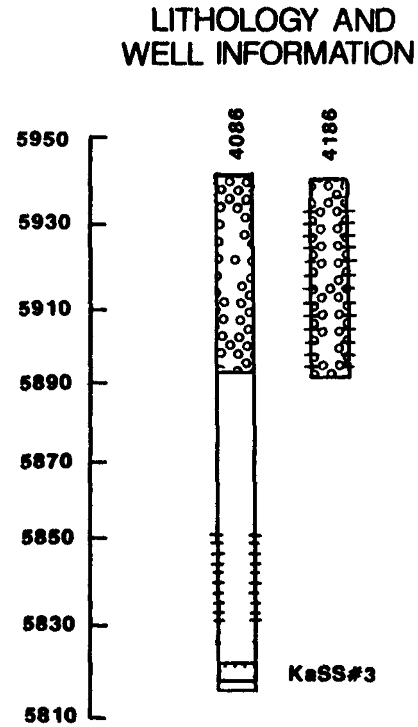
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

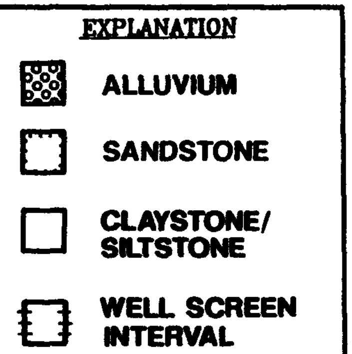
WELL HYDROGRAPHS (SOUTH CENTRAL EAST TRENCHES AREA)

Figure 2 19

6/21/91



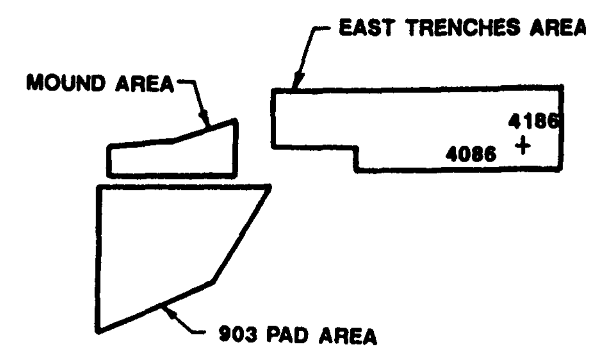




APPARENT VERTICAL GROUNDWATER GRADIENTS (ΔH/L)

INTERVAL	GRADIENT (ft/ft)	HORIZONTAL DISTANCE BETWEEN WELLS (ft)
4086 4186	0 84	39

GRADIENTS ARE POSITIVE DOWNWARD



U.S DEPARTMENT OF ENERGY
Rocky Flats Pl nt, Golden Col d

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

WELL HYDROGRAPHS (EAST EAST TRENCHES AREA)

Figure 2 20

6/21/91

The South Walnut Creek retention pond system consists of five ponds (B 1 B 2, B 3 B-4 and B 5) that retain surface water runoff and Plant discharges for monitoring and evaluation before downstream release of these waters The South Walnut Creek drainage is located in Operable Unit 6 which is just north of Operable Unit 2 Ponds B 1 and B 2 are reserved for spill control, surface water runoff or treated sanitary waste of unknown quality and Pond B 3 is a holding pond for sanitary sewage treatment plant effluent In the past the normal discharge of Pond B 3 was to a spray system located in the vicinity of the East Trenches The spray system has ceased operating since then Ponds 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 This includes storm runoff diverted via the two large diameter culverts The discharge of Pond B 5 is currently released to retention Pond A-4 located in the North Walnut Creek drainage

2 1.3.2 <u>Woman Creek</u>

Woman Creek is located south of the Plant with headwaters in largely undisturbed Rocky Flats Alluvium Runoff from the southern part of the Plant is collected in the South Interceptor Ditch located due north of the creek and delivered to Pond C 2 Pond C 1 (upstream of C 2) receives stream flow from Woman Creek The Woman Creek drainage is located in Operable Unit Number 5 which is just south of Operable Unit Number 2 The discharge from Pond C 1 is diverted around Pond C 2 into the Woman Creek channel downstream Water in Pond C 2 was previously discharged to Woman Creek in accordance with the Plant NPDES permit (Discharge Point 007) but is not currently being discharged Future plans call for a transfer of water from Pond C 2 to the South Walnut Creek Retention Pond B 5

Flow in Woman Creek and the South Interceptor Ditch is intermittent it appears and disappears along various reaches During the 1986 initial site characterization, measurable flow occurred at less than one half of the ten stations located along Woman Creek and the South Interceptor Ditch (Rockwell International 1986e) All recorded flows were less than ten gallons per minute During the 1986 and 1987 investigations there was no surface flow in Woman Creek downstream of Pond C 2 The intermittent surface water flow observed in Woman Creek and the South Interceptor Ditch may indicate groundwater inflow and outflow

2.2 NATURE AND EXTENT OF CONTAMINATION

2.2 1 Introduction

The description of the nature and extent of contamination presented in this Subsection is based on data obtained from the Rocky Flats Environmental Database System (RFEDS) supplied by EG&G Most of the data were presented in the alluvial work plan, however the RFEDS contains some data collected and/or validated since preparation of the alluvial work plan Background data discussed in Subsection 2 2 2 were taken from the Background Geochemical Characterization Report for 1989 (EG&G 1990d)

Currently available validated bedrock and bedrock groundwater analytical chemistry data are relatively few in number and are insufficient to draw definitive conclusions concerning the presence or absence of contamination Validated data are identified in the data summary tables in Appendix B by a V (validated and valid) an R (validated and rejected) or an A (validated and acceptable with qualifications) J indicates that data are present but below the detection limit The code B indicates that contamination was detected in the blank for this sample

Most of the available analytical chemistry data have not been validated Data collected prior to 1989 were collected under less stringent QA/QC protocols than are currently in place Sufficient documentation is not available to validate the data according to EPA data validation guidelines It is therefore not anticipated that this pre 1989 data will be validated in the future More recent data that had not been validated at the time of work plan preparation are currently being validated or have recently been validated and will be available in the near future

Only a few organic and metal sample results have been validated Relatively high levels of several contaminants have been observed in the unvalidated data and occasionally in validated data Most of the maximum contaminant levels identified in the bedrock are unvalidated and therefore the quality of these data is unknown The unvalidated data have been included in this work plan and utilized for planning because without the use of these data, there would be a very limited basis for making initial decisions from a chemical contamination standpoint in determining locations of wells and boreholes Data collected during the Phase II RFI/RI alluvial and bedrock sampling efforts may provide some indication of the reliability of the unvalidated data

2.2.2 Background Characterization

2.2.2 1 Introduction

To facilitate the interpretation of chemical results obtained during RFI/RIs a background characterization program was implemented to define the spatial and temporal variability of naturally occurring constituents Field work was conducted in 1989 and a draft Background Geochemical Characterization Report was prepared and submitted to the regulatory agencies on December 15 1989 (Rockwell International 1989e) The report was recently finalized and a Background Geochemical Characterization Report for 1989 was issued in December 1990 (EG&G 1990d) These documents summarize the background data for groundwater surface water sediments and geologic materials, and identify statistical boundaries of background variability based on the available data Spatial variations in the chemistry of geologic materials and water were addressed by sampling locations throughout background areas at the Plant The sampling well locations were primarily in the Northern and Southern Buffer Zones of the Plant The goal of evaluating temporal variations in groundwater chemistry has not yet been achieved because a minimum of two years of quarterly data is needed Additionally not all parameters were measured for every well in every quarter The background report is viewed as a living document which will continue to evolve as additional background data are collected Additional background well locations and statistical approaches to evaluating the data may also be evaluated in the future To date the background geochemical characterization of the Plant has concentrated on the soil, bedrock and groundwater in the upper HSU However for the purpose of this work plan information from the Background Geochemical Characterization Report for 1989 (EG&G 1990d) has been used to preliminarily characterize inorganic contamination in Operable Unit 2 bedrock

The boundary of background variability in the Background Geochemical Characterization Report for 1989 was quantified through the calculation of statistical tolerance intervals assuming a normal or log normal distribution for chemicals that have greater than 50 percent detectable concentrations and a minimum of four detectable concentrations If a given constituent s concentration was normally distributed, a normal tolerance interval was calculated Log normal tolerance intervals were calculated for log normally distributed data The minimum and maximum detected values or the upper and lower limits of the tolerance interval for each analyzed parameter in background groundwater surface water sediment and geologic samples are provided in the Background Geochemical Characterization Report for 1989 Additional statistics provided in the report include the mean, standard deviation, sample size and percent of samples with detected results Maximum detected values are provided for each naturally occurring chemical constituent where there were insufficient data to calculate tolerance intervals This occurred when there was an insufficient number of samples or an insufficient number of detectable concentrations for a given chemical constituent A summary of the upper and lower limits of the tolerance interval or minimum and maximum detected values in groundwater for metals other inorganics and radionuclides is provided for the weathered claystone the weathered sandstone and the unweathered sandstone in Appendix B Tables B 1A through B 1E Tables B 2A through B 2D and Tables B 3A through B 3E Background information on the unweathered claystone is very limited since unweathered claystone wells frequently do not produce sufficient water for sampling Tables B 4A B-4B and B 4C provide information on well designations and lithologies screened by the wells A discussion of the statistical methods employed and rationale for their use is given in the Background Chemical Characterization Report for 1989 (EG&G 1990d) A more detailed description of these procedures is provided in EPA/530/SW/89/026 Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Interim Final (U S EPA 1989f)

The background sampling stations are associated with one of three drainage basins Rock Creek, Walnut Creek and Woman Creek The Walnut Creek and Rock Creek drainage basins were combined to create a North Rocky Flats spatial variable while the Woman Creek drainage basin forms the South Rocky Flats spatial variable The north south groundwater boundary is defined as the hydrologic groundwater divide between the Walnut and Woman Creek drainages North and South Rocky Flats are similar in groundwater geochemistry for all analytes except chloride For this reason, chloride results are presented separately for North and South Rocky Flats while all other constituents are presented with North and South Rocky Flats data combined

2.2.2.2 Organics

Background samples were not analyzed for EPA Contract Laboratory Program (CLP) Target Compound List (TCL) organics because organics are assumed not to be present in background areas Validated results of a sample analysis that are above the method detection limit will be considered to represent potential contamination and additional data will be collected at that location (i e resampling) to evaluate whether the groundwater is actually contaminated at that location or if the analysis results may contain lab errors or artifacts

2.2.2.3 Inorganics

To assess the presence of inorganic contamination in Operable Unit 2, site specific chemical data will be compared to the background tolerance intervals determined by the ongoing background geochemical characterization This information will guide borehole and monitoring well placement plans Since the 95 percent confidence level is being utilized, it can be expected that approximately 5 percent of the time constituent concentrations will be found to exceed the upper tolerance level even when contamination is not present Therefore resampling will be necessary to confirm the presence of contamination when the upper tolerance level is exceeded

Available background information on the weathered claystone weathered sandstone and unweathered sandstone is provided for inorganics in Tables B 1A, B 2A, and B 3A (metals) and B 1B B 1C B 1D B 2B B 2C B 3B B 3C and B 3D (non metallic inorganics) The background data generally indicate that uncontaminated groundwater within the deeper confined (lower HSU) sandstones can be distinguished from that in the unconfined (upper HSU) sandstones and alluvium by the presence of higher concentrations of sodium and potassium and to a lesser extent sulfate and chloride in water within the lower HSU sandstones Comparison of concentrations in the Operable Unit 2 groundwater with ARARs is presented in Section 3 0

2.2.2 4 Radionuclides

Radionuclides are analyzed by counting sub atomic particle emissions Since the counting of radioactive disintegration is a process that may be evaluated statistically using a probability distribution, results are reported as a measured value with an associated two standard deviation propagated counting error term indicated in parentheses immediately following the measured value For the purposes of this plan, the boundaries of the background range for radionuclides is based on the tolerance interval values presented in the Background Geochemical Characterization Report for 1989 and contained in Tables B 1E, B 2D and B 3E However it should be noted that the computation of tolerance intervals for radionuclides did not account for the error term associated with each analysis value reported It is noted that the upper limits of the tolerance intervals are similar in magnitude to the maximum concentrations observed for the background data set For discussions on radiochemical counting statistics and the handling of minimum detectable activities and zero and negative values, the reader is referred to Gilbert and Kinnison (1981) Kanipe (1977) and National Council on Radiation Protection and Measurements (NCRP) Report No 58 (1978)

2.2.3 Groundwater

The 903 Pad, Mound, and East Trenches areas located on the east side of the Rocky Flats Plant security area, were selected for investigation because of their suspected relationship to groundwater contamination Based on existing results CCl_4 PCE and TCE are the primary volatile organic contaminants found in the upper HSU at these areas Trace elements occasionally exceeding background levels in the upper HSU include barium copper nickel, manganese and zinc Also major anions and total dissolved solids are elevated above background in the upper HSU throughout and downgradient of the 903 Pad, Mound, and East Trenches areas Radionuclide levels are generally within the tolerance limits for the background groundwater data but a few samples indicate minimum detectable amounts of plutonium and americium in the vicinity of the 903 Pad and possibly north of the Mound

There are 20 existing wells in the 903 Pad, Mound, and East Trenches areas that are screened entirely with depth intervals believed to represent the lower (bedrock) HSU(s) (i e below the conceptual boundary shown in Figure 1 1) Analytical data are available for twelve of these wells Of these twelve lower HSU wells with analytical data one of them Well 1487BR may be more representative of upper HSU groundwater chemistry since it is screened in weathered, subcropping Arapahoe Sandstone No 5 at relatively shallow depth Similarly Wells 1287BR and 6286 are screened entirely in bedrock but are probably more representative of groundwater chemistry of the upper HSU than of the lower HSU They are both relatively shallow and have the tops of their screens 1 5 to 3 feet below the bedrock surface These two wells are considered to be upper HSU wells since they are not entirely screened more than 5 feet into the bedrock

Samples collected from lower HSU wells contain various concentrations of organic, inorganic and radioactive constituents The screened intervals for these wells range from relatively shallow (Well 1487BR 19 24 feet) to relatively deep (Well 2887 BR 187 197 feet) Although the currently available bedrock groundwater data are limited, it generally appears that contamination in the deeper zones of bedrock are in the same general areas as the maximum contaminant concentrations in the upper HSU (i e the area east of the 903 Pad, the area southeast and east of the Mound Area, and the East Trenches Area)

Areas where concentrations of contaminants in the upper HSU were relatively low or not present also tended to have lower or non detectable levels of contaminants in the lower HSU Figures 2 21 through 2 23 show plumes identified by the Phase I RI for the primary organic contaminants in the upper HSU

2.2.3 1 Organic Compounds

The primary contaminants identified in the upper HSU [the volatile organic species carbon tetrachloride (CCl_4) tetrachloroethylene (PCE) and trichloroethylene (TCE)] are relatively mobile and, therefore more likely to migrate into the lower HSU(s) than many inorganic compounds Therefore volatile organic contaminants are believed to have a greater potential to be present in the lower HSU(s) than inorganic contaminants

Most of the validated groundwater analytical results for detected volatile organic compounds in the lower HSU(s) are below or only slightly higher than the reporting limits required by the EPA Contract Laboratory Program In many cases the detected organic compounds are also common laboratory contaminants that appeared in the laboratory method blanks However higher levels of several organic contaminants such as trichloroethane (TCA) and TCE have been identified in the unvalidated results (Table B 5)

Samples collected from Well 3687BR which is screened in the Arapahoe Sandstone No 1 and located northeast of IHSS 111 1 contained 1 1 dichloroethylene (1 1 DCE) 1,2 dichloroethylene (1 2 DCE) 2 hexanone 1 1 trichloroethane and toluene 1 1 DCE was also reported in Well 1587 and 1 2 DCE was reported on one occasion in Well 2587BR Only four wells screened in depth intervals believed to represent the lower HSU(s) were found to contain volatile organic compounds These results are unvalidated PCE was found in wells 1887BR and 2087BR both of which are screened in lower sandstones The concentrations were 16 $\mu g/l$ in Well 1887BR screened in the Arapahoe Formation Sandstone No 4 and as high as 140 $\mu g/l$ in well 2087BR screened in the Arapahoe Formation Sandstone No 3 These two wells are located in the eastern portion of the Mound Area Less than 10 $\mu g/l$ of methylene chloride was measured in Well 3487BR and 18 $\mu g/l$ of TCE was measured in well 4086 Both of these wells are screened in unweathered claystone in the east portion of the East Trenches Area

Well 1487BR is considered a lower HSU well by the criteria used to distinguish the upper from the lower HSU in this work plan However as discussed above in Subsection 2 2 3 analytical chemistry results from this well may not be representative of the lower HSU groundwater chemistry since it is screened in weathered subcropping sandstone at relatively shallow depth (19 to 24 feet) This well may be hydrologically connected to the upper HSU

Carbon Tetrachloride

Based on unvalidated data, carbon tetrachloride (CCl_4) was found as a dissolved constituent in groundwater from four wells in the upper HSU 1587 1287BR 2587BR and 3687BR (Table B 5) The dissolved contaminant plume in the upper HSU was defined in the Phase II Alluvial Work Plan and is shown in Figure 2 21 The highest values found in the upper HSU were in 1587 (4305 $\mu g/l$) and 3687BR (3673 $\mu g/l$) Both are located to the east of the 903 Pad Area Wells 2587BR and 3687BR are screened at deeper intervals in the upper HSU (18 to 44 feet and 19 to 63 feet respectively) in the Arapahoe Formation Sandstone No 1

With the exception of Well 1487BR which may be hydrologically connected to the upper HSU CCl_4 was generally not found in lower HSU wells However an estimated value of 1 ppb was recorded for bedrock Well 2387BR located at the south central portion of the Mound Area, in August 1989 This value is well below the method detection limit and is an isolated incident that when validated may receive additional qualifiers or may result in a different interpretation as to its significance

Tetrachloroethylene (PCE)

The Phase I RI indicates the Mound Area appears to be a source of PCE contamination (Figure 2 22) A plume of PCE in the upper HSU with maximum concentrations greater than 100 $\mu g/l$ extends east and northeast from the Mound Area to Well 3687

PCE was detected in Well 2387BR during the first (3 $\mu g/l$(J)) and third (1 $\mu g/l$(J)) quarters of 1989 although the concentrations were considerably lower than in wells toward the east end of the Mound Area The detected values are below the method detection limit for PCE and should be considered suspect since the results are unvalidated This well is screened in Arapahoe Formation Sandstone No 1

PCE (140 $\mu g/l$) was also noted in Well 2087BR which is located at the east end of IHSS 113 and in well 1887BR (16 $\mu g/l$) located at the southeast corner of Mound Area The screened depth interval for Well 2087BR is from 107 to 116 feet which is in the Arapahoe Formation Sandstone No 3 and the screened depth interval for Well 1887BR is from 127 to 134 feet, which is in the Arapahoe Formation Sandstone No 4 This finding may suggest that some vertical migration has occurred, or that the well annulus is not well sealed Alternatively it could indicate lateral migration of contamination from an upgradient source

Trichloroethylene (TCE)

The distribution of TCE shown in the alluvial work plan (Figure 2 23) indicates concentrations ranging up to 200 000 $\mu g/l$ (Table B 5) in wells screened in the upper HSU Significant concentrations of TCE were measured in upper HSU Wells 1587 1287BR 2587BR and 3687BR with 3687BR having concentrations of 49000 12000 and 18000 $\mu g/l$ over the first third, and fourth quarter sampling events of 1989 respectively In the lower HSU(s) isolated occurrences of TCE have been documented in 4086 BR and 3487BR both screened at depths of approximately 100 feet in unweathered claystone (18 $\mu g/l$ and 3$\mu g/l$ (J) 1$\mu g/l$ (J) respectively) However it should be noted that these values are near or below the method detection limit and the results are unvalidated Validation of these results could result in qualification of the data as non detects As with CCl_4 TCE has been detected in Well 1487BR which may by hydrologically connected to the upper HSU

Other Volatile Organic Compounds

Other volatile organic contaminants reported in groundwater samples from the deeper bedrock were toluene chloroform acetone methylene chloride and carbon disulfide Toluene was found in Wells 4086 3487BR 1887BR and 4587BR All values were low and were found in the blanks as well The highest value 5 $\mu g/l$ (B,A) was from Well 1887BR (Table B 5) Chloroform acetone and methylene chloride were present in many of the wells All three of these compounds are common laboratory contaminants and many of the reported values were near or below the analytical detection limits and many of the laboratory blanks also contained these compounds Carbon disulfide was detected only in Well 4587BR Validation of these data may well result in qualification of most of these values as non detects Validation of existing data and additional sampling are needed to resolve whether or not these compounds are present in the bedrock None of the other organic contaminants reported in the upper HSU were detected in the deeper bedrock

2.2.3.2 Radionuclides

The radionuclide data were found not to have been validated and, therefore should be used only to guide the placement of additional sampling locations The interpretation of the radionuclide results was conducted in the same manner as they were in the Phase II Alluvial Work Plan In general, data from the nine lower HSU wells with data indicate radionuclides do not exceed reported background levels however data are not sufficient to draw firm conclusions about the presence or absence of radionuclide contamination in the bedrock groundwater In a few cases where background levels appear to be exceeded, the error terms associated with the reported values are near the reported values and it is therefore uncertain whether or not background levels were actually exceeded

Results from Well 2387BR were the most elevated for plutonium 239 240 (0 07±0 05 pCi/l) and from Well 2287BR for americium 241 (0 11±0 08 pCi/l) (Table 2 7) These are bedrock wells however the top of the screen in Well 6286 is only 3 feet below the bedrock surface Strontium 89 and 90 were detected in Wells 4587 BR (0 60±0.52 pCi/l) and 6286 (3 0±0 4 pCi/l) Radium was also detected in 4587 BR during the second quarter of 1989 Radium was not detected in previous or subsequent samples Cesium 137 was reported in only six of the samples from lower HSU wells with the highest level being 0.3±0.5 pCi/l (Well 6286) The values for plutonium 239 and 240 and cesium 137 have error terms greater than the analytical value and should be considered as not exceeding background The error terms for the other radionuclides listed above are also nearly as large as the reported concentrations therefore, the significance of those reported concentrations is also questionable

Well 4587BR located southwest of the 903 Pad Area, consistently had gross beta values above background (Table B 6) with the highest being 113±13pCi/l This well is screened at depths of 90-101 feet in the Arapahoe Formation Sandstone No 5 Wells 1887BR and 2087BR in the vicinity of the Mound Area each had a single gross beta value above background

Values above background were found in Well 1287BR for uranium 238 These values ranged from 18 9±3 1 pCi/l to 28±2 pCi/l The screen interval for this well is at depths 5 11 feet in weathered claystone with the top of the screen only 1 5 feet below the bedrock surface

To summarize the extent of radionuclides in the bedrock is not well defined However elevated gross beta values appear to occur in Well 4587BR which is screened in the Arapahoe Sandstone Formation No 5 While there is no firm evidence of radionuclide contamination in the bedrock, the available data are limited and the data are unvalidated For these reasons, it cannot be concluded whether or not bedrock radionuclide contamination exists at the present time The presence or absence of radionuclide contamination will be evaluated during this Phase II RFI/RI

2.2.3.3 Metals

The majority of the dissolved inorganic elements data (Tables 2-8A, B and C) that had been validated were at or near the detection limits Unvalidated data indicate metal concentrations exceeding background levels in the upper HSU in Operable Unit 2 include barium copper nickel, manganese and zinc

Within Operable Unit 2, the wells with the highest concentrations of dissolved inorganic elements were in the 903 Pad Area Silver antimony arsenic, barium mercury cadmium selenium beryllium lead, and chromium were at their maximum values (see Tables B 7A, B 7B and B 7C) in wells associated with the 903 Pad however available data are not sufficient to confirm the presence or absence of contamination

In general, elevated metal concentrations were not detected in bedrock wells however available data are not sufficient to confirm the presence or absence of contamination Well 6286BR which is screened at depths 25 to 35 feet in the Arapahoe Formation Sandstone No 3 had the highest values for mercury cadmium and selenium 0 0008 mg/l, 0 009 mg/l, and 0 0710 mg/l, respectively However the top of the screen in this well is only 3 feet below the bedrock surface and may therefore be hydraulically connected to the upper HSU All values were unvalidated except for two selenium values, 0 0616 mg/l and 0 0565 mg/L which have been validated (Table B 7C)

Within Operable Unit 2, samples from wells in the East Trenches Area had the highest reported values for iron lithium molybdenum and manganese

2.2.3 4 Major Ions

Data (Table B 8) indicate that the lower sandstones have higher concentrations of sulfates chloride and TDS than were found in groundwater in the upper HSU The data from the monitoring wells screened in the bedrock in Operable Unit 2 generally show the reverse of this trend Major ions tend to be more elevated in shallow wells than in deeper wells The significance of this trend will be more fully explored during this Phase II RFI/RI

2.2 4 Bedrock

Analytical chemistry testing was conducted on samples of the bedrock collected during the Phase I RI Data reported here are from boreholes drilled into the bedrock with samples collected at or below the alluvial/bedrock interface Borehole summary information is shown in Table 2 1

The majority of metal concentrations in bedrock samples were below either the reported background (Rockwell International 1989e) for those formations or at the analytical method detection limits A single sample from BH2587 contained 20 mg/kg arsenic above the background level of 15 mg/kg No radionuclide values reported for these samples were above the background levels However there is not adequate information from existing soil data to determine if the deeper bedrock is contaminated with metals or radionuclides

The only boreholes with volatile organic compounds reported at or below the alluvial/bedrock interface were BH 2587 BH3187 and BH5087 (Table B 9) The BH2587 sample collected at the 19 7 20.5 foot interval contained toluene methylene chloride acetone TCE, PCE 2 butanone and 1 1 1 trichloroethane (TCA) The depths above the 19 7 20.5 ft interval also showed higher concentration of these compounds as well as ethyl benzene 4-methyl 2 pentanone xylene and chloroform The alluvium/bedrock contact was at depth 14 8 feet in this borehole BH3187 at the 15 7 foot to 22 9 foot depth contained methylene chloride acetone and 1 2 dichloropropene while BH5087 at the 17 to 18.5 foot depth contained acetone and 1 2 dichloropropene

Low levels of methylene chloride acetone and chloroform were found in numerous samples from many boreholes However these compounds are common laboratory contaminants These compounds are also frequently found in laboratory blanks

Semi volatile organic compounds were observed in a number of boreholes (Table B 10) While most phthalate compounds are laboratory contaminants, one borehole (BH 3387) had a validated concentration of 240 ppb which is high for laboratory contamination This borehole is located near the Mound Oil Burn Pit and trench T 1 sites

There is not adequate information from existing soil data to determine if the deeper bedrock is contaminated with organic compounds

2.3 CONCEPTUAL MODEL

A site conceptual model was developed to illustrate how contamination may be dispersed to the environment via potential pathways identified in the Phase I RI report and during Phase II RFI/RI planning The conceptual model is shown graphically in Figure 2 24 The interrelationships between the upper and lower hydrostratigraphic units (HSUs) and between Operable Unit 2 and adjacent operable units are depicted in this figure

This conceptual model was used to assist in identifying sampling needs and will be further used for the baseline risk assessment Additional data will be obtained to refine risk assessment calculations and to conduct the Feasibility Study (FS)

2.3 1 Bedrock Contamination Sources

Potential sources of contamination in bedrock have been divided into 3 general categories (1) plumes of dissolved (aqueous phase) contaminants in the upper HSU (2) pools or pockets of non aqueous phase liquid contaminants near the bottom of the upper HSU and (3) unidentified off site sources located topographically and/or hydraulically upgradient of the site

At present the primary contaminants identified in the bedrock are aqueous phase trichloroethylene (TCE) and tetrachloroethylene (PCE) Plumes of these volatile organic contaminants and carbon tetrachloride (CCl_4) dissolved in groundwater were identified in the upper HSU during the Phase I RI Other volatile and semivolatile organics and inorganics have also been identified in the upper HSU but, for the most part have not been identified in the bedrock The three primary volatile organic contaminants are all able to exist as dense non aqueous phase liquids at concentrations above their concentration of saturation in water In the unlikely event they are present on site pools of dense non aqueous phase liquids could accumulate in depressions at the bottom of the upper HSU However of the many monitoring wells and boreholes that have been drilled at Rocky Flats there have never been reports of non aqueous phase liquids found in wells

It is not known if there are potential sources of bedrock contamination that are located upgradient of Operable Unit 2 The bedrock beneath Operable Unit 1 (881 Hillside) has not been characterized sufficiently to determine whether or not it is a potential source of contamination that may contribute to the bedrock system in Operable Unit 2

2.3.2 Release Mechanisms

There is a potential for contaminants in the upper HSU to have impacted the bedrock system There are six pre 1986 monitoring wells that have been identified in Operable Unit 2 These wells (Well Nos 171 271 174 374 774 and 2274) were constructed in 1971 and 1974 Design details of these wells are not available other than estimates of total depth The first five of these six wells range from approximately 24 to 50 feet in depth However Well 2274 is 162 feet deep and may penetrate lower sandstone layers These wells represent potential release mechanisms from the upper HSU to lower HSU(s) either by long screened intervals or ineffective seals

Contaminated groundwater in the upper HSU may also potentially enter lower sandstones where they subcrop beneath the colluvium on the valley side slopes (see Figure 2 24) This may be the situation at Well 1487BR Another potential mechanism of release into bedrock is by percolation through fractures in the weathered and unweathered claystone bedrock downward to a lower sandstone layer if such fractures exist This release mechanism is judged to have a low probability at this time as a result of the low hydraulic conductivity values reported in the unweathered claystone units

2.3.3 Potential Exposure Pathways

The primary potential pathways for migration of contaminants through groundwater flow in bedrock to potential receptors are by seepage to surface waters, pumping from water supply wells that tap the affected groundwater downgradient of the site and contamination of surface water by the interaction of surface water and groundwater Secondary potential exposure pathways may occur through wind dispersal of contaminated dust or soil gas resulting from the seepage of contaminated groundwater and subsequent drying at outcrop areas

2.3 4 Receptors

There may be different potential receptor populations exposed via each of the potential exposure pathways described above For each pathway there are three potential intake routes ingestion, inhalation, and dermal contact Potential receptors of groundwater contamination are human Biota may be present at downgradient or downwind of seep locations

2.3.5 Summary

The elements of the site conceptual model described above are shown in Figure 2-24 This figure depicts the potential sources of contamination mechanisms of contaminant release exposure pathways and primary receptors The model as pictured is based on an evaluation of available Phase I RFI/RI data and postulated exposure pathways not yet proven As additional information is obtained, the overall model and specific portions of the model (for example the confined groundwater flow regime) may be refined or expanded to address risk assessment issues

The Baseline Risk Assessment for both upper and lower HSUs will be combined for the RI Report The Phase II RFI/RI Alluvial Work Plan describes how this is to be done

3 0
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section provides a preliminary identification of chemical specific applicable or relevant and appropriate requirements (ARARs) for groundwater in the lower (confined) HSU(s) at Operable Unit 2 so that appropriate analytical detection limits are used during the RFI/RI Identification of detection limits is necessary to allow evaluation of compliance with ARARs in the CMS/FS Report As described in Subsection 3 2 evaluation and establishment of location specific ARARs are part of the RI process and will be addressed in the RFI/RI Report Final chemical specific ARAR determinations will also be addressed in the RFI/RI Report Identification of action specific ARARs and remediation goals is part of the feasibility study process and will be addressed in the CMS/FS Report

3 1 THE ARAR BASIS

The basis for ARARs is cited in Section 121(d) of CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) which requires that Fund financed, enforcement and federal facility remedial actions comply with applicable or relevant and appropriate federal laws or promulgated state laws whichever is more stringent For the purposes of identification and notification of promulgated state standards the term promulgated means that the standards are of general applicability and are legally enforceable (National Contingency Plan [NCP] 40 CFR 300 400(g)(4))

Health based chemical specific ARARs pertinent to ground water quality have been identified for the EPA Contract Laboratory Program (CLP) Target Compound List (TCL) organic and Target Analyte List (TAL) inorganic compounds as well as radionuclides and conventional pollutants that were detected The chemical specific ARARs are derived primarily from federal and state health and environmental statutes and regulations As discussed below in some instances these standards are classified as items to be considered (TBC) A summary of chemical specific ARARs for the contaminants found at the 903 Pad, Mound and East Trenches areas is presented in Table 3 1

The parameters for which proposed ARARs are identified are compiled from maximum concentrations above detection limits in bedrock groundwater wells within Operable Unit 2 However the same application of ARARs pertain to both the upper and lower hydrostratigraphic units (alluvial and bedrock groundwater) due to the potential cross connection of the two units A common list of parameters will be analyzed for both hydrostratigraphic units (see Section 8 0 Field Sampling Plan)

Chemical specific ARARs do not currently exist for soils As the remedial investigation proceeds information will become available from the risk assessment which will allow a determination of acceptable contaminant concentrations in soils to ensure environmental protectiveness

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (µg/ℓ)	Well Designation # & Sample Date	Detection Limit (µg/ℓ)	Proposed ARAR (µg/ℓ)	Proposed TBC (µg/ℓ)	Reference	Comment
Organic Compounds							
Acetone	27B	2887BR (12/14/89) and (12/06/89)	10		10U	Acetone is RCRA (40 CFR Part 264 Subpart F) Appendix IX constituent (Background is TBC)	
Methylene Chloride	12	4587BR (02/25/88)	5		5U	RCRA (40 CFR Part 264 94) S bpart F (Background is TBC)	
Tetrachloroethylene	140	2087BR (08/09/89)	5		10	WQCC Ground Water Standard Interim Organic Pollutant Standard is TBC.	
Toluene	5AB	1887BR (01/03/89)	5		2420	WQCC Ground Water Standard Interim Organic Pollutant Standard is TBC.	Maximum detected concen tration is below proposed standard
Trichloroethylene	120V	1487BR (01/25/89)	5		5U	SWDA MCL (40 CFR 141 61[a])	
Carbon Disulfide	5	4587BR (08/17/89)	5		5U	RCRA (40 CFR Part 264 94) Subpart F (Background is TBC)	
Chloroform	36V	1887BR (03/07/88) and 1487BR (11/28/89)	5	100		SDWA MCL (40 CFR 141 12)	Standard is for total trihalomethanes Maximum detected concentration is below proposed standard
Carbon Tetrachloride	450	1487BR (11/28/89)	5	5		SDWA MCL (40CFR 141 61[a])	

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Dissolved Metals							
Aluminum	1 1972	1487BR (10/13/87)	0 20		5 0	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC	Maximum detected concen tration is below proposed standard
Antimony	0 0728	3486 (11/04/88)	0 06		0 06U	RCRA (40 CFR Part 264 94) Subpart F (Background is TBC)	
Arsenic	0 040	3087BR (01/22/88)	0 01	0 05		SDWA MCL (40CFR 141 11[b])	Maximum detected concen tration is below proposed standard
Barium	0 7860	1687BR (03/01/88)	0 20	1 0		SDWA MCL (40 CFR 141 11 [b])	Maximum detected concen tration is below proposed standard
Beryllium	0 0022J	3087BR (02/01/89)	0 005		0 1	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC.	Maximum detected concen tration is below proposed standard
Cadmium	0 009A	6286 (06/10/89)	0 005	0 01		SDWA MCL (40 CFR 141 11[b])	Maximum detected concen concentration is below proposed standard
Calcium	242 3112	3486 (07/28/87)	5	NS		No Standard	
Chromium	0 0453	6286 (10/16/87)	0 01	0 05		SDWA MCL (40 CFR 141 11 [b])	Analytical results are for total chromium Maximum detected concentration is below proposed standard

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/ℓ)	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Dissolved Metals (cont)							
Copper	0 0463	2887BR (05/12/88)	0 025		0 2	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC.	Maximum detected concen tration is below proposed standard
Iron	2 1817	3486 (11/04/88)	0 1		0 3	WQCC Gro nd Water Standard Table 2 Secondary Drinking Water Standard is TBC	Analytical res lts are for soluble iron
Lead	0 004J	1487BR (10/13/87)	0 005	0 05		SDWA MCL (40 CFR 141 11[b])	Maximum detected concen tration is below proposed standard
Lithium	0 22	3487BR (03/10/88)	0 1		2.5	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC.	Maximum detected concen tration is below proposed standard
Magnesium	92 1996	3486 (05/03/88)	5	NS		No Standard	
Manganese	0.5351	4086 (05/06/87)	0 015		0 05	WQCC Ground Water Standard Table 2, Secondary Drinking Water Standard is TBC.	Analytical results are for soluble manganese
Mercury	0 0008	6286 (07/07/87)	0 0002	0 002		SDWA MCL (40 CFR 141 11[b])	Maximum detected concen tration is below proposed standard
Molybdenum	0 1347	2887BR (05/12/88)	0 008	NS		No Standard	

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (mg/ℓ)	Well Designation # & Sample Date	Detection Lim t (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Dissolved Metals (cont)							
Nickel	0 1041	6286 (10/16/87)	0 04		0 2	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC	Maximum detected concen tration is below proposed standard
Potassi m	31	1487BR (08/31/87)	5	NS		No Standard	
Selenium	0 071	6286 (04/14/88)	0 005	0 01		SDWA MCL (40 CFR 141 11[b])	
Silver	0 0291	4086 (03/11/88)	0 01	0 05		SDWA MCL (40 CFR 141 11[b])	Maximum detected concen-tration is below proposed standard
Sodium	232 1001	3486 (05/03/88)	5	NS		No Standard	
Strontium	1 4379	1487BR (10/13/87)	0 2	NS		No Standard	Background is 7 12 mg/ℓ
Zinc	0 1214	4587BR (04/19/88)	0 02		2 0	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC	Maximum detected concen tration is below proposed standard

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Gro nd Water (mg/ℓ)[2]	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Non Metallic Inorganics							
pH (min)	7 4	4086 (02/19/90)			6.5	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC	Minimum pH value is within proposed standard
pH (max)	8 6	1887BR (11/02/89)			8.5	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC	
Nitrite	7 41A	6286 (10/20/88)	1 0		1 0	WQCC Ground Water Standard Table 1 Human Health Standard is TBC.	Analytical results are total nitrite plus nitrate as nitrogen Reanalysis is required to determine if proposed nitrite standard is exceeded
Nitrate	7 41A	6286 (10/20/88)	5	10 0		SDWA MCL (40 CFR 141 11 [b])	Analytical results are total nitrite plus nitrate as nitrogen Results indicate that proposed nitrate standard is not exceeded.
Chloride	132A	3087BR (02/01/89)	5		250	WQCC Ground Water Standard Table 1 Human Health Standard is TBC.	Maximum detected concen tration is below proposed standard
Fluoride	1 0	6286 (02/16/90)	1		2 0	WQCC Ground Water Standard Table 3 Agricultural Standard is TBC.	Maximum detected concen tration is below proposed standard

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Gro nd Water (mg/ℓ)[2]	Well Designation # & Sample Date	Detection Limit (mg/ℓ)	Proposed ARAR (mg/ℓ)	Proposed TBC (mg/ℓ)	Reference	Comment
Non Metallic Inorganics (cont)							
Sulfate	1084A	3486 (11/04/88)	5		250	WQCC Ground Water Standard Table 2, Secondary Drinking Water Standard is TBC.	
Bicarbonate	530	1487BR (09/01/87)	10	NS		No Standard	
TDS	1886A /	3486 (02/09/89)	5		1643	WQCC Ground Water Standard Table 4 TDS Water Quality Standard is TBC	Proposed standard is calculated from the upper tolerance interval in background bedrock wells Value includes 95% of the population at 95% confi dence multiplied by 1 25

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Continued)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (pCi/ℓ)	Well Designation # & Sample Date	Detection Limit (pCi/ℓ)	Proposed ARAR (pCi/ℓ)	Proposed TBC (pCi/ℓ)	Reference	Comment
Radionuclides							
Gross Alpha	106±18	4086 (10/27/87) and 6286 (04/09/87)	2	15		SDWA MCL (40 CFR 141 15[b])	
Gross Beta	207±15	4086 (10/27/87)	4	4 (mrem/yr)		SDWA MCL (40 CFR 141 16[A])	
$Pu^{39\ 240}$	0 07±0 05	2387BR (08/12/88)	0 01		15	WQCC Statewide Standard for Radion clide Materials in Ground Water is TBC	Maximum detected concen tration is below proposed standard Concentration is estimated below minimum detectable limit (MDL)
Am^{24}	0 1±0 16	4587BR (04/19/88)	0 01		0 05	WQCC Surface Water Standard is TBC	
H	220	6286 (07/15/88) and 4086 (03/11/88)	400	20000		SDWA MCL (40 CFR 141 16[b])	Maximum detected concen tration is below proposed standard
Cs^{37}	0 3±0.5	6286 (06/10/89)	1	NS		No Standard	Concentration is estimated below MDL.
Ra^{226}	0 4±0 4	4587BR (06/13/89)	0.5	5		SDWA MCL (40 CFR 141 15[a])	Maximum detected concen tration is below proposed standard Concentration is estimated below MDL.

TABLE 3 1

PROPOSED CHEMICAL-SPECIFIC ARARs FOR COMPOUNDS AND ELEMENTS DETECTED IN BEDROCK GROUNDWATER AT THE 903 PAD, MOUND, AND EAST TRENCHES (Concluded)

Chemical	Maximum Concentrations In OU2 Area Bedrock Ground Water (pCi/ℓ)	Well Designation # & Sample Date	Detection Limit (pCi/ℓ)	Proposed ARAR (pCi/ℓ)	Proposed TBC (pCi/ℓ)	Reference	Comment
Radionuclides (cont)							
$Sr^{89\ 90}$	1 2	3486 (10/17/87) and 4587BR (10/20/89)	1	8		SDWA MCL (40 CFR 141 16[b])	Maximum detected concen tration is below proposed standard
U^{total}	21 8±1 9	6286 (06/10/89)	1 8		5	CDH Surface Water Standard is TBC.	

Maximum compound concentrations determined from data collected through the fourth quarter of 1989
Maximum compound concentrations determined from limited well data through the first quarter of 1990
Monitor Wells 1487BR and 6286 are screened at relatively shallow depths in lower intervals of weathered sandstone that supcrop on the hillside south and southeast of the 903 pad Both the bedrock and alluvial workplans will commonly utilize the laboratory data from these two wells because of the potential cross connection between the lower and upper hydrostratigraphic units where these two wells are located

A Acceptable with qualifications.
B Compound also present in blank
D Value was for duplicate sample Original sample result was 5U ppb
J Estimated below detection limit
U Detection limit
V Validated

ARARs addressing contaminants in air will be included in the CMS/FS Report In general federal and state standards for air exist only as source or activity specific requirements and accordingly will be addressed in detail during the FS process

3.2 THE ARAR PROCESS

3.2 1 ARARs

Applicable requirements as defined in 40 CFR 300.5 are those cleanup standards standards of control and other substantive requirements criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance pollutant contaminant remedial action location or other circumstance found at a CERCLA site Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable Relevant and appropriate requirements also defined in 40 CFR 300 5 are those cleanup standards standards of control, and other substantive requirements criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that while not applicable to a hazardous substance pollutant contaminant remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate The most stringent promulgated standards are applied as ARAR (Preamble to NCP 55 FR 8741)

3.2.2 TBCs

In addition to applicable or relevant and appropriate requirements advisories criteria or guidance may be identified to be considered (TBC) for a particular release As defined in 40 CFR 300 400(g)(3) the TBC category consists of advisories criteria, or guidance developed by EPA, other federal agencies or states that may be useful in developing remedies Use of TBCs is discretionary rather than mandatory as is the case with applicable or relevant and appropriate requirements

3.2.3 ARAR Categories

In general there are three categories of ARARs These categories are

1 Ambient or chemical specific requirements
2 Location specific requirements
3 Performance design, or other action specific requirements

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site cleanup process Initially during the RI work plan stage probable chemical specific ARARs may be identified, usually based on a limited amount of data Chemical specific ARARs at this point have meaning only in that they may be used to ensure appropriate detection limits have been established so that data collected in the RI will be amenable for comparison to ARAR standards It is also appropriate to identify location specific ARARs early in the RI process so that information may be gathered to determine if restrictions may be placed on the concentration of hazardous substances or on the conduct of an activity solely because it occurs in a special location As discussed in the introductory paragraph to this section (3 0) detailed location specific ARARs will be proposed in the RFI/RI Report Identification of action specific ARARs and remediation goals is part of the Feasibility Study process and will be addressed in the CMS/FS Report For the proper management of investigation derived wastes, as required in the IAG Attachment 2 Statement of Work, Section IV DOE has developed SOPs for field investigation activities All waste generated by the various investigations conducted at RFP will follow the SOPs The SOPs satisfy the IAG requirement to comply with ARARs as they relate to investigation activities This approach is consistent with EPA policy as provided in the Draft Guide to Management of Investigation Derived Waste (U S EPA 1991b)

Chemical specific ARARs do not currently exist for soils As the remedial investigation proceeds information will become available from the risk assessment which will allow a determination of acceptable contaminant concentrations in soils to ensure environmental protectiveness

3.2 4 Feasibility Study ARAR Requirements

Development of a preliminary list of potential chemical specific ARARs in the RI process also allows the establishment of a list of preliminary remediation goals in the early FS process which is essentially a tentative listing of contaminants together with initially anticipated cleanup concentrations or risk levels for each medium Preliminary remediation goals serve to focus the development of alternatives on remedial technologies that can achieve the remediation goals, thereby limiting the number of alternatives to be considered in the detailed remedial alternative analysis conducted later in the FS process As more information becomes available during the RI stage chemical specific ARARS may become more refined as constituents are added or deleted, which is often the case when the RI takes place in numerous phases Once data collection is complete revised chemical specific ARAR selection may be proposed

When the data collection is complete it is also appropriate to refine location specific ARARs which may affect the development of remedial alternatives During development of remedial action alternatives at the beginning of the FS process, a preliminary consideration of action specific ARARs will be conducted As remedial alternatives are screened during the FS action specific ARARs will be identified When a detailed analysis of the remedial alternatives is conducted all action specific ARARs are refined and finalized with respect to each alternative before a comparison of alternatives begins At this point a discussion is provided in the FS report for each remedial alternative regarding the rationale for all ARAR determinations

3.3 REMEDIAL ACTION

CERCLA §121 specifically requires attainment of all ARARs Moreover as explained in the preamble to the National Contingency Plan (55 CFR 8741) in order to attain all ARARs a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs Furthermore CERCLA requires that the remedies selected attain ARARs and be protective of human health and the environment Consequently preliminary remediation goals based on ARARs will require modification as new information and data are collected in the RI including the baseline risk assessment (to be conducted) when ARARs are not available or are determined to be inadequate for protection of human health and the environment

3.3 1 Remediation Goals

Development of remediation goals is actually a portion of the overall development of remedial action objectives which ultimately will define the required endpoint of the selected remedial action As stated in the preamble to the NCP (55 FR 8713) remedial action objectives are the more general description of what the remedial action will accomplish Remediation goals are a subset of remedial action objectives and consist of medium specific or operable unit specific chemical concentrations that are protective of human health and the environment and serve as goals for the remedial action The remedial action objectives should specify (1) the contaminants of concern, (2) exposure routes and receptors, and (3) an acceptable contaminant level or range of levels for each exposure medium (i e a preliminary remediation goals) According to 40 CFR 300 430 (e)(2)(i) Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed by considering the following

(A) ARARs (chemical specific) and

- (1) Acceptable exposure levels for systemic toxicants,
- (2) Acceptable exposure levels for known or suspected carcinogens,
- (3) Technical limitations (e g. detection limits)
- (4) Uncertainty factors and
- (5) Other pertinent information

(B) Maximum Contaminant Levels (MCLs)

(C) Acceptable exposure levels where multiple contaminants or multiple exposure pathways will cause exposure at ARAR levels will result in cumulative risk in excess of 10^{-4}

(D) Clean Water Act (CWA) Water Quality Criteria, where relevant and appropriate

(E) A CERCLA Alternative Concentration Limit (ACL) established pursuant to CERCLA § 121(d)(2)(B)(ii)

(F) Environmental evaluations performed to assess specific threats to the environment

Once a remedial action alternative is formally selected, all chemical location and action specific ARARs have also been defined in final form If it is found that the most suitable remedial alternative does not meet an ARAR the NCP at 40 CFR 300 430 (f)(1)(ii)(C) provides for waivers of ARARs under certain circumstances such as technical impracticability risk, or inconsistent application of state requirements From this point the alternative will become the final remedy as it is incorporated into the Record of Decision (ROD) Once the final ROD has been signed, requirements may be modified only when they are determined to be applicable or relevant and appropriate and necessary to ensure that the remedy is protective of human health and the environment (40 CFR 300 430(f)(1)(ii))

3 4 OPERABLE UNIT 2 BEDROCK GROUNDWATER ARARs

The ARARs for bedrock groundwater listed in Table 3-1 were developed using the ARARs rationale described above and were identified by examining the following promulgated standards

- Safe Drinking Water Act (SDWA) MCLs
  RCRA Subpart F concentration limits (40 CFR 264 94)

3 4 1 Safe Drinking Water Act MCLs

The NCP [55 FR 8848 40 CFR 300 430 (e)] requires that in development of alternatives for final remediation the following be considered for current or potential sources of drinking water attainment of MCLs and attainment of Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC) where relevant and appropriate Because groundwater at Operable Unit 2 is a potential source of drinking water the MCLs should be attained The AWQC are not ARARs and are not considered with respect to groundwater since they are intended for the protection of surface water relative to fish ingestion and drinking water or only fish ingestion Therefore it is inappropriate to apply such criteria to groundwater

3 4.2 RCRA Groundwater Protection Standards

Owners or operators of facilities that treat store or dispose of hazardous waste must ensure that hazardous constituents listed in 6 CCR (Colorado Code of Regulations) 1007 3 and 40 CFR 261 Appendix VIII entering the groundwater from a regulated unit do not exceed concentration limits (6 CCR 1007 3 and 40 CFR 264 94) at the point of compliance in the uppermost aquifer The concentration limits include standards for 14 compounds (these standards are equivalent to SDWA MCLs and are identified at 40 CFR 264 94 Table 1) with background or alternate concentration limits (ACLs) used as the standard for the other RCRA Appendix VIII (40 CFR Part 261) constituents or Appendix IX (40 CFR Part 264) constituents (TBC background groundwater values for RCRA Subpart F are applied using maximum concentrations from background groundwater in both the alluvial and bedrock units at RFP) These concentration limits apply to RCRA regulated units subject to permitting/closure (landfills surface impoundments waste piles and land treatment units) that received RCRA hazardous waste after July 26 1982 As a result these RCRA Subpart F (40 CFR Part 264) regulations are considered relevant and appropriate for groundwater remediation

3 4.3 RCRA Alternate Concentration Limits

As discussed above RCRA (40 CFR Part 264) Subpart F requires that corrective actions be taken if hazardous constituents are found to exist at the point of compliance in excess of the established constituent concentrations Although these constituent concentrations are specifically comprised of RCRA Subpart F Table 1 constituents Appendix VIII (40 CFR Part 261) or Appendix IX (40 CFR Part 264) constituent background values Subpart F does provide a mechanism for variances from these standards According to 40 CFR 264 94(b) an ACL may be established for a hazardous constituent if it is determined that attainment of a RCRA Subpart F Table 1 constituent standard or background standard is not necessary to ensure adequate protection of human health and the environment Furthermore EPA has stated that for potential drinking water sources the Agency's preference is to set remediation levels that are the equivalent of health based ACLs under RCRA (55 FR 8666) Therefore it is inappropriate to establish background as an ARAR unless it may be determined through risk assessment that attainment of background is necessary for adequate protection of human health and the environment Accordingly hazardous constituent background values will be applied as TBC until such time as risk assessment information indicates some other alternative standard is necessary to ensure protectiveness Alternatively when a standard listed in 40 CFR 264 94 Table 1 has been established for a constituent the Table 1 standard is considered to be relevant and appropriate Table 3-1 however will identify SDWA MCLs rather than RCRA 40 CFR 264 94 Table 1 standards since the RCRA Table 1 standards are only a subset of all the SDWA MCLs

3 4 4 Colorado Water Quality Control Commission Groundwater Standards

The Colorado Water Quality Control Commission (WQCC) state wide groundwater standards are applied as TBC since they are not yet enforceable Similarly since groundwater at Rocky Flats Plant has not been classified, the use specific standards in Tables 1-4 of the WQCC Basic Standards for Groundwater at 3 11 0 (5 CCR 1002 8) will also be applied as TBC where ARARs are not available

Of the elements/compounds detected in groundwater at Operable Unit 2, there are no ARARs for calcium magnesium molybdenum potassium sodium bicarbonate strontium acetone methylene chloride and carbon disulfide However the Total Dissolved Solids (TDS) TBC establishes the acceptable aggregate concentration for the above major metal ions (excluding strontium) For the volatile organic compounds the RCRA (40 CFR Part 264) Subpart F standard of background (detection limit) is applied as TBC

3 4.5 Operable Unit 2 ARARs Summary

Table 3 1 shows that certain volatile organics metals and major ions that were analyzed have exceeded potential chemical specific ARARs at some locations within Operable Unit 2 This does not indicate that releases of these constituents are occurring, for the concentrations of some substances may be due to a past release or to natural geochemical processes The listing of Table 3 1 has been presented to identify parameters for which analysis should be conducted in this Phase II RFI/RI and to identify the minimum acceptable detection limits for analytes found in Operable Unit 2 bedrock groundwater The FS will evaluate technologies that address these constituents

Note that chemical data from monitoring wells 6286 and 1487BR are included in both the alluvial and bedrock work plans for ARARs identification Well 6286 is considered to be in the upper hydrostratigraphic unit (HSU) while Well 1487BR is a lower HSU well based on the HSU delineation shown in Figure 1 1 However both of these wells are relatively shallow wells screened in lower intervals of weathered sandstone that subcrop on the hillside south and southeast of the 903 Pad As a result, these wells represent a potential cross connection between the upper and lower HSUs, as described in the site conceptual model (Figure 2 24)

4 0
DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)

The primary objective of a RFI/RI is to collect the data necessary to determine the nature distribution, and migration pathways of contaminants This information is used to support a baseline risk assessment which determines the need for remediation and evaluates risks associated with various remedial alternatives Five general goals of a RFI/RI are (EPA 1988a)

- Characterize site physical features
- Define contaminant sources
- Determine the nature and extent of contamination
- Describe contaminant fate and transport
- Provide a baseline risk assessment

This section of the RFI/RI workplan summarizes the site conceptual model developed in Section 2 0 and identifies data needs and use of data to meet the outlined objectives

4 1 SITE SPECIFIC RFI/RI DQO PROCESS

Through application of the data quality objectives (DQOs) process site specific RFI/RI DQOs are established and data needs are identified for achieving identified goals DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI (EPA 1987) These determination are facilitated through the development of DQOs

DQOs are developed using the following three stage process

- STAGE 1 Identify decision types

    identify and involve data users
    evaluate available data
    develop conceptual model
    specify objectives/decisions

- STAGE 2 Identify data uses and needs

  identify data uses
  identify data types
  identify data quality needs
  identify data quantity needs
  evaluate sampling/analysis options
  review PARCC parameters

- STAGE 3 Design data collection program

  assemble data collection components
  develop data collection documentation

The three stages are implemented for each phase of the RFI/RI The DQO stages are undertaken in an interactive and iterative manner whereby all the elements of the DQO process are continually being reviewed and applied during the execution of the data collection activities Throughout the RFI/RI these stages occur in a natural progression and flow together without a formal stage delineation It may not be possible to identify all data needs during the RFI/RI activity Data needs will become more apparent as additional data are obtained and evaluated

4.2 SUMMARY OF EXISTING SITE DATA AND CONCEPTUAL MODEL

The existing data have been evaluated and support the following tentative conclusions

> The groundwater in the upper HSU contains volatile organic compounds The principal volatile organic compounds present as dissolved constituents are tetrachloroethylene (PCE) trichloroethylene (TCE) and carbon tetrachloride (CCl_4) Although areas of relatively high concentrations of these dissolved contaminants have been delineated, their extent in the upper HSU has not been determined Although non aqueous phases of volatile organic contaminants have not been identified in the subsurface in the past, considering the reported volumes of contaminants that may have been spilled or leaked onto the site there appears to be a potential for dense non aqueous phase liquids to be present in localized depressions in the relatively permeable portions of the upper HSU and in weathered or fractured claystone at the bottom of the uppermost unconfined aquifer
>
> Relatively low concentrations of volatile organic compounds have been detected in samples of groundwater from four wells screened in the unweathered claystone and lower sandstone

bedrock These four wells are 1887BR 2087BR 3487BR and 4086BR For the most part these data have not been validated There is a potential for contaminated groundwater in the unconfined groundwater flow system to enter lower sandstones where they subcrop beneath relatively shallow colluvium south and southeast of the 903 Pad area Wells constructed prior to 1986 may also represent a potential pathway of contamination from the upper HSU to the lower HSU(s)

- The predominant component of the groundwater hydraulic gradient in the bedrock is potentially downward The horizontal component of the hydraulic gradient appears to be generally toward the east However in general the bedrock groundwater flow regime is not well understood and gradients in the deeper sandstones are not known At present it is believed that the majority of bedrock groundwater flow occurs laterally in the lower sandstones The low hydraulic conductivity of the claystone impedes the downward flow of groundwater

Considering the proximity of Operable Unit 1 (881 Hillside) and its location to the west of the 903 area there appears to be a potential for contamination from topographically or hydraulically upgradient sources to be present Lower sandstones beneath the 881 Hillside site may be upgradient of lower sandstones beneath Operable Unit 2

4.3 SITE SPECIFIC PHASE II RFI/RI (BEDROCK) OBJECTIVES AND DATA NEEDS

This section of the Phase II Bedrock RFI/RI Work Plan establishes the objectives and data needs for achieving identified goals Based on existing data and on the site conceptual model, site specific RFI/RI objectives and data needs associated with identifying potential sources of bedrock contamination and nature and extent of contamination in the bedrock are shown in Table 4-1 The specific plans and rationale for obtaining the required data are presented in the Field Sampling Plan Section 8 0

Data of a quality consistent with the objectives specified in Table 4-1 will be collected in accordance to the Rocky Flats Plant Environmental Restoration (ER) Program Standard Operating Procedures (SOPs) and through adherence to the Rocky Flats Plant ER site wide Quality Assurance Project Plant (QAPjP) Chemical analyses will be performed in accordance with General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990f)

Analytical methods with detection limits below or near potential chemical specific ARARs (see Section 3 0) will be used to facilitate comparisons of resulting data to potential ARARs Table 4-2 summarizes the required analytical levels referenced in Table 4-1

TABLE 4 1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
CHARACTERIZE PHYSICAL FEATURES			
• Delineate and characterize physical nature of sandstone units	• Boreholes in appropriate areas to refine existing geologic model Combine information on sandstone units from Geologic Characterization Report with high resolution seismic profiling data • Laboratory classification testing • Borehole and laboratory permeability testing	I & II	• Site Characterization • Alternatives Evaluation
• Delineate and characterize physical nature of weathered claystone/siltstone	• Borehole logging of weathered zone of bedrock • Borehole/well hydraulic conductivity testing • Laboratory classification testing	I & II	• Site Characterization • Alternatives Evaluation
Characterize physical nature of unweathered claystone/siltstone	• Borehole logging of unweathered bedrock • Borehole/well hydraulic conductivity testing • Laboratory classification testing	I & II	• Site Characterization Alternatives Evaluation
• Develop model of bedrock groundwater flow regime that addresses flow directions velocities, gradients, and interaction with surface water and groundwater in the upper HSU	• Analysis of water level and hydraulic conductivity data from new and existing wells screened in appropriate HSUs Must consider geometry of HSUs • Combine with results of upper HSU groundwater flow model (which is intended to evaluate interconnection of upper and lower HSUs	I	• Site Characterization • Alternatives Evaluation

TABLE 4 1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)
(Continued)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
CHARACTERIZE AND DELINEATE CONTAMINANT SOURCES			
• Plume areas in upper HSU	• Alluvial RFI/RI will characterize plumes of dissolved contaminants in groundwater in the upper HSU May be potential for additional wells/boreholes near alluvial/bedrock contact and analytical testing on soil and groundwater samples	I & II (field) IV (analytical)	Site Characterization • Alternatives Evaluation • Risk Assessment
• Old wells	• Evaluate the potential for existing wells particularly those constructed prior to 1986 to act as conduits across confining layers resulting in cross contamination	I & II (field) IV (analytical)	• Site Characterization • Alternatives Evaluation • Risk Assessment
• Dense non aqueous phase liquids pooled or flowing in depressions or channels in bottom of upper HSU	• Alluvial RFI/RI will address but may not fully characterize dense non aqueous phase liquids since occurrence will tend to be near alluvial/bedrock contact Boreholes and wells with analytical testing on soil/liquid samples will be used Water sampling will check for immiscible phases of contaminants	I & II (field) IV (analytical)	• Site Characterization • Alternatives Evaluation • Risk Assessment
• Offsite sources located topographically or hydraulically upgradient	• Boreholes and wells with analytical testing on soil and groundwater samples Limited evaluation of conditions at the upgradient (west) end of Operable Unit 2 will be conducted initially More detailed characterization of potential upgradient sources will be required only if interim findings demonstrate the need to gather additional data	I & II (field) IV (analytical)	• Site Characterization • Alternatives Evaluation • Risk Assessment

TABLE 4 1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)
(Continued)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
CHARACTERIZE NATURE AND EXTENT OF CONTAMINATION			
• Determine whether the contamination in the upper HSU has migrated into the bedrock and characterize the horizontal and vertical extent of any migration	• Drilling of boreholes into the bedrock to collect soil samples Lower sandstone and weathered and unweathered claystone/siltstone will be sampled	IV V (radiological analyses)	• Site Characterization • Risk Assessment • Fate and Transport Modeling • Alternatives Evaluation
	• Installation of and sampling of monitoring wells with screened intervals in the intervals of concern to evaluate groundwater contamination Field screening using GC headspace techniques on samples of the bedrock from the boreholes will be used to assist in targeting well screen intervals Analyses will emphasize volatile organic compounds and radiological constituents Selected sites will be analyzed for full TCL and TAL	II (Field GC screening) IV V (radiological analyses)	
• Assess the role of the lower sandstones and weathered siltstone/claystone in the transport of contaminants	• Boreholes will be drilled into the lower sandstones and weathered claystone/siltstone Areas of potentially subcropping lower sandstones will be explored and characterized Conduct analytical testing on the samples	IV V (radiological analyses)	• Site Characterization • Risk Assessment • Fate and Transport Modeling • Alternatives Evaluation

TABLE 4 1

DATA NEEDS AND DATA QUALITY OBJECTIVES (DQOs)
(Concluded)

Data Need	Sample/Analysis Method	Analytical Level	Data Use
	• Install and sample monitoring wells in the lower sandstone and weathered claystone/siltstone Field screening using GC headspace techniques on samples of the bedrock from the boreholes will be used to assist in targeting well screen intervals This will include wells near subcrop areas to evaluate hydraulic gradients groundwater flow directions, potential hydraulic connection with uppermost aquifer and groundwater quality based on analytical testing	II (Field GC screening) IV V (Radiological analyses)	

Note Summary of analytical levels given in Table 4-2

TABLE 4-2

SUMMARY OF ANALYTICAL LEVELS

Required Analytical Level	Task
Level I (Field Screens)	• Water level measurement • pH measurement • Eh measurement • Screening for organics (OVA/HNu) • Screening for radionuclides (beta gamma) • Temperature • Specific conductance • Screening for buried objects (magnetometer pipe locator)
Level II (Field Analyses)	• Screening for organics (GC) Screening for metals (ICP) • Screening for radionuclides (gross beta/gross alpha gamma spec) • Analysis of engineering properties
Level III (Laboratory Analyses using EPA Standard Methods)	• Major ion analysis • Organics analysis • Inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	• Analysis of Target Compound List (TCL) and Target Analyte List (TAL)
Level V (Nonstandard Analyses)	• Radiological analyses • Chemical analyses requiring modification of standard methods • Special Analytical Services (SAS)

Source EPA (1987)

Note Specific methods described in SOPs and/or QAA

The following is a list of tasks to be accomplished during the RFI/RI for Operable Unit 2 Each task as discussed in detail in the Phase II Bedrock RFI/RI Work Plan will be coordinated with the corresponding task in the Phase II RFI/RI Alluvial Work Plan

5 1 TASK 1 PROJECT PLANNING

The project planning task includes all efforts required to initiate both the alluvial and bedrock components of this Phase II RFI/RI of Operable Unit 2 Activities undertaken for this project have included a review of the Phase I RI results as well as other previous investigation results review of historical aerial photography preliminary evaluation of ARARs and scoping of the Phase II RI Results of these activities are presented in the alluvial work plan (EG&G 1990c) and in Sections 1 0 (Introduction) and 2 0 (Site Characterization)

During the Phase I RI a complex depositional pattern was recognized in the bedrock beneath the 903 Pad Mound and East Trenches areas This work plan incorporates the results of on going geologic characterization efforts (EG&G 1990a and 1990b) intended to define the location, extent and orientation of bedrock sandstone units and outlines further work to refine the site bedrock geologic model The geologic characterization has been combined with analytical chemistry data obtained during Phase I to develop a model of the nature and extent of contamination

Two project planning documents including this Work Plan, have been prepared which pertain to this Phase II RI as required by the draft Inter Agency Agreement (IAG) between DOE, EPA, and CDH This Work Plan presents results of the project planning task in addition to plans for the Phase II RFI/RI A Field Sampling Plan (FSP) included in this document presents the locations media and frequency of sampling efforts The second document required by the IAG is a Sampling and Analysis Plan (SAP) Included in the SAP are a Quality Assurance Project Plan (QAPjP) and Standard Operating Procedures (SOPs) for all field activities

5.2 TASK 2 COMMUNITY RELATIONS

In accordance with the draft IAG the Communications Department at Rocky Flats is developing a Plant wide Community Relations Plan (CRP) to actively involve the public in the decision making process as it relates to environmental restoration activities A Draft Community Relations Survey Plan has been completed and forwarded to EPA CDH and the public for review This Phase II RFI/RI work plan specifies activities planned to complete the Plant wide CRP including plans for community interviews The draft CRP will be completed in September 1990 in accordance with the draft IAG schedules Accordingly a site specific CRP is not required for Operable Unit 2

The Communications Department also is continuing other public information efforts to keep the public informed of environmental restoration activities and other issues which relate to Plant operations A Speakers Bureau program sends speakers to civic groups and educational organizations, while a public tour program allows the public to visit Rocky Flats Road tours of areas such as the 903 Pad, Mound and East Trenches areas are common during public tours as well as other tours arranged for public officials An Outreach Program also is in place according to which Plant officials will visit elected officials, the news media and business and civic organizations to further discuss issues related to Rocky Flats and environmental restoration activities The Communications Department also receives numerous public inquiries which are answered through telephone conversations or by sending written informational materials to the requestor

5.3 TASK 3 FIELD INVESTIGATION

The Phase II RFI/RI (Bedrock) field investigation is designed to meet the objectives outlined in Section 4 0 The following activities will be performed as part of the field investigation

- Drill and sample soils and bedrock and conduct geotechnical and geochemical laboratory testing on samples to further characterize the potential contaminants that may be present within the pore spaces in bedrock or that may be present as separate phase immiscible liquids

- Drill and log borings and install monitoring wells to further characterize the distribution of aquifer and aquitard zones within the bedrock Field volatile organic screening by gas chromatography (GC) methods will be used to assist in determining well screen intervals

- Perform in situ hydraulic conductivity testing in borings and wells to further characterize the hydraulic connection between surficial materials and bedrock and to further characterize groundwater flow rates

- Collect water level measurements in the monitoring wells to further characterize hydraulic gradients that will be used to evaluate groundwater flow directions

- Collect and analyze groundwater samples from monitoring wells to characterize the nature and extent of bedrock groundwater contamination

Sample locations frequency and analyses are presented in Section 8 0 All field activities will be performed in accordance with the Rocky Flats Plant ER Program SOP

5 4 TASK 4 SAMPLE ANALYSIS AND DATA VALIDATION

Analytical methods for chemical analyses are provided in the ER Program QAPjP Also provided in this document are the analytical detection limits sample container and volume requirements preservation requirements and sample holding times Project specific requirements are included in the Quality Assurance Addendum Section 9 0 of this Work Plan

Data will be reviewed and validated by the ER Program staff Results of data review and validation activities will be documented in data validation reports EPA data validation functional guidelines will be used for validating organic and inorganic (metals) data (EPA 1988b) Validation methods for radiochemistry and major ions data have not been published by the EPA however data and documentation requirements have been developed by ER Program QA staff Data validation methods for these data are derived from these requirements Details of the data validation process are described in the QAPjP

5.5 TASK 5 DATA EVALUATION

Data collected during the Phase II bedrock RI will be incorporated, with Phase II alluvial data, into the existing database and used to better define site characteristics source characteristics the nature and extent of contamination, and to support the baseline risk assessment and evaluation of proposed remedial alternatives

5.5 1 Site Characterization

Geologic and hydrologic data will be incorporated into appropriate site maps and cross sections Geologic data will be used to detail the stratigraphy of the bedrock in the 903 Pad, Mound, and East Trenches areas Hydrogeologic data will be used to characterize the subsurface geometry of aquifer and aquitard zones and groundwater flow in the bedrock This characterization will include gathering data on effective porosities hydraulic conductivities and hydraulic gradients that will be used as a basis for evaluating flow directions, the interaction between alluvial and bedrock groundwater groundwater velocities, and contaminant migration rates

5.5.2 Source Characterization

The results of the alluvial RFI/RI will be carefully evaluated to identify potential sources of bedrock contamination The potential sources evaluated will include (1) plumes of dissolved (aqueous phase contaminants in the upper HSU (2) pools or pockets of non aqueous phase contaminants near the bottom of the upper HSU and (3) unidentified off site sources located topographically and/or hydraulically upgradient of the site

Analytical data from the source boreholes will be used to

- Confirm IHSS locations
- Characterize the nature of source contaminants
- Characterize the lateral and vertical extent of source contaminants
- Determine the maximum onsite contaminant concentrations
- Quantify the volume of source materials

At those IHSS locations which are trenches geologic data from the source boreholes will determine the trench depths and characterize trench contents

5.5.3 Nature and Extent of Contamination

Analytical data from samples of bedrock groundwater will be used to characterize the nature and extent of contamination The criteria for the identification of contamination will be analyte specific, as discussed in Subsection 2 2 2 Background Characterization Essential to the implementation of these statistical techniques for groundwater and borehole samples is the categorization of each analytical data set into appropriate hydrogeologic units (e g the samples from similar sandstone lithologic units or claystone would be categorized together) The identification of the appropriate geologic unit will be based on geological data collected during the Phase II RFI/RI The natural range of background concentrations of inorganic parameters will be further characterized and evaluated in the context of the potential role of evaporative concentrations as a mechanism for localized occurrences of inorganic constituents at high concentrations at outcrops or shallow subcrops

The extent of contamination will be delineated through the use of isopleth maps and cross sections The possible use of kriging or other computerized calculation methods to contour the isopleths for the most widely distributed contaminants will be investigated Appropriate statistical techniques will be used to identify and characterize constituent distribution and source areas

Comparisons of analytical data from alluvial and bedrock groundwater will be made to investigate the movement of contaminants

5 6 TASK 6 BASELINE RISK ASSESSMENT

A baseline risk assessment will be prepared for the 903 Pad, Mound, and East Trenches areas as part of the Phase II RI to evaluate the potential threat to the public health and the environment in the absence of remedial action One risk assessment combining the bedrock and alluvial components of the RFI/RI will be conducted The baseline risk assessment will provide the basis for determining whether or not remedial action is necessary in the area and serve as the justification for performing remedial action (EPA 1988a)

Several objectives will be accomplished under the risk assessment task including identification and characterization of the following (EPA 1988a)

- Toxicity and concentrations of hazardous substances present in relevant media (e g air groundwater soil, surface water sediment and biota)

- Environmental fate and transport mechanisms within specific environmental media and cross media fate and transport where appropriate

- Potential human and environmental receptors

- Potential exposure routes and extent of actual or expected exposure

- Extent of expected impact or threat and the likelihood of such impact or threat occurring (i e risk characterization)

- Level(s) of uncertainty and limitations associated with the above factors

The public health risk assessment and the environmental evaluation will be performed utilizing accepted guidance including that provided by U S EPA (1989a) and other relevant direction in the general risk assessment literature

5 6 1 Public Health Evaluation

The risk assessment process is divided into five tasks including

- Contamination identification
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainty analysis

The task objectives and description of work for each task are described below

5 6 1 1 <u>Contaminant Identification</u>

The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants for the risk assessment process Previous work characterizing aspects of the Rocky Flats Plant and the surrounding area has been performed

Additional sampling and analysis of various media will take place in order to support the human health risk assessment the ecological assessment and to further characterize the site It is possible that the number of contaminants identified can be reduced to a list of contaminants of concern as is frequently done for hazardous waste site risk assessments involving many contaminants

5 6 1.2 <u>Exposure Assessment</u>

The objectives of the exposure assessment are to identify actual or potential exposure pathways, to identify and characterize potentially exposed populations, and to determine the extent of exposure An exposure pathway is comprised of five elements

1 A source of the chemical
2 A mechanism for the chemical to be released from the source to the environment
3 An environmental transport medium (e g air groundwater) for the released constituent
4 A point of potential contact of humans or biota with the affected medium (the exposure point)
5 An exposure route (e g inhalation of contaminated dust) at the exposure point

In order for exposure to occur all five elements must be present

The exposure assessment process will include the following actions

Analyze the probable fate and transport of compounds for both the present and the future uses

Identify the human populations in the area, typical activities that would influence exposure and sensitive population subgroups

- Identify potential and complete exposure pathways under current and future land use conditions

Develop exposure scenarios for each identified pathway and select those scenarios that are plausible

- Identify scenarios assuming both existing and potential future uses

Develop an estimate of the expected exposure concentrations and intakes at the exposure points from the potential release of contaminants

Appropriate exposure scenarios will be identified for the site Scenarios which could potentially be considered include natural residential, commercial/industrial, and/or recreational use Factors to be examined in the pathway and receptor identification process will include

- Location of contaminant source
- Local topography
- Local meteorological data
- Local geohydrology/surface water hydrology
- Surrounding land use
- Local water use
- Prediction of contaminant migration
- Persistence and mobility of migrating contaminants

  Influence of the physical and chemical processes expected to occur during contaminant migration

For each migration pathway and for existing and future land use receptors will be identified and characterized Potential receptors will be defined by the appropriate exposure scenarios

5 6 1.3 Toxicity Assessment

In accordance with EPA s risk assessment guidelines the projected concentrations of chemicals of concern at exposure points will be compared with ARARs to judge the degree and extent of risk to public health and the environment (including plants animals and ecosystems) Because ARARs do not exist for certain media (such as soils) and not all ARARs are health based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process Additionally receptors may be exposed to multiple contaminants and through more than one medium Nevertheless the comparison with standards and criteria is useful in defining the exceedance of institutional requirements In addition to ARARs listed in Table 3-1 the following criteria will be examined

- Drinking water health advisories
- Ambient water quality criteria for protection of human health
- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories
- National Ambient Air Quality Standards

Critical toxicity values (i e numerical values derived from dose response information for individual compounds) will be used in conjunction with calculated media intake determinations to evaluate potential risk Toxicity reference values from EPA s Integrated Risk Information System (IRIS) will be used chiefly in lieu of reference values from other sources

The baselne rısk assessment wıll also ınclude a summary of sıgnıficant toxıcologıcal studıes performed for chemıcals of concern An evaluatıon wıll be conducted as to the qualıty of these studıes and theır approprıateness for evaluatıng human health rısks assocıated wıth the specıfied exposure scenarıos presented A more detaıled explanatıon of the toxıc effects for chemıcals of concern wıll be provıded ın appendıxes to the human health rısk assessment and the envıronmental evaluatıon Suıtable reference values wıll also be summarızed For the human health rısk assessment, thıs wıll ınclude a brıef descrıptıon of the studıes upon whıch selected reference values were based, the uncertaınty factors used to calculate rısk reference doses (RfDs) and the EPA weıght of evıdence classıficatıon for carcınogens For those chemıcals wıthout EPA toxıcıty reference values a lıterature search, ıncludıng computer data bases may be conducted for selected compounds A toxıcıty value wıll then be derıved, when possıble from thıs ınformatıon Guıdance from germane sources such as the Natıonal Academy of Scıences wıll be followed regardıng the approprıateness of the data and the methodologıes to be used ın derıvıng reference values Uncertaıntıes regardıng the toxıcıty assessment wıll be evaluated

Two types of crıtıcal toxıcıty values wıll be used

- The rısk RfD
  Slope factor (for carcınogenıc chemıcals only)

5 6 1 4 Risk Characterization

Rısk characterızatıon ınvolves ıntegratıng exposure assumptıons and toxıcıty ınformatıon to quantıtatıvely estımate the potentıal added publıc health rısk assocıated wıth exposure to sıte related contamınants Rısk characterızatıon wıll be performed for those compounds determıned to be chemıcals of concern To assess the potentıal adverse health effects assocıated wıth access to the sıte the potentıal level of human exposure to the chemıcals of concern must be determıned Chemıcal ıntakes of receptor populatıons wıll be calculated separately for all approprıate exposure pathways for chemıcals Then, for each populatıon at rısk the total ıntake by each route of exposure wıll be calculated by addıng the ıntakes from each pathway Total oral, ınhalatıon and dermal exposures wıll be estımated separately Because short term (subchronıc) exposures to relatıvely hıgh concentratıons of chemıcals may cause dıfferent non carcınogenıc effects than those caused by long term (chronıc) exposures to lower concentratıons two ıntake levels wıll be calculated for non carcınogens for each route of exposure to carcınogens Rısk wıll be quantıfied by comparıson of contamınant ıntakes at exposure poınts to quantıtatıve crıterıa for protectıon of human health RfDs and by computıng estımated added lıfetıme cancer rısk usıng slope factors

5 6 1.5 Uncertainty Analysis

An uncertaınty analysıs wıll be performed to ıdentıfy and evaluate factors that produce uncertaınty ın the rısk assessment such as assumptıons ınherent ın the development of toxıcologıcal endpoınts (potency slope factors reference doses) and assumptions considered in the exposure assessment (model input variability population dynamics) Techniques employed to assess uncertainty may include propagation of errors analysis (i e first order analysis) sensitivity analysis and statistical sampling techniques (Monte Carlo) or other methods appropriate to the assessment The goal of this task will be to quantify to the extent practicable the magnitude and extent of uncertainty propagated through the risk assessment process This uncertainty analysis will present the spectrum of potential risks under specified scenarios so that the risk management decision maker can acquire an understanding of the level of confidence associated with all estimates of human health risk

5 6.2 Environmental Evaluation

The objective of the environmental evaluation for Operable Unit 2 is to determine if the contaminants have caused or are causing an adverse environmental impact The data to be collected will be utilized in conjunction with existing data to determine the bio availability and toxicity of the contaminants to the flora and fauna of the 903 Pad Mound, and East Trenches areas

The environmental evaluation will be conducted according to guidance provided in Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual (EPA 1989d) as part of the 903 Pad Mound and East Trenches areas Phase II RFI/RI The scope of the investigation will be limited to the use of existing data as is recommended in the cited EPA guidance The radioecology study (Rocky Flats Plant Radioecology and Airborne Pathway Summary Report [Rockwell International 1986f]) the Final Environmental Impact Statement (DOE 1980) the soils and surface water chemical data, and any biological parameters collected during this environmental evaluation will be utilized to assess both the current and future ecological impacts within Operable Unit 2

In order to accomplish the work plan objective a number of activities are prepared and executed These are briefly described below·

Project Preparation This activity represents the project planning, preparation of the work plan and preparation of the sampling and analyses plan (SAP) The SAP incorporates two other supporting documents the field sampling plan (FSP) and quality assurance project plan (QAPjP) Included also is the review and analysis of existing information, identification of data gaps, and the preparation of a site specific conceptual model of release transport, and exposure

Field Investigation This activity represents all Phase II remedial investigation and ecological assessment fieldwork, including the installation of monitoring wells, soil borings sampling and analysis of ground and surface waters collection and analysis of soil scrapes collection and analysis of biological samples and air quality sampling necessary for the baseline risk assessment

Data Analysis During data analysis, all collected field data are reduced, evaluated compared with, and integrated into the existing data bank to provide up to-date information on conditions A second activity is to identify and provide data on specific chemical/radiological contaminants transport mechanisms and environmental receptors in order to conduct the baseline risk assessment

Environmental Risk Assessment The environmental risk assessment incorporates the environmental data gathered in the previous activities characterizes documented or potential contaminant exposure pathways and exposure point concentrations, and assesses the risk or threat to wildlife protected species or habitats

Remediation Criteria Statutes require the selection of remedial actions sufficient to protect the environment This activity entails the consideration of federal and Colorado state laws and regulations pertaining to the preservation and protection of natural resources that are applicable for the environmental risk assessment are utilized to the extent they are available Available data will be evaluated and, to the extent practicable criteria will be established that address environmental protection

Environmental Evaluation Report This activity entails the preparation of the report that addresses the scope of the investigation site environmental characteristics and contaminants characterization of exposure and risk, remediation criteria, conclusions and limitations of assessment

5 7 TASK 7 TREATABILITY STUDIES

This task includes efforts to provide technical support in the form of bench scale treatability tests to the Rocky Flats Plant Environmental Restoration Program These tests are intended to support the Operable Unit 2 bedrock component of the RFI/RI It is assumed at this time that, if contamination of the bedrock is found, remediation will involve groundwater treatment possibly in conjunction with containment and monitoring However other technologies may be applicable to local areas of relatively high levels of contamination where treatment of the bedrock itself may be feasible

Treatability studies are conducted primarily to (1) provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and to support the design of a selected remedial alternative and (2) reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected Treatability study requirements are developed during the development and screening of remedial alternatives (Subsection 6 1)

Numerous technologies that appeared to be potentially applicable for treating Operable Unit 2 were identified for treatability testing Contaminants consist of spent solvents, radionuclides, and oils The technologies identified 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 relatively short time frame (as opposed to technologies that would require a research and development phase) Innovative and alternative technologies were not considered

Depending on the specific yield of the bedrock matrix considered for remediation, it may be feasible to collect groundwater for treatment above ground In that case the following technologies have been identified for potential testing

- Chemical Oxidation of Organics Chemical oxidation is used to degrade hazardous organic materials to less toxic compounds Oxidation systems particularly those using ultraviolet (UV) light ozone and hydrogen peroxide are powerful tools for treating a wide variety of common organic environmental contaminants Disadvantages are similar to those for inorganic oxidation reduction potential nontarget organics and inorganics can produce undesirable side products and increase oxidant requirements

  Granular Activated Carbon (GAC) Adsorption of Organics GAC adsorption is the most fully developed and widely used technology for treating groundwater contaminated with organics It is effective for the removal of a wide range of organics from aqueous waste streams Bench scale testing would consist of running a series of descriptive tests to determine isotherms for the groundwater contaminants GAC is typically regenerated with a thermal process and the regeneration process can be performed at either off site or on site facilities

  Reverse Osmosis Reverse osmosis processes involve the use of semipermeable membranes By applying water pressure greater than the osmotic pressure to one side of the membrane water is passed through the membrane while particulate 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

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

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

- Biological Reactor Depending on the specific yield of the bedrock matrix, it may be possible to extract groundwater and use biological reactors utilizing microorganisms to remove organic contaminants from the water Most organic contaminants can be biologically degraded by introducing the appropriate microorganisms High concentrations of some organics and the presence of metals may prove toxic to the organisms and pretreatment may be required Several types of aerobic reactors exist such as activated sludge systems trickling filters, rotating biological contactors and immobilized cell reactors In general, these methods generate sludges that require disposal

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 proved sorption processes include ion exchange and 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 groundwater (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 sorbends for low level radionuclide removal

Ion Exchange of Radionuclides Ion exchange processes are used for a wide range of water treatment 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 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 runoff 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 $1\mu/l$ (Jelinek and Sorg 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)

In cases where collection of groundwater is not feasible or practical, the following technology was identified for potential testing

In Situ Biological Treatment Depending on the effective porosity of the bedrock in situ biological treatment may be feasible In situ biological treatment of groundwater involves the stimulation of biological growth in the contaminated zone in order to reduce the contaminant concentrations Microorganisms that can use some or all of the contaminants as substrates will normally exist in a contaminated environment The microorganisms are stimulated to increase their biological growth and consumption of contaminants through addition of essential nutrients Aerobic treatment systems also require the introduction of oxygen In situ treatment is dependent on geological and hydrological conditions The process is relatively inexpensive

Vacuum Extraction Volatile contaminants can be removed from soil using vacuum extraction, which is an in situ treatment technology that involves the air stripping of contaminants by inducing a vapor flow through the soil Since this technology involves the transfer of contaminants to the vapor air emission treatment is generally required The efficiency of the process is highly dependent on geologic conditions and would tend to be ineffective in low permeability bedrock

In cases where contaminants are entrained in bedrock, the bedrock is accessible and the contamination is of limited areal extent the following technologies have been identified for potential testing·

- 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 volumes of solidified materials in proportion to the contaminated material treated 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 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

5.8 TASK 8 REMEDIAL INVESTIGATION REPORT

An RI Report will be prepared to consolidate and summarize the data obtained during Phase I and both the alluvial and bedrock components of the Phase II field work This report will

- Describe in detail the field activities which serve as a basis for the RI report This will include any deviations from the work plan that occurred during implementation of the field investigation

- Thoroughly discuss site physical conditions This discussion will include surface features meteorology surface water hydrology surficial geology groundwater hydrology demography and land use and ecology

- Present site characterization results from all RI investigative activities at Operable Unit 2 in order to further characterize the nature and extent of contamination, as well as the rate of contamination migration The media to be addressed will include contaminant sources soils groundwater surface water air and biota

- Discuss contaminant fate and transport This discussion will include potential migration routes contaminant persistence and contaminant migration

- Present a baseline risk assessment The risk assessment will include human health and environmental evaluations

- Present a summary of the findings and conclusions and recommendations for the feasibility study

Some of the above tasks such as project planning, field investigation, sample analysis, validation and evaluation and possibly treatability studies will be implemented separately for the alluvial and bedrock components of the RFI/RI However other tasks such as community relations and baseline risk assessment will treat Operable Unit 2 as a whole A single RFI/RI report will be prepared to consolidate and summarize the data obtained during Phase I and both the alluvial and bedrock components of the Phase II field work

The following are tasks to be accomplished during the CMS/FS for Operable Unit 2 Each task is discussed in detail in the Phase II Bedrock RFI/RI Work Plan (Task 9) will be coordinated with the corresponding task in the Phase II RFI/RI Alluvial Work Plan

6 1 TASK 9 REMEDIAL ALTERNATIVES DEVELOPMENT/SCREENING

This section identifies potential technologies applicable to the remediation of contaminated bedrock at Operable Unit 2 The identified technologies are based on the site characterization and the site conceptual model developed in Section 2 0 Identification and screening of technologies and assembling an initial screening of alternatives will be conducted while the RFI/RI is being conducted However these activities are early stages of the Feasibility Study and as such, the results will be presented in the FS report

This section provides a brief overview of the EPA Superfund process that will be employed to develop and evaluate alternatives for Operable Unit 2 bedrock The Superfund Comprehensive Environmental Recovery Compensation and Liability Act of 1980 (CERCLA) process is described in detail in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a) The CERCLA process was adopted because it specifies in the greatest detail the steps that should be followed and because the IAG requires general compliance with both RCRA and CERCLA guidance

The steps followed to develop alternatives for the bedrock beneath the 903 Pad, Mound and East Trenches areas are discussed below

- Develop site remedial action objectives based on chemical and radionuclide specific standards (when available) site specific, risk related factors and other criteria as appropriate

- Develop a list of general types of actions appropriate for the bedrock beneath the 903 Pad Mound and East Trenches areas (such as containment, treatment, and/or removal) that may be taken to satisfy the objectives defined in the previous step These general types or classes of action are generally referred to as general response actions in EPA guidance

- Evaluate preliminary remediation goals early in the remedial alternatives development/screening process Preliminary remediation goals will be applied as performance objectives for evaluating effectiveness of specific technology processes identified as candidate components of viable remedial action alternatives Consistent with the NCP preliminary remediation goals will be established at a $1x10^{-6}$ excess cancer risk point of departure level As the FS evolves preliminary remediation goals may be revised to a different risk level based on the consideration of appropriate factors including exposure uncertainty and technical issues

- Identify and screen technology groups for each general response action For example the general response action of containment can be further defined to include the in situ stabilization of contaminants in a form that is less mobile or immobile in the biosphere Other containment alternatives could consist of groundwater barriers such as slurry walls Screening should eliminate those groups that are not technically feasible at the site

- Identify and evaluate technology options for each technology group to identify representative process or processes for each group under consideration Although specific process options are identified for alternative development and evaluation, these processes are intended to represent the broader range of options within a general technology group For example a soil bentonite slurry wall may be identified as representative of vertical barriers and would be used for technical and cost comparisons

  Assemble the selected representative technologies into site closure and corrective action alternatives for the bedrock beneath the 903 Pad, Mound and East Trenches areas and that represent a range of treatment and containment combinations as appropriate

  Screen the assembled alternatives against the short and long term aspects of three broad criteria effectiveness implementability and cost Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a thorough and extensive analysis alternatives will be evaluated in less detail than subsequent evaluations

Effectiveness is an evaluation of the protectiveness of human health and the environment achieved by a remedial alternative action during construction and implementation, and after the response objectives have been met Evaluation of effectiveness in the short term is based on protection of the community and workers impacts to the environment, and the time required to meet remedial response objectives Long term evaluation of effectiveness addresses the risk remaining to human health and the environment and is based on the percentage of permanent destruction, decreased mobility and/or reduction in volume of toxic compounds achieved after response objectives have been met

Implementability is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative It is used during screening to evaluate the combinations of process options with respect to the site specific conditions Technical feasibility refers to the ability to construct reliably operate and comply with action specific (technology specific) requirements in order to complete the remedial action Administrative feasibility refers to the ability to obtain required permits and approvals to obtain the necessary services and capacity for treatment storage and disposal of hazardous wastes and to obtain essential equipment and technical expertise

Cost estimates for screening will be derived from cost curves generic unit costs vendor information conventional cost estimating guides and prior estimates made for Rocky Flats and similar sites with modifications made for Rocky Flats Plant conditions Absolute cost accuracy is not necessary The cost estimates for the alternatives however will have the same relative accuracy for comparison and screening The cost estimating procedures used during screening are similar to those that will be used during the later detailed alternatives analysis The later detailed analysis however will receive more in depth and detailed cost estimates for the components for each alternative The screening cost estimates will include capital operating and maintenance costs The operating and maintenance costs will be calculated for the lifetime of the treatment unit operation at the site Present worth cost analysis will be used for alternatives in order to make the costs for the various alternatives comparable

Alternatives with the most favorable results from the composite evaluation will be retained for further scrutiny during the detailed analysis Not more than eight alternatives will be retained for detailed analysis (including containment and no action) At that time it may be determined that additional site specific information or technology specific treatability studies are necessary for an objective detailed analysis Also it will be necessary to identify and verify the action specific applicable or relevant and appropriate requirements (ARARs) that each respective alternative will be required to meet

At the Phase II RFI/RI Work Plan state the appropriate level of alternatives analysis requires the listing of general response actions most applicable to the type of site under investigation General response actions are defined as those broad classes of actions that may satisfy the objectives for remediation defined for Operable Unit 2 bedrock Table 6 1 provides a list and description of general response actions and typical technologies associated with remediating bedrock and bedrock waters Table 6-1 also includes a general statement regarding the applicability of the general response action to potential exposure pathways

The response actions outlined in Table 6 1 must be applied to the potential exposure pathways that will be identified for Operable Unit 2 bedrock The response actions can individually be capable of providing control over all or some of the potential pathways Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways

TABLE 6 1

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Applicability of General Response Typical Technologies	Action to Potential Pathways
No Action	No remedial action taken at site	Some monitoring and analyses may be performed	National Contingency Plan requires consideration of no action as an alternative Would no address potential pathways although existing access restriction would continue to control onsite contact
Access and use restrictions	Permanent prevention of entry into contaminated area of site Control of land use	Site security fencing deed use restrictions warning signs	Could control onsite exposure and reduce potential for offsite exposure Site security fence and some signs are in place Additional short term or long term access restriction would likely be part of most remedial actions
Containment	In place actions taken to prevent migration of contaminants	Capping· groundwater containment barriers soil stabilization enhanced vegetation	If applied to source could be used to control all pathways If applied to transport media, could be used to mitigate past releases (except air)
Pumping	Transfer of accumulated subsurface or surface contaminated water usually to treatment and disposal	Groundwater pumping leachate collection liquid removal from surface impoundments	Applicable to leachate removal prior to in situ treatment or waste removal Applicable removal of contaminated groundwater and bulk liquids (for example from buried drums)
Removal	Excavation and transport of primarily nonaqueous contaminated material from area of concern to treatment or disposal area	Excavation and transfer of drums soils sediments wastes contaminated structures	If applied to source could be used to control all pathways If applied to transport medial will control corresponding pathway Must be used with treatment or disposal response actions to be effective

TABLE 6 1
GENERAL RESPONSE ACTION, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATIONS
(Concluded)

General Response Action	Description	Applicability of General Response Typical Technologies	Action to Potential Pathways
Treatment	Application of technology to change the physical or chemical characteristics of the contaminated material Applied to material that has been removed	Incineration solidification land treatment biological chemical and physical treatment	Applied to removed source material could be used to control all pathways Applied to removed transport medial could control air surface water groundwater and sediment pathways
In Situ Treatment	Application of technologies in situ to change the in place physical or chemical characteristics of contaminated material	In situ vitrification densification flushing bioremediation	Applied to source could be used to control all pathways Applied to transport medial could be used to control corresponding pathways
Storage	Temporary stockpiling of removed material in a storage area or facility prior to treatment or disposal	Temporary storage structures	May be useful as a means to implement removal actions but definition would not be considered a final action for pathways
Disposal	Final placement of removed contaminated material or treatment residue in a permanent storage facility	Permitted landfill repositories	With source removal, could be used to control all pathways With removal of contaminated transport medial could be used to control corresponding pathway (except air)
Monitoring	Short and/or long term monitoring is implemented to assess site conditions and contamination levels	Sediment soil, surface water and groundwater sampling and analysis	RCRA requires post closure monitoring to assess performance of closure and corrective action implementation

In general terms potential human exposure may be avoided by prevention of contaminant release transport and/or contact Rocky Flats has developed a Plan for the Prevention of Contaminant Dispersion (PPCD) an IAG deliverable that outlines a strategy for controlling emissions during the Environmental Restoration program activities Thus application of the response actions may be considered at three different points in each potential exposure pathway (1) at the point where the contaminant could be released from the source (2) in the transport medium and (3) at the point where the contact with the released contaminant could be prevented

While the identification of general response actions is discussed above the selection of the most appropriate action or combination of actions is not warranted at this time Site and contaminant data are not sufficient to initiate the screening process The following data requirements have been established for the Phase II RFI/RI effort for characterization of the source and groundwater contaminants and for the preliminary screening of alternatives

- Describe contaminant fate and transport in bedrock
  - Collect and analyze bedrock and groundwater samples beneath release areas to evaluate contaminant spread
  - Describe and characterize bedrock geohydrology
  - Determine depth to water table and areas of saturated bedrock

- Site physical characterization
  - Groundwater flow regime within bedrock
  - Rock types and general engineering properties
  - Depth to bedrock
  - Depth to groundwater
  - Hydrogeologic boundaries and parameters

These data will enable a thorough comparative evaluation of the technologies with respect to implementability effectiveness and cost and will allow for informed decisions to be made with respect to the selection of preferred technologies The Field Sampling Plan (Section 8 0) describes the methodology that will be followed to obtain the required information

6.2 TASK 10 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The final step involving a detailed analysis of each alternative is performed during the FS The detailed analysis is not a decision making process but it is the process of analyzing and comparing relevant information in order to select a remedial action Each alternative will be assessed against nine evaluation criteria and the assessments will be compared to identify the key tradeoffs among the alternatives Assessment against the nine NCP evaluation criteria is necessary for the FS and the subsequent Record of

Decision (ROD)/Corrective Action Decision (CAD) to comply with the requirements of CERCLA/RCRA The nine specific evaluation criteria are listed below

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

The above criteria are described in the CERCLA EPA guidance document (EPA 1988a) The initial two criteria are considered threshold criteria because these alternatives must be satisfied before further consideration of the remaining criteria The next five criteria are considered the primary criteria on which the analysis is based The final two criteria state and community acceptance are addressed during the final decision making process after completion of the FS/CMS A more detailed description of each criteria follows

<u>Overall Protection of Human Health and the Environment</u>

The alternatives will be individually analyzed to determine whether they provide adequate protection of human health and the environment The protectiveness evaluation focuses on how the risks posed by each pathway are being eliminated reduced or controlled by treatment engineering, or institutional measures This evaluation will consider the point of departure yardstick preliminarily and revised remediation goals and EPA s $1x10^{-4}$ to $1x10^{-6}$ acceptable risk range

<u>Compliance with ARARs</u>

Each alternative will be analyzed to determine whether it will comply with all state and federal ARARs that have been identified The analysis will address compliance with chemical specific, location specific and action specific ARARs If an alternative will not comply with an ARAR the FS report will present the basis for justifying a waiver

<u>Long Term Effectiveness and Permanence</u>

This criterion assesses the risks that remain at the site after the response objectives have been met The risks associated with any remaining untreated wastes or treatment residuals will be evaluated For each alternative the magnitude of the residual risk and the reliability and adequacy of the controls used to manage untreated wastes and treatment residuals will be addressed

<u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u>

This criterion evaluates the statutory preference of selecting remedial actions that permanently reduce toxicity mobility or volume of the hazardous materials Factors evaluated for each alternative will include the proposed treatment process and the materials treated the quantity of materials to be treated or destroyed and how the primary hazardous threat will be addressed the estimated degree of the reduction in toxicity mobility or volume that will be achieved the extent to which the treatment will be irreversible the type and quantity of treatment residuals that will remain following treatment and the determination whether the alternative will comply with the statutory preference for treatment

<u>Short Term Effectiveness</u>

Short term effectiveness refers to the effects an alternative may have during construction and implementation phases until the cleanup objectives have been achieved Alternatives will be evaluated to determine the effects on human health and the environment during implementation Each alternative will be assessed against the following factors protection of the community and workers during the remedial action environmental impacts and the time required to achieve the remedial action objectives

<u>Implementability</u>

This criterion assesses the technical and administrative feasibility of implementing an alternative and the availability of necessary services and materials The following factors will be analyzed during the implementability assessment the technical feasibility of construction and operation the reliability of the technology the practicability of employing additional remedial actions the ability to monitor the effectiveness of the remedial action administrative coordination with other offices and agencies the availability of adequate offsite hazardous (or mixed) waste treatment storage and disposal and the availability of equipment expertise and other services and materials

<u>Costs</u>

A cost estimate will be prepared and if necessary a cost sensitivity analysis will be prepared to evaluate costing assumptions Capital costs include direct construction costs indirect non construction costs, and overhead costs Operating and maintenance costs are incurred after construction in order to operate the remedial action on a continuous basis until the remedial action objectives have been achieved FS cost estimates are expected to be within an accuracy range of minus 30 percent to plus 50 percent If this accuracy cannot be achieved the fact (with supporting documentation) will be stated in the FS report

A costs sensitivity analysis may be conducted to determine the effect that specific cost assumptions have on the total estimated cost of an alternative The cost assumptions will be based on site specific data technological operating data etc although the assumptions will be subject to varying degrees of uncertainty depending on the accuracy of the data

State Acceptance

This criterion addresses the state s administrative and technical issues and concerns with each of the alternatives

Community Acceptance

The community acceptance program addresses the public s concerns and issues with each of the alternatives

6.3 TASK 11 FEASIBILITY STUDY REPORT

The FS report will contain a narrative discussion of each alternative s evaluation against the nine criteria listed above As with the RI report the FS report will address both the alluvial and bedrock components of the site There is a potential for different alternatives to be considered for the bedrock than for the uppermost aquifer The narrative will describe how each alternative addresses the technical treatability issues long term and short term effectiveness costs protection of human health and the environment compliance with ARARs etc Once the alternatives have been described, a comparative analysis will be conducted to evaluate the relative performance of each alternative The relative advantages and disadvantages of each alternative with respect to the other alternatives will be determined in order to assess the key tradeoffs that must be made in selecting a remedial action A candidate alternative must generally attain the primary objectives of compliance with ARARs and overall protection of human health and the environment in order for it to be eligible for selection as the remedial action A narrative discussion of the alternatives comparison describing the tradeoffs benefits and shortcomings of each alternative in comparison to the others will be included in the FS report

Following completion of the FS process the results of the detailed alternatives comparison and risk management will be used as the rationale for selecting a preferred alternative and a remedial action Although the purpose of the FS report and process is not to select a remedial action, it will present and evaluate the alternatives in sufficient detail in order to objectively consider all significant issues and select a feasible cost effective and defensible remedial action

The FS Report will present a description of the feasibility study and its results The report will include sections describing site background nature and extent of problem summary results of the RI risk assessment and environmental evaluation identification, screening, and detailed evaluation of remedial alternatives and the recommended remedial actions This task includes development of a Draft FS a revised Draft FS that incorporates EPA and CDH comments and preparation of a Final FS that incorporates public comments

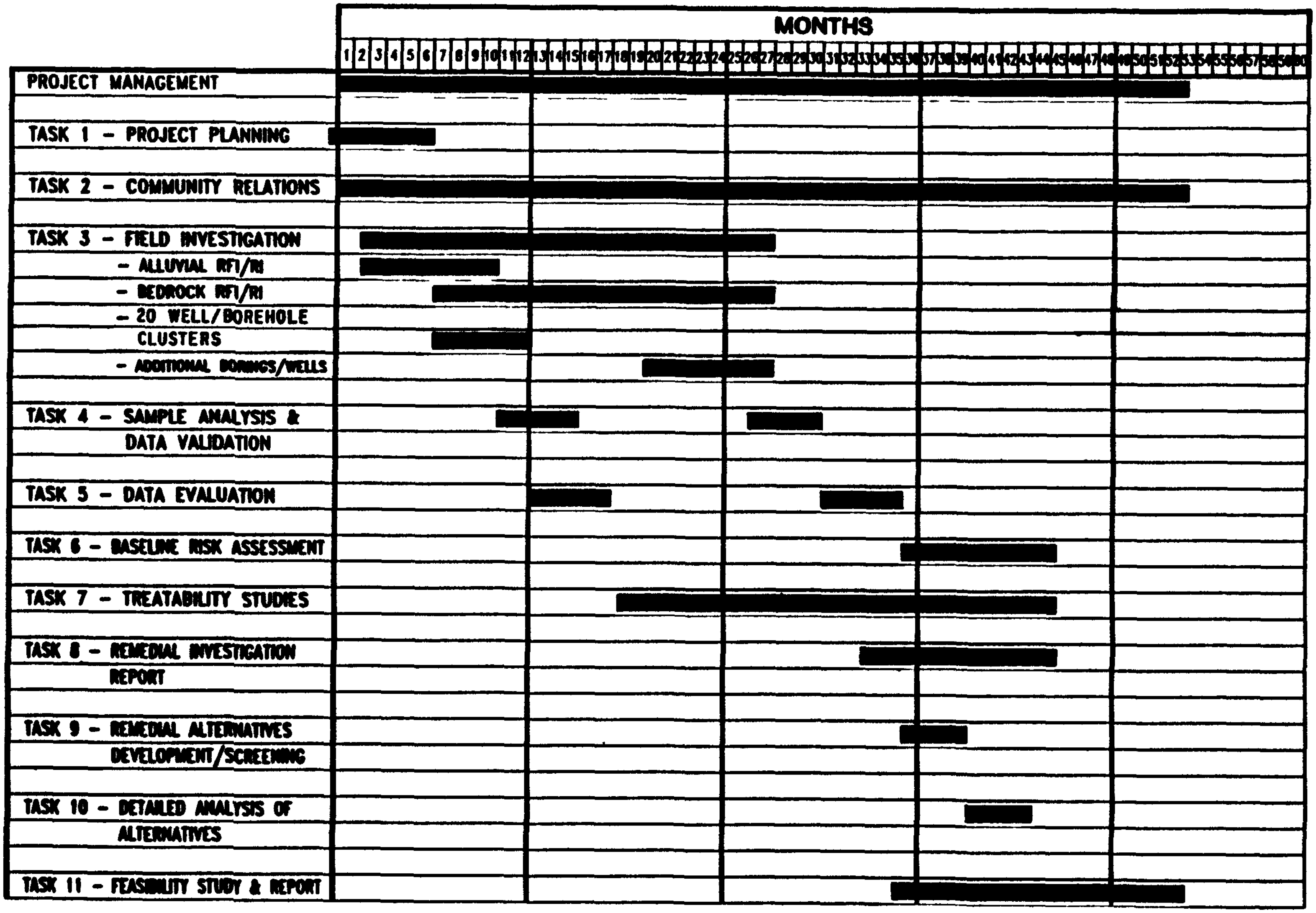
As with the RFI/RI some portions of the CMS/FS may be conducted separately for the bedrock and alluvial components of the site It is likely that remediation requirements will not be the same for the bedrock as for the upper hydrostratigraphic unit (HSU) However both the bedrock and alluvium will be addressed during the CMS/FS and only one CMS/FS report will be prepared

7 0
SCHEDULE

The schedule for conductıng the Phase II RFI/RIFS ıs summarızed ın Fıgure 7 1 The schedule ıncludes both the alluvıal and bedrock components of the RFI/RI and the Correctıve Measures Study/Feasıbılıty Study (CMS/FS) actıvıtıes Dates are not shown however the schedule ıs consıstent wıth the IAG schedules

After the field program outlıned ın the FSP ıs complete sample analysıs and data valıdatıon wıll be conducted followed by ınterım data evaluatıon Addıtıonal field ınvestıgatıon may be requıred to further characterıze the sıte ıf necessary and to satısfy data needs and data qualıty objectıves for the CMS/FS After addıtıonal field ınvestıgatıon, there wıll be further sample analysıs and data valıdatıon, data evaluatıon and preparatıon of the draft and final RFI/RI reports

Durıng RFI/RI report preparatıon, on goıng treatabılıty studıes wıll be ın progress and the CMS/FS wıll start The CMS/FS wıll ınclude remedıal alternatıves development and screenıng, and detaıled analysıs of alternatıves Accordıng to thıs schedule nearly 4 years wıll elapse from the tıme thıs work plan ıs finalızed untıl the final CMS/FS report ıs ıssued



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OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN

PHASE II RFI/RIFS SCHEDULE

FIGURE 7-1 6/21/91

8 1 BACKGROUND

The objectives of the bedrock component of the Phase II RFI/RI are to adequately characterize the bedrock to support the baseline risk assessment and to sufficiently characterize the nature and extent of bedrock contamination to support the feasibility study further risk assessment, and, if necessary remedial design Within these broad objectives site specific data needs have been identified in Section 4 0 The purpose of this section of the work plan is to provide a Field Sampling Plan (FSP) that will address these data needs and describe the work required to fulfill the data quality objectives (DQOs)

The Phase II RFI/RI for Operable Unit 2 has been divided into a bedrock component and an alluvial component This field sampling plan describes the bedrock component of the Phase II RFI/RI The alluvial component described in a previously prepared work plan (EG&G 1990c) includes both source and plume characterization within the upper hydrostratigraphic unit (HSU)

The bedrock component of OU2 Phase II RFI/RI includes plume characterization within the lower HSU (see Subsection 2 3 Site Conceptual Model and Section 4 0 Data Needs and Data Quality Objectives) Three potential sources of contamination may occur in bedrock (1) plumes of dissolved (aqueous phase) contaminants in the upper HSU (2) pools or pockets of dense non aqueous phase liquid contaminants near the bottom of the upper HSU and (3) unidentified plumes from off site sources located topographically and/or hydraulically upgradient of the site These sources are the targets for the bedrock borehole sampling and monitoring well programs

The sampling activities required to characterize the bedrock will involve drilling 20 boreholes and installing approximately 38 groundwater monitoring wells As discussed in more detail in Subsection 8.2, these 20 locations have been identified to confirm various significant features, to verify the proposed geologic model, and to establish stratigraphic control for clusters of boreholes and wells for the Phase II RFI/RI investigation

All sampling and analysis activities will be conducted according to the project Health and Safety Plan (HSP) and the Sample Analysis Plan (SAP) The SAP will include the Standard Operating Procedures (SOPs) and the Quality Assurance Project Plan (QAPjP) which were under development at the time this work plan was being prepared A project specific Quality Assurance Addendum (QAA) is also under development to supplement the QAPjP

8.2 FIELD SAMPLING

8.2 1 Samplıng Rationale

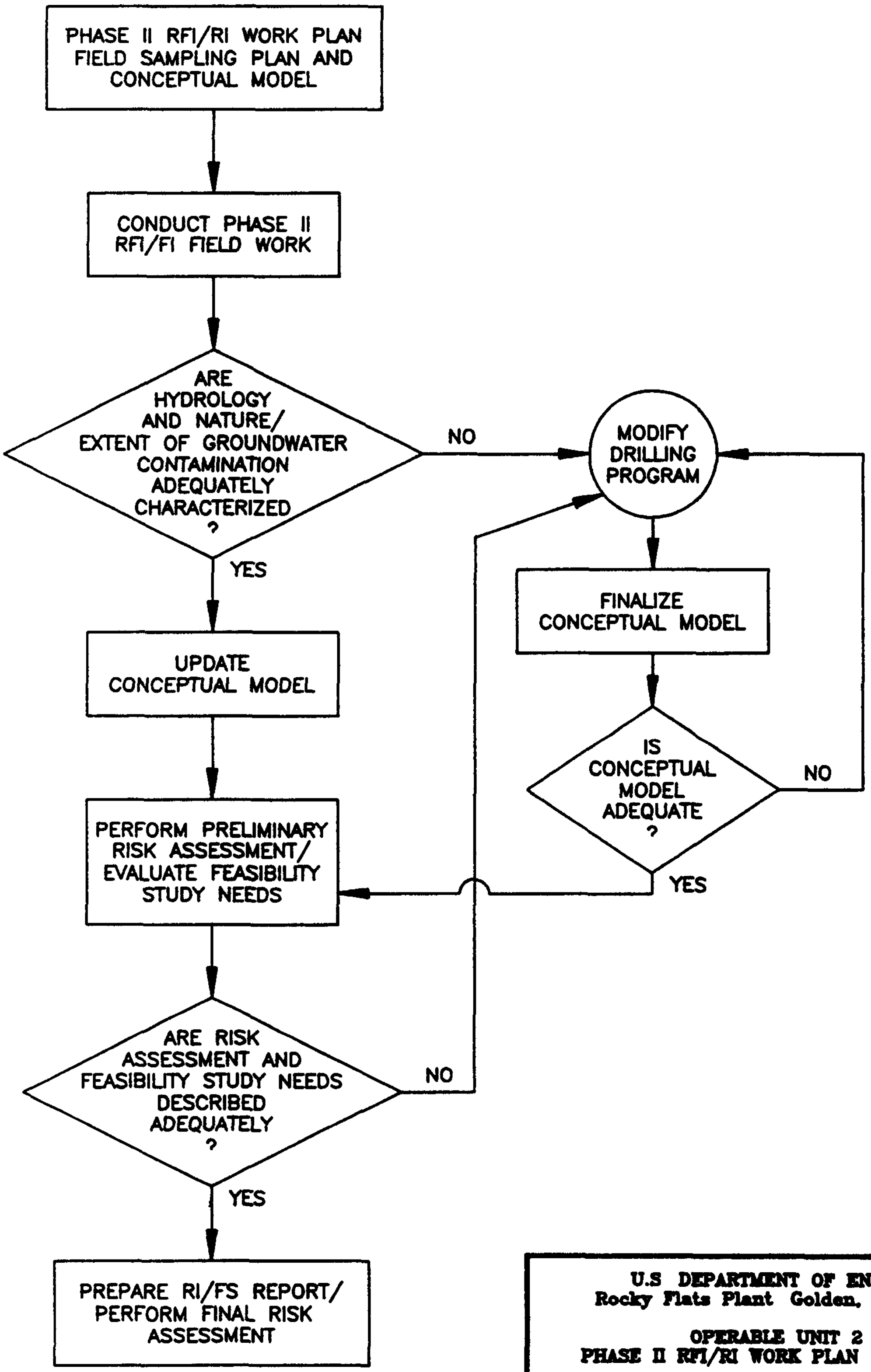
Fıgure 8 1 shows the locatıons of 20 proposed well/borehole clusters These 20 cluster sıtes have been selected based on the results of the Phase RI whıch ıncluded 10 alluvıal wells and 14 bedrock monıtorıng wells and on the ongoıng sıte geologıc characterızatıon After thıs round of drıllıng and samplıng, the workıng hydrogeologıc sıte model wıll be revısed. In addıtıon, the ınvestıgatıon wıll ındıcate eıther that sıgnıficant bedrock contamınatıon exısts or that ıt appears not to The scope of subsequent steps to fill data gaps may depend on the field results of the proposed ınvestıgatıon

Fıgure 8 2 presents a flow dıagram demonstratıng the scope and sequencıng of subsequent steps of the RFI/RI field ınvestıgatıon that wıll be requıred dependıng on the ınterım results obtaıned after the proposed borıng and samplıng program If bedrock contamınatıon ıs not ıdentıfied, subsequent steps may consıst of demonstratıng that potentıal pathways have been suffıcıently characterızed to conclude that contamınatıon does not exıstıng along any potentıal pathway and to provıde a suffıcıent data set for the baselıne rısk assessment

After the proposed ınvestıgatıon has been conducted, the requırements for further samplıng wıll be establıshed based on the ratıonale presented ın thıs Fıeld Samplıng Plan These ratıonale ınclude two questıons ıs the sıte conceptual model adequately descrıbed, geologıcally and hydrogeologıcally· and ıs the newly collected data set suffıcıent to conduct the baselıne rısk assessment The work may be redırected based on ınterım field results by EG&G and on ongoıng evaluatıon of the data Geologıc and chemıstry data wıll be evaluated as ıt ıs obtaıned EG&G wıll dırect the contınuous updatıng of the hydrogeologıc sıte model throughout thıs ınvestıgatıon

The physıcal propertıes and contamınatıon of the bedrock ımmedıately beneath and downgradıent of the potentıal bedrock source areas ıdentıfied durıng the alluvıal RI wıll be characterızed by laboratory physıcal and chemıcal analysıs of bedrock samples and by chemıcal analysıs of groundwater obtaıned from wells ınstalled ın the ıntervals of ınterest Characterızatıon of unweathered bedrock chemıstry wıll be based solely on groundwater chemıstry testıng Selectıon of well screen ıntervals wıll be based on ınspectıng the core samples for the presence of sandstone lıthology weatherıng and fracturıng, and vısual presence of contamınatıon

Lımıted hydraulıc conductıvıty ınformatıon ıs currently avaılable for the bedrock The results of packer tests conducted durıng the Phase I RI do not ındıcate a sıgnıficant dıfference ın hydraulıc conductıvıty between the unweathered sandstone and the claystone However geologıc ınterpretatıon ındıcates the lower sandstones may control the groundwater flow regıme ın the lower HSU(s) All of the hydraulıc conductıvıty values measured ın the unweathered bedrock were relatıvely low· on the order of 1×10^{-6} to 1×10^{-8} cm/sec



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PHASE II RFI/RI WORK PLAN (BEDROCK)

RFI/RI PROCESS
FLOW DIAGRAM

FIGURE 8-2 6-21-91

225788-2

Hydraulic conductivity measurements performed in the different lithologic units will, therefore be an important part of characterizing the bedrock hydrogeology Packer tests will be conducted in rock cored sections of the central borehole at each cluster location, and slug tests will be conducted in all wells The packer testing program will concentrate on distinguishing the hydraulic conductivities of the unweathered claystones and siltstones from those of the unweathered sandstones Slug test results will be used to distinguish hydraulic conductivity of unweathered claystone from that of weathered claystone However slug tests may be unsuccessful if small saturated thicknesses (i e less than about 3 feet) are found Initially conventional pump-out tests will not be conducted in the claystone and lower sandstones because the wells are not expected to yield sufficient quantities of water to make this a practical method Hydraulic head and hydraulic conductivity data will be used to develop potentiometric surface maps and/or flow nets for the various lithologic intervals

8.2.2 Boreholes

Location and depth criteria for boreholes are presented in Table 8 1 Typically the boreholes will be relatively deep on the order of 100 to 300 feet however there are several shallower boreholes proposed toward the bottom of the hillside to the southeast of the 903 Pad area. Seventeen of the boreholes will penetrate the Arapahoe Formation Sandstone No 5 interval, and three boreholes will fully penetrate the Arapahoe Formation

Lithology of all boreholes including holes drilled for wells, will be logged the entire depth in accordance with SOP Number GT 1 Logging Alluvial and Bedrock Material Logging will be based on continuous lithologic sampling of the boreholes Sampling soils above the bedrock will be conducted using hollow stem auger continuous coring techniques Once bedrock is encountered, grouted casing will be embedded into the bedrock to isolate the alluvium from the bedrock prior to further drilling (see SOP Number GT.3 Isolating Bedrock from Alluvium with Grouted Surface Casing) SOP Number GT.3 requires that the surface casing embedment be 2 feet into the weathered bedrock However the intent is to place the bottom of the casing approximately 2 feet below the interface describing a substantial reduction in hydraulic conductivity If the uppermost weathered bedrock is highly weathered and/or fractured, this embedment depth will be adjusted downward A conservative approach will be used early in the program with casing embedment into the bedrock on the order of 5 feet The EG&G project hydrogeologist responsible for the on going hydrogeologic site characterization will be responsible for establishing and documenting protocols for surface casing embedment after the first several boreholes are completed and evaluated

Weathered bedrock will also be drilled and sampled using hollow stem auger continuous coring techniques Hollow stem auger continuous core runs will be 2 feet long in the alluvium and weathered bedrock Once the weathered bedrock has been fully penetrated, NX rock core sampling techniques will be used with carbide or diamond bits using air and/or potable water NX core runs will not exceed 5 feet in length

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2

Cluster Number (Approx Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
1 (5950)	B1	Located in the northwest portion of the East Trenches in an area of high concentrations of volatile organic contamination in the upper HSU (alluvium and SS#1) Evaluate vertical gradients Define stratigraphy at the four wells in the cluster evaluate bedrock contamination beneath source area and evaluate lateral extent of various sandstone intervals	Approximately 150 (penetrate SS#5 interval)	
	W1	Evaluate groundwater quality in weathered claystone (if present) immediately beneath SS#1	70	60-70
	W2	Evaluate groundwater quality in unweathered bedrock above first sandstone encountered beneath SS#1	105	95-105
	W3	Evaluate groundwater quality in first sandstone encountered beneath SS#1	135	120-135
	W4	Evaluate groundwater quality in claystone beneath sandstone screened by W3	145	135-145

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
2 (5968)	B2	Located in Mound Area between two existing wells (1887 and 2087) where volatile organic contamination has tentatively been detected in SS#3 and SS#4 Additional information will be obtained on lateral extent of SS#3 and SS#4 Evaluate vertical gradients, define stratigraphy at wells in cluster and evaluate lateral extent of SS#3 and SS#4	Approximately 145 (penetrate SS#5 interval)	
	W5	Evaluate groundwater quality in weathered bedrock immediately beneath alluvial soils (or beneath SS#1 if encountered)	35	25-35
	W6	Evaluate groundwater quality in uppermost unweathered claystone	70	60-70
	W7	Evaluate groundwater quality in SS#3 if present	115	105-115
	W8	Evaluate groundwater quality in SS#4 if present	135	125-135
3 (5972)	B3	Located in south-central portion of Mound Area Evaluate vertical gradients. Evaluate stratigraphy at wells in cluster and lateral extent of lower sandstones.	Approximately 140 (penetrate SS#5 interval)	
	W9	Evaluate groundwater quality in weathered claystone (if present) immediately beneath SS#1	45	35-45
	W10	Evaluate groundwater quality in uppermost unweathered claystone	80	70-80

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
4 (5982)	B4	Located at upgradient end of Operable Unit 2 to evaluate upgradient groundwater quality and entire depth of Arapahoe Formation stratigraphy for use in site wide geologic characterization Define stratigraphy at all wells in cluster and evaluate soil/bedrock contamination at upgradient end of Operable Unit 2 Data will supplement on-going site wide geologic characterization	Approximately 280 (penetrate basal Arapahoe sandstone and confirm Laramie Formation)	
	W11	Evaluate upgradient groundwater quality in weathered claystone (if present) immediately beneath SS#1	45	35-45
	W12	Evaluate upgradient groundwater quality in uppermost unweathered claystone	60	50-60
	W13 W14 W15	Evaluate upgradient groundwater quality and hydraulic heads in SS#2 SS#3 and SS#4 if encountered	85 110 130	75-85 100-110 120-130

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx. Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
5 (5972)	B5	Located near southeast corner of 903 Pad Evaluate contamination of soil/bedrock in 903 Pad source area Use well cluster to evaluate vertical and horizontal gradients in lower sandstones potentially subcropping in hillside to south	Approximately 145 (penetrate SS#5 interval)	
	W16	Evaluate groundwater quality in uppermost weathered bedrock (or immediately beneath SS#1 if encountered)	35	25 35
	W17 W18 W19 W20	Evaluate groundwater quality and hydraulic heads in SS#2, SS#3 SS#4 and SS#5 if encountered	80 110 130 145	70-80 100-110 120-130 135-145

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
6 (5961)	B6	Located approximately 300 feet south of southwest corner of East Trenches Area Evaluate vertical gradients and horizontal gradients in lower sandstones. Evaluate stratigraphy at wells in cluster and lateral extent of lower sandstones.	Approximately 140 (penetrate SS#5 interval)	
	W21	Evaluate groundwater quality in weathered claystone (if present) immediately beneath SS#1	55	45 55
	W22	Evaluate groundwater quality in uppermost unweathered claystone	85	75-85
	W23 W24	Evaluate groundwater quality and hydraulic heads in both SS#3 and SS#4 if present	110 130	100-110 120-130
7 (5955)	B7	Located just south of central portion of East Trenches Area Evaluate lateral extent of SS#4 and hydraulic heads/gradients in it if encountered Also evaluate stratigraphy at wells in cluster and vertical gradients	Approximately 155 (penetrate SS#5 interval)	
	W25	Evaluate groundwater quality in unweathered claystone	35	25-35
	W26	Evaluate groundwater quality and hydraulic heads in SS#4 if encountered	140	130-140

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx. Elevation-ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
8 (5925)	B8	Located approximately 500 feet south of central portion of East Trenches Area Evaluate lateral extent of lower sandstones for potential pathway evaluation	Approximately 115 (penetrate SS#5)	
9 (5943)	B9	Located in eastern portion of East Trenches Area between two existing wells where low levels of volatile organic contaminants have tentatively been detected in claystone at approximate depth of SS#2 interval Evaluate soil/bedrock contamination and evaluate vertical gradients	Approximately 175 (penetrate SS#5)	
	W27	Evaluate groundwater quality in uppermost weathered bedrock (or immediately beneath SS#1 if encountered)	55	45-55
	W28	Evaluate groundwater quality in claystone at depth of SS#2 interval or in SS#2 if encountered	100	90-100
10 (5920)	B10	Located approximately 700 feet northeast of northeast corner of East Trenches Area Evaluate entire depth of Arapahoe Formation stratigraphy for use in evaluating potential pathways and for site-wide geologic characterization	Approximately 280 (penetrate basal Arapahoe Sandstone and confirm Laramie Formation)	

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
11 (5945)	B11	Located on hillside south of 903 Pad Area in area of potentially subcropping SS#2 and confined SS#5 Evaluate potential for contaminated groundwater in upper HSU to enter SS#2 Evaluate vertical gradient between SS#2 and SS#5 intervals and horizontal gradients within SS#2	Approximately 100 (penetrate SS#5 interval)	
	W29	Evaluate groundwater quality and hydraulic head in SS#2	30	20-30
	W30	Evaluate groundwater quality and hydraulic head in SS#5	100	90-100
12 (5895)	B12	Located on hillside south of 903 Pad Area in area of potentially subcropping SS#3 Evaluate potential for contaminated groundwater in upper HSU to enter SS#3 Evaluate horizontal gradient in SS#3 by comparing with Cluster 5	Approximately 70 (penetrate SS#5)	
	W31	Evaluate groundwater quality and hydraulic head in SS#3	35	25 35
13 (5920)	B13	Located on hillside south of 903 Pad Area in area of potentially subcropping SS#2. Evaluate potential for contaminated groundwater in upper HSU to enter SS#2 Evaluate horizontal gradient in SS#2 by comparing with Cluster 5	Approximately 110 (penetrate SS#5)	
	W32	Evaluate groundwater quality and hydraulic head in SS#2.	25	15 25

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Continued)

Cluster Number (Approx. Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
14 (5865)	B14	Located on hillside southeast of 903 Pad Area in area of potentially subcropping SS#4 Evaluate potential for contaminated groundwater in upper HSU to enter SS#4 Evaluate horizontal gradient in SS#4 by comparing with Clusters 5 6 and 7	Approximately 35 (penetrate SS#5 interval)	
	W33	Evaluate groundwater quality and hydraulic head in SS#4	25	15-25
15 (5815)	B15	Located east of 903 Pad Area near center of sandstone channel sequence identified by high resolution seismic profiling. Evaluate stratigraphy to provide control for seismic work Place wells in sandstone at the discretion of the EG&G project hydrogeologist	Approximately 200 (penetrate basal Arapahoe Sandstone and confirm Laramie Formation)	
16 (5925)	B16	Located just southeast of 903 Pad Area near center of sandstone channel sequence identified by high resolution seismic profiling. Evaluate stratigraphy to provide control for seismic work Place wells in sandstone at the discretion of the EG&G project hydrogeologist	Approximately 100 (penetrate SS#5 interval)	
17 (5920)	B17	Located just north of central portion of East Trenches Area Evaluate vertical gradients and horizontal gradients in lower sandstones if found	Approximately 110 (penetrate SS#5 interval)	
	W34	Evaluate groundwater quality in weathered claystone if present.	45	35-45
	W35	Evaluate groundwater quality in uppermost unweathered claystone	65	55-65
	W36	Evaluate groundwater quality and hydraulic head in SS#3 or SS#4 whichever is shallower if encountered	80	70-80

TABLE 8 1

PROPOSED WELLS AND BOREHOLES
PHASE II RFI/RI BEDROCK CHARACTERIZATION
OPERABLE UNIT 2
(Concluded)

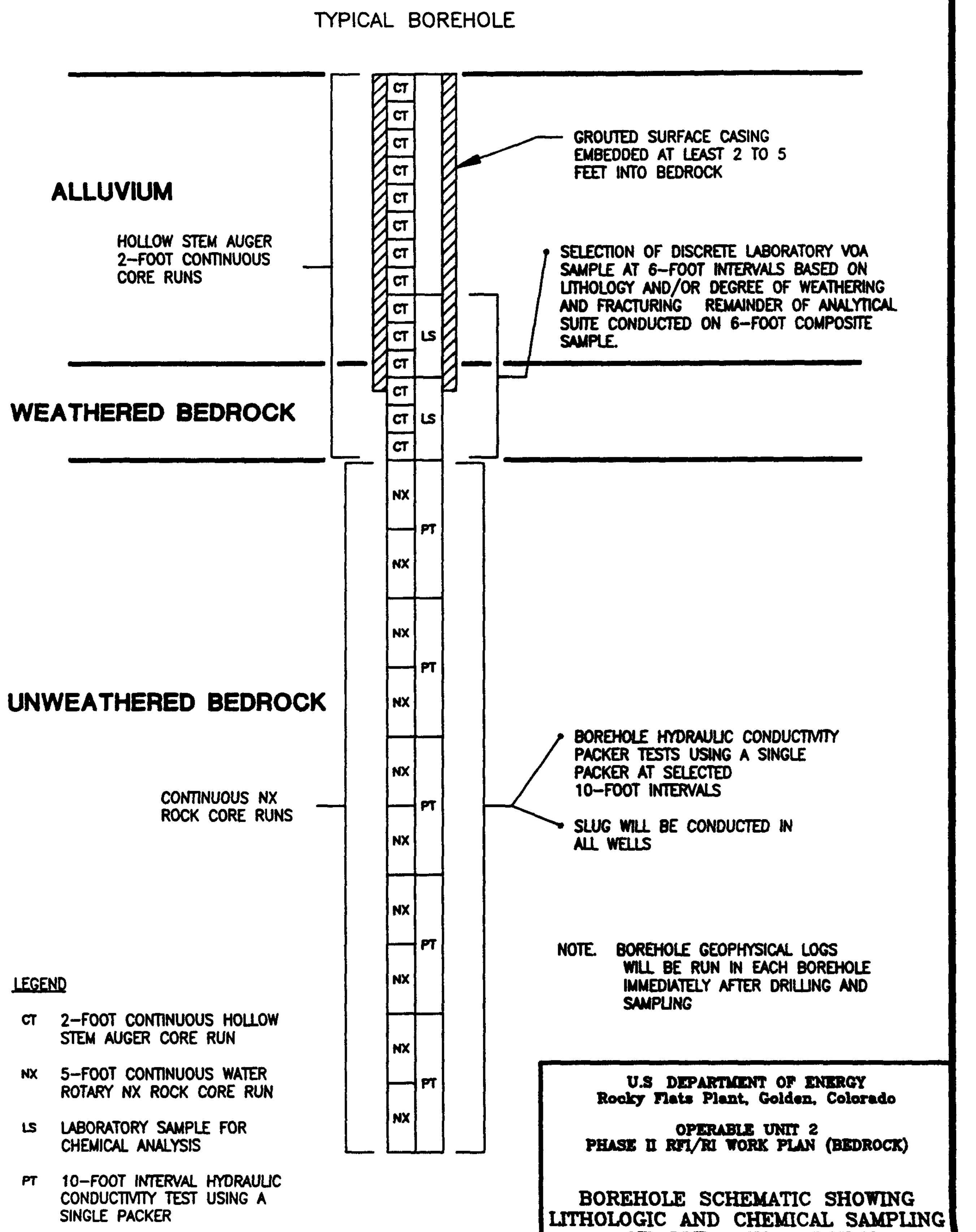
Cluster Number (Approx Elevation ft above MSL)	Well/ Borehole Number	Purpose	Anticipated Total Depth (ft below ground)	Anticipated Screened Interval (ft below ground)
18 (5972)	B18	Located at east end of Mound Area Determine presence or absence of SS#3 and SS#4 for pathway evaluation	Approximately 195 (penetrate SS#5)	
	W37 W38	Evaluate upgradient groundwater quality in SS#3 and SS#4 if encountered	120 135	110-120 125 135
19 (5959)	B19	Located adjacent to Well 22-74 just south of east portion of East Trenches Area Evaluate lithology penetrated by Well 22-74 to evaluate it as a potential pathway	190	
20 (5966)	B20	Located east of northeast corner of 903 Pad Evaluate extent of SS#3 and SS#4 for pathway evaluation	Approximately 145 (penetrate SS#5 interval)	140-145
			TOTALS	20 Boreholes 2 710 lineal feet 38 Wells 3 235 lineal feet

A discrete sample for potential laboratory volatile organic analysis (VOA) will be obtained from each 2 foot long continuous soil and weathered rock sample Out of 3 sequential samples one will be selected for VOA based on screening with an organic vapor detector (OVD) and on the degree of weathering or fracturing of the core Samples displaying a higher degree of fracturing and/or weathering will be preferred for analysis Chemical analyses other than VOA will be conducted on samples composited from the remaining material from the 3 sequential 2 foot samples (see SOP Number 3 2, Drilling and Sampling Using Hollow Stem Auger Techniques) Collection of samples for chemical analysis will start approximately 5 feet above bedrock (estimated based on Phase I RI and Phase II alluvial RFI/RI results) and continue to the base of the weathered bedrock Figure 8 3 shows a schematic representation of sampling requirements The borehole/well cluster locations were generally not located to search for small depressions where dense non aqueous phase liquids may collect However during drilling, samples of weathered and unweathered bedrock will be screened using an OVD High concentrations of volatile organic compounds could potentially indicate the presence of non aqueous phases of contaminants

Borehole hydraulic conductivity tests (pump-in packer tests) will be conducted at selected 10-foot intervals in the NX cored unweathered bedrock within the central borehole at each cluster Single packer tests will be conducted at selected intervals less than 10 feet in length after a 10-foot segment of hole is advanced Packer test procedures are given in SOP Number 2.3 Pump-In Borehole Packer Testing Packer test intervals will be selected by the project hydrogeologist based on lithology and degree of weathering and fracturing

The physical characteristics of the weathered and unweathered bedrock will be evaluated based on standard material properties such as grain size distribution and Atterberg limits Laboratory hydraulic conductivity tests will be conducted on at least two samples of sandstone from each lithologic interval of the lower sandstones (i e Arapahoe Formation Sandstone Nos 2, 3 4 and 5) Similarly laboratory hydraulic conductivity tests will be conducted on at least eight samples each of weathered claystone and unweathered claystone Selection of samples for testing will be made by the project hydrogeologist responsible for the ongoing geohydrologic site characterization The laboratory hydraulic conductivity tests will generally be conducted to measure vertical hydraulic conductivity however at the project hydrogeologist s discretion horizontal tests should also be conducted if it appears that they can be successfully completed with the available samples

The central borehole at each cluster will be logged geophysically from the base of the cased off alluvium to the bottom of the hole in order to obtain additional stratigraphic information Stratigraphic correlation between geophysical logs will aid the interpretation of the geologic extent of identified units Sonic log data will assist the integration of the existing seismic data with the ongoing geologic characterization program



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

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

BOREHOLE SCHEMATIC SHOWING LITHOLOGIC AND CHEMICAL SAMPLING AND HYDRAULIC TESTING

FIGURE 8-3 6-21-91

225788-3

Borehole geophysical logging will be conducted in accordance with SOP GT 15 immediately after drilling and sampling activities have been completed and before the hole is cased or abandoned Geophysical logging will consist of a full suite of downhole logs including

- Temperature
- Fluid resistivity
- Spontaneous potential
- Resistivity 16 + 64
- Induction
- Gamma gamma density
- Neutron
- Natural gamma ray
- Sonic log (full wave form)
- Caliper log

At the discretion of the EG&G project hydrogeologist boreholes may be completed as wells SOPs GT 3 and GT 6 apply to casings and well completions respectively If the bottom of the well screen interval is not at the bottom of the borehole the portion of the borehole below the screen will be properly grouted prior to well construction Well screens will not be placed in zones that have been packer tested If a well is completed at the bottom of a borehole hydraulic conductivity will be evaluated by means of a pump-out or bail down recovery test If not completed as wells abandonment of boreholes will be conducted in accordance with SOP Number GT.5 Plugging and Abandonment of Boreholes

8.2.3 Groundwater Monitoring Wells

The investigation outlined in Table 8-1 will involve installing 2 inch diameter groundwater monitoring wells Unless otherwise directed by the project hydrogeologist, wells will be constructed within 15 feet of the central borehole at each cluster For planning purposes, 38 wells are anticipated during the investigation however the installation of a number of these wells will be contingent upon whether or not certain intervals of sandstone are found at some of the cluster locations In other words a well targeted for a particular sandstone interval may not be constructed if sandstone is not found at that depth interval in the borehole unless the project hydrogeologist determines a well at that location and depth would be beneficial Depth criteria for anticipated screened intervals are presented in Table 8-1 Wells will be developed according to SOP No GW 2 Well Development

Wells that are scheduled to be screened in sandstone will be screened in the interval indicated in Table 8 1 if that lithology is encountered in the borehole made for the well However screen intervals for wells in both weathered and unweathered claystone may depend on the degree of weathering or fracturing observed in the core The EG&G field hydrogeologist designated to supervise well installation and logging may select the screened interval based on the amount of weathering or fracturing observed and assumed to represent potential secondary hydraulic conductivity Relatively weathered or fractured zones will be preferred for well screen intervals Otherwise the screened sections will be placed mid depth between the overlying and underlying sandstone intervals The screened interval of wells installed in unweathered claystone will be 10 feet in length

The bedrock will be isolated from potential contamination by groundwater from the upper HSU using grouted casing Similarly if zones of contaminated bedrock will be penetrated during the construction of wells screened beneath those contaminated zones nested surface casings will be provided to isolate the screened interval of the wells from the overlying potential contamination

The RFI/RI will be based on at least one round of groundwater chemistry analysis from each well However there is a potential for more rounds of data to be available for some of the earlier wells Groundwater measurements and sampling will be conducted according to SOP No GW 1 Water Level Measurements in Wells and Piezometers SOP No GW.5 Measurement for Groundwater Field Parameters and SOP No GW 6 Groundwater Sampling Water level measurements will be obtained monthly throughout the field investigation During groundwater sampling, an interface probe will be used to check for the presence of low and high density non aqueous phase liquids in wells where previous characterizations of alluvial groundwater indicate they may be present If they are detected, a discrete sampler will be used to sample them before purging the well for water samples Detailed procedures are presented in SOPA Number 10 1 in Section 10 0

There is a potential for some wells, primarily those completed in claystone to produce water slowly enough that they can not be sampled using conventional methods (i e purging prior to sampling) In these wells two alternatives will be used to obtain samples

(1) In weathered claystone where the alluvial RFI/RI results indicate relatively high concentrations of volatile organic compounds (i e greater than about 1 percent of the saturation concentration in water) a conventional well will be installed to check for non aqueous phase liquids Sampling will be conducted by purging one borehole volume and obtaining the sample as soon as possible Conventional wells will also be installed if in the opinion of the EG&G field hydrogeologist, there appears to be sufficient primary or secondary hydraulic conductivity for the well to be successful based on the appearance of the core

(2) In weathered and unweathered claystone where there do not appear to be relatively high concentrations of volatile or semivolatile organic compounds and where the core is relatively unfractured and a conventional well is anticipated to be ineffective a conventional well will not be installed, but rather an electronic or pneumatic piezometer tip and a

porous stone type isolated sampler (e g BAT system sampler) will be installed in the uncased bottom of the borehole An SOP for installation of electronic and pneumatic piezometers and porous stone type isolated groundwater samplers was under development during the preparation of this work plan

8.2 4 Location Surveying

Locations of all boreholes and wells will be surveyed in accordance with SOP GT 17 Three elevations will be determined for each well ground surface top of well casing, and top of surface casing. Locations are based on State Plane reference and elevations are feet above mean sea level (USGS datum)

8.2.5 Data Reporting Requirements

Field data will be input into the RFEDS environmental database to satisfy QA/QC requirements outlined in the QAPjP and QAA using a remote data entry module supplied by EG&G Data will be entered on a timely basis and diskettes will be delivered to EG&G A hard copy report will be generated from the module for contractor use The data will be put through a prescribed QC process based on a SOPA to be generated by EG&G

8.3 SAMPLE ANALYSIS

8.3 1 Soil Samples from Boreholes

8.3 1 1 <u>Chemical Analysis</u>

Soil samples will be collected for chemical analysis from soil and weathered bedrock, as discussed in Subsections 8 1 and 8 2 Samples designated for analysis (see Subsection 8.2) will be analyzed for the chemical parameters listed in Table 8-2 in accordance with the QAPjP and QAA

8.3 1.2 <u>Physical Analysis</u>

Physical analysis on soil and bedrock samples will consist of classification (ASTM [American Society for Testing and Materials] D2488) moisture content (ASTM D2216) and dry density for intact samples (ASTM D2216) Laboratory classification tests will consist of grain size distribution (ASTM D422) (including hydrometer analysis) and Atterberg limits (ASTM D4318) Laboratory classifications will be conducted for a minimum of 10 samples of each general bedrock material type Laboratory hydraulic conductivity tests will be flexible wall tests using a triaxial cell with a confining pressure approximating that of the overburden pressure

TABLE 8 2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2

METALS

Target Analyte List Soil and Bedrock	Target Analyte List Groundwater
Aluminum	Aluminum
Antimony	Antimony
Arsenic	Arsenic
Barium	Barium
Beryllium	Beryllium
Cadmium	Cadmium
Calcium	Calcium
Chromium	Chromium
Cobalt	Cobalt
Copper	Copper
Iron	Iron
Lead	Lead
Magnesium	Magnesium
Manganese	Manganese
Mercury	Mercury
Nickel	Nickel
Potassium	Potassium
Selenium	Selenium
Silver	Silver
Sodium	Sodium
Thallium	Thallium
Vanadium	Vanadium
Zinc	Zinc
Other Metals	**Other Metals**
Molybdenum	Molybdenum
Cesium	Cesium
Strontium	Strontium
Lithium	Lithium
Tin	Tin

TABLE 8 2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)

OTHER INORGANICS Soil and Bedrock

- pH
- Nitrate
- Percent Solids
- Cyanide
- Moisture Content

FIELD PARAMETERS Groundwater

- pH
- Specific Conductance
- Temperature

INDICATORS Groundwater

- Total Dissolved Solids

ANIONS Groundwater

- Carbonate
- Bicarbonate
- Chloride
- Sulfate
- Nitrate as N
- Cyanide

DISSOLVED RADIONUCLIDES Soil and Bedrock

- Gross Alpha
- Gross Beta
- Uranium 233+234 235 and 238
- Americium 241
- Plutonium 239+240
- Tritium
- Strontium 90 89
- Cesium 137

DISSOLVED RADIONUCLIDES Groundwater

- Gross Alpha
- Gross Beta
- Uranium 233+234 235 and 238
- Americium 241
- Plutonium 239+240
- Tritium
- Strontium 90
- Cesium 137
- Radium 226 228

TABLE 8 2

PHASE II RFI/RI
SOIL BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Contınued)

ORGANICS VOLATILES

Target Compound Lıst Soıl and Bedrock	Target Compound Lıst Groundwater
Chloromethane	Chloromethane
Bromomethane	Bromomethane
Vınyl Chlorıde	Vınyl Chlorıde
Chloroethane	Chloroethane
Methylene Chlorıde	Methylene Chlorıde
Acetone	Acetone
Carbon Dısulfide	Carbon Dısulfide
1 1 Dıchloroethene	1 1 Dıchloroethene
1 1 Dıchloroethane	1 1 Dıchloroethane
total 1 2 Dıchloroethene	total 1 2 Dıchloroethene
Chloroform	Chloroform
1 2 Dıchloroethane	1 2 Dıchloroethane
2 Butanone	2 Butanone
1 1 1 Trıchloroethane	1 1 1 Trıchloroethane
Carbon tetrachlorıde	Carbon tetrachlorıde
Vınyl Acetate	Vınyl Acetate
Bromodıchloromethane	Bromodıchloromethane
1 1 2 2 Tetrachloroethane	1 1 2,2 Tetrachloroethane
1 2 Dıchloropropane	1 2 Dıchloropropane
trans 1,3 Dıchloropropene	trans 1,3-Dıchloropropene
Trıchloroethene	Trıchloroethene
Dıbromochloromethane	Dıbromochloromethane
1 1 2 Trıchloroethane	1 1 2 Trıchloroethane
Benzene	Benzene
cıs 1 3 Dıchloropropene	cıs 1,3-Dıchloropropene
Bromoform	Bromoform
2 Hexanone	2 Hexanone
4-Methyl 2 pentanone	4-Methyl 2 pentanone
Tetrachloroethene	Tetrachloroethene
Toluene	Toluene
Chlorobenzene	Chlorobenzene
Ethyl Benzene	Ethyl Benzene
Styrene	Styrene
Total Xylenes	Total Xylenes

TABLE 8 2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)

ORGANICS SEMI VOLATILES

Target Compound List Soil and Bedrock	Target Compound List Groundwater
Phenol	Phenol
bis(2 Chloroethyl)ether	bis(2 Chloroethyl)ether
2 Chlorophenol	2 Chlorophenol
1 3 Dichlorobenzene	1 3 Dichlorobenzene
1 4-Dichlorobenzene	1 4-Dichlorobenzene
Benzyl Alcohol	Benzyl Alcohol
1 2 Dichlorobenzene	1 2 Dichlorobenzene
2 Methylphenol	2 Methylphenol
bis(2 Chloroisopropyl)ether	bis(2 Chloroisopropyl)ether
4-Methylphenol	4-Methylphenol
N Nitroso-Dipropylamine	N Nitroso-Dipropylamine
Hexachloroethane	Hexachloroethane
Nitrobenzene	Nitrobenzene
Isophorone	Isophorone
2 Nitrophenol	2 Nitrophenol
2 4-Dimethylphenol	2,4-Dimethylphenol
Benzoic Acid	Benzoic Acid
bis(2 Chloroethoxy)methane	bis(2 Chloroethoxy)methane
2 4-Dichlorphenol	2,4-Dichlorphenol
1 2,4-Trichlorobenzene	1,2,4-Trichlorobenzene
Naphthalene	Naphthalene
4-Chloroaniline	4-Chloroaniline
Hexachlorobutadiene	Hexachlorobutadiene
4-Chloro 3 methylphenol (para chloro-meta cresol)	4-Chloro-3 methylphenol (para chloro-meta cresol)
2 Methylnaphthalene	2 Methylnaphthalene
Hexachlorocyclopentadiene	Hexachlorocyclopentadiene
2,4 6-Trichlorophenol	2,4 6-Trichlorophenol
2,4,5 Trichlorophenol	2,4 5 Trichlorophenol
2 Chloronaphthalene	2 Chloronaphthalene
2 Nitroaniline	2 Nitroaniline
Dimethylphthalate	Dimethylphthalate
Acenaphthylene	Acenaphthylene
3 Nitroaniline	3-Nitroaniline
Acenaphthene	Acenaphthene

TABLE 8-2

PHASE II RFI/RI
SOIL, BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Continued)

ORGANICS SEMI VOLATILES

Target Compound List Soil and Bedrock	Target Compound List Groundwater
2,4-Dinitrophenol	2,4-Dinitrophenol
4-Nitrophenol	4-Nitrophenol
Dibenzofuran	Dibenzofuran
2 4-Dinitrotoluene	2,4-Dinitrotoluene
2,6 Dinitrotoluene	2,6-Dinitrotoluene
Diethylphthalate	Diethylphthalate
4-Chlorphenyl Phenyl ether	4-Chlorphenyl Phenyl ether
Fluorene	Fluorene
4-Nitroaniline	4-Nitroaniline
4 6-Dinitro 2 methylphenol	4 6-Dinitro-2 methylphenol
N nitrosodiphenylamine	N nitrosodiphenylamine
4-Bromophenyl Phenyl ether	4-Bromophenyl Phenyl ether
Hexachlorobenzene	Hexachlorobenzene
Pentachlorophenol	Pentachlorophenol
Phenanthrene	Phenanthrene
Anthracene	Anthracene
Di n butylphthalate	Di n butylphthalate
Fluoranthene	Fluoranthene
Pyrene	Pyrene
Butyl Benzylphthalate	Butyl Benzylphthalate
3 3 Dichlorobenzidine	3 3 Dichlorobenzidine
Benzo(a)anthracene	Benzo(a)anthracene
bis(2 ethylhexyl)phthalate	bis(2 ethylhexyl)phthalate
Chrysene	Chrysene
Di n octyl Phthalate	Di n octyl Phthalate
Benzo(b)fluoranthene	Benzo(b)fluoranthene
Benzo(k)fluoranthene	Benzo(k)fluoranthene
Benzo(a)pyrene	Benzo(a)pyrene
Indeno(1 2,3-cd)pyrene	Indeno(1 2,3-cd)pyrene
Dibenz(a,h)anthracene	Dibenz(a,h)anthracene
Benzo(g,h i)perylene	Benzo(g,h,i)perylene

TABLE 8-2

PHASE II RFI/RI
SOIL BEDROCK, AND GROUNDWATER SAMPLING
ANALYTES AND COMPOUNDS
OPERABLE UNIT 2
(Concluded)

ORGANICS PESTICIDES/PCBs

Target Compound List Soils and Bedrock	Target Compound List Groundwater
alpha BHC	alpha BHC
beta BHC	beta BHC
delta BHC	delta BHC
gamma BHC (Lindane)	gamma BHC (Lindane)
Heptachlor	Heptachlor
Aldrin	Aldrin
Heptachlor Epoxide	Heptachlor Epoxide
Endosulfan I	Endosulfan I
Dieldrin	Dieldrin
4 4 DDE	4 4 DDE
Endrin	Endrin
Endosulfan II	Endosulfan II
4 4 DDD	4 4 DDD
Endosulfan Sulfate	Endosulfan Sulfate
4 4 DDT	4 4 DDT
Endrin Ketone	Endrin Ketone
Methoxychlor	Methoxychlor
alpha Chlordane	alpha Chlordane
gamma Chlordane	gamma Chlordane
Toxaphene	Toxaphene
AROCLOR 1016	AROCLOR 1016
AROCLOR 1221	AROCLOR 1221
AROCLOR 1232	AROCLOR 1232
AROCLOR 1242	AROCLOR 1242
AROCLOR 1248	AROCLOR 1248
AROCLOR 1254	AROCLOR 1254
AROCLOR 1260	AROCLOR 1260

Note Samples will also be tested for O phosphate Ammonia Silica (as Si or SiO_2) Dissolved Organic Carbon (DOC) Total Organic Carbon (TOC) and Bromide Analytical procedures have not yet been selected for these analytes

8.3.2 Groundwater Samples

Groundwater samples will be collected from all wells identified in Subsection 8.2 Samples will be measured in the field for pH specific conductance and temperature according to SOP GW.5 Measurement of Groundwater Field Parameters Laboratory analyses for dissolved metals will be performed on samples filtered in the field using a 0 45 μm cellulose acetate filter prior to sample preservation During the initial investigation samples will be analyzed for the parameters listed in Table 8 2 Subsequent sampling iterations may only require analyses for contaminants of concern These may be identified after the initial investigation Samples will be analyzed in accordance with the QAPjP and QAA

8.3.3 Sample Containers and Preservation and Sample Control and Documentation

Sample volume requirements preservation techniques holding times, and container material requirements are dictated by the matrix being sampled and by the analyses to be performed. The QAPjP and QAA list the requirements for samples collected and analyses specified in this FSP

Additional guidance on the appropriate use of materials and preservatives is provided in SOP GT 13 Containerizing Preserving, Handling and Shipping of Soil and Water Samples

Sample control and documentation is necessary to ensure the defensibility of data and to verify the quality and quantity of work performed in the field Accountable documents include logbooks data collection forms sample labels or tags chain of custody forms photographs and analytical records and reports Guidance defining the necessary sample control, identification, and chain of custody documentation is discussed in SOP GT 13 Containerizing, Preserving, Handling and Shipping of Soil and Water Samples

8.3 4 Field QC Procedures

Sample duplicates field preservation blanks and equipment rinsate blanks will be prepared Trip blanks will be obtained from the laboratory The analytical results obtained for these samples will be used by the ER Project Manager to assess the quality of the field sampling effort The types of field QC samples to be collected and their application are discussed below The frequency with which each type is to be collected and analyzed is provided in the QAA

Duplicate samples will be collected by the sampling team and will be used as a relative measure of the precision of the sample collection process These samples will be collected at the same time using the same procedures the same equipment and in the same types of containers as required for the samples They will also be preserved in the same manner and submitted for the same analyses as required for the samples

Field blanks will be prepared by the sampling team in accordance with the QAPjP and QAA and will be used to provide an indication of any contamination introduced during field sample preparation technique

Equipment blanks (rinsate) will be collected from a final decontamination rinse to evaluate the success of the field sampling team s decontamination efforts on nondedicated sampling equipment Equipment blanks are obtained by running distilled water over sampling equipment prior to sample collection Equipment blanks are applicable to all analyses for water and soil samples as indicated in the QAPjP and QAA

Trip blanks will be prepared by the laboratory technician and will accompany each shipment of water samples for volatile organic analysis Trip blanks will be stored with the group of samples with which they are associated Analysis of the trip blank will indicate any migration of volatile organics or any problems associated with the shipment handling, or storage of the samples

QA/QC blank samples will consist of ASTM Type II laboratory reagent water The QAPjP outlines sample preparation requirements Procedures for monitoring field QC are given in the site wide QAPjP

9 0
QUALITY ASSURANCE ADDENDUM (QAA)

The QAA for OU No 2 and the QAPP will be submitted to EPA and CDH as controlled documents under separate cover These documents will establish specific QA controls applicable to the field investigations for OU No 2

The following items will be presented in the QAA

- ER Program organization and responsibilities
- Data quality objectives
- Analytical methods and detection limits for the FSP parameters
- EG&G SOPs applicable to the field activities
- Data reduction validation and reporting requirements and guidelines
- Document control specifications
- Information on sample containers preservation and holding times
- Chain of custody protocol
- Control of measuring and testing equipment
- Handling, storage and shipping of samples
- Recordkeeping

10 1 SOP ADDENDUM TO SOP NO GW 6 DETECTION AND SAMPLING OF NON AQUEOUS PHASE LIQUIDS IN MONITORING WELLS

10 1 1 Introduction

Wells screened across the bedrock/alluvial interface or at other zones of vertical permeability contrast have the greatest potential for containing dense non aqueous phase liquids These wells and any other wells where dense or light non aqueous phase liquids are suspected will be checked for these contaminants during groundwater sampling Samples of the non aqueous phase liquids will be collected if present

10 1.2 Determination of the Depth and Thickness of Non Aqueous Phase Immiscible Layers

The presence of immiscible layers will be checked for using an interface probe Prior to use the interface probe will be decontaminated following SOP No FO 3 General Equipment Decontamination The interface probe will have differing sound tones or patterns to distinguish between aqueous and immiscible organic layers As with water level measurements the probe will be sufficiently accurate to measure water levels to the nearest 0 01 foot Manufacturer s instructions and SOP No GW 1 Water Level Measurements In Wells and Piezometers will be followed to measure the depth to the bottom of the well, the depth to the non aqueous/aqueous layer interface and the depth to the top of the water column or non aqueous layer/air interface All depths will be recorded to the nearest 0 01 foot The probe will be moved slowly up and down to determine the point where the indicator tone or sound is reproducibly obtained Measurements will be considered reproducible when consecutive readings do not differ by more than ±0 02 foot The average of the reproducible readings will be used to determine the measurement level Care will be taken when lowering and raising the probe to minimize rubbing of the tape against the well casing Once measurement levels have been determined the probe will be retrieved and decontaminated according to SOP No FO 3 General Equipment Decontamination

10 1.3 Collection of Non Aqueous Phase Liquid Samples

If detected non aqueous phase liquid samples will be collected before purging activities begin The method of choice for collecting immiscible layer samples is dependent on the thickness of the layer and the depth to the surface of the layer When the thickness of the floating layer is less than 2 feet, a peristaltic pump or a bailer which fills from the top will be used If the thickness of the phase is 2 feet or greater samples will be collected with a bottom valve bailer Dense immiscible liquids will be collected with a bottom double check valve bailer before purging the well In all cases care will be taken to carefully lower the bailer into the well so that minimal agitation of the immiscible layer is achieved

Equipment used for collecting non aqueous phase liquid samples will be cleaned before use All sample containers will consist of bottles precleaned to EPA specifications The following procedure will be followed when sampling wells with immiscible layers

- The bailer and bailer line will be precleaned following the procedures outlined in SOP No FO 3 General Equipment Decontamination

  Bailers and line will be wrapped in aluminum foil for transport to the field or from one site to the next

- The bailer intake will be carefully lowered to the midpoint of the immiscible layer and the bailer filled while it is being held at this level The bailer will be lowered into the immiscible layer slowly so that minimal agitation of the immiscible layer occurs If a layer floating immiscible liquid less than 2 feet thick is being collected, use a top-filling bailer or peristaltic pump If a floating layer greater than 2 feet thick is being collected, the bottom filling bailer or peristaltic pump is preferable If a dense liquid layer is being collected, use the double check valve bailer

  At no time will the bailer or line be allowed to touch the ground or otherwise come in contact with other objects that might introduce contaminants into the well

  Sampling will follow the procedures specified for the collection of volatile organics in SOP No GW 6 Groundwater Sampling

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APPENDIX A

GEOLOGIC CHARACTERIZATION STUDY LITHOLOGY SUMMARY TABLE FOR BOREHOLES/WELLS USED IN BEDROCK WORK PLAN

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	RFP NORTH	RFP EAST	STATE NORTH	STATE EAST	SURFACE ELEVATIO	TD	TD ELEVATION	TYPE ALLUVIUM	THICK ALLUVIU	EL TOP BEDROCK	SUB ALLUV FORMATION
2686		SOLAR POND	37426	21737	750428	2084841	5974 48	17	5957 48	Qd/Qrf	10 5	5963 98	Ka
3486		EAST TRENCHES											Ka
3486		EAST TRENCHES	37171	23088	750173	2086192	5910 44	100	5810 44	Qc	15 9	5894 54	Ka
4086		EAST TRENCHES											Ka
4086		EAST TRENCHES											Ka
4086		EAST TRENCHES	36613	25398	749615	2088502	5941 23	124 8	5816 43	Qrf	45	5896 23	Ka
4186		EAST TRENCHES											Ka
4186		EAST TRENCHES											Ka
4186		EAST TRENCHES	36611	25437	749613	2088541	5940 03	44 8	5895 23	Qrf	44 6	5895 43	Ka
4186		EAST TRENCHES											Ka
4186		EAST TRENCHES											Ka
4186		EAST TRENCHES											Ka
4186		EAST TRENCHES											Ka
4286		EAST TRENCHES	36566	24008	749568	2087112	5954 34	35	5919 34	Qrf	28 3	5926 04	Ka
4286		EAST TRENCHES											Ka
5986		881 HILLSIDE											Ka
5986		881 HILLSIDE											Ka
5986		881 HILLSIDE	34770	21153	747772	2084257	5914 32	32 5	5881 82	Qc	7 5	5906 82	Ka
6286		903 PAD											Ka
6286		903 PAD	35154	22613	748156	2085717	5897 54	59 3	5838 24	Qc	22	5875 54	Ka
6286		903 PAD											Ka
6286		903 PAD											Ka
6386		903 PAD											Ka
6386		903 PAD											Ka
6386		903 PAD	35156	22642	748158	2085745	5896 55	17 3	5879 25	Qc	14 8	5881 75	Ka
0287		881 HILLSIDE	34726	20820	747709	2083933	5930 56	16	5914 56	Qc	7 25	5923 31	Ka
0287		881 HILLSIDE											Ka
0387BR		881 HILLSIDE											Ka
0387BR		881 HILLSIDE	34723	20848	747706	2083961	5930 58	117	5813 58	Qc	20 8	5909 78	Ka
0587BR		881 HILLSIDE	35095	21736	748081	2084849	5927 76	61	5866 76	Qc	11	5916 76	Ka
BH0587		881 Hillside	34994	20921	747978	2084033	5954 20	13	5941 2	Qc	4 5	5949 7	Ka
0687A			34984	22355	747972	2085468	5898 22	32 6	5865 62		5 2	5893 02	Ka
0787BR(A)		881 HILLSIDE	35077	21689	748063	2084801	5928 21	47 5	5880 71	Qc	6	5922 21	Ka
0887BR		881 HILLSIDE											Ka

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	RFP NORTH	RFP EAST	STATE NORTH	STATE EAST	SURFACE ELEVATIO	TD	TD ELEVATION	TYPE ALLUVIUM	THICK ALLUVIU	EL TOP BEDROCK	SUB ALLUV FORMATION
0887BR		881 HILLSIDE											Ka
0887BR		881 HILLSIDE	34774	21181	747758	2084294	5919 70	106	5813 7	Qc	8 7	5911	Ka
0887BR		881 HILLSIDE											Ka
0987		903 PAD											Ka
0987		903 PAD	36081	22239	749068	2085348	5980 22	37 5	5942 72	Qrf	12 7	5967 52	Ka
0987		903 PAD											Ka
0987		903 PAD											Ka
1087		903 PAD											Ka
1087		903 PAD	35960	22180	748947	2085289	5981 96	17	5964 96	Qrf	11 3	5970 66	Ka
1287		903 PAD	35591	22956	748581	2086066	5934 74	15 9	5918 84	Qc	3 5	5931 24	Ka
1487BR		903 PAD											Ka
1487BR		903 PAD											Ka
1487BR		903 PAD	35237	23505	748228	2086616	5855 00	25 5	5829 5	Qc	5 2	5849 8	Ka
1587		903 PAD	36020	23140	749010	2086249	5970 89	27	5943 89	Qrf	21 85	5949 04	Ka
1587		903 PAD											Ka
1687BR		903 PAD											Ka
1687BR		903 PAD											Ka
1687BR		903 PAD	36140	23140	749130	2086249	5969 06	174	5795 06	Qrf	22 2	5946 86	Ka
1687BR		903 PAD											Ka
1787		MOUND AREA	36425	23201	749415	2086308	5967 56	30 3	5937 26	Qrf	25	5942 56	Ka
BH1787		881 HILLSIDE	35359	22121	748346	2085232	5956 00	12 4	5943 6	Qc	5 25	5950 75	Ka
1887BR		MOUND AREA											Ka
1887BR		MOUND AREA											Ka
1887BR		MOUND AREA											Ka
1887BR		MOUND AREA											Ka
1887BR		MOUND AREA	36414	23231	749404	2086339	5967 38	147	5820 38	Qrf	25 2	5942 18	Ka
2087BR		MOUND AREA											Ka
2087BR		MOUND AREA											Ka
2087BR		MOUND AREA	36644	23048	749634	2086155	5968 10	126 2	5841 9	Qrf	11 8	5956 3	Ka
2187		MOUND AREA	36980	22694	749969	2085800	5927 58	17	5910 58	Qrf	8	5919 58	Ka
2287BR		MOUND AREA	36935	22716	749924	2085822	5930 70	111	5819 7	Qrf	12 8	5917 9	Ka
BH2287		903 PAD	35790	22536	748778	2085646	5978 50	27 2	5951 3	Qrf	22 2	5956 3	Ka
2287BR		MOUND AREA											Ka
2287BR		MOUND AREA											Ka

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	RFP NORTH	RFP EAST	STATE NORTH	STATE EAST	SURFACE ELEVATIO	TD	TD ELEVATION	TYPE ALLUVIUM	THICK ALLUVIU	EL TOP BEDROCK	SUB ALLUV FORMATION
2287BR		MOUND AREA											Ka
2387BR		MOUND AREA											Ka
2387BR		MOUND AREA											Ka
2387BR		MOUND AREA											Ka
BH2387		903 PAD	35777	22778	748765	2085888	5964 20	12 5	5951 7	Qrf	8	5956 2	Ka
2387BR		MOUND AREA											Ka
2387BR		MOUND AREA	36415	22803	749404	2085910	5972 34	45 3	5927 04	Qrf	15 25	5957 09	Ka
2487		EAST TRENCHES	36759	23640	749751	2086746	5957 79	18 3	5939 49	Qrf	15 1	5942 69	Ka
BH2487		903 PAD	35839	23081	748829	2086190	5953 60	12 3	5941 3	Qc	4 9	5948 7	Ka
2587BR		EAST TRENCHES											Ka
BH2587		903 PAD	35601	22720	748590	2085830	5953 20	25 2	5928	Qc	14 8	5938 4	Ka
2587BR		EAST TRENCHES	36727	23641	749719	2086748	5958 91	47	5911 91	Qrf	16 5	5942 41	Ka
2587BR		EAST TRENCHES											Ka
2787		EAST TRENCHES											Ka
2787		EAST TRENCHES											Ka
2787		EAST TRENCHES											Ka
2787		EAST TRENCHES	36442	24945	749438	2088052	5947 52	47 7	5899 82	Qrf	44 2	5903 32	Ka
BH2787		903 PAD	35660	22899	748649	2086009	5944 70	17	5927 7	Qc	9 9	5934 8	Ka
2787		EAST TRENCHES											Ka
2887BR		EAST TRENCHES											Ka
2887BR		EAST TRENCHES											Ka
2887BR		EAST TRENCHES											Ka
2887BR		EAST TRENCHES											Ka
2887BR		EAST TRENCHES	36442	24983	749438	2088090	5947 17	207	5740 17	Qrf	43 5	5903 67	Ka
2887BR		EAST TRENCHES											Ka
2887BR		EAST TRENCHES											Ka
BH2887		903 PAD	35803	23131	748794	2086241	5946 70	15	5931 7	Qc	5 9	5940 8	Ka
3087BR		BUFFER SOUTH											Ka
3087BR		BUFFER SOUTH	35095	24312	748089	2087424	5811 87	110	5701 87	Qc	16	5795 87	Ka
3087BR		BUFFER SOUTH											Ka
3187BR		EAST TRENCHES											Ka
3187BR		EAST TRENCHES											Ka
3187BR		EAST TRENCHES	36503	25202	749500	2088309	5945 02	140	5805 02	Qrf	45	5900 02	Ka
BH3187		MOUND AREA	36499	22297	749486	2085405	5973 80	15 9	5957 9	Qrf	7 6	5966 2	Ka

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	RFP NORTH	RFP EAST	STATE NORTH	STATE EAST	SURFACE ELEVATIO	TD	TD ELEVATION	TYPE ALLUVIUM	THICK ALLUVIU	EL TOP BEDROCK	SUB ALLUV FORMATION
BH3187		MOUND AREA											Ka
3187BR		EAST TRENCHES											Ka
BH3187		MOUND AREA											Ka
3287		EAST TRENCHES											Ka
3287		EAST TRENCHES											Ka
BH3287		MOUND AREA											Ka
3287		EAST TRENCHES	36514	25256	749511	2088363	5946 12	51 3	5894 82	Qrf	46 2	5899 92	Ka
BH3287		MOUND AREA	36498	22421	749485	2085528	5971 70	20 5	5951 2	Qrf	7 7	5964	Ka
3287		EAST TRENCHES											Ka
BH3387		MOUND AREA											
3387		MOUND AREA	36859	24815	749855	2087921	5945 27			Qrf			Ka
BH3387		MOUND AREA	36499	22659	749488	2085766	5967 90	20 8	5947 1	Qrf	9 2	5958 7	Ka
BH3387		MOUND AREA											Ka
3487BR		EAST TRENCHES	36840	24826	749836	2087931	5945 21	124	5821 21	Qrf	20	5925 21	Ka
BH3487		MOUND AREA											Ka
BH3487		MOUND AREA											Ka
BH3487		MOUND AREA											Ka
BH3487		MOUND AREA	36474	22786	749463	2085893	5971 40	24 7	5946 7	Qrf	16 7	5954 7	Ka
BH3587		MOUND AREA	36440	22962	749430	2086069	5970 50	20 3	5950 2	Qrf	14 3	5956 2	Ka
BH3587		MOUND AREA											Ka
BH3587		MOUND AREA											Ka
3587		EAST TRENCHES	36981	24163	749975	2087268	5949 36	14 4	5934 96	Qrf	9 1	5940 26	Ka
3687BR		EAST TRENCHES											Ka
3687BR		EAST TRENCHES	36986	24190	749979	2087295	5949 04	74 5	5874 54	Qrf	7 4	5941 64	Ka
3687BR		EAST TRENCHES											Ka
BH3687		MOUND AREA	36512	23042	749502	2086149	5969 40	26	5943 4	Qrf	20 6	5948 8	Ka
3687BR		EAST TRENCHES											Ka
BH3787		EAST TRENCHES											Ka
BH3787		EAST TRENCHES	36621	23021	749610	2086128	5968 80	28	5940 8	Qrf	14	5954 8	Ka
BH3887		MOUND AREA	36679	23202	749670	2086308	5965 30	23 9	5941 4	Qrf	14 6	5950 7	Ka
BH3887		MOUND AREA											Ka
BH3987		EAST TRENCHES	36768	23799	749760	2086905	5956 90	22	5934 9	Qrf	14 5	5942 4	Ka
BH4087		EAST TRENCHES	36857	23920	749850	2087026	5953 70	14 5	5939 2	Qrf	8	5945 7	Ka
BH4187		EAST TRENCHES											Ka

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	RFP NORTH	RFP EAST	STATE NORTH	STATE EAST	SURFACE ELEVATIO	TD	TD ELEVATION	TYPE ALLUVIUM	THICK ALLUVIU	EL TOP BEDROCK	SUB ALLUV FORMATION
BH4187		EAST TRENCHES	36944	24212	749938	2087318	5950 20	19 5	5930 7	Qrf	15	5935 2	Ka
BH4187		EAST TRENCHES											Ka
BH4287		EAST TRENCHES											Ka
BH4287		EAST TRENCHES											Ka
BH4287		EAST TRENCHES	36869	24279	749863	2087385	5950 50	55 5	5895	Qrf	24	5926 5	Ka
BH4387		EAST TRENCHES	36642	23920	749635	2087026	5956 50	34 7	5921 8	Qrf	27 2	5929 3	Ka
BH4387		EAST TRENCHES											Ka
4487		903 PAD	35318	22324	748306	2085435	5949 53	7	5942 53	Qc	3 2	5946 33	Ka
BH4487		EAST TRENCHES	36692	23978	749685	2087085	5956 10	34 5	5921 6	Qrf	27	5929 1	Ka
BH4487		EAST TRENCHES											Ka
BH4487		EAST TRENCHES											Ka
4587BR		903 PAD											Ka
4587BR		903 PAD	35325	22340	748313	2085451	5949 42	112	5837 42	Qc	4	5945 42	Ka
BH4587		EAST TRENCHES											Ka
BH4587		EAST TRENCHES	36744	24158	749738	2087264	5952 70	40	5912 7	Qrf	20	5932 7	Ka
BH4687		EAST TRENCHES	36701	24215	749695	2087322	5952 60	32	5920 6	Qrf	27	5925 6	Ka
BH4787		EAST TRENCHES											Ka
BH4787		EAST TRENCHES	36620	24463	749615	2087570	5951 40	28 2	5923 2	Qrf	26 2	5925 2	Ka
BH4787		EAST TRENCHES											Ka
BH4887		EAST TRENCHES	36555	24642	749550	2087749	5949 40	17 35	5932 05	Qrf	13 2	5936 2	Ka
BH4887		EAST TRENCHES											Ka
4987		881 HILLSIDE	35005	21891	747991	2085004	5912 68	10	5902 68	Qc	9	5903 68	Ka
BH4987		EAST TRENCHES	36501	24460	749495	2087567	5953 00	25 84	5927 16	Qrf	22	5931	Ka
BH4987		EAST TRENCHES											Ka
5087		881 HILLSIDE	35134	22222	748121	2085334	5933 21	27	5906 21	Qc	12 5	5920 71	Ka
5087		881 HILLSIDE											Ka
BH5087		EAST TRENCHES	36558	24760	749554	2087866	5949 20	19 5	5929 7	Qrf	12	5937 2	Ka
BH5087		EAST TRENCHES											Ka
5087		881 HILLSIDE											Ka
B217489	5689BR	EAST TRENCHES											Ka
B217489	5689BR	EAST TRENCHES											Ka
B217489	5689BR	EAST TRENCHES	36462	23711	749454	2086818	5961 20	220	5741 2	Qrf	25	5936 2	Ka
B217489	5689BR	EAST TRENCHES											Ka
B217489	5689BR	EAST TRENCHES											Ka

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	RFP NORTH	RFP EAST	STATE NORTH	STATE EAST	SURFACE ELEVATIO	TD	TD ELEVATION	TYPE ALLUVIUM	THICK ALLUVIU	EL TOP BEDROCK	SUB ALLUV FORMATION
B217589	5789BR	EAST TRENCHES	36824	24082	749817	2087189	5952 90	221 3	5731 6	Qrf	17 3	5935 6	Ka
B217689	5889BR	EAST TRENCHES	36637	23639	749629	2086746	5960 50	220 1	5740 4	Qrf	22	5938 5	Ka
B217689	5889BR	EAST TRENCHES											
B217689	5889BR	EAST TRENCHES											
B217689	5889BR	EAST TRENCHES											
B217689	5889BR	EAST TRENCHES											
B217689	5889BR	EAST TRENCHES											
B217689	5889BR	EAST TRENCHES											
B217789	6089BR	EAST TRENCHES	36517	24231	749494	2087341	5954 90	220 1	5734 8	Qrf	23 6	5931 2	Ka
B217789	6089BR	EAST TRENCHES											
B217789	6089BR	EAST TRENCHES											
5587		881 HILLSIDE	34633	21805	747619	2084919	5858 08	9 3	5848 78	Qc	5 5	5852 58	Ka
BH5587		EAST TRENCHES											Ka
BH5587		EAST TRENCHES	36738	24935	749734	2088041	5944 90	39 5	5905 4	Qrf	37	5907 9	Ka
5587A		881 HILLSIDE	34928	21671	747913	2084784	5912 44						Ka

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	SUB ALLUV LITHOLOGY	GRAIN SIZE (mm)	GRAIN SIZE DEPTH	Ka SS #1 Strat Eqv ELEVATION	Ka SS #1 Strat Eqv THICK	Ka SS #1 GRAIN SIZE % 200/230 SE	Ka SS #1 GRAIN SIZE DEPTH	Ka SS #2 Strat Eqv ELEVATION
2686		SOLAR POND	CLYSTN							
3486		EAST TRENCHES								
3486		EAST TRENCHES	CLYSTN							
4086		EAST TRENCHES								
4086		EAST TRENCHES								
4086		EAST TRENCHES	CLYSTN							5851 1
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES	CLYSTN							
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4286		EAST TRENCHES	CLYSTN SILTY							
4286		EAST TRENCHES								
5986		881 HILLSIDE								
5986		881 HILLSIDE								
5986		881 HILLSIDE	CLYSTN							
6286		903 PAD								
6286		903 PAD	CLYSTN							
6286		903 PAD								
6286		903 PAD								
6386		903 PAD								
6386		903 PAD								
6386		903 PAD	CLYSTN							
0287		881 HILLSIDE								
0287		881 HILLSIDE								
0387BR		881 HILLSIDE								
0387BR		881 HILLSIDE								
0587BR		881 HILLSIDE	CLYSTN							
BH0587		881 Hillside	CLYSTN							
0687A			CLYSTN							
0787BR(A)		881 HILLSIDE	CLYSTN							
0887BR		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	SUB ALLUV LITHOLOGY	GRAIN SIZE (mm)	GRAIN SIZE DEPTH	Ka SS #1 Strat Eqv ELEVATION	Ka SS #1 Strat Eqv THICK	Ka SS #1 GRAIN SIZE % 200/230 SE	Ka SS #1 GRAIN SIZE DEPTH	Ka SS #2 Strat Eqv ELEVATION
0887BR		881 HILLSIDE								
0887BR		881 HILLSIDE								
0887BR		881 HILLSIDE								
0987		903 PAD	SS #1	0 095	31 5	5967 52	19 2	57	31 5	
0987		903 PAD	SS #1	0 1	17 5 19 5	5967 52	19 2	61	17 5 19 5	
0987		903 PAD								
0987		903 PAD	SS #1	0 095	20 21 5	5967 52	19 2	59	20 21 5	
1087		903 PAD								
1087		903 PAD	SS #1	EST 06	12	5970 66	6	38	12	
1287		903 PAD	SLTSTN CLAYEY							
1487BR		903 PAD								
1487BR		903 PAD								
1487BR		903 PAD	CLYSTN							
1587		903 PAD	CLYSTN SILTY							
1587		903 PAD								
1687BR		903 PAD								
1687BR		903 PAD								
1687BR		903 PAD	CLYSTN							
1687BR		903 PAD								
1787		MOUND AREA	CLYSTN SILTY							
BH1787		881 HILLSIDE	CLYSTN							
1887BR		MOUND AREA								
1887BR		MOUND AREA								
1887BR		MOUND AREA								
1887BR		MOUND AREA								
1887BR		MOUND AREA	CLYSTN							
2087BR		MOUND AREA								
2087BR		MOUND AREA								
2087BR		MOUND AREA	CLYSTN							
2187		MOUND AREA	CLYSTN							
2287BR		MOUND AREA	CLYSTN							
BH2287		903 PAD	CLYSTN							
2287BR		MOUND AREA								
2287BR		MOUND AREA								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	SUB ALLUV LITHOLOGY	GRAIN SIZE (mm)	GRAIN SIZE DEPTH	Ka SS #1 Strat Eqv ELEVATION	Ka SS #1 Strat Eqv THICK	Ka SS #1 GRAIN SIZE % 200/230 SE	Ka SS #1 GRAIN SIZE DEPTH	Ka SS #2 Strat Eqv ELEVATION
2287BR		MOUND AREA								
2387BR		MOUND AREA	SS #1							
2387BR		MOUND AREA	SS #1	0 065	23 25	5971 1	17 5	45	23 25	
2387BR		MOUND AREA	SS #1	0 17	25 27	5971 1	17 5	80	25 27	
BH2387		903 PAD	CLYSTN SILTY							
2387BR		MOUND AREA			35 35 5	5971 1	17 5	23	35 35 5	
2387BR		MOUND AREA	SS #1	0 091	17 19	5957 1	17 5	60	17 19	
2487		EAST TRENCHES	SILTSTN CLAYEY							
BH2487		903 PAD	SILTSTN CLAYEY							
2587BR		EAST TRENCHES								
BH2587		903 PAD	CLYSTN							
2587BR		EAST TRENCHES	SS #1	0 08	19 5 23	5941 4	27 2	49	19 5 23	
2587BR		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES	CLYSTN							
BH2787		903 PAD	CLYSTN							
2787		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES	CLYSTN SANDY							
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
BH2887		903 PAD	CLYSTN							
3087BR		BUFFER SOUTH								
3087BR		BUFFER SOUTH	CLYSTN							
3087BR		BUFFER SOUTH								
3187BR		EAST TRENCHES								
3187BR		EAST TRENCHES								
3187BR		EAST TRENCHES	CLYSTN SILTY							
BH3187		MOUND AREA	SS #1 (*REMARKS)		9 05 9 75	5965 8	2 2	39	9 05 9 75	

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	SUB ALLUV LITHOLOGY	GRAIN SIZE (mm)	GRAIN SIZE DEPTH	Ka SS #1 Strat Eqv ELEVATION	Ka SS #1 Strat Eqv THICK	Ka SS #1 GRAIN SIZE % 200/230 SE	Ka SS #1 GRAIN SIZE DEPTH	Ka SS #2 Strat Eqv ELEVATION
BH3187		MOUND AREA								
3187BR		EAST TRENCHES								
BH3187		MOUND AREA								
3287		EAST TRENCHES								
3287		EAST TRENCHES								
BH3287		MOUND AREA	SS #1		11	5964	6 9	41	11	
3287		EAST TRENCHES	CLYSTN SILTY							
BH3287		MOUND AREA	SS #1	0 048	10 2 12 7	5964	6 9	41	10 2 12 7	
3287		EAST TRENCHES								
BH3387		MOUND AREA				5947 6	0 5			
3387		MOUND AREA								
BH3387		MOUND AREA	SS #1	0 093	12 8 15 3	5956 9	4 3	56	12 8 15 3	
BH3387		MOUND AREA		0 057	19 EST	5950 3	2	40	19 EST	
3487BR		EAST TRENCHES	CLYSTN							
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3487		MOUND AREA	SS #1		20 7 22 7	5954 7	8	43	20 7 22 7	
BH3487		MOUND AREA	SS #1		16 7 18 7	5954 7	8	23	16 7 18 7	
BH3587		MOUND AREA	CLYSTN SANDY			5956 2	6	16	17	
BH3587		MOUND AREA								
BH3587		MOUND AREA								
3587		EAST TRENCHES	CLYSTN SILTY							
3687BR		EAST TRENCHES								
3687BR		EAST TRENCHES	CLYSTN			5929	43	50	26	
3687BR		EAST TRENCHES				5929	43	90	43	
BH3687		MOUND AREA	CLYSTN							
3687BR		EAST TRENCHES								
BH3787		EAST TRENCHES								
BH3787		EAST TRENCHES	CLYSTN SANDY			5947 1	6 3	12	23	
BH3887		MOUND AREA	SILTSTN SANDY							
BH3887		MOUND AREA								
BH3987		EAST TRENCHES	SS #1		18	5942 4	7 5	1	18	
BH4087		EAST TRENCHES	CLYSTN							
BH4187		EAST TRENCHES								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	SUB ALLUV LITHOLOGY	GRAIN SIZE (mm)	GRAIN SIZE DEPTH	Ka SS #1 Strat Eqv ELEVATION	Ka SS #1 Strat Eqv THICK	Ka SS #1 GRAIN SIZE % > 200/230 SE	Ka SS #1 GRAIN SIZE DEPTH	Ka SS #2 Strat Eqv ELEVATION
BH4187		EAST TRENCHES	CLYSTN							
BH4187		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4287		EAST TRENCHES	SS #1	0 22	37 39	5926 5	26 8+	84	37 39	
BH4287		EAST TRENCHES	SS #1	0 08	26	5926 5	26 8+	53	26	
BH4387		EAST TRENCHES	SILTSTN CLAYEY							
BH4387		EAST TRENCHES								
4487		903 PAD	CLYSTN							
BH4487		EAST TRENCHES	SS #1	0 11	32 34	5929 1	6 2	67	32 34	
BH4487		EAST TRENCHES								
BH4487		EAST TRENCHES								
4587BR		903 PAD								
4587BR		903 PAD	CLYSTN							
BH4587		EAST TRENCHES								
BH4587		EAST TRENCHES	SS #1	0 08	20 20 5	5932 7	20	54	20 20 5	
BH4687		EAST TRENCHES	CLYSTN SILTY							
BH4787		EAST TRENCHES								
BH4787		EAST TRENCHES	SILTSTN CLAYEY							
BH4787		EAST TRENCHES								
BH4887		EAST TRENCHES	CLYSTN SANDY							
BH4887		EAST TRENCHES								
4987		881 HILLSIDE	CLYSTN							
BH4987		EAST TRENCHES	CLYSTN							
BH4987		EAST TRENCHES								
5087		881 HILLSIDE	SILTSTN SANDY							5918 7
5087		881 HILLSIDE								5918 7
BH5087		EAST TRENCHES	CLYSTN							
BH5087		EAST TRENCHES								
5087		881 HILLSIDE								
B217489	5689BR	EAST TRENCHES						36	28	
B217489	5689BR	EAST TRENCHES						3	32	
B217489	5689BR	EAST TRENCHES	CLYSTN SILTY					67	44	
B217489	5689BR	EAST TRENCHES						29	50	
B217489	5689BR	EAST TRENCHES				5921 8	31 7	40 5	58	

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	SUB ALLUV LITHOLOGY	GRAIN SIZE (mm)	GRAIN SIZE DEPTH	Ka SS #1 Strat Eqv ELEVATION	Ka SS #1 Strat Eqv THICK	Ka SS #1 GRAIN SIZE % 200/230 SE	Ka SS #1 GRAIN SIZE DEPTH	Ka SS #2 Strat Eqv ELEVATION
B217589	5789BR	EAST TRENCHES	CLYSTN SILTY			5906 9	10			
B217689	5889BR	EAST TRENCHES	CLYSTN SANDY			5938 5	32			
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES	CLYSTN SILTY							
B217789	6089BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
5587		881 HILLSIDE	CLYSTN							
BH5587		EAST TRENCHES								
BH5587		EAST TRENCHES	CLYSTN							
5587A		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #2 Strat Eqv THICK	Ka SS #2 GRAIN SIZE % > 200/230 SE	Ka SS #2 GRAIN SIZE DEPTH	Ka SS #3 Strat Eqv ELEVATION	Ka SS #3 Strat Eqv THICK	Ka SS #3 GRAIN SIZE % 200/230 SE	Ka SS #3 GRAIN SIZE DEPTH	Ka SS #4 Strat Eqv ELEVATION
2686		SOLAR POND								
3486		EAST TRENCHES								
3486		EAST TRENCHES				5862 4	6	37	50	
4086		EAST TRENCHES								
4086		EAST TRENCHES								
4086		EAST TRENCHES	12	22	100	5823 2	4	11	121	
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4286		EAST TRENCHES								
4286		EAST TRENCHES								
5986		881 HILLSIDE								
5986		881 HILLSIDE								
5986		881 HILLSIDE				5894 32	3 5	43	20 22	
6286		903 PAD								
6286		903 PAD				5872 24	7 7	32	25 27 7	5857 24
6286		903 PAD								
6286		903 PAD								
6386		903 PAD								
6386		903 PAD								
6386		903 PAD								
0287		881 HILLSIDE								
0287		881 HILLSIDE								
0387BR		881 HILLSIDE								
0387BR		881 HILLSIDE				5902 6	3	9	27 8 28 5	
0587BR		881 HILLSIDE				5882 1	5 3	9	45 7	
BH0587		881 Hillside								
0687A						5886 02	14 6			5868 22
0787BR(A)		881 HILLSIDE				5889 6	9	7	40	
0887BR		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #2 Strat Eqv THICK	Ka SS #2 GRAIN SIZE % 200/230 SE	Ka SS #2 GRAIN SIZE DEPTH	Ka SS #3 Strat Eqv ELEVATION	Ka SS #3 Strat Eqv THICK	Ka SS #3 GRAIN SIZE % 200/230 SE	Ka SS #3 GRAIN SIZE DEPTH	Ka SS #4 Strat Eqv ELEVATION
0887BR		881 HILLSIDE								
0887BR		881 HILLSIDE				5900 8	12 3			
0887BR		881 HILLSIDE								
0987		903 PAD								
0987		903 PAD								
0987		903 PAD								
0987		903 PAD								
1087		903 PAD								
1087		903 PAD								
1287		903 PAD								
1487BR		903 PAD								
1487BR		903 PAD								
1487BR		903 PAD								5846
1587		903 PAD								
1587		903 PAD								
1687BR		903 PAD								
1687BR		903 PAD								
1687BR		903 PAD				5868 56	16 5	57	102	
1687BR		903 PAD								
1787		MOUND AREA								
BH1787		881 HILLSIDE								
1887BR		MOUND AREA								
1887BR		MOUND AREA								
1887BR		MOUND AREA								5840 4
1887BR		MOUND AREA								
1887BR		MOUND AREA				5858 2	8	QUESTIONABLE	111	5840 4
2087BR		MOUND AREA								
2087BR		MOUND AREA								
2087BR		MOUND AREA				5860 8	9	30	112	
2187		MOUND AREA								
2287BR		MOUND AREA								5846 9
BH2287		903 PAD								
2287BR		MOUND AREA								
2287BR		MOUND AREA								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #2 Strat Eqv THICK	Ka SS #2 GRAIN SIZE % 200/230 SE	Ka SS #2 GRAIN SIZE DEPTH	Ka SS #3 Strat Eqv ELEVATION	Ka SS #3 Strat Eqv THICK	Ka SS #3 GRAIN SIZE % > 200/230 SE	Ka SS #3 GRAIN SIZE DEPTH	Ka SS #4 Strat Eqv ELEVATION
2287BR		MOUND AREA								
2387BR		MOUND AREA								
2387BR		MOUND AREA								
2387BR		MOUND AREA								
BH2387		903 PAD								
2387BR		MOUND AREA								
2387BR		MOUND AREA								
2487		EAST TRENCHES								
BH2487		903 PAD								
2587BR		EAST TRENCHES								
BH2587		903 PAD								
2587BR		EAST TRENCHES								
2587BR		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
BH2787		903 PAD								
2787		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES				5838 2	9	9	112	
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
BH2887		903 PAD								
3087BR		BUFFER SOUTH								
3087BR		BUFFER SOUTH								
3087BR		BUFFER SOUTH								
3187BR		EAST TRENCHES				5832 5	16 5	41	115	
3187BR		EAST TRENCHES				5832 5	16 5	54	112 5 116	
3187BR		EAST TRENCHES				5832 5	16 5	20	112 5	
BH3187		MOUND AREA								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #2 Strat Eqv THICK	Ka SS #2 GRAIN SIZE % > 200/230 SE	Ka SS #2 GRAIN SIZE DEPTH	Ka SS #3 Strat Eqv ELEVATION	Ka SS #3 Strat Eqv THICK	Ka SS #3 GRAIN SIZE % 200/230 SE	Ka SS #3 GRAIN SIZE DEPTH	Ka SS #4 Strat Eqv ELEVATION
BH3187		MOUND AREA								
3187BR		EAST TRENCHES								
BH3187		MOUND AREA								
3287		EAST TRENCHES								
3287		EAST TRENCHES								
BH3287		MOUND AREA								
3287		EAST TRENCHES								
BH3287		MOUND AREA								
3287		EAST TRENCHES								
BH3387		MOUND AREA								
3387		MOUND AREA								
BH3387		MOUND AREA								
BH3387		MOUND AREA								
3487BR		EAST TRENCHES				5844 5	8 5			
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3587		MOUND AREA								
BH3587		MOUND AREA								
BH3587		MOUND AREA								
3587		EAST TRENCHES								
3687BR		EAST TRENCHES								
3687BR		EAST TRENCHES								
3687BR		EAST TRENCHES								
BH3687		MOUND AREA								
3687BR		EAST TRENCHES								
BH3787		EAST TRENCHES								
BH3787		EAST TRENCHES								
BH3887		MOUND AREA								
BH3887		MOUND AREA								
BH3987		EAST TRENCHES								
BH4087		EAST TRENCHES								
BH4187		EAST TRENCHES								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #2 Strat Eqv THICK	Ka SS #2 GRAIN SIZE % > 200/230 SE	Ka SS #2 GRAIN SIZE DEPTH	Ka SS #3 Strat Eqv ELEVATION	Ka SS #3 Strat Eqv THICK	Ka SS #3 GRAIN SIZE % > 200/230 SE	Ka SS #3 GRAIN SIZE DEPTH	Ka SS #4 Strat Eqv ELEVATION
BH4187		EAST TRENCHES								
BH4187		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4387		EAST TRENCHES								
BH4387		EAST TRENCHES								
4487		903 PAD								
BH4487		EAST TRENCHES								
BH4487		EAST TRENCHES								
BH4487		EAST TRENCHES								
4587BR		903 PAD								
4587BR		903 PAD								
BH4587		EAST TRENCHES								
BH4587		EAST TRENCHES								
BH4687		EAST TRENCHES								
BH4787		EAST TRENCHES								
BH4787		EAST TRENCHES								
BH4787		EAST TRENCHES								
BH4887		EAST TRENCHES								
BH4887		EAST TRENCHES								
4987		881 HILLSIDE								
BH4987		EAST TRENCHES								
BH4987		EAST TRENCHES								
5087		881 HILLSIDE	12 5	6	16					
5087		881 HILLSIDE	12 5	3	23					
BH5087		EAST TRENCHES								
BH5087		EAST TRENCHES								
5087		881 HILLSIDE								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #2 Strat Eqv THICK	Ka SS #2 GRAIN SIZE % > 200/230 SE	Ka SS #2 GRAIN SIZE DEPTH	Ka SS #3 Strat Eqv ELEVATION	Ka SS #3 Strat Eqv THICK	Ka SS #3 GRAIN SIZE % 200/230 SE	Ka SS #3 GRAIN SIZE DEPTH	Ka SS #4 Strat Eqv ELEVATION
B217589	5789BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES				5853 2	3 4			
B217789	6089BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
5587		881 HILLSIDE								
BH5587		EAST TRENCHES								
BH5587		EAST TRENCHES								
5587A		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #4 Strat Eqv THICK	Ka SS #4 GRAIN SIZE % > 200/230 SE	Ka SS #4 GRAIN SIZE DEPTH	Ka SS #5 Strat Eqv ELEVATION	Ka SS #5 Strat Eqv THICK	Ka SS #5 GRAIN SIZE % 200/230 SE	Ka SS #5 GRAIN SIZE DEPTH	Upper Laramie Sandstones ELEVATION
2686		SOLAR POND								
3486		EAST TRENCHES								
3486		EAST TRENCHES								
4086		EAST TRENCHES								
4086		EAST TRENCHES								
4086		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4286		EAST TRENCHES								
4286		EAST TRENCHES								
5986		881 HILLSIDE								
5986		881 HILLSIDE								
5986		881 HILLSIDE								
6286		903 PAD								
6286		903 PAD	7	16	40 3 42 8	5847 54	9 2	55	55 3 57 8	
6286		903 PAD								
6286		903 PAD								
6386		903 PAD								
6386		903 PAD								
6386		903 PAD								
0287		881 HILLSIDE								
0287		881 HILLSIDE								
0387BR		881 HILLSIDE								
0387BR		881 HILLSIDE								
0587BR		881 HILLSIDE								
BH0587		881 Hillside								
0687A			2 6							
0787BR(A)		881 HILLSIDE								
0887BR		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #4 Strat Eqv THICK	Ka SS #4 GRAIN SIZE % 200/230 SE	Ka SS #4 GRAIN SIZE DEPTH	Ka SS #5 Strat Eqv ELEVATION	Ka SS #5 Strat Eqv THICK	Ka SS #5 GRAIN SIZE % > 200/230 SE	Ka SS #5 GRAIN SIZE DEPTH	Upper Laramie Sandstones ELEVATION
0887BR		881 HILLSIDE								
0887BR		881 HILLSIDE								
0887BR		881 HILLSIDE								
0987		903 PAD								
0987		903 PAD								
0987		903 PAD								
0987		903 PAD								
1087		903 PAD								
1087		903 PAD								
1287		903 PAD								
1487BR		903 PAD								
1487BR		903 PAD								
1487BR		903 PAD	3 5	59	10 5	5836	6 5	40	19 5 22 5	
1587		903 PAD								
1587		903 PAD								
1687BR		903 PAD								
1687BR		903 PAD								
1687BR		903 PAD				5828 56	4	28	142	
1687BR		903 PAD								
1787		MOUND AREA								
BH1787		881 HILLSIDE								
1887BR		MOUND AREA								
1887BR		MOUND AREA								
1887BR		MOUND AREA	6 2	40	131					
1887BR		MOUND AREA								
1887BR		MOUND AREA	6 2	26	128					
2087BR		MOUND AREA								
2087BR		MOUND AREA								
2087BR		MOUND AREA								
2187		MOUND AREA								
2287BR		MOUND AREA	4			5834 7	5	44	82 5 84 5	
BH2287		903 PAD								
2287BR		MOUND AREA								
2287BR		MOUND AREA								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #4 Strat Eqv THICK	Ka SS #4 GRAIN SIZE % 200/230 SE	Ka SS #4 GRAIN SIZE DEPTH	Ka SS #5 Strat Eqv ELEVATION	Ka SS #5 Strat Eqv THICK	Ka SS #5 GRAIN SIZE % 200/230 SE	Ka SS #5 GRAIN SIZE DEPTH	Upper Laramie Sandstones ELEVATION
2287BR		MOUND AREA								
2387BR		MOUND AREA								
2387BR		MOUND AREA								
2387BR		MOUND AREA								
BH2387		903 PAD								
2387BR		MOUND AREA								
2387BR		MOUND AREA								
2487		EAST TRENCHES								
BH2487		903 PAD								
2587BR		EAST TRENCHES								
BH2587		903 PAD								
2587BR		EAST TRENCHES								
2587BR		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
2787		EAST TRENCHES								
BH2787		903 PAD								
2787		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
2887BR		EAST TRENCHES								
BH2887		903 PAD								
3087BR		BUFFER SOUTH								
3087BR		BUFFER SOUTH								
3087BR		BUFFER SOUTH								
3187BR		EAST TRENCHES								
3187BR		EAST TRENCHES								
3187BR		EAST TRENCHES								
BH3187		MOUND AREA								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #4 Strat Eqv THICK	Ka SS #4 GRAIN SIZE % > 200/230 SE	Ka SS #4 GRAIN SIZE DEPTH	Ka SS #5 Strat Eqv ELEVATION	Ka SS #5 Strat Eqv THICK	Ka SS #5 GRAIN SIZE % 200/230 SE	Ka SS #5 GRAIN SIZE DEPTH	Upper Laramie Sandstones ELEVATION
BH3187		MOUND AREA								
3187BR		EAST TRENCHES								
BH3187		MOUND AREA								
3287		EAST TRENCHES								
3287		EAST TRENCHES								
BH3287		MOUND AREA								
3287		EAST TRENCHES								
BH3287		MOUND AREA								
3287		EAST TRENCHES								
BH3387		MOUND AREA								
3387		MOUND AREA								
BH3387		MOUND AREA								
BH3387		MOUND AREA								
3487BR		EAST TRENCHES								
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3487		MOUND AREA								
BH3587		MOUND AREA								
BH3587		MOUND AREA								
BH3587		MOUND AREA								
3587		EAST TRENCHES								
3687BR		EAST TRENCHES								
3687BR		EAST TRENCHES								
3687BR		EAST TRENCHES								
BH3687		MOUND AREA								
3687BR		EAST TRENCHES								
BH3787		EAST TRENCHES								
BH3787		EAST TRENCHES								
BH3887		MOUND AREA								
BH3887		MOUND AREA								
BH3987		EAST TRENCHES								
BH4087		EAST TRENCHES								
BH4187		EAST TRENCHES								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #4 Strat Eqv THICK	Ka SS #4 GRAIN SIZE % 200/230 SE	Ka SS #4 GRAIN SIZE DEPTH	Ka SS #5 Strat Eqv ELEVATION	Ka SS #5 Strat Eqv THICK	Ka SS #5 GRAIN SIZE % 200/230 SE	Ka SS #5 GRAIN SIZE DEPTH	Upper Laramie Sandstones ELEVATION
BH4187		EAST TRENCHES								
BH4187		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4287		EAST TRENCHES								
BH4387		EAST TRENCHES								
BH4387		EAST TRENCHES								
4487		903 PAD								
BH4487		EAST TRENCHES								
BH4487		EAST TRENCHES								
BH4487		EAST TRENCHES								
4587BR		903 PAD								
4587BR		903 PAD				5853 63		4 QUESTIONABLE	98	
BH4587		EAST TRENCHES								
BH4587		EAST TRENCHES								
BH4687		EAST TRENCHES								
BH4787		EAST TRENCHES								
BH4787		EAST TRENCHES								
BH4787		EAST TRENCHES								
BH4887		EAST TRENCHES								
BH4887		EAST TRENCHES								
4987		881 HILLSIDE								
BH4987		EAST TRENCHES								
BH4987		EAST TRENCHES								
5087		881 HILLSIDE								
5087		881 HILLSIDE								
BH5087		EAST TRENCHES								
BH5087		EAST TRENCHES								
5087		881 HILLSIDE								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES					3 7		5818 7	
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Ka SS #4 Strat Eqv THICK	Ka SS #4 GRAIN SIZE % > 200/230 SE	Ka SS #4 GRAIN SIZE DEPTH	Ka SS #5 Strat Eqv ELEVATION	Ka SS #5 Strat Eqv THICK	Ka SS #5 GRAIN SIZE % 200/230 SE	Ka SS #5 GRAIN SIZE DEPTH	Upper Laramie Sandstones ELEVATION
B217589	5789BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								5748 5
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
5587		881 HILLSIDE								
BH5587		EAST TRENCHES								
BH5587		EAST TRENCHES								
5587A		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Upper Laramie Sandstones THICK	Kab SS GRAIN SIZE % 200/230 SE	Kab SS GRAIN SIZE DEPTH	ALLUVIUM TYPE	ALLUVIUM RANGE	GRAIN SIZE % 200/230 SE	GRAIN SIZE DEPTH	CALICHE TYPE
2686		SOLAR POND				GRAVEL	0 10 5			AB
3486		EAST TRENCHES								
3486		EAST TRENCHES				GRAVEL	0 15 9			SM
4086		EAST TRENCHES				GRAVEL	41 44			
4086		EAST TRENCHES				SAND	38 41			
4086		EAST TRENCHES				GRAVEL	0 38			N
4186		EAST TRENCHES				SAND	30 31 5			
4186		EAST TRENCHES				GRAVEL	31 5 37			
4186		EAST TRENCHES				GRAVEL	1 12			AB
4186		EAST TRENCHES				GRAVEL	43 5 49 6	87	43 5 44 8	
4186		EAST TRENCHES				GRAVEL	13 7 30			
4186		EAST TRENCHES				SAND	12 13 7			SM
4186		EAST TRENCHES				SAND	37 43 5			
4286		EAST TRENCHES				GRAVEL	0 20			AB
4286		EAST TRENCHES				SAND	20 28 3	90	27 29	SM
5986		881 HILLSIDE								SM
5986		881 HILLSIDE								TR
5986		881 HILLSIDE				SAND	2 7 5			AB
6286		903 PAD				SAND	14 5 17 8			
6286		903 PAD				GRAVEL	12 8 14			SM
6286		903 PAD				GRAVEL SANDY	20 3 22			
6286		903 PAD				GRAVEL	17 8 20 3			
6386		903 PAD				GRAVEL	4 5			
6386		903 PAD				GRAVEL	14 3 14 8			
6386		903 PAD				SAND	0 5			SM
0287		881 HILLSIDE								SM
0287		881 HILLSIDE								AB
0387BR		881 HILLSIDE								SM
0387BR		881 HILLSIDE				GRAVEL	0 1			SM
0587BR		881 HILLSIDE				GRAVEL	9 11			N
BH0587		881 Hillside				GRAVEL	2 4			SM
0687A										
0787BR(A)		881 HILLSIDE								N
0887BR		881 HILLSIDE								SM

TABLE 1 ROCKY FLATS GEOLOGICAL DATA 13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Upper Laramie Sandstones THICK	%	Kab SS GRAIN SIZE 200/230 SE	Kab SS GRAIN SIZE DEPTH	ALLUVIUM TYPE	ALLUVIUM RANGE	%	GRAIN SIZE 200/230 SE	GRAIN SIZE DEPTH	CALICHE TYPE
0887BR		881 HILLSIDE										TR
0887BR		881 HILLSIDE					GRAVEL	5 7 7				TR
0887BR		881 HILLSIDE										SM
0987		903 PAD										N
0987		903 PAD					GRAVEL	0 12 7		76 9 5 11 5		N
0987		903 PAD										
0987		903 PAD										N
1087		903 PAD										
1087		903 PAD					GRAVEL	0 11 3				SM
1287		903 PAD					GRAVEL	0 8				TR
1487BR		903 PAD										
1487BR		903 PAD										SM
1487BR		903 PAD					GRAVEL	0 6				SM
1587		903 PAD					GRAVEL SDY	20 5 21 85	47+47		20 21 5	AB
1587		903 PAD					GRAVEL	0 20 5				
1687BR		903 PAD										AB
1687BR		903 PAD					GRAVEL	20 5 22 2				AB
1687BR		903 PAD					GRAVEL SDY	17 20 5				SM
1687BR		903 PAD										TR
1787		MOUND AREA					GRAVEL	0 25		75 16 18		AB
BH1787		881 HILLSIDE					GRAVEL	0 1				TR
1887BR		MOUND AREA										SM
1887BR		MOUND AREA										TR
1887BR		MOUND AREA										SM
1887BR		MOUND AREA										TR
1887BR		MOUND AREA					GRAVEL	0 25 2		91 4 12 7 15 2		AB
2087BR		MOUND AREA					GRAVEL SDY	6 4 11 8		82 8 8 10 8		TR
2087BR		MOUND AREA										TR
2087BR		MOUND AREA					GRAVEL	0 6 4				SM
2187		MOUND AREA					GRAVEL	0 4 3				SM
2287BR		MOUND AREA					GRAVEL	0 4 3				SM
BH2287		903 PAD					GRAVEL	0 22 2		82 7 2 8 8		AB
2287BR		MOUND AREA										TR
2287BR		MOUND AREA										TR

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Upper Laramie Sandstones THICK	%	Kab SS GRAIN SIZE 200/230 SE	Kab SS GRAIN SIZE DEPTH	ALLUVIUM TYPE	ALLUVIUM RANGE	%	GRAIN SIZE 200/230 SE	GRAIN SIZE DEPTH	CALICHE TYPE
2287BR		MOUND AREA										SM
2387BR		MOUND AREA										
2387BR		MOUND AREA										
2387BR		MOUND AREA										
BH2387		903 PAD					GRAVEL	0 8				N
2387BR		MOUND AREA										
2387BR		MOUND AREA					GRAVEL	0 15 25		77 13 14 7		AB
2487		EAST TRENCHES					GRAVEL	0 12 1				SM
BH2487		903 PAD					GRAVEL	0 4 9				SM
2587BR		EAST TRENCHES					SAND	9 5 10 5				AB
BH2587		903 PAD					GRAVEL	7 14 8				TR
2587BR		EAST TRENCHES					GRAVEL	0 9 5				AB
2587BR		EAST TRENCHES					GRAVEL	10 5 16 5				TR
2787		EAST TRENCHES					SAND	18 5 23 7		65 19 1 21 12		
2787		EAST TRENCHES					GRAVEL	23 7 44 2				
2787		EAST TRENCHES										
2787		EAST TRENCHES					GRAVEL	2 8 18 5		89 16 1 17 2		AB
BH2787		903 PAD					GRAVEL	0 9 9				N
2787		EAST TRENCHES										
2887BR		EAST TRENCHES										
2887BR		EAST TRENCHES					SAND	15 2 24 5		63 15 2 16 8		
2887BR		EAST TRENCHES										
2887BR		EAST TRENCHES										
2887BR		EAST TRENCHES					GRAVEL	0 15 2				AB
2887BR		EAST TRENCHES										
2887BR		EAST TRENCHES					GRAVEL	24 5 40				
BH2887		903 PAD					GRAVEL	0 5 9				SM
3087BR		BUFFER SOUTH					SAND	13 14				SM
3087BR		BUFFER SOUTH					GRAVEL	0 3 8				SM
3087BR		BUFFER SOUTH										TR
3187BR		EAST TRENCHES					GRAVEL	30 45		88 30 32 5		AB
3187BR		EAST TRENCHES					SAND	25 30				SM
3187BR		EAST TRENCHES					GRAVEL	0 25				SM
BH3187		MOUND AREA					GRAVEL	4 7 6				AB

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Upper Laramie Sandstones THICK	Kab SS GRAIN SIZE % 200/230 SE	Kab SS GRAIN SIZE DEPTH	ALLUVIUM TYPE	ALLUVIUM RANGE	GRAIN SIZE % 200/230 SE	GRAIN SIZE DEPTH	CALICHE TYPE
BH3187		MOUND AREA								TR
3187BR		EAST TRENCHES								TR
BH3187		MOUND AREA								SM
3287		EAST TRENCHES				GRAVEL	34 2 41 2			TR
3287		EAST TRENCHES				GRAVEL	42 8 46 2			
BH3287		MOUND AREA								
3287		EAST TRENCHES				GRAVEL	2 27 2			AB
BH3287		MOUND AREA				GRAVEL	0 7 7			AB
3287		EAST TRENCHES				SAND	27 2 34 2			AB
BH3387		MOUND AREA								
3387		MOUND AREA								
BH3387		MOUND AREA				GRAVEL	0 9 2			SM
BH3387		MOUND AREA								SM
3487BR		EAST TRENCHES				GRAVEL	0 20			N
BH3487		MOUND AREA								
BH3487		MOUND AREA				GRAVEL	14 7 16 7			
BH3487		MOUND AREA				SAND	4 5 14 7	51 12 7 14 7		
BH3487		MOUND AREA				GRAVEL	0 4 5	79 4 0 6 0		SM
BH3587		MOUND AREA				GRAVEL	0 14 3			AB
BH3587		MOUND AREA								SM
BH3587		MOUND AREA								TR
3587		EAST TRENCHES				GRAVEL	0 9 1			SM
3687BR		EAST TRENCHES								
3687BR		EAST TRENCHES				GRAVEL	0 7 4			AB
3687BR		EAST TRENCHES								SM
BH3687		MOUND AREA				GRAVEL	0 20 6			AB
3687BR		EAST TRENCHES								
BH3787		EAST TRENCHES								
BH3787		EAST TRENCHES				GRAVEL	0 14	69 4 0 7 0		AB
BH3887		MOUND AREA				GRAVEL	0 14 6			AB
BH3887		MOUND AREA								TR
BH3987		EAST TRENCHES				GRAVEL	0 14 5			SM
BH4087		EAST TRENCHES				GRAVEL	0 8	85 4 0 7 0		SM
BH4187		EAST TRENCHES								SM

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Upper Laramie Sandstones THICK	Kab SS GRAIN SIZE % 200/230 SE	Kab SS GRAIN SIZE DEPTH	ALLUVIUM TYPE	ALLUVIUM RANGE	GRAIN SIZE % > 200/230 SE	GRAIN SIZE DEPTH	CALICHE TYPE
BH4187		EAST TRENCHES				GRAVEL	0 15			SM
BH4187		EAST TRENCHES								AB
BH4287		EAST TRENCHES				GRAVEL	22 24			SM
BH4287		EAST TRENCHES				SAND	19 5 22			TR
BH4287		EAST TRENCHES				GRAVEL	0 19 5			AB
BH4387		EAST TRENCHES				GRAVEL	0 27 2	75 19 7 24 7		N
BH4387		EAST TRENCHES								
4487		903 PAD				GRAVEL	0 0 5			N
BH4487		EAST TRENCHES				GRAVEL	0 15			N
BH4487		EAST TRENCHES				SAND	15 20			
BH4487		EAST TRENCHES				GRAVEL	20 27			
4587BR		903 PAD								
4587BR		903 PAD				GRAVEL	0 4			N
BH4587		EAST TRENCHES								TR
BH4587		EAST TRENCHES				GRAVEL	0 20			AB
BH4687		EAST TRENCHES				GRAVEL	0 27			TR
BH4787		EAST TRENCHES								AB
BH4787		EAST TRENCHES				GRAVEL	0 26 2			TR
BH4787		EAST TRENCHES								SM
BH4887		EAST TRENCHES				GRAVEL	0 13 2			AB
BH4887		EAST TRENCHES								AB
4987		881 HILLSIDE				GRAVEL	0 4			SM
BH4987		EAST TRENCHES				GRAVEL	0 22			AB
BH4987		EAST TRENCHES								SM
5087		881 HILLSIDE				GRAVEL	0 2			AB
5087		881 HILLSIDE								SM
BH5087		EAST TRENCHES				GRAVEL	0 12			AB
BH5087		EAST TRENCHES								TR
5087		881 HILLSIDE								TR
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								
B217489	5689BR	EAST TRENCHES								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

13 JUNE 91

WELL NAME	OLD WELL NAME	AREA	Upper Laramie Sandstones THICK	Kab SS GRAIN SIZE % > 200/230 SE	Kab SS GRAIN SIZE DEPTH	ALLUVIUM TYPE	ALLUVIUM RANGE	GRAIN SIZE % 200/230 SE	GRAIN SIZE DEPTH	CALICHE TYPE
B217589	5789BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES		4						
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES								
5587		881 HILLSIDE								N
BH5587		EAST TRENCHES				GRAVEL	0 29 5		74 27 28 9	
BH5587		EAST TRENCHES				GRAVEL	0 29 5		23 10 9 14	SM
5587A		881 HILLSIDE								

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	CALICHE RANGE	DIP ANGLE	DEPTH	REMARKS	SAMPLE DEPTH	SAMPLE % GRAVEL	SAMPLE % SAND	SAMPLE % < 200/230
2686		SOLAR POND	0 14				9 11	35	42	23
3486		EAST TRENCHES					91	0	3	97
3486		EAST TRENCHES	2 9 4	0 1	90		50	0	37	63
4086		EAST TRENCHES					121	0	11	89
4086		EAST TRENCHES			96 5		100	0	22	78
4086		EAST TRENCHES		0 1	78	CARBONACEOUS M	78	0	3	97
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES	0 12				43 5 44 8	47	40	13
4186		EAST TRENCHES								
4186		EAST TRENCHES								
4186		EAST TRENCHES	12 20							
4186		EAST TRENCHES								
4286		EAST TRENCHES	2 5			TD AT 5919 34	27 29	49	41	10
4286		EAST TRENCHES	5 16 5							
5986		881 HILLSIDE	22 5 26 5							
5986		881 HILLSIDE	15 20							
5986		881 HILLSIDE	2 10				20 0 22 0	0	43	57
6286		903 PAD					25 3 27 7	0	32	68
6286		903 PAD	0 5 10 3			6 DEGREE SANDS	10 3 12 8	2	24	74
6286		903 PAD					55 3 57 8	0	55	45
6286		903 PAD					40 3 42 8	0	16	84
6386		903 PAD								
6386		903 PAD								
6386		903 PAD	14 8 17 3							
0287		881 HILLSIDE	0 6 75							
0287		881 HILLSIDE	6 75 16							
0387BR		881 HILLSIDE	13 19	1 5	106		104	4	25	71
0387BR		881 HILLSIDE	1 7 11	4	89	WESTON SS AT 1	27 8 28 5	0	9	91
0587BR		881 HILLSIDE		1	48 6	Ka SS#3 IS CLY	46	0	9	91
BH0587		881 Hillside	0 6 2							
0687A						THICKNESS OF K	17 6 18 86	14	61	25
0787BR(A)		881 HILLSIDE				THICKNESS OF K	40	0	7	93
0887BR		881 HILLSIDE	46 49 7							

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	CALICHE RANGE	DIP ANGLE	DEPTH	REMARKS	SAMPLE DEPTH	SAMPLE % GRAVEL	SAMPLE % SAND	SAMPLE % 200/230
0887BR		881 HILLSIDE	50 55 8				98 7 100 3	0	69	31
0887BR		881 HILLSIDE	43 44 5	2 5	103+105 7	GOOD SS AT 582	97	0	2	98
0887BR		881 HILLSIDE	59 73							
0987		903 PAD					17 5 19 5	0	61	39
0987		903 PAD					9 5 11 5	7	69	24
0987		903 PAD					31 5	9	48	43
0987		903 PAD					20 0 21 5	0	59	41
1087		903 PAD					12	1	37	62
1087		903 PAD	5 17			SS #1 THICKNES	9 0 10 5	27	59	14
1287		903 PAD	0 4							
1487BR		903 PAD					19 5 22 5	0	40	60
1487BR		903 PAD	12 5 17 5				16	0	14	86
1487BR		903 PAD	0 9			Ka SS#3 084 m	10 5	0	59	41
1587		903 PAD	0 7				20 0 21 5	47	47	6
1587		903 PAD								
1687BR		903 PAD	48 52 2				155	0	48	52
1687BR		903 PAD	5 7	1	69 7		122	0	28	72
1687BR		903 PAD	4 5	4	120 3	BLK CLAY 5919	102	0	57	43
1687BR		903 PAD	7 8				142	0	28	72
1787		MOUND AREA	2 10				16 18	30	45	25
BH1787		881 HILLSIDE	0 12							
1887BR		MOUND AREA	60 61 5				128	0	26	74
1887BR		MOUND AREA	65 67 4				131	0	40	60
1887BR		MOUND AREA	54 57 3				111	92	4	4
1887BR		MOUND AREA	75 2 77							
1887BR		MOUND AREA	1 5 7 7			GRAIN SIZE DAT	12 7 15 2	37 1	54 3	8 6
2087BR		MOUND AREA	13 8 20 8				112	0	30	70
2087BR		MOUND AREA	28 8 33 8							
2087BR		MOUND AREA	0 10 8				8 8 10 8	40	42	18
2187		MOUND AREA	0 13 5							
2287BR		MOUND AREA	0 4				45 1 49 5	0	30	70
BH2287		903 PAD	2 6 35				7 2 8 8	46	36	18
2287BR		MOUND AREA	41 45							
2287BR		MOUND AREA	4 16				82 5 84 5	0	44	56

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	CALICHE RANGE	DIP ANGLE	DEPTH	REMARKS	SAMPLE DEPTH	SAMPLE % GRAVEL	SAMPLE % SAND	SAMPLE % < 200/230
2287BR		MOUND AREA	18 2 20 2							
2387BR		MOUND AREA					25 27	0	80	20
2387BR		MOUND AREA					17 19	0	60	40
2387BR		MOUND AREA					23 25	0	45	55
BH2387		903 PAD								
2387BR		MOUND AREA					35 35 5	1	22	77
2387BR		MOUND AREA	0 11				13 0 14 7	58	31	11
2487		EAST TRENCHES	4 18 3							
BH2487		903 PAD	7 5 10 75							
2587BR		EAST TRENCHES	7 9 5							
BH2587		903 PAD	7 8 85							
2587BR		EAST TRENCHES	2 2 5 5				19 5 23	0	49	51
2587BR		EAST TRENCHES	9 5 12 5							
2787		EAST TRENCHES					19 1 21 12	12	53	35
2787		EAST TRENCHES					35 54 36 9	29	49	22
2787		EAST TRENCHES					38 9 40	25	48	27
2787		EAST TRENCHES	1 5 9 4				16 1 17 2	52	37	11
BH2787		903 PAD								
2787		EAST TRENCHES					41 9 42 9	0	14	86
2887BR		EAST TRENCHES					100	0	12	88
2887BR		EAST TRENCHES					37 3 38 7	14	60	26
2887BR		EAST TRENCHES					112	0	9	91
2887BR		EAST TRENCHES					104	0	7	93
2887BR		EAST TRENCHES	2 4			CARBONACEOUS M	15 2 16 8	18	45	37
2887BR		EAST TRENCHES					40 41 1	13	50	37
2887BR		EAST TRENCHES					82 0 86 0	0	0	100
BH2887		903 PAD	5 9 9							
3087BR		BUFFER SOUTH	4 10 8							
3087BR		BUFFER SOUTH	0 2							
3087BR		BUFFER SOUTH	10 8 12							
3187BR		EAST TRENCHES	2 11 2				112	0	20	80
3187BR		EAST TRENCHES	11 2 14 5			WESTON SHOWS C	115	0	41	59
3187BR		EAST TRENCHES	0 2			BLK CLAY AT 51	30 0 32 5	16	72	12
BH3187		MOUND AREA	0 7 6			MAY BE ALLUVIU	9 05 9 75	16	23	61

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	CALICHE RANGE	DIP ANGLE	DEPTH	REMARKS	SAMPLE DEPTH	SAMPLE % GRAVEL	SAMPLE % SAND	SAMPLE % < 200/230
BH3187		MOUND AREA	17 8 20 3							
3187BR		EAST TRENCHES	14 5 22				112 5 116	0	54	46
BH3187		MOUND AREA	10 1 17 8							
3287		EAST TRENCHES	12 5 14							
3287		EAST TRENCHES								
BH3287		MOUND AREA					11	2	40	58
3287		EAST TRENCHES	4 11 5				35 2 36 2	18 8	72 5	8 7
BH3287		MOUND AREA	7 7 15 2				10 2 12 7	2	41	57
3287		EAST TRENCHES	14 22							
BH3387		MOUND AREA								
3387		MOUND AREA				SAME BOREHOLE AS BH56 87				
BH3387		MOUND AREA	0 2				19	0	40	60
BH3387		MOUND AREA	9 2 17 8			SS #1 THICKNES	12 8 15 3	1	56	43
3487BR		EAST TRENCHES								
BH3487		MOUND AREA					20 7 22 7	0	43	57
BH3487		MOUND AREA					16 7 18 7	0	23	77
BH3487		MOUND AREA					12 7 14 7	4	47	49
BH3487		MOUND AREA	0 16 7			SS #1 THICKNES	4 0 6 7	48	31	21
BH3587		MOUND AREA	0 10 4			SS #1 THICKNES	17	0	16	84
BH3587		MOUND AREA	12 5 14 3							
BH3587		MOUND AREA	10 7 12 5							
3587		EAST TRENCHES	1 5 14 4							
3687BR		EAST TRENCHES					65	0	15	85
3687BR		EAST TRENCHES	2 5				26 27 5	0	50	50
3687BR		EAST TRENCHES	5 21				43	0	90	10
BH3687		MOUND AREA	0 4							
3687BR		EAST TRENCHES				Ka SS#?	54	0	65	35
BH3787		EAST TRENCHES					23	0	12 1	87 9
BH3787		EAST TRENCHES	0 11			SS #1 THICKNES	4 0 7 0	31	38	31
BH3887		MOUND AREA	1 5 10 2				16 5	0	7 2	92 8
BH3887		MOUND AREA	10 2 16 4							
BH3987		EAST TRENCHES	2 14 5			SS #1 THICKNES	18	0	1	99
BH4087		EAST TRENCHES	2 14 5				4 0 7 0	45	40	15
BH4187		EAST TRENCHES	9 5 14 5							

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	CALICHE RANGE	DIP ANGLE	DEPTH	REMARKS	SAMPLE DEPTH	SAMPLE % GRAVEL	SAMPLE % SAND	SAMPLE % < 200/230
BH4187		EAST TRENCHES	0 2							
BH4187		EAST TRENCHES	2 7							
BH4287		EAST TRENCHES	27 29 5				54 5	1	39	60
BH4287		EAST TRENCHES	7 12				37 39	0	84	16
BH4287		EAST TRENCHES	0 7				26	0	53	47
BH4387		EAST TRENCHES					19 7 24 7	23	52	29
BH4387		EAST TRENCHES								
4487		903 PAD								
BH4487		EAST TRENCHES				TD 5921 6	33	0	2	98
BH4487		EAST TRENCHES								
BH4487		EAST TRENCHES					32 34 5	1	64	35
4587BR		903 PAD				QUESTIONABLE G	98	63	22	15
4587BR		903 PAD					92	3	11	86
BH4587		EAST TRENCHES	14 5 16 5							
BH4587		EAST TRENCHES	2 14 5			SS #1 THICKNES	20 0 20 5	1	53	46
BH4687		EAST TRENCHES	0 12							
BH4787		EAST TRENCHES	2 9 5							
BH4787		EAST TRENCHES	0 2							
BH4787		EAST TRENCHES	9 5 18 5							
BH4887		EAST TRENCHES	0 6							
BH4887		EAST TRENCHES	8 8 5							
4987		881 HILLSIDE	9 10							
BH4987		EAST TRENCHES	2 10							
BH4987		EAST TRENCHES	10 22							
5087		881 HILLSIDE	2 9 2			MINIMAL Ka SS	16	0	6	94
5087		881 HILLSIDE	9 2 9 5			MINIMAL Ka SS	23	0	3	97
BH5087		EAST TRENCHES	0 7							
BH5087		EAST TRENCHES	7 12							
5087		881 HILLSIDE	9 5 14 5							
B217489	5689BR	EAST TRENCHES					50	0	29	71
B217489	5689BR	EAST TRENCHES					44	0	67	33
B217489	5689BR	EAST TRENCHES					28	3	33	64
B217489	5689BR	EAST TRENCHES					32	0	3	97
B217489	5689BR	EAST TRENCHES					58	0	40 5	59 5

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

TABLE 1 ROCKY FLATS GEOLOGICAL DATA

WELL NAME	OLD WELL NAME	AREA	CALICHE RANGE	DIP ANGLE	DEPTH	REMARKS	SAMPLE DEPTH	SAMPLE % GRAVEL	SAMPLE % SAND	SAMPLE % < 200/230
B217589	5789BR	EAST TRENCHES								
B217689	5889BR	EAST TRENCHES					83	0	50 6	49 4
B217689	5889BR	EAST TRENCHES					87 2	0	1 8	98 2
B217689	5889BR	EAST TRENCHES					96	0	3 5	96 5
B217689	5889BR	EAST TRENCHES					98	0	33 6	66 4
B217689	5889BR	EAST TRENCHES					99	0	9 3	90 7
B217689	5889BR	EAST TRENCHES					103	0	27 6	72 4
B217689	5889BR	EAST TRENCHES								
B217789	6089BR	EAST TRENCHES					139 3	0	33 7	66 3
B217789	6089BR	EAST TRENCHES					188 6	0	11 5	88 5
B217789	6089BR	EAST TRENCHES					214 4	0	14 7	85 3
5587		881 HILLSIDE				0 1 5 SOIL	5	8	44	48
BH5587		EAST TRENCHES					27 0 28 9	47	27	26
BH5587		EAST TRENCHES	0 10 9				10 9 14	24	53	23
5587A		881 HILLSIDE								

WELL NAME	OLD WELL NAME	AREA	SAMPLE % SILT	SAMPLE % CLAY	SAMPLE D 50
2686		SOLAR POND			1 7
3486		EAST TRENCHES			
3486		EAST TRENCHES			
4086		EAST TRENCHES			
4086		EAST TRENCHES			
4086		EAST TRENCHES			
4186		EAST TRENCHES			
4186		EAST TRENCHES			
4186		EAST TRENCHES	7	6	4 1
4186		EAST TRENCHES			
4186		EAST TRENCHES			
4186		EAST TRENCHES			
4186		EAST TRENCHES			
4286		EAST TRENCHES	4	6	4 5
4286		EAST TRENCHES			
5986		881 HILLSIDE			
5986		881 HILLSIDE			
5986		881 HILLSIDE	26	31	0 055
6286		903 PAD	30	38	0 028
6286		903 PAD	22	52	0 0038
6286		903 PAD	22	23	0 095
6286		903 PAD	34	50	0 0055
6386		903 PAD			
6386		903 PAD			
6386		903 PAD			
0287		881 HILLSIDE			
0287		881 HILLSIDE			
0387BR		881 HILLSIDE			
0387BR		881 HILLSIDE			
0587BR		881 HILLSIDE			
BH0587		881 Hillside			
0687A			8	17	
0787BR(A)		881 HILLSIDE			
0887BR		881 HILLSIDE			

WELL NAME	OLD WELL NAME	AREA	SAMPLE % SILT	SAMPLE % CLAY	SAMPLE D 50
0887BR		881 HILLSIDE	13	18	0 095
0887BR		881 HILLSIDE			
0887BR		881 HILLSIDE			
0987		903 PAD			0 1
0987		903 PAD			0 7
0987		903 PAD			0 095
0987		903 PAD	25	16	0 095
1087		903 PAD			
1087		903 PAD			0 95
1287		903 PAD			
1487BR		903 PAD	40	20	0 061
1487BR		903 PAD			
1487BR		903 PAD			0 085
1587		903 PAD			4 2
1587		903 PAD			
1687BR		903 PAD			0 074
1687BR		903 PAD			
1687BR		903 PAD			0 085
1687BR		903 PAD			
1787		MOUND AREA			1 1
BH1787		881 HILLSIDE			
1887BR		MOUND AREA			
1887BR		MOUND AREA			
1887BR		MOUND AREA			27
1887BR		MOUND AREA			
1887BR		MOUND AREA			1 8
2087BR		MOUND AREA			
2087BR		MOUND AREA			
2087BR		MOUND AREA			2 1
2187		MOUND AREA			
2287BR		MOUND AREA			
BH2287		903 PAD			3 6
2287BR		MOUND AREA			
2287BR		MOUND AREA			

WELL NAME	OLD WELL NAME	AREA	SAMPLE % SILT	SAMPLE % CLAY	SAMPLE D 50
2287BR		MOUND AREA			
2387BR		MOUND AREA			0 17
2387BR		MOUND AREA			0 091
2387BR		MOUND AREA	29	26	0 065
BH2387		903 PAD			
2387BR		MOUND AREA			
2387BR		MOUND AREA			7
2487		EAST TRENCHES			
BH2487		903 PAD			
2587BR		EAST TRENCHES			
BH2587		903 PAD			
2587BR		EAST TRENCHES	24	27	0 075
2587BR		EAST TRENCHES			
2787		EAST TRENCHES	13	22	0 2
2787		EAST TRENCHES			1 05
2787		EAST TRENCHES			0 69
2787		EAST TRENCHES			5 3
BH2787		903 PAD			
2787		EAST TRENCHES			
2887BR		EAST TRENCHES			
2887BR		EAST TRENCHES			0 69
2887BR		EAST TRENCHES			
2887BR		EAST TRENCHES			
2887BR		EAST TRENCHES	11	26	0 65
2887BR		EAST TRENCHES	10	27	0 25
2887BR		EAST TRENCHES	25	75	0 0015
BH2887		903 PAD			
3087BR		BUFFER SOUTH			
3087BR		BUFFER SOUTH			
3087BR		BUFFER SOUTH			
3187BR		EAST TRENCHES			
3187BR		EAST TRENCHES			
3187BR		EAST TRENCHES			0 98
BH3187		MOUND AREA			

WELL NAME	OLD WELL NAME	AREA	SAMPLE % SILT	SAMPLE % CLAY	SAMPLE D 50
BH3187		MOUND AREA			
3187BR		EAST TRENCHES	19	27	0 082
BH3187		MOUND AREA			
3287		EAST TRENCHES			
3287		EAST TRENCHES			
BH3287		MOUND AREA			
3287		EAST TRENCHES			1 5
BH3287		MOUND AREA	24	33	0 048
3287		EAST TRENCHES			
BH3387		MOUND AREA			
3387		MOUND AREA			
BH3387		MOUND AREA			
BH3387		MOUND AREA			0 092
3487BR		EAST TRENCHES			
BH3487		MOUND AREA			
BH3487		MOUND AREA			
BH3487		MOUND AREA	14	35	0 082
BH3487		MOUND AREA			4
BH3587		MOUND AREA			
BH3587		MOUND AREA			
BH3587		MOUND AREA			
3587		EAST TRENCHES			
3687BR		EAST TRENCHES			
3687BR		EAST TRENCHES	29 5	20 5	0 071
3687BR		EAST TRENCHES			0 19
BH3687		MOUND AREA			
3687BR		EAST TRENCHES			0 12
BH3787		EAST TRENCHES	28	60	0 002
BH3787		EAST TRENCHES	10	21	0 91
BH3887		MOUND AREA			
BH3887		MOUND AREA			
BH3987		EAST TRENCHES			
BH4087		EAST TRENCHES			4 5
BH4187		EAST TRENCHES			

WELL NAME	OLD WELL NAME	AREA	SAMPLE % SILT	SAMPLE % CLAY	SAMPLE D 50
BH4187		EAST TRENCHES			
BH4187		EAST TRENCHES			
BH4287		EAST TRENCHES			
BH4287		EAST TRENCHES	6	10	0 22
BH4287		EAST TRENCHES			0 08
BH4387		EAST TRENCHES			0 56
BH4387		EAST TRENCHES			
4487		903 PAD			
BH4487		EAST TRENCHES			
BH4487		EAST TRENCHES			
BH4487		EAST TRENCHES			0 11
4587BR		903 PAD			11
4587BR		903 PAD			
BH4587		EAST TRENCHES			
BH4587		EAST TRENCHES	19	27	0 08
BH4687		EAST TRENCHES			
BH4787		EAST TRENCHES			
BH4787		EAST TRENCHES			
BH4787		EAST TRENCHES			
BH4887		EAST TRENCHES			
BH4887		EAST TRENCHES			
4987		881 HILLSIDE			
BH4987		EAST TRENCHES			
BH4987		EAST TRENCHES			
5087		881 HILLSIDE			
5087		881 HILLSIDE			
BH5087		EAST TRENCHES			
BH5087		EAST TRENCHES			
5087		881 HILLSIDE			
B217489	5689BR	EAST TRENCHES	31	40	0 015
B217489	5689BR	EAST TRENCHES	14	19	0 165
B217489	5689BR	EAST TRENCHES	28	36	0 026
B217489	5689BR	EAST TRENCHES	22	75	
B217489	5689BR	EAST TRENCHES	31	28 5	0 035

WELL NAME	OLD WELL NAME	AREA	SAMPLE % SILT	SAMPLE % CLAY	SAMPLE D 50
B217589	5789BR	EAST TRENCHES			
B217689	5889BR	EAST TRENCHES	(28)	(21 4)	(065)
B217689	5889BR	EAST TRENCHES	53 8	44 4	0 0055
B217689	5889BR	EAST TRENCHES	32	64 5	0 002
B217689	5889BR	EAST TRENCHES	(40)	(26 4)	(04)
B217689	5889BR	EAST TRENCHES	(55 7)	(35)	
B217689	5889BR	EAST TRENCHES	(40)	(32 4)	(018)
B217689	5889BR	EAST TRENCHES			
B217789	6089BR	EAST TRENCHES	41 4	24 9	0 043
B217789	6089BR	EAST TRENCHES	(50 5)	(38)	(009)
B217789	6089BR	EAST TRENCHES	(45)	(40 3)	(0095)
5587		881 HILLSIDE			0 09
BH5587		EAST TRENCHES			0 34
BH5587		EAST TRENCHES			0 37
5587A		881 HILLSIDE			

APPENDIX B
ANALYTE CONCENTRATION TABLES

TABLE B 1A

STATISTICS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND WEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l)

	Al	Sb	As	Ba	Be	Cd	Ca	Cs	C	Co	Cu	F	Pb	Li
Normal or Log Normal	Normal	Normal	N rmal	Normal	Normal	N rmal	Log	Normal	Normal	Normal	Normal	Normal	N rmal	Normal
Upper Tolerance Limit							76.7449							
Lower Tolerance Limit														
Maximum Concentration	0.2U	0.5U	0 1U	0.2U	0.005U	0.005U	167.0	2.5U	0.02U	0.05U	0.477	0.0909	0.0049	0.4
Minimum Concentration	0.0405	0.06U	0.002U	0.05U	0.002U	0.004U	31.8	1.0U	0.01U	0.02U	0.025U	0 1U	0.003U	0.013U
Cohen or Unrevised	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	0.0933	0.0575	0.0043	0.0953	0.0023	0.0024	58.8797	0.6406	0.0056	0.0230	0.0168	0.0549	0.0024	0.0753
Standard Deviation	0.0181	0.0751	0.0015	0.0188	0.0005	0.0002	7.0791	0.3023	0.0017	0.0053	0.0118	0.0130	0.0011	0.1062
Sample Size	15	16	16	16	16	15	16	16	16	15	16	15	14	16
Percent Detected	13.3	0.0	6.3	6.3	0.0	0.0	100.0	0.0	0.0	0.0	12.5	13.3	21.4	31.3
Classification Method	KA	KA	KA	KA	KA	KA	KA	A	KA	KA	KA	KA	KA	KA

	Mg	M	Hg	M	Ni	K	Se	Ag	N	Sr	Tl	S	V	Zn
Normal or Log Normal	Log	Log	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit	33.2559	0.4441							99.6049					0 1241
Lower Tolerance Limit														
Maximum Concentration	179.0	0.846	0.0008	0.5U	0.04U	5.31	0.0628	0.03U	714.0	7.12	0.05U	1.0U	0.05U	0 107
Minimum Concentration	5 15	0.015U	0.0002U	0.015U	0.02U	1 72	0.005U	0.01U	13.4	0 198	0.003U	0 1U	0.01U	0.02U
Cohen or Unrevised	UN	C	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	C
Mean	20.0602	0.1723	0.0002	0.0677	0.0183	2.6393	0.0095	0.0063	57.0263	0.8971	0.0059	0 1344	0.0225	0.0259
Standard Deviation	5.2288	0.1077	0.0002	0.0728	0.0039	0 7661	0.0171	0.0034	16.8718	1.6735	0.0055	0 1814	0.0068	0.0367
Sample Size	16	16	16	16	12	15	15	16	16	16	16	16	16	13
Percent Detected	100.0	68.8	25.0	12.5	0.0	20.0	20.0	0.0	100.0	43.8	6.3	0.0	0.0	69.2
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U Concentration below detection limit.
M MANOVA
Value not computed.
C Cohen revised statistics
UN Unrevised statistics.
A Parametric ANOVA.
K Kruskal-Wallis nonparametric ANOVA.
No classification.
P Test of proportions.

TABLE B 1B

STATISTICS FOR INORGANIC (EXCEPT CHLORIDE) CONCENTRATIONS IN BACKGROUND WEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
Normal or Log Normal	Log	Normal		Normal	Normal	Log	Log
Upper T lerance Limit	298.4996				8.6888	0.6143	49.3145
Lower T lerance Limit					6.6168		
Maximum Concentration	400.0	5.0U		0.01U	8.4	0.66	100.0
Minimum Concentratio	144.0	5.0U		0.0025U	7.0	0.05U	11.0
Cohen Unrevised	UN	UN		UN	UN	UN	UN
Mean	235 7107	2.5000		0.0033	7.6528	0.3413	33.4302
Standard Deviation	22.9463	0.0000		0.0019	0.4223	0.1022	5.8049
Sample Size	12	12		14	18	13	12
Perce t De ected	100.0	0.0		7.1	100.0	92.3	100.0
Classificat on Method	A				KA	KA	KA

N rmal log normal data distributions were assumed. All statistics presented are untransformed (antilog) values
U Concentration below detection limit
M MANOVA
Value not computed
C C hen revised statistics
UN Unrevised statistics
A Parametric ANOVA
K Kruskal-Wallis nonparametric ANOVA.
N classification.
P Test f proport ns

TABLE B 1C

STATISTICS FOR CHLORIDE CONCENTRATIONS IN BACKGROUND NORTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
N rmal or Log Normal			Log				
Upper T lerance Limit							
Lower T lerance Limit							
Maximum Concen ratio			4.0				
Minimum Concen ra ion			3.0U				
C he or Unrevised			UN				
Mean			1.8872				
Standard Deviatio			0.3083				
Sample Size			6				
Perce Detected			16.7				
Classifica Method							

N rmal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.
U Co cen ration below detection limit
M MANOVA.
Value not comp ed
C C hen revised statistics
UN Unrevised st istics
A Parametric ANOVA
K Kruskal Wallis nonparametric ANOVA.
N classificatio
P Test f proportions

TABLE B 1D

STATISTICS FOR CHLORIDE CONCENTRATIONS IN BACKGROUND SOUTH ROCKY FLATS WEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
Normal or Log Normal			Log				
Upper T lerance Limi							
Lower T lerance Limit							
Maximum Concentration			26.0				
Minimum Concen ration			3.0U				
C hen Unrevised			C				
Mean			12.4599				
Standard Devia			5.1094				
Sample Siz			6				
Percen Detected			83.3				
Classifica ion Method							

N rmal or l g normal data distributions were assumed All statistics presented are untransformed (antilog) values.
U Concentration below detection limit
M MANOVA
Value not comp ted
C C hen revised statistics
UN Unrevised statistics
A Paramet ANOVA.
K Kruskal-Wallis nonparametric ANOVA.
N classifica ion.
P Test f proportions

TABLE B 1E

STATISTICS FOR DISSOLVED RADIOCHEMICAL CONCENTRATIONS IN BACKGROUND WEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS pCi/l)

	Am241	Cs137	Alpha	Beta	Pu239	Ra226	Ra228	Sr90	Tritium	U233,234	U235	U238
Normal or Log Normal	Normal	Normal	Normal	Normal	Normal	Normal		Normal	Normal		Normal	Normal
Upper Tolerance Limit	0.0347	0.5916	24 9838	13.2977	0.0305			0.6422	291.8227		0.3693	5.2006
Lower Tolerance Limit												
Maximum Concentration	0.034	0.4	24.0	12.0	0.03	0 7		0.44	300.0		0.28	4.68
Minimum Concentration	0.0	-0.2	0.0	2.2	0.0	0.29		-0.3	100.0		0.0	0.4
Cohen or Unrevised	UN	UN	UN	UN	UN	UN		UN	UN		UN	UN
Mean	0.0034	0 1046	7 7000	5.4846	0.0044	0.4817		0.0462	40.8421		0 1140	1.9533
Standard Deviation	0.0108	0 1824	6.4721	2.9257	0.0093	0 1497		0.2232	103.5810		0.0995	1.2655
Sample Size	10	13	13	13	11	6		13	19		15	15
Percent Detected	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0
Classification Method	KA	A	KA	KA	KA	KA		KA	A		KA	KA

Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U Concentration below detection limit

M MANOVA.

Value not computed

C Cohen revised statistics.

UN Unrevised statistics.

A Parametric ANOVA.

K Kruskal-Wallis nonparametric ANOVA.

No classification.

P Test of proportions.

TABLE B 2A

STATISTICS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND WEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l)

	Al	Sb	As	Ba	Be	Cd	Ca	Cs	C	Co	C	F	Pb	Li
Normal or Log Normal	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit														
Lower Tolerance Limit														
Maximum Concentration	0.2U	0 176	0.01U	0.2U	0.005U	0.005U	65 7	2.5U	0.0122	0.05U	0.025U	0 1U	0.005U	1 79
Minimum Concentration	0.2U	0.06U	0.01U	0.2U	0.005U	0.005U	30.9	1.0U	0.01U	0.05U	0.025U	0 1U	0.005U	0.0106
Cohen or Unrevised	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	0 1000	0.0665	0.0050	0 1000	0.0025	0.0025	46.0332	0.6250	0.0064	0.0250	0.0125	0.0500	0.0025	0.3334
Standard Deviation	0.0000	0.0730	0.0000	0.0000	0.0000	0.0000	5.8860	0.3062	0.0032	0.0000	0.0000	0.0000	0.0000	0 7137
Sample Size	6	4	4	5	4	5	6	6	5	5	5	6	5	6
Percent Detected	0.0	25.0	0.0	0.0	0.0	0.0	100.0	0.0	20.0	0.0	0.0	0.0	0.0	33.3
Classification Method	KA	KA	KA	KA	KA	KA	KA	A	KA	KA	KA	KA	KA	KA

	Mg	Mn	Hg	Mo	Ni	K	Se	Ag	Na	Sr	Tl	Sn	V	Zn
Normal or Log Normal	Log	Log	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit														
Lower Tolerance Limit														
Maximum Concentration	9.41	0.292	0.0002U	0 1U		10.2	0.005U	0.01U	25.6	2.03	0.05U	0 1U	0.05U	0.0258
Minimum Concentration	5.25	0.015U	0.0002U	0.015	0.04U	5.0U	0.005U	0.01U	12.6	0.288	0.01U	0 1U	0.05U	0.02U
Cohen or Unrevised	UN	C	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	7.3261	0 1124	0.0001	0.0442	0.0200	4.0400	0.0025	0.0050	20.4354	0 7197	0.0083	0.0500	0.0250	0.0126
Standard Deviation	0.7506	0.0722	0.0000	0.0143	0.0000	3.4435	0.0000	0.0000	2.6519	0.6475	0.0082	0.0000	0.0000	0.0065
Sample Size	6	6	5	6	6	5	4	5	6	6	6	6	6	6
Percent Detected	100.0	83.3	0.0	16.7	0.0	20.0	0.0	0.0	100.0	33.3	0.0	0.0	0.0	16.7
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U Concentration below detection limit
M MANOVA
Value not computed.
C Cohen revised statistics
UN Unrevised statistics.
A Parametric ANOVA.
K Kruskal-Wallis nonparametric ANOVA.
No classification.
P Test of proportions.

TABLE B 2B

STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND WEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
Normal or Log Normal	Log	Normal		Normal	Normal	Log	Log
Uppe T lerance Limit	236.8072				8.8076	2.1648	39.1245
Lower T lerance Limit					5.6674		
Maximum Concen ration	240.0	5.0U		0.01U	8.4	1.6	48.0
Minimum C ncen ration	130.0	5.0U		0.0025U	6.9	0.18	13.0
Cohen Unrevised	UN	UN		UN	UN	UN	UN
Mean	175.5991	2.5000		0.0025	7.2375	0.9473	23.7154
Standard Devia io	18.0052	0.0000		0.0019	0.4926	0.3581	4.5328
Sampl Siz	7	7		6	8	7	7
P rcent Detected	100.0	0.0		0.0	100.0	100.0	100.0
Classifica io Method							

N rmal log normal data distributions were assumed All statistics presented are untransformed (antilog) values.
U Conce ra on below detection limit
M MANOVA.
Value no computed
C C h revised sta ist cs
UN Unrevised statistics
A Paramet ANOVA.
K Kruskal Wallis nonparametric ANOVA.
N classification.
P Test f proportions

TABLE B 2C

STATISTICS FOR CHLORIDE CONCENTRATIONS IN BACKGROUND SOUTH ROCKY FLATS WEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
Normal or Log Normal			Log				
Upper T lerance Limit			17.2107				
Lower T lerance Limit							
Maximum Concen ration			18.0				
Minimum Concentration			6.0				
Cohen or Unrevised			UN				
Mean			10.2500				
Standard Devia io			2.0476				
Sampl Size			7				
Percen De ected			100.0				
Classifica io Method							

N rmal log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.
U Co centratio below detection limit
M MANOVA.
Value t computed
C C hen revised statist cs
UN Unrevised statistics
A Parametric ANOVA
K Kruskal Wallis onparametric ANOVA.
N lassification
P Test f proportions

TABLE B 2D

STATISTICS FOR DISSOLVED RADIOCHEMICAL CONCENTRATIONS IN BACKGROUND WEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS pCi/l)

	Am241	Cs137	Alpha	Bet	Pu239	Ra226	Ra228	Sr90	Tritium	U233,234	U235	U238
Normal or Log Normal	N rmal	N rmal	Normal	N rmal	N rmal	Normal		Normal	Normal		Normal	Normal
Upper Tolerance Limit	0.0263	0 9777	12.7000	5.6214	0.0159			0.9394	235 1185		0.2170	1.0706
Lower Tolerance Limit												
Maximum Concentration	0 016	0.3	8.0	4.0	0.01	0.4		0.52	100.0		0 13	0.62
Minimum Concentration	0.0	-0.5	0 7	0.0	0.0	0.3		-0.2	100.0		-0.07	0 1
Cohen or Unrevised	UN	UN	UN	UN	UN		UN	UN	UN	UN	UN	UN
Mean	0.0046	-0.0313	3.9125	1.9250	0.0030	0.3667		0 1125	1.2500		0.0188	0.3500
Standard Deviation	0.0064	0.3166	2.7570	1 1597	0.0040	0.0577		0.2594	73.3753		0.0622	0.2261
Sample Size	7	8	8	8	8	3		8	8		8	8
Percent Detected	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0
Classification Method	KA	KA	KA	KA	KA		KA	KA	A	KA	KA	KA

Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U Concentration below detection limit
M MANOVA.
Value not computed.
C Cohen revised statistics.
UN Unrevised statistics.
A Parametric ANOVA.
K Kruskal-Wallis nonparametric ANOVA.
No classification.
P Test of proportions.

TABLE B 3A

STATISTICS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l)

	Al	Sb	As	Ba	Be	Cd	Ca	Cs	C	Co	Cu	F	Pb	Li
Normal or Log Normal	Normal	Normal	Normal	N rmal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit							38.8630							
Lower Tolerance Limit														
Maximum Concentration	0.327	0.5U	0.0186	0.2U	0.005U	0.005U	99.3	2.5U	0.0177	0.05U	0.0695	0.0539	0.024	0.283
Minimum Concentration	0.03U	0.06U	0.002U	0.05U	0.002U	0.004U	5.0U	0 1U	0.01U	0.02U	0.02U	0.0336	0.002U	0.024
Cohen or Unrevised	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	0 1109	0.0647	0.0055	0.0947	0.0023	0.0024	24.4479	0.4925	0.0067	0.0228	0.0166	0.0489	0.0055	0.0624
Standard Deviation	0.0690	0.0824	0.0036	0.0171	0.0006	0.0002	6.0163	0.2255	0.0035	0.0055	0.0140	0.0043	0.0059	0.0538
Sample Size	13	19	20	20	18	17	20	20	16	20	19	19	20	20
Percent Detected	7 7	0.0	15.0	10.0	0.0	0.0	90.0	0.0	6.3	0.0	10.5	15.8	10.0	25.0
Classification Method	KA	KA	KA	KA	KA	KA	KA	A	KA	KA	KA	KA	KA	KA

	Mg	Mn	Hg	Mo	Ni	K	Se	Ag	N	Sr	Tl	Sn	V	Zn
Normal or Log Normal	Log	Log	Normal	Normal	Normal	Normal	Normal	Normal	Log	Normal	Normal	Normal	Normal	Normal
Upper Tolerance Limit									213.3108					0.2582
Lower Tolerance Limit														
Maximum Concentration	35.0	0.0774	0.0003	0.5U	0.04U	21.9	0.041	0.03U	454.0	1.43	0.04U	1.0U	0.05U	0.374
Minimum Concentration	1.91	0.01U	0.0002U	0 1U	0.02U	5.0U	0.002U	0.01U	61 7	0 139	0.003U	0 1U	0.01U	0.02U
Cohen or Unrevised	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Mean	4.2178	0.0167	0.0001	0.0859	0.0182	5.9247	0.0062	0.0066	155.9665	0.5658	0.0063	0 1175	0.0215	0.0440
Standard Deviation	0 7074	0.0035	0.0001	0.0730	0.0039	6.0886	0.0094	0.0037	23.9334	0.2773	0.0050	0.1649	0.0079	0.0861
Sample Size	20	19	19	20	17	19	19	19	20	20	19	20	17	17
Percent Detected	35.0	31.6	26.3	10.0	0.0	47.4	31.6	0.0	100.0	40.0	0.0	0.0	0.0	58.8
Classification Method	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA	KA

Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.

U Concentration below detection limit.
M MANOVA
Value not computed.
C Cohen revised statistics
UN Unrevised statistics.
A Parametric ANOVA.
K Kruskal-Wallis nonparametric ANOVA.
No classification.
P Test of proportions.

TABLE B-3B

STATISTICS FOR INORGANIC CONCENTRATIONS IN BACKGROUND NORTH ROCKY FLATS UNWEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
Normal Log Normal	Log	Normal		Normal	Normal	Log	Log
Upper T lerance Limit	302.2308	30 1793			10.6483		290.9021
Lower T lerance Limi					7.2917		
Maximum C cen ratio	390.0	25.0		0.01U	10.4	3.6	670.0
Minimum Concen rat	140.0	5.0U		0.0025U	8.0	0.05U	5.0U
C hen Unrevised	UN	C		UN	UN	C	C
Mean	255.6284	6.3774		0.0037	8.9700	0 7294	88.9962
Standard Deviatio	17.4508	8.9129		0.0017	0.7005	0.6543	75.6059
Sampl Size	13	13		1	20	12	13
Percent Detected	100.0	69.2		18.2	100.0	50.0	61.5
Classifica Method	A				KA		

N rmal log rmal data distributions were assumed All statistics presented are untransformed (antilog) values. U Concentration below detection limit
M MANOVA.
Value no computed C Cohen revised statistics UN Unrevised statistics A Parametric ANOVA. K Kruskal-Wallis nonparametric ANOVA.
N classification. P Test f proportions.

TABLE B 3C

STATISTICS FOR CHLORIDE CONCENTRATIONS IN BACKGROUND NORTH ROCKY FLATS UNWEATHERED CLAYSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
N rmal or Log Normal			Log				
Upper T lerance Limit							
Lowe T lerance Limit							
Maximum Co centratio			230.0				
Minimum C ncentratio			4.0				
Cohen or Unrevised			UN				
Mean			23.8698				
Standard Devia io			14 1990				
Sample Siz			6				
Perce t De ected			100 0				
Classification M hod							

Normal log normal data distributions were assumed All statistics presented are untransformed (antilog) values. U Concentration below detection limit M MANOVA.
Value not comp ed C Cohen revised statistics. UN Unrevised statistics A Parametric ANOVA. K Kruskal-Wallis nonparametric ANOVA.
N classification. P Test f proportions.

TABLE B 3D

STATISTICS FOR CHLORIDE CONCENTRATIONS IN BACKGROUND SOUTH ROCKY FLATS UNWEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS mg/l EXCEPT pH)

	HCO_3	CO_3	Cl	CN	Field pH	NO_3/NO_2	SO
Normal Log N rmal			Log				
Upper T lerance Limi			4123540				
Lower T lerance Limi							
Maximum Co cen ra io			260.0				
Minimum Concen ratio			6.0				
Cohen Unrevised			UN				
Mean			159.6799				
Standard Deviat on			74.3275				
Sampl Siz			7				
Percen Detected			100.0				
Classificat Method							

N rmal log normal data distributions were assumed All statistics presented are untransformed (antilog) values. U Concentration below detection limit
M MANOVA.
Value no computed C Cohen revised statistics. UN Unrevised statistics. A Parametric ANOVA. K Kruskal-Wallis nonparametric ANOVA.
N classifica on. P Test f proportions.

TABLE B 3E

STATISTICS FOR DISSOLVED RADIOCHEMICAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUNDWATER SAMPLES (CONCENTRATION UNITS pCi/l)

	Am241	Cs137	Alpha	Beta	Pu239	Ra226	Ra228	Sr90	Tritium	U233,234	U235	U238
Normal or Log Normal	Normal	Normal	Normal	Normal	Normal	Normal		Normal	Normal		Normal	Normal
Upper Tolerance Limit	0.0636	0.8192	28.4866	33.4236	0.0109			0.9283	495.8059		1.0681	7.0858
Lower Tolerance Limit												
Maximum Concentration	0.082	0.85	38.9	43.8	0.01	0.6		1.0	340.0		1 7	11.59
Minimum Concentration	0.0	-0.3	-4.0	2.0	-0.002	0.2		-0.3	-680.0		0.0	-0 1
Cohen or Unrevised	UN	UN	UN	UN	UN	UN		UN	UN		UN	UN
Mean	0.0091	0.1040	5.4947	10.0800	0.0023	0.4000		0 1650	25.0000		0 1580	1.0135
Standard Deviation	0.0213	0.2985	9.4889	9 7427	0.0036	0.2828		0.3186	217.3646		0.3799	2.5343
Sample Size	15	20	19	20	19	2		20	20		20	20
Percent Detected	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0
Classification Method	KA	A	KA	KA	KA			KA	A		KA	KA

Normal or log normal data distributions were assumed. All statistics presented are untransformed (antilog) values.
U Concentration below detection limit.
M MANOVA.
Value not computed.
C Cohen revised statistics.
UN Unrevised statistics.
A Parametric ANOVA.
K Kruskal-Wallis nonparametric ANOVA.
No classification.
P Test of proportions.

TABLE B-4A

SUMMARY OF WELLS USED FOR BACKGROUND CONCENTRATIONS OF DISSOLVED METALS

Well Designation	Screened Formation
B203189	KCL
B203289	KCL
B203489	KCL
B203589	KCL
B203689	KCL
B304889	KCL
B305389	KCL
B405489	KCL
B203789	KSSU
B203889	KSSU
B203989	KSSU
B204089	KSSU
B204189	KSSU
B304289	KSSU
B304989	KSSU
B405289	KSSU
B402189	KSSW
B405889	KSSW
B201189	QC
B201289	QC
B205589	QC
B302089	QC
B401989	QC
B200589	QRF
B200689	QRF
B200789	QRF
B200889	QRF
B400189	QRF
B400289	QRF
B400389	QRF
B400489	QRF
B405586	QRF
B405689	QRF

TABLE B-4A

SUMMARY OF WELLS USED FOR BACKGROUND CONCENTRATIONS OF DISSOLVED METALS (Concluded)

Well Designation	Screened Formation
B405789	QRF
B102289	QVF
B102389	QVF
B202489	QVF
B202589	QVF
B302789	QVF
B302889	QVF
B302989	QVF
B402689	QVF

KCL = Weathered Claystone
KSSU = Unweathered Sandstone
KSSW = Weathered Sandstone
QC = Colluvium
QRF = Rocky Flats Alluvium
QVF = Valley Fill Alluvium

TABLE B-4B

SUMMARY OF WELLS USED FOR BACKGROUND CONCENTRATIONS OF INORGANICS

Well Designation	Screened Formation
B203189	KCL
B203289	KCL
B203489	KCL
B203589	KCL
B203689	KCL
B304889	KCL
B305389	KCL
B405489	KCL
B203789	KSSU
B203889	KSSU
B203989	KSSU
B204089	KSSU
B204189	KSSU
B304289	KSSU
B304989	KSSU
B405289	KSSU
B402189	KSSW
B405889	KSSW
B201189	QC
B201289	QC
B205589	QC
B302089	QC
B401989	QC
B200589	QRF
B200689	QRF
B200789	QRF
B200889	QRF
B400189	QRF
B400289	QRF
B400389	QRF
B400489	QRF
B405586	QRF
B405689	QRF

TABLE B-4B

SUMMARY OF WELLS USED FOR BACKGROUND CONCENTRATIONS OF INORGANICS (Concluded)

Well Designation	Screened Formation
B405789	QRF
B102289	QVF
B102389	QVF
B202489	QVF
B202589	QVF
B302789	QVF
B302889	QVF
B302989	QVF
B303089	QVF
B402689	QVF

KCL = Weathered Claystone
KSSU = Unweathered Sandstone
KSSW = Weathered Sandstone
QC = Colluvium
QRF = Rocky Flats Alluvium
QVF = Valley Fill Alluvium

TABLE B-4C

SUMMARY OF WELLS USED FOR BACKGROUND EVALUATION OF GROUNDWATER RADIOCHEMISTRY

Well Designation	Screened Formation
B203189	KCL
B203289	KCL
B203489	KCL
B203589	KCL
B203689	KCL
B304889	KCL
B305389	KCL
B405489	KCL
B203789	KSSU
B203889	KSSU
B203989	KSSU
B204089	KSSU
B204189	KSSU
B304289	KSSU
B304989	KSSU
B405289	KSSU
B402189	KSSW
B405889	KSSW
B201189	QC
B201289	QC
B205589	QC
B401989	QC
B200589	QRF
B200689	QRF
B200789	QRF
B200889	QRF
B400189	QRF
B400289	QRF
B400389	QRF
B400489	QRF
B405586	QRF
B405689	QRF
B405789	QRF

TABLE B-4C

SUMMARY OF WELLS USED FOR BACKGROUND EVALUATION OF GROUNDWATER RADIOCHEMISTRY (Concluded)

Well Designation	Screened Formation
B102289	QVF
B102389	QVF
B202489	QVF
B202589	QVF
B302789	QVF
B302889	QVF
B302989	QVF
B402689	QVF

KCL = Weathered Claystone
KSSU = Unweathered Sandstone
KSSW = Weathered Sandstone
QC = Colluvium
QRF = Rocky Flats Alluvium
QVF = Valley Fill Alluvium

TABLE B 5

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs

W ll Designation	Lithology of Screened Interval[a]	Analytical Data Availability[b]	Sample Date[c]	Volatile Organic Compounds Detected (µg/ℓ)											
				Carbon Tetrachloride	Chloroform	Acetone	1,1 DCE	1,2-DCE	2-Hexanone	1 1 1 TCA	Methylene Chloride	Toluene	TCE	PCE	Carbon Disulfide
UPPER HSU															
1587	AL	Y	09/10/87(3)	4080									510	900	
			02/29/88(1)	1591	35		5				8		96	212	
			04/20/88(2)	4305	42		9						269	782	
			05/01/89(2)	1100J	21		5J						120	190	
			08/02/89(3)	1200	36		4J			2J			110	200	
1287BR	CS	Y	08/31/87(3)	58	33								3750	43	
			02/25/88(1)	20	17						9		547	34	
			04/20/88(2)	43	17								751	57	
			11/14/89(4)										310		
			11/20/89(4)										310		
2587BR	SS#1	Y	9/10/87(3)	61	18								56	320	
			10/21/87(4)	75									42	528	
			3/3/88(1)	110	4J								83	598	
			2/15/89(1)	180										360	
			5/8/59(2)	290	5J								120	840	
			8/17/89(3)	110	3J								92	330	
			11/2/89(4)	120	3J			22			4JB		86	440	
3687BR	SS#1/CS	Y	11/5/87(3)	3673	5427	38	1044		28	1472	119	53	118298	4654	
			3/9/88(1)	545	1370				975				131820		
			5/4/88(2)		2810	11	230						221860	2450	
			11/10/88(4)	1611	486		506	92		8			2451	396	
			2/15/89(1)	620			32			63			49000	260	
			5/8/89(3)	610	290E		22J					2J	12000	350E	
			11/10/89(4)										18000		
2387BR	SS#1	Y	03/02/88(1)								8				

TABLE B 5
SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)

W ll Designation	Lithology of Screened Interval[a]	Analytical Data Availability[a]	Sample Date[b]	Volatile Organic Compounds Detected (µg/ℓ) Carbon Tetrachloride	Chloroform	Acetone	1 1 DCE	1,2-DCE	2-Hexanone	1 1,1 TCA	Methylene Chloride	Toluene	TCE	PCE	Carbon Disulfide
			5/9/88(2)										19		
UPPER HSU															
			01/03/89(1)		3JBA						6BA			3JA	
			02/07/89(1)		2JA										
			08/07/89(3)	1J										1J	
			12/04/89(4)								2JB				
4086	CS	Y	11/16/88(4)		2JBA						3JBA	4JBA			
			2/15/89(1)										18		
			12/13/89(4)								5BA				
6286	SS#33	YN													
LOWER HSU															
3487BR	CS	Y	03/09/88(1)										3J		
			11/16/88(4)		2JBA						3JBA	5JBA			
			08/23/89(3)										1J		
			12/13/89(4)								8A				
1687BR	SS#3	Y	02/29/88(1)								8				
			02/07/89(1)		2JA										
			08/02/89(3)											1J	
			11/06/89(4)												
			11/09/89(4)								5B				
2087BR	SS#3	Y	03/03/88(1)			13								70	
			02/07/89(1)								5JA			3JA	
			08/09/89(3)			19								140	
			12/13/89(4)			22BA					11A				
			02/09/90(1)			6J					3J	2J		39	
3486	SS#3	Y	03/02/88(1)								6				

TABLE B 5
SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)

W ll Designation	Lithology f Screened Interval**	Analytical Data Availability**	Sample Date**	V latile Organic Compounds Detected (µg/ℓ)											
				Carbon Tetrachloride	Chloroform	Acet ne	1 1 DCE	1,2-DCE	2-Hexanone	1 1 1 TCA	Methylene Chloride	Toluene	TCE	PCE	Carbon Disulfide
LOWER HSU															
3187BR	SS#3	YN													
1887BR	SS#4	Y	03/07/88(1)		29									16	
			01/03/89(1)		4JBA							5BA			
			11/04/89(4)			9J					7B				
2287BR	SS#4	YN													
1487BR	SS#5	Y	08/31/87(3)	404	23								109		
			10/12/87(4)	258	17								47		
			02/29/88(1)	38	7	26					7		28		
			08/08/88(3)	110R									54R		
			10/26/88(4)	77V	8BA								36A		
			01/25/89(1)	120V									54JA		
			01/25/89(D)	150V									58JA		
			04/24/89(2)	160JA	16V								68V	4JA	
			08/02/89(3)	100	11								34	2J	
			11/28/89(4)	450	36A						7JBA		120A	4JA	
			11/28/89(D)	410	36V								120V	4JA	
4587BR	SS#5	Y	11/23/87(3)		18										
			02/25/88(1)		6						12				
			04/18/88(2)		3J	5J									
			10/17/88(4)									0.7JBV			
			08/17/89(3)			2JB									5
			08/18/89(3)			2JB					3JB				5
2887BR	CS	Y	08/14/88(3)		27										
			11/16/88(4)		3JBA						4JBA				
			12/06/89(4)			27B									
			12/14/89(4)			27B					7				

TABLE B 5
SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Concluded)

W ll Designation	Lithology of Screened Interval**	Analytical Data Availability**	Sample Date**	Volatile Organic Compounds Detected (μg/ℓ)											
				Carbon Tetrachloride	Chloroform	Acetone	1 1 DCE	1,2-DCE	2 Hexanone	1 1 1 TCA	Methylene Chloride	Toluene	TCE	PCE	Carbo Disulfide
LOWER HSU															
3087BR	CS	Y	03/02/88(1)								8		5	5	

SS#1 Arapahoe Formation Sandstone #1 CS Arapahoe Formation claystone/siltstone· Al Alluvium, HSU Hydrostratigraphic Unit
** Y Yes as follows; YN Yes but no data above detection limits
Number in parentheses calendar quarter sample was collected; D duplicat sample

NOTES.
(1) VALUE QUALIFIERS.
NR Analyte not reported U Analyzed but not detected Holding time not met E Estimated value J Present below detection limit B Present in laboratory blank
N Batch spike not in 80-120% range
(2) DATA VALIDATION QUALIFIERS. (No validation qualifier indicates data has not been validated) R Rejected· A Acceptable with qualifications; V Valid
(3) Wells in upper HSU have portion of well screen or entire well screen in upper HSU
(4) Wells in lower HSU have entire well screen below boundary between alluvial" and "bedrock components of RFI/RI shown in Figure 1 1
(5) Well 1487BR is in lower HSU according to Note (4) above· however it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pCi/l[c]	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pC /l	Uranium 238 pC /l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Trit um pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
UPPER HSU														
1587BR	AL	09/11/87(3)	46±33	37±41	NR	NR	2.743±0.374	NR	0.522±0 117	0.831±0 148	NR	460	NR	NR
		10/08/87(4)	NR	NR	NR	NR	1.364±0.216	NR	0.036±0.063	0.039±0.049	NR	NR	NR	NR
		10/08/87(D)	27±22	24±42	NR	0.06±0.01	0 73±0 18	NR	0.00±0.16	0.00±0.25	NR	500	NR	NR
		03/01/88(1)	14±7	-5±17	NR	0.04±0.06	0.94±0.20	NR	0.00±0.19	0.00±0.10	NR	210	NR	NR
		04/21/88(2)	2±5 (12)	-8±14 (34)	NR	0.05±0.04 (0 10)	0.84±0.27 (0.94)	NR	0.00±0.05 (0 13)	0.00±0 16 (0.75)	NR	210	NR	NR
		08/03/89(3)	0.7±0.6 (0.9)	3.2±2.3 (3.4)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		12/04/89(4)	3±3 (4)	5±3 (5)	NR	0.01±0.12 (0 19)	0.9±0.2 (0 10)	0 1±0.2 (0.4)	0.007±0.004 (0.004)	0.001±0.008 (0.010)	-0.06±0.14 (0.4)	NR	NR	NR
4086	CS	05/06/87(2)	33±13	41±21	10±2	0.39±0.52	6.1±1.5	0.66	0.24±0 73	1.0±4.6	NR	110	NR	NR
		10/27/87(4)	106±18	207±15	NR	0 19±0.09	3.6±0.5	1.0	0.00±0.14 (0.84)	0.00±1.6 (4.4)	NR	460	NR	NR
		03/11/88(1)	46±16	23±16	NR	0.45±0.39	3.9±1.3	NR	0.00±0.11	0.00±0.53	NR	220	NR	NR
		05/12/88(2)	17±6	2±14(33)	NR	0 12±0.04 (0.20)	2.3±0.3	NR	0.00±0.03 (0 18)	0.00±0.09 (0.89)	NR	210	NR	NR
6286	SS#3	04/09/87(2)	36±27	3±9	0.9±1.6	0.11±0.65	1.8±1.6	0.6	0.0±1 1	0.0±1.3	NR	110	NR	NR
		04/29/87(2)	30±12	8±37	4.9±1.3	0.75±0.54	3.6±1 1	0.44	0.0±1.3	0.0±1.4	NR	110	NR	NR
		05/26/87(2)	14±3	35±13	3.4±1.2	0.10±0.35	2.8±1.0	1.0	0.04±0 76	0.0±1.2	NR	110	NR	NR
		07/07/87(3)	22±22	44±45	NR	0.50±0.40	3.2±1.0	1.0	0.06±0.71	NR	NR	493	NR	NR
		10/16/87(4)	13±5	11±10(19)	NR	0.15±0.07 (0 17)	3.0±0.4	1.0	0.04±0.09 (0.44)	0.0±0.03 (1.0)	NR	520	NR	NR
		02/18/88(1)	14±5	1±12	NR	0.00±0.05	0.47±0 17	NR	0.0±0 18	0.0±0.13	NR	200	NR	NR
		04/14/88(2)	13±8(13)	24±18(39)	NR	0.10±0.06 (0.23)	3.2±0.6	NR	0.05±0.06 (0.48)	0.0±0.16 (0.48)	NR	200	NR	NR
		07/15/88(3)	5±1	6±1	NR	0.10±0.04	3.3±0.4	NR	0.0±0 11	0.0±0.17	NR	220	NR	NR

Phase RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 21, 1991
22570B/R2T.B-6 06-19-91/RPT/3

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pCi/l[c]	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
		10/20/88(4)	6±1	7±2	NR	0.07±0.04	NR	3 0±0.4	0.01±0.03	-0.01±0.08	NR	210	NR	NR
		01/24/89(1)	6±2	7±2	NR	NR	NR	NR	NR	NR	NR	220	NR	NR
		04/20/89(2)	5.3±1 7(1.0)	9.2±3.8(5.0)	NR	NR	NR	NR	NR	NR	NR	270	NR	NR
		06/10/89(3)	27±14	14±8	12.0±1.0	0.3±0 1	9.5±0.8	0.3±0.4	0.00±0.01	0.00±0.01	0.3±0.5	80±210	NR	NR
		07/20/89(3)	5±0.9(0.8)	9.2±2.7(3.5)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		10/19/89(4)	4.4±1.0(0.6)	5±1.8(2.4)	NR	0.07±1.3	0.26±0.27	0.63±0.44(0.63)	NR	NR	-0 1±0.39(0.66)	120±240(390)	NR	NR
1287BR	CS	09/02/87(3)	121±48	47±45	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		02/26/88(1)	47±12	46±16	NR	1 7±0.3	28±2	NR	NR	0.0±0.09	NR	220	NR	NR
		04/21/88(2)	52±14	57±20	NR	0.97±0 13	25±2	NR	0.0±0.04 (0 17)	0.01±0.20 (0 75)	NR	210	NR	NR
		07/26/88(3)	37±4	22±3	NR	0.80±0.13	21±2	NR	0.0±0.08 (0.23)	0.05±0 17 (1.20)	NR	210	NR	NR
		11/14/89(4)	30±3.2 (2)	25.3±3 (2)	NR	1 11±0.82 (0)	18.9±3.1 (0)	0.02±0.48 (0)	0.004±0.004 (0)	NR	0.08±0.40 (0)	0±250 (42)	NR	NR

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pCi/l[c]	Gross Beta pCi/l	Uranium 233 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
UPPER HSU														
2387BR	SS#1	09/11/87(3)	4±23	14±38	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		09/11/87D	NR	NR	NR	NR	4.299±0.563	NR	0.002±0.052	0.001±0.036	NR	460	NR	NR
		10/22/87(4)	39±27	30±45	NR	NR	NR	NR	NR	NR	NR	520	NR	NR
		03/03/88(1)	6±4 (6)	11±12 (26)	NR	0.14±0.07 (0.17)	2.2±0.3	NR	0.00±0.19 (0.84)	0.00±0.17 (1.1)	NR	210	NR	NR
		04/29/88(2)	14±5	5±11 (24)	NR	0.13±0.04 (0.16)	1.9±0.3	NR	0.00±0.03 (0.22)	0.00±0.10 (0.65)	NR	200	NR	NR
		08/12/88(3)	5±1	5±2	NR	0.08±0.05	1.9±0.3	NR	0.07±0.05	0.00±0.08	NR	210	NR	NR
		11/04/88(4)	4±2	4±2	NR	0.10±0.05	2.0±0.3	NR	-0.01±0.3	-0.04±0.08	NR	230	NR	NR
		02/08/89(1)	6±2	4±2	NR	0.09±0.04	2.1±0.2	NR	0.00±0.03 (0.09)	-0.07±0.08 (0.30)	NR	250	NR	NR
		05/04/89(2)	4.5±0.7 (0.6)	5.9±2.7 (4.0)	NR	NR	NR	NR	NR	NR	NR	260	NR	NR

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pCi/l[c]	Gross Beta pCi/l	Uranium 233 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
							UPPER HSU							
		08/08/89(3)	2.5±0.3 (0.3)	1.3±2.2 (3.8)	NR	0.05±0.19 (0.25)	2.18±0.69 (0)	NR	0.025±0.011 (0.008)	0.003±0.007 (0)	NR	NR	NR	NR
		08/08/89(D)	4.6±0.9 (0.8)	6.9±2.7 (3.7)	NR	0.33±0.49 (0.51)	2.64±1.12 (0.51)	NR	0.00±0.003 (0)	NR	NR	NR	NR	NR
		12/04/89(4)	7±4 (3)	10±4 (6)	NR	0.0±0.07 (0.03)	0.06±0.06 (0.05)	-0.1±0.2 (0.4)	0.0±0.002 (0.005)	0.0±0.004 (0.004)	-0.08±0.12 (0.4)	NR	NR	NR
		02/20/90(1)	3±3 (3)	4±1 (2)	NR	0.3±0.2 (0.07)	1.5±0.4 (0.2)	0.1±0.3 (0.5)	0.000±0.001 (0.003)	-0.001±0.003 (0.005)	0.1±0.2 (0.6)	NR	NR	NR
		02/20/90(D)	3±2 (3)	2±1 (2)	NR	0.1±0.1 (0.1)	1.5±0.4 (0.1)	0.3±0.2 (0.4)	0.002±0.004 (0.005)	0.003±0.007 (0.009)	0.0±0.2 (0.5)	NR	NR	NR
2587BR	SS#1	09/11/87(3)	14±25	30±36	NR	NR	NR	NR	NR	NR	NR	460	NR	NR
		09/11/87(D)	NR[d]	NR	NR	NR	2.845±0.401	NR	NR	0.065±0.040	NR	NR	NR	NR
		10/22/87(4)	4±16	12±37	NR	NR	NR	NR	NR	NR	NR	520	NR	NR
		03/04/88(1)	7±5 (8)	2±11 (26)	NR	0.06±0.08 (0.40)	1.8±0.32	NR	0.00±0.19 (0.78)	0.00±0.46 (1.3)	NR	210	NR	NR
		05/12/88(2)	19±7	8±14 (33)	NR	0.04±0.04 (0.10)	0.77±0.26 (0.81)	NR	0.01±0.04 (0.29)	0.00±0.09 (0.41)	NR	200	NR	NR
		08/16/88(3)	3±1	3±1	NR	0.01±0.04	0.82±0.20	NR	0.01±0.04	0.07±0.08	NR	210	NR	NR
		08/16/88(D)	3±1	2±1	NR	0.01±0.03	0.97±0.22	NR	0.00±0.04	0.00±0.08	NR	210	NR	NR
		02/16/89(1)	2±3 (4)	1±2 (4)	NR	0.09±0.04	0.92±0.15	NR	0.01±0.03 (0.07)	-0.08±0.08 (0.36)	NR	260	NR	NR
		05/09/89(2)	1.8±1.1 (1.5)	7.4±2.5 (3.3)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/18/89(3)	1.7±0.8 (1.0)	1.5±2.3 (3.7)	NR	0.05±0.10 (0)	0.93±0.43 (0)	NR	0.006±0.005 (0)	0.014±0.020 (0.028)	NR	NR	NR	NR
3687BR	SS#1/CS	11/06/87(4)	2±20	-6±39	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		03/10/88(1)	17±7	23±14	NR	0.10±0.08	0.98±0.22	NR	0.00±0.12	0.00±0.15	NR	210±92	NR	NR
		05/05/88(2)	10±4	21±11(24)	NR	0.00±0.03(0.15)	0.63±0.25(1.2)	NR	0.00±0.05(0.10)	NR	NR	220	NR	NR
		08/19/88(3)	2±1	2±1	NR	0.02±0.04	0.92±0.22	NR	0.03±0.04	0.04±0.08	NR	310±90	NR	NR
		02/16/89(1)	4±3	2±2(4)	NR	0.03±0.02(0.03)	1.4±0.2	NR	0.02±0.03(0.07)	0.00±0.05(0.10)	NR	260	NR	NR

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pC /l[c]	Gross Beta pCi/l	Uranium 233 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pC /l	Stront um 89 90 pC /l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Trit um pCi/l	Radium 226 pCi/l	Radium 228 pC /l
UPPER HSU														
		05/09/89(2)	3.9±1.5(1.8)	6.1±2.6(3 7)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/22/89(3)	1.5±0.5(0.5)	3 1±2.5(3 7)	NR	0 16±0.22(0)	1.32±0 71(0.51)	NR	0.013±0.004(0.002)	NR	NR	NR	NR	NR
		03/05/90(1)	7±3(2)	1±1(2)	NR	0.2±0.2(0 1)	1.6±0.5(0.2)	-0.3±0.2(0.5)	0.001±0.008(0.011)	0.015±0.014(0.017)	0.08±0.08(0.5)	NR	NR	NR
LOWER HSU														
3486	SS #3	03/17/87(1)	46±13	18±10	0.0±0.45	0.0±0.38	0.5±1 1	0.6	0.00±0.92	0.0±2.2	NR	110	NR	NR
		04/06/87(2)	27±19	26±23	1 7±2.2	0.0±1.2	0.0±2.2	NR	0.0±1.5	NR	NR	110	NR	NR
		06/02/87(2)	66	18±20	0.39±0.85	0.0±0.34	0.04±0.53	1.4	0.98±0.99	0.0±1.8	NR	110	NR	NR
		07/28/87(3)	0.0±59(11)	9±62(11)	NR	0.2±0.4	0.4±0 7	1.0	-0.6±0 72	-0.4±5.5	NR	478	NR	NR
		10/17/87(4)	3±10(18)	6±11(20)	NR	0 18±0.11(0.22)	1.2±0.3	1.2	0.00±0.72(1.3)	0.00±0.09(0.26)	NR	460	NR	NR
		03/03/88(1)	6±13(28)	4±21(49)	NR	0.0±0.04(0.28)	0 13±0 13(0.43)	NR	0.00±0.40(3.6)	0.00±0.47(3.0)	NR	210	NR	NR
		05/03/88(2)	8±9(17)	5±24(35)	NR	0.01±0.03(0.24)	0 19±0.23(2.0)	NR	0.00±0.04(0 13)	0.02±0.10(0.33)	NR	210	NR	NR
		08/12/88(3)	3±3	7±5	NR	0.00±0.03	0.10±0.16	NR	0.00±0.04	0.00±0.09	NR	210	NR	NR
		11/04/88(4)	2±3(8)	9±6(14)	NR	0.00 ±0.02(0.06)	0.06±0.07(0.25)	NR	0.00±0.03(0.05)	-0.11±0.08(0.29)	NR	220	NR	NR
		02/10/89(1)	5±4(11)	13±10(20)	NR	-0.01±0.02(0.05)	-0 11±0.08(0.20)	NR	-0.03±0.10(0.16)	-0.01±0.08(0.41)	NR	260	NR	NR
		05/04/89(2)	7.0±2.6(2.7)	10.2±3.1(4.0)	NR	NR	NR	NR	NR	NR	NR	270	NR	NR
1487BR	SS#5	09/01/87(3)	17±21	23±41	NR	NR	NR	NR	NR	NR	NR	500	NR	NR
		10/13/87(4)	6±17	16±40	NR	0.00±0.05	0.00±0.06	NR	0.00±0 15	0.00±0.22	NR	460	NR	NR
		03/01/88(2)	10±7	19±13	NR	0.00±0.04	0 12±0.09	NR	0.00±0 19	0.00±0 11	NR	210	NR	NR
		04/22/88(2)	8±4	18±11	NR	0.01±0.03	0.37±0.25	NR	0.00±0.03	0.00±0.16	NR	200	NR	NR
		08/09/88(3)	1±1	7±2	NR	0.01±0.04	0.86±0.21	NR	0.00±0.04	0.03±0.09	NR	210	NR	NR

Note RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 21, 1991
22576BR/R2T B-6 06- 9-91/RPT/3

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pCi/l[c]	Gross Beta pCi/l	Uranium 233, 234 pCi/l	Uranium 235 pC/l	Uranium 238 pC/l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
							LOWER HSU							
		01/26/89(1)	1±1	5±2	NR	0.05±0.03	1.3±0.2	NR	-0.02±0.02	-0.01±0.03	NR	230	NR	NR
		01/26/89(D)	NR	NR	NR	NR	NR	NR	0.00±0.03	0.01±0.08	NR	230	NR	NR
		04/25/89(2)	1.0±0.6	3.6±2.5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/03/89(3)	3 1±0.9	3.7±2.3	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		11/28/89(4)	7±4	9±2	NR	0±0.05	0.23±0.11	0±0 16	0±0.003	-0.01±0.03	0.01±0 18	NR	0.28±0 12	NR
		11/28/89(D)	5±4	12±3	NR	0±0.09	0.4±0.2	0 1±0 16	0.003±0.005	0.004±0.005	-0.03±0 15	NR	0 17±0 15	NR
1687BR	SS#3	09/14/87(3)	14±24	23±40	NR	NR	NR	NR	NR	NR	NR	500	NR	NR
		10/17/87(4)	48±27	17±39	NR	0.21±0.08	2.2±0.34	NR	0.05±0.09	0.01±0.07	NR	460	NR	NR
		03/01/88(1)	10±4	12±18	NR	0 14±0.07	1.8±0.2	NR	0.00±0.14	0.03±0 12	NR	220	NR	NR
		04/22/88(2)	12±4	16±10	NR	0.04±0.03 (0.09)	1 7±0.2	NR	0.02±0.04 (0 14)	0.02±0 16 (0.51)	NR	210	NR	NR
		08/10/88(3)	2±1 (3)	0±2 (4)	NR	NR	NR	NR	0.00±0.04 (0 12)	0.02±0.09 (0.36)	NR	210	NR	NR
		02/08/89(1)	2±1 (3)	6±2	NR	0.03±0.02 (0.06)	1.2±0.2	NR	-0.08±0.09 (0 17)	0.03±0.08 (0.48)	NR	230	NR	NR
		05/02/89(2)	4.4±1.8 (0 7)	8.3±2.6 (3.5)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/03/89(3)	4.4±1.2 (1 1)	4.6±2.5 (3.7)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		11/06/89(4)	6±2 (2)	3.8±.9 (1)	NR	0.1±0.2 (0.07)	2.5±0.6 (0.05)	0±0.2 (0.5)	-0.001±0.005 (0.01)	-0.003±0.004 (0.007)	0.20±0.16 (0 7)	NR	NR	NR
		11/09/89(4)	6±2 (2)	3.8±.9 (1)	NR	0 1±0.2 (0.07)	2.5±0.6 (0.05)	0±0.2 (0.5)	-0.001±0.005 (0.01)	–.003±0.004 (0.007)	0.20±0 16 (0 7)	NR	NR	NR
1887BR	SS#4	03/08/88(1)	7±9 (16)	24±15 (34)	NR	0.09±0 12 (0.9)	0.21±0.24 (1.2)	NR	0.02±0.09 (0.4)	0.00±0.24 (1.2)	NR	220	NR	NR
2087BR	SS#3	03/04/88(1)	8±12 (27)	37±22 (47)	NR	NR	NR	NR	0.00±0.18 (0.68)	0.00±0.24 (1 1)	NR	200	NR	NR
2287BR	SS#4	03/08/88(1)	22±9	12±16	NR	0 18±0 10	1.6±0.3	NR	0.00±0 16	0.00±0.04	NR	210	NR	NR
		05/03/88(1)	6±6	5±16	NR	0 14±0.05	1.0±0.3	NR	0.00±0.04	0.00±0 10	NR	210	NR	NR

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

W ll Designation	Lithology of Screened Interval**	Sample Date**	Gross Alpha pCi/l**	Gross Beta pCi/l	Uranium 233 234 pC /l	Uranium 235 pCi/l	Uranium 238 pC /l	Stront um 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
							LOWER HSU							
		08/12/88(3)	3±1	11±2	NR	0.02±0.04	1.2±0.2	NR	0.00±0.04	0.02±0.08	NR	210	NR	NR
		11/09/88(4)	3±2	12±2	NR	0.02±0.03	1.4±0.2	NR	-0.8±0 13	-0.6±0.5	NR	220	NR	NR
		02/10/89(1)	5±3	11±2	NR	0.03±0.03	1.4±0.2	NR	-0.05±0 10	0 11±0.08	NR	250	NR	NR
		05/04/89(2)	7.5±1.3	12.5±3 1	NR	NR	NR	NR	NR	NR	NR	270	NR	NR
		08/16/89(3)	6.4±1.5	12.5±4.2	NR	0.07±0 14	1.25±0.59	NR	0.005±0.004	0.031±0.026	NR	NR	NR	NR
		11/10/89(4)	3±4	3±3	NR	0 11±0 15	1 1±0.4	-0.01±0 14	0.002±0.005	-0.001±0.003	0±0.3	NR	NR	NR
		11/13/89(4)	3±4	3±3	NR	0 11±0 15	1 1±0.4	-0.01±0 14	0.002±0.005	-0.001±0.003	0±0.3	NR	NR	NR
2887BR	CS	03/15/88(1)	6±5	14±12	NR	0.01±0.05	0.25±0 11	NR	0.0±0.23	0.0±0.29	NR	210	NR	NR
		05/12/88(2)	4±4 (8)	10±15 (36)	NR	0.07±0.04 (0 14)	1.6±0.3	NR	0.0±0.03 (0 14)	0 1±0.07 (0.65)	NR	220	NR	NR
		02/21/89(1)	7±2	6±2	NR	0.07±0.03	1.8±0.2	NR	-0.02±0.03 (0.07)	0.05±0.05 (0 15)	NR	260	NR	NR
		12/06/89(4)	14.8±4.2 (3.0)	9.5±5.4 (7.0)	NR	0 11±0.37 (0)	1.58±0.92 (0)	NR	NR	NR	NR	NR	NR	NR
3087BR	CS	01/22/88(1)	1±5	3±12	NR	0.01±0.04	0 11±0.09	1.0	0.00±0 15	0 17±0 12	NR	200	NR	NR
		03/03/88(1)	33±11	4±27	NR	NR	NR	NR	0.00±0.25	0.05±0 13	NR	220	NR	NR
		04/22/88(2)	3±5	1±10	NR	0.00±0.03	0.53±0.26	NR	0.00±0.04	0.01±0 16	NR	210	NR	NR
		08/09/88(3)	2±1	2±1	NR	0.00±0.03	0.24±0.17	NR	0.00±0.04	0.00±0.09	NR	210	NR	NR
		08/09/88(D)	1±1	1±1	NR	0.00±0.03	0.37±0 18	NR	0.00±0.04	0.00±0.09	NR	210	NR	NR
		02/02/89(1)	0±1	3±2	NR	0.00±0.02	0.09±0.07	NR	0.01±0 10	0.06±0.08	NR	230	NR	NR
		04/25/89(2)	1.5±0.4	2.8±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/03/89(3)	0.0±1.3	4.6±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/03/89(D)	0.0±1.3	4.6±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Gross Alpha pCi/l[c]	Gross Beta pCi/l	Uranium 233 234 pCi/l	Uranium 235 pCi/l	Uranium 238 pCi/l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Radium 226 pCi/l	Radium 228 pCi/l
LOWER HSU														
		12/08/89(4)	1.8±1.4	1.6±0.8	NR	0±0 10	0.3±0.2	0±0.2	0.009±0.006	-0.001±0.004	0.33±0 10	NR	NR	NR
		12/12/89(4)	1.8±1.4	1.6±0.8	NR	0±0 10	0.3±0.2	0±0.2	0.009±0.006	-0.001±0.004	0.33±0.10	NR	NR	NR
3187BR	SS#3	10/29/87(4)	36±34	26±43	NR	NR	NR	NR	NR	NR	NR	460	NR	NR
		03/10/88(1)	14±8	15±16	NR	NR	NR	NR	0.00±0 11	0.0±0.17	NR	220	NR	NR
		05/12/88(2)	12±6	2±14	NR	0.08±0.04	0.24±0.23	NR	0.00±0.04	0.03±0.09	NR	200	NR	NR
		08/25/88(3)	1±1	4±1	NR	0.00±0.03	0.45±0.18	NR	0.00±0.04	0.08±0.08	NR	200	NR	NR
		02/23/89(1)	2±1	4±2	NR	0.03±0.03	0.44±0.09	NR	0.00±0.03	-0.04±0.08	NR	260	NR	NR
		05/11/89(2)	1.9±1.0	5.4±2.6	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		12/14/89(4)	3.6±1.8	1 7±0.8	NR	0.07±0 14	0.08±0.5	0±0.5	0.005±0.004	0.002±0.007	0±0.08	NR	NR	NR
3487BR	CS	03/10/88(1)	4±10	16±16	NR	0.21±0 12	0.90±0.23	NR	0.0±0.15	0.0±0.24	NR	200	NR	NR
		05/12/88(2)	6±4 (7)	4±8 (18)	NR	0.04±0.03 (0.25)	1.3±0.3 (2.1)	NR	0.0±0.03 (0 14)	0.00±0.09 (0.53)	NR	210	NR	NR
		05/12/88(D)	1±5 (12)	7±8 (19)	NR	0.07±0.04 (0.09)	1.0±0.3	NR	0.0±0.03 (0 16)	0.03±0 12 (0.72)	NR	210	NR	NR
		02/21/89(2)	4±2	3±3 (8)	NR	0.04±0.02	1.0±0.1	NR	-0.02±0.03 (0.06)	0.01±0.05 (0.07)	NR	260	NR	NR
		08/24/89(3)	4.2±0.9 (0.8)	5±2.4 (3.5)	NR	0.11±0.23 (0.26)	0 73±0.44 (0.26)	NR	NR	NR	NR	NR	NR	NR
4587BR	SS#5	11/24/87(4)	32±9	113±13	NR	0.08±0.05 (0 10)	1.4±0.2	1.0	0.00±0 12 (0.56)	0.00±1.4 (6.9)	NR	220	NR	NR
		02/26/88(1)	9±5	29±11	NR	0.12±0 10	1.2±0.3	NR	0.00±0 18	NR	NR	200	NR	NR
		04/19/88(2)	7±8 (14)	21±15 (32)	NR	0.03±0.03 (0.10)	1 1±0.2	NR	0.00±0.03 (0 15)	0 10±0 16 (0.81)	NR	200	NR	NR
		07/22/88(3)	2±1	14±2	NR	0.02±0.04	0.79±0.20	NR	0.00±0.04	0.00±0 12	NR	210	NR	NR
		01/24/89(1)	2±1	11±2	NR	NR	NR	NR	NR	NR	NR	230	NR	NR
		04/20/89(1)	3.5±1.3 (1.5)	11.1±3.0 (3.8)	NR	NR	NR	NR	NR	NR	NR	270	NR	NR

TABLE B 6

SUMMARY OF DISSOLVED RADIONUCLIDE CONCENTRATIONS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Concluded)

W ll Designation	Lithology of Screened Interval**	Sample Date**	Gross Alpha pCi/l**	Gross Beta pCi/l	Uranium 233 234 pCi/l	Uranium 235 pC /l	Uranium 238 pC /l	Strontium 89 90 pCi/l	Plutonium 239 240 pCi/l	Americium 241 pCi/l	Cesium 137 pCi/l	Tritium pCi/l	Rad um 226 pCi/l	Radium 228 pCi/l
LOWER HSU														
		06/13/89(2)	5±5 (7)	10±3 (4)	NR	0.0±0 1 (0 1)	0.2±0 1 (0 1)	0.2±0.6 (1.0)	0.00±0.01 (0.01)	0.00±0.01 (0.01)	0 1±0.6 (1 1)	90±210 (290)	0.4±0.4 (0.4)	NR
		07/27/89(3)	2.0±0.5 (0.6)	8.9±2.7 (3.6)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		08/17/89(3)	1±4 (6)	8±3 (4)	NR	0.0±0 1	0.2±0.2	0.3±0.5	0.00±0.01	0.00±0.01	0.0±0.5	140±200 (27)	NR	NR
		10/20/89(4)	3.0±1.4 (1 7)	7.2±2.2 (3.0)	NR	0.04±0.14 (0 18)	0 73±0.43	0.60±0.52 (0 77)	NR	NR	0 16±0.68(1 1)	120±220 (370)	NR	NR
		10/20/89(D)	2.8±1 1 (1.2)	9 7±2.2 (2.7)	NR	0.04±0.08	0.40±0.29 (0.06)	-0.09±0 75 (1.24)	NR	NR	0 14±0.45 (0 72)	200±210 (360)	NR	NR

SS#1 Arapahoe Formation Sandstone #1 CS Arapahoe Formation Claystone/Siltstone Al Alluvium

** Number in parenthesis the calendar quarter sample was collected. D Duplicate

** Values in parenthesis are detection limits.

** NR value not reported

Wells screened in interval representing lower hydrostratigraphic unit( ) (i.e top of screen below boundary between alluvial" and "bedrock" components of RFI/RI shown in Figure 1 1)

NOTES.

(1) VALUE QUALIFIERS.

NR Analyte not reported; LL Analyzed but not detected; Holding time not met, E Estimated value J Present below detection limit B Present in laboratory blank N Batch spike not in 80-120% range

(2) DATA VALIDATION QUALIFIERS. (No validation qualifier indicates data has not been validated) R Rejected; A Acceptable with qualifications; V Valid

(3) Wells in upper HSU have portion of well screen or entire well screen in upper HSU

(4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock" components of RFI/RI shown in Figure 1 1

(5) Well 1487BR is in lower HSU according to Note (4) above; however it is screened in weathered SS #5 that subcrops and may be hydrologically connected to upper HSU

TABLE B 7A

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Aluminum Chromium)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Aluminum (Al) diss. mg/l	Antimony (Sb) diss. mg/l	Arsenic (As) diss. mg/l	Barium (Ba) diss mg/l	Beryllium (Be) diss. mg/l	Cadmium (Cd) diss. mg/l	Calcium (Ca) diss. mg/l	Cesium (Cs) diss. mg/l	Chromium (C) diss. mg/l
						UPPER HSU					
1587	AL	10/08/87(D)	0.0290 U	NR	NR	0 1920	NR	NR	134.0580	NR	0.0100 U
		10/08/87(4)	0.0358	0.020 U	0.005 U	0 1917	0.005 U	0.001 U	133.3401	0.020 U	0.0100 U
		03/01/88(1)	0.0449	0.019	0.005 U	0 1807	0.003 J	0.001 U	117.2322	0.020 U	0.0380
		04/21/88(2)	0.0499	0.034 U	0.005 U	0 1561	0.001 U	0.005 U	125.8376	0.020 U	0.0100 U
		08/03/89(3)	0.0316 J	0.050 U	NR	0 1358 J	0.002 U	0.005 U	92.7538	NR	0.0090 U
		12/04/89(4)	0.200 U	0.060 U	0.010 U	0.2000 U	0.005 U	0.005 U	113.0000	2.500 U	0.0100 U
6286	SS#3	04/09/87(2)	0 1455	0.060 U	0.010 U	0.0239	0.005 U	0.005 U	37 1320	0.02 U	0 1280
		04/29/87(2)	0.0839	0.060 U	0.010 U	0.0191	0.005 U	0.005 U	32.5061	0.02 U	0.0100 U
		07/07/87(3)	0.0600	0.020 U	0.005 U	0.0356	0.005 U	0.0003 J	35.4258	0.02 U	0.0189
		10/16/87(4)	0.0479	0.020 U	0.005 U	0.0375	0.005 U	0.001 U	27 7660	0.02 U	0.0453
		02/18/88(1)	0.0300	0.020 U	0.003 J	0.0412	0.005 U	0.001 U	28.6004	0.02 U	0.0216
		04/14/88(2)	0.0381	0.034 U	0.005 U	0.0358	0.001 U	0.005 U	32.9081	0.02 U	0.0193
		07/15/88(3)	0.0341	0.034 U	0.005 U	0.0404	0.001 U	0.005 U	32.9175	0.02 U	0.229
		10/20/88(4)	0.0626	0.034 U	0.005 U	0.0499	0.001 U	0.005 U	37.0527	0.02 U	0.0231
		01/23/89(1)	0.0095 V	0.050 U V	0.001 U V	0.0415 V	0.002 U V	0.005 U R	33.2800 V	0.005 U V	0.0290 V
		06/10/89(2)	0.200 U V	0.600 U A	0.010 U V	0.2000 U R	0.005 U A	0.009 A	34.5000 A	1.00 U V	0.0246 A
		07/20/89(3)	0.0333 J	0.050 U	NR	0.0453 J	0.002 U	0.005 U	33 7356	NR	0.0189
		10/19/90(4)	0.0304	0.5000 U	0.0072	0.0500 U	0.002 U	0.004 U	32.1000	0.001 U	0.0215
1287BR	CS	02/26/88(1)	0.0290 U	0.02 U	0.005 U	0.0434	0.005 U	0.001 U	31.0631	0.020 U	0.0100 U
		04/21/88(2)	0.0470	0.034 U	0.005 U	0.0332	0.001 U	0.005 U	36.1776	0.020 U	0.0100 U
		07/26/88(3)	0.0351	0.034 U	0.005 U	0.0508	0.001 U	0.005 U	38.1220	0.020 U	0.0561

TABLE B7 A

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum Chromium)
(Continued)

Well Designation	Lithology of Screened Interval**	Sample Date**	Aluminum (Al) diss. mg/l	Antimony (Sb) diss. mg/l	Arsenic (As) diss. mg/l	Barium (Ba) diss mg/l	Beryllium (Be) diss. mg/l	Cadmium (Cd) diss. mg/l	Calcium (Ca), diss. mg/l	Cesium (Cs), diss. mg/l	Chromium (Cr) diss. mg/l
UPPER HSU											
2387BR	SS#1	10/22/87(4)	0 1725	NR	NR	0.1632	NR	NR	94.3186	NR	0.0676
		03/03/88(1)	0.0969	0.020 U	0.005 U	0 1949	0.005 U	0.001 U	130 1240	0.020 U	0.0100 U
		04/29/88(2)	0.0290 U	0.034 U	0.005 U	0 1625	0.001 U	0.005 U	115.0052	0.020 U	0.0100 U
		11/04/88(4)	0.0290 U	0.034 U	0 005 U	0 1693	0.001 U	0.005 U	120.6239	0.020 U	0.0100 U
		02/07/89(1)	0 1920 J	0.050 U	0.001 U	0 1731 J	0.002 U	0.005 U	118.1832	0.005 U	0.0090 U
		12/04/89(4)	0.2000 U	0.060 U	0.010 U	0.2000 U	0.005 U	0.005 U	115.0000	2.500 U	0.0100 U
2587BR	SS#1	10/22/87(4)	2.6796	NR	NR	0 1524	NR	NR	110 7037	NR	0.0785
		03/04/88(1)	0.0290 U	0.020 U	0.005 U	0 1128	0.005 U	0.001 U	116.7854	0.020 U	0.0100 U
		05/12/88(2)	0.0968	0.034 U	0.005 U	0.0769	0.001 U	0.005 U	105.3446	0.020 U	0.0100 U
		08/16/88(3)	0.0897	0.034 U	0.005 U	0.0937	0.001 U	0.005 U	119.8486	0.020 U	0.0100 U
		02/15/89(1)	0.6140 J	0.050 U	0.001 U	0.1269 J	0.002 U	0.005 U	124.3472	0.005 U	0.0090 U
		11/02/89(4)	0.0300 U	0.500 U	0.002 U	0 1050	0.002 U	0.004 U	115.0000	0.001 U	0.0200 U
3687BR	SS#1/CS	11/06/87(4)	0.0327	NR	NR	0 1858	NR	NR	98.4384	NR	0.0100 U
		03/10/88(1)	0.0290 U	0.02 U	0.005 U	0 1700	0.005 U	0.001 U	110.3891	0.020 U	0.0100 U
		05/05/88(2)	0.0680	0.034 U	0.005 U	0.1176	0.001 U	0.005 U	104.1592	0.020 U	0.0220
		08/19/88(3)	0.0290 U	0.034 U	0.005 U	0.1435	0.001 U	0.005 U	112.5375	0.020 U	0.0154
		02/15/89(1)	0.0249 J	0.0500 U	0.0010 U	0.2179	0.0020 U	0.0050 U	123.4178	0.0050 U	0.0090 U
		11/10/89(4)	0.200 U V	0.060 U R	0.010 U V	0.200 U V	0.005 U V	0.005 U V	127.0000 A	2.500 U V	0.100 U A

TABLE B7 A

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Aluminum Chromium) (Continued)

Well Designation	Lithology of Screened Interval**	Sample Date**	Aluminum (Al) diss. mg/l	Antimony (Sb) diss. mg/l	Arsenic (As) diss. mg/l	Barium (Ba) diss mg/l	Beryllium (Be) diss mg/l	Cadmium (Cd) diss. mg/l	Calcium (Ca) diss. mg/l	Cesium (Cs) diss. mg/l	Chromium (C) diss. mg/l
						LOWER HSU					
3486	SS#3	03/17/87(1)	0.0290 U	0.06 U	0.010 U	0.0288	0.005 U	0.005 U	241.5299	0.2 U	0.0100 U
		04/06/87(2)	0.0290 U	0.06 U	0.010 U	0.0878	0.005 U	0.005 U	236.2398	0.2 U	0.0100 U
		06/02/87(2)	0.0334	0.06 U	0.010 U	0.0247	0.005 U	0.005 U	235.2524	0.2 U	0.0114
		07/28/87(3)	0.0524	0 02 U	0.005 U	0.0354	0.005 U	0.001 U	242.3112	0.02 U	0.0100 U
		10/17/87(4)	0.0290	0.02 U	0.002 J	0.0308	0.005 U	0.001 U	209.5497	0.02 U	0.0120
		03/03/88(1)	0 1729	0.02 U	0.004 J	0 1216	0.005 U	0.001 U	18.6393	0.02 U	0.0100 U
		05/03/88(2)	0.029 U	0.034 U	0.005 U	0.0271	0.001 U	0.005 U	207.6940	0.02 U	0.0100 U
		11/04/88(4)	0.0379	0.0728	NR	0.0276	0.001 U	0.005 U	233.7848	0.02 U	0.0100 U
		02/09/89(1)	0.0193 J	0.05 U	0.024 UB	0.0219 J	0.002 U	0.005 U	220.7841	0.005 U	0.0167
4086	CS	05/06/87(2)	0.4668	0.060 U	0.0100 U	0.0719	0.005 U	0.0050 U	152.5210	0.200 U	0.0100 U
		10/27/87(4)	0.0561	0.020 U	0.0050 U	0.0729	0.005 U	0.0003 J	75.2480	0.020 U	0.0270
		03/11/88(1)	0.290 U	0.020 U	0.0050 U	0.0540	0.005 U	0.004	76.2347	0.020 U	0.0100 U
		05/12/88(2)	0.2900 U	0.0340 U	0.0050 U	0.0476	0.0010 U	0.0050 U	67.6288	0.2000 U	0.0100 U
		12/04/89(4)	0.0364	0.500 U	0.0020 U	0.0598	0.002 U	0.004 U	77.2000	1.00 U	0.0200 U
1487BR	SS#5	10/13/87(4)	1 1972	0.029	0.005 U	0 1196	0.001 J	0.001 U	81.2350	0.02 U	0.0382
		03/01/88(1)	0.1598	0.02 U	0.005 U	0.0297	0.005 U	0.001 U	7.5573	0.02 U	0.0287
		04/23/88(1)	0 1141	0.0340 U	0.005 U	0.0269	0.0010 U	0.0050 U	6.0019	0.02 U	0.0252
		08/09/88(3)	0 1238	0.0340 U	0.005 U	0.0298	0.0010 U	0.0050 U	7 7025	0.02 U	0.0100 U
		01/25/89(1)	0.0683 J	0.050 U	0.001 U	0.0684 J	0.002 U	0.0050 U	27 1815	0.0050 U	0.0182
		01/25/89(D)	0.0572 J	0.050 U	0.001 U	0.0666 J	0.002 U	0.0050 U	26.2288	0.0050 U	0.0184

TABLE B7 A

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Aluminum Chromium)
(Continued)

Well Designation	Lithology of Screened Interval**	Sample Date**	Aluminum (Al) diss. mg/l	Antimony (Sb) diss. mg/l	Arsenic (As) diss. mg/l	Barium (Ba) diss. mg/l	Beryllium (Be) diss. mg/l	Cadmium (Cd) diss. mg/l	Calcium (Ca) diss. mg/l	Cesium (Cs) diss. mg/l	Chromium (C) diss. mg/l
LOWER HSU											
		08/03/89(3)	0.0605 J	0.0500 U	NR	0.0537 J	0.0020 U	0.0050 U	14.4856	NR	0.0109
		11/28/89(4)	0.200 U	0.0600 U	0.0100 U	0.200 U	0.0050 U	0.0050 U	53.40	1.00 U	0.0100 U
1687BR	SS#3	10/17/87(4)	0.0876	NR	NR	0.0354	NR	NR	20.5145	NR	0.2780
		03/01/88(1)	0.0814	0.020 U	0.004 J	0.7860	0.005 U	0.001 U	18.4820	0.02 U	0.0100 U
		04/22/88(2)	0.4850	0.034 U	0.003 J	0.0456	0.001 U	0.005 U	24.7026	0.02 U	0.0100 U
		08/10/88(3)	0.0433	0.034 U	0.005 U	0.0280	0.001 U	0.005 U	26.4029	0.02 U	0.0114
		02/07/89(1)	0.0455 J	0.050 U	0.0028 J	0.0442 J	0.002 U	0.005 U	29.3102	0.005 U	0.0123
		08/03/89(3)	0.0260 J	0.050 U	NR	0.0285 J	0.200 U	0.005 U	30.3920	NR	0.0097 J
		11/09/89(3)	0.0200 U	0.0600 U	0.0100 U	0.2000 U	0.0050 U	0.0050 U	29.8000	2.5000 U	0.0100 U
		11/06/89(4)	0.2000 U	0.060 U	0.010 U	0.200 U	0.005 U	0.005 U	29.8000	2.50 U	0.0100 U
1887BR	SS#4	03/08/88(1)	0.0879	0.0200 U	0.0030 J	0.1084	0.0050 U	0.0010 U	12.3260	0.0200 U	0.0118
2287	CS	03/08/88(1)	0.0406	0.02 U	0.004 J	0.0594	0.005 U	0.001 U	30.2374	0.020 U	0.0115
		05/03/88(2)	0.0376	0.034 U	0.005 U	0.0343	0.001 U	0.005 U	34.1294	0.020 U	0.0100
		11/09/88(4)	0.0476	0.034 U	0.003 J	0.0411	0.001 U	0.005 U	49.0811	NR	0.0100 U
		02/09/89(1)	0.01944	0.050 U	0.0045 J	0.0411 J	0.002 U	0.005 U	54.2755	0.005 U	0.0106
		11/10/89(4)	0.200 U V	0.060 U R	0.0100 U V	0.200 U V	0.005 U V	0.005 U V	62.70	2.50 U V	0.010 U V
		11/13/89(4)	0.200 U V	0.060 U R	0.0100 U V	0.200 U V	0.005 U V	0.005 U V	62.70	2.50 U V	0.010 U V
2887BR	CS	03/15/88(1)	0.0290 U	0.02 U	0.004 J	0.0238	0.005 U	0.001	13.1315	0.02 U	0.0100 U
		05/12/88(2)	0.2705	0.034 U	0.005 U	0.0913	0.001 U	0.005 U	19.9311	0.02 U	0.0100 U
		02/20/89(1)	0.0918 J	0.05 U	0.0022 J	0.042 J	0.002 U	0.005 U	35.1215	0.005 U	0.0151

Phase RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 21, 1991
22578B/R2T B7 06-19-91/RPT/3

TABLE B7 A

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Aluminum Chromium) (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Aluminum (Al) diss. mg/l	Antimony (Sb) diss mg/l	Arsenic (As) diss. mg/l	Barium (Ba) diss. mg/l	Beryllium (Be) diss. mg/l	Cadmium (Cd) diss. mg/l	Calcium (Ca) diss. mg/l	Cesium (Cs) diss. mg/l	Chromium (Cr) diss. mg/l
						LOWER HSU					
3087BR	CS	01/22/88(1)	0.0833	0.0200 U	0.040	0.0308	0.005 U	0.001 U	17.5065	0.02 U	0.0100 U
		03/03/88(1)	0.0646	0.0200 U	0.013	0.0626	0.005 U	0.001 U	16.8116	0.02 U	0.0100 U
		04/22/88(2)	0.0328	0.0340 U	0.006	0.0534	0.0010 U	0.0050 U	18.9773	0.02 U	0.0100 U
		08/09/88(3)	0.0290 U	0.0340 U	0.005 U	0.0984	0.0010 U	0.0050 U	19.3281	0.02 U	0.0100 U
		02/01/89(1)	0.015 U	0.0500 U	0.0017 J	0.0847 J	0.0022 J	0.005 U	17.9101	0.005 U	0.009 U
		12/08/89(4)	0.0331	0.5000 U	0.0020 U	0.101	0.0020 U	0.0040 U	19.30	1.00 U	0.0200 U
		12/12/89(4)	0.0331	0.5000 U	0.0020 U	0.101	0.0020 U	0.0040 U	19.30	1.00 U	0.0200 U
		02/09/90(1)	0.200 U	0.0100 U	0.0100 U	0.200 U	0.0050 U	0.0050 U	21.80	1.00 U	0.0100 U
3187BR	SS#3	10/29/87(4)	0.2634	NR	NR	0.0562	NR	NR	15.3345	NR	0.0260
		05/12/88(2)	0.2029	0.0340 U	0.008	0.0472	0.0010 U	0.0050 U	20.2619	0.02 U	0.0100 U
		08/25/88(3)	0.0419	0.0340 U	0.0053	0.0408	0.0010 U	0.0050 U	22.0879	0.020 U	0.0100 U
		02/22/89(1)	0.0165 J	0.0500 U	0.0047 J	0.0179 J	0.002 U	0.0050 U	19.2669	0.005 U	0.009 U
3487BR	CS	03/10/88(1)	0.0290 U	0.02 U	0.007	0.0424	0.005 U	0.001 U	192.5822	0.002 U	0.0123
		05/12/88(D)	0.1194	0.034 U	0.005 U	0.0486	0.001 U	0.005 U	19.3843	0.02 U	0.0111
		05/12/88(2)	0.1204	0.034 U	0.005 U	0.0463	0.001 U	0.005 U	17.8546	0.02 U	0.0109
		02/20/89(1)	0.0442 J	0.050 U	0.0024 J	0.0441 J	0.002 U	0.005 U	15.7051	0.005 U	0.0090 U
		12/13/89(4)	0.200 U	0.060 U	0.0036	0.200 U	0.005 U	0.005 U	18.5000	1.00 U	0.0100 U
4587BR	SS#5	11/24/87(4)	0.1306	0.020 U	0.004 J	0.1658	0.005 U	0.0058	19.7961	0.02 U	0.0100 U
		02/26/88(1)	0.0357	0.020 U	0.003 J	0.0829	0.005 U	0.001 U	26.9376	0.02 U	0.0100 U
		04/19/88(2)	0.0369	0.034 U	0.005 U	0.0569	0.001 U	0.005 U	29.3511	0.02 U	0.0109

Phase RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 199
225788/R2T.B7 06-19-91/RPT/3

TABLE B 7A

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Aluminum Chromium) (Concluded)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Aluminum (Al) diss. mg/l	Antimony (Sb) diss. mg/l	Arsenic (As) diss. mg/l	Barium (Ba) diss. mg/l	Beryllium (Be) diss. mg/l	Cadmium (Cd) diss. mg/l	Calcium (Ca) diss. mg/l	Cesium (Cs) diss. mg/l	Chromium (Cr) diss. mg/l
						LOWER HSU					
		07/22/88(3)	0.0290 U	0.034 U	0.005 U	0.0380	0.001 U	0.005 U	34.3743	0.02 U	0.0100 U
		01/23/89(1)	0.0232 U	0.050 U	0.001 U R	0.0622	0.002 U V	0.005 U R	40.2000 V	0.005 U V	0.0090 U V
		06/13/89(2)	0.200 U V	0.060 U V	0.010 U A	0.200 U A	0.005 U A	0.0052 A	43.70 A	1.00 U V	0.0100 U A
		01/27/87(3)	0.0407 J	0.050 U	NR	0.0564 J	0.002 U	0.005 U	35.9096	NR	0.0090 U
		08/17/89(3)	0.200 U V	0.060 U V	0.0100 U A	0.200 U V	0.005 U V	0.005 U V	40.30 V	1.00 U V	0.0100 U R
		08/18/89(3)	0.200 U V	0.060 U V	0.0100 U A	0.200 U V	0.005 U V	0.005 U V	40.30 V	1.00 U V	0.0100 U R
		10/20/89(4)	0.030 U	0.500 U	0.0117	0.0659	0.002 U	0.004 U	38.30	0.001 U	0.0200 U
		10/20/89(D)	0.030 U	0.500 U	0.0061	0.0634	0.002 U	0.0043	37.00	0.001 U	0.0200 U

[a] SS#1 Arapahoe Formation Sandstone #1 CS Arapahoe Formation claystone/siltstone AL alluvium, HSU Hydrostratigraphic Unit
[b] Number in parenthesis the calendar quarter sample was collected.

Notes:

(1) VALUE QUALIFIERS. NR Analyte not reported; U Analyzed but not detected; Holding time not met, E Estimated value; J Present below detection limit B Present in laboratory blank; N Batch spike not in 80-120% range
(2) DATA VALIDATION QUALIFIERS. (No validation qualifier indicates data has not been validated); R Rejected; A Acceptable with qualifications; V Valid
(3) Wells in upper HSU have portion of well screen or entire well screen or entire well screen in upper HSU
(4) Wells in lower HSU have entire well screen below boundary between "alluvial" and "bedrock components of RFI/RI shown in Figure 1 1
(5) Wells 1487BR is in lower HSU according to Note (4) above; however it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU

TABLE B 7B

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Cobalt Molybdenum)

W ll Designation	Lithology of Screened Interval[a]	Sample Date[b]	Cobalt (Co) diss. mg/l	Copper (Cu) diss. mg/l	Iron (F) diss. mg/l	Lead (Pb) diss. mg/l	Lithium (Li) diss mg/l	Magnesium (Mg) diss. mg/l	Manganese (M) diss. mg/l	Mercury (Hg) diss. mg/l	Molybdenum (M) diss mg/l
						UPPER HSU					
1587	AL	10/08/87(D)	0.0220 U	0.0088	0.0069 U	NR	NR	10.4154	0 1393	NR	0.0220 U
		10/08/87(4)	0.0200 U	0.0087	0.0069 U	0.0050 U	0.0100 J	10.5314	0.1396	0.0002 U	0.0220 U
		03/01/88(1)	0.0220 U	0.0063 U	0.0285	0.0050 U	0 1000 U	11 1265	0.0394	0.0002 U	0.0220 U
		04/21/88(2)	0.0220 U	0.0115	0.0487	0.0050 U	0.0100 U	10.5472	0.0051 U	0.0002 U	0.0220 U
		08/03/89(3)	0.0290 U	0.0042 J	0.0350 U	NR	NR	7.8672	0.0020 U	NR	0.0270 U
		12/04/89(4)	0.0500 U	0.0250 U	0 100 U	0.0030 U	0 1000 U	10.000	0.0150 U	0.0002	0 1000 U
6286	SS#3	04/09/87(2)	0.0220 U	0.0063 U	0.0069 U	0.0050 U	NR	4.1261	0.0051 U	0.0002 U	0 1000 U
		04/29/87(2)	0.0220 U	0.0063 U	0.0069 U	0.0050 U	NR	4.3072	0.0051 U	0.0002 U	0.0220 U
		07/07/87(3)	0.0220 U	0.0166	0.0272	0.0050 U	NR	8.1709	0.0051 U	0.0008	0.0220 U
		10/16/87(4)	0.0220 U	0.0087	0.1330	0.0050 U	0.030 J	8.6855	0.0051 U	0.0001 J	0.0220 U
		02/18/88(1)	0.0220 U	0.0063 U	0.0078	0.0050 U	0 100 U	9.9492	0.0051 U	0.0002 U	0.0220 U
		04/14/88(2)	0.0220 U	0.0063 U	0.0255	0.0050 U	0.0100 U	11.5102	0.0051	0.0002 U	0.0220 U
		07/15/88(3)	0.0220 U	0.0063 U	0.0409	0.0050 U	NR	11.2686	0.0051 U	0.0002 U*	0.0220 U
		10/20/88(4)	0.0220 U	0.0276	0.0396	0.0050 U	NR	12.4129	0.0051 U	0.0002 U	0.0220 U
		01/23/89(1)	0.0290 U V	0.0040 U V	0.0490 V	0.0015 V	NR	11.3000 V	0.0020 U V	0.0002 U A	0.0270 U V
		06/10/89(2)	0.0500 U A	0.0250 U R	0 1000 U V	0.0050 U A	0.100 U V	11.4000 A	0.0150 U V	0.0002 U V	0.1000 U
		07/20/89(3)	0.0290 U	0.0040 U	0.0350 U	NR	NR	11 7349	0.0020 U	NR	0.0270 U
		10/19/89(4)	0.0200 U	0.0200 U	0.1800	0.0025	0.0410	10.4000	0.0100 U	0.0002 U	0.5000 U
1287BR	CS	02/26/88(1)	0.0220 U	0.0088	0.0169	0.0050 U	0.1100	7 1516	0.0447	0.0002 U	0.0220 U
		04/21/88(2)	0.0220 U	0.0098	0.0811	0.0050 U	0 1000 U	7.5445	0.0078	0.0002 U	0.0220 U

Source RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 2 1991
225700/R2T.B7B 06-19-91/RPT/3

TABLE B 7B

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Cobalt Molybdenum) (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Cobalt (Co) diss. mg/l	Copper (Cu) diss mg/l	Iron (Fe) diss. mg/l	Lead (Pb) diss mg/l	Lithium (Li) diss. mg/l	Magnesium (Mg) diss. mg/l	Manganese (Mn) diss. mg/l	Mercury (Hg) diss. mg/l	Molybdenum (Mo) diss mg/l
UPPER HSU											
		07/26/88(3)	0.0220 U	0.0076	0.2085	0.0050 U	NR	7.8634	0.0227	0.0002 U	0.0220 U
2387BR	SS#1	10/22/87(4)	0.0220 U	0.0063 U	0.1942	NR	NR	12.8861	0.2422	NR	0.0220 U
		03/03/88(1)	0.0220 U	0.0063 U	0.0333	0.0050	0.100 U	13.8849	0.1289	0.0002 U	0.0220 U
		04/29/88(2)	0.0220 U	0.0063 U	0.0135	0.0050 U	0.100 U	13.4011	0.0720	0.0002 U	0.0220 U
		11/04/88(4)	0.0220 U	0.0063 U	0.0238	0.0050 U	NR	12.9893	0.0178	0.0002 U	0.0220 U
		02/07/89(1)	0.0290 U	0.0040 U	0.0350 U	0.0010 U	NR	12.9433	0.0043 J	0.0002 U	0.0270 U
		12/04/89(4)	0.0500 U	0.0250 U	0.1000 U	0.0030 U	0.100 U	13.4000	0.0163	0.0002 U	0.1000 U
2587BR	SS#1	10/22/87(4)	0.0220 U	0.0063 U	4.3470	NR	NR	8.0261	0.3485	NR	0.0220 U
		03/04/88(1)	0.0220 U	0.0063 U	0.0171	0.0050 U	0.0100 U	7.8072	0.0051 U	0.0002 U	0.0220 U
		05/12/88(2)	0.0220 U	0.0126	0.0220	0.0050 U	NR	7.3872	0.0051 U	0.0002 U	0.0220 U
		08/16/88(3)	0.0220 U	0.0063 U	0.0319	0.0050 U	NR	7.1069	0.0051 U	0.0002 U	0.0220 U
		02/15/89(1)	0.0290 U	0.0040 U	0.0767 J	0.0111	NR	8.7065	0.0023 J	0.0002 U	0.027 U
		11/02/89(4)	0.0280 U	0.0200 U	0.0544	0.0020 U	0.0130	7.9200	0.0100 U	0.0002 U	0.0500 U
3687BR	SS#1/CS	11/06/87(4)	0.0220 U	0.0109	0.0261	NR	NR	9.6752	0.3544	NR	0.0220 U
		03/10/88(1)	0.0220 U	0.0063 U	0.0122	0.0050 U	0.1000 U	8.5566	0.0916	0.0002 U	0.0220 U
		05/05/88(2)	0.0220 U	0.0065 U	0.0303	0.0050 U	NR	8.5449	0.0486	0.0002 U	0.0220 U
		08/19/88(3)	0.0220 U	0.0063 U	0.0295	0.0050 U	NR	8.6749	0.0499	0.0002 U	0.0220 U
		02/15/89(1)	0.0290 U	0.0040 U	0.0373 J	0.0010 U	NR	10.3045	0.1653	0.0002 U	0.0270 U
		11/10/89(4)	0.0500 U V	0.025 U A	0.1000 U V	0.0030 U V	0.0100 U V	10.5000 A	0.0419 V	0.0002 U V	0.1000 U V

TABLE B 7B

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt Molybdenum)
(Continued)

W ll Designation	Lithology of Screened Interval[a]	Sample Date[b]	Cobalt (C) diss. mg/l	Copper (Cu) diss. mg/l	Iron (F) diss. mg/l	Lead (Pb) diss. mg/l	Lithium (Li) diss. mg/l	Magnesium (Mg) diss. mg/l	Manganese (M) diss. mg/l	Mercury (Hg) diss. mg/l	Molybdenum (Mo), diss. mg/l
LOWER HSU											
3486	SS#3	03/17/87(1)	0.0220 U	0.0063 U	0.6726	0.005 U	NR	62.6727	0.0718	0.0002 U	0.0220 U
		04/06/87(2)	0.0220 U	0.0063 U	0.4421	0.005 U	NR	65.0379	0.1019	0.0002 U	0.0220 U
		06/02/87(2)	0.0220 U	0.0096	1.0040	0 005 U	NR	72.6015	0.0159	0.0002 U	0.0220 U
		07/28/87(3)	0.0220 U	0.0063 U	1.5312	0.005 U	NR	72.7323	0 1205	0.0002 U	0.0220 U
		10/17/87(4)	0.0220 U	0.0063 U	1.4362	0.005 U	0.2	67.4890	0 1445	0.0001 J	0.0220 U
		03/03/88(1)	0.0220 U	0.0092	0 1353	0.005 U	0 1 U	2.0699	0.0070	0.0002U	0.0509
		05/03/88(2)	0.0220 U	0.0124	1.5495	0.005 U	NR	92.1996	0.0892	0.0002 U	0.0220 U
		11/04/88(4)	0.0220 U	0.0063 U	2.1817	0.005 U	NR	68.6772	0 1348	0.0002 U	0.0220 U
		02/09/89(1)	0.029 U	0.004 U	2.1491	0.0011 J	NR	73 7748	0.0957	0.0002 U	0.027 U
4086	CS	05/06/87(2)	0.0220 U	0.0130 U	0.2441	0.0050 U	NR	31.2705	0.5351	0.0002 U	0 1035
		10/27/87(4)	0.0220 U	0.0092	0.0955 U	0.0050	0.040 J	17.0217	0.1816	0.0002 U	0.0497
		03/11/88(1)	0.0220 U	0.0063 U	0.0227	0.0050 U	0.100 U	17.6838	0.0432	0.0002 U	0.0256
		05/12/88(2)	0.0220 U	0.0101	0.0228	0.0050 U	NR	18.6570	0.0125	0.002 U	0.0220 U
		12/04/89(4)	0.0200 U	0.0200 U	0.0045	0.0032	0.051	17 1000	0.0157	0.0002 U	0.5000 U
1487BR	SS#5	10/13/87(4)	0.0220 U	0.0090	0.0599	0.004 J	0.04 J	0 1458	0.0051 U	0.0002 U	0.0220 U
		03/01/88(1)	0.0220 U	0.0118	0.0366	0.005 U	0.06 J	1.3191	0.0051 U	0.0002 U	0.0220 U
		04/22/88(2)	0.0220 U	0.0064	0.0172	0.005 U	0.06 J	4.0380	0.0051 U	0.0002 U	0.0220 U
		08/09/88(3)	0.0220 U	0.0090	0.0131 U	0.005 U	NR	7.5092	0.0051 U	0.0002 U	0.0220 U
		01/25/89(1)	0.029 U	0.0048 J	0.035 U	0.001 U	NR	12.9274	0.002 U	0.0002 U	0.027 U
		01/25/89(D)	0.029 U	0.0265	0.0730 U	0.001 U	NR	11.8875	0.002 U	0.0002 U	0.027 U

TABLE B 7B

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Cobalt Molybdenum) (Continued)

W II Designation	Lithology of Screened Interval**	Sample Date**	Cobalt (Co) diss. mg/l	Copper (Cu) diss. mg/l	Iron (F) diss mg/l	Lead (Pb) diss. mg/l	Lithium (Li) diss. mg/l	Magnesium (Mg) diss. mg/l	Manganese (M) diss. mg/l	Mercury (Hg) diss. mg/l	M lybdenum (M) diss. mg/l
						LOWER HSU					
		08/03/89(3)	0.0290 U	0.0040 U	0.0350 U	NR	NR	11.8479	0.0020 U	NR	0.0270 U
		11/28/89(4)	0.0500 U	0.0250 U	0 100 U	0.0050 U	0 102	1630	0.0150 U	0.0002 U	0 100 U
1687BR	SS#3	10/17/87(4)	0.0220 U	0.0063 U	0 1731	NR	NR	2.6440	0.0051 U	NR	0.0250
		03/01/88(1)	0.0220 U	0.0074	0.0644	0.0050 U	0.050 J	3.5134	0.0051 U	0.0002 U	0.0295
		04/22/88(2)	0.0220 U	0.0063 U	0.0186	0.0050 U	0 100 U	4 7883	0.0051 U	0.0002 U	0.0220 U
		08/10/88(3)	0.0020 U	0.0108	0.0219	0.0050 U	NR	4.9487	0.0072	0.0002 U	0.0225
		02/07/89(1)	0.0290 U	0.0040 U	0.0652 J	0.0010 U	NR	6.0696	0.0063 J	0.0002 U	0.0270 U
		08/03/89(3)	0.0290 U	0.0397	0.0350 U	NR	NR	6.5807	0.0121 J	NR	0.0270 U
		09/11/89(3)	0.0500 U	0.0250 U	0 1000 U	0.0020 U	0.0100 U	5 7300	0.0692	0.0002 U	0 1000 U
		11/06/89(4)	0.0500 U	0.0250	0 1000 U	0.0030 U	0 100 U	5 7300	0.0692	0.0002 U	0 1000 U
1887BR	SS#4	03/07/88(1)	0.0220 U	0.0379	0.0631	0.0050 U	0 1000 U	1 1415	0.1154	0.0002 U	0.0286
2287BR	CS	03/08/88(1)	0.0220 U	0.0063 U	0.0230	0.005 U	0 1 U	6.4239	0.0319	0.0002 U	0.0843
		05/03/88(2)	0.0220 U	0.0122	0.0423	0.005 U	NR	7.8109	0.0439	0.0002 U	0.0764
		11/09/88(4)	0.0220 U	0.0063 U	0.0080	NR	NR	12.5151	0.0426	0.0002 U	0.0582
		02/09/89(1)	0.029 U	0.004 U	0.0351 J	0.001 U	NR	16.8731	0.0651	0.0002 U	0.0545
		11/10/89(4)	0.0500 U V	0.025 U A	0.100 U V	0.003 V A	0 100 U V	21.50 A	0.0504 V	0.0002 U	0 100 U V
		11/13/89(4)	0.0500 U V	0.025 V A	0 100 U V	0.003 J A	0 100 U V	21.50 A	0.0504 V	0.0002 U	0 100 U V
2887BR	CS	03/15/88(1)	0.0220 U	0.0063 U	0.0143	0.0050 U	0.100 U	1 7166	0.0092	0.0002 U	0.0251
		05/12/88(2)	0.0220 U	0.0463	0.1786	0.0050 U	NR	3 1309	0.0304	0.0002 U	0 1347
		02/20/89(1)	0.0290 U	0.0127 J	0.0983 J	0.0010 U	NR	6.2484	0.0295	0.0002 U	0.0902

TABLE B 7B

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Cobalt Molybdenum) (Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Cobalt (Co) diss. mg/l	Copper (Cu) diss. mg/l	Iron (Fe) diss. mg/l	Lead (Pb) diss. mg/l	Lithium (Li) diss. mg/l	Magnesium (Mg) diss. mg/l	Manganese (Mn) diss. mg/l	Mercury (Hg) diss. mg/l	Molybdenum (Mo) diss. mg/l
						LOWER HSU					
3087BR	CS	01/22/88(1)	0.0220 U	0.0063 U	0.0414	0.005 U	0.01 U	2.2105	0.0060	0.0002 U	0.0220 U
		03/03/88(1)	0.0220 U	0.0063 U	0.0167	0.005 U	0.01 U	1.9955	0.0071	0.0002 U	0.0248
		04/22/88(2)	0.0220 U	0.0063 U	0.0679	0.005 U	0.01 U	2.9272	0.0087	0.0002 U	0.0220 U
		08/09/88(3)	0.0220 U	0.0063 U	0.0090	0.005 U	NR	3 1945	0.0124	0.0002 U	0.0220 U
		02/01/89(2)	0.029 U	0.020 J	0.0392	0.001 U	NR	2.8943 J	0.0117 J	0.002 U	0.027 U
		12/08/89(4)	0.0200 U	0.0200 U	0 140	0.0035	0.0417	3.41	0.0132	0.0002 U	0.500 U
		12/12/89(4)	0.0200 U	0.0200 U	0 140	0.0035	0.0417	3.41	0.0132	0.0002 U	0.500 U
		02/09/90(2)	0.0500 U	0.0250 U	0.100 U	0.005 U	0 100 U	5.00 U	0.0385	0.0002 U	0.100 U
3187BR	SS#3	10/29/87(4)	0.0220 U	0.0141	0.1701	NR	NR	0 1157	0.0051	NR	0.0568
		05/12/88(2)	0.0220 U	0.0121	0.0906	0.005 U	NR	0.3730	0.0051 U	0.0002 U	0.0408
		08/25/88(3)	0.0220 U	0.0106	0.0239	0.005 U	NR	0 7221	0.0051 U	0.0002 U	0.0440
		02/22/89(2)	0.0290 U	0.004 U	0.0371 J	0.001 U	NR	1 1088 J	0.0024 J	0.0002 U	0.027 U
3487BR	CS	03/10/88(1)	0.0220 U	0.0063 U	0.9745	0.0050 U	0.220	63.8066	0.1477	0.0002 U	0.0243
		05/12/22(2)	0.0220 U	0.0125	0.0874	0.0050 U	NR	2.9255	0.0105	0.0002 U	0.0323
		05/12/88(D)	0.0220 U	0.0128	0.0882	0.0050 U	NR	2.8998	0.0106	0.0002 U	0.0358
		02/20/89(1)	0.0290 U	0.0044 J	0.0764 J	0.0010 U	NR	4 1140 J	0.0099 J	0.0002 U	0.0270 U
		12/13/89(4)	0.0500 U	0.0250 U	0 100 U	0.0026	5.000 U	5.0000 U	0.0150 U	0.0002 U	0.1000 U
4587BR	SS#5	11/24/87(4)	0.0220 U	0.0133	0.0899	0.0050 U	NR	2.3647	0.0493	0.0002 U	0.0650
		02/26/88(1)	0.0220 U	0.0063	0.0286	0.0050 U	0.060 J	5.2957	0.1277	0.0002 U	0.0582
		04/19/88(2)	0.0220 U	0.0096	0 1218	0.0050 U	0.060 J	7.8306	0.2899	0.0002 U	0.0567

TABLE B 7B

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Cobalt Molybdenum)
(Concluded)

Well Designation	Lithology of Screened Interval*	Sample Date**	Cobalt (Co) diss. mg/l	Copper (Cu) diss. mg/l	Iron (Fe) diss. mg/l	Lead (Pb), diss. mg/l	Lithium (Li) diss. mg/l	Magnesium (Mg) diss. mg/l	Manganese (Mn) diss. mg/l	Mercury (Hg) diss. mg/l	Molybdenum (Mo) diss. mg/l
LOWER HSU											
		07/22/88(3)	0.0220 U	0.0063 U	0.0264	0.0050 U	NR	8.7134	0.3414	NR	0.0270
		01/23/89(1)	0.0290 U V	0.0040 U V	0.0350 U V	0.0010 U V	NR	10.2000 V	0.4000 V	0.0002 U A	0.0270 U V
		06/13/89(2)	0.0500 U R	0.0250 U R	0 1000 U V	0.0050 U A	0 100 U V	13.3000 A	0.3320 V	0.0002 U V	0.1000 U V
		07/27/89(3)	0.0290 U	0.0041 J	0.0350 U	NR	NR	9 7787	0.3280	NR	0.0270 U
		08/17/89(3)	0.0500 U V	0.0250 U V	0.1000 U V	0.0030 U V	0 100 U V	10.5000 V	0.2770 V	0.0002 U V	0.1000 U V
		08/18/89(3)	0.0500 U V	0.0250 U V	0 1000 U V	0.0030 U V	0 100 U V	10.5000 V	0.2770 V	0.0002 U V	0.1000 U V
		10/20/89(4)	0.0200 U	0.0200 U	0.2440	0.0030	0.049	9.6100	0.2760	0.0002 U	0.5000 U
		10/20/89(D)	0.0200 U	0.0200 U	0.2840	0.0020 U	0.051	9.3300	0.2880	0.0002 U	0.5000 U

* SS#1 Arapahoe Formation Sandstone #1 CS Arapahoe Formation claystone/siltstone AL alluvium, HSU Hydrostratigraphic Unit
** Number in parenthesis the calendar quarter sample was collected.

Notes

(1) VALUE QUALIFIERS: NR Analyte not reported; U Analyzed but not detected; Holding time not met, E Estimated value J Present below detection limit B Present in laboratory blank; N Batch spike not in 80-120% range
(2) DATA VALIDATION QUALIFIERS. (No validation qualifier indicates data has not been validated) R Rejected; A Acceptable with qualifications; V Valid
(3) Wells in upper HSU have portion of well screen or entire well screen or entire well screen in upper HSU
(4) Wells in lower HSU have entire well screen below boundary between alluvial" and "bedrock" components of RFI/RI shown in Figure 1 1
(5) Wells 1487BR is in lower HSU according to Note (4) above however it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU

TABLE B 7C

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Nickel Zinc)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Nickel (Ni) diss. mg/l	Potassium (K) diss mg/l	Selenium (Se) diss mg/l	Silver (Ag) diss mg/l	Sodium (Na) diss mg/l	Strontium (Sr) diss mg/l	Thallium (Tl) diss. mg/l	Tin (Sn) diss. mg/l	Zinc (Zn) diss. mg/l
						UPPER HSU					
1587	AL	10/08/87(D)	0.0370 U	NR	NR	0.0076 U	7.6207	0.4800	NR	NR	0.0200 U
		10/08/87(4)	0.0370 U	1.4900	0.0050 U	0.0076 U	9.3217	0.4795	0.0100 U	NR	0.0200 U
		03/01/88(1)	0.0370 U	0.8000	0.0050 U	0.0424	11.9562	0.4859	0.0100 U	NR	0.0361
		04/21/88(2)	0.0370 U	0.7000	0.0050 U	0.0076 U	8.5874	0.4283	0.0100 U	NR	0.0712
		08/03/89(3)	0.0220 U	NR	NR	0.0040 U	9.6778	0.3557	NR	NR	0.0080 U
		12/04/89(4)	0.0400 U	5.0000 U	0.0050 U	0.0100 U	10.6000	0.4880	0.0100 U	0.100 U	0.0200 U
6286	SS#3	04/09/87(2)	0.0370 U	13.0000	0.0060	0.0076 U	53.4960	0.4131	0.0100 U	NR	0.0500
		04/29/87(2)	0.0370 U	10.0000	0.0400	0.0076 U	58.5839	0.3812	0.0100 U	NR	0.0200 U
		07/07/87(3)	0.0370	8.2000	0.050	0.0076 U	60.8007	0.4878	0.0100 U	NR	0.0200 U
		10/16/87(4)	0.1041	9.1000	0.0270	0.0076 U	51.3986	0.3823	0.0100 U	NR	0.0200 U
		02/18/88(1)	0.0539	5.9000	0.0620	0.0076 U	49.7036	0.4234	0.0100 U	NR	0.0200 U
		04/14/88(2)	0.0485	4.2000	0.0710	0.0076 U	47.0577	0.4104	0.0100 U	NR	0.0200 U
		07/15/88(3)	0.0370 U	4.1000	0.0410	0.0076 U	53.1023	0.4450	0.0100 U	NR	0.0291
		10/20/88(4)	0.0370 U	4.8000	0.0440	0.0076 N U	54.8659	0.5031	0.0100 U	NR	0.0918
		01/23/89(1)	0.0220 U V	3.8600 V	0.0565 V	0.0040 U V	54.8000 V	0.4510 V	0.0010 U V	NR	0.0080 U V
		06/10/89(2)	0.0400 U A	5.0000 U A	0.0616 V	0.0100 U A	51.4000 V	1.0000 U V	0.0100 U A	0.1000 U V	0.0200 U A
		07/20/89(3)	0.0220 U	NR	NR	0.0040 U	52.2509	0.5188	NR	NR	0.0080 U
		10/19/89(4)	0.0200 U	3.2300	0.0550	0.0300 U	43.3000	0.4110	0.0030 U	1.0000 U	0.0291
1287BR	CS	02/26/88(1)	0.1154	1.3000	0.0020 J	0.0076 U	172.5999	0.2467	0.0100 U	NR	0.0200 U
		04/21/88(2)	0.0610	0.8000	0.0050 U	0.0076 U	179.5822	0.2582	0.0050 U	NR	0.0553
		07/26/88(3)	0.0422	1.1000	0.0050 U	0.0076 U	193.4917	0.2735	0.0100 U	NR	0.0200 U

TABLE B 7C

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel Zinc)
(Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Nickel (Ni) diss. mg/l	Potassium (K) diss mg/l	Selenium (Se) diss. mg/l	Silver (Ag) diss. mg/l	Sodium (Na) diss. mg/l	Strontium (Sr) diss. mg/l	Thallium (Tl) diss. mg/l	Tin (Sn) diss. mg/l	Zinc (Zn) diss. mg/l
					UPPER HSU						
2387BR	SS#1	10/22/87(4)	0.0370 U	NR	NR	0.0076 U	8.8855	0.5299	NR	NR	0.0301
		03/08/88(1)	0.0370 U	1.7000	0.0050 U	0.0076 U	9.6792	0.6205	0.0100 U	NR	0.0200 U
		04/29/88(2)	0.0558	1.6000	0.0050 U	0.0076 U	8.0978	0.5278	0.0100 U	NR	0.0221
		11/04/88(4)	0.0370 U	1.2000	0.0050 U	0.0076 U	10.9816	0.6030	0.0100 U	NR	0.0237
		02/07/89(1)	0.0347 J	1.6500 J	0.0011 J	0.0040 U	9.5868	0.5680	0.0010 U	NR	0.0082 J
		12/04/89(4)	0.0492	5.0000 U	0.0050 U	0.0100 U	9.2300	0.6220	0.0100 U	0.1000 U	0.0200 U
2587BR	SS#1	10/22/87(4)	0.0370 U	NR	NR	0.0076 U	9.3252	0.3112	NR	NR	0.0886
		03/04/88(1)	0.0370 U	1.1000	0.0050 U	0.0076 U	11.7683	0.2998	0.0100 U	NR	0.0200 U
		05/12/88(2)	0.0370 U	0.6000	0.0050 U	0.0076 U	11.0605	0.2345	0.0100 U	NR	0.0200 U
		08/16/88(3)	0.0370 U	0.5000	0.0050 U	0.0076 U	13.3006	0.2606	0.0100 U	NR	0.0264
		02/15/89(1)	0.0220 U	0.6000 J	0.0014 J	0.0040 U	13.0472	0.3480	0.0010 U	NR	0.0195 J
		11/02/89(4)	0.0200 U	0.7040	0.0020 U	0.0300 U	10.9000	0.2940	0.0030	1.000 U	0.0100 U
3687BR	SS#1/CS	11/06/87(4)	0.0548	NR	NR	0.0076 U	11.0671	0.3658	NR	NR	0.0365
		03/10/88(1)	0.0370 U	0.700	0.0050 U	0.0076 U	9.3131	0.2984	0.0100 U	NR	0.0225
		05/05/88(2)	0.0370 U	0.900	0.0050 U	0.0076 U	9.4793	0.2872	0.0100 U	NR	0.0200 U
		08/19/88(3)	0.0370 U	0.900	0.0050 U	0.0076 U	8.8509	0.2950	0.0100 U	NR	0.0200 U
		11/10/89(4)	0.0400 U V	5.000 U V	0.0050 U A	0.0100 U V	9.7400 A	0.3360 V	0.0700 U V	0.100 U V	0.0200 U A
		02/15/89(1)	0.0347 J	1.5000 J	0.0011 J	0.0040 U	14.2014	0.4245	0.0010 U	NR	0.0300

TABLE B 7C

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel Zinc)
(Continued)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Nickel (Ni) diss. mg/l	Potassium (K) diss. mg/l	Selenium (Se) diss. mg/l	Silver (Ag) diss. mg/l	Sodium (Na) diss. mg/l	Strontium (Sr) diss. mg/l	Thallium (Tl) diss. mg/l	Tin (Sn) diss. mg/l	Zinc (Zn) diss. mg/l
					LOWER HSU						
3486	SS#3	03/17/87(1)	0.0370 U	8.6	0.005 U	0.0076 U	227.7501	2.8304	0.01 U	NR	0.06
		04/06/87(2)	0.0370 U	8.0	0.005 U	0.0076 U	220.6902	2.8040	0.01 U	NR	0.08
		06/02/87(2)	0.0370 U	8.2	0.005 U	0.0076 U	221.9862	2.8541	0.01 U	NR	0.02 U
		07/28/87(3)	0.0370 U	3.2	0.005 U	0.0076 U	231.0510	2.9499	0.01 U	NR	0.02004
		10/17/87(4)	0.0370 U	10.9	0.005 U	0.0076 U	221.9791	2.7239	0.01 U	NR	0.02 U
		03/03/88(1)	0.0370 U	3.1	0.005 U	0.0076 U	76.7449	0.2005	0.01 U	NR	0.034
		05/03/88(2)	0.0370 U	8.9	0.005 U	0.0076 U	232.1001	2.8410	0.01 U	NR	0.02 U
		11/04/88(4)	0.0370 U	7.5	NR	0.0076 U	224.1979	3.1113	0.01 U	NR	0.02 U
		02/09/89(1)	0.022 U	7.9	0.001 U	0.004 U	226.5604	3.0086	0.001 U	NR	0.02 U
4086	CS	05/06/87(2)	0.0551	6.0	0.005 U	0.0076 U	134.5506	1.4881	0.0100 U	NR	0.050
		10/27/87(4)	0.0468	3.9000	0.005	0.0076 U	101.0152	0.8204	0.0100 U	NR	0.0229
		03/11/88(1)	0.0370 U	5.3000	0.004 J	0.0291	99.9352	0.8327	0.100 U	NR	0.0269
		12/04/89(4)	0.0280 U	3.8000	0.002 U	0.0300 U	102.0000	0.7890	0.0030 U	1.0000 U	0.0207
		05/12/88(2)	0.0378	3.8000	0.0050 U	0.0076 U	90.0279	0.7155	0.0100 U	NR	0.0380
1487BR	SS#5	10/13/87(4)	0.0370 U	12.3	0.011	0.0076 U	76.9625	1.4379	0.01 U	NR	0.02 U
		03/01/88(1)	0.0370 U	8.0	0.012	0.0076 U	77.9638	0.3449	0.01 U	NR	0.0295
		04/22/88(2)	0.0370 U	7.9	0.013	0.0073 U	84.0615	0.3095	0.01 U	NR	0.0200 U
		08/09/88(3)	0.0370 U	6.7	0.014	0.0076 U	85.1056	0.3517	0.01 U	NR	0.0255
		01/25/89(1)	0.022 U	4.750 B	0.016	0.004 U	7.4038	0.6339	0.001 U	NR	0.0109 J
		01/25/89(D)	0.022 U	4.820 J	.0166	.0044 J	81.7647	0.6635	0.001 U	NR	0.008 U

TABLE B 7C

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Nickel Zinc) (Continued)

Well Designation	Lithology f Screened Interval[a]	Sample Date[a]	Nickel (Ni) diss. mg/l	Potassium (K) diss. mg/l	Selenium (Se) diss. mg/l	Silver (Ag) diss. mg/l	Sodium (Na) diss mg/l	Strontium (Sr) diss. mg/l	Thallium (Tl) diss. mg/l	Tin (Sn) diss. mg/l	Zinc (Zn) diss. mg/l
LOWER HSU											
		08/03/89(3)	0.0220 U	NR	NR	0.0040 U	80.3288	0.4839	NR	NR	0.0080 U
		11/28/89(4)	0.0400 U	5.00 U	0.0106	0.0100 U	77.20	1.00 U	0.0100 U	0 100 U	0.0200 U
1687BR	SS#3	10/17/87(4)	0.0370 U	NR	NR	0.0076 U	60.8289	0.2522	NR	NR	0.0200 U
		03/01/88(1)	0.0370 U	8.1000	0.0020 J	0.0076 U	67.6220	0.2834	0.01400 U	NR	0.0200 U
		04/22/88(2)	0.0370 U	4.2000	0.0040 J	0.0076 U	66.4353	0.3042	0.0100 U	NR	0.0200 U
		08/10/88(3)	0.0370 U	4.0000	0.0050 U	0.0076 U	72.4248	0.02867	0.0100 U	NR	0.0200 U
		02/27/89(1)	0.0220 U	3.2500 J	0.0014 J	0.0040 U	73.5594	0.3652	0.0010 U	NR	0.0170 J
		08/03/89(3)	0.0220 U	NR	NR	0.0040 U	76.0211	0.3603	NR	NR	0.0169 J
		11/06/89(4)	0.0400 U	5.0000 U	0.0050 U	0 100 U	66.0000	0.3020	0.0100 U	0 1000 U	0.0315
		09/11/89(3)	0.0400 U	5.000 U	0.0050 U	0.0100 U	66.0000	0.3020	0.0100 U	0 1000 U	0.0315
1887BR	SS#4	03/08/88(1)	0.0661	0.8	0.003	0.0103	22.8139	0 1107	0.010 U	NR	0.0279
2287BR	CS	03/08/88(1)	0.0372	14	0.005 U	0.0076 U	88.6237	0.4659	0.010 U	NR	0.0339
		05/03/88(2)	0.0370 U	13.3	0.005 U	0.0076 U	100.1685	0.4906	0.010 U	NR	0.0200 U
		11/09/88(4)	0.0370 U	9.2	0.005 U	0.0076 U	135.7162	0 7709	NR	NR	0.0200 U
		02/09/89(1)	0.022 U	10.7	0.001 U	0.0064	148.1065	0.8774	0.001 U	NR	0.0080 U
		11/10/89(4)	0.0400 U V	8.00 V	0.005 U A	0.0100 U V	159.00 A	0.934 V	0.001 U V	0 100 U V	0.0384 A
		11/13/89(4)	0.0400 U V	8.00 V	0.005 U A	0.0100 U V	159.00 A	0.934 V	0.001 U V	0 100 U V	0.0384 A
2887BR	CS	03/15/88(1)	0.0370 U	14.000	0.003 J	0.0076 U	19.3060	0 1373	0.0100 U	NR	0.0200 U
		05/12/88(2)	0.0370 U	5.200	0.005 U	0.0076 U	92.0039	0.2427	0.0010 U	NR	0.0489
		02/20/89(1)	0.0220 U	5.600	0.002 J	0.0040 U	142.8783	0.4937	0.0010 U	NR	0.0364

TABLE B 7C

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel Zinc)
(Continued)

Well Designation	Lithology of Screened Interval**	Sample Date**	Nickel (Ni) diss. mg/l	Potassium (K) diss. mg/l	Selenium (Se) diss. mg/l	Silver (Ag) diss. mg/l	Sodium (N) diss. mg/l	Strontium (Sr) diss. mg/l	Thallium (Tl) diss. mg/l	Tin (Sn) diss. mg/l	Zinc (Zn) diss. mg/l
LOWER HSU											
3087BR	CS	01/22/88(1)	0.0370 U	5.3	0.005 U	0.0076 U	85.6715	0.2057	0.010 U	NR	0.0280
		03/03/88(1)	0.0370 U	4.9	0.005 U	0.0076 U	120 1536	0.2415	0.010 U	NR	0.0224
		04/22/88(2)	0.0370 U	3 7	0.005 U	0.0076 U	132.7649	0.2789	0.010 U	NR	0.0200 U
		08/09/88(3)	0.0370 U	3 1	0.005 U	0.0076 U	134 1108	0.2764	0.010 U	NR	0.0200 U
		02/01/89(1)	0.022 U	2.9 J	0.001 U	0.004 U	118.557	0.2621	0.001 U	NR	0.008 U
		12/08/89(4)	0.0200 U	2.66 J A	0.0020 U	0.0300 U	123.00	0.288	0.0150 U	1.0 U	0.0100 U
		12/12/89(4)	0.0200 U	2.66 J A	0.0020 U	0.0300 U	123.00	0.288	0.0150 U	1.0 U	0.0100 U
		02/09/90(1)	0.0400 U	5.00 U	0.0050 U	0.0100 U	124.00	1.00 U	0.0100 U	0 100 U	0.0200 U
3187BR	SS#3	10/29/87(4)	0.0370 U	NR	NR	0.0076 U	78.5306	0.1768	NR	NR	0.0237
		05/12/88(2)	0.0370 U	3.0	0.005 U	0.0076 U	69.2878	0 1697	0.010 U	NR	0.0258
		08/25/88(3)	0.0370 U	3.0	0.005 U	0.0076 U	72.9478	0.2119	0.010 U	NR	0.0306
		02/22/89(1)	0.0220 U	2.45	0.001 U	0.0040 U	70.2818	0.1968 J	0.001 U	NR	0.0207
3487BR	CS	03/09/88(1)	0.0370 U	7.600	0.005 U	0.0076 U	219 1668	2.5972	0.0100 U	NR	0.0200 U
		05/12/88(2)	0.0370 U	2.500	0.005 U	0.0076 U	74.7950	0.2137	0.0100 U	NR	0.0334
		05/12/88(D)	03070 U	2.500	0.005 U	0.0076 U	67.5259	0.1978	0.0100 U	NR	0.0294
		02/28/89(1)	0.0220 U	2.800 J	0.001 U	.0040 U	78.4420	0.2345	0.0010 U	NR	0.0184 J
		12/13/89(4)	0.0400 U	5.000 U	0.0023	0.0100 U	70.4000	0.2420	0.0030 U	1.0000 U	0.0200 U
4587BR	SS#5	11/24/87(4)	0.0370 U	NR	0.003 J	0.0076 U	34.6104	0.2063	0.0100 U	NR	0.0229
		02/26/88(1)	0.370 U	30.000	0.004 J	0.00764	060 7991	0.3238	0.0100 U	NR	0.0200 U
		04/19/88(2)	0.0388	20.000	0.004 J	0.076 U	60.9966	0.3460	0.0100 U	NR	0 1214

TABLE B 7C

SUMMARY OF DISSOLVED INORGANIC ELEMENTS DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs
(Nickel Zinc)
(Concluded)

Well Designation	Lithology of Screened Interval[a]	Sample Date[b]	Nickel (Ni) diss. mg/l	Potassium (K) diss. mg/l	Selenium (Se) diss. mg/l	Silver (Ag) diss mg/l	Sodium (Na) diss mg/l	Strontium (Sr) diss. mg/l	Thallium (Tl) diss. mg/l	Tin (Sn) diss mg/l	Zinc (Zn) diss. mg/l
LOWER HSU											
		07/22/88(3)	0.0370 U	15.000	0.005 U	0.0076 U	69.9706	0.4038	0.0100 U	NR	0.0200 U
		01/23/89(1)	0.0220 U V	11.900 V	0.0013 U A	0.0040 U V	79.4000 V	0.4850 V	0.0010 U V	NR	0.0127 U A
		06/13/89(3)	0.0400 U A	10.000 A	0.0050 U A	0.0100 U A	78.7000 V	1.0000 U V	0.0100 U A	0.1000 U V	0.0298 A
		07/27/89(3)	0.0220 U	NR	NR	0.0040 U	74.5441	0.4486	NR	NR	0.0080 U
		08/17/89(3)	0.0400 U R	7.690 A	0.0050 U V	0.0100 U V	75.6000 V	1.0000 U V	0.0010 U A	0.1000 U V	0.0200 U R
		08/18/89(3)	0.0400 U R	7.690 A	0.0050 U V	0.0100 U V	75.6000 V	1.0000 U V	0.0010 U A	0.100 U V	0.0200 U R
		10/20/89(4)	0.0200 U	6.030	0.0020 U	0.0300 U	73.9000	0.4440	0.0030 U	1.0000 U	0.0413
		10/20/89(D)	0.0200 U	6.780	0.0020 U	0.0300 U	72.7000	0.4560	0.0030 U	1.0000 U	0.0159

[a] SS#1 = Arapahoe Formation Sandstone #1 CS = Arapahoe Formation claystone/siltstone AL = alluvium HSU = Hydrostratigraphic Unit
[b] Number in parenthesis = the calendar quarter sample was collected.

Notes

(1) VALUE QUALIFIERS. NR = Analyte not reported, U = Analyzed but not detected, = Holding time not met, E = Estimated value J = Present below detection limit B = Present in laboratory blank, N = Batch spike not in 80-120% range
(2) DATA VALIDATION QUALIFIERS. (No validation qualifier indicates data has not been validated) R = Rejected A = Acceptable with qualifications, V = Valid
(3) Wells in upper HSU have portion of well screen or entire well screen or entire well screen in upper HSU
(4) Wells in lower HSU have entire well screen below boundary between alluvial and "bedrock components of RFI/RI shown in Figure 1 1
(5) Wells 1487BR is in lower HSU according to Note (4) above, however it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU

TABLE B-8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs

Well Designation	Lithology of Screened Interval [a]	Sample Date[b]	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO)	Nitrate Nitrite as N	TDS	Bicarbonate
UPPER HSU										
1587	AL	10/08/87 (4)	56 7	NR	NR	15.5	40.2857	9 1	487 0	261 0
		03/01/88 (1)	58.8	NR	NR	24 6	17 1768	3.88	456 0	138 0
		04/21/88 (2)	48 1	NR	NR	25 8	21.3381	4 82	437 0	244 0
		08/03/89 (3)	23.5	NR	NR	12.7	NR	3 73	354 0	233 0
		12/04/89 (4)	NR	0 0100 U	NR	NR	NR	NR	NR	NR
4086	CS	05/06/87 (2)	19 9	1 0 U	NR	470 0	6 1978	1 40	1011 0	205 0
		06/01/87 (2)	14 9	1 0 U	NR	390 0	NR	NR	NR	NR
		10/26/87 (4)	8 79	NR	NR	218 0	29.3067	6 62	679 0	255 0
		03/11/88 (1)	7.56	NR	NR	131 0	16 6898	3 77	598 0	180 0
		05/12/88 (2)	7.24	NR	NR	135 0	16.8226	3 80	576 0	293 0
		02/01/90 (1)	10 0	NR	0 6	120 0	NR	2.40	560 0	400 0
6286	SS#3	04/09/87 (2)	28.0	1 0	NR	60 0	10 1821	2.30	274 0	67.5
		04/29/87 (2)	26.9	1 0 U	NR	90 0	11.5102	2.60	286 0	124 0
		05/26/87 (2)	25.5	1 0 U	NR	48 0	15 0518	3 40	295 0	164 0
		07/07/87 (3)	102.0	1 0 U	NR	23 0	10 1821	2.30	280 0	157 0
		02/18/88 (1)	29 7	NR	NR	39 0	7 0832	1.60	275 0	172.0
		04/14/88 (2)	26.8	NR	NR	57 7	12.7940	2.89	302 0	134 0
		07/15/88 (3)	30.2	NR	NR	57 6	13.2367	2.99	283 0	151 0
		10/20/88 (4)	71 0 A	NR	NR	54 1 A	32.8041	7 41 A	328 0 A	164 0 A
UPPER HSU										

Source RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 1991
22570/R2T B-8 06-19-91/RPT/3

TABLE B 8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval (a)	Sample Date(b)	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO)	Nitrate Nitrite as N	TDS	Bicarbonate
		01/23/89 (1)	28 2 V	NR	NR	53 9 V	NR	2 46 V	288 0 A	132 0 V
		07/20/89 (3)	31 6	NR	NR	64 0	NR	2 79	309 0	140 0
		02/16/90 (1)	35 0	NR	1 0	45 0	NR	3.5	320 0	180 0
1287BR	CS	02/26/88 (1)	38.8	NR	NR	46 2	3 1432	0 71	617 0	212.0
		04/21/88 (2)	57 0	NR	NR	102 0	5 8879	1.33	641 0	354 0
		07/26/88 (3)	53.3	NR	NR	203 0	7 0832	1 60	635 0 JA	348 JA
		01/24/90 (1)	37 0	NR	2.5	92.0	NR	2.20	540	400
2387BR	SS#1	10/22/87 (4)	55 9	NR	NR	27 0	12.2628	2.77	414 0	243 0
		03/03/88 (1)	62.8	NR	NR	17 1	12.4841	2.82	431 0	146.0
		04/29/88 (2)	64 0	NR	NR	17.5	11 9529	2.70	392.0	242 0
		08/12/88 (3)	49 0 JA	NR	NR	18.1 JA	12.1742	2.75 JA	446 0 R	261 0 JA
		11/04/88 (4)	65 1 V	NR	NR	16 6 A	13 1925	2.98 V	344 0 A	192 0 A
		02/07/89 (1)	65.8 V	NR	NR	18 4 V	NR	2.31 V	459 0 A	237 0 A
		12/04/89 (4)	NR	0 0100 U	NR	NR	NR	NR	NR	NR
		02/20/90 (1)	73	NR	0 7	19	NR	4.3	440	310
		02/20/90 (D)	72	NR	0.5 U	18	NR	4 4	470	310
2587BR	SS#1	10/22/87 (4)	36 0	NR	NR	35.5	34 0436	7 69	448 0	250 0
		03/04/88 (1)	37.3	NR	NR	32.5	34 0436	7 69	466 0	152 0
		05/12/88 (2)	34.8	NR	NR	28.5	30.5463	6 90	496 0	235 0

UPPER HSU

TABLE B 8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval [a]	Sample Date[b]	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO)	Nitrate Nitrite as N	TDS	Bicarbonate
		08/16/88 (3)	34 6 JA	NR	NR	32 4 R	34 0436	7 69 JA	457 0	267 0 JA
		02/15/89 (1)	39 1 A	NR	NR	28 1 V	NR	7 31 V	475 0 A	248 0 A
		01/01/90 (1)	37 0	NR	0 6	230 0	NR	0 66	670 0	360 0
3687BR	SS#1/CS	11/06/87 (4)	218.0	NR	NR	43.5	20 2314	4.57	375 0	218 0
		03/10/88 (1)	29 6	NR	NR	34 4	21 1611	4 78	395 0	133 0
		05/05/88 (2)	29 9	NR	NR	33 0	19 4788	4 40	405 0	212 0
		08/19/88 (3)	34 2 JA	NR	NR	40.5 JA	18.2392	4 12 JA	431 0 JA	240 0 JA
		02/15/89 (1)	41 9 A	NR	NR	27 7 V	NR	8 06 V	444 0 A	242.0 A
		03/05/90 (1)	48.0	NR	0.5 U	30 0	NR	6.1	540 0	350 0
LOWER HSU										
3486	SS#3	03/17/87 (1)	65 9	1 0 U	NR	800	0.8854 U	0 20 U	1789	372
		04/06/87 (2)	53.5	1 0 U	NR	40 0	0.8854 U	0.20 U	1772	357
		06/02/87 (2)	54 0	1 0 U	NR	940	0.8854 U	0.20 U	1761	333
		07/28/87 (3)	54 4	1 0 U	NR	990	0.8854 U	0.20 U	1813	319
		03/03/88 (1)	59.6	NR	NR	763	0 0885 U	0 02 U	1700	111
		05/03/88 (2)	58.3	NR	NR	725	0 0885 U	0 02 U	1760	239
		11/04/88 (4)	56.2 V	NR	NR	1084 A	0 0885 U	0 02 UV	1750 A	316 A
		02/09/89 (1)	0 0167	NR	NR	1058 V	NR	0 02 UV	1886 A	306A

TABLE B 8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval [a]	Sample Date[b]	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO)	Nitrate Nitrite as N	TDS	Bicarbonate
LOWER HSU										
1487BR	SS#5	9/1/87 (3)	27 0	1 0	NR	27 0	7.5259	1 70	661	530
		10/13/87 (4)	30 2	NR	NR	41 0	7 0832	1 60	635	48
		3/1/88 (1)	28 0	NR	NR	43 1	7 0389	1.59	265	36 3
		4/22/88 (2)	24.8	NR	NR	48.8	7.5259	1 70	275	75 4
		8/9/88 (3)	26 1 JA	NR	NR	41 9 R	7.5702	1 71 JA	287 JA	112 JA
		1/25/89 (1)	32 6 V	NR	NR	46.5 VU	NR	1 83 A	320 A	158 A
		1/25/89 (D)	32.7 V	NR	NR	47 0 VU	NR	1 74 A	308 A	155 A
		8/3/89 (3)	34 0	NR	NR	47.8	NR	2.12	326	177
		1/25/90 (1)	46 0	NR	0 9	60 0	NR	2.6	420	290
		1/25/90 (D)	46 0	NR	0 9	50 0	NR	2.7	430	310
1687BR	SS#3	10/17/87 (4)	3 7	NR	NR	77 0	6 9947	1.58	264 0	133 0
		03/01/88 (1)	7 46	NR	NR	93.8	1.5494	0.35	282.0	83 1
		04/22/88 (2)	4 04	NR	NR	84.8	0.2213	0 05	277 0	166 0
		08/10/88 (3)	3.33 JA	NR	NR	64 6 R	0 0885 U	0 02 UA	286 0 JA	176 0 JA
		02/07/89 (1)	3.34 V	NR	NR	77 0 V	NR	1.56 V	312.0 A	171 0 A
		08/03/89 (3)	3.57	NR	NR	85 4	NR	1.89	337 0	185 0
		03/17/90 (1)	10 0	NR	0 6	62 0	NR	2.5	340 0	220 0
1887BR	SS#4	03/08/88 (1)	5.85	NR	NR	28.9	0 0885 U	0 02 U	163 0	41 4
		11/04/89 (4)	23 V	NR	NR	59 0 V	NR	6.2 V	340 0 A	360 A
LOWER HSU										

Phase II RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 1991
22570B/R2T.B-8 06-19-91/RPT/73

TABLE B 8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval [a]	Sample Date[b]	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO)	Nitrate Nitrite as N	TDS	Bicarbonate
2087BR	SS#3	12/13/89 (4)	8.0	NR	NR	100 0	NR	NR	500 0	228.0
		02/09/90 (1)	NR	NR	NR	NR	NR	3.3	NR	NR
2287BR	CS	3/8/88 (1)	8.22	NR	NR	121	0 0885 U	0 02 U	465	54
		5/3/88 (2)	5 70	NR	NR	230	0 1771	0 04	480	99
		8/12/88 (3)	6.56 JA	NR	NR	337 JA	0 1771	0 04 JA	586 R	119 JA
		11/9/89 (4)	7 84 V	NR	NR	387 A	0 4870	0 11 V	638 A	97 A
		2/9/89 (1)	9 27 V	NR	NR	458 V	NR	0 14 V	759 A	105 A
		2/8/90 (1)	16	NR	0.5	370	NR	0 06	870	190
2887BR	CS	03/15/88 (1)	6.27	NR	NR	32.0	0.3984	0 09	137 0	38.1
		05/12/88 (2)	23 4	NR	NR	130 0	0 1771	0 04	516 0	93 6
		02/20/89 (1)	77 9 A	NR	NR	195 0 V	NR	0 04 V	529 0 A	114 0 A
		03/14/90 (1)	NR	NR	NR	NR	NR	3.8	NR	NR
3087BR	CS	01/22/88 (1)	40 1	NR	NR	22.2	0 0885 U	0 02U	118	87
		03/03/88 (1)	114	NR	NR	16 1	0 0885 U	0 02U	376	84
		04/22/88 (2)	125	NR	NR	16.5	0 1771	0 04	412	157
		08/09/90 (3)	124 JA	NR	NR	2.82 R	0 0885 U	0 02 UA	419 JA	169 JA
		08/09/90 (D)	127 JA	NR	NR	2.78 R	0 0885 U	0 02 UA	419 JA	180 JA
		02/01/89 (1)	132 A	NR	NR	2.91 V	NR	0 02 UV	419 A	156 A
LOWER HSU										
3187	SS#3	10/29/87 (4)	10.3	NR	NR	125	0.8854 U	0.20U	346	60.8

Phase RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final Rocky Flats Plant, Golden, Colorado, June 1991
22570B/RT.B-8 06-19-91/RPT73

TABLE B 8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Continued)

Well Designation	Lithology of Screened Interval [a]	Sample Date[b]	Chloride	Cyanide	Fluoride	Sulfate	Nitrate (NO)	Nitrate Nitrite as N	TDS	Bicarbonate
		5/12/88 (2)	9 01	NR	NR	115	0 7526	0 17	312	67 6
		8/25/88 (3)	9 07 JA	NR	NR	113 JA	15 7158	3.55 V	308 JA	94 1 JA
		2/22/89 (1)	9 79 A	NR	NR	118 V	NR	0 05 V	307 A	74 6 A
		3/13/90 (1)	12	NR	1 0	120	NR	0 05	410	130
3487BR	CS	03/10/88 (1)	5 37	NR	NR	114 0	0 7526	0 17	288 0	61 4
		05/12/88 (2)	3 94	NR	NR	97 0	0 2656	0 06	314 0	125 0
		05/12/88 (D)	4.58	NR	NR	100 0	0.2213	0 05	319 0	127 0
		02/20/89 (1)	7 25 A	NR	NR	80 6 V	NR	0 14V	381 A	142 0 A
4587BR	SS#5	11/23/87 (4)	6.38	NR	NR	73 6	0 0885 U	0 02 U	327 0	111 0
		02/26/88 (1)	8.33	NR	NR	55 0	0 0885 U	0 02 U	342 0	114 0
		04/19/88 (2)	10 6	NR	NR	104 0	0.2213	0 05	344 0	119 0
		07/22/88 (3)	11 0	NR	NR	47 0	0.3099	0 07	341 0	232.0
		01/23/89 (1)	13 9 V	NR	NR	50.5 V	NR	0 02 UV	376 0 A	233 0 V
		07/27/89 (3)	15.2	NR	NR	54.3	NR	02 U	388 0	263 0
		03/15/90 (1)	21 0	NR	0 7	59 0	NR	0 05 U	410 0	350 0

TABLE B 8

SUMMARY OF NON METALLIC INORGANIC COMPOUNDS (mg/l) DETECTED IN SELECTED GROUNDWATER MONITORING WELLS SCREENED IN THE UPPER AND LOWER HSUs (Concluded)

(a) SS#1 = Arapahoe Formation Sandstone #1 CS = Arapahoe Formation Claystone/Siltstone Al = Alluvium
(b) Number in parenthesis = the calendar quarter sample was collected

NOTES

(1) VALUE QUALIFIERS NR = Analyte not reported U = Analyzed but not detected = Holding time not met E = Estimated value
J = Present below detection limit B = Present in laboratory blank N = Batch spike not in 80-120% range

(2) DATA VALIDATION QUALIFIERS (No validation qualifier indicates data has not been validated) R = Rejected A = Acceptable with qualifications, V = Valid
(3) Wells in upper HSU have portion of well screen or entire well screen in upper HSU
(4) Wells in lower HSU have entire well screen below boundary between alluvial and "bedrock components of RFI/RI shown in Figure 1 1
(5) Well 1487BR is in lower HSU according to Note (4) above, however it is screened in weathered SS#5 that subcrops and may be hydrologically connected to upper HSU
(6) Nitrate calculated from measured concentration of Nitrate Nitrite as N

TABLE B 9

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN BEDROCK SAMPLES FROM BOREHOLES

Borehole Desig-nation	Sample Depth	Lith-ology[a]	Analytical Data Available[b]	V latile Organic Compund Concentrations (µg/kg)[b]															
				Ethyl Benzene	4-methyl 2-pentanone	Toluene	Methylene Chloride	Acetone	Carbon Di-sulfide	Carbo Tetra-chloride	Trichloro-ethylene	cis 1,3-dichloro-propene	Tetra-chloro-ethylene	1,2-Dichloro-propene	2-Butanone	Chloro-ethane	1,1,1 Trichloro-ethane	Total Xylenes	Chloro-form
2287	22.2-23.4	CS	Y				9J												
2387	11.2-11.9	CS	Y				5J												
2487	10.0-10.9	CS	Y				19B												
2587	14.5-15.9	CS	Y	780		640					7000		10000		210J		3300		
	18.5-19.3	CS	Y	290	120J	330	150JB	760B			16000		3800			50J	755	480	130J
	19 7 20.5	CS	Y			300	59J	1100B			13000		2100		150J		180J		
2787	13.0-14.4	CS	Y				6J	170B											
2887	8.8-9.0	CS	Y					11JB	58	29	5J	6J	14J						
3187	11 7 12.6	CS	Y			7J		100					20J	32					
	15.7 22.9	CS	Y				9J	110						5J					
3287	8.0-15	SS#1	Y				9J	120						11J					
	15 1 16.2	CS	Y					86											
	17.2-18	CS	Y					170						19J					
3387	7.8-14 7	AL/SS#1 /CS	Y					190						12J					
	14 7 15.9	CS	Y					170						11J					
	18.9-19.8	CS	Y				14J	320						10J					
	19.5-20.8	CS	Y				15J	96						7J					

TABLE B 9

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN BEDROCK SAMPLES FROM BOREHOLES
(Continued)

Borehole Desig-nation	Sample Depth	Lith-ology[a]	Analytical Data Available[b]	Volatile Organic Compound Concentrations (μg/kg)[c] Ethyl Benzene	4-methyl 2-pentanone	Toluene	Methylene Chloride	Acetone	Carbon Di-sulfide	Carbon Tetra-chloride	Trichloro-ethylene	cis 1,3-dichloro-propene	Tetra-chloro-ethylene	1,2-Dichloro-propene	2-Butanone	Chloro-ethane	1 1 1 Trichloro-ethane	Total Xylenes	Chloro-form
3487	17.0-18.0	SS#1	YN																
	21.0-22.1	SS#1	YN																
3687	23.4-24.5	CS	Y				8J	64											
3787	18.0-21 7	SS#1	Y				12JB	130B				6J							
	25.0-26.2	CS	Y				17JB	150B											
3987	14.5-17.0	SS#1	Y					170							72				
	17.0-19.5	SS#1	Y					120							58				
	19.5-22.0	SS#1	Y					140							55				
4087	7.0-9.3	AL/ CS	Y					120											
	9.5-12.0	CS	Y					150											
4187	14.5-17.0	AL/ CS	Y					210											
	17.0-19.5	CS	Y					150			34								7J
4287	22-24.5	PL/ SS#1	Y																
	24.5-27	SS#1	Y																
	27 29.5	SS#1	Y					140											
	29.5-32	SS#1	Y																
	32-34.5	SS#1	Y					140											
	34.5-35.9	SS#1	Y					68			11J								6J
	37-39.5	SS#1	Y					62											

Phase II RFI/RI Work Plan (Bedrock) 903 Pad, Mound, and East Trenches Areas, Final
Rocky Flats Plant, Golden, Colorado, June 21, 1991
22578B/R2T B-9 06-19-91/RPT73

TABLE B 9

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN BEDROCK SAMPLES FROM BOREHOLES (Continued)

Borehole Desig-nation	Sample Depth	Lith-ology[a]	Analytical Data Available[b]	V latile Organic Compund Concentrations (µg/kg)[c]																
				Ethyl Benzene	4-methyl 2-pentanone	Toluene	Methylene Chloride	Acetone	Carbon Di-sulfide	Carbon Tetra-chloride	Trichloro-ethylene	cis 1,3-dichloro-propene	Tetra-chloro-ethylene	1,2-Dichloro-propene	2-Butanone	Chloro-ethane	1 1 1 Trichloro-ethane	Total Xylenes	Chloro-form
	39.5-40.4	SS#1	Y					120											
	45.5-47	SS#1	Y					78											
4387	27.2-29 7	CS	YN																
	29 7 32.0	CS	YN																
4487	29.5-32	SS#1	Y				10J	140B											
	32-34.5	SS#1 /CS	Y				25J	180B											
4587	20-22.3	SS#1	YN																
	22.5-25	SS#1	YN																
	32.5-33.9	SS#1	YN																
	35-37.5	SS#1	YN																
4687	27 29.5	CS	Y					170B											
	29.5-32	CS	Y				7J	270B											
4787	26.2-27.2	CS	Y			21J	12JB	480B						100					
	27.2-28.2	CS	Y				6JB	770B						38					
4887	13.2-15.11	CS	YN																
	15.2-16.7	CS	YN																
4987	22-24	CS	Y				7JB	90B						15J					

TABLE B 9

SUMMARY OF VOLATILE ORGANIC COMPOUNDS DETECTED IN BEDROCK SAMPLES FROM BOREHOLES (Concluded)

Borehole Designation	Sample Depth	Lithology[a]	Analytical Data Available[b]	Volatile Organic Compund Concentrations (µg/kg)[c] Ethyl Benzene	4-methyl 2-pentanone	Toluene	Methylene Chloride	Acetone	Carbon Disulfide	Carbon Tetrachloride	Trichloroethylene	cis 1,3-dichloropropene	Tetrachloroethylene	1,2-Dichloropropene	2-Butanone	Chloroethane	1 1 1 Trichloroethane	Total Xylenes	Chloroform
5087	12.0-12.9	CS	Y					1000B											
	14.5-17	CS	Y					1000B						110					
	17 19.5	CS	Y					510B						98					

(a) AL = Alluvial SS#1 = Arapahoe Formation, sandstone lithologic unit #1 CS = Arapahoe formation claystone/siltstone
(b) Y = yes as follows, YN yes, but no data above detection limits
(c) None of the available data has been validated J = present below detection limit B = present in laboratory blank

TABLE B 10

SUMMARY OF SEMI VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK

Borehole Designation	Sample Depth	Lithology[a]	Analytical Data Available[b]	Semi Volatile Organic Compound (μg/kg)[c] N Nitrosodi phenylamine	di n-butyl phthalate	di n-octyl phthalate	bis (2-ethylhexyl) phthalate
BH2287	22.2 23 4	CS	Y	89J			1600
BH2387	11 2 11 9	CS	Y				2700
BH2487	10 0 10 9	CS	Y				2600B
BH2587	18.5 19 3	CS	Y			56J	930B
	19 7 20.5	CS	Y				870B
BH2787	13 0 14 4	CS	Y				220J
BH2887	11 0 12.0	CS	Y		59J		2100
BH3187	15 7 22 9	CS	Y	40J			580
BH3287	17.2 18 0	CS	Y				9J
BH3387	7.8 14 7	AL/SS#1/CS	Y	41J			
	14 7 15 9	CS	Y	37J			
	18 9 19 8	CS	Y	42J			240V
	19.5 20 8	CS	Y	49J			450
BH3487	17 0 18 0	SS#1	Y	33J			
	21 0 22 1	SS#1	Y		35J		220J
BH3687	23 4 24.5	CS	Y		38J		360
BH3787	18.0 21 7	SS#1	Y				550
	25 0 26 2	CS	Y		41J		420

TABLE B 10

SUMMARY OF SEMI VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK
(Continued)

Borehole Designation	Sample Depth	Lithology[a]	Analytical Data Available[b]	Semi Volatile Organic Compound (μg/kg)[c]			
				N Nitrosodi phenylamine	di-n-butyl phthalate	di-n-octyl phthalate	bis (2-ethylhexyl) phthalate
BH3987	14.5 17.0	SS#1	Y				250V
	17.0 19.5	SS#1	YN				
	19.5 22.0	SS#1	YN				
BH4087	7.0 9.3	AL/CS	Y				160J
	9.5 12.0	CS	Y				200J
BH4187	14.5 17.0	AL/CS	Y				150J
	17.0 19.5	CS	Y				190J
BH4287	22.0 24.5	AL/SS#1	Y		170J		500
	24.5 27.0	SS#1			39J		520
	27.0 29.5						480
	29.5 32.0				34J		720
	32.0 34.5						640
	34.5 35.9			100J	34J		410
	37.0 39.5						520
	39.5 40.4				34J		610
	45.5 47.0						160V
BH4387	27.2 29.7	CS	Y	37JB			310JB

TABLE B 10

SUMMARY OF SEMI VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK (Continued)

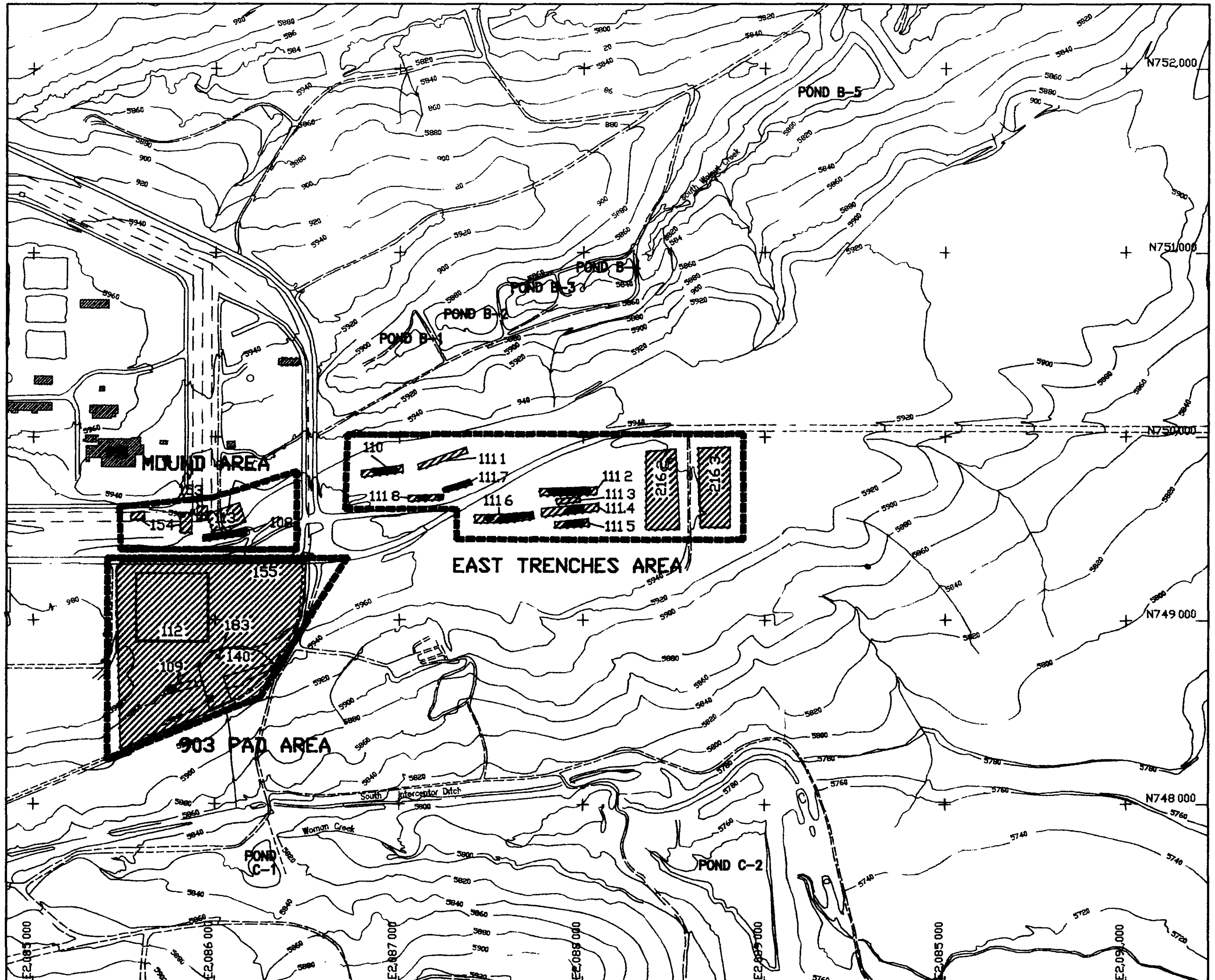
Borehole Designation	Sample Depth	Lithology[a]	Analytical Data Available[b]	Semi Volatile Organic Compound (μg/kg)[c]			
				N Nitrosodi phenylamine	di n-butyl phthalate	di-n-octyl phthalate	bis (2-ethylhexyl) phthalate
	29 7 32.0	CS	Y		34JB		730JB
BH4487	24.5 27 0	SS#1	Y		38JB		
	29.5 32.0	SS#1	Y		38JB		
	32 0 34.5	SS#1/CS	Y		38JB		
BH4587	20 0 22 3	SS#1	Y				180J
	22.5 25 0		Y				120J
	25 0 27.5		Y				190J
	27.5 30 0		Y				130J
	30 0 32.5		Y				150J
	32.5 33 9		Y				220J
	35 0 37.5		Y				140J
BH4687	27 0 29.5	CS	Y				230J
	29.5 32.0	CS	Y				350
BH4787	26.2 27.2	CS	Y		44JB		960B
	27.2 28.2	CS	Y		44JB		1100B
BH4887	13.2 15 1	CS	Y		42JB		478B
	15.2 16 7	CS	Y		35JB		560B
BH4987	20 0 22 0	CS	Y				710B

TABLE B 10

SUMMARY OF SEMI VOLATILE ORGANIC COMPOUNDS DETECTED IN SOIL SAMPLES FROM BOREHOLES DRILLED INTO BEDROCK (Concluded)

Borehole Designation	Sample Depth	Lithology[a]	Analytical Data Available[b]	Semi Volatile Organic Compound (μg/kg)[c] N-Nitrosodi phenylamine	di n-butyl phthalate	di n-octyl phthalate	bis (2-ethylhexyl) phthalate
	22.0 24 0	CS	Y				720B
	24 1 25 6	CS	Y				580B
BH5087	12.0 12 9	CS	Y		36JB		450B
	14.5 17 0	CS	Y		55JB		690B
	17 0 19.5	CS	Y		35JB		370B

[a] AL = Alluvial SS#1 = Arapahoe Formation sandstone lithologic unit #1 CS = Arapahoe formation claystone/siltstone
[b] Y = yes as follows, YN yes but no data above detection limits
[c] VALUE QUALIFIERS J = present below detection limit B = present in laboratory blank
DATA VALIDATION QUALIFIERS V = Valid



EXPLANATION

216.2 — INDIVIDUAL HAZARDOUS SUBSTANCE SITE AND IHSS DESIGNATION

LOCATION OF BARRELS DETERMINED BY VISUAL INSPECTION OR MAGNETOMETER SURVEY

SOURCE AREAS

Scale 1 = 600

0' 300' 600'

CONTOUR INTERVAL = 20'

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

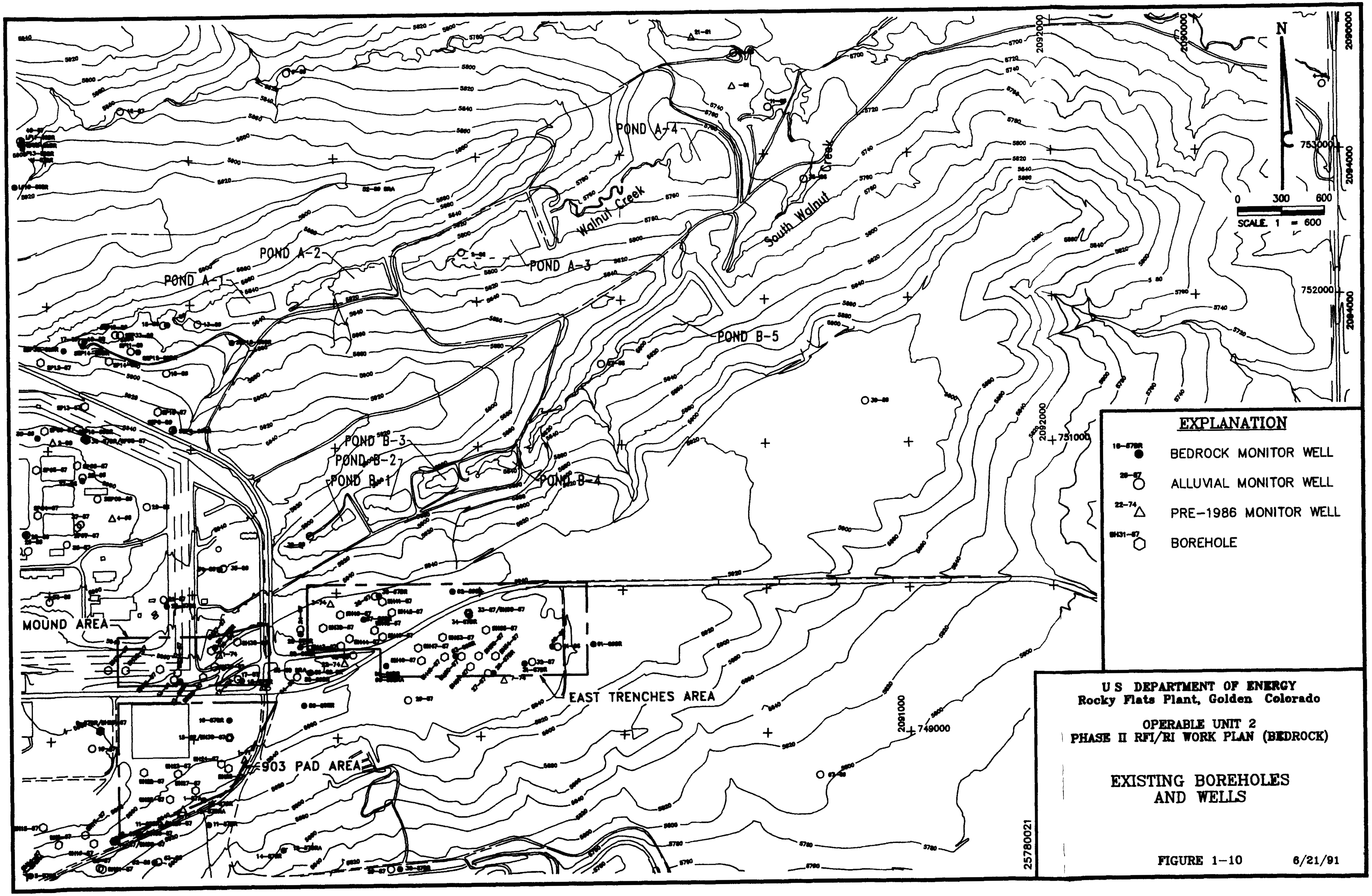
OPERABLE UNIT NO 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

REMEDIAL INVESTIGATION AREAS AND INDIVIDUAL HAZARDOUS SUBSTANCE SITES

FIGURE 1-8

June, 1991

R33M003A.PAL-062091



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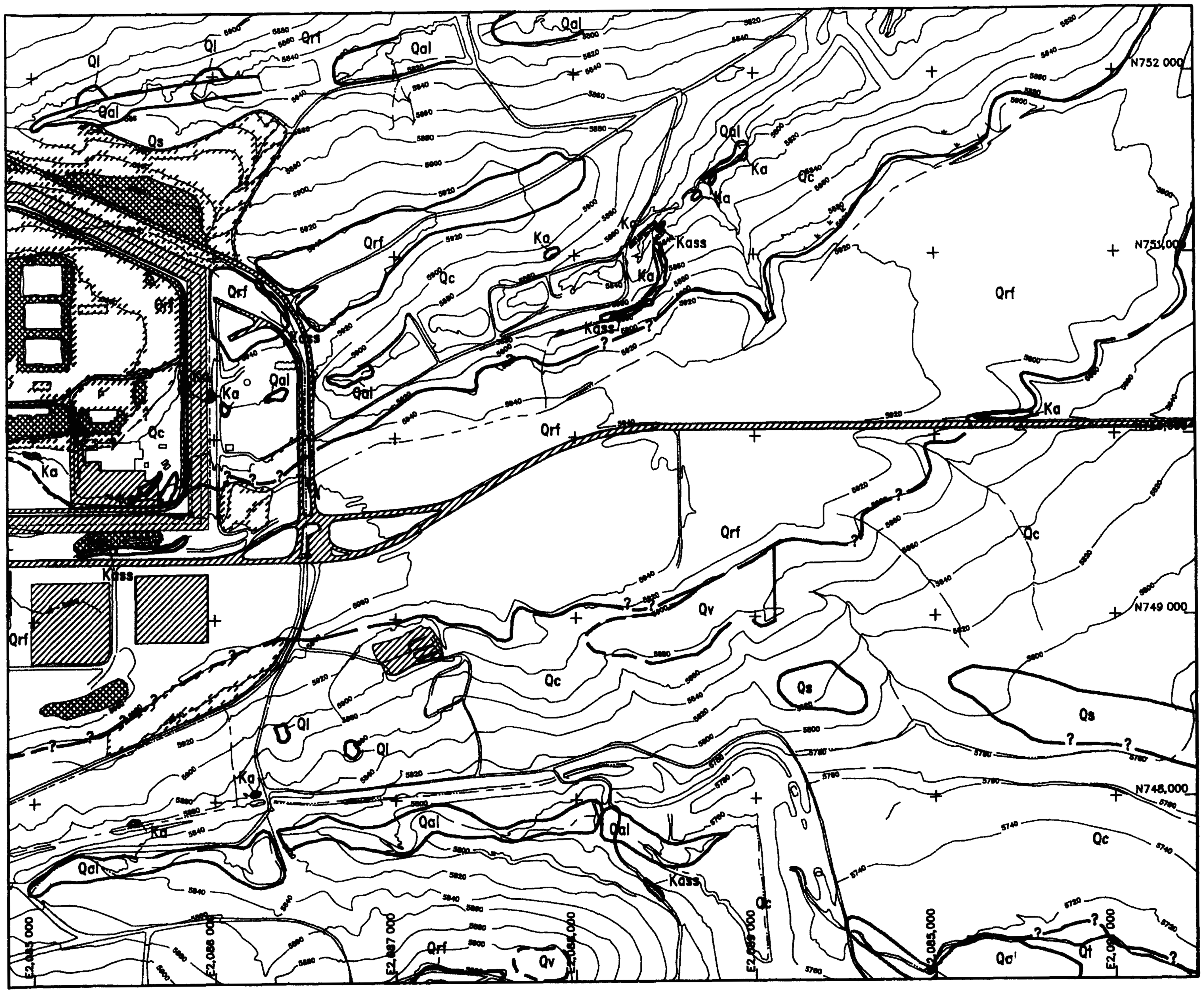
Rocky Flats Plant, Golden Colorado

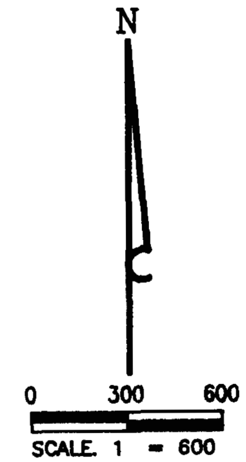
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

EXISTING BOREHOLES AND WELLS

FIGURE 1-10 6/21/91

25780021





EXPLANATION

CONTACT

DASHED WHERE APPROXIMATELY LOCATED, QUERIED WHERE INFERRED.

ARTIFICIAL FILL

PAVEMENT OR GRAVEL

DISTURBED GROUND

QUATERNARY

Qal	RECENT VALLEY FILL
Ql	LANDSLIDE
Qc	COLLUVIUM
Qt	TERRACE ALLUVIUM
Qs	SLOCUM ALLUVIUM
Qv	VERDOS ALLUVIUM
Qrf	ROCKY FLATS ALLUVIUM

CRETACEOUS

Kass	ARAPAHOE FORMATION, SANDSTONE
Ka	ARAPAHOE FORMATION, CLAYSTONE

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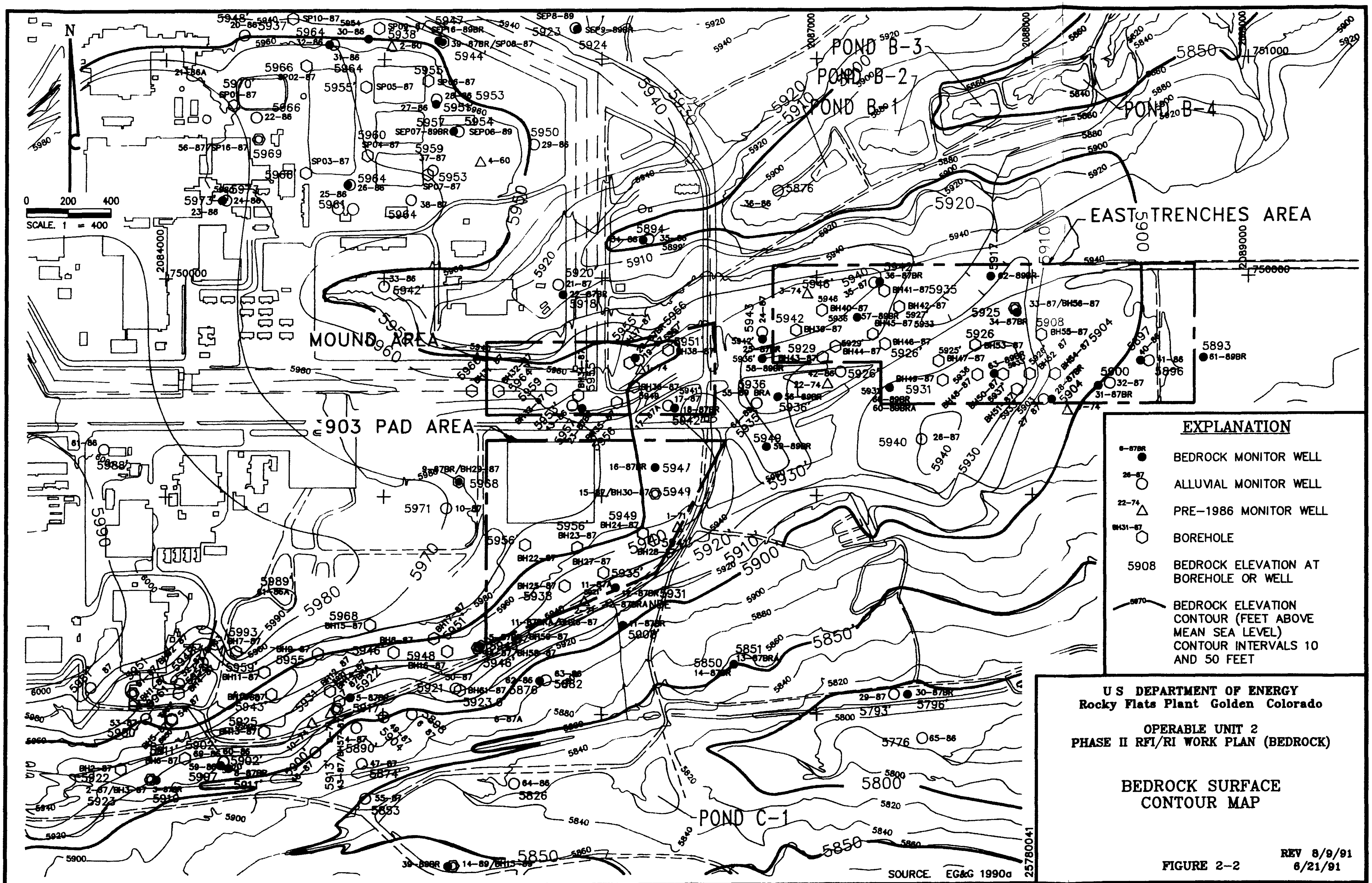
Rocky Flats Plant Golden Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

SURFICIAL GEOLOGY

FIGURE 2-1 6/21/91

25780031



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OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

BEDROCK SURFACE CONTOUR MAP

FIGURE 2-2

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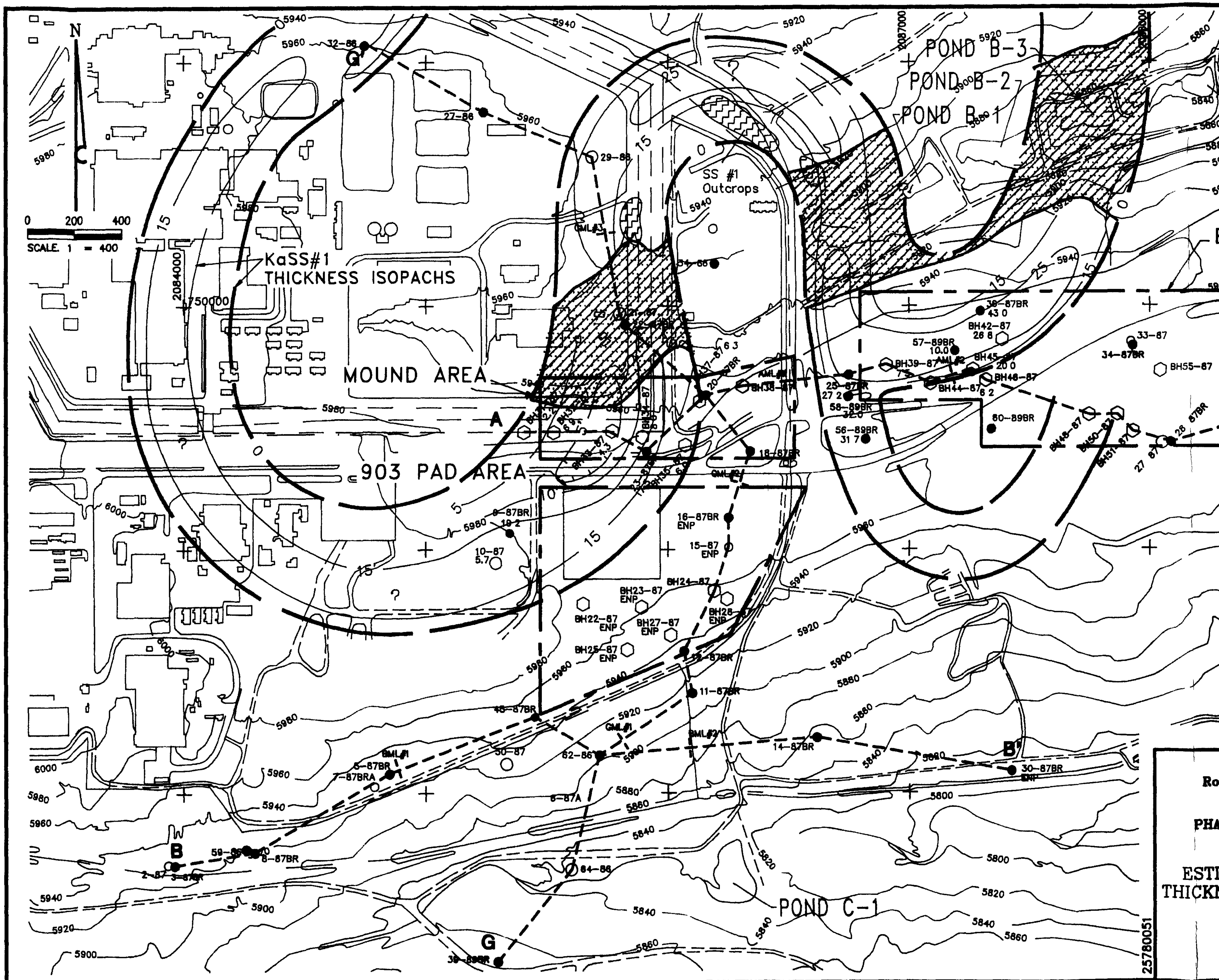
6/21/91



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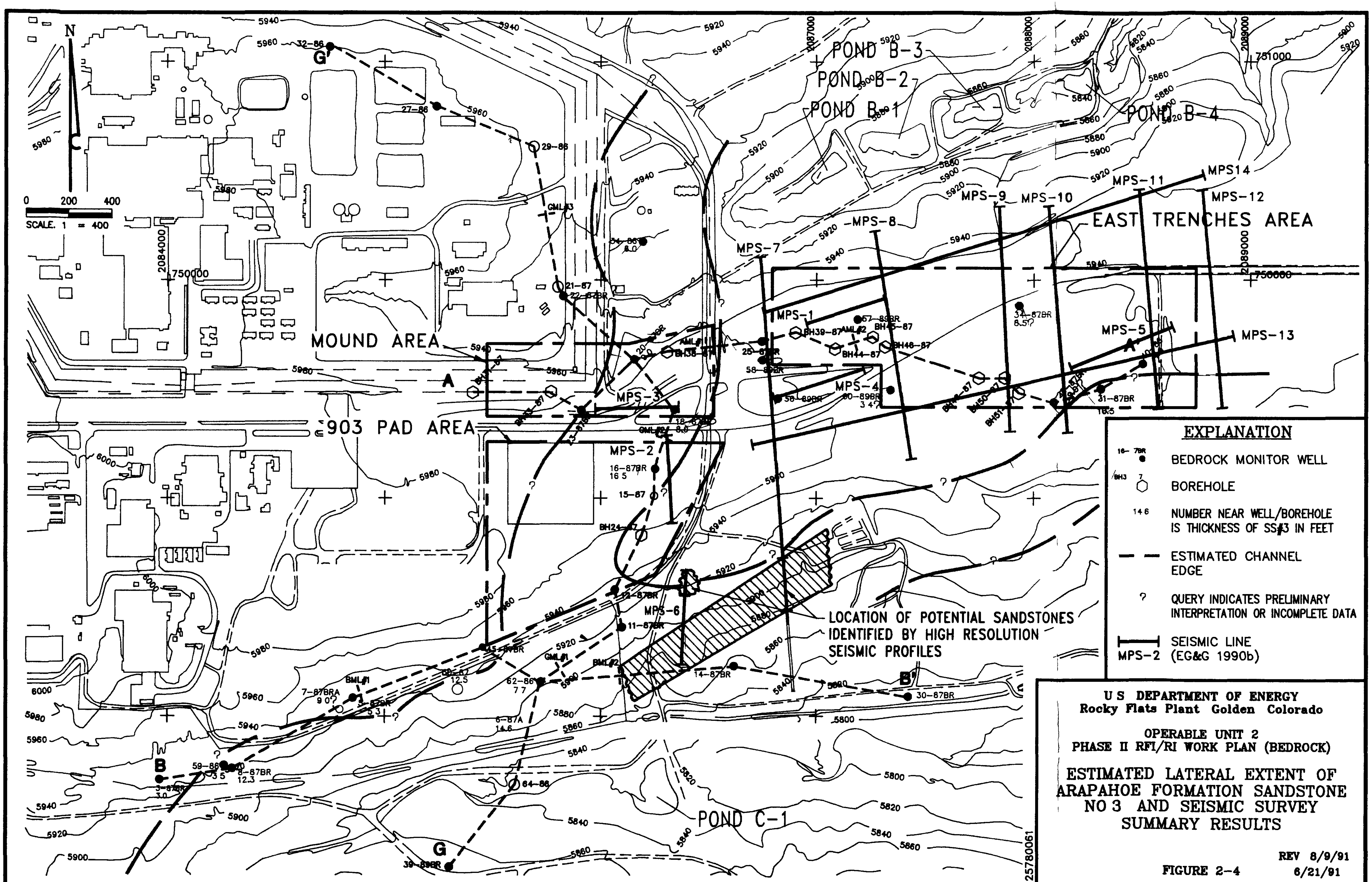
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

ESTIMATED LATERAL EXTENT AND THICKNESS OF ARAPAHOE FORMATION SANDSTONE NUMBER 1

FIGURE 2-3 6/21/91

25780051



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OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

ESTIMATED LATERAL EXTENT OF ARAPAHOE FORMATION SANDSTONE NO 3 AND SEISMIC SURVEY SUMMARY RESULTS

FIGURE 2-4

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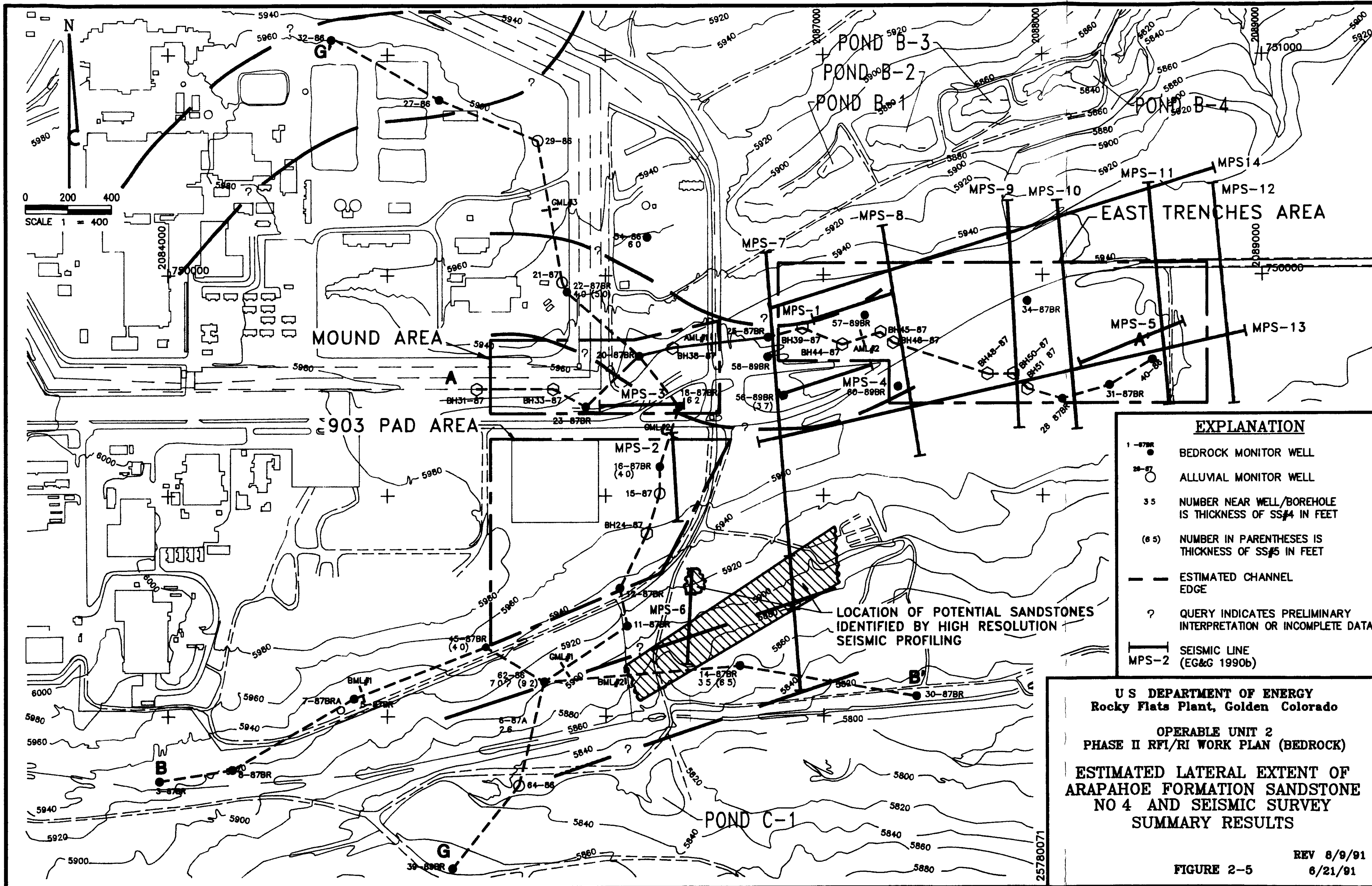
6/21/91



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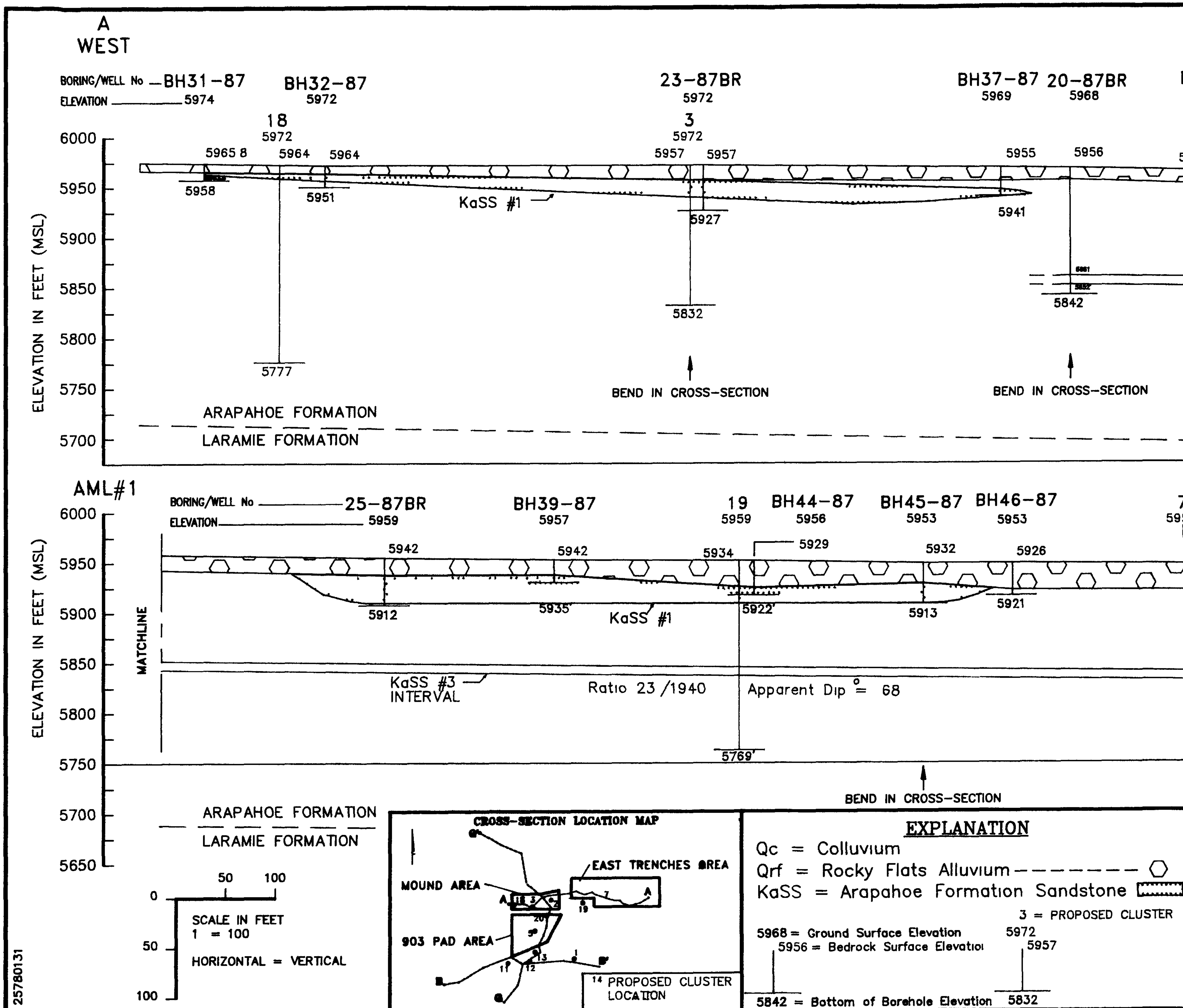
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

ESTIMATED LATERAL EXTENT OF ARAPAHOE FORMATION SANDSTONE NO 4 AND SEISMIC SURVEY SUMMARY RESULTS

FIGURE 2-5

REV 8/9/91
6/21/91

25780071



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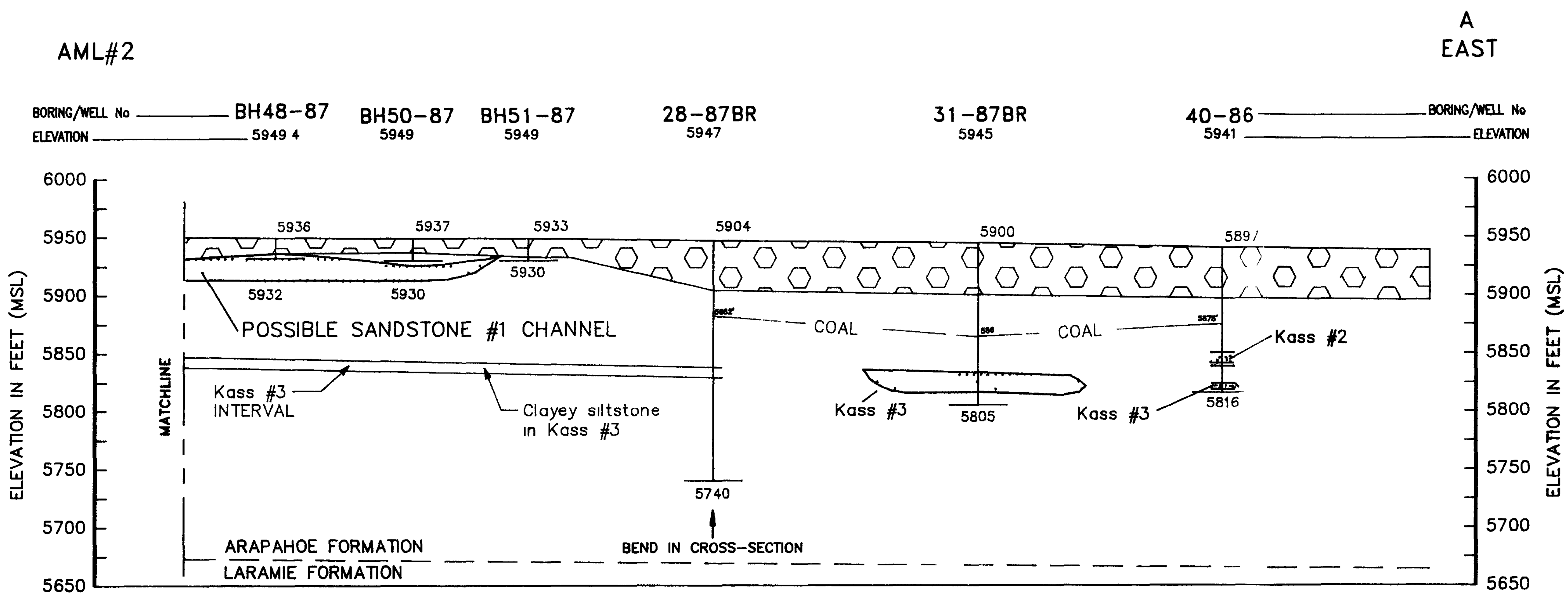
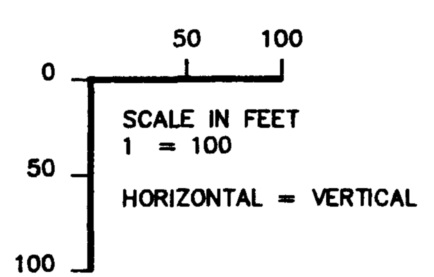
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

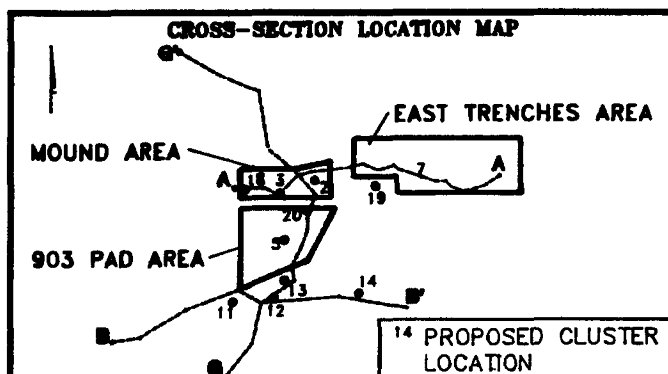
GEOLOGIC CROSS-SECTION A-A

FIGURE 2-6A **6/21/91**

25780131







EXPLANATION

Qc = Colluvium

Qrf = Rocky Flats Alluvium

KaSS = Arapahoe Formation Sandstone

3 = PROPOSED CLUSTER

5968 = Ground Surface Elevation 5972

5956 = Bedrock Surface Elevation 5957

5842 = Bottom of Borehole Elevation 5832

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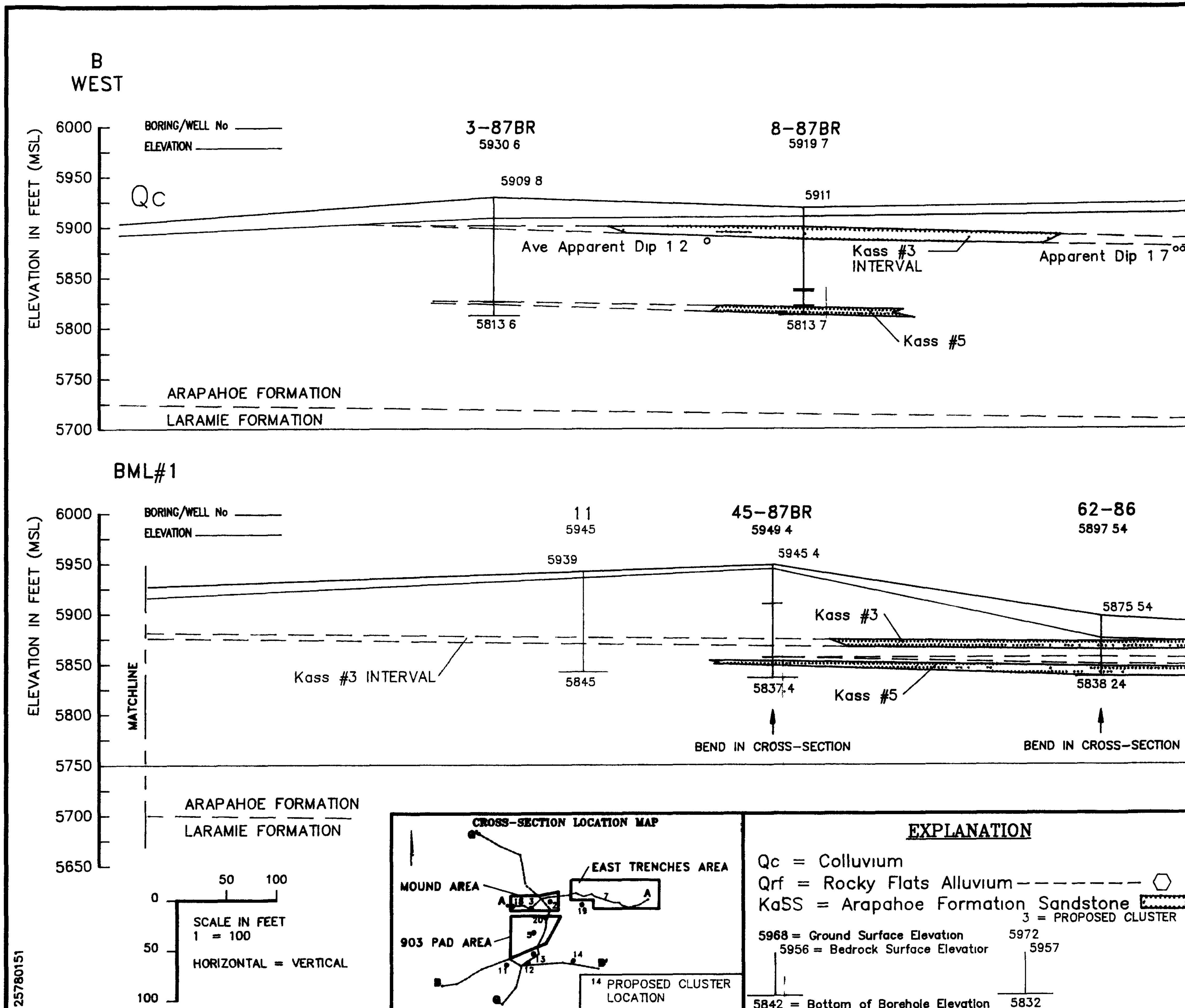
Rocky Flats Plant Golden Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GEOLOGIC CROSS-SECTION A-A

FIGURE 2-6B **6/21/91**

25780141



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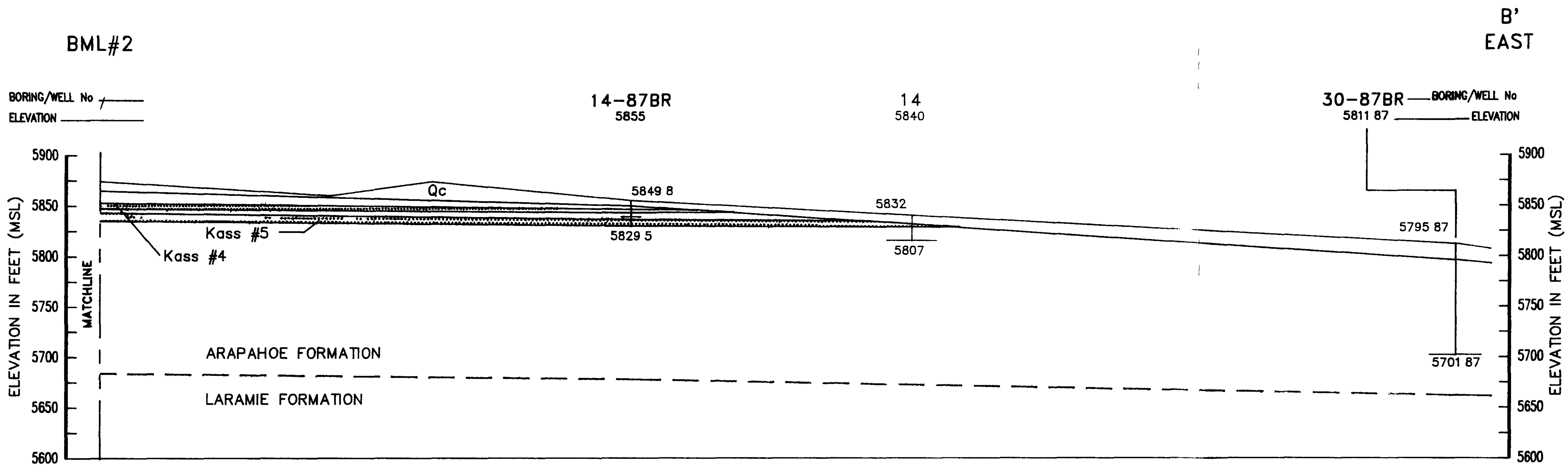
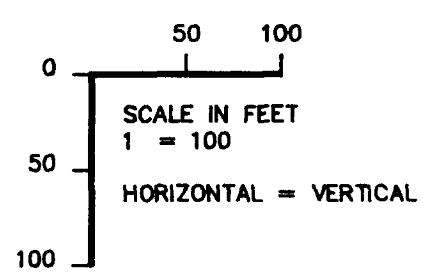
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

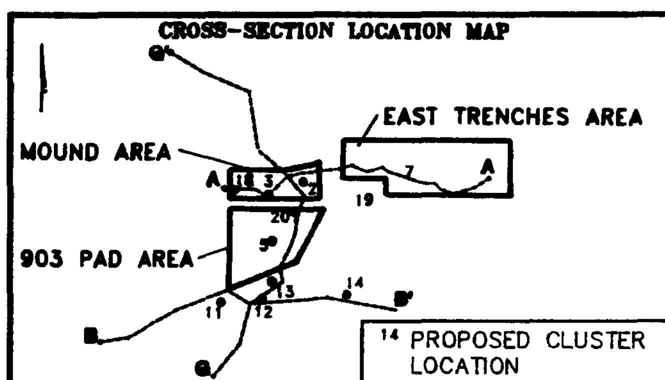
GEOLOGIC CROSS SECTION B-B

FIGURE 2-7A 6/21/91

25780151







EXPLANATION

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3 = PROPOSED CLUSTER

5968 = Ground Surface Elevation

5956 = Becrock Surface Elevation

5842 = Bottom of Borehole Elevation

5972
5957
5832

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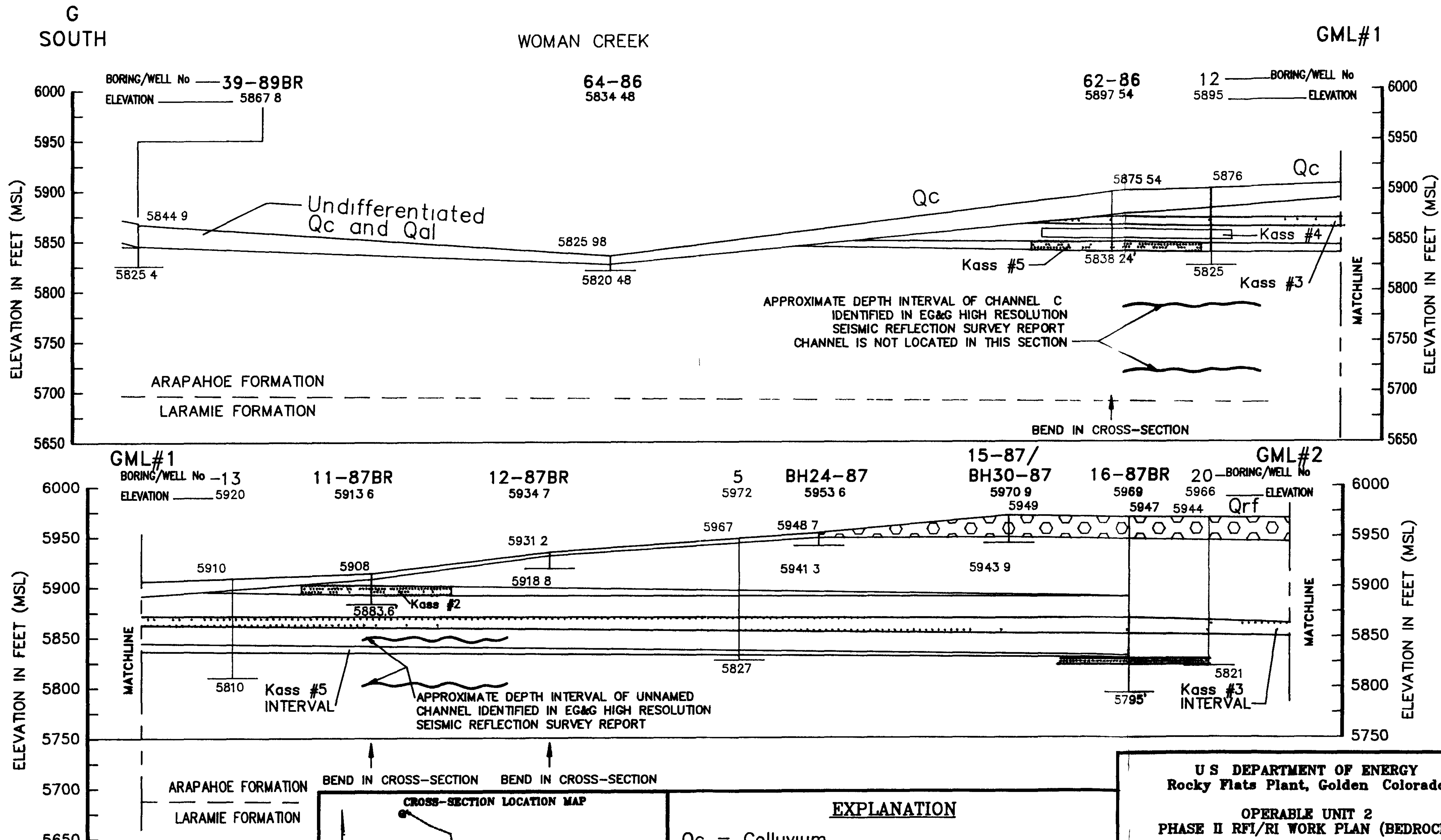
Rocky Flats Plant Golden Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

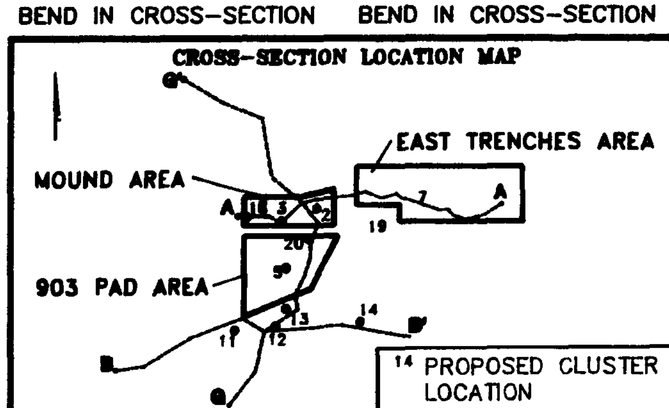
GEOLOGIC CROSS-SECTION B-B

FIGURE 2-7B **6/21/91**

25780161



SCALE IN FEET
1 = 100
HORIZONTAL = VERTICAL



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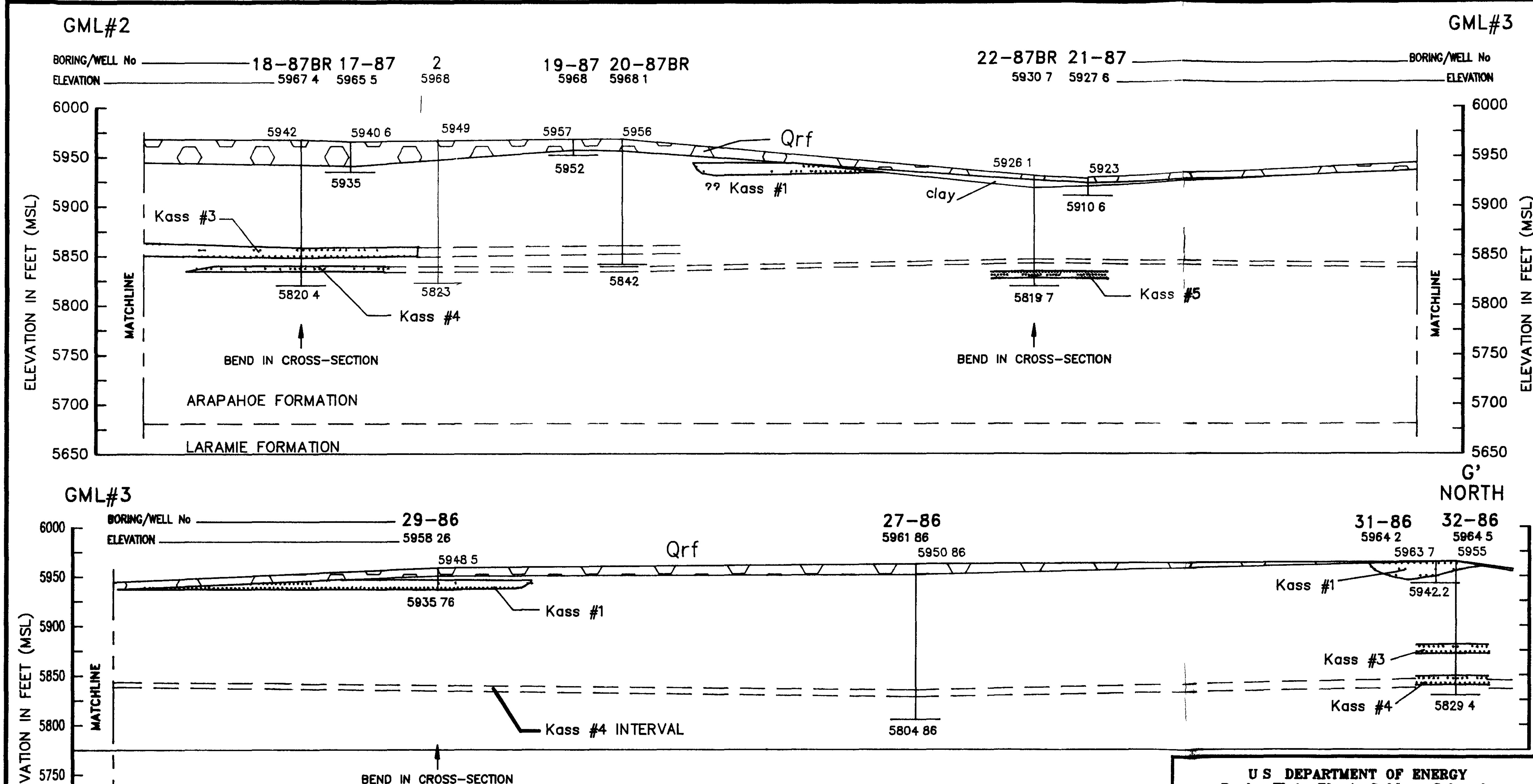
Rocky Flats Plant, Golden Colorado

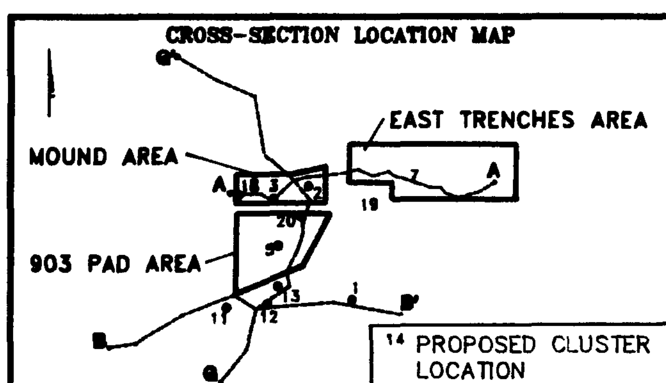
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GEOLOGIC CROSS-SECTION G-G

FIGURE 2-8A 6/21/91

25780171





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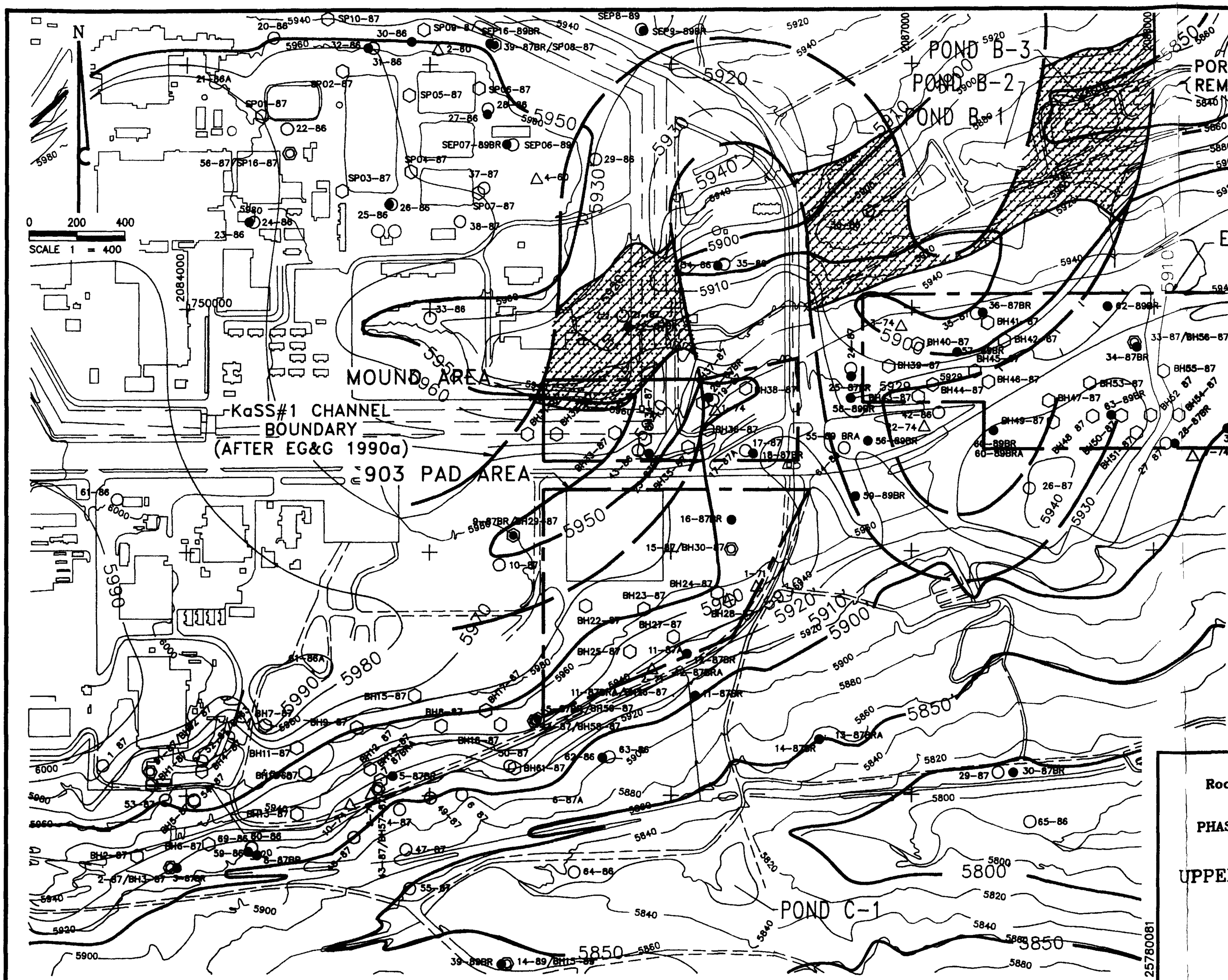
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

GEOLOGIC CROSS-SECTION G-G

FIGURE 2-8B **6/21/91**

25780181



EXPLANATION

- BEDROCK MONITOR WELL
- ALLUVIAL MONITOR WELL
- PRE-1986 MONITOR WELL
- BOREHOLE
- 5908 BEDROCK ELEVATION AT BOREHOLE OR WELL
- BEDROCK ELEVATION CONTOUR (FEET ABOVE MEAN SEA LEVEL) CONTOUR INTERVALS 10 AND 50 FEET

NOTE. CONTOURS ARE SAME AS BEDROCK SURFACE CONTOURS SHOWN IN FIGURE 2-2 OUTSIDE OF KaSS#1 AREA. CONTOURS INDICATE BOTTOM OF KaSS#1 WITHIN CHANNEL AREA.

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OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

UPPER HYDROSTRATIGRAPHIC UNIT (HSU) BOTTOM SURFACE CONTOUR MAP

FIGURE 2-9

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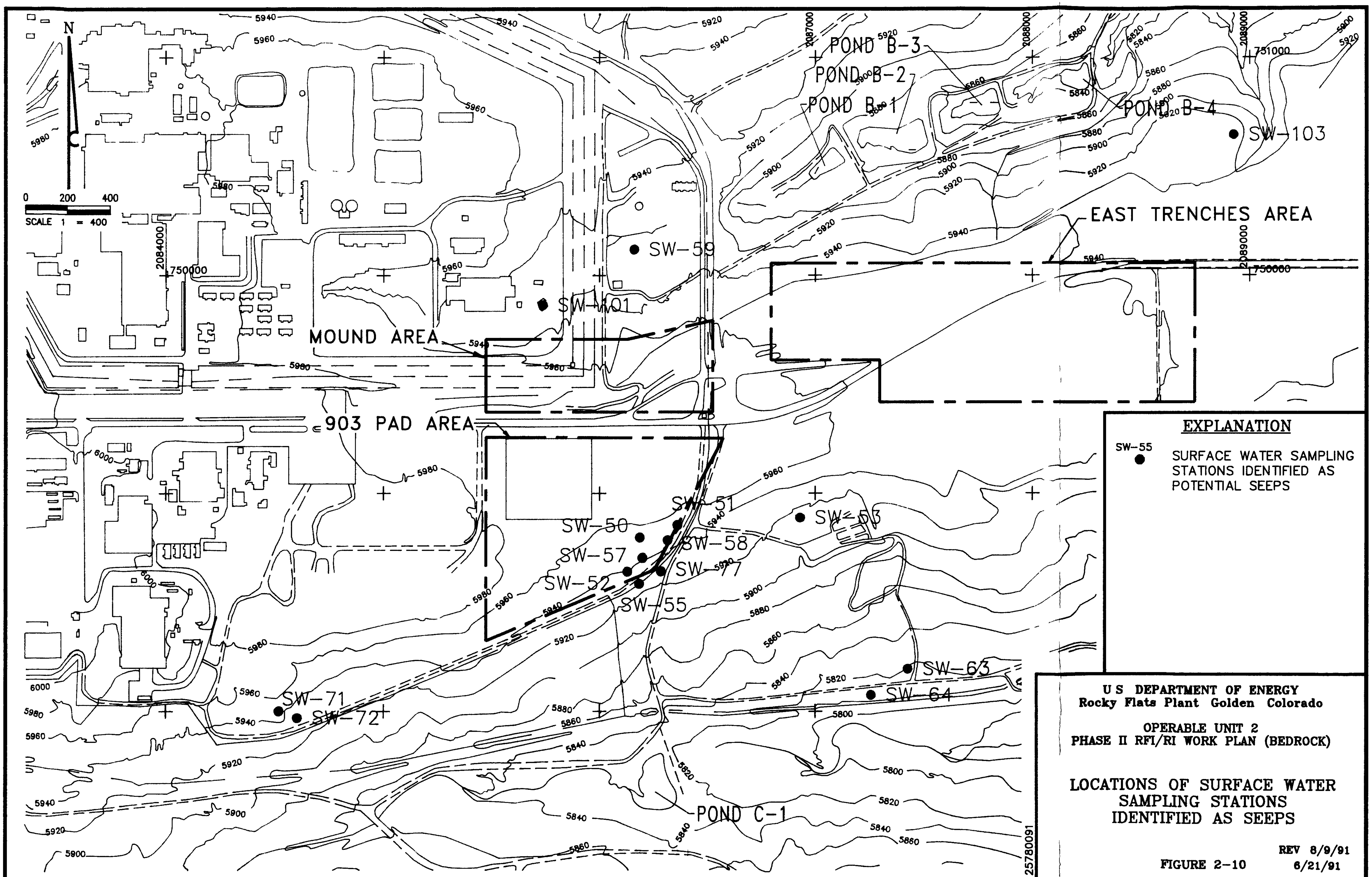
6/21/91



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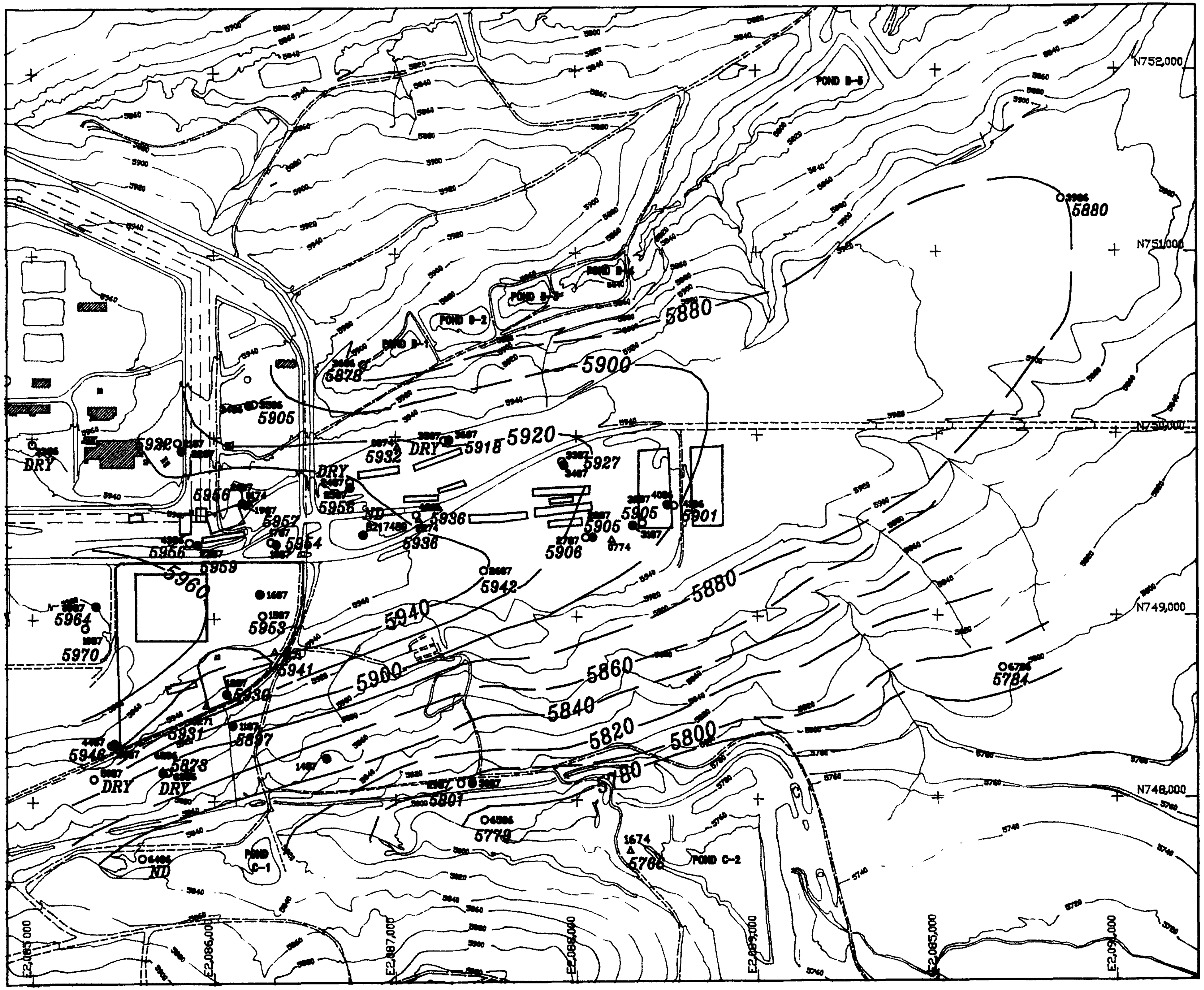
OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

LOCATIONS OF SURFACE WATER SAMPLING STATIONS IDENTIFIED AS SEEPS

FIGURE 2-10

REV 8/9/91
6/21/91

25780091



EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

5798 POTENTIOMETRIC SURFACE ELEVATION (feet above mean sea level)

ALL DATA BASED ON MEASUREMENTS MADE APRIL 4–8, 1988 INCLUSIVE

5860 LINE OF EQUAL POTENTIOMETRIC SURFACE ELEVATION (feet above mean sea level)—DASHED WHERE APPROXIMATELY LOCATED

ND NO DATA

B217489 ● BEDROCK MONITOR WELL

B213789 ○ ALLUVIAL MONITOR WELL

0382 ▲ PRE-1986 MONITOR WELL

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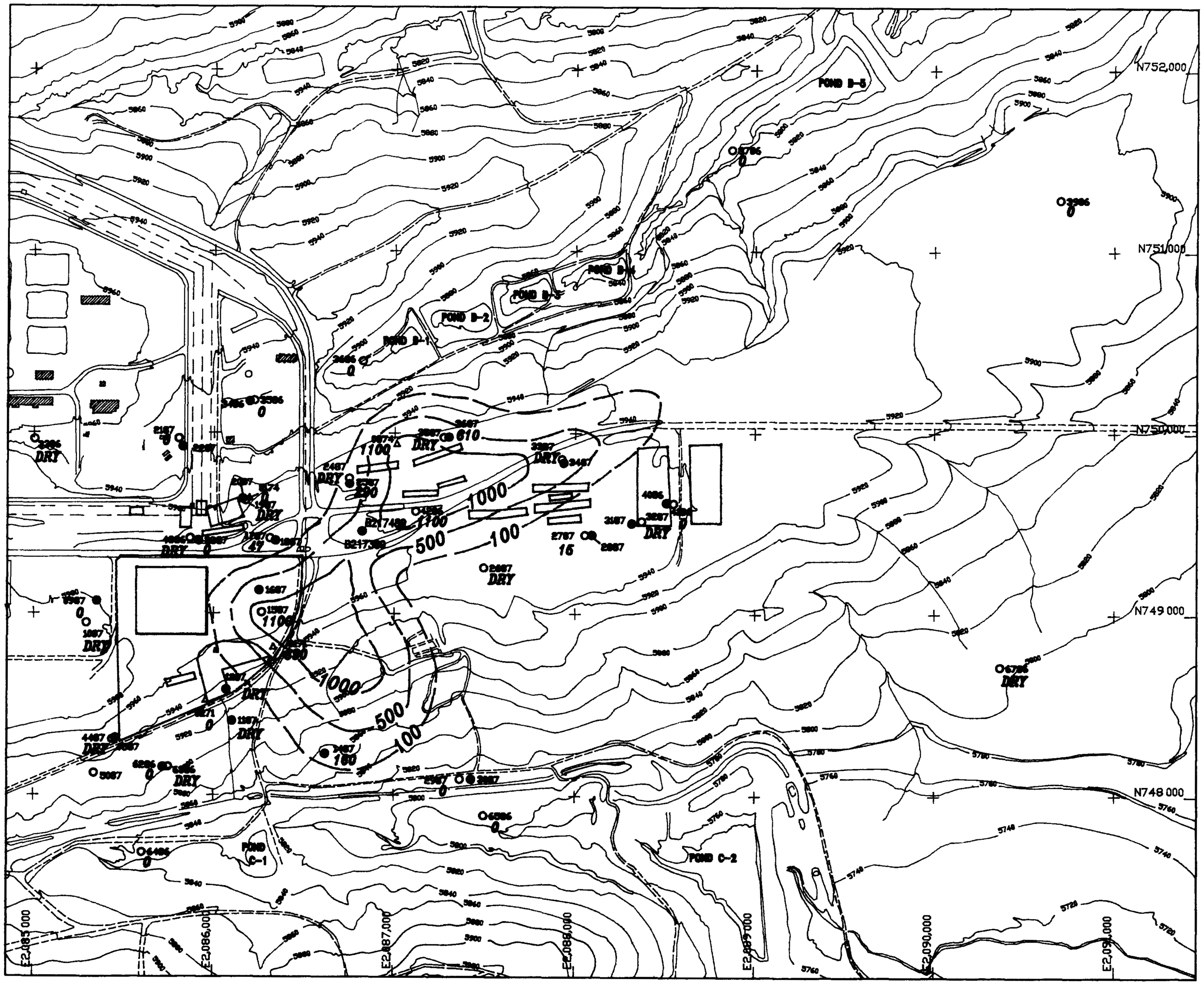
Rocky Flats Plant, Golden Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

POTENTIOMETRIC SURFACE OF UPPER HYDROSTRATIGRAPHIC UNIT (HSU)

FIGURE 2 11 6/21/91

25780100



EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

500 — LINE OF EQUAL CCl_4 CONCENTRATION (µg/l) DASHED WHERE APPROXIMATELY LOCATED

290 — CCl_4 CONCENTRATION (µg/l)

2587 ● BEDROCK MONITOR WELL

3789 ○ ALLUVIAL MONITOR WELL

0382 △ PRE-1986 MONITOR WELL

Scale 1 = 600

0' 300' 600'

CONTOUR INTERVAL = 20'

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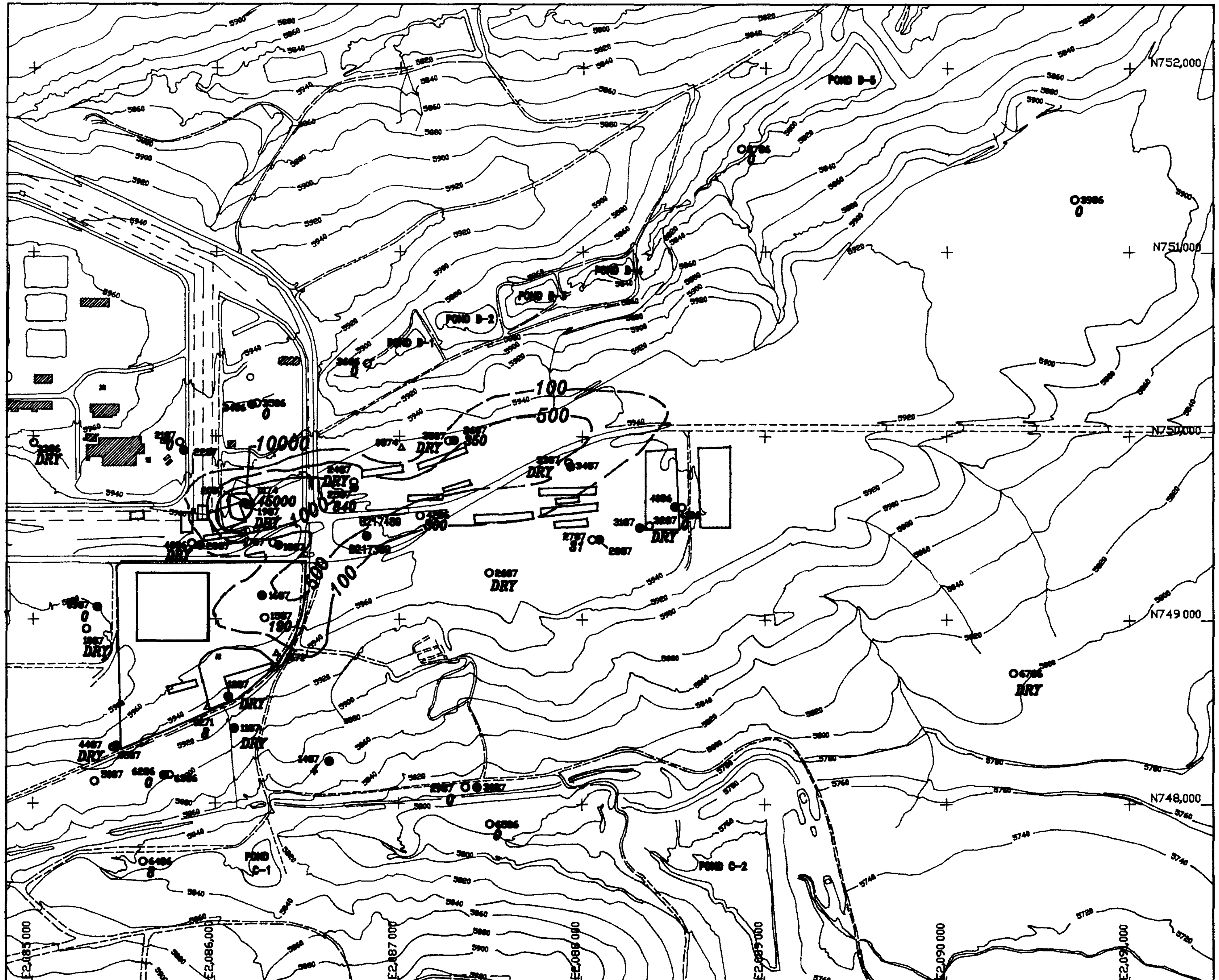
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

CARBON TETRACHLORIDE ISOPLETHS FOR THE UPPER HYDROSTRATIGRAPHIC GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-21

July 1991



EXPLANATION

(box symbol)	INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)
500	LINE OF EQUAL PCE CONCENTRATION (µg/l) DASHED WHERE APPROXIMATELY LOCATED
160	PCE CONCENTRATION (µg/l)
2587 ●	BEDROCK MONITOR WELL
3789 ○	ALLUVIAL MONITOR WELL
0382 △	PRE-1986 MONITOR WELL

Scale 1" = 600

0' 300' 600'

CONTOUR INTERVAL = 20'

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

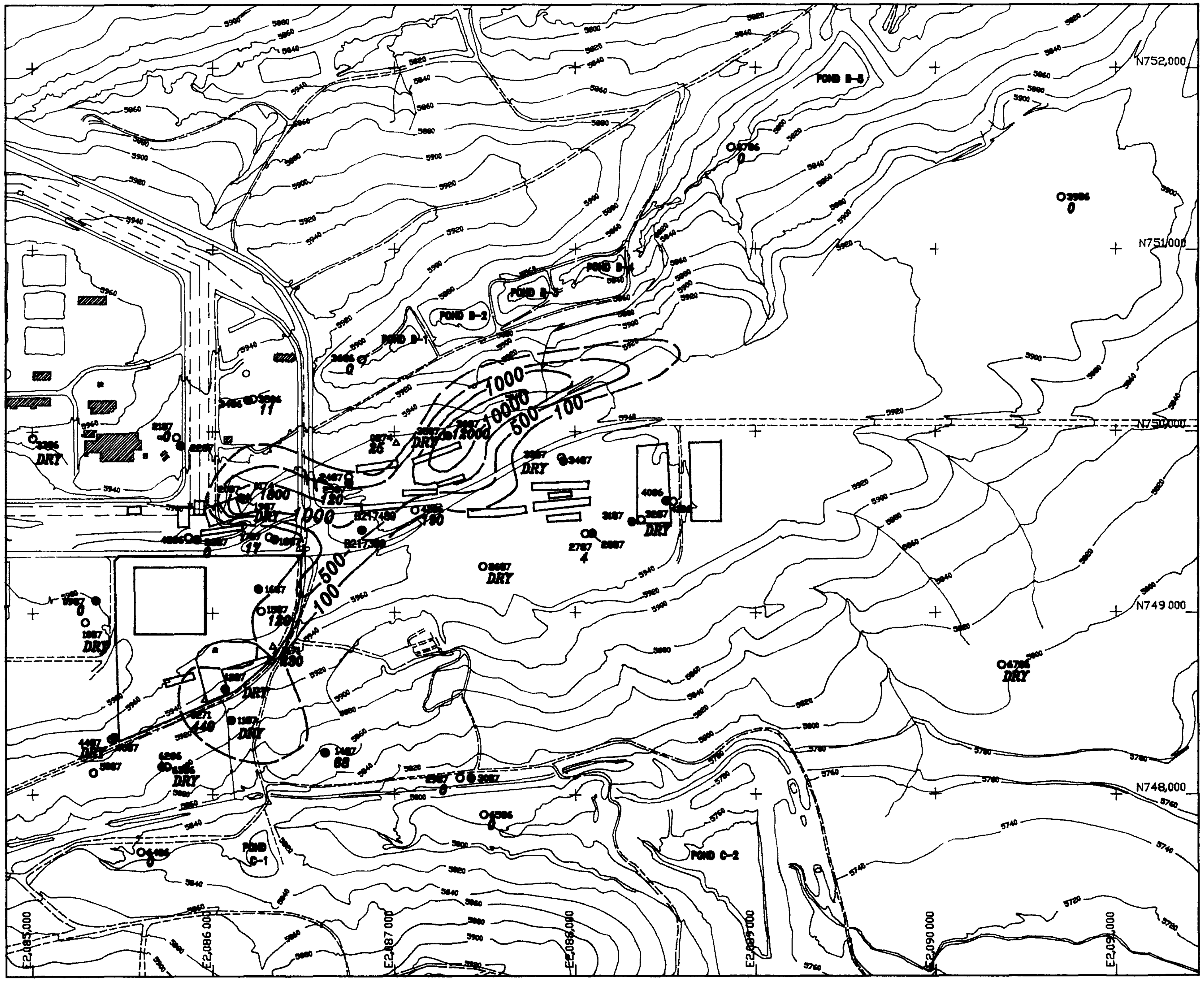
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

TETRACHLOROETHENE ISOPLETHS FOR THE UPPER HYDROSTRATIGRAPHIC GROUND-WATER FLOW SYSTEM Second Quarter 1989

FIGURE 2-22

July 1991

R33N031.MBH-090791/600



EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

500 — LINE OF EQUAL TCE CONCENTRATION (μg/l) DASHED WHERE APPROXIMATELY LOCATED

120 — TCE CONCENTRATION (μg/l)

2587 ● BEDROCK MONITOR WELL

3789 ○ ALLUVIAL MONITOR WELL

0382 △ PRE-1986 MONITOR WELL

N

Scale 1 = 600

0' 300' 600'

CONTOUR INTERVAL = 20'

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

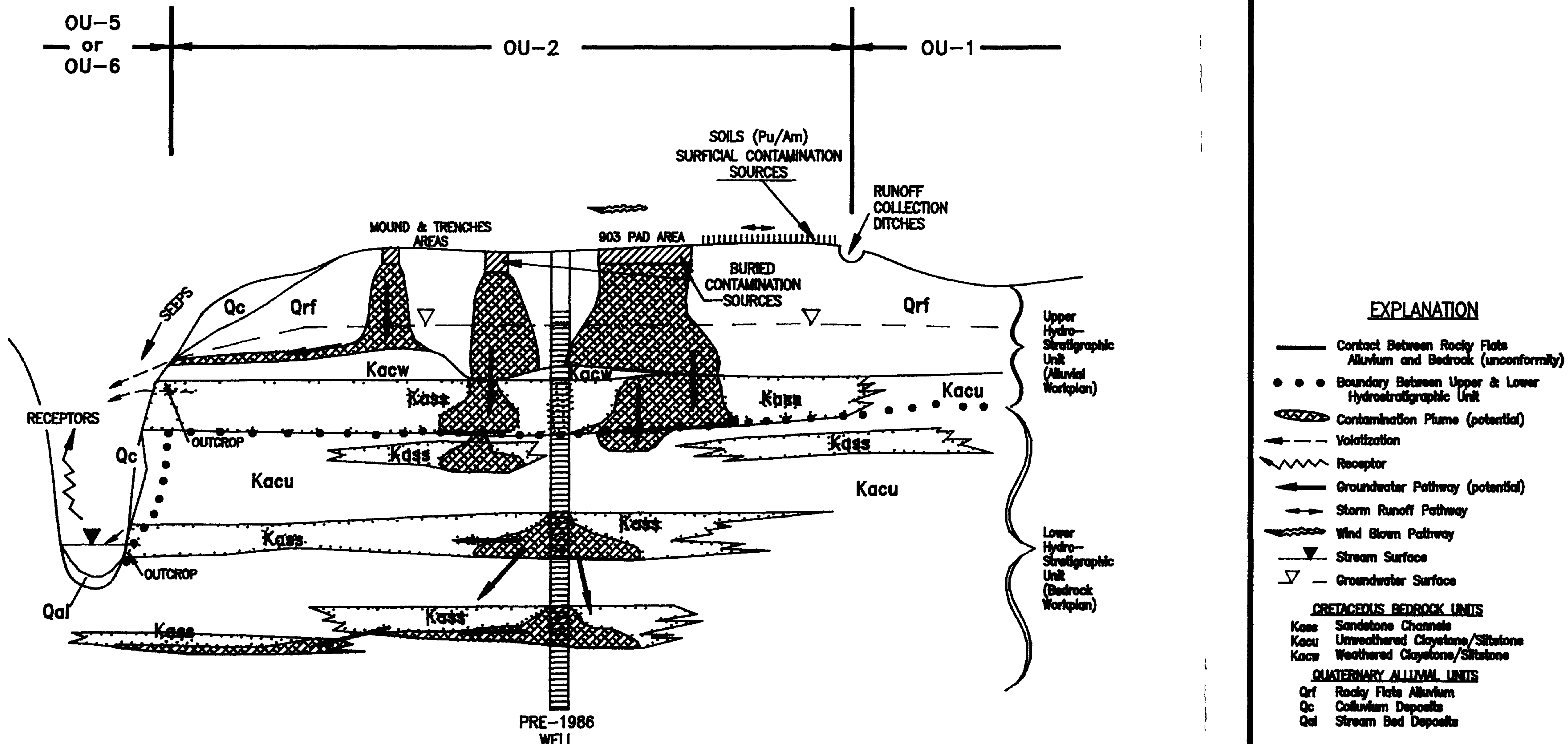
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

TRICHLOROETHENE ISOPLETHS FOR THE UPPER HYDROSTRATIGRAPHIC GROUND-WATER FLOW SYSTEM
Second Quarter 1989

FIGURE 2-23

July 1991

R33M032.MB5-080791/800



NOT TO SCALE

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

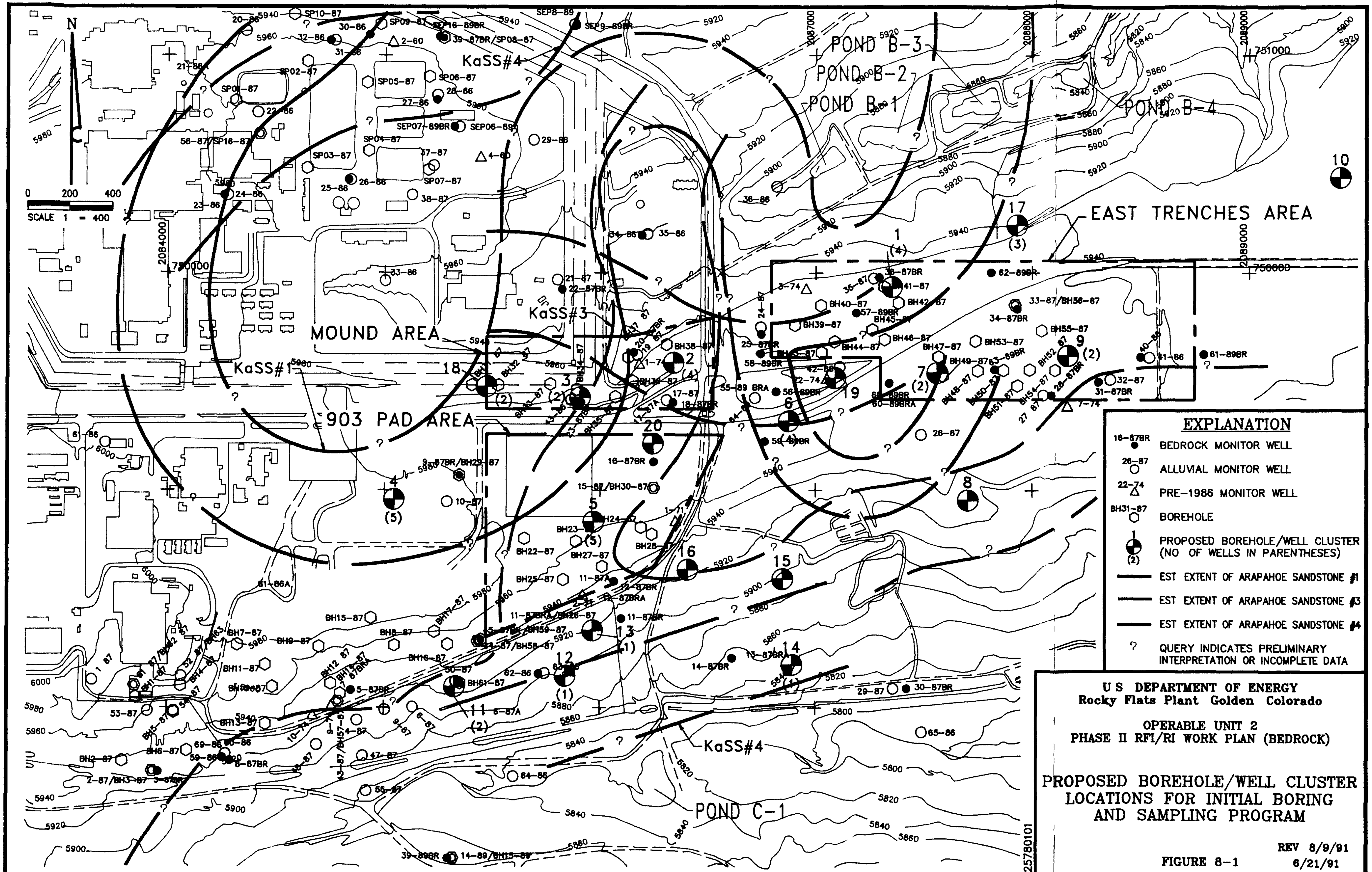
OPERABLE UNIT NO 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

SITE CONCEPTUAL MODEL

FIGURE 2 24

6/21/91

R33055.PJ-012191



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Rocky Flats Plant Golden Colorado

OPERABLE UNIT 2
PHASE II RFI/RI WORK PLAN (BEDROCK)

PROPOSED BOREHOLE/WELL CLUSTER LOCATIONS FOR INITIAL BORING AND SAMPLING PROGRAM

REV 8/9/91
6/21/91

FIGURE 8-1